CENTENNIAL HALL IN WROCŁAW
CONSERVATION MANAGEMENT PLAN

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The Getty Foundation

Keeping It Modern

HALA STULECIA
CENTENNIAL HALL

Museum of Architecture in Wrocław
Wrocław 2016

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TABLE OF CONTENTS

Dear Ladies and Gentlemen!

The Conservation Management Plan (CMP), a tool for proper management of valuable historical objects was prepared by a team of professionals in 2015. Thanks to the CMP, the management company that oversees the Centennial Hall and the Exhibition Grounds – Wrocławskie Przedsiębiorstwo Hala Ludowa Sp. z o.o. (WP Hala Ludowa Sp. z o.o.) received a complete analysis of the building's infrastructure. The CMP not only describes the current state of the building but also analyzes its compatibility with the original intentions of the architect, which serve as principal guidelines for the conservation strategy of the most important elements of the building. Very importantly, the CMP clearly describes the degree to which interference to the building and its surroundings is permitted, defining the limits of potential changes. For WP Hala Ludowa Sp. z o.o., which oversees events that bring more than three quarters of a million visitors annually, the CMP, is an essential tool. Since 1913, the Centennial Hall has served people in accordance with the architect's original ideas, and it is clear from the visitors' numbers that Max Berg's genial project continues to maintain its enormous popularity.

The fundamental condition for the functioning of a medium-sized enterprise, such as WP Hala Ludowa Sp. z o.o. is its developmental strategy. In the case of companies that manage historic buildings, such strategy must be based on the awareness of boundaries set by historical and preservation constraints. I am convinced that the CMP developed for Centennial Hall thanks to the generous support of the Getty Foundation as part of its Keeping It Modern initiative will be such a strategic guide for all future courses of action.

Since July 2006, Centennial Hall has been inscribed on the UNESCO World Heritage List. The CMP published in 2016 is the best commemoration of the 10th anniversary of its entry on the List. Together with the recently introduced "Plan of Management of UNESCO Heritage Sites", the CMP will be the standard for all managerial decisions in the next century.

Andrzej Baworowski
Chairman of the Board
Wrocławskie Przedsiębiorstwo Hala Ludowa Sp. z o.o.

Foreword

In September 2011, close to six thousand spectators gathered under the dome of the Centennial Hall to hear the world premiere of Krzysztof Penderecki's concert in it's experimental interpretation by Aphex Twin and Jonny Greenwood. The event was a part of the European Congress of Culture, which took place in Centennial Hall and inaugurated the first historical Polish presidency in the European Union. Extraordinary music filled Centennial Hall's spectacular interior, which was unveiled for the first time following its general revalorization. The process, which took five years and included conservation work on the main building as well as the surrounding area, cost more than sixty million Euro – the majority of which were public funds from the European Union and the local government. In this way, one of the most important monuments of world Modernist architecture was rescued and returned to its rightful position among the world's iconic meeting and cultural complexes.

The experimental performance in 2011 made historical reference to the time of Centennial Hall's grand opening in 1913 where the premiere spectacle of *Commemoration Masque* (*Festspiel in deutschen Reimen*) written by Gerhart Hauptmann and directed by Maks Reinhardt was performed for a crowd of six thousand spectators. The continuity of Centennial Hall's function over the course of more than a hundred years is exceptional especially when we taking into consideration its geographical location in the epicenter of 20th century European wars and conflicts. Despite the changes of borders and political regimes, Centennial Hall, a work of genius of the municipal architect of German Breslau is now a central figure for the citizens and leaders of Polish Wrocław, constituting a key element of the vision of the city as an open and welcoming meeting place. We would like to stress the importance of international institutions in ensuring this historical endurance. The inscription of Centennial Hall on the UNESCO World Heritage List in 2006 was an immediate impulse, which set the limits and principles for subsequent revalorization of the building. Thanks to the support of the Getty Foundation, we were able to prepare the conservation principles for future generations of users. It is our hope that this document will help ensure the material and functional continuity of Centennial Hall as it enters the second century of its existence.

1.

Conservation Management Plan for Centennial Hall in Wrocław

1. Conservation Management Plan for Centennial Hall in Wrocław

1.1. Introduction

The Conservation Management Plan (CMP) for Centennial Hall in Wrocław is historically the first of this kind of document in Poland. Its preparation was financed by the Getty Foundation as part of its Keeping It Modern initiative designed to protect unique Modernist buildings of the world. From now on, the CMP should serve as the principal source of knowledge and reference in the process of decision-making concerning any changes to the building and its surroundings. The document presents the history of Centennial Hall, points to its exceptional architectural values and contains detailed conservation recommendations whose goal is to ensure that its future management and conservation are systematic, methodical and careful. In the future, the CMP – together with other Polish legal regulations – should provide the foundation for the introduction of a unified management plan for the whole area inscribed on the UNESCO World Heritage List.

Both Centennial Hall and other surrounding buildings located on the former Exhibition Grounds face similar challenges of needing to adapt to contemporary needs and functionality to fulfill the standards of the 21st century. The only acceptable changes however, are those that respect the historical value and architectural fabric of the building and retain features that have made Centennial Hall and the Exhibition Grounds one of the most important monuments of 20th century cultural heritage in Poland, Europe and the world.

1.2. Objectives of the CMP

The main objective of the CMP is to formulate the principles of protection of the unique urban cultural landscape of Centennial Hall and its surrounding area. This document:

- Presents the history and significance of the building in order to define acceptable changes;
- Defines the various ways and degrees of protection as they pertain to different parts of the buildings to facilitate its proper function;
- Formulates detailed conservation recommendations to facilitate future repairs and revalorizations.

The CMP should allow for comprehensive understanding of the building and its' particular architectural and historical features, which under all circumstances must be protected. It must be emphasized that:

- **The document should be regularly verified and the implementation of its recommendations should be monitored.**
- **The conservation recommendations specified in the CMP should be treated as the main source of knowledge and information when planning any kind of interventions in the building of Centennial Hall or the surroundings of the Exhibition Grounds.**

1.3. Scope and Methodology

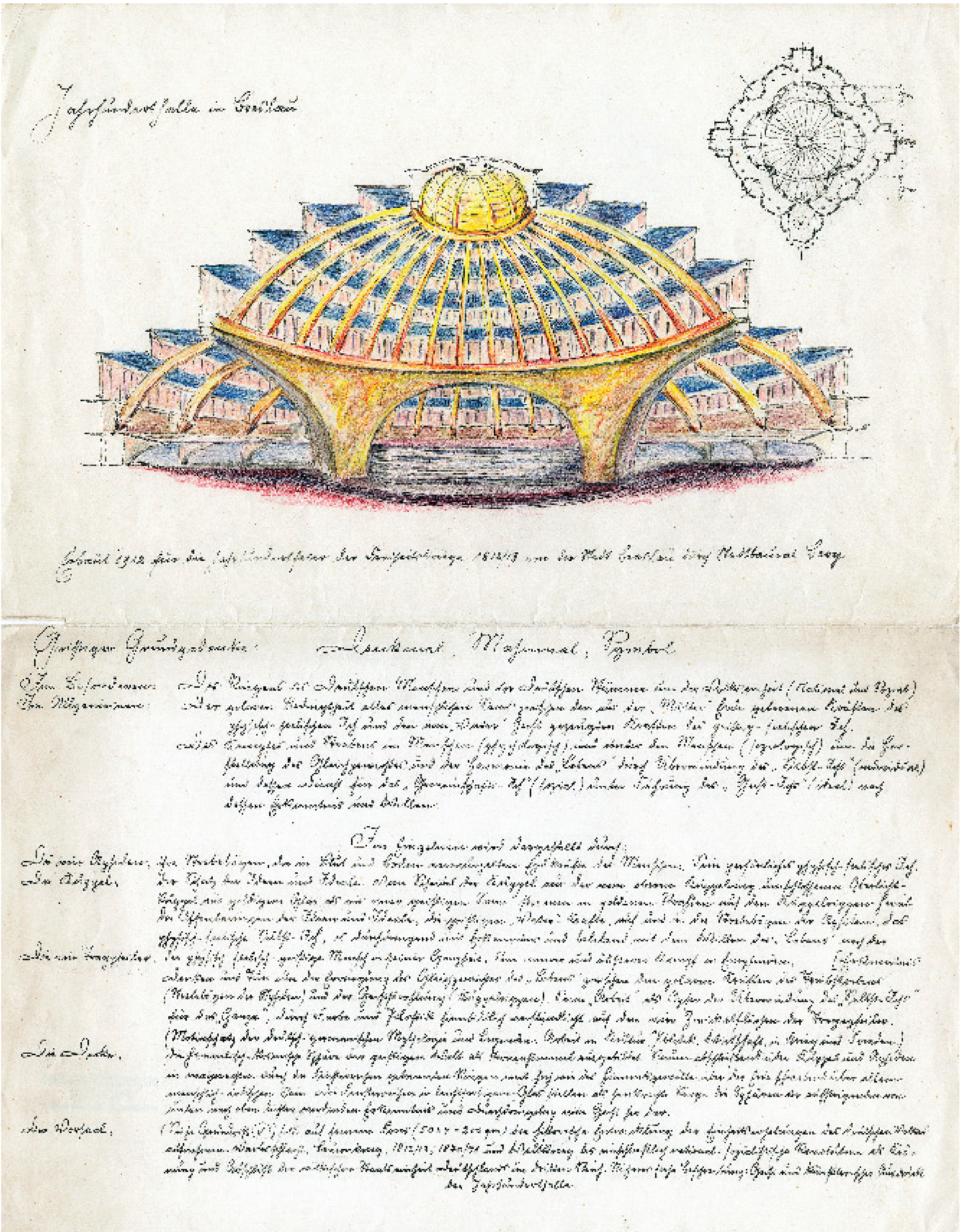
The multifunctional character of Centennial Hall and the surrounding areas, have dictated the scope of the present study. The building and grounds have served as venues for the following types of activities:

- **Cultural space** – artistic events (concerts, operas, theatre performances, exhibitions);
- **Exhibition space** – presentation of products, solutions and technologies in various fields (e.g. tourism, construction and engineering, medicine, sports, motorization);
- **Convention space** – the city's principal venue for conferences, congresses, symposia, and conventions;
- **Museum and educational space** – important temporary exhibitions and a permanent exhibition presenting the history of the Centennial Hall in the context of 20th-century architecture located in the Learning Center (Centrum Poznawcze) established in 2011;
- **Recreational space** – especially the historic Pergola designed by Hans Poelzig surrounding a pond with a new multimedia "light and sound" fountain.

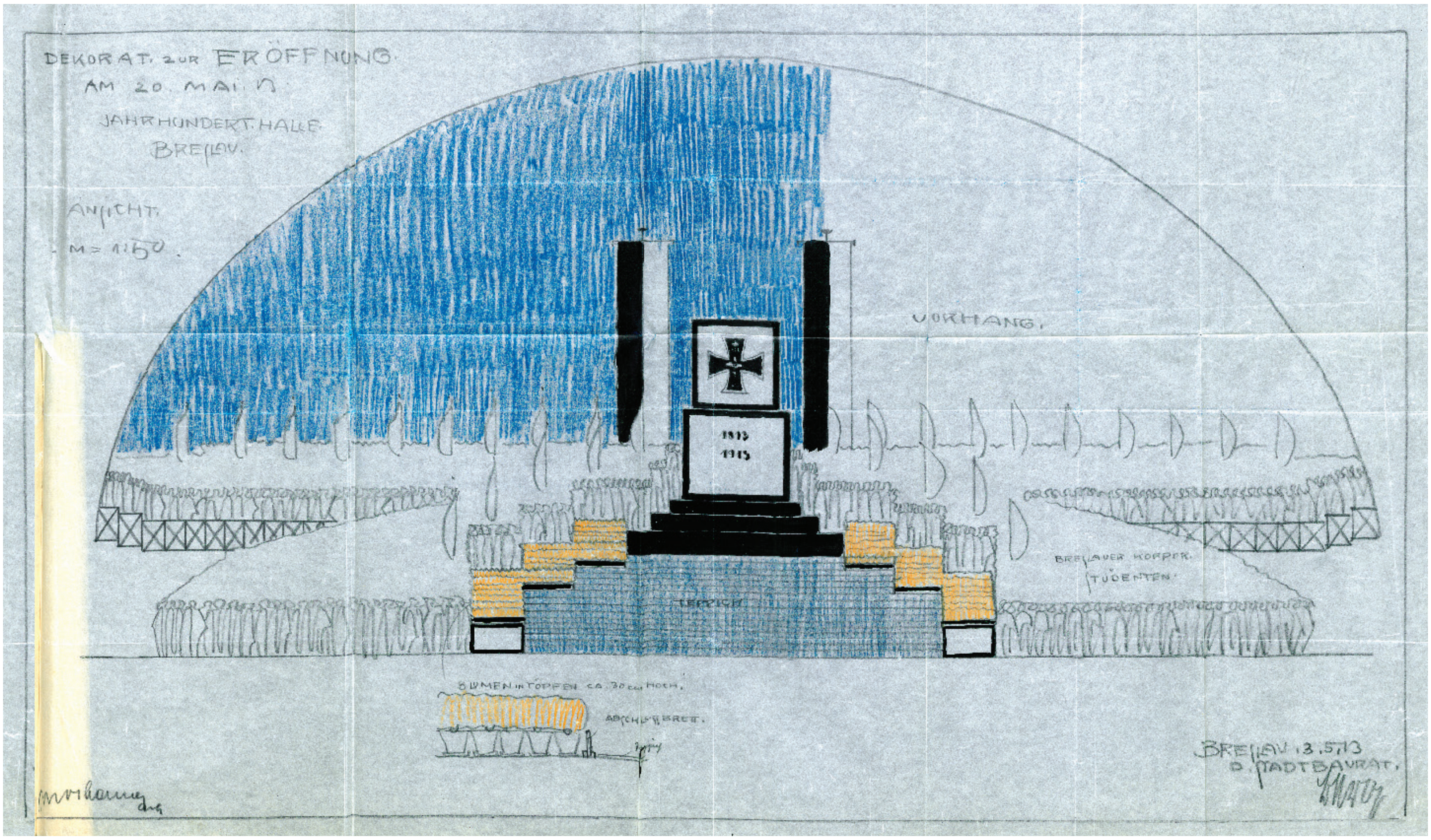
These functions, which have provided continuity throughout Centennial Hall's existence, have been taken into consideration in the preparation of the CMP. It is important that the same policy of usage and function, tested through time and history, is maintained in the future.

The CMP for Centennial Hall has been divided into four parts:

- Architectural analysis of the building, including archival, iconographic and bibliographical research;
- Structural analysis of the building, its color design as well as the composition and condition of the greenery in the surrounding areas;



1 Max Berg, design conception for the Centennial Hall, interior view, projection, description, 1912. Deutsches Museum in Munich, archive, legacy of Max Berg



2 Max Berg, set design for the opening reception of the Centennial Exhibition staged at the Centennial Hall on May 20, 1913.
Colored drawing. National Archives in Wrocław, Files of the City of Wrocław

- Analysis of changes to the building and its revalorizations and implemented conservation programs, including conservation recommendations;
- Analysis of cultural heritage management.

Under the first point, the following tasks have been completed:
The building's architectural analysis has been conducted on the basis of archival research and contains a list of archival documents and iconography dating to the period from the beginning of the design process to World War II. The following queries have been conducted:

a) Archival research:
- The National Archives in Wrocław (Archiwum Państwowe we Wrocławiu): files on the building's construction, including drawings, contracts, lists of building materials, shorthand notes from the meetings of the City Building Commission regarding Centennial Hall, tender documentation concerning construction work and architectural drawings. Overall, there are almost 150 volumes related to the construction and functioning of the Centennial Hall and Exhibition Grounds;
- Building Archive of the City of Wrocław, a branch of the Museum of Architecture in Wrocław (Archiwum Budowlane Miasta Wrocławia, oddział Muzeum Architektury we Wrocławiu): more than 300 designs and architectural drawings from 1911–1930 covering changes to the building and construction work, including the architectural design from 1911 made by Max Berg and accepted by the City Building Inspectorate;
- Leibniz Institute for Research on Society and Space in Erkner near Berlin (Leibniz-Institut für Raumbezogene Sozialforschung formerly Institut für Regionale Entwicklung und Strukturplanung in Erkner near Berlin): Max Berg's archive, including preliminary drawings and designs of the Centennial Hall from 1910–1913;
- Deutsches Museum in Munich (Deutsches Museum von Meisterwerken der Naturwissenschaft und Technik München): the remainder of Max Berg's archive, including drawings of the Centennial Hall's proportions, designs and drawings concerning the extension of the Centennial Hall and Exhibition Ground in 1920–1925, and many other documents and letters of Max Berg concerning Centennial Hall and his other architectural work;
- Archives in Berlin: Max Berg's personal files.

b) Iconographic research:
Iconographic research resulted in compiling an almost complete documentation of photographs and images at the time of Centennial Hall's construction as well as from later periods. Iconographic research was conducted during archival research in institutions listed above and also in the special collections of the following institutions:
- The University Library in Wrocław (Biblioteka Uniwersytecka we Wrocławiu),
- The National Museum in Wrocław (Muzeum Narodowe we Wrocławiu),
- The Art Institute of the Polish Academy of Sciences in Warsaw (Instytut Sztuki Polskiej Akademii Nauk),
- in local journals, magazines, and newspapers published between 1910–1945 in Silesia and Germany, with special focus on publications dedicated to architecture, such as the "Deutsche Bauzeitung", "Bauwelt", "Zentralblatt der Bauerwaltung" (bibliographical queries).

c) Bibliographical queries:
Bibliographical queries of publications concerning Centennial Hall, conservation issues related to domed structures and reinforced-concrete structures from the time of Centennial Hall's construction to the present were conducted in libraries in Wrocław, Berlin, Munich and the Royal Library in London.

d) Queries concerning sources published in the press in the period of the Centennial Hall's construction
Based on queries conducted in the University Library in Wrocław and in the Library of Arts (Kunstbibliothek) in Berlin focused primarily on the regional press from the period before and during Centennial Hall's construction (1908–1920), the process of designing and building of Centennial Hall was reconstructed in detail.

Under the second point, three studies were completed, including:

A) Examination and testing of the building's structure and materials. Monitoring its safety and state of preservation (including the analysis of the state of preservation of window and door frames following the recent revalorization);

B) Conservation reconnaissance and the study of color design of Centennial Hall;

C) Survey of the area surrounding Centennial Hall, in particular an analysis of the composition and condition of greenery.

A) Examination and testing of the building's structure and materials, monitoring its safety and the state of preservation.
The following issues were addressed:

- Analysis of the physical and mechanical properties of the building materials used to construct the structure of Centennial Hall;
- Laser measurements of Centennial Hall's structure and development of a 3D model as the basis for creating digital models;
- Developing BIM (Building Information Modeling) and FEM (Finite Element Method) models to describe, outline, illustrate and show Centennial Hall's state of preservation;
- Developing the conception of monitoring the condition and safety of Centennial Hall's structure.

The principal objective was to collect research data to determine the present technical condition of Centennial Hall's structure and materials and set the reference framework for future cyclical assessment of the building's structure according to the presented concept of monitoring.

Scope
The scope of the study was determined by the need to monitor the condition of Centennial Hall's structure, principally with regard to the deterioration of materials, specifically:

- Examining Centennial Hall's materials and structure;
- Examining and assessing the technical condition of reinforced steel;
- Examining and assessing the technical condition of the bearings;
- Testing the physical, chemical, and mechanical properties of concrete;
- Assessing the waterproofness of concrete;
- Identifying areas prone to corrosion;
- Assessing the continuity of cross-sections of concrete elements;
- Developing an interactive digital model of Centennial Hall based on three basic models: FEM (Finite Element Method) – for structural calculations; BIM (Building Information Modeling) – as a model for updating the building's infrastructure and for project purposes; LMS (Long-Term Monitoring System) – a model allowing continuous collecting and storage of data from sensors located inside and outside the building.

The detailed description of the condition of Centennial Hall's materials and structure and the system of monitoring, provides scientific and technical foundations for monitoring the building's safety and changes over time.

B) The Study of Centennial Hall's color design

- Preparing preliminary photographic documentation;
- Completing analysis of surfaces to collect samples for testing;
- Analyzing the state of preservation of selected fragments and determining factors causing damage to original colors;
- Collecting samples for laboratory testing;
- Laboratory testing in two independent laboratories based in the city of Toruń;
- Analysis and interpretation of the collected materials, including data from laboratory tests;
- Identifying the color design of Centennial Hall's exterior walls in reference to contemporary color systems.

C) Analysis of the Condition of Greenery around Centennial Hall

The objective of the study was to evaluate the condition of plants and to develop recommendations for the revalorization of the historic landscape design and plants around Centennial Hall (in the building's immediate surroundings and the square in front of its western façade). The study included the 5 hectare (6 hectares including the Centennial Hall) area located between Wystawowa Street, Zygmunta Wróblewskiego Street, the underground parking garage on Mikołaja Kopernika Street and the Pergola. A detailed dendrological inventory was taken in May 2015, listing over 520 plant specimens (trees and shrubs) and identifying 29 botanical specimens, including several non-indigenous (acclimatized) specimens. The study documents in detail the plants that grow around Centennial Hall in terms of their type, parameters, forms, and condition. The dendrological inventory confronted with archival sources provided the basis for the analysis and recommendations concerning the cultivation and conservation of plants and trees.

Under the third point, the following tasks were completed:

- Archival research of designs and documentation concerning repairs and revalorizations carried out in the Centennial Hall from 1945 through to 2011 (most recent revalorization) in Wrocław's archives;
- Analysis of existing conservation studies and previous work implemented, involving a number of detailed queries concerning:
  a) Existing conservation studies of Centennial Hall (located in the archives of the Wrocław City Historic Preservation Office and Lower Silesia Voivodship Historic Preservation Office as well as archives at Centennial Hall);
  b) Documentation of all conservation work completed after 2006 located in the archives of the Wrocław Municipal Historic Preservation Office and Lower Silesia Voivodship Historic Preservation Office as well as archives at Centennial Hall.
- Analysis of land use in the area around Centennial Hall, involving research of relevant documentation located in the archives of municipal agencies (Wrocław Municipality – Department of Architecture and City Development). Thanks to this research, we were able to prepare illustrations presenting:
  a) Chronological stratification of greenery within the area included on the UNESCO World Heritage List;
  b) Chronological stratification of architectural elements of exhibitions organized before and after 1945;

c) Analysis of the systems of preservation of buildings located on the former Exhibition Grounds;
d) Analysis of pedestrian, motor, and shared traffic paths within the area of the former Exhibition Grounds.

- Preparation of conclusions and conservation recommendations regarding Centennial Hall and the Exhibition Grounds (area inscribed on the UNESCO World Heritage List). At this stage, illustrations were prepared presenting:
  a) the functional layout of Centennial Hall,
  b) chronological stratification of Centennial Hall,
  c) conservation protection zones for individual parts of Centennial Hall.

The fourth part included the following tasks:

- Analysis of the history of ownership and management;
- Analysis of the CMP's potential target groups taking into consideration the building's location, functions, use and ownership as well as management structure;
- Public access analysis;
- Historic preservation SWOT analysis.

1.4. Authors of the CMP

The present document was prepared by a team of experts from different academic and cultural institutions in Wrocław. The whole project was managed and coordinated by the Museum of Architecture in Wrocław.

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- **The Getty Foundation** – for selecting Centennial Hall and the application team among the first ten projects to prepare CMPs for the most outstanding architectural works of Modernism in the world;
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- **Wrocław University of Technology** for making specialized equipment needed to conduct a detailed survey of the building's structure and state of conservation of the reinforced concrete and windows available;
- **Twentieth Century Society** – for co-organizing an inspiring international CMP workshop in London.

2.

Centennial Hall in the Historical Context

2. Centennial Hall in the Historical Context

2.1 History of the Site

2.1.1. Szczytniki

Centennial Hall is situated on the Exhibition Grounds in the district of Wrocław called Szczytniki, between Szczytnicki Park and the Zoological Garden, in the formerly rural area once occupied by meadows and pastures. The village of Szczytniki, after which the urban district was later named, is first mentioned in a document from 1259, which implies that by that date the village had already been settled. The settlement also owned plots on the western and eastern shore of the Old Odra. The village became referred to as Old Szczytniki once a new settlement was founded north of the Old Odra and name New Szczytniki (at present Wybrzeże Wyspiańskiego, Hoene-Wrońskiego Street and a fragment of Joliot-Curie Street and Benedyktyńska Street). In 1318 the estate of Szczytniki was acquired by the City of Wrocław. The surrounding meadows and forests had remained municipal property until some were sold in 1720.

Two river crossings across the Old Odra were located in Szczytniki, the southern one on the road to Dąbie, the other one located in the settlement's northern section. Initially, they were ferry crossings but as early as 1655, a bridge called the Scheitniger Brücke (Szczytnicki Bridge) is mentioned, later called Ziegelbrücke (Brick Bridge), because it led to a brickyard. The bridge was erected on the site of the northern crossing, in the area of the present Szczytnicki Bridge. There, municipal guardhouses were built in 1704 and from then on the bridge was called Paßbrücke (at present Zwierzyniecki Bridge). It existed until 1790 when it was replaced by a new bridge built by the Prince Hohenlohe.

2.1.2. Szczytnicki Park

In the 18th century, the area around Szczytniki and the neighboring land adjoining the village of Grüneiche ("Green Oak"), at present Dąbie, were used by city dwellers for recreation. It is mentioned in a rhymed city guide from 1732 which praised the natural beauty of the area of Szczytniki. This recreational potential persuaded Prince Friedrich Ludwig von Hohenlohe-Ingeflingen, who purchased the estate in 1783, to build his suburban residence there. The Szczytniki estate, systematically expanded, and occupied an area of about

90 acres in 1802. It was located on the eastern bank of the Old Odra, by the Paßbrücke. The construction of a summer palace and auxiliary buildings most likely started in 1783. Simultaneously with the palace, an expansive garden-cum-park complex was founded adjoining the municipally-owned forest of Briskenwalde. The garden, linked with the city by a new road located behind the Old Szczytniki settlement buildings, was to occupy some 16.5 hectares by 1789–1790. Opened in August 1789, it was used by the prince mainly in the summertime. It was not fenced and hence from the very beginning it was accessible to Wrocław city residents.

During the Napoleonic wars, troops were stationed at the estate and many park features suffered partial damage. In 1815, the estate was auctioned: the area on the Old Odra by today's Szczytnicki Bridge was sold and so were the plots located south of the farm and the symmetrical garden. The landscape garden remained municipal property and would later become the core of a municipal park founded in the 1850s.

In 1854 the municipality purchased the lots of Prince Hohenlohe's former garden in Old Szczytniki and founded a municipal park there that incorporated this area and the adjoining Szczytnicki Forest already owned by the city. In fact, the tradition of Old Szczytniki as the recreation area for the city's residents was never broken despite the changing ownership and partial damage suffered by the garden complex and its architectural features.

In August 1861, in connection with the awarding of the honorary doctorate of Wrocław University to the well-known Berlin architect Peter Lenné for his "outstanding contribution to the art of garden design," the opportunity presented itself to commission him to convert the old complex into an urban park. At this time the City's Executive Board decided to renovate the recreation area at Szczytniki and to remodel the former garden of the Prince Hohenlohe. Presumably it was also decided that Peter Lenné would prepare plans for the development of the Szczytnicki Park. The decision to arrange a municipal park there was likely influenced by the proximity of the horserace track and Zoological Garden.

Works on the project started in the fall of 1865 and were supervised by Julius Lösener. Gustav Heinze became the park gardner in 1865. He was promoted to the park inspector in 1885, a position he held until 1891.

In 1865 the Szczytnicki Park occupied an area of 40 hectares. It was later expanded and reached the size of 100 hectares in the 20th century. Its enlargement reflected the process of incorporating municipal plots that had been previously leased to private leaseholders. In addition to buying out parcels from their private owners, the park's expansion was made possible by land donations from sponsors appreciative of the park's public role.

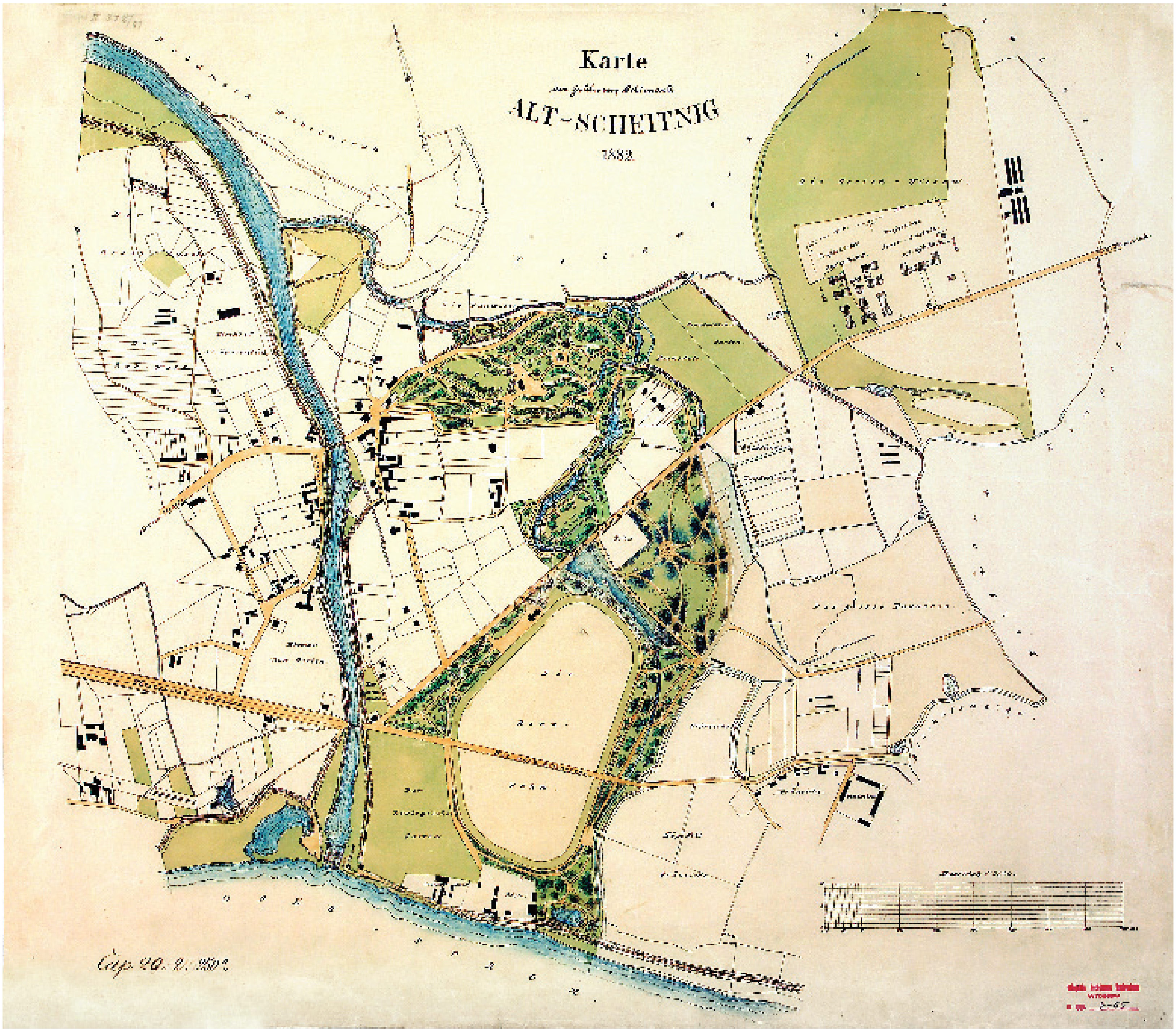
In 1868, Old Szczytniki was incorporated into the city, increasing the attractiveness of the whole area.

The interest in the eastern suburbs of Wrocław also increased thanks to the decision announced in 1863 to found the Zoological Garden at Dąbie. The area of 37 hectares designated for this purpose was purchased by a joint-stock company established to build the ZOO.

2.1.3. Former Horserace track

Centennial Hall was built on the site of the former horserace track once situated in the district of Szczytniki between Szczytnicki Park and the Zoological Garden. In 1832 the Silesian Society for Horseracing (Schlesischer Verein für Pferdezucht und Pferderennen) established a horserace track in the area of former pastures in the village of Dąbie, on a plot, which they leased from the municipality until 1906. The first race was organized in 1833. Over the following years, annual horse races were organized there, but the horserace track remained a temporary facility and each year a temporary stand would be erected in its eastern section by the road to Dąbie.

In the early 1870s the Silesian Society of Horseracing decided to build a permanent horserace track with necessary facilities. The horserace track was laid out on an oval shaped area of about 21 hectares. Its longer axis lead from the south-west to the north-east. The road from Wrocław to the village of Dąbie (at present Ol-



3 Plan of Old Szczytniki, 1882. Museum of Architecture in Wrocław – Building Archive of the City of Wrocław

4 Horserace track in Szczytniki, print showing the event organized on May 30, 1834. Pickelhäring, *Das Fest des Wettrenns zu Breslau am 30. und 31. Mai 1834*, Breslau 1834

szewskiego Street) divided it in two sections: the southern section occupied about 1/3 of the area, the northern section comprised of the remaining 2/3.
Already in 1892 the Silesian Society for Horseracing began to consider purchasing land for the construction of a new horserace track. This decision was motivated by the Society's concern that the Municipality might not extend the lease of the area, which was being considered by the City as a potential location for Exhibition Grounds. The last race at the old horserace track took place on September 2, 1906.

5 Portrait of Professor Karl Masner, 1913. "Schlesische Woche", 1913, vol. 1 (4), p. (3)

2.1.4. Exhibition Grounds

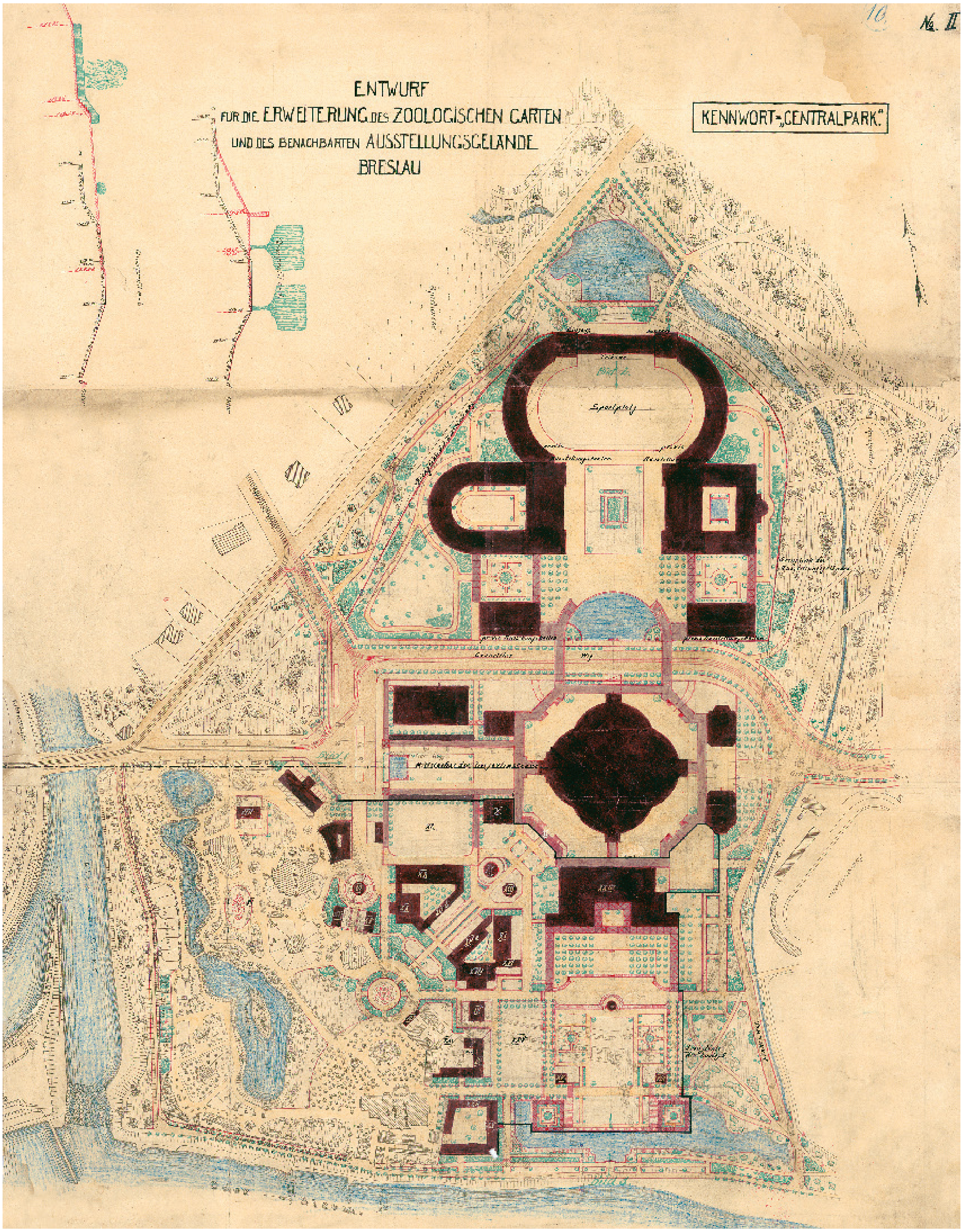
In 1907, after the old horserace track was closed, the City decided to allocate the site for future Exhibition Grounds. In 1908 Karl Masner, the Director of the Museum of Arts and Crafts (Kunstgewerbemuseum) in Wrocław, addressed the local community in an article published in the "Schlesien" posing the following question: "Does the city need an exhibition hall?" The author emphasized that the reputation and status of many cities benefited from their fame as exhibition venues. As the capital of a large province, Wrocław also ought to have appropriate facilities to present the achievements of the local art community and industries. Having no such venue, the city was in no position to stage such cyclical events. In his opinion, the approaching 100th anniversary of King Friedrich Wilhelm III's address *An mein Volk* ("To My People"), proclaimed in Wrocław in 1813, provided an excellent opportunity to carry out such a project. Masner also wanted to stage a special exhibition commemorating the Prussian victory over Napoleon and to use it for promotion of cultural and economic achievements of the Province of Silesia and its capital city. Masner advocated the construction of an exhibition hall that could host exhibitions, singing and sports tournaments, festivals and public assemblies. He referred to Friedrich von Thiersch's Festhalle in Frankfurt-am-Main as a model structure. In Masner's opinion, the site of the former horserace track on the outskirts of the Szczytnicki Park would be an ideal location. He envisioned the jubilee exhibition modelled after the Congress of the Vienna Exhibition of 1896. At the same time, the Municipality – due to financial reasons and the lack of a clear concept of the future use of the former horserace track – organized only festivities on the occasion of the Days of Wrocław (Breslauer Festwoche). On October 24, 1910, a special meeting of the City Council took place, dedicated to the organization of the Centennial Exhibition, attended by prominent personalities from the whole province. It was at this meeting that Georg Bender, the Mayor of the City proposed to designate the northern section of the former horserace track for the future exhibition. Between 1912–1913, the area was expanded by incorporating the park complexes surrounding the former horserace track. In the east and west they stretched to Mickiewicza and Kopernika Streets while in the north-east they extended beyond Dąbska Avenue. Initially, the Exhibition Grounds were to occupy 50 hectares but subsequently the area was expanded to 75 hectares.

6 Georg Bender, Mayor. University Library in Wrocław, Graphic Collection Department

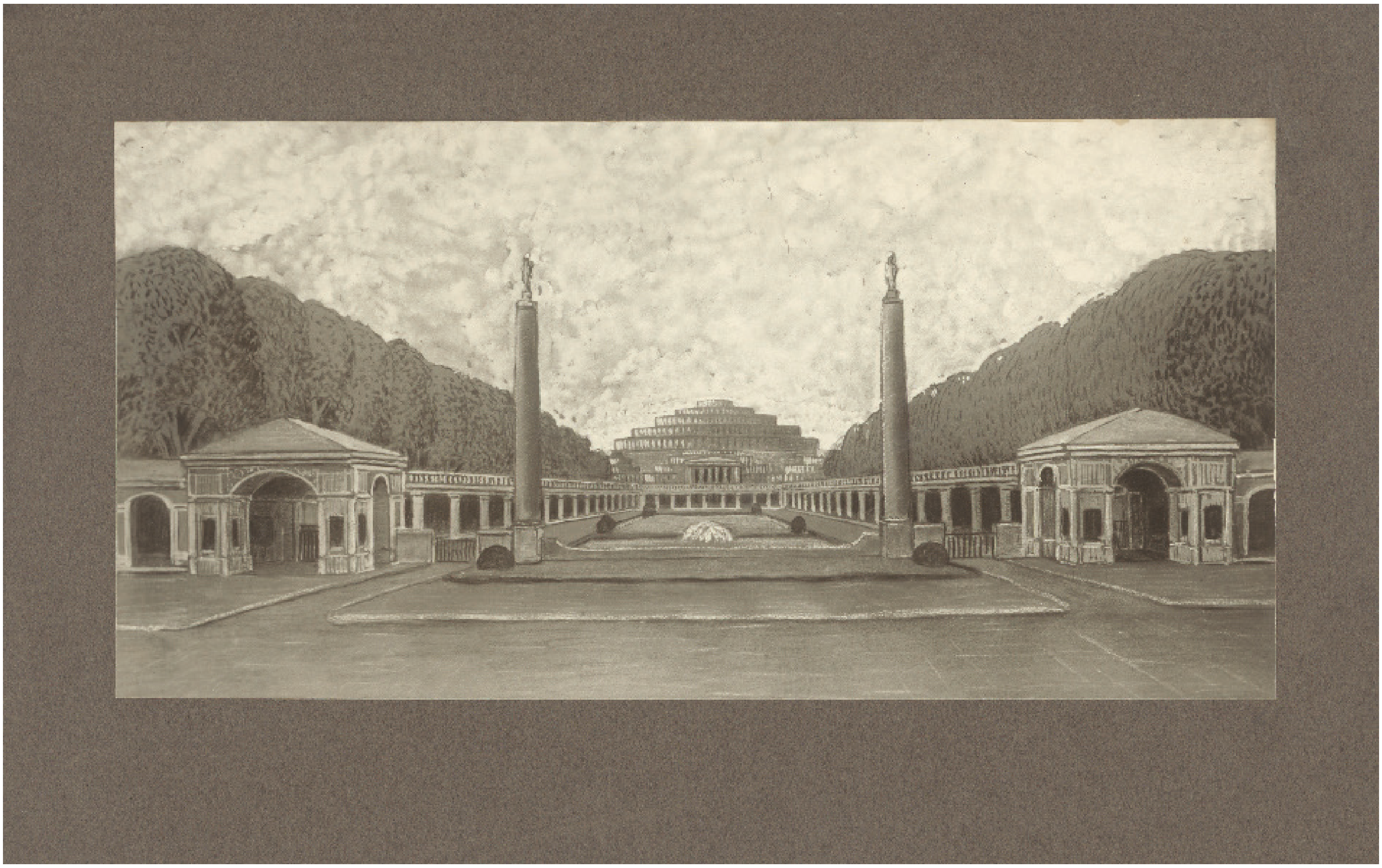
2.2. Designing and Constructing Centennial Hall and the History of the Centennial Exhibition

2.2.1. Primary framework – competition for the development of the Exhibition Grounds in connection with the Zoological Garden

It was probably as early as 1910 that Max Berg started to design the future Exhibition hall, in response to the ongoing discussion in the local press and the Municipality. The earliest drawings of the hall date



7 I.P. Grossmann, competition design for the expansion of the Zoological Garden and development of the Exhibition Grounds in Wrocław, second prize, site plan. Building Archive of the City of Wrocław



8 I.P. Grossmann, competition design for the expansion of the Zoological Garden and development of the Exhibition Grounds in Wrocław, second prize, view from the east. Building Archive of the City of Wrocław

back to February and November 1910. In late 1910 the first practical steps were taken toward the organization of the Centennial Exhibition. On December 10, the joint stock company of Wrocław Zoological Gardens (Aktiengesellschaft Breslauer Zoologischer Garten A.G.) invited German architects and landscape designers to participate in a competition for the conception of the future Exhibition Grounds and their connection to the Zoological Garden. The idea behind the competition was to provide an inspiration for the preliminary and final design. The competition specifications stated that the southern section of the former horserace track was to be designated for the extension of the Zoological Garden with new pavilions for animals and a large restaurant. The northern section was to accommodate the Exhibition Grounds and the Centennial Hall designed by Berg.

In early January 1911, at a session of the Wrocław Association for City Promotion (Breslauer Verein zur Hebung des Fremdenverkehrs), which organized the Days of Wrocław (Breslauer Festwoche), Max Berg made the first public presentation of his design for Centennial Hall, showing slides which included both design and perspective drawings. The City Council's session on December 26 was devoted exclusively to the preparations for the exhibition. The Municipality allocated 100 000 Marks to establish a guarantee fund and earmarked an additional 100 000 Marks to cover any deficit in case the income from the exhibition proved insufficient. At that time, the Main Commission for the exhibition's organization was established: its members included five councilors and five members of the City Executive Board. In order to win more support, on February 24, 1911 Berg made an illustrated presentation during the session of the local Arts and Crafts Society (Kunstgeverbeverein) and declared that the final version would be ready in two months time, comparing his conception with monumental buildings in Frankfurt-am-Main, Dresden and Berlin.

In early April 1911 the results of the competition for the extension of the Zoological Garden and development of the Exhibition Grounds were announced. No decision was made at that time concerning the construction of the Centennial Hall as Berg's design had many opponents. The unifying treatment of the Exhibition Grounds and Zoological Garden promoted by the City Council was perceived by the architects as a threat to their uniform urban and architectural character. In May 1911 the company controlling the Zoological Garden (Aktiengesellschaft Breslauer Zoologischer Garten A.G.) approached the City Council applying for a transfer of terrain for the future Exhibition Grounds in order to implement its' developmental plans. The City Council postponed their decision for half a year to never to return to the original idea of the Zoological Garden becoming incorporated with the Exhibition Grounds.

Independent of the competition entries, in early 1911 Max Berg created his own version of the layout of the future Exhibition Grounds and presented it to the Magistrates. This conception, guided by the results of the competition for the extension of the Zoological Garden and the development of the Exhibition Grounds, never turned out due to the changes to the Centennial Exhibition's program. Berg's initial concept remains important as the basic layout and principal axes that it defined would be later copied in Hans Poelzig completed design for the Centennial Exhibition. Visible in both his competition entries and conceptions are strong influences of Neo-Classical tendencies, often interpreted in the spirit of Academism.

2.2.2. Battle for the construction of the Centennial Hall

In early 1911, the campaign began to gain the City Council's approval for Berg's preliminary design for the Centennial Hall which was presented to the Council on January 2nd of that year. The Council obliged the architect to be ready with cost calculations within a six month period of time. In April, a wooden model of the Centennial Hall was made and displayed along with the designs for the extension of the Zoological Garden which were to be submitted at the competition of the first East German Exhibition in Poznań in May 1911. The first public presentation of Berg's design was widely commented in the press. On the 18th of June, the documentation together with the specification of construction costs (estimated at 1.9 million Marks) was submitted to the City Council. A several-day-long debate ensued with the project's opponents arguing that the construction, operation and maintenance costs may overburden the Municipal budget. Another contention point was the safety of the enormous dome: some argued that the dome of such exceptional size could collapse. Those less fond of the avant-garde compared Berg's design to a layer cake, hatbox or gasworks. One councilor suggests that a new competition should be announced as any design would be better than the monstrosity presented by Berg. The City Council temporarily postponed its decision. Finally, on the 28th of July, following a debate that dragged on for 8 hours, the City Council agreed to the construction of the Centennial Hall and earmarked 1.8 million Marks. Although preliminary works had already began in early May, at that point no decision was made concerning the architectural form and program of the Centennial Exhibition.

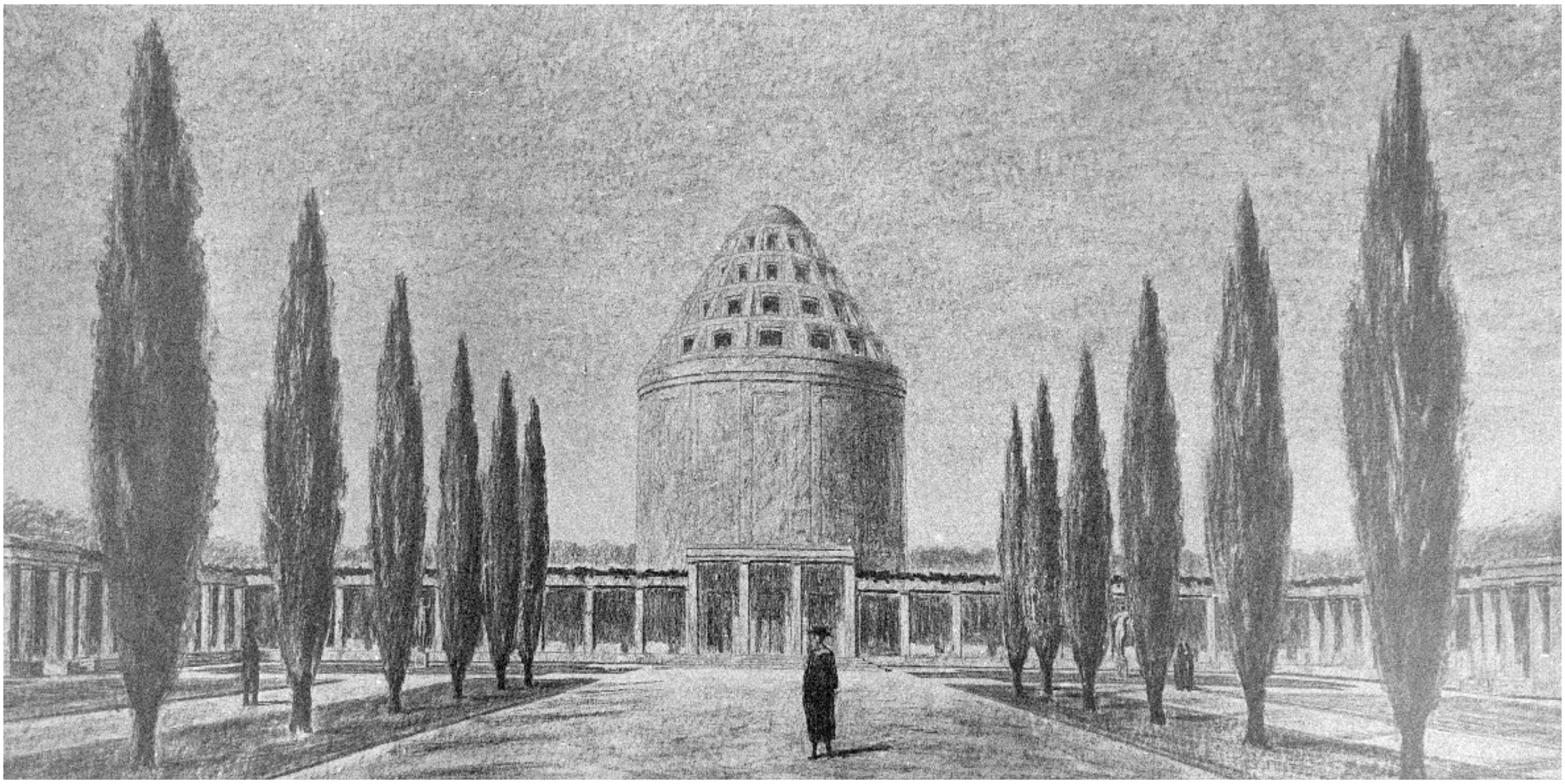
2.2.3. Centennial Hall's designer Max Berg

Max Berg was born on April 17, 1870 in Szczecin, to parents Nicolaus Eduard Heinrich Berg, a junior high school teacher in Szczecin, and Emilie Luise Theresis nee Radeloff. He attended primary as well as junior high school in Szczecin. In 1889–1893, he studied at the Technical University in Berlin-Charllotenburg under Karl Schäfer, a proponent of German Gothic Revival style. He attended the Technical University in Munich briefly (for one semester). After graduation, he climbed the professional ladder as an architect in public services: from the position of site architect to government architect (Regierunggsbaumeister). In 1900, he got a job in the Municipal Building Inspectorate in Szczecin. The same year he moved to Frankfurt-am-Mein where he was appointed Municipal Building Inspector (Stadtbauinspektor). He stayed in Frankfurt until 1909. It is there that he encountered new architectural ideas that would be later elaborated in Wrocław. In Frankfurt, he designed public buildings, schools, a town hall and bathhouse, administrative buildings, and a hangar for airships (Zeppelin). In Frankfurt, the young architect also became acquainted with new tendencies in urban planning which were based on the reform of Municipal Property Management implemented by Mayor Franz Adickes, particularly the "garden-city" conception. In Frankfurt, Berg was associated with progressive and reform-minded artists who were active in the Dürerbund and German Werkbund. He joined the aforementioned organizations and also became a member of the Deutsche Akademie für Städtebau and Deutsche Gartenstadt Gesellschaft. During his stay in Frankfurt, Berg married a pianist named Edelgarde Gerlach.

9 Max Berg, portrait, ca. 1909. University Library in Wrocław, Graphic Collection Department

On December 17, 1908, Berg was elected City Architect in Wrocław and took his post in April 1909. Soon after, he became associated with the local art community gathered around the architect Hans Poelzig, director of the Academy of Arts and Crafts (Akademie für Kunst und Kunstgewerbe), and authors Gerhart and Carl Hauptmanns. In 1909, he joined the Künstlerbund Schlesien (Association of Silesian Artists) founded by Poelzig. During his Wrocław period, which lasted until 1925, Berg designed his most monumental and innovative works anticipating many solutions of the International Modern Art Movement. He employed ferro-concrete (at the time a new structural material) frame construction, and prefabricated elements. His approach to ornament was reductive and minimalistic and he simplified the building's volumetrics deriving its architectural form and layout from its stipulated functions, thus opposing the dominant approaches rooted in Art Nouveau and Historicism. He drew inspiration from industrial architecture, Gothic structures, English domestic architecture, and vernacular Silesian architecture propagated by Poelzig and the Künstlerbund Schlesien.

In Wrocław, Berg designed: a water tower for the city's northern districts (1909; never completed), façade of a school on Świstackiego Street, a children's hospital on Hoene-Wrońskiego Street (1909), his own house (1910), a Municipal bathhouse on Skłodowskiej-Curie Street (1912), the Josef Gothelf Foundation's houses for the poor on Pracy Avenue (1912), a crematorium (1913–1924, in collaboration with Oskar Kokoschka), and a chapel at



10 Max Berg in collaboration with Oskar Kokoschka and Albert Kempter, design of a crematorium. Deutsches Museum in Munich, archive, legacy of Max Berg

Osobowicki Cemetery (1919–1920, in collaboration with local painter Hans Leistikow). The crowning glory of his activity before World War I was the design of the Centennial Hall and the structures related to the Centennial Exhibition (1910–1913). He contributed to the debate regarding plans for the redevelopment of the City Center in Berlin (the so-called Great Berlin, 1910) and Wrocław (1910 and 1919–1920), and designed the first garden-city in Sobótka, the first of this type of complex conceived in Silesia. He was one of the first European architects to design skyscrapers (for Wrocław, Cologne, and Berlin). His designs initiated a nationwide debate on the role of skyscrapers in the modern city. During his final years in Wrocław, he designed two water power plants (1924) and the Exhibition Hall on the Exhibition Grounds (1924–1925, in collaboration with Ludwig Moshamer).

In 1925, Berg retired and moved to Berlin where he focused primarily on the theory of urban planning. In 1927, he took part in a competition for the Municipal Administration and Fire Department Building in Wrocław and in 1928, he participated in a closed competition (only six architects were invited to participate: Max Berg, Aloys Klement, Willy Ludewig, Hannes Mayer, Erich Mendelsohn and Max Taut) for the building of the trade unions' school in Bernau near Berlin: the project however was never completed. In the 1930s, especially after the Nazis came to power, Berg's pursuits were focused exclusively on theoretical aspects of architecture and urban planning. He sat on the Executive Board of the Deutsche Städtebau and elaborated on designs for a University Campus. He took part in the debate on the redevelopment of Berlin and commented on the conceptions of Martin Wagner and Hans Poelzig. During World War II, Berg moved to Baden-Baden where he died on January 22, 1947.

2.2.4. Design, structure and materials

Presenting the drawings to be featured at the Industrial Exhibition in Poznań during his lecture at the Kunstgewerbeverein, Max Berg declared that the design had not been finished yet and that small changes may be introduced even on the construction site itself. Lecturing before the Society for the Suburb of Szczytniki (Ortsvereins der Scheitniger Vorstadt), shortly before the City Council's final approval for the Centennial Hall's construction, Berg stated: "The whole structure will be built of reinforced concrete and the walls – as far as possible – of glass." During the City Council's debate Berg explained why he rejected historical forms and declared that he has chosen ferro-concrete for fire protection (at the time the material was considered fireproof). Another issue to be addressed was the size of the dome. The architect observed that Ancient Romans built the Pantheon with its dome spanning 43 [44] meters, the Hagia Sophia was 35 [31] meters. Can our modern technology not produce a structure spanning 65 meters? Against all the opponents, it must be emphasized that in this respect the East does not trail far behind the West.

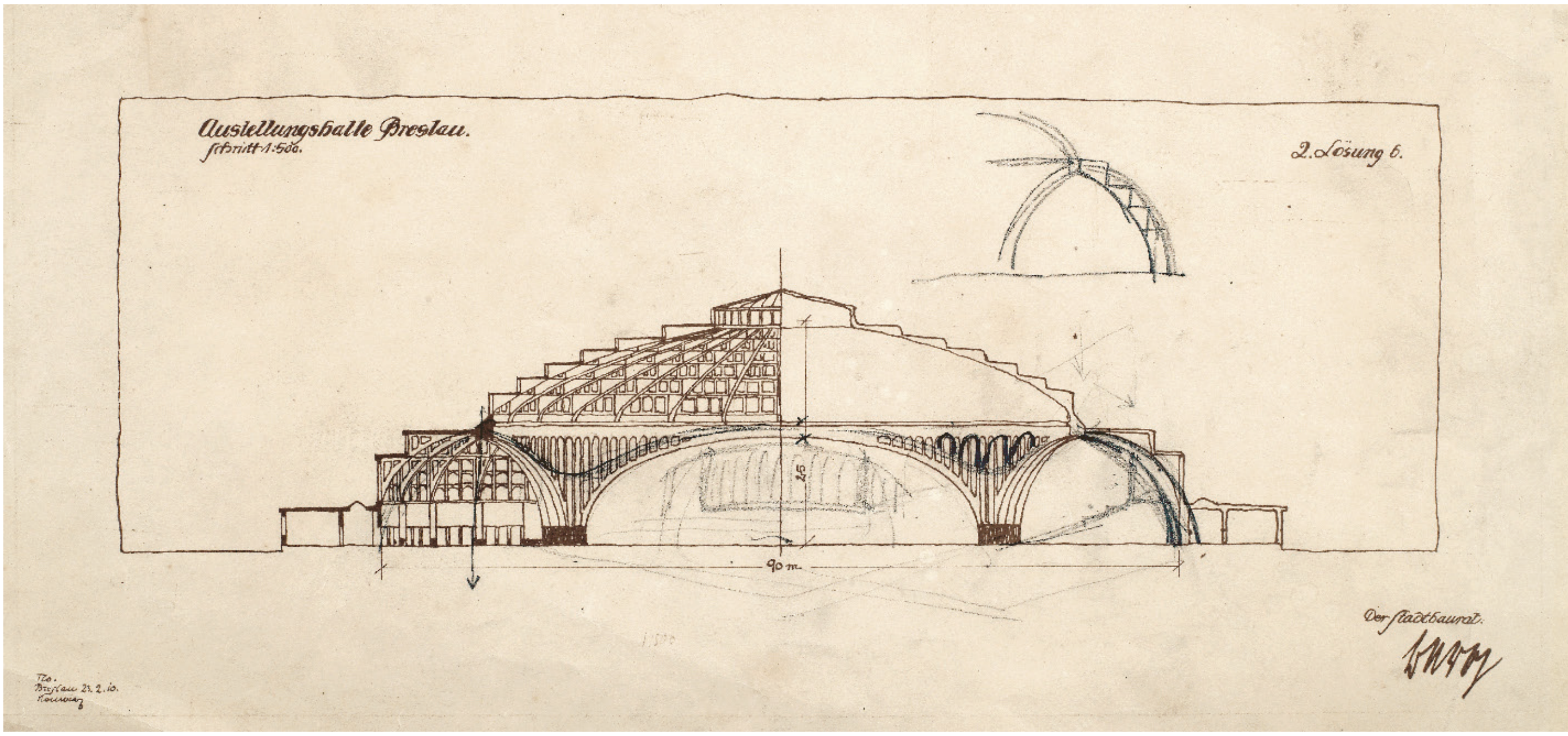
The surviving archival records show that Berg made several design variations of the Centennial Hall but his preliminary sketches had already included the basic features of the now completed structure. Many years later, Richard Konwiarz, Berg's collaborator, recalled that Berg's first design had been directly inspired by Friedrich von Thiersch's Festhalle. Berg's designs were often elaborated on by his collaborators, among them architects Richard Konwiarz and Paul Heim and the aforementioned painter Hans Leistikow (perspective and presentation drawings). Like Poelzig, Berg only made sketches and clay models. The first stage is illustrated by three drawings from the Erkner collection and one from the National Museum in Wrocław which has been preserved in the form of transparency. Of the former, two are dated February 21 and 23, 1910. They represent the Centennial Hall's cross-section in two variants distinguished by the dome's size. Both are signed "Der Stadtbaurat Berg" depict the same design and are done to the same scale. The third one, dated February 28, 1910, shows an unusual perspective view of the Centennial Hall. The fourth drawing (undated) shows the interior. Since the dome's lantern is rendered in the same manner as in the two cross-sections, it presumably dates back to

11 Friedrich von Thiersch, exhibition and convention hall in Frankfurt-am-Main, interior. “Deutsche Bauzeitung”, 1909, vol. 43, no. 41, p. 279

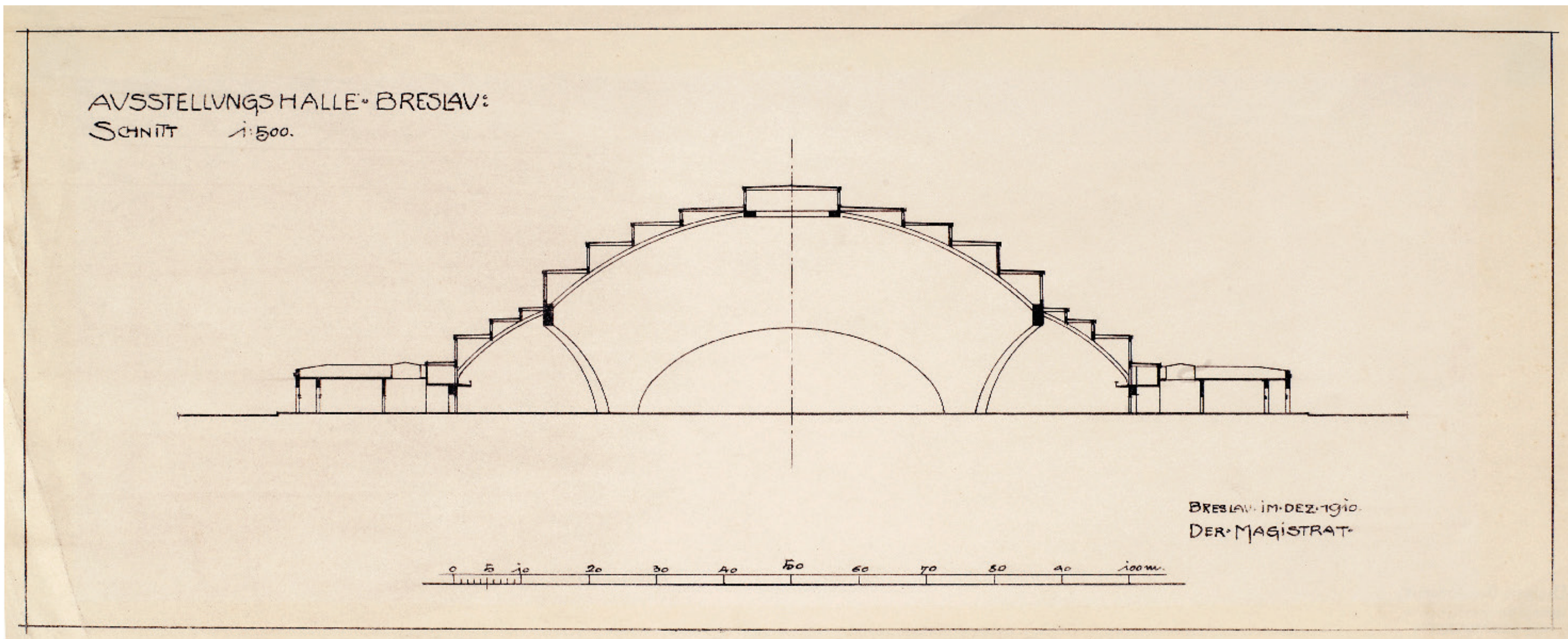
the same period. These four drawings are the earliest drawings of the Centennial Hall known today. In terms of style, they refer to the last phase of the architect’s work in Frankfurt and his first designs originating in Wrocław. The gigantic hall with its dome covered by a stepped roof with eight tiers is rendered in the spirit of Art Nouveau asymmetry. The ornament-free façades are filled with monumental windows divided into smaller panes. The main entrance hall features a colonnaded portico – Berg’s favorite motif during this period.

The preliminary design for the Centennial Hall from early 1910 gets elaborated on in the drawings preserved at Erkner and the transparencies from the National Museum in Wrocław from late 1910 and early 1911. The two Erkner drawings – one dated November and the other December 1910, are both inscribed “Der Magistrat”. Their linear scale indicates that the dome spans about 72–73 metres – 8 metres more than the one actually erected. The span between the apses is also larger – 100 metres – as compared to 95 metres in the completed building. The height of the Centennial Hall, on the other hand, is about 30 metres – that is 12 metres less than in the actual building. As compared to the preliminary design, this version shows more clarity and by revealing structural elements it refers to engineering structures. Certain details are also different as compared to the completed version. The portico of the main entrance hall for example, has a rectangular as opposed to an elliptical layout and features no colonnade. The lantern, mirrors and stepped tiers of windows enclosing the dome are different as well. The transparency from the National Museum’s collection, dated February 1911 showing the Centennial Hall’s floor plan, with the indicated span of 100 metres between the edges of opposite apses, reflects the same conception. Thus, until early 1911 a larger dome was being planned than that which would be built in the end. In all the sketches, the Centennial Hall is situated at its current site. In front of the main entrance the architect envisioned a rectangular lake with greenery and an Avenue of trees.

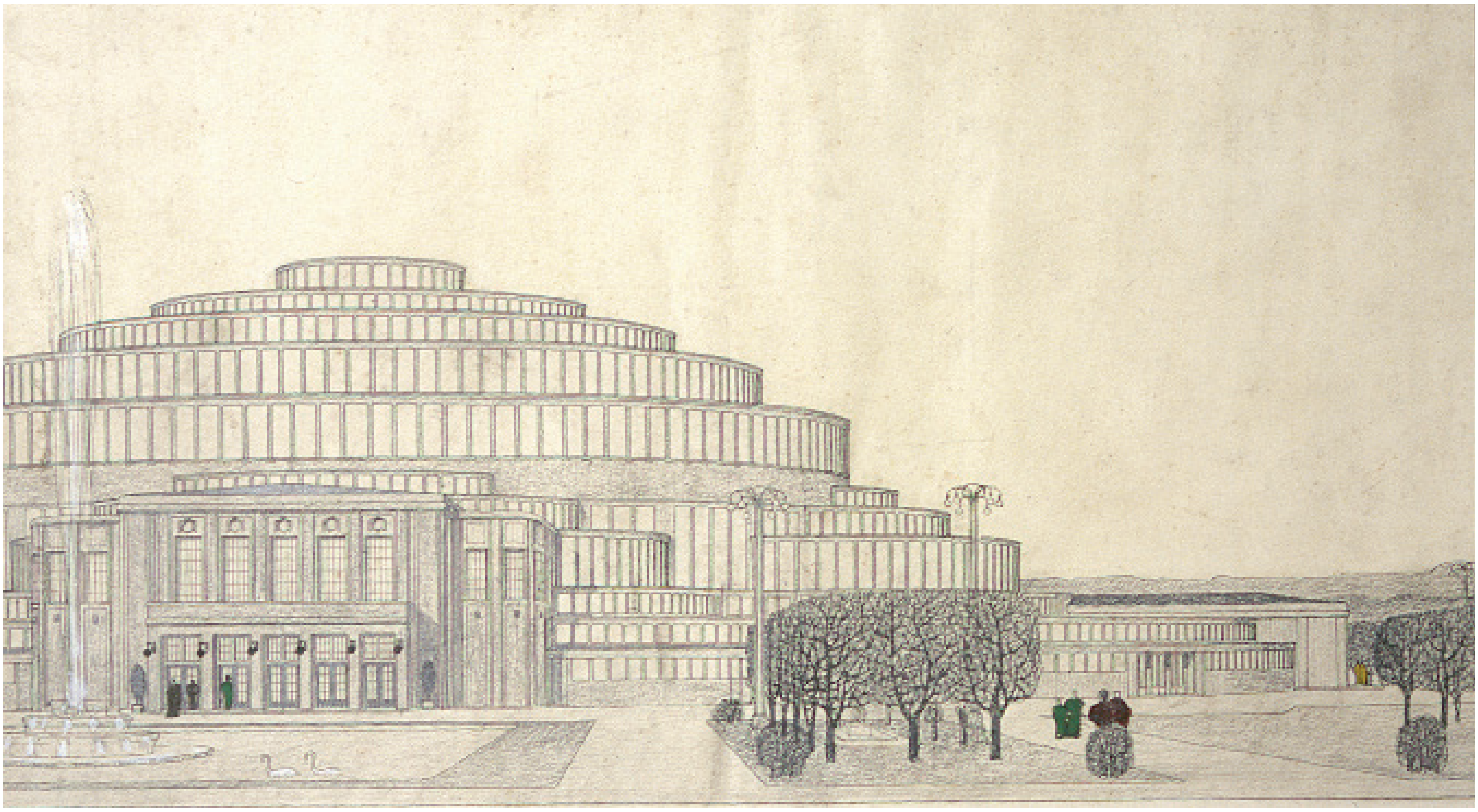
It does not seem very probable that Berg’s intention was to overdo the record-holding structures covered with steel domes. Willy Gehler and Günther Tauer, entrusted with stability analysis of the Centennial Hall, were well aware of the fact that only a few domes built of steel and glass had ever exceeded the span of 65 metres. At the time it was impossible to increase the span of a reinforced-concrete structure above 100 metres.



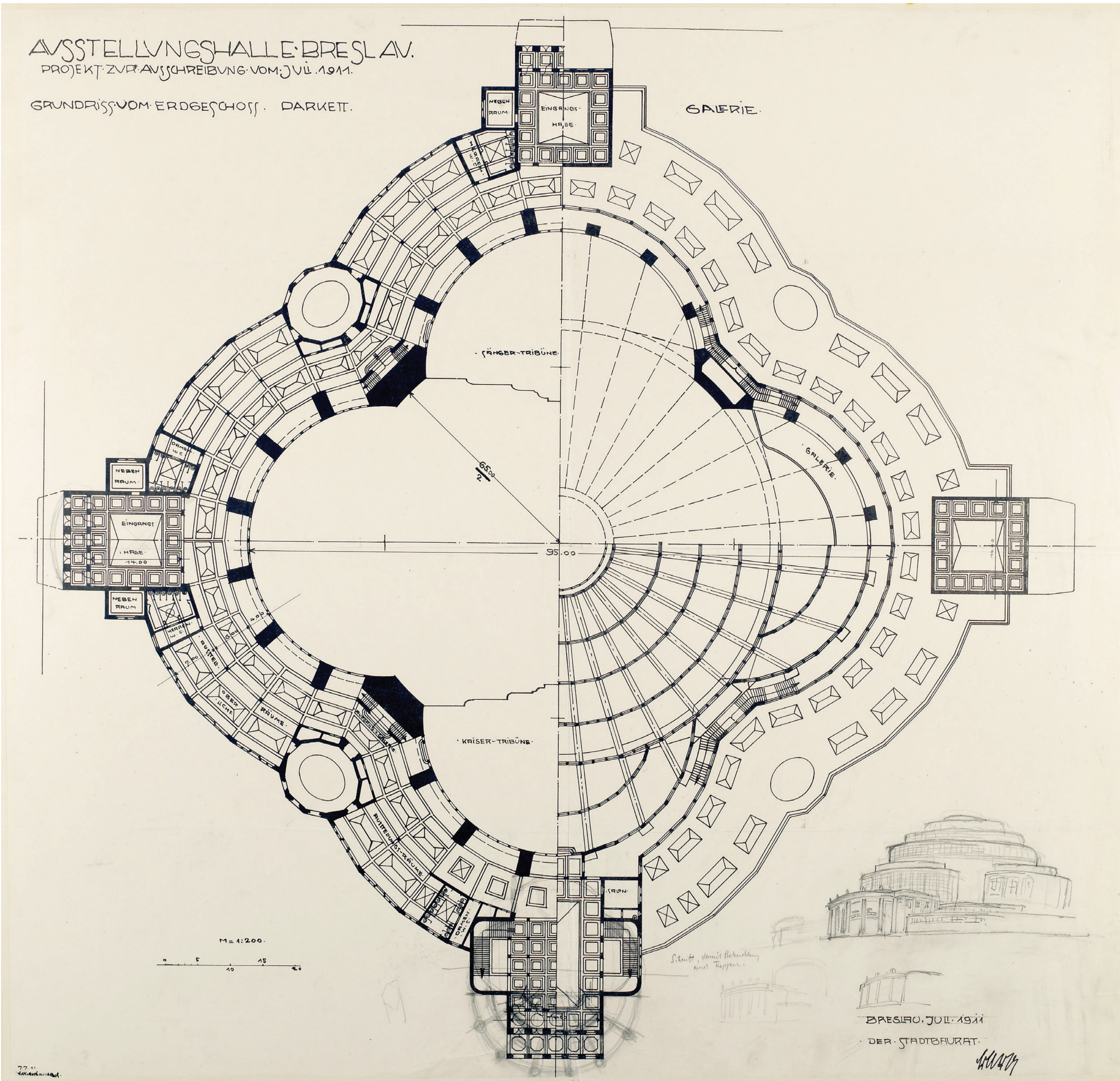
12 Max Berg in collaboration with Richard Konwiarz, Centennial Hall, design, second version, section, February 21, 1910. Leibniz Institute for Research on Society and Space in Erkner near Berlin



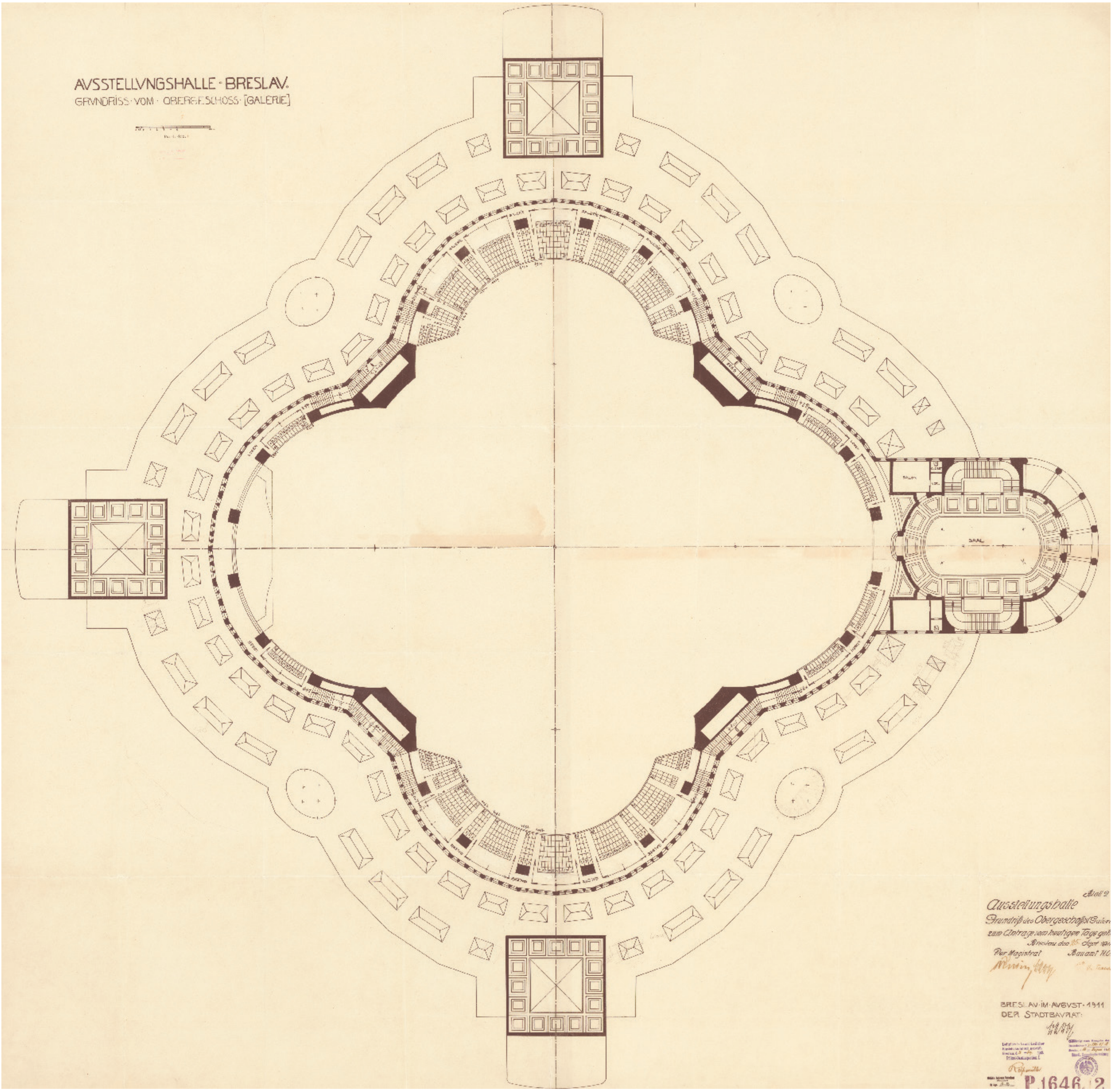
13 Max Berg in cooperation with Richard Konwiarz, Centennial Hall, design, second version, section, December 21, 1910. Leibniz Institute for Research on Society and Space in Erkner near Berlin



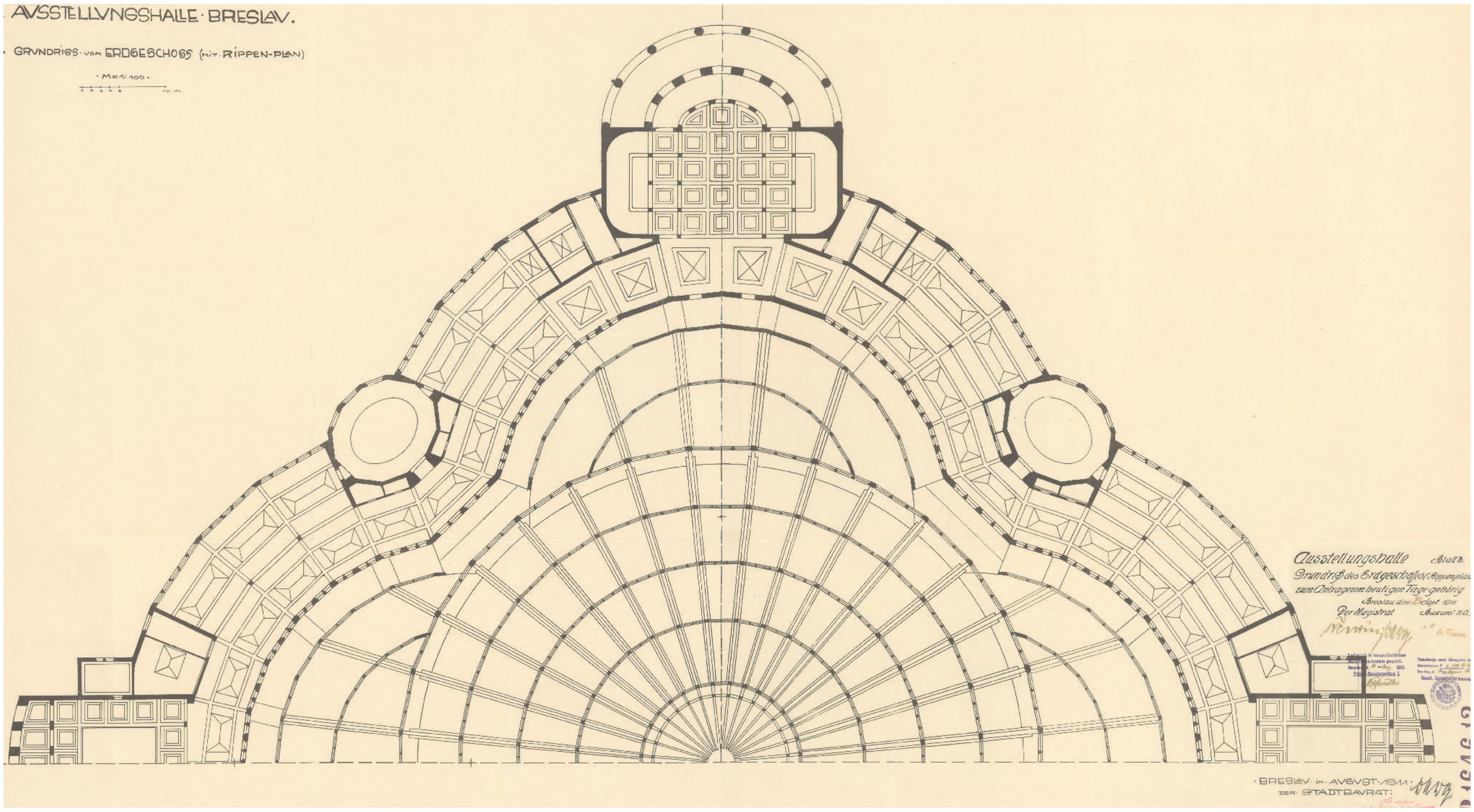
14 Max Berg, design for the Centennial Hall, front view, ca. 1910/1911. Leibniz Institute for Research on Society and Space in Erkner near Berlin



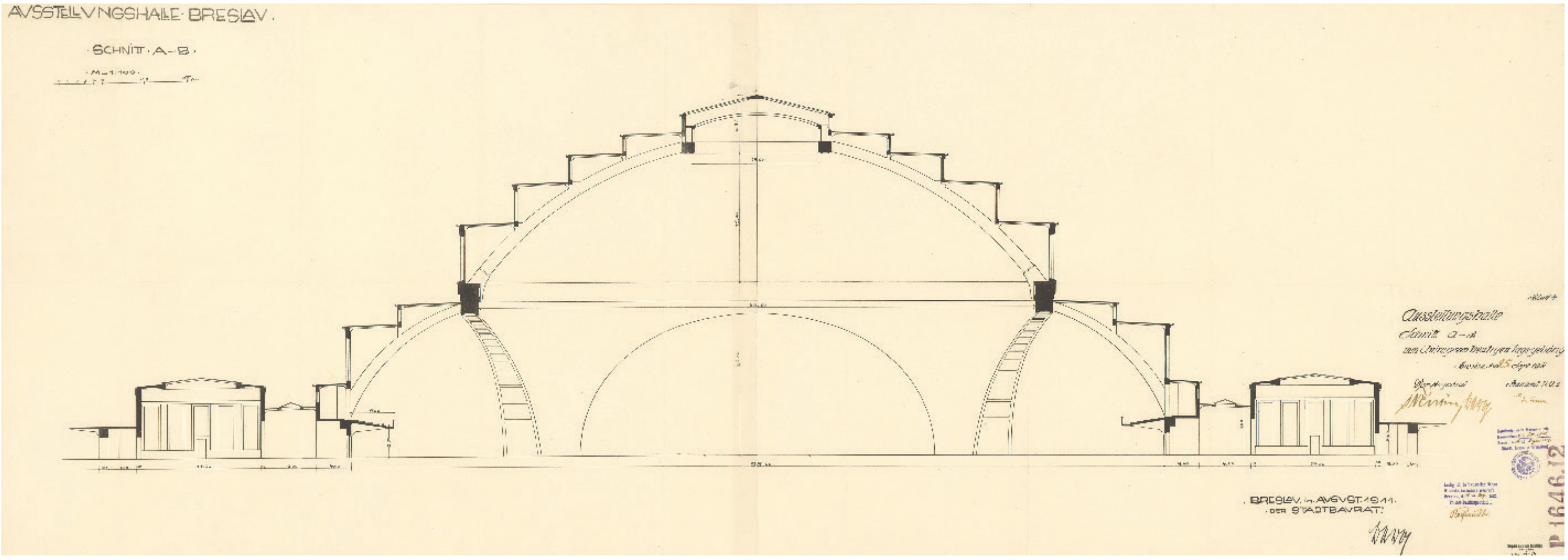
15 Max Berg, Centennial Hall, design. Projection indicating changes in the main entrance and a perspective sketch, July 1911.
Leibniz Institute for Research on Society and Space in Erkner near Berlin



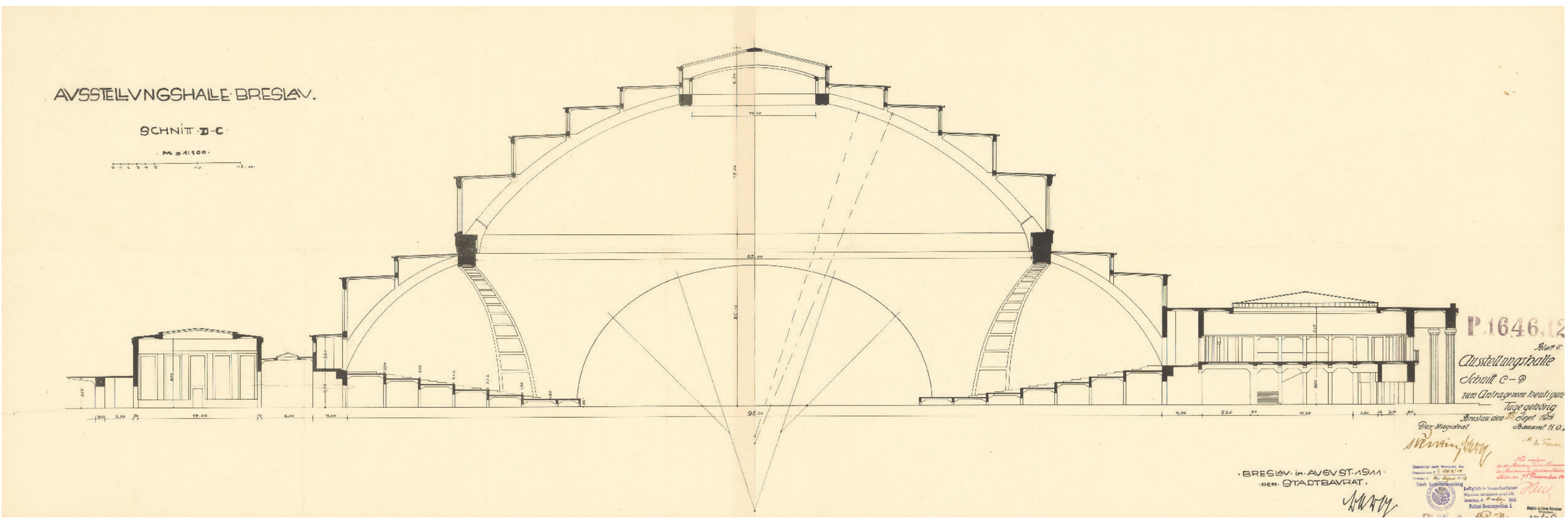
16 Max Berg, detailed design finally developed in August 1911 and approved by the Municipality of Wrocław on September 25, 1911, plan of second floor and galleries. Museum of Architecture in Wrocław – Building Archive of the City of Wrocław



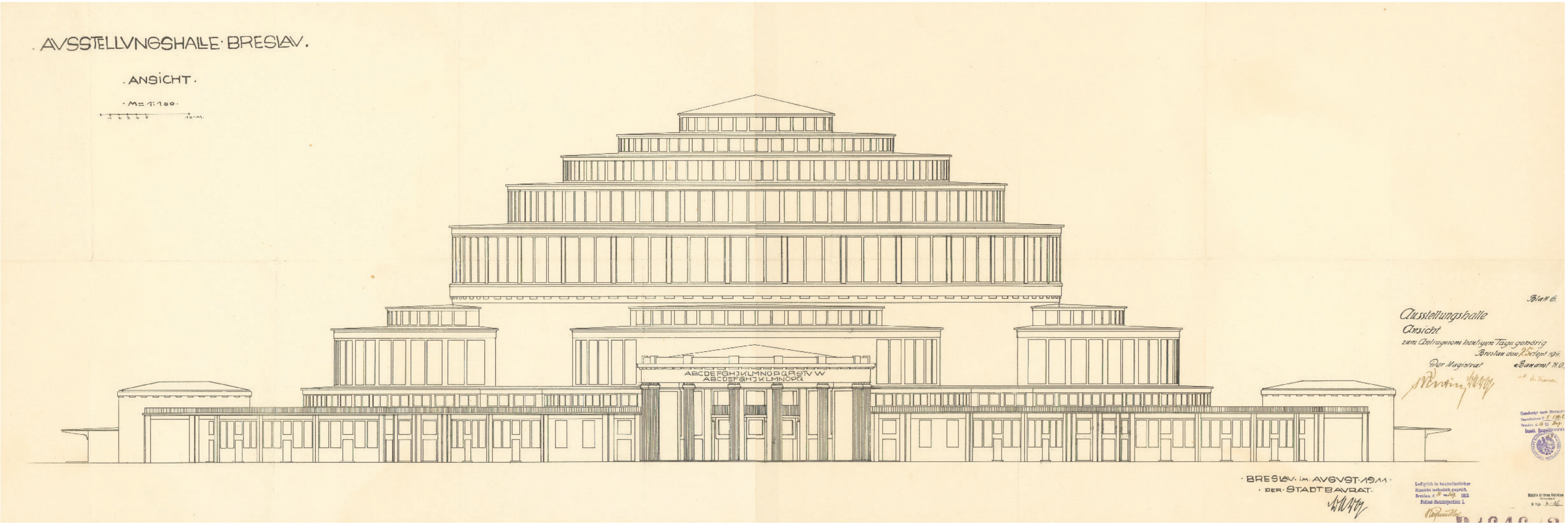
17 Max Berg, detailed design finally developed in August 1911 and approved by the Municipality of Wrocław on September 25, 1911, plan of ground floor and rib layout. Museum of Architecture in Wrocław – Building Archive of the City of Wrocław



18 Max Berg, detailed design finally developed in August 1911 and approved by the Municipality of Wrocław on September 25, 1911, section. Museum of Architecture in Wrocław – Building Archive of the City of Wrocław



19 Max Berg, detailed design finally developed in August 1911 and approved by the Municipality of Wrocław on September 25, 1911, section. Museum of Architecture in Wrocław – Building Archive of the City of Wrocław



20 Max Berg, detailed design finally developed in August 1911 and approved by the Municipality of Wrocław on September 25, 1911, elevation view from the side of the main entrance. Museum of Architecture in Wrocław – Building Archive of the City of Wrocław

It is important to note that from the very beginning Berg had planned to install a monumental organ: it is featured in the 1910 plans and the drawing (transparency) representing the interior that were carried out in late 1910. This confirms the hypothesis that Berg had perceived his building not only as an assembly hall, Convention Center and Exhibition venue but also as a space for staging theatrical productions and concerts. With its gigantic apses framing oversize statues and the decoration of Laurel wreaths at the base of the dome, the envisioned interior strikes a monumental accord akin to that of the Pantheon in Rome.

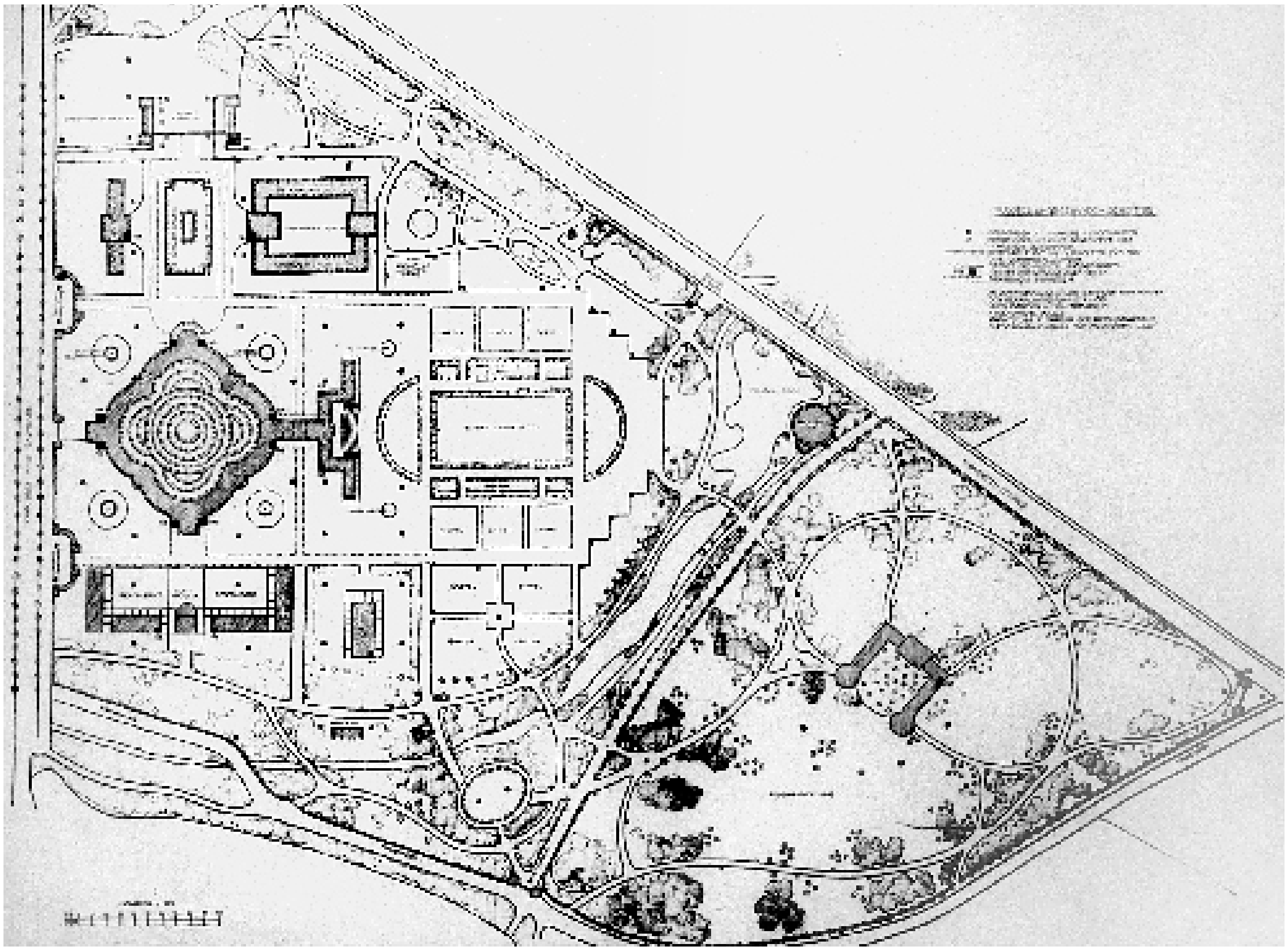
Perhaps responding to suggestions of the structural engineers, Berg reduced the size of the dome to 67 metres in his model presented at the East-German Exhibition in Poznań. He further quoted this number (67 meters) in the presentation of the Centennial Hall in the “Schlesische Zeitung”. It was also at this stage that the lantern was altered. Originally envisioned with its structure exposed, it is presented covered with a steel-framed glass dome, and comes close to the one which can be seen in the completed version. The front of the main entrance was also changed. Following the City Council’s approval for the erection of the Centennial Hall, Berg prepared the design’s final version in July 1911. He altered the main entrance, presumably in response to Hans Poelzig’s layout of the Centennial Exhibition. The drawings depicting this version (today in Erkner) provided the basis for the on-site building scheme finished by Berg in August 1911 and approved by the City Council on August 25th of the same year. At that time the earthwork and laying of foundations were already in progress. These design drawings as well as all mechanical draftings and construction drawings have been preserved in the Building Archive of the City of Wrocław which is a branch of the Museum of Architecture in Wrocław.

2.2.5. The Centennial Exhibition

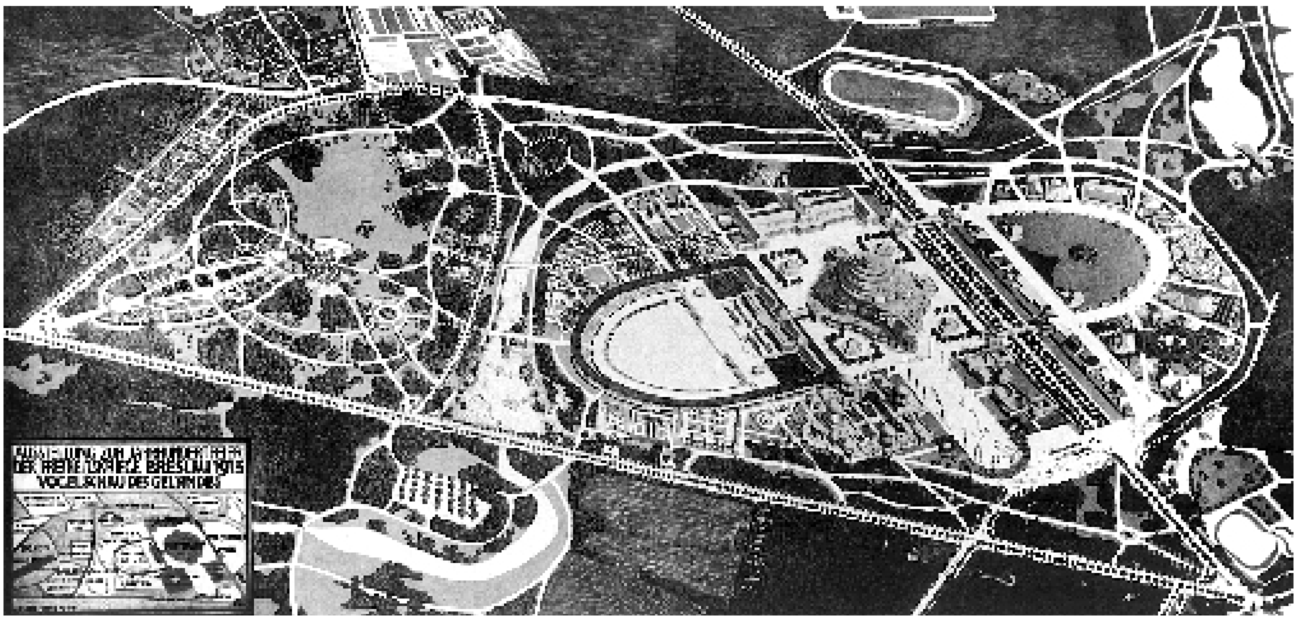
Independent of the work conducted in connection with the construction of the Centennial Hall, work continued on the Exhibition Grounds project. In October 1911, the City Council made decisions concerning the master plan. The project was entrusted to Max Berg and Hans Poelzig, Director of the local Academy of Arts and Crafts (Akademie für Kunst und Kunstgewerbe). On Poelzig’s initiative, the idea of “*parlante architecture*” was accepted with the form of exhibition pavilions referencing the architecture of the Napoleonic period. The decision was made to have the Exhibition Grounds laid out around the road which used to divide the former horserace track. The Main Exhibition facilities were to be located in the northern section while in the southern section an amusement park and a picturesque Street-market called Alt-Breslau (“Old Wrocław”) was planned. North of the centrally located Centennial Hall, the planners envisioned a stadium, a restaurant and an amphitheater with space reserved for garden design exhibitions.

In late February 1912, the City Council approved the proposal to build the second massive exhibition hall. The so-called Four Dome Pavilion designed by Hans Poelzig was to accommodate a historical exhibition devoted to the Napoleonic Wars. This involved yet another change to the layout of the Exhibition Grounds. The main entrance to the Centennial Hall was to be placed on an axis parallel to today’s Wróblewskiego Street. On the northern side, it was preceded by the Four Dome Pavilion and an administration building resulting in the formation of a courtyard, closed with the main entrance to the Exhibition Grounds on the west. On the perpendicular axis, north of the Centennial Hall, a terrace restaurant was planned which would allow a splendid view of the oval lake and Pergola. The remaining space was allocated for garden exhibitions. The plans to arrange an amusement park had not been changed and planned to be connected with the Exhibition Grounds by means of two footbridges. The design of the Pergola, administration buildings and gate was entrusted to Hans Poelzig while Max Berg was to design the restaurant and footbridges.

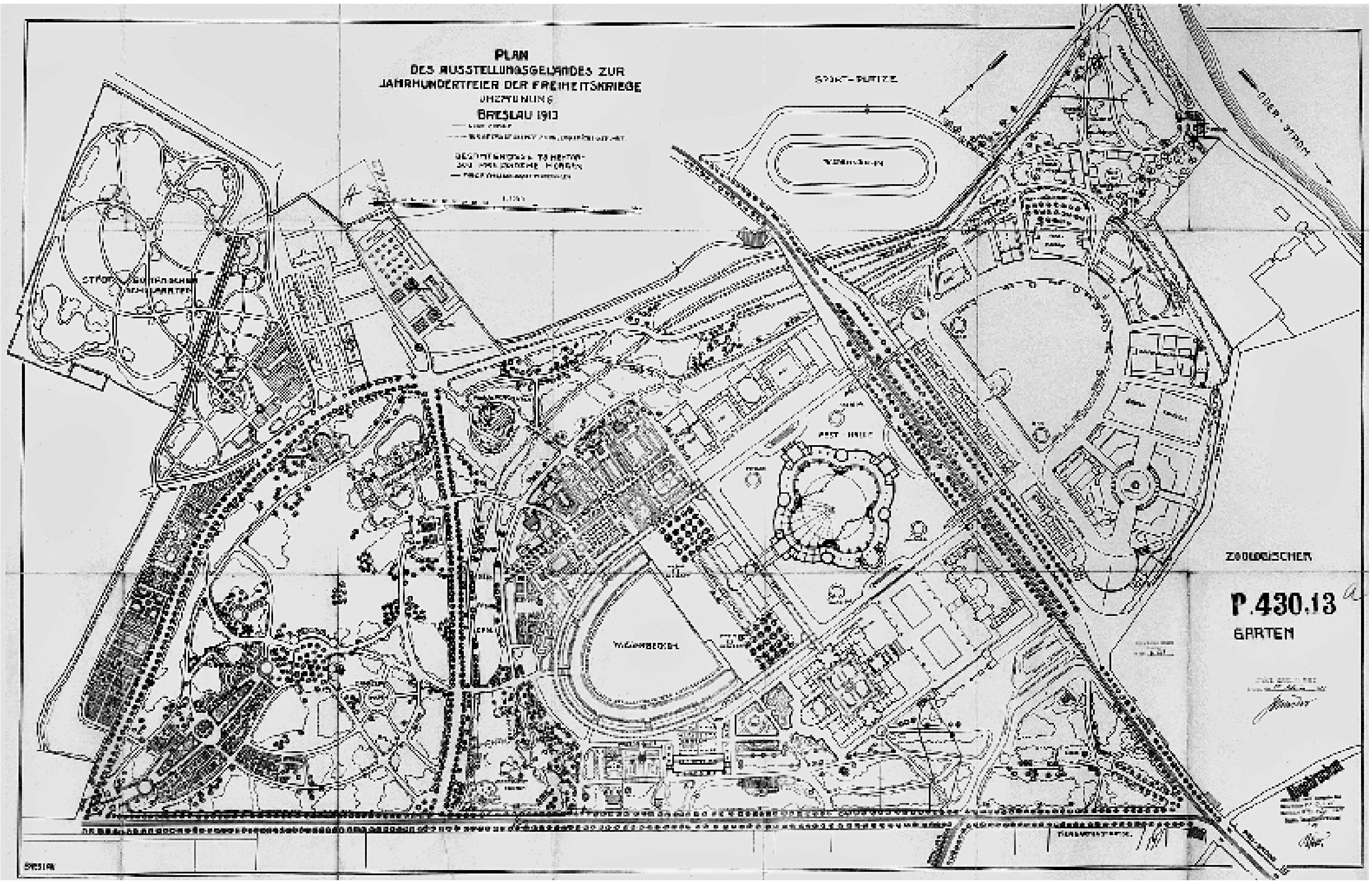
A number of architects and artists associated with the local Academy of Arts and Crafts got involved in the organization of the Centennial Exhibition: Theo Effenberger (designed several historical gardens and remodeled



21 Hans Poelzig, rough draft layout of the Centennial Exhibition, 1911/1912, reproduction of a dispositive used by the architect during a lecture given on February 27 in the hall of the Silesian Museum of Arts, Crafts and Antiquities in Wrocław. National Museum in Wrocław, Documents Collection Department



22 Centennial Exhibition, design, bird's eye view, 3.5 x 5 m, developed by students of the Royal College of Art and Crafts in Wrocław in August 1912, presented at the exhibition in Berlin, photograph reproduction. National Museum in Wrocław, Documents Collection Department



23 Hans Poelzig, second master plan for the Centennial Exhibition for the area of 75 hectares, July-September 1912.
Museum of Architecture in Wrocław – Building Archive of the City of Wrocław

the former horserace track stand into a Renaissance Belvedere), Fritz Behrendt (Pavilion of Cemetery Art Exhibition), Paul Schmitthenner (designed a model garden of a "Garden-City" featured in one of the special garden design exhibitions), Paul Schreiber (designer of the Amphitheater and some smaller exhibition pavilions).

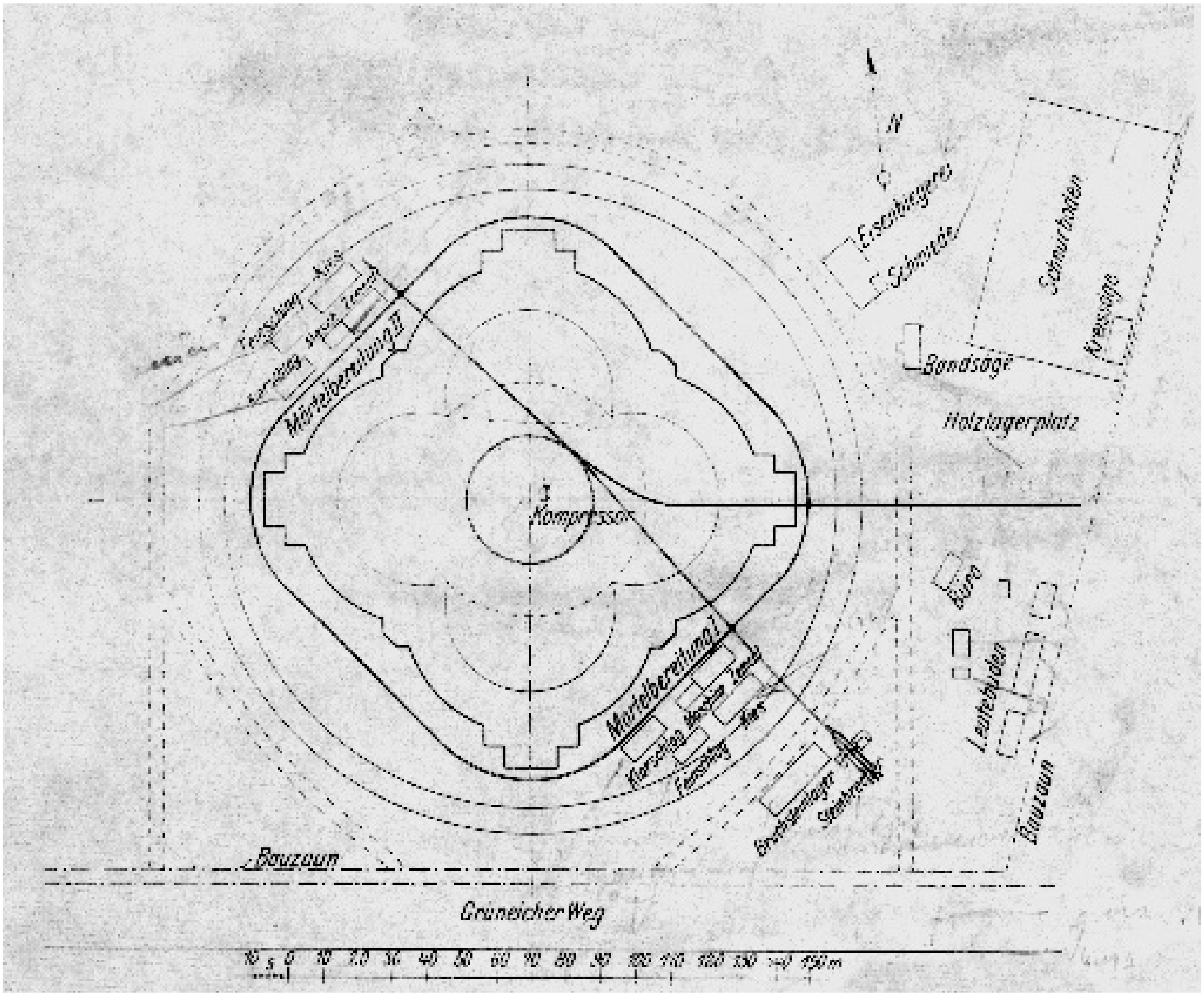
Throughout 1912 construction work continued on the Centennial Hall and Hans Poelzig's Historical Exhibition Pavilion (Four Dome Pavilion). By December, the concrete shell of the Centennial Hall was ready and it was formally presented to the municipal authorities by the main contractor Dyckerhoff & Widmann. Max Berg approached the City Council with the proposal to commission a large organ for the Centennial Hall, the instrument was an essential element of his vision of the Centennial Hall as it was to be a venue for mass cultural events. In March 1913, the competition for the design of the relief to be placed over Centennial Hall's main entrance took place. The winner Alfred Vocke, was Berg's collaborator and future Professor of Sculpture at the Art Academy in Kassel. The concrete relief depicting St Michael vanquishing the devil was to be placed on the architrave with a quotation from King Friedrich Wilhelm III's address *An mein Volk* ("To My People") on March 17, 1813.

Berg designed the setting for the opening ceremony which took place at Centennial Hall on May 20 1913 in the presence of the heir to the imperial throne, Prince Wilhelm.

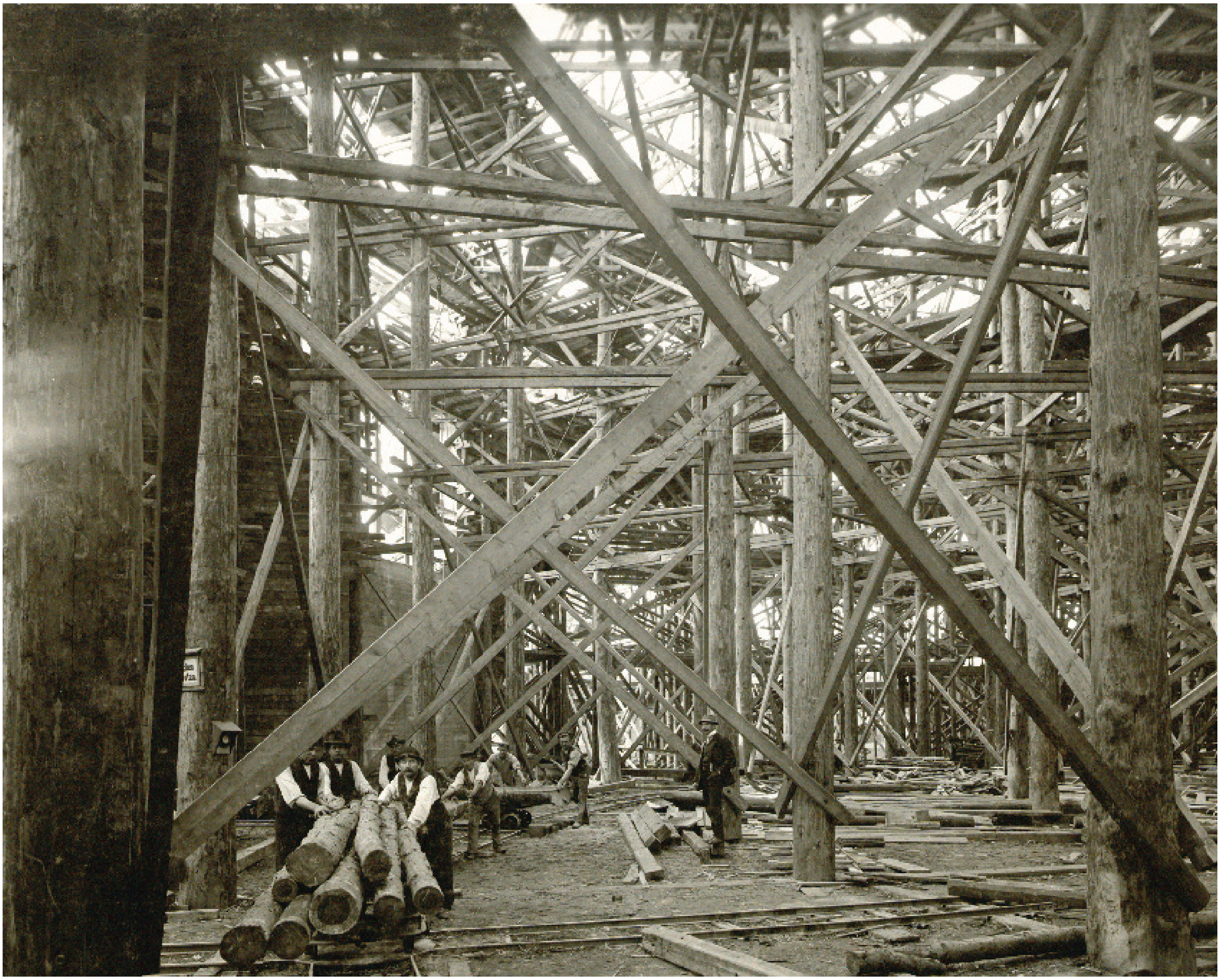
2.2.6. Construction of the Centennial Hall

Preparatory work began in early May 1911 while ground examination began on July 19 1911. The construction, organized in a carefully planned manner, resembled a modern factory producing building components. In August 1911, a company from Dresden Dyckerhoff & Widmann got selected from among 19 competitors as the main contractor while the local company from Wrocław, Lolat A.G., was chosen to build the foyer. Earthwork started on August 31st with the laying out of the building's principal axes. After a careful double checking of structural calculations and a successful lowering of underground water levels, work on the foundation started on October 12, 1912 and was completed by the January 12, 1912. A special mobile crane was built on site, with two 14 metre towers which moved along tracks that encircled the future Hall. Connected by means of a steel rope the third tower rose to the imposing height of 52 metres. Together they formed a carousel cable railway that was elevated above the scaffolding and capable of carrying loads from 1600 up to 2500 kg. On two opposite sides of the construction site two stations were arranged to produce concrete. Mills grinding Silesian granite to make gravel and a sawmill to supply boards for planking and scaffoldings were also installed on site. A specially-designed system of compressors was employed to prestress concrete. In 1914, Willy Gehler, President of Dyckerhoff & Widmann who supervised the project, would write that the organization of the construction site and the crane's design "had been inspired by American construction sites". All equipment was powered by electricity and locomobiles.

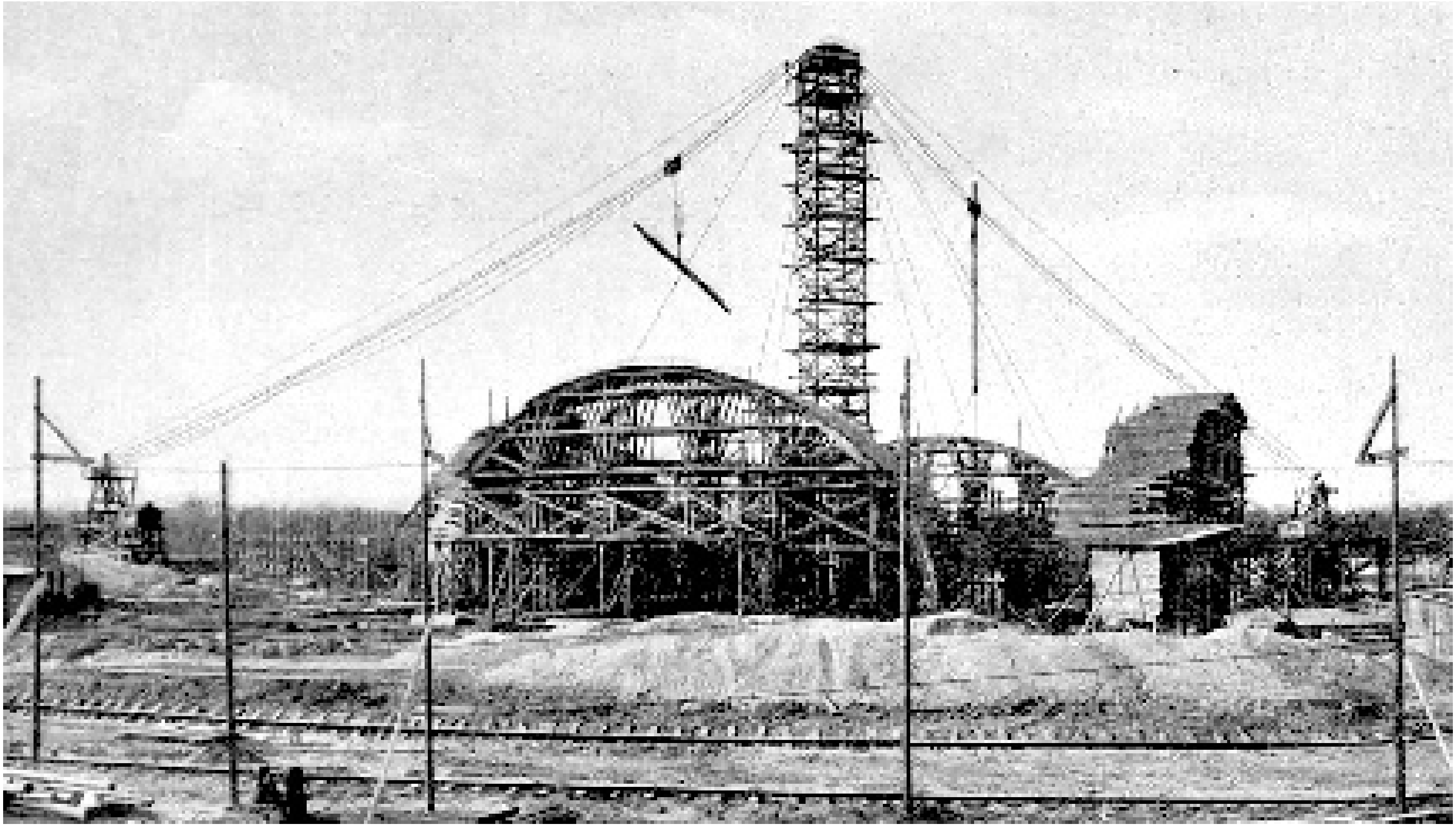
In April 1912 work began on the scaffolding and formwork for the four monumental arcades, each spanning 40 metres, and the four principal pillars. Concreting of the arcades began from their top section down in order to exert uniform pressure preventing any deformation to the arches. By mid-June the job was completed and the formwork removed. Soon, the ring crowning the arcades, on which the dome was to rest, was ready. In late June work began on the concreting of the relieving arches of the apses. A local newspaper informed that "Inside the formwork, in the successive layers of poured concrete, special iron sections are being placed to create ducts for pipes, cables, and ventilation. It is the formwork that is paramount of building skills." After the base had been completed, the concreting of the dome itself began. Proceeding, with great care and precision, from two opposite sections of the ring crowning the base in order to counterbalance its' enormous weight. The dome's ribs (32 half-trusses) were reinforced with sway bracing. The concreting of the dome was



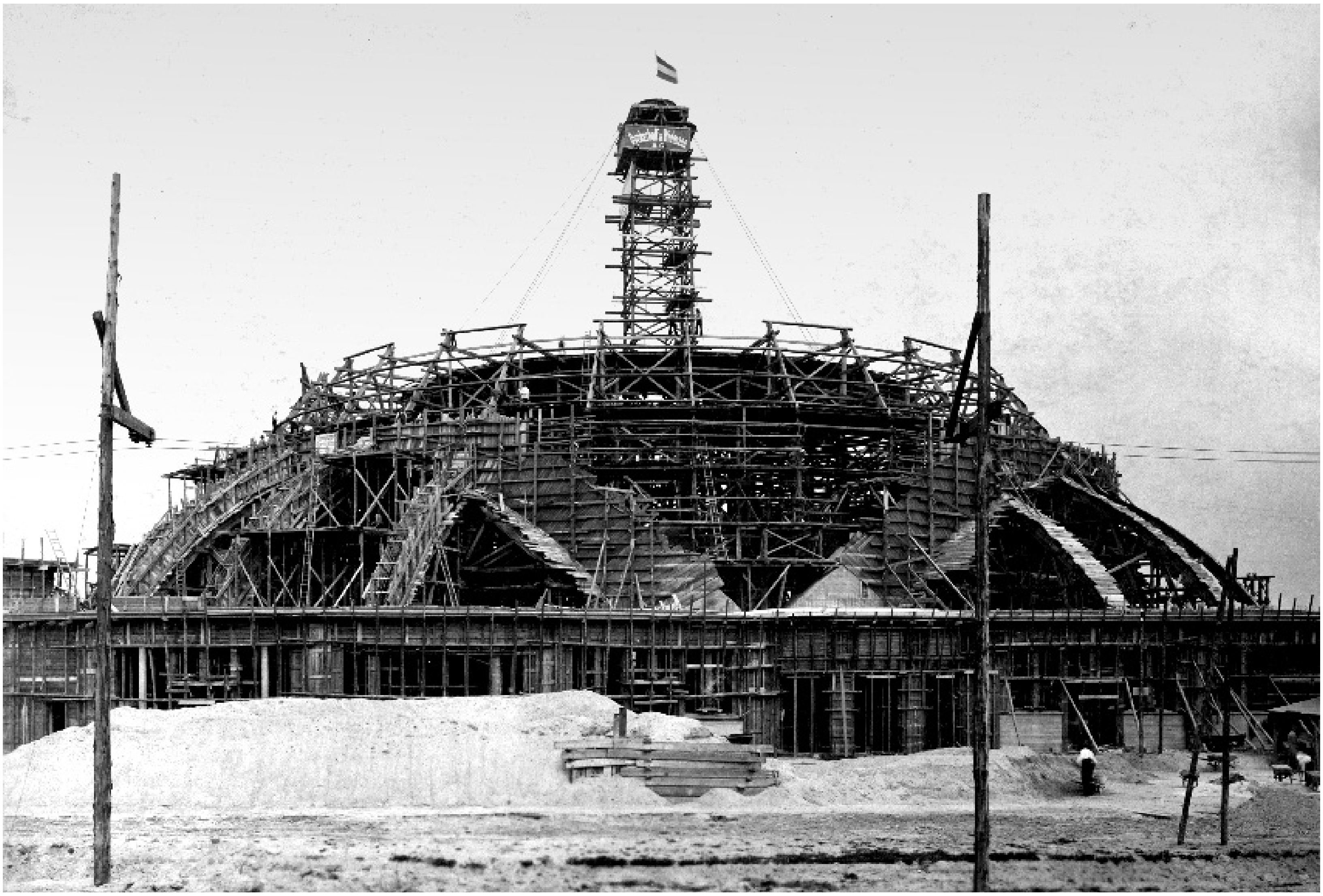
24 Diagram of the Centennial Hall construction site. Günther Trauer, Willy Gehler, *Die Jahrhunderthalle in Breslau*, Berlin 1914, p. 62



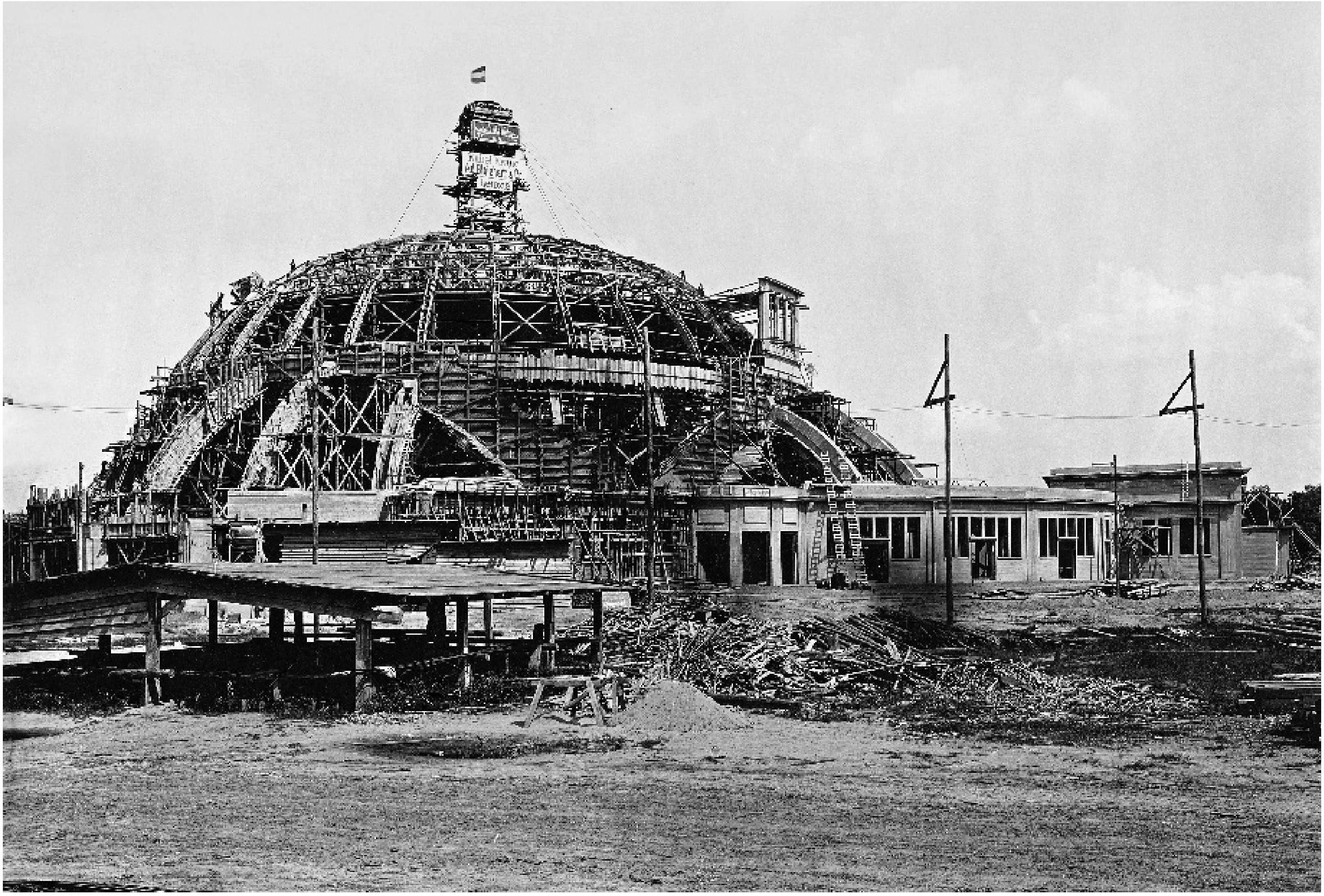
25 Centennial Hall, interior under construction, autumn 1912. University Library in Wrocław, Graphic Collection Department



26 Centennial Hall, concreting of substructure, ca. July 1912. Trauer Günther, Gehler Willy, *Die Jahrhunderthalle in Breslau*, Berlin 1914, p. 63



27 Centennial Hall, foyer construction, ca. September 1912. Museum of Architecture in Wrocław



28 Centennial Hall, concrete dome ribs, beginning of assembly of prefabricated window frames, ca. September-October 1912.
Deutsches Museum in Munich, archive, legacy of Max Berg

29 Completion of concreting works, group photograph of employees of Eisenbetonbau Dyckerhoff & Widmann Dresden-Neustadt, end of 1912.
SLUB Dresden / Deutsche Fotothek

30 Centennial Hall, concrete shell, 1912/1913. Leibniz Institute for Research on Society and Space in Erkner near Berlin

completed by September 1, 1912 and celebrated in traditional fashion that involved putting up a decoration of branches, grass, and flowers on the structure's top. The next stage involved mounting the stepped rings of glazed walls and floors. A pioneering assembly method was employed that would become popular only in the 1920s. The windows were assembled of prefabricated modules and produced on site. The concrete frames and floors were cast in molds, then lifted by crane and mounted one by one on the sway braces of the dome's ribs. The mounting job took only ten minutes. Only after all the frames were mounted, was the tower of the crane dismantled and scaffolding erected to rest on the ring bracing the dome's top section in order to construct the lantern. By December 1912 the reinforced-concrete shell was finished and subsequently formally presented to the Municipal authorities by Dyckerhoff & Widmann.

2.2.7. Collaborators and contractors

Architect:

Max Berg.

Design collaboration:

Günther Trauer – structural engineer,
Richard Konwiarz and Paul Heim – architects,
Hans Leistikow – painter, designer of the never completed painted decoration of the interior,
Paul Schreiber – architect,
Professor Karl Straube from Leipzig – design for the organ,
Alfred Vocke – sculptor, author of the relief placed above the main entrance.

Contractors:

Dyckerhoff & Widmann from Dresden – Centennial Hall – dome,
Lolat Eisenbethon A.G. from Wrocław – Centennial Hall – ambulatory (foyer)

Site supervision on behalf of the Municipality:

Hochbauamt H. D. II under Paul Schreiber – architecture,
Brückenbauamt under Günther Trauer – structural engineering,
Eng. Matthes – clerk of works (architecture)
Meyer – clerk of works (engineering),
Liebchen under Eng. Bechtl – site manager for Dyckerhoff & Widmann,
Eng. Oeber – site manager for Lolat Eisenbeton A.G.

Verification of structural calculations on behalf of the Construction Supervision Inspector:

Stadtbauinspektor Ernst Reissmüller and Eng. Erlenkämper,
Eng. Schulz from Dresden under Regierungsbaumeister Professor Willy Gehlera from Dresden – calculations for Dyckerhoff & Widmann.

Interiors and furnishings:

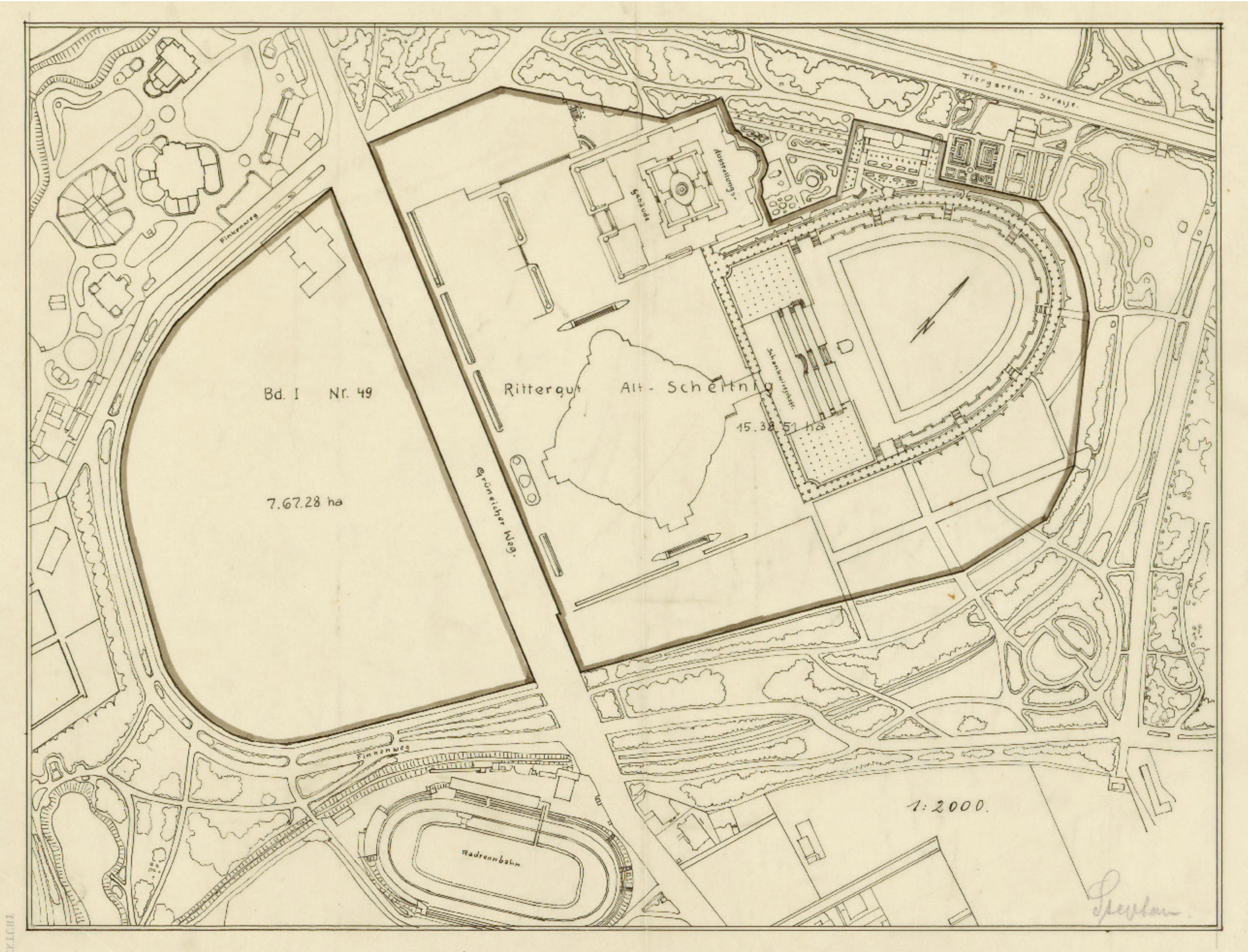
Organ: Sauer Inh. Paul Walcker, Frankfurt/Oder,
Doors: Isaak, Wrocław; Kaliski, Wrocław; Alfred Schulze G.m.b.H., Wrocław,
Window frames (Jarrahholz): Freytag, Wrocław-Leśnica; Alfred Schulze G.m.b.H., Wrocław,
Cost calculations: Füllborn Nachf., Wrocław,
Skylights in the ambulatory (foyer): Trelenberg, Wrocław (steel frame); Spanier of the firm of Bley, Wrocław (glazing),
Skylight in the dome: Trippel, Wrocław,

Skylight in the reception room: Salkowsky, Wrocław,
Glazing of the Centennial Hall's windows: Seiler, Wrocław; Hoffmann, Wrocław,
Roofing: Röbert & Mathies, Dessau; Rudel, Wrocław; Finger & Co., Wrocław,
Tin-smithing: Rudel, Wrocław,
Furnishing of the reception room: Gebr. Bauer, Wrocław (partially funded by the firm),
Base for the organ: Freytag, Wrocław-Leśnica (funded by the firm),
Wood paneling of the organ apse: Baum, Wrocław,
Heating system: Rud. Otto Meyer, Hamburg,
Lighting: Städt. Elektr. Werke; Bergmann-Elektrizitätswerke; Gesellschaft für Elektrizitäts--Unternehmungen,
Concrete floors: Jerschke, Wrocław,
Benches: Hyan, Berlin; Krimke & Co, Wrocław; Pilzer, Wrocław,
Granite thresholds: Völker & Nicolair, Wrocław; Jache, Wrocław,
Insulation of the organ apse: Haase, Wrocław,
Blacksmithing jobs: Kreutzer, Wrocław; Salkowsky, Wrocław; Lehnhardt, Wrocław; Wohlfart, Wrocław; Hold & Helbig, Wrocław,
Fire protection system: Siemens & Halske, Wrocław,
Fencing: Daum, Wrocław,
Stuccoes: Kuntze & Brinke, Wrocław,
Flooring: Bieneck, Wrocław,
Access roads and earthworks: Hoffmann, Wrocław; Kuppe, Wrocław; Maschefski, Wrocław; Kleinert, Wrocław; Wilhalm, Wrocław; Scholz, Wrocław,
Pavements and curbs: Schall, Wrocław; Steibrich & Oelsner, Wrocław,
Foldable stands seating 5000 people, purpose-built for the performance of Gerhart Hauptmann's *festspiel* produced by Professor Max Reinhard: Hugo Baum, Wrocław; Gustav Hossenfelder, Wrocław.

2.2.8. The Exhibition Grounds 1914–1918

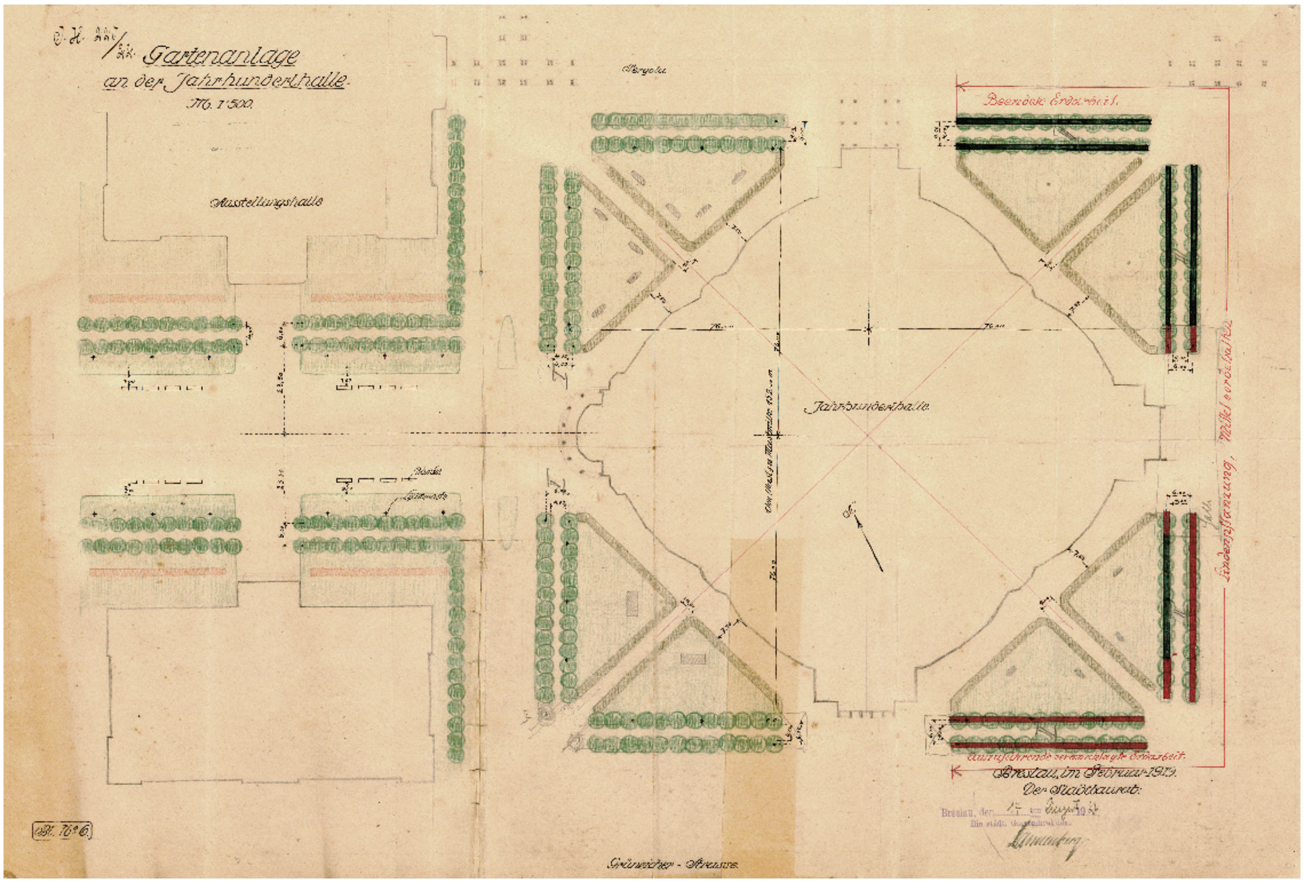
Once the Centennial Exhibition had ended, its organizers decided to dismantle all temporary structures and pavilions leaving only the Centennial Hall, Historical Exhibition Four Dome Pavilion, Pergola, Terraced Restaurant, part of the historical gardens with the Belvedere and a fragment of the Japanese Garden. The future of the restaurant located between the Pergola and the Centennial Hall was uncertain but in the end this semi-permanent structure (not suitable for wintertime) was spared because of the income it brought and its popularity with the guests.

During World War I, the Centennial Hall was used to store foodstuffs. In 1916, the idea was put forward to establish a joint-stock company to supervise the organization of industrial fairs and presentations of building trades at the venue. This was considered the best way to make the Exhibition Grounds sustainable and self-financing. The first Industrial Fair took place from September 29 to October 14, 1917. Soon after, on the initiative and with the participation of the Municipality the joint-stock company called Breslauer Messe A.G. was founded.

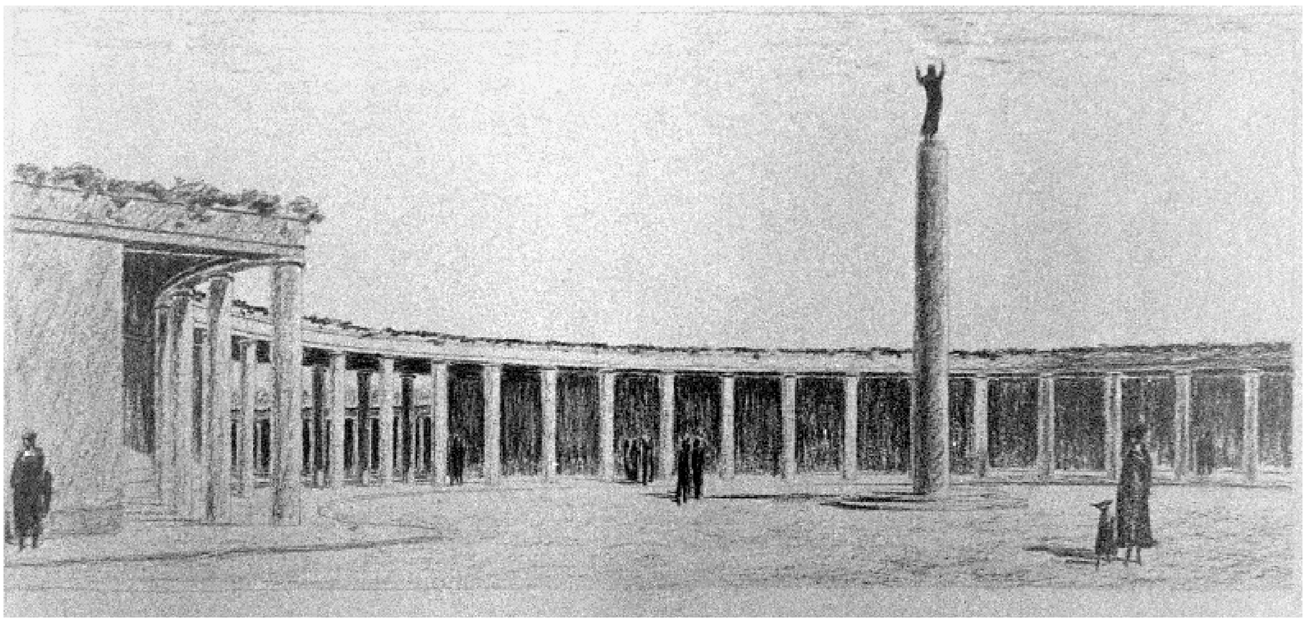


31 Exhibition Grounds, site plan, ca. 1918. Museum of Architecture in Wrocław – Building Archive of the City of Wrocław

32 Exhibition Grounds, bird’s eye view, ca. 1920, photograph. Deutsches Museum in Munich, archive, legacy of Max Berg



33 Hugo Richter, Centennial Hall, linden rows, planting design 1922 by Gartenanlage an der Jahrhunderthalle.
National Archives in Wrocław, Files of the City of Wrocław



34 Max Berg, design for the development of the Exhibition Grounds in Wrocław, 1919–1920.
Deutsches Museum in Munich, archive, legacy of Max Berg

2.3. The Centennial Hall and Exhibition Grounds in the interwar period (1918–1939)

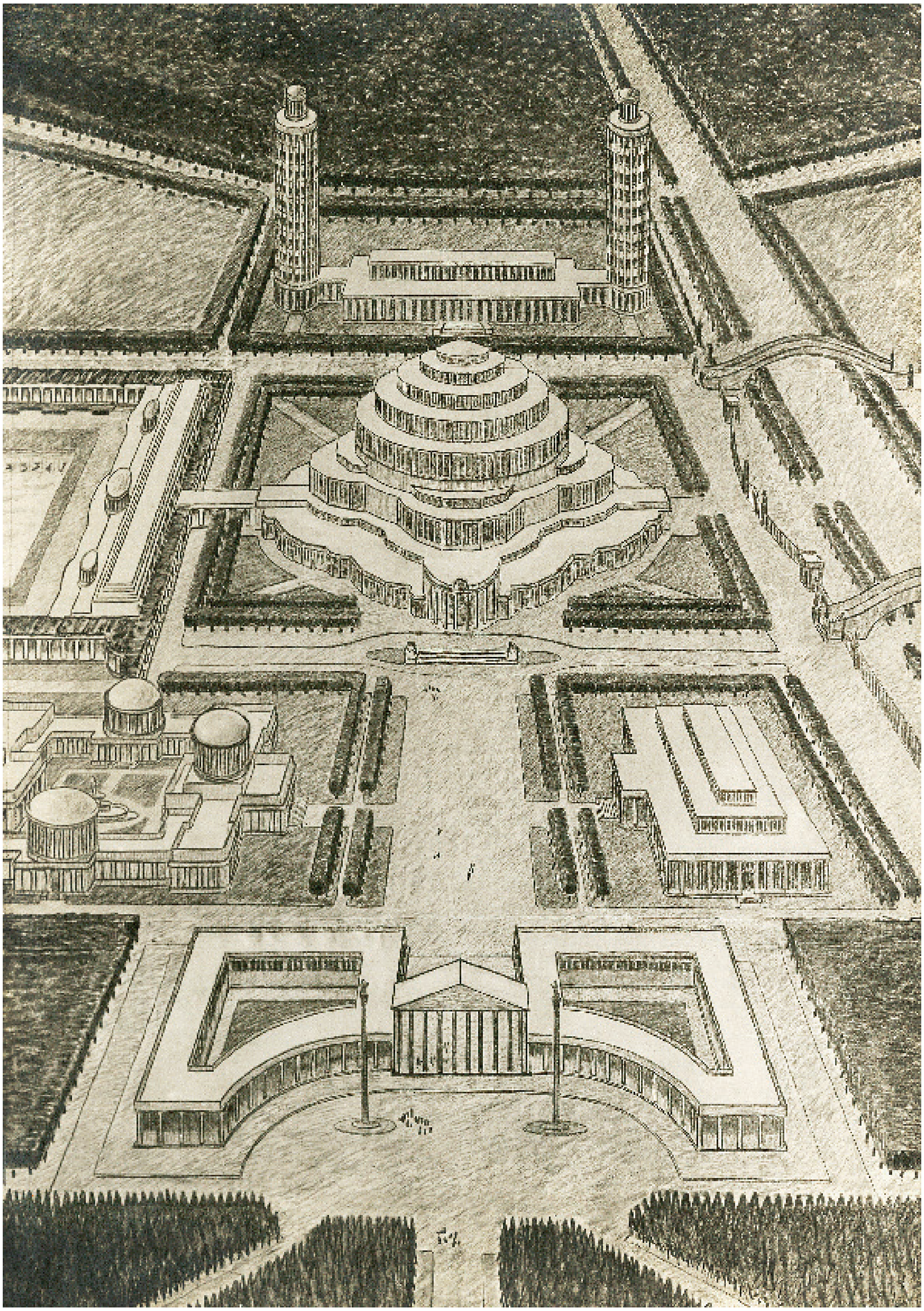
From 1918, Industrial Fairs (showcasing mostly building trades) were regularly organized, initially in the fall and later also in the spring. They were staged in the Centennial Hall and the Historical Exhibition (Four Dome Pavilion), in temporary wooden pavilions, as well as outdoors in the southern section of the Exhibition Grounds. Soon, however, it became obvious that the Centennial Hall and the Historical Exhibition Pavilion did not offer adequate exhibition space and facilities since the Centennial Hall had been originally conceived as an assembly space and the Historical Exhibition Pavilion as a venue for art exhibitions. It was a pressing challenge to develop a sustainable financing and management plan for the Centennial Hall and Exhibition Grounds.

After the demolition of the temporary pavilions, the remaining part of the complex became subject to gradual degradation. An empty plot once occupied by Hans Poelzig's Pavilion of the Society of Silesian Artists compromised the original layout of the monumental courtyard in front of the Centennial Hall. Flowerbeds and lawns were arranged to ameliorate the situation. In 1918, the Director of the Municipal Gardens Hugo Richter designed a new garden around the Centennial Hall and the square in front of it. Corrected by Berg in 1919, it was completed in 1920 and has survived until today. The design envisioned the planting of trees along the square circumscribed around Centennial Hall and along the courtyard in front of the Centennial Hall. Richter selected Linden trees while in Berg's design no specific tree types were indicated.

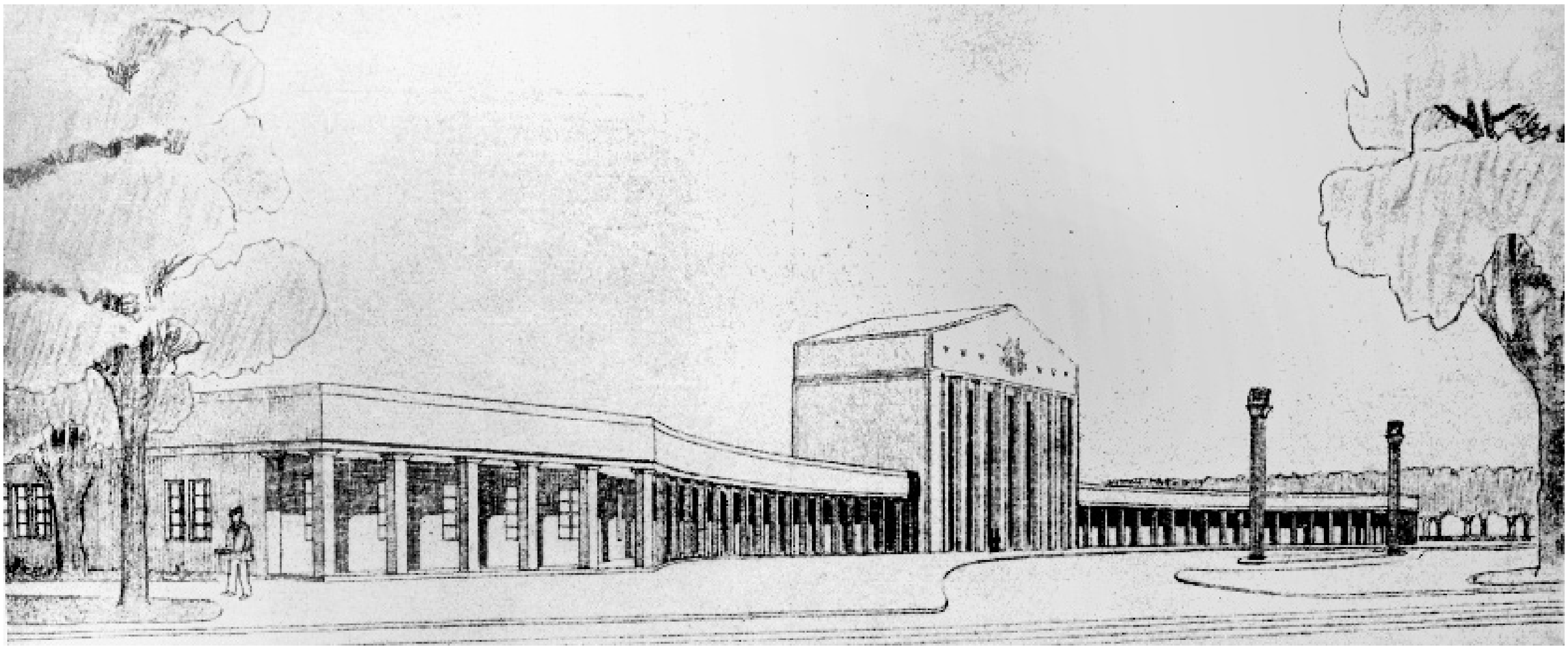
2.3.1. First (never built) design for the expansion of the Exhibition Grounds 1919–1921

In 1919–1921 Max Berg (together with Ludwig Moshamer and Richard Konwiarz) developed a modernisation program for the city center that referred to his earlier vision for Greater Berlin. Berg's master plan stipulated, among others, the expansion of the Exhibition Grounds in connection with the Centennial Hall. Berg proposed to expand the Exhibition Grounds by erecting new structures to replace the demolished pavilions designed by Poelzig. In urban planning terms, Berg's idea referred to Poelzig's layout with its two principal axes. While Poelzig had emphasized the north-south axis, Berg's approach was more balanced as he focused on expanding the east-west axis to comprise four zones. The west was to be the new monumental complex of the main entrance to the Exhibition Grounds; then the courtyard in front of the Centennial Hall with a new pavilion on the former site of the Pavilion of the Association of Silesian Artists; the Centennial Hall would remain the centerpiece of the third zone; and in the fourth zone – on the site of the former Pavilion of Garden Design Exhibition – Berg designed a new pavilion surrounded in the south and north by two 11-storey circular towers. Characteristically, by introducing columns in their façades, Berg infused all new pavilions and other structures with the spirit of simplified Classicism.

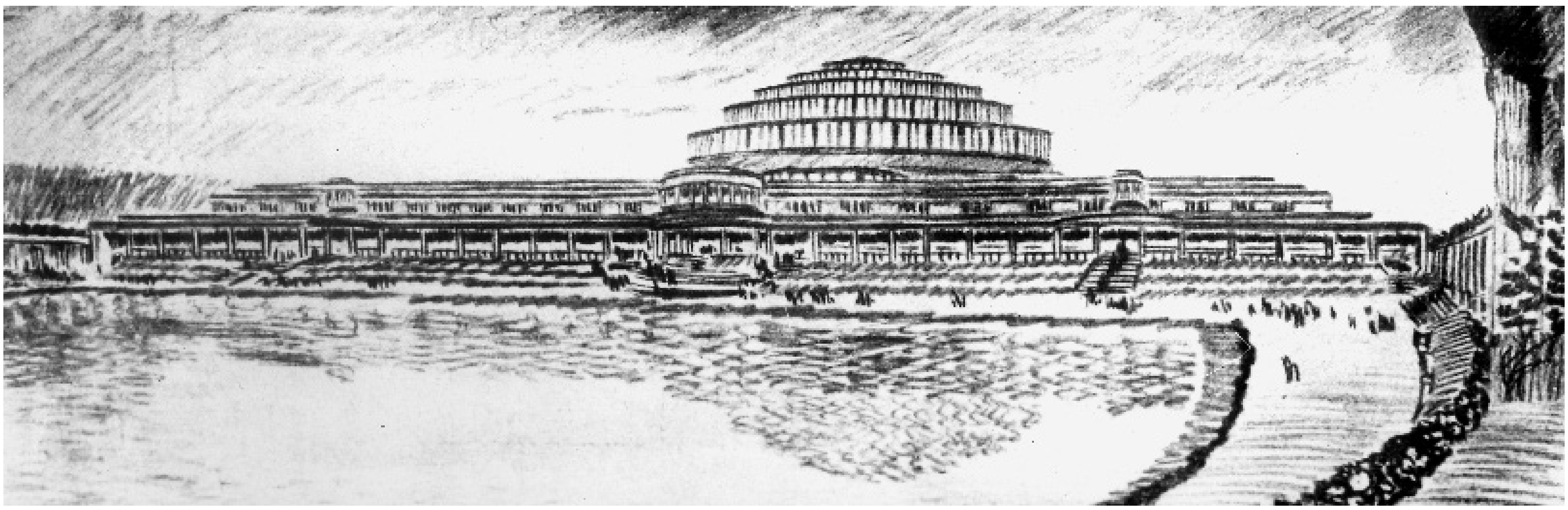
The pavilions designed by Berg were laid out on a rectangle and featured a terraced roof. The towers surrounding the eastern pavilion resembled the famous Leaning Tower in Pisa. The new Terraced Restaurant in front of the Pergola was designed in the same style. Berg made it span the whole width of the lake so it would adjoin the Pergola. On the lake's side, he modified the terraces correspondingly, placing three elliptical domed belvederes on the roof. A drawing from the architect's archive at Erkner shows the restaurant's interior as a unified space with Expressionist reinforced-concrete ceilings and piers. The interior illustrates the evolution of Berg's architectural vision probably in connection with his collaboration with Oskar Kokoschka on the crematorium project.



35 Max Berg, design for the development of the Exhibition Grounds in Wrocław, 1919–1920.
Deutsches Museum in Munich, archive, legacy of Max Berg

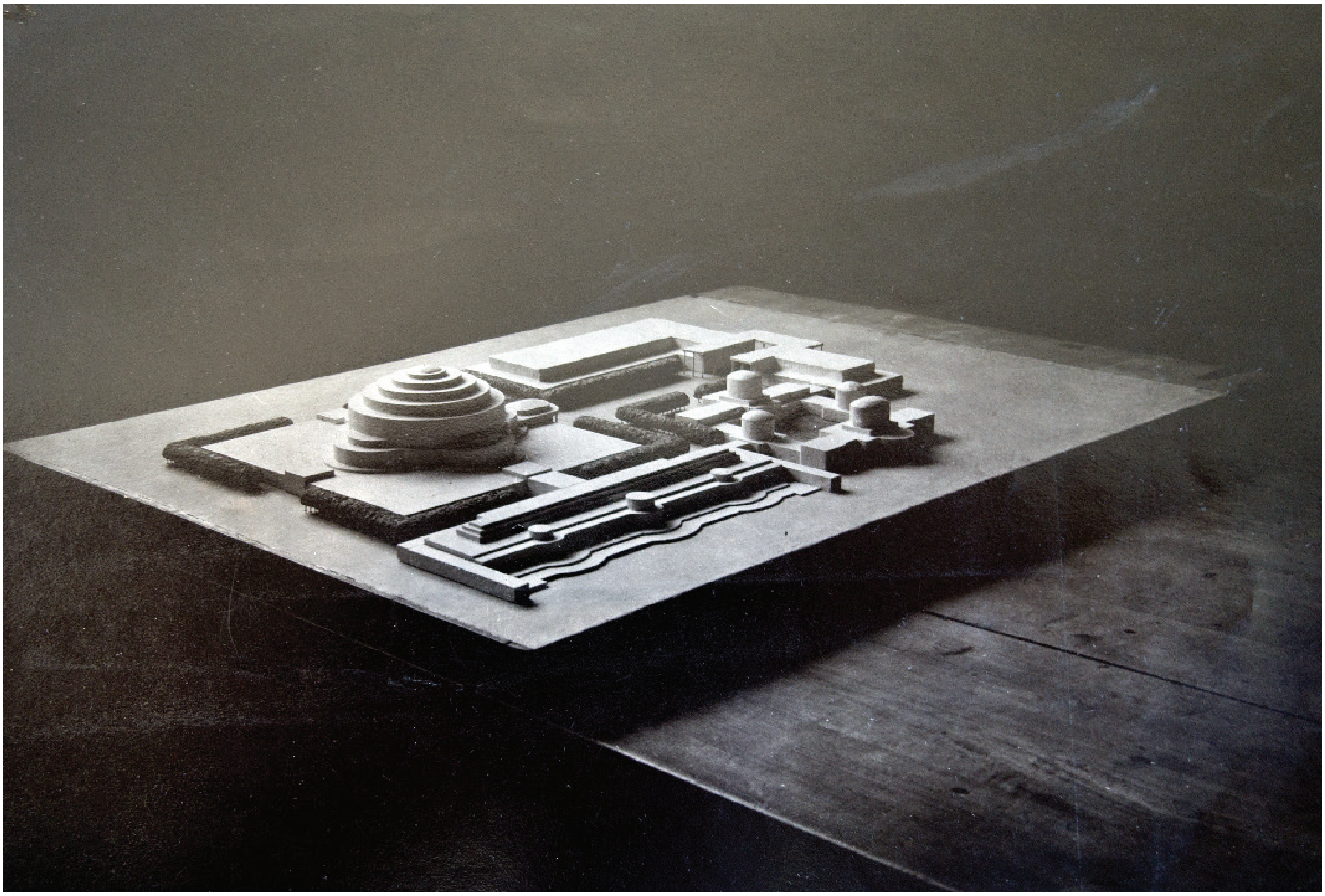


36 Max Berg, design for the development of the Exhibition Grounds in Wrocław, 1919–1920. “Wasmuth Monatshefte für Baukunst”, 1921–1922, vol. 6



37 Max Berg, design for the development of the Exhibition Grounds in Wrocław, 1919–1920. “Wasmuth Monatshefte für Baukunst”, 1921–1922, vol. 6

38 Max Berg, design for the development of the Exhibition Grounds in Wrocław, restaurant interior design, 1919–1920.
Leibniz Institute for Research on Society and Space in Erkner near Berlin



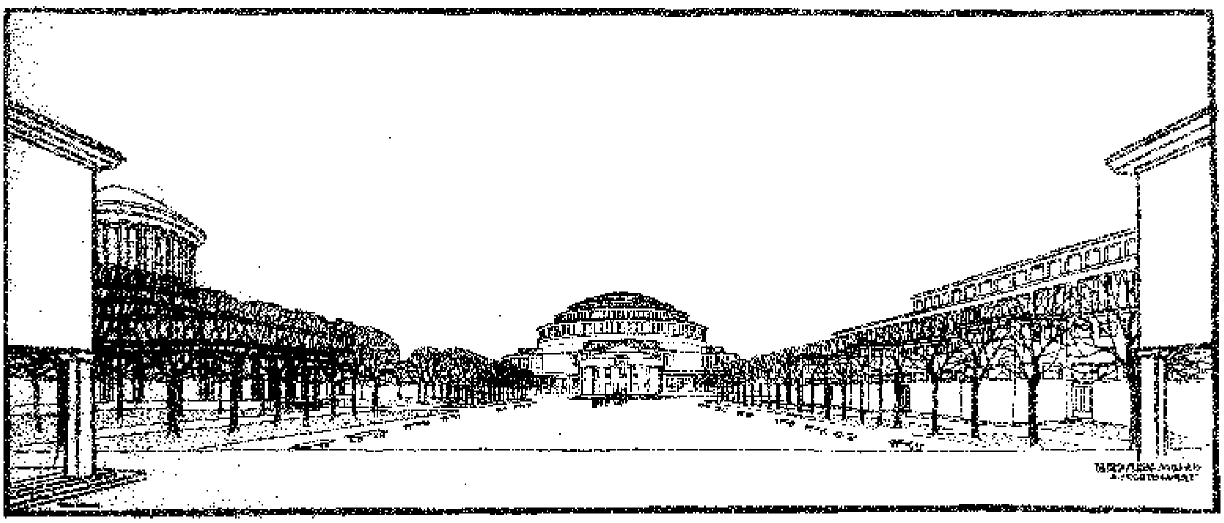
39 Max Berg, design for a new exhibition hall (Messehalle), gypsum model, 1924. Leibniz Institute for Research on Society and Space in Erkner near Berlin

2.3.2. Second (never built) design for the expansion of the Exhibition Grounds 1922–1924

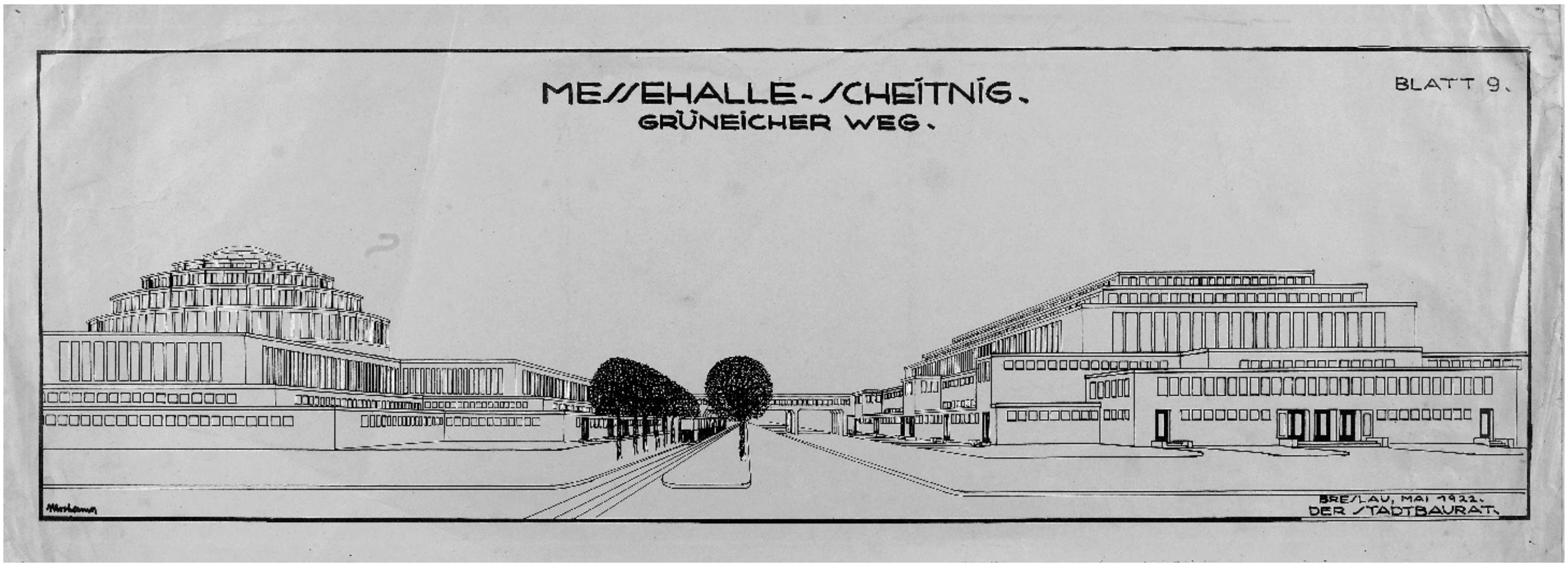
Although at the time there was no real chance for the expansion of the Exhibition Grounds after Berg's first design, developed soon after World War I, the architect in collaboration with Ludwig Moshamer and Wilhelm Anders continued to elaborate on new conceptions. In 1922–1924, working with the Executive Board of Breslauer Messe A.G., he designed new exhibition halls extending the exhibition space to accommodate industrial and building trade exhibitions that were organized several times a year.

The relevant design drawings that are now in the architect's archive in Erkner and in Munich have never been published so they remain virtually unknown. The conception of the expansion of the Exhibition Grounds documented by two photographs (Erkner) showing two plans – the layout and the bird's eye view of the Exhibition Grounds – date back to probably early 1922. The undated plans constitute the entire area of the Exhibition Grounds, together with the section on the southern side of the street whose program gets expanded. The caption suggests that Berg prepared two versions but only one has survived. The description gives an idea of the program but the photograph does not allow for deciphering all numbers marking individual structures and thus not all of them can be identified. Both drawings feature the existing structures: Centennial Hall, Poelzig's Historical Exhibition Pavilion, the Belvedere (remnant of the Garden Design Exhibition), the Terraced Restaurant, and the Pergola. Among the newly-designed structures are four exhibition pavilions which join the Centennial Hall, crowned with stepped domes. To the west pavilions flank the main entrance to the Exhibition Grounds housing the administration offices of Breslauer Messe A.G. and accommodating guests. The complex was to feature the "House of Nations" (Haus der Nationen), Hall of Arts (Kunsthalle), a hotel, textile industry hall, machine-building industry hall, crafts hall, industry hall, and a concert hall connected to a garden and restaurant. In his designs, the architect also indicated that in the future the area of the Zoological Garden should be incorporated into the Exhibition Grounds.

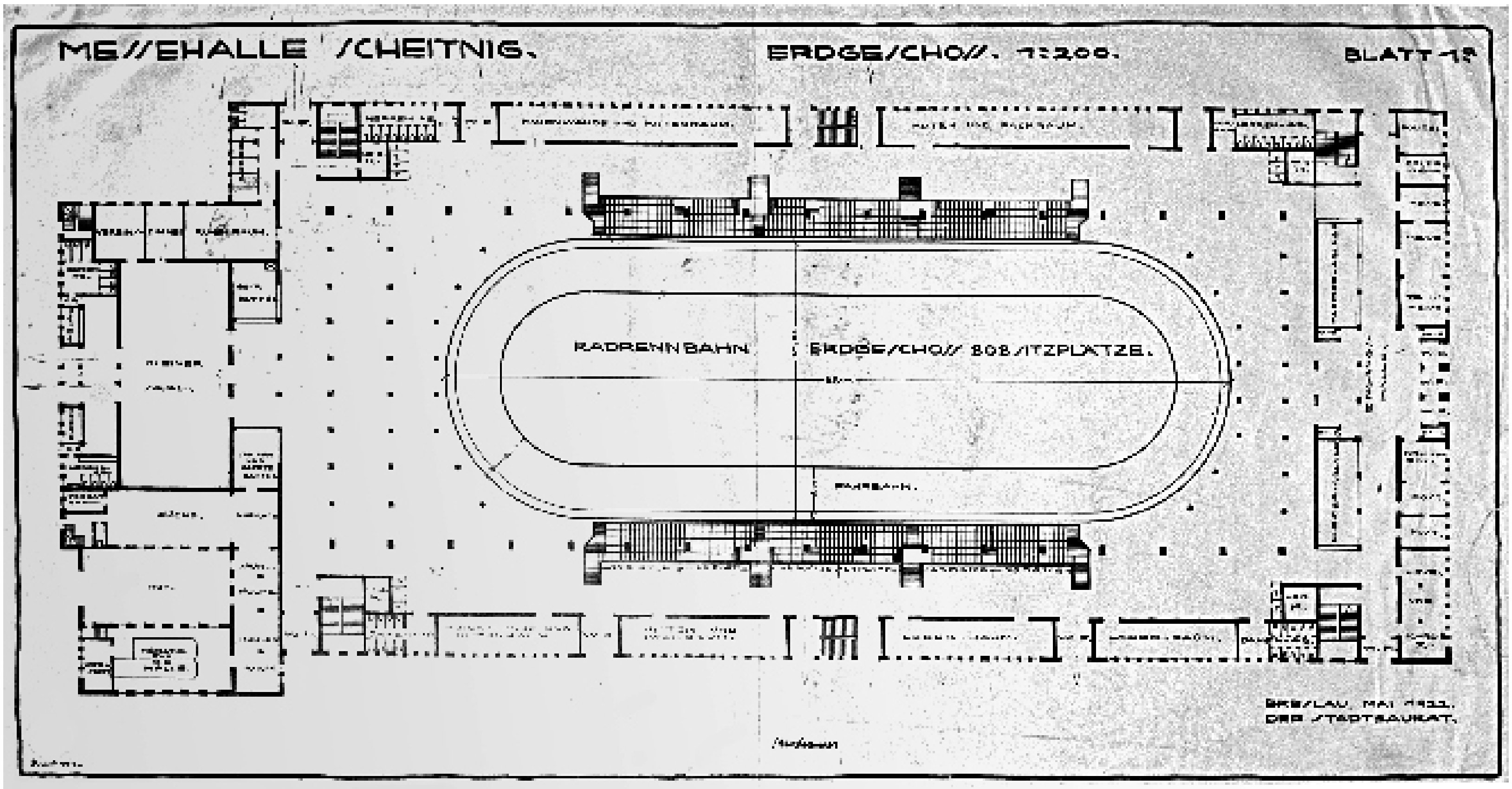
One of the proposed new halls (Messehalle) was designed as a unified rectangular space with annexes in the west and east, 150-metres-long, 60-metres-wide, and 20-metres-high. According to this first design, it was a compact structure covered with a terraced roof corresponding to the Centennial Hall. The roof stretched over an open structure comprising of elliptical ribs with the main beams supporting glazed walls and a flat ceiling. The



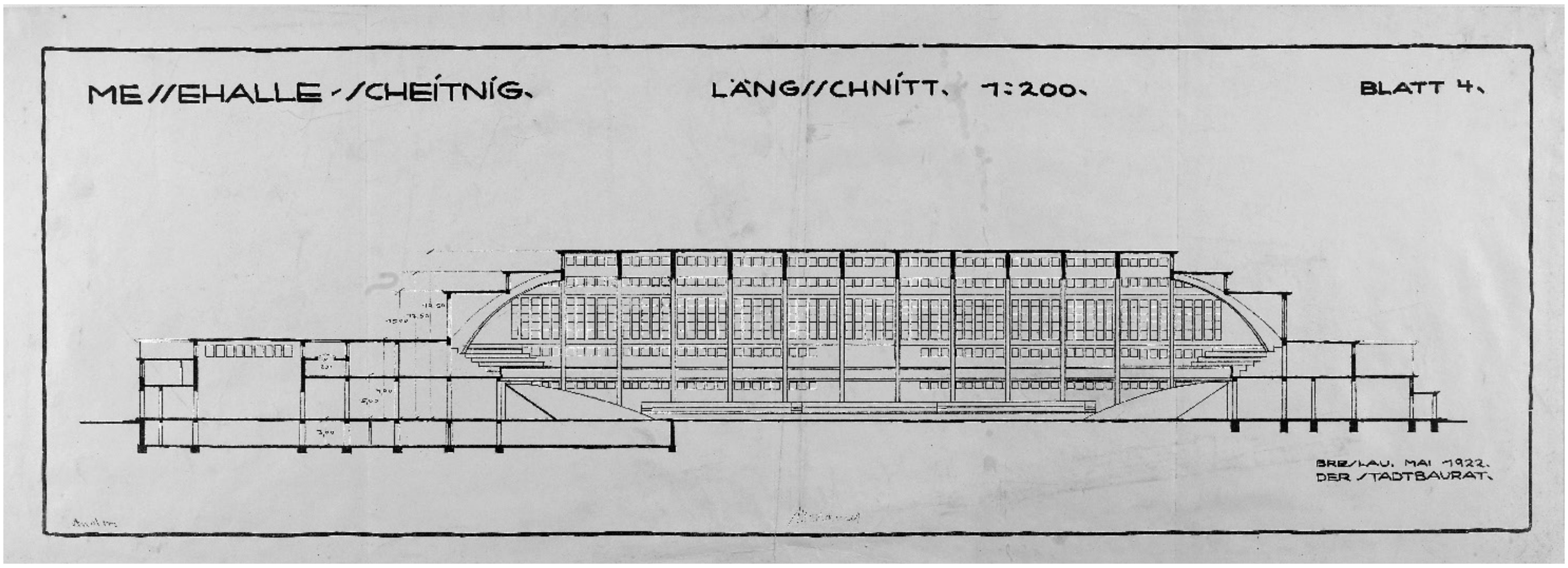
40 Max Berg in collaboration with Ludwig Moshamer, design for a new exhibition hall (Messehalle), view from the monumental courtyard, 1924. Leibniz Institute for Research on Society and Space in Erkner near Berlin



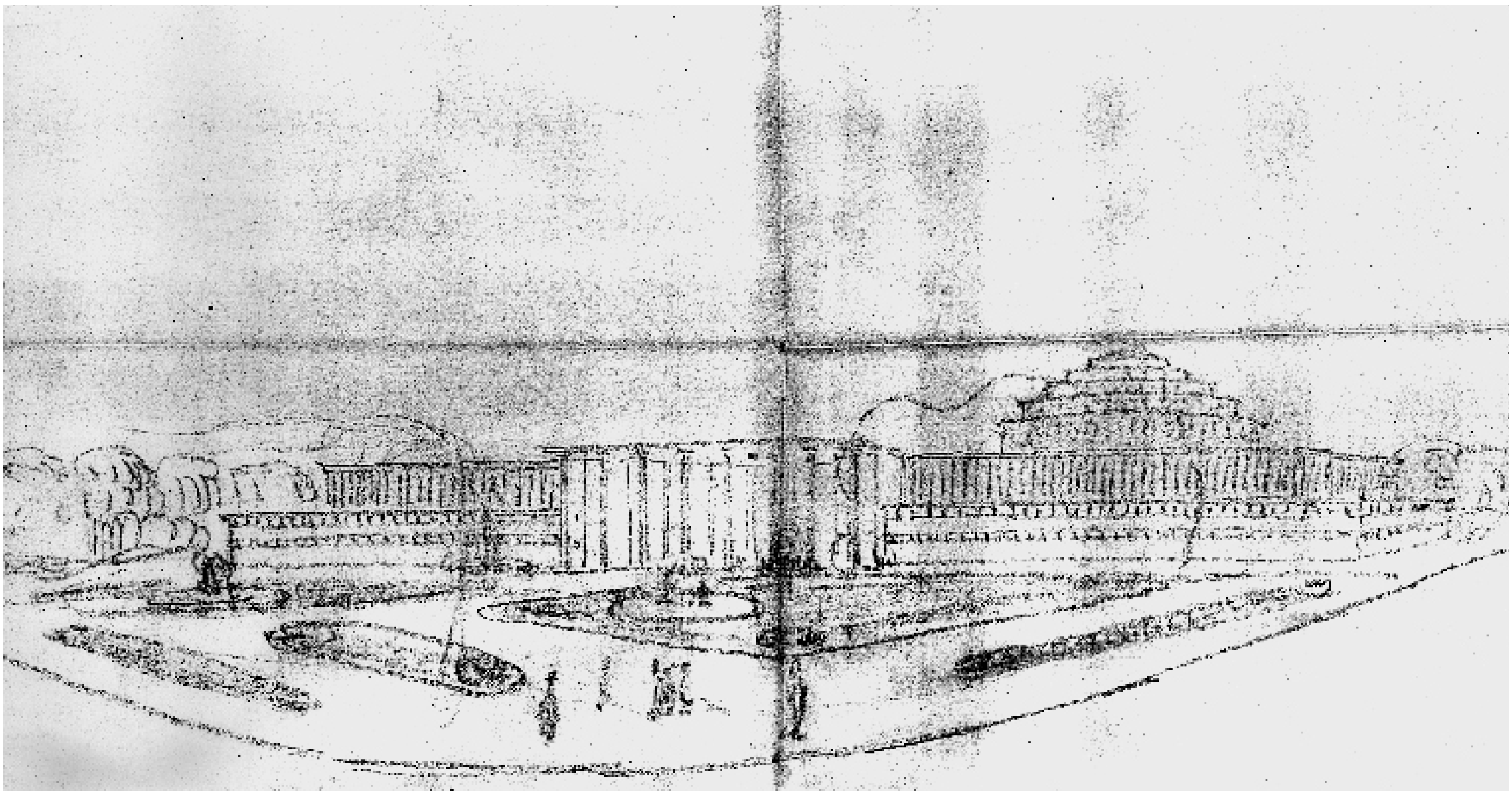
41 Max Berg, design for expansion of the Exhibition Grounds in Wrocław, exhibition hall design, view, 1922.
Leibniz Institute for Research on Society and Space in Erkner near Berlin



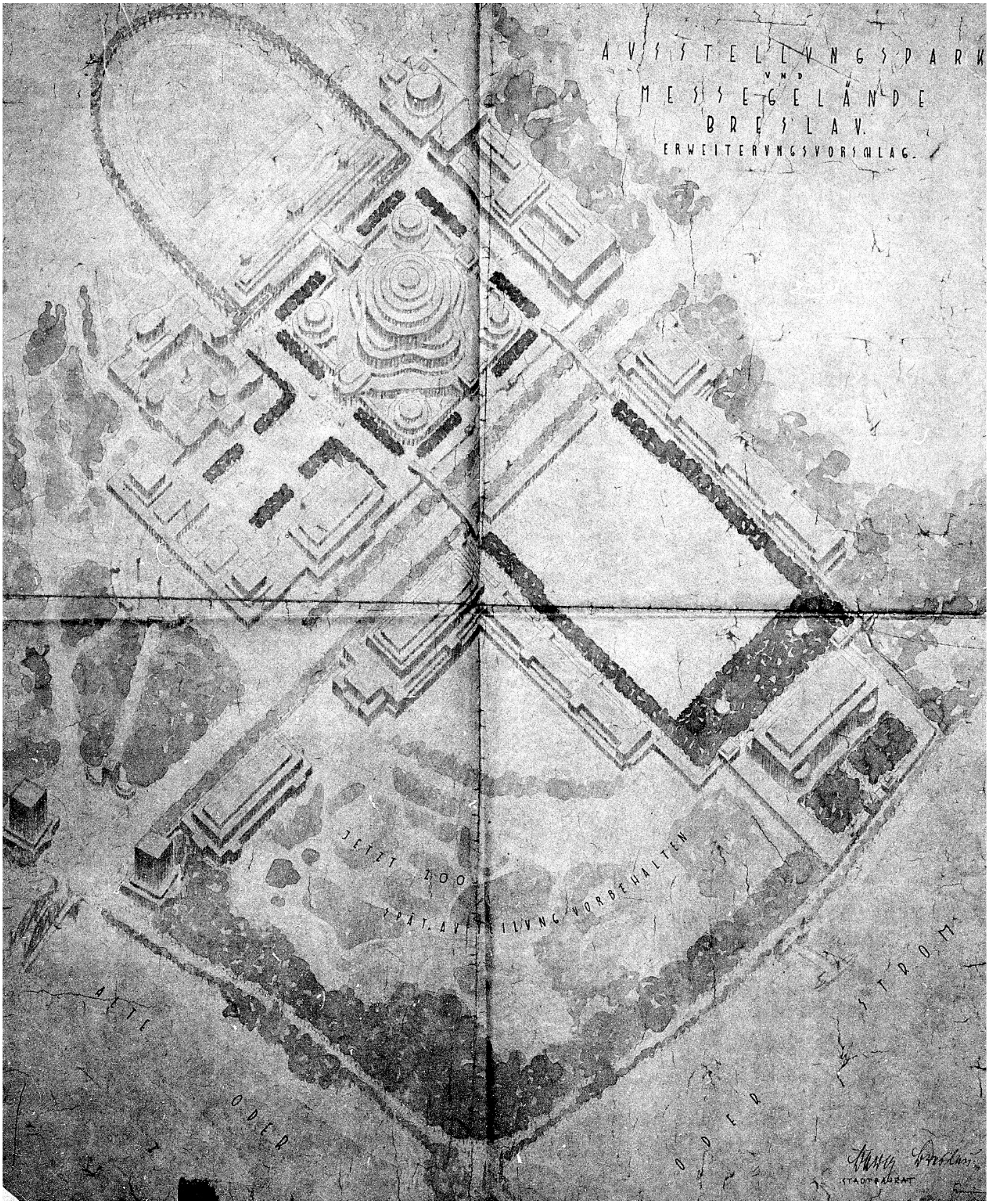
42 Max Berg, design for expansion of the Exhibition Grounds in Wrocław, exhibition hall design, ground floor plan, 1922.
Leibniz Institute for Research on Society and Space in Erkner near Berlin



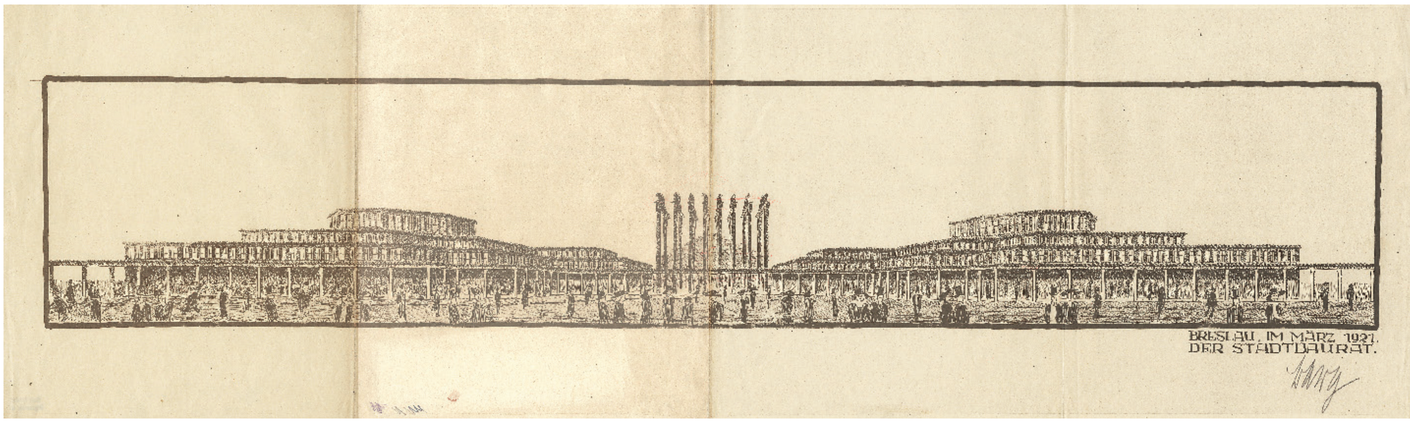
43 Max Berg, design for expansion of the Exhibition Grounds in Wrocław, exhibition hall design, section, 1922. Leibniz Institute for Research on Society and Space in Erkner near Berlin



44 Max Berg in collaboration with Ludwig Moshamer, design for a new exhibition hall (Messehalle), view, 1924. Deutsches Museum in Munich, archive, legacy of Max Berg



45 Max Berg, design for expansion of Exhibition Grounds in Wrocław, site plan, 1922.
Leibniz Institute for Research on Society and Space in Erkner near Berlin



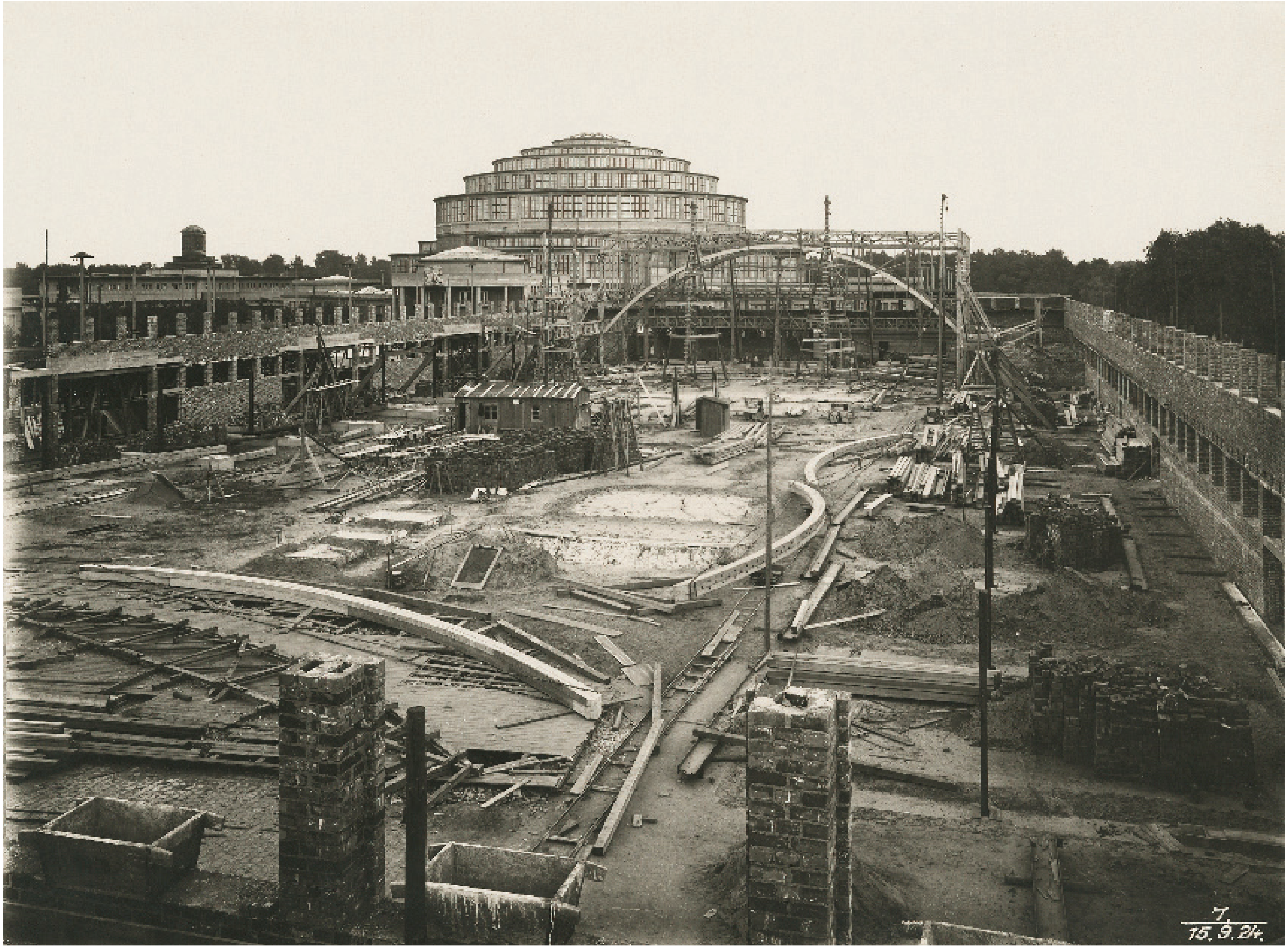
46 Max Berg, design for expansion of Exhibition Grounds in Wrocław, overall view, 1921.
Deutsches Museum in Munich, archive, legacy of Max Berg

arched ribs spanned almost the entire width of the interior (about 50 meters). The interior featured folded seats arranged to form an amphitheater that could be dismantled if needed. The Messehalle was to serve similar functions as the Centennial Hall. The drawings show that it could have accommodated exhibitions (exhibition space of 1808 m^2) and sporting tournaments (cycling track), with a seating capacity of 808 seats located on the main floor and galleries lining the walls. In his design for this monumental and versatile space, Berg proposed two alternative structural systems – one of reinforced concrete, the other one of wood. In the reinforced-concrete version, he introduced monumental relieving arches in the eastern and western ends (solution analogous to the Centennial Hall) probably to ensure stability of the immense structure. Berg had no previous experience of working with wooden structures and his venturing into this hitherto unfamiliar domain was dictated by the investor's insistence on cost-cutting solutions.

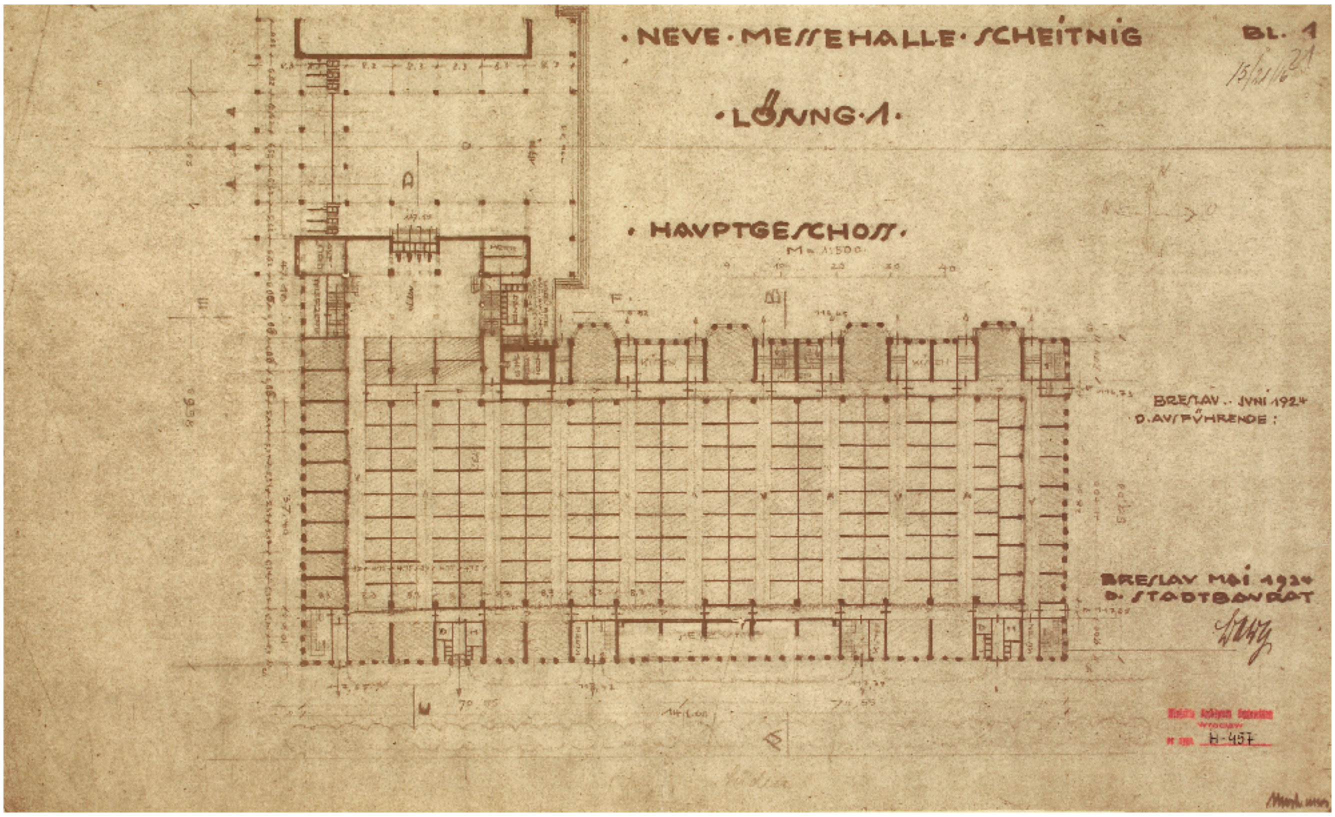
2.3.3. Construction of the Exhibition Hall (Messehalle) and the Main Gateway to the Exhibition Grounds (Messehof), 1924–1925

Of the ambitious plans for the expansion of the Exhibition Grounds presented by Berg in the early 1920s, the magistrates and Breslauer Messe A.G. decided to go for just one Exhibition Hall located on the site of the temporary Pavilion of the Association of Silesian Artists and to erect the monumental main entrance to the Exhibition Grounds.

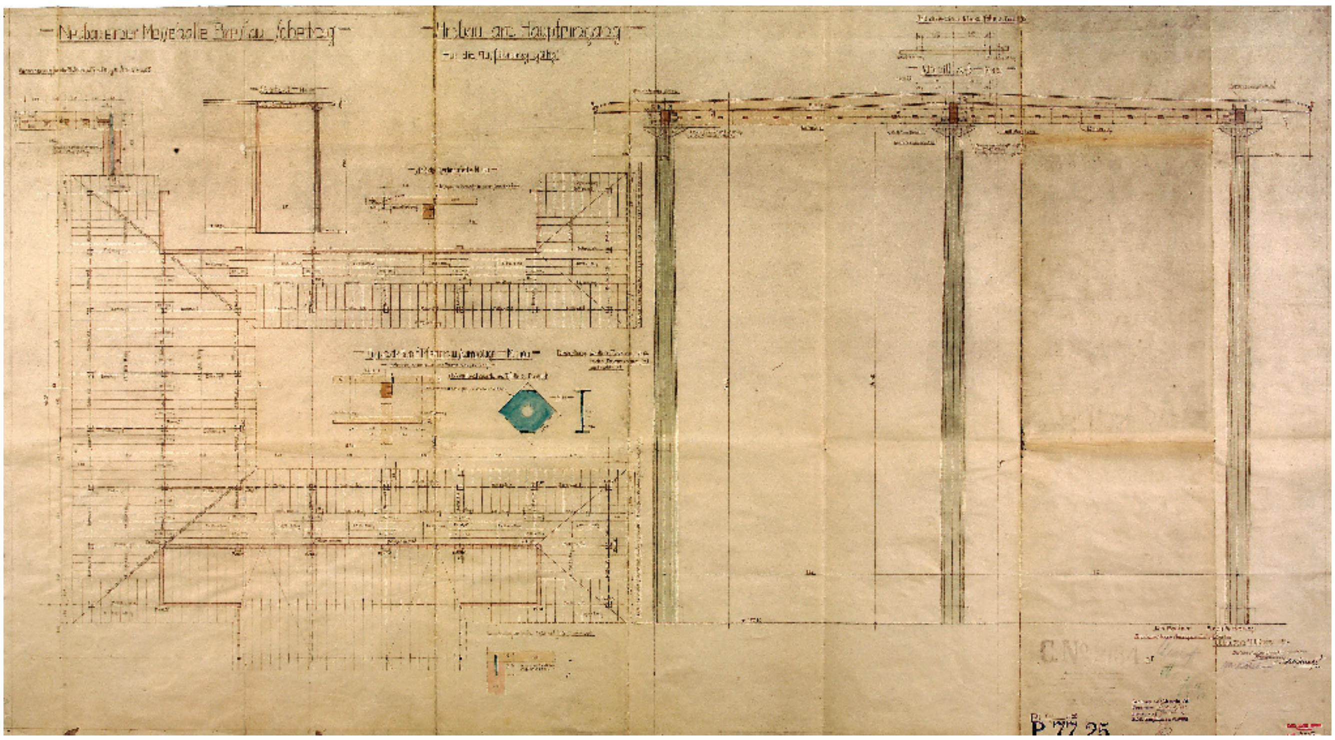
In early 1924 the City Executive Board commissioned Berg to design the new large Exhibition Hall (Messehalle). In March 1924, on the occasion of the Spring Fair's opening, the local press published the first details concerning the size of the planned structure: 9000 m^2 of total space and 6000 m^2 of usable space. Quoting the designer, the newspapers suggested that the structure be built of reinforced concrete. According to one brief description, it would stretch along Grüneicher Weg (at present Wróblewskiego Street) and comprise of two wings of which one would adjoin Poelzig's Four-Dome Pavilion. The project would be financed by the city and completed by the fall of the same year to accommodate the Fall Fair. Then the new Messehalle would be rented by Breslauer Messe A.G. to house presentations for the textile industry. The short deadline imposed by the investor suggested that the new Messehalle was being envisioned as employing cost-cutting and simple solutions. Supposedly, Berg hoped that – like in the case of the Centennial Hall – he would be able to persuade the investor to go for the architect's ideas. However, both the short deadline and the limited funds excluded reinforced concrete and Berg was forced to look for different solutions to erect a monumental building well suited to its exhibition function. He conceived



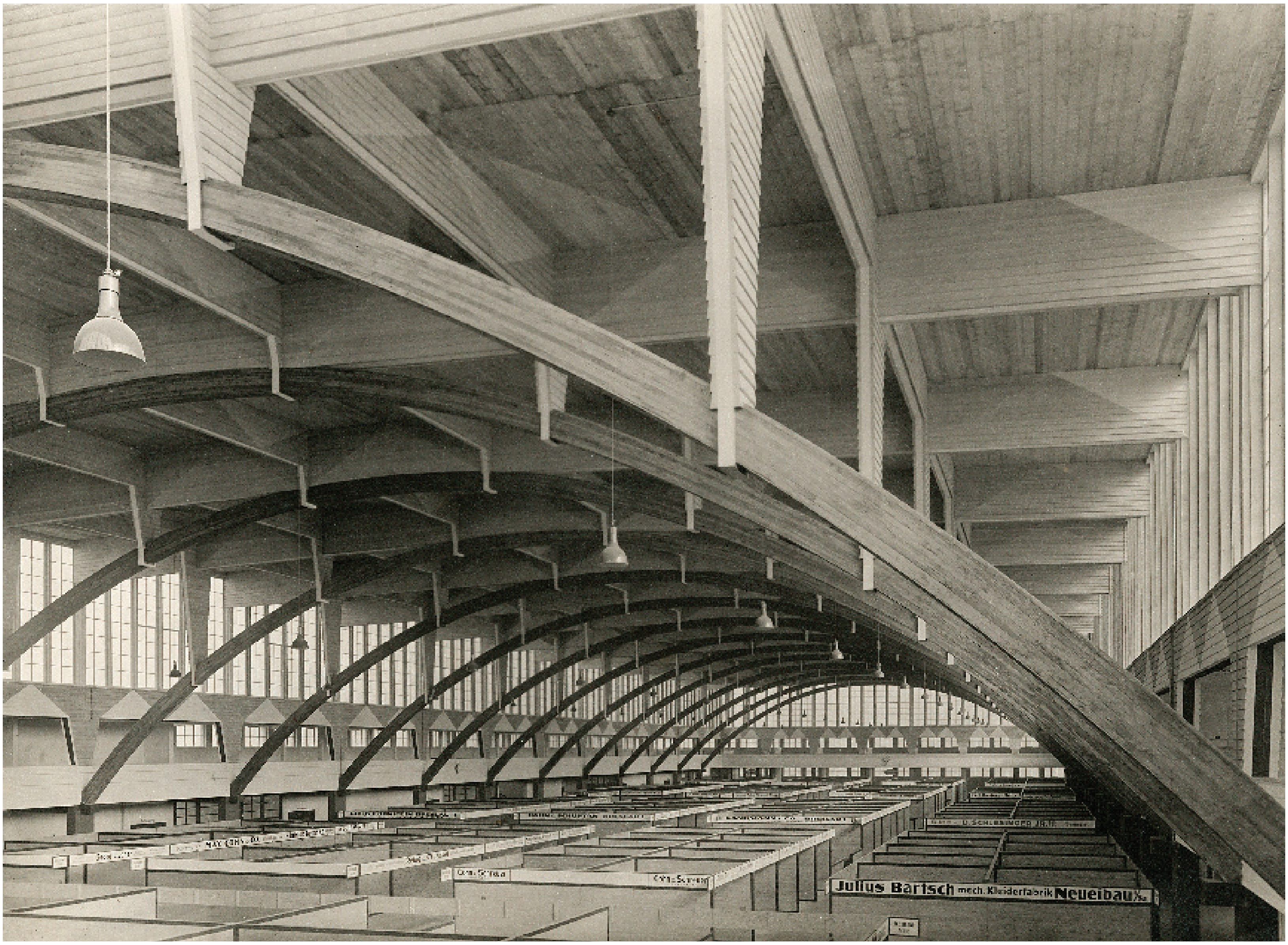
47 Max Berg, exhibition hall (Messehalle), photograph of site under construction, 1924.
Deutsches Museum in Munich, archive, legacy of Max Berg



48 Max Berg in collaboration with Ludwig Moshamer, design for a new exhibition hall (Messehalle), plan, first version, 1924.
Museum of Architecture in Wrocław – Building Archive of the City of Wrocław



49 Max Berg, Exhibition Grounds, monumental courtyard design (Messehof), 1924.
Museum of Architecture in Wrocław – Building Archive of the City of Wrocław



50 Max Berg, exhibition hall (Messehalle), photograph of the interior, 1925. Deutsches Museum in Munich, archive, legacy of Max Berg

51 Max Berg, exhibition hall (Messehalle), photograph of the interior, 1925. Deutsches Museum in Munich, archive, legacy of Max Berg

52 Max Berg. exhibition hall (Messehalle), photograph of the interior, 1925. Deutsches Museum in Munich, archive, legacy of Max Berg

53 Max Berg, exhibition hall (Messehalle), photograph, view from the entrance, 1925. Deutsches Museum in Munich, archive, legacy of Max Berg

54 Max Berg, new exhibition hall (Messehalle) and monumental courtyard (Messehof), photograph, view from the entrance, 1925. Deutsches Museum in Munich, archive, legacy of Max Berg

55 Max Berg, new exhibition hall (Messehalle) and monumental courtyard (Messehof), photograph, view from the street, 1925.
Deutsches Museum in Munich, archive, legacy of Max Berg

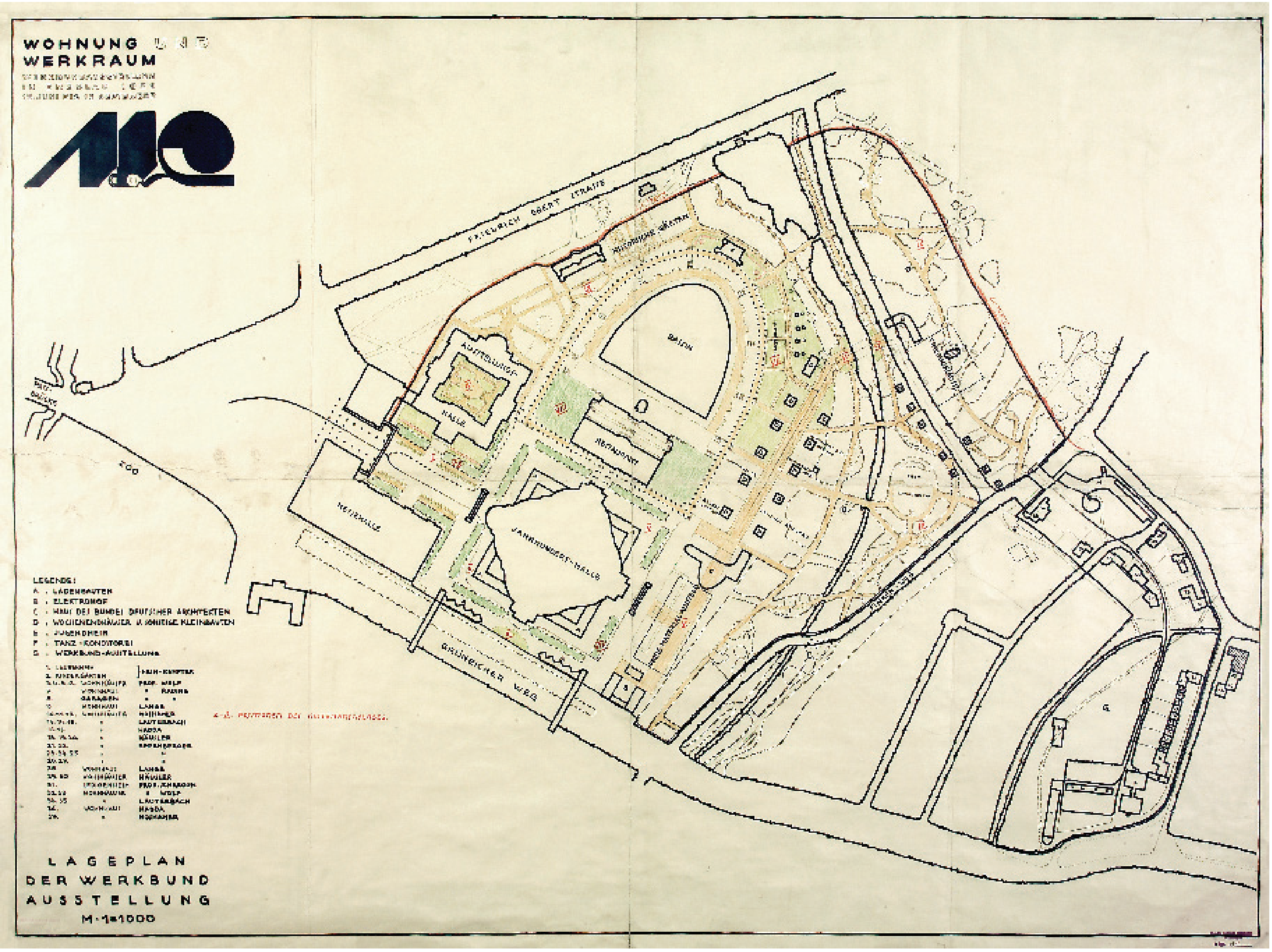
56 Max Berg, new exhibition hall (Messehalle) and monumental courtyard (Messehof), photograph, view from the street, 1925. Deutsches Museum in Munich, archive, legacy of Max Berg

a brick structure featuring concrete piers and a wooden ceiling. The contract was awarded to Deutsche Holzbau--Werke Carl Tuchscherer A.G. and the opening scheduled for the Spring Fair of 1925. Although he could not employ reinforced concrete or steel, Berg again developed an innovative construction, like at the Centennial Hall, this time using traditional material – wood. The contractor had extensive experience working with timber structures. The architect devised a system of wooden arches supporting the roof with binding joists. The arches rested on ferro-concrete bearings placed on the gallery level. The construction allowed for large expanses of glazed walls and skylights. In terms of architecture, the exterior façade of the Messehalle was co-ordinated with the façade of the Centennial Hall. The color design was by the painter Hans Lestikow, alumnus of the local Academy, who had already collaborated with Berg while still a student.

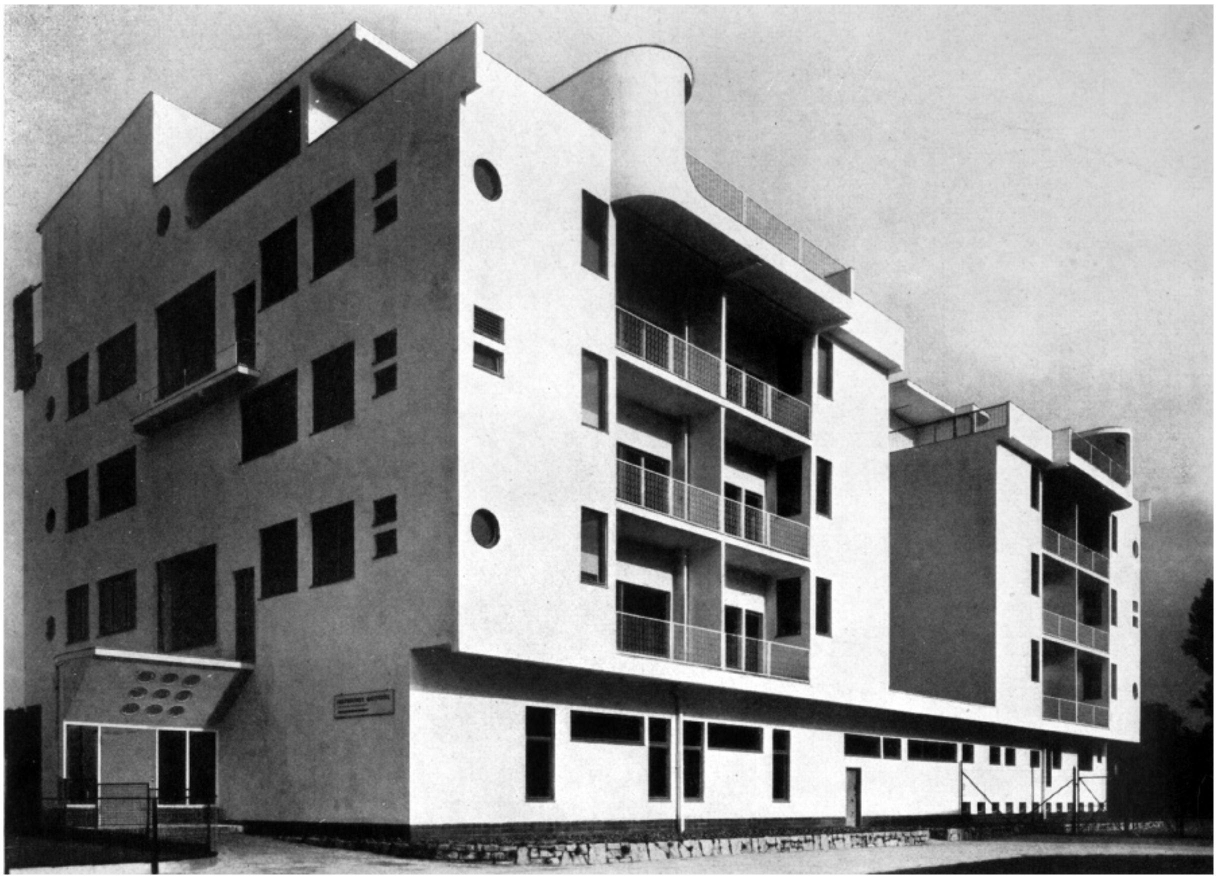
The courtyard of the Main Gateway was aligned with Centennial Hall's main entrance. Its rectangular layout referred to Antiquity (Greek *dipteros* with the Colonnade projecting before the façade of the Exhibition Hall). From there broad stairs led to the large rectangular courtyard built in 1913. The columns were covered with a flat roof reinforced with crossed beams. The ceiling and eaves were painted with a geometric pattern of overlapping triangles.

2.3.4. Living- and Work Space Exhibition under the auspices of the Werkbund ("Wohnung und Werkraum Ausstellung", WuWA), 1929

In 1929, the Silesian section of the German Werkbund organized the famous Living and Work Space Exhibition ("Wohnung und Werkraum Ausstellung", known as the WuWA) in Wrocław. The exhibition was comprised of two parts: the exposition staged on the Exhibition Grounds in and around the Centennial Hall and a model housing estate. Its objective was to present current local and international trends in domestic architecture, first of all various types of affordable and hygienic small and medium-size apartments, new materials, and innovative building technologies. The exhibition opened on June 15, 1929. It was scheduled to close on September 15, 1929 but, having attracted much interest, was extended through to the end of the month. One of the exhibition's ideas was the promotion of the Province of Silesia and its capital city.



57 Werkbund WuWA ("Wohnung und Werkraum Austellung"/Living- and Work Space) Exhibition in Wrocław, first exhibtion layout. Museum of Architecture in Wrocław – Building Archive of the City of Wrocław



58 Adolf Rading, apartment block on Werkbund WuWA Exhibition (house no. 7), 1929. “Die Form”, 1929, p. 459

The section arranged on the Exhibition Grounds was housed in its three principal buildings: the Centennial Hall designed by Max Berg, the Four Dome Pavilion designed by Hans Poelzig, and the Messehalle designed by Berg and Moshamer. Several simple temporary pavilions were built to accommodate topical exhibitions.
The Centennial Hall featured a number of exhibitions: the international exhibition of the German Werkbund entitled *Neue Bauen*, the exhibition of the local Technische Hochschule (Technical University), the exhibition of local building co-operatives (Siedlungsgenossenschaft Eigenheim, Eichborngarten G.m.b.H. and Siedlungsgesellschaft Breslau A.G.), the exhibition of the Bauhaus in Dessau showcasing the school’s innovative curriculum presented by its illustrious avant-garde faculty members (Vassily Kandinsky – analytical drawing, Paul Klee – study of form, Joost Schmidt – visual advertising, Oskar Schlemmer – stage design), works by its workshops (murals, weavings, metalwork, woodwork, architecture) as well as paintings and photographs.
The exhibition presented in the Messehalle focused on the design process, new building materials and technologies, new paints and color design, interior finishes, furniture, lighting, interior design, and household equipment. It featured model office interiors and studios for the urban professional (architect, engineer, physician, lawyer) as well as residential interiors, kitchens, dining rooms, bedrooms, living rooms and also small apartments of the Existenzminimum type (40 square meters).
Hans Poelzig’s Four Dome Pavilion featured a topical exhibition devoted to the past and present of the apartment and housing estate as it appeared in various countries (Argentina, Denmark, Great Britain, France, Italy, Austria,

59 Heinrich Lauterbach, single-family house on Werkbund WuWA Exhibition (house no. 35), photograph, 1929. Museum of Architecture in Wrocław

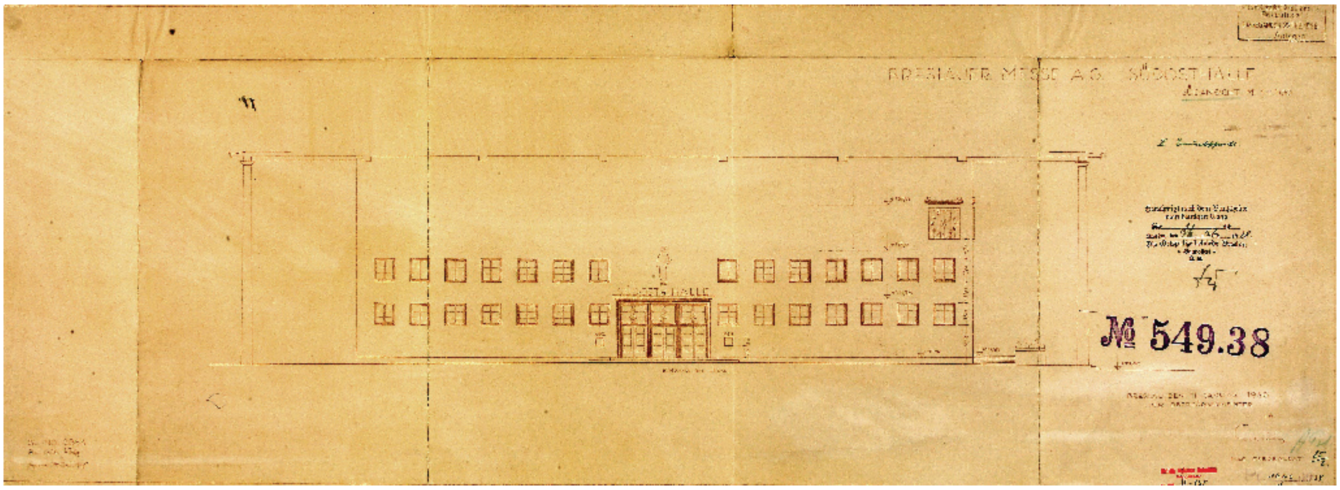
60 Terraced houses on Werkbund WuWA Exhibition, photograph, 1929. Museum of Architecture in Wrocław

Sweden, Switzerland, Poland), and new approaches to landscape architecture in many German cities (including Wrocław) in the context of international trends (Switzerland, Holland, France, Czechoslovakia, Austria, Denmark, United States).
A prominent feature was the purpose-built pavilion called Werkraum des Handwerks (Workshop of Handicrafts) that was erected south-east of the Centennial Hall based on the design of Gustav Wolf. It showcased handcrafted objects (clocks, lighting fixtures, radiators, metalwork) and model workshops representing various trades: weaver, glass engraver, upholsterer, blacksmith, paperhanger, leatherworker, tailor, potter, hairdresser, photographer, painter, joiner, bookbinder, shoemaker, engraver, goldsmith, woodcarver, glassblower, enameler and varnisher.

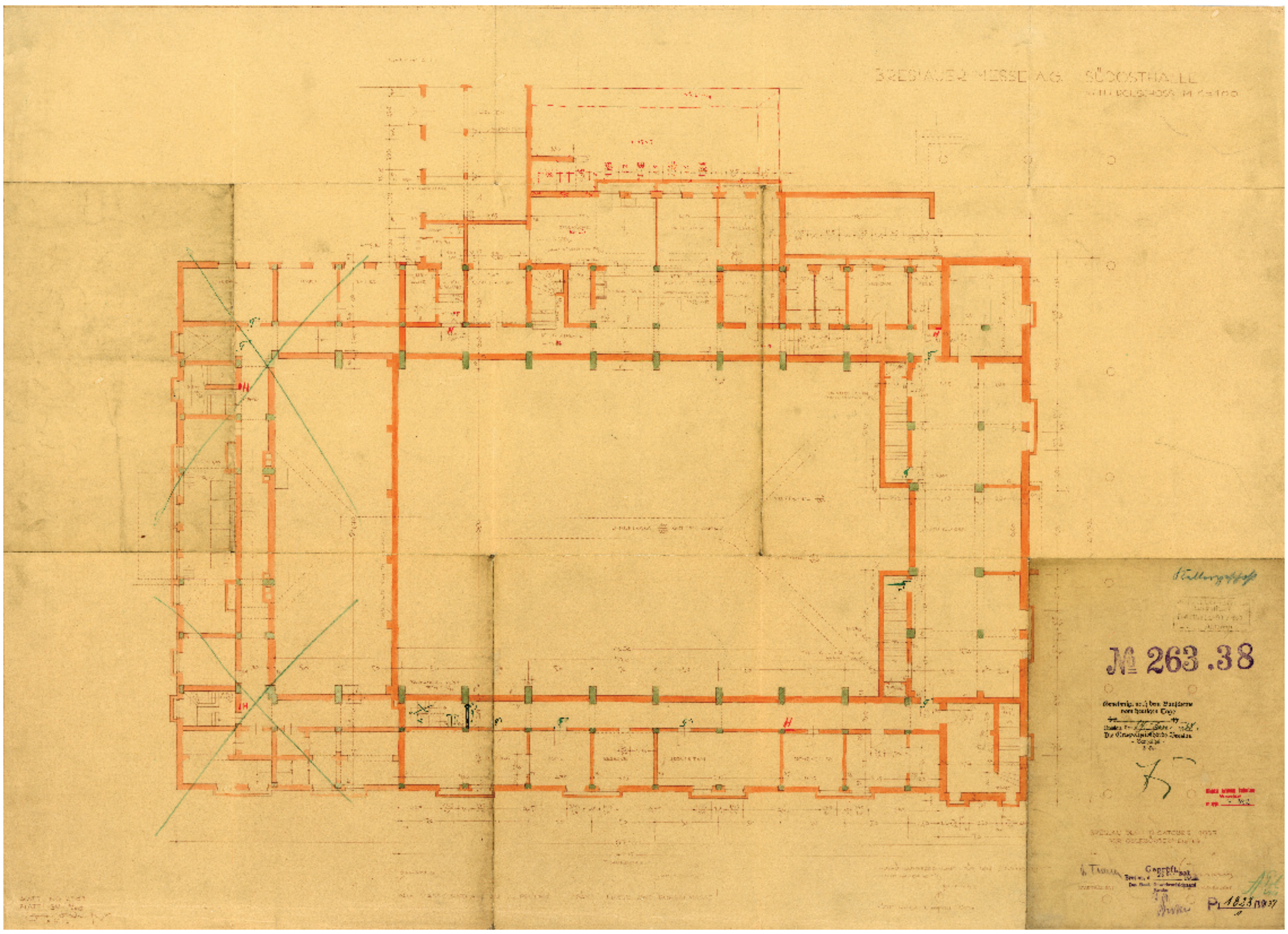
The topical presentation stages outdoors featured: a model shopping street (south-west of the Centennial Hall), means of transportation (purpose-built Verkershalle pavilion north-west of the Centennial Hall), building machinery, topical gardens, glasshouses and gardening equipment north-west of the Centennial Hall. There was also a model farm complete with livestock arranged under the supervision of Fritz Roder in the southern section of the Exhibition Grounds, in today's Wróblewskiego Street (former Grüneicher Weg and Horst Wessel Straße). The eastern section of the Exhibition Grounds featured a model children's playground and school garden, daycare, children's sanatorium (for children with pulmonary problems) and puppet theatre designed by Richard Konwiarz; while the north-eastern section accommodated model weekend homes and the Cemetery Art Exhibition arranged around a historic wooden church (Schrotholzkirche).
In the area surrounding the Exhibition Grounds, between what is today Wróblewskiego, Tramwajowa, Dembowskiego, Zielonego Dębu and Kopernika Streets (formerly known as: Grüneicher Weg, Uechtritzweg, Zimpeler Straße, zur Grünen Eiche, and Finkenweg), an experimental model housing estate was built by the initiative of the German Werkbund in collaboration with the Municipality funded by Breslau Dwelling Estates Joint Stock Company (Siedlungsgesellschaft Breslau A.G.)
Other attractions included a bakery, a café, an outdoor cinema, and a ride-on miniaturized train named the Liliputbahn.

2.3.5. New Exhibition Hall – Hall of States (Staatenhalle) and office space for Breslauer Messe A.G. (1937–1938)

After Max Berg had left Wrocław in 1925, he was succeeded as the Exhibition Grounds' site architect by Richard Konwiarz, the designer of the then largest sports stadium in Europe located near Szczytnicki Park. Konwiarz had already collaborated with Berg on the Centennial Hall, town planning conceptions and skyscraper designs. He had also continued to elaborate on Berg's preliminary designs (the crematorium). He was regarded as Berg's pupil and the influence of Berg is certainly visible in his own work.
In the 1930s, the Exhibition Grounds hosted industrial fairs, sporting tournaments and circus performances. Despite the construction of the new pavilions, any further expansion of the Exhibition Grounds was uncertain due to the lack of space for development as well as transportation problems. In the meantime, the need to expand the Zoological Garden resulted in the appropriation of the southern section of the Exhibition Grounds (undeveloped plot in the west). To compensate, a new plot on the eastern side, freed by the demolition the early-20th-century cycling track, was incorporated into the Exhibition Grounds. In March 1936 Richard Konwiarz designed a new gateway leading to this section of the Exhibition Grounds.
The modernization of the Exhibition Grounds was connected to the plans to organize a large international Spring Fair called "Südost Ausstellung" to promote trade exchange between Germany and its eastern and southern neighbors. The municipal authorities saw an opportunity for the city's economy in the development of trade with Poland and Czechoslovakia.

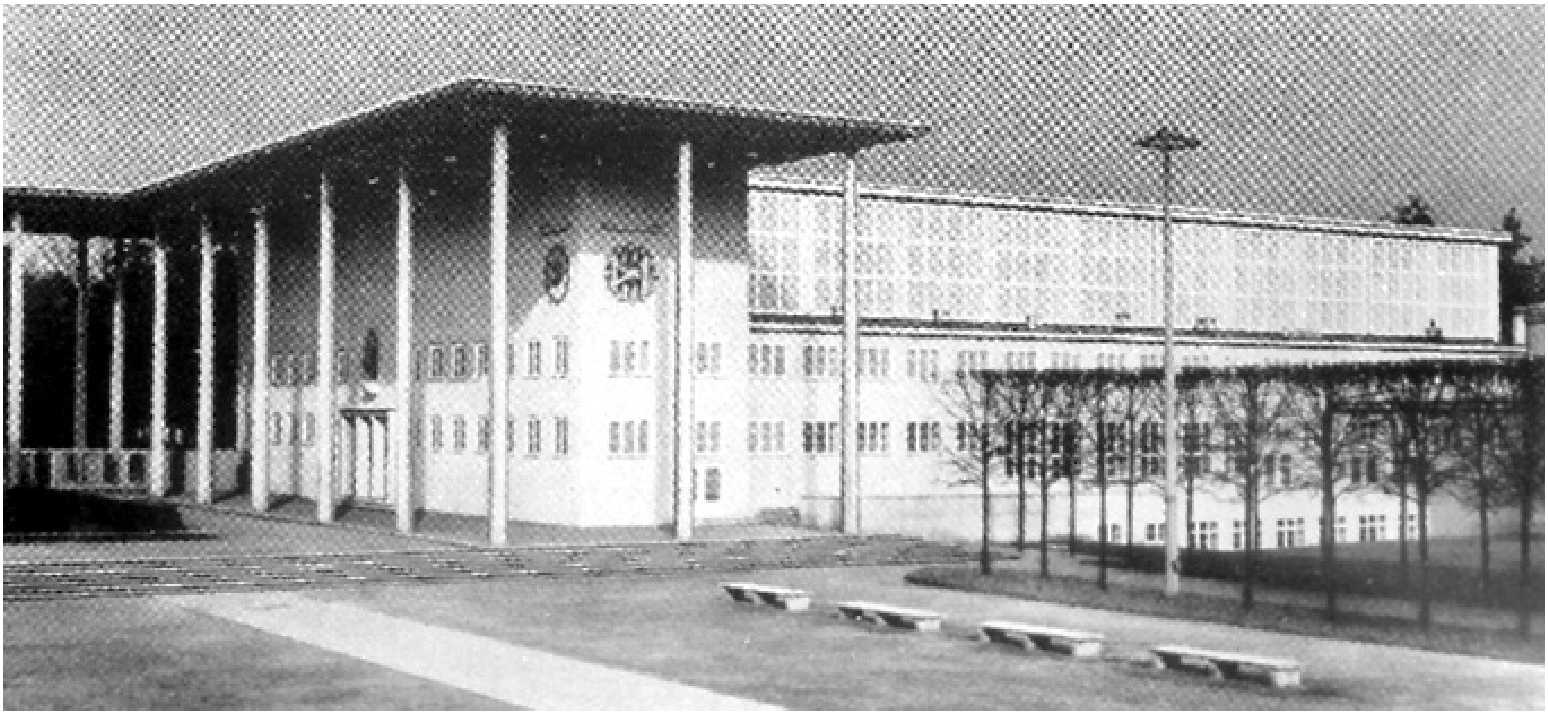


61 Richard Konwiarz, design for the Hall of States (Staatenhalle) for “Breslauer Messe A.G.”, façade.
Museum of Architecture in Wrocław – Building Archive of the City of Wrocław



62 Richard Konwiarz, design for the Hall of States (Staatenhalle) for “Breslauer Messe A.G.”, plan.
Museum of Architecture in Wrocław – Building Archive of the City of Wrocław

63 Richard Konwiarz, Hall of States (Staatenhalle), photograph, 1939. Museum of Architecture in Wrocław



64 Richard Konwiarz, hall of States (Staatenhalle), photograph, 1939. Museum of Architecture in Wrocław

In connection with the plans to organize the International Fair in 1937 in Wrocław, another building was planned to house an exhibition hall and administration offices of Breslauer Messe A.G. The new hall, called "Hall of States" (Staatenhalle), was erected opposite the Messehalle (built in 1925) as part of the complex planned in the early 1920s. Max Taubert's design from the early 1920s could not be finished in 1937 due to financial constraints and political reasons as its style found no favor with the Nazi authorities. The commission was awarded to Richard Konwiarz and assisted by young local architects Harry Weiss and Oscar Zimbal. The plans were ready in October 1937. During the first phase, the wall enclosing the Messehof in the north (which hitherto supported the wooden roof over the entire courtyard) was demolished. Scaffolding was built to secure the roof and the foundations of the future façade were reinforced. Construction work under the supervision of Kurt Conrad, architect of the City Building Deputation, lasted through the Juli 1938. In May 1939 the Südost Ausstellung opened and the newly erected Hall of States hosted presentations from Eastern and Southern Europe: Bulgaria, Yugoslavia, Poland, Romania, Hungary and Turkey. The structure, whose exterior referred to Berg's 1925 Messehalle was laid out on a rectangle measuring 67 x 41.5 meters and was situated north of the courtyard of the Exhibition Grounds. The front of its façade (arranged on the rectangle's shorter side) faced the courtyard. The structure accommodated a cubic hall measuring 25 x 50 meters which was 12-metre-high. In terms of construction, it comprised of reinforced concrete piers supporting the steel trusswork of the roof. The hall was encircled by corridors located on two storeys which provided access to smaller rooms. The corridors of the second floor had open loggias imitating a gallery surrounding the hall. The architect designed the hall to accommodate two functions: fairs and cultural events. The articulation of the front façade referred to that of Berg's Messehalle. Above the entrance was a statue of Demeter holding a globe topped with a statuette of Mercury personifying commerce and fairs. The sculptures were cast in a lightweight metal and done by Fritz Theilmann, professor at the school of ceramics in Bolesławiec (Bunzlau).

65 Hall of States (Staatenhalle) at present the Center of Audiovisual Technology, contemporary photograph, 2009.
Photograph by Waldemar Borski, Museum of Architecture in Wrocław

66 Recovered Territories Exhibition, photograph, 1948. Museum of Architecture in Wrocław

2.4. The People's Hall (Centennial Hall) and the Exhibition Grounds after World War II

The Exhibition Grounds survived World War II, in particular the siege of Wrocław (Festung Breslau) lasting from February to early May 1945, relatively intact. At Centennial Hall, the uppermost level of the terrace roof of the ribbed dome suffered damage and explosions shattered glass in the windows. The Messehalle designed by Max Berg and Ludwig Moshamer in 1924 was destroyed and so was the wooden ceiling of the Main Gateway. The Terrace Restaurant burnt down and only the external walls, central staircase and pillars supporting the roof over the northern terrace survived.

2.4.1. The Exhibition of the Reclaimed Territories

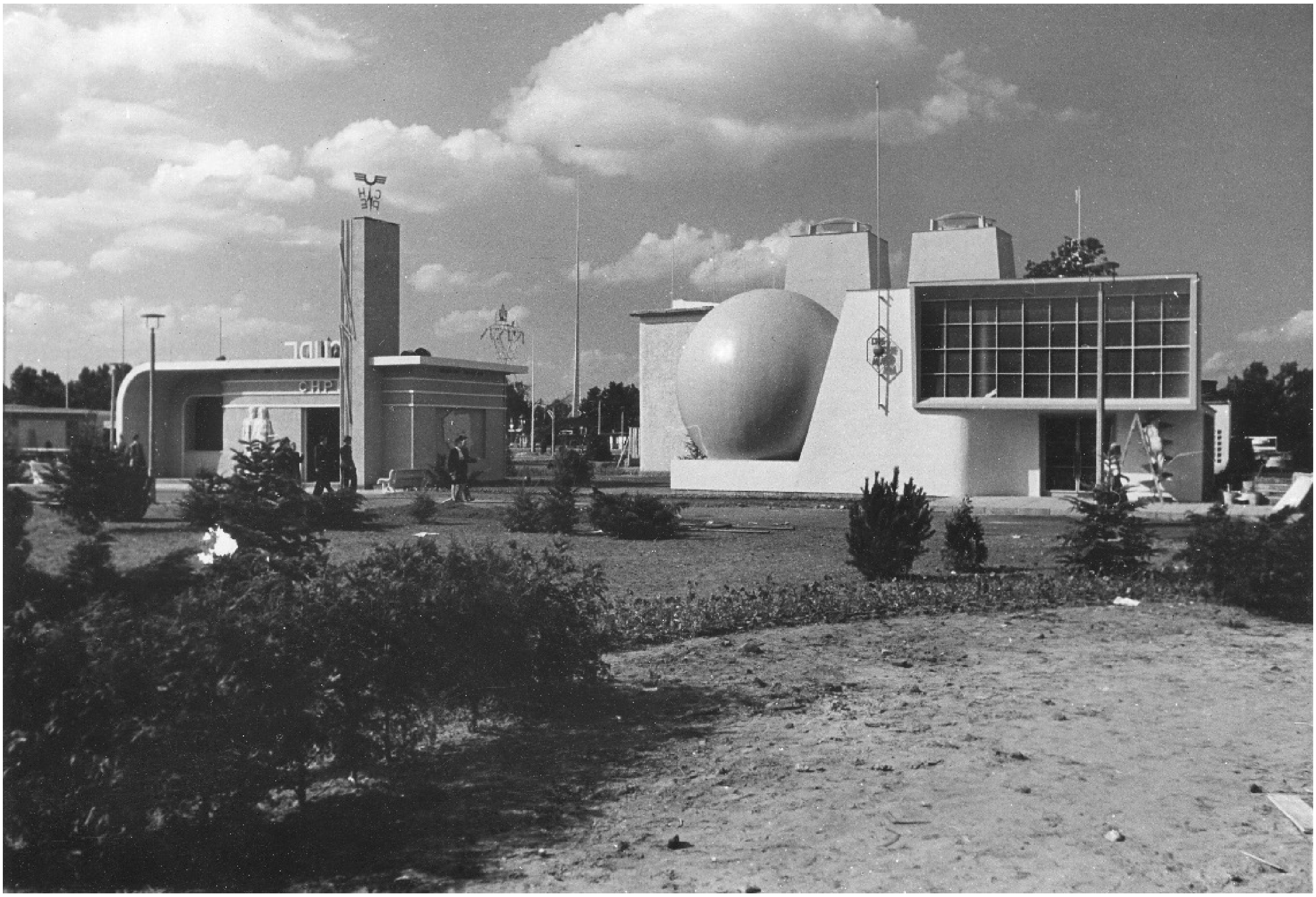
From July 21 to October 31, 1948, the former Exhibition Grounds became the venue of the monumental Exhibition of the Reclaimed Territories. It was staged to showcase Polish achievements along with decisions taken at the Yalta and Potsdam Conference in the formerly German territories that were incorporated in Poland in the aftermath of World War II. Architect Jerzy Hryniewiecki was the exhibition's artistic director. The exhibition's layout was comprised of three sections A, B, and C. Section A, located around the Centennial Hall, housed topical exhibitions. Section B, situated in the southern part of the former Exhibition Grounds (at present the Zoological Garden), accommodated an exposition devoted to social and political issues in postwar Poland, while Section C dealt with the area of the city of Wrocław.

Section A was coordinated by Warsaw architect Mikołaj Kokoz. The remnants of the western brick section of the no-longer existing Messehalle designed by Berg and Moshamer were used to erect the Industrial Pavilion. The principal elements of the exhibition 14 meter-tall "the Bucket Tower" and 35 meter-tall high-voltage tower, a spiral fountain built of prefabricated ceramic elements and railway cars manufactured by Pafawag in Wrocław" were displayed in the courtyard in front of the Centennial Hall according to a design by Warsaw architect Marek Leykam. The most prominent feature in this part of the exhibition was the steel spire aptly named "Iglica" ("needle") rising over 100 meters over the terrain, designed by structural engineer Stanisław Hempel and made by Łabędy Steelworks in Gliwice in Upper Silesia. It was installed in the center of the square in front of the Centennial Hall on July 3, 1948 and has remained there ever since as one of the city's characteristic landmarks. Lining the square's left side, massive white display cases showcased two triptychs painted by Jan Cybis and Jerzy Wolff (referring to Poland's Reclaiming the Territories on the Odra River and rebuilding the country after the war) along with six paintings on glass maintained in a dark color scheme, that were painted by avant-garde artists Henryk Stażewski and Bogdan Urbanowicz, along with Xavery Dunikowski's sculpture of the head of *The Worker* (*Robotnik*). Behind the line of trees, this outdoor art exhibition continued with sculptures of the Silesian Mother, Miner, Steel Worker, and Farmer that were designated for the mountain of St. Anna (Góra św. Anny) and done likewise by Dunikowski. Hans Poelzig's Four Dome Pavilion housed topical expositions devoted to the rebuilding and cultivation of the Reclaimed Territories.

The Centennial Hall (renamed the People's Hall) was used for concerts and congresses accompanying the exhibition. From the 25th to the 28th of August 1948, it hosted the World Congress of Intellectuals attended by Pablo Picasso, Max Frisch, and many other leftist intellectuals. The topical "Man" exhibition featured at the Centennial Hall was to provide evidence to the fact that "for centuries there has been a presence of Poles in the Reclaimed Territories." North of the Centennial Hall, the recreational part of Section A was located, and organized around the Terrace Restaurant with a view of the Pergola and pond, and Szczytnicki Park.

67 Recovered Territories Exhibition, photograph, 1948. Museum of Architecture in Wrocław

68 Recovered Territories Exhibition, exhibition layout. Museum of Architecture in Wrocław, according to the periodical: “Architektura”, 1948



69 Recovered Territories Exhibition, photograph, 1948. Museum of Architecture in Wrocław

Section B was designed by Tadeusz Ptaszycki and Stefan Porębowicz in collaboration with Michał Jassem, Anna Ptaszycka, and Janusz Szablowski. Some 50 temporary pavilions were built to display products of local manufacturers (state-owned companies, cooperatives, and private entrepreneurs). The Exhibition of the Reclaimed Territories was a monumental manifestation of the creative potential of the Polish Art community, particularly architects and urban planners. Many pavilions featured interesting architectural solutions and there were many references to buildings of World Expositions, in particular tower in front of the Polish Pavilion at the World Expo in New York in 1939 (ie. the Bucket Tower – tower of the National Commerce Center) and eccentric structures often featured at World Expos whose function is symbolic rather than utilitarian (ie. Iglica). There were also some analogies to the National Exposition in Poznań in 1929 and other expositions in Poznań that had opened several months earlier. The Exhibition of the Reclaimed Territories in Wrocław showcased some innovative solutions inspired by the avant-garde aesthetic of the interwar period and some eclectic features intended for propaganda purposes rather than artistic ideas. After the exhibition closed on October 31, 1948, the temporary structures were dismantled except for Iglica and the pavilion of the Worker's Society of the Friends of Children. In 1954, the Exhibition of Innovation and Progress was staged in and around the Centennial Hall. In 1957, the southern section of the former Exhibition Grounds was incorporated into the Zoological Garden.

2.5. The Significance of Centennial Hall

2.5.1. Centennial Hall in Wrocław. The continuity of Cultural Landscape against the Backdrop of Changing European Borders and Identities

Centennial Hall is an example of an urban cultural landscape, which was a historical site of technological development and innovation that has eventually become a place of heritage. Despite these complex dynamics taking place in the context of changing economic and political conditions of Central Europe, the cultural landscape that is Centennial Hall has exhibited a remarkable continuity of purpose throughout history.

This unique urban complex was constructed in the early part of the 20th century when today's Polish Wrocław was the German city of Breslau, as a revolutionary architectural development in mass-audience structures intended for multi-functional recreation and cultural purposes. Integral to Centennial Hall were its surroundings located in the middle of one of the oldest municipal parks in Europe, which served not only exhibition and business purposes, but which were planned and used as important health and recreational areas for citizens of German Breslau.

In the aftermath of the border shifts of World War II, German Breslau became Polish Wrocław and like many other prominent landmarks, sites of memory of the German past, Centennial Hall was renamed the People's Hall to separate it from its German provenance. However, despite this symbolic change of name, its purpose as a mass-meeting multi-functional exhibition, recreation and cultural facility remained unchanged and the People's Hall continued to serve the purposes for which its German architect designed it. During this period, the structure was not a subject of significant revalorizations or reconstructions. This changed in the post-1989 democratic history of Poland, and the inscription of Centennial Hall under its original name on the UNESCO World Heritage List. Centennial Hall underwent major revalorization efforts between 2006 and 2012, which made this place of heritage a competitive mass meeting and cultural site in the context of the rapidly development meeting industry in Poland and Europe. The continuity of its original function characterizes this cultural landscape also in this latest period of its existence.

1913–1945

Berg's monumental hall was designed as a multifunctional structure to host exhibitions, concerts, theatrical and opera performances, and sporting events. The revolutionary character of Berg's design consisted of his choice of the material (reinforced concrete), the method of construction (modeled after American construction sites developed for the rapid erection of high-rise buildings in cities like New York and Chicago), the size of the structure, which included the largest dome ever built. Even more important, however, was the social aspect of Berg's and his cohort Hans Poelzig's vision. Berg referred to the Hall as a "Cathedral of Democracy" – an egalitarian space that encouraged shared experiences among people gathered under the dome. In his design for the surrounding the central structure of Centennial Hall, Poelzig sought to offer the citizens of Breslau freely accessible recreational space that would improve the health conditions of those living in overcrowded and often miserable urban conditions. His colonnaded Pergola adjacent to Centennial Hall encloses a large pond, covered and surrounded with lush greenery aimed at recreating the healthy atmosphere of the mountain spa towns were the upper echelons of society could find respite from the oppressive industrial urban climate. Driven as they were in their architectural visions by ideas of social justice and progressive change, Berg and Poelzig figure as important representatives of what is today recognized as the early Modern Movement.

To implement these progressive visions, city officials linked the timing of the opening of Centennial Hall with national celebrations planned for the summer of 1913 of the 100th anniversary of the defeat of Napoleon's army. A large exhibition was opened by the Crown Prince of Germany, that included a broad range of historical and patriotic messages tied to the anniversary of the defeat of Napoleon, as well as thematic exhibits of an educational nature directed to a wide audience. But other elements of the exhibition contained progressive social agenda. At a time when urban planners and architects sought to improve living conditions through the development of healthy green spaces, the Garden Exhibit was designed to inspire planners who could model contemporary designs on exotic and historical gardens, including Japanese, Gothic, Renaissance and Baroque. In addition, an exposition of Cemetery art presented examples of headstones and other memorial pieces that were proposals for mass-production possible in the machine age.

Other exhibitions organized later in the interwar period built on this legacy of innovation and used the extensive – parts of the surrounding park to erect temporary as well as permanent model housing units designed by Modernist architects to inspire innovative solutions to growing housing problems of interwar Europe. Embedded in the cultural landscape of Centennial Hall and the Exhibition Grounds was on the one hand a tradition of innovation in architecture, construction and urban design, on the other hand, a legacy of a political nature, tied as it was at its inception to the dramatic events of the Napoleonic Wars that played out in the politics of the German nation. The duality of this heritage would re-emerge in Centennial Hall's cultural landscape, but in a different geopolitical context in the years following World War II.

1946–1989

Due of its location east of the Oder-Niesse line, the German city of Breslau found itself in Poland as a result of the redrawing of the European map in the dramatic aftermath of World War II. Renamed and resettled by Poles, the city underwent profound processes of Polonization in the postwar era and Centennial Hall, then renamed People's Hall, became a centerpiece of a national program to integrate former German territories into Poland. In 1948 the Communist government in Poland organized the Recovered Territories Exhibition and the Congress of Intellectuals for Peace. These events were meant to promote achievements in jump-starting industry and in successfully integrating the new lands into Poland. Moreover, they were to show the success of the Polish government in garnering international backing for the newly independent country.

Partly because of its austere design, empty of overt or nation-specific patriotic references, new life was surprisingly easily breathed into the highly functionalist structure envisioned by Max Berg. The name change was enough to allow the complex to serve the needs of Poland and the Polish Wroclaw. As one of the few mass meeting and exhibition facilities in Communist Poland, the People's Hall continued to operate as an iconic meeting spot in the city and the country.

1989–2015

In 1989 one-party rule ended in Poland and the period of democratization and the market economy opened ways for urban development. Wroclaw, the fourth largest city in Poland has experienced an unprecedented urban growth characterized in part by high absorption of EU funding and growth in international recognition that has in turn buttressed its attractiveness to foreign investors. Central to Wrocław's economic success was the city strategy marked by the official promotional slogan Wrocław – the Meeting Place, branding that focused on attracting large international events as the engines of the local economy.

The direction of the post-1989 city strategy bears marked similarity to the path chosen by the administrators of German Breslau in the early 20th century who bet the future of the city on the construction of a mass exhibition and meeting complex with the hope of achieving prominence that would drive city development. The city brand, Wrocław – the Meeting Place, drew inspiration from Centennial Hall and placed this iconic meeting place at the center of the new strategy. This prestigious and highly visible mass-meeting venue whose historical significance as a site of architectural and urban innovation was by now officially recognized by turning it into a World Heritage Site, served the city in its search for a new identity and development direction as a symbol on which this strategy could be hinged.

Centennial Hall's central position eventually yielded tangible benefits in the form of financial investments into the structure's much-needed revalorization, which began in 2007. However, even prior, Centennial Hall had already been the site of the first large-scale international events entrusted to the city in the post-Communist era. After the Eucharistic Congress that launched the Pope's pilgrimage through Poland in 1997, events such as the business mass meeting Futurallia 2006 or the European Summit of Regions and Cities in 2005 were held in Centennial Hall and served as defining moments in the city's development. The major part of the revalorization process was concluded with the launching of the European Culture Congress in September 2011, which took place in Centennial Hall and the surrounding that launched the Polish Presidency in the European Union. Centennial Hall also plays a crucial role in the celebrations and events of the 2016 European Culture Capital.

Parallel to the growing recognition gained as an outcome of these high-profile international undertakings, Centennial Hall and Wrocław also garnered international prominence through the inscription of Centennial Hall on the list of protected heritage sites of UNESCO in 2006. This recognition confirmed the city's choice of Centennial Hall as the linchpin of its strategy. In the context of European expansion and the accompanying effort to erase past divisions resulting from more than a half-century of upheavals, the inscription on the heritage list served to confirm Wroclaw's commitment to being opened to the city's pre-WWII heritage. It is important to highlight that the structure is inscribed on the World Heritage List under its original name – Hala Stulecia (Centennial Hall/Jahrhunderthalle), not its post-WWII Polish named – Hala Ludowa (People's Hall/Volkshalle). As a result, in the promotional efforts following the inscription, Centennial Hall and city managers sought to reinvigorate the Hall to compete as a vital International Conference Center under the original name Centennial Hall and not its Polish equivalent Hala Stulecia. This move provoked debates on a local and national scale about the city's German past and limits of how that past figures in the present and future of the city and the country, underscoring the significance of Centennial Hall as a cultural landscape.

Since its grand opening in 1913, Centennial Hall has dominated the cultural and political landscapes of first German Breslau and later Polish Wrocław. A masterpiece of architecture and an achievement in modern building technology, it was added to UNESCO World Heritage List as a world cultural treasure that testifies to the genius, determination and courage of its creators. At the same time, the meaning of the site is tied to its original innovative function – a mass cultural complex and democratic meeting place – which has been retained since the Hall's inception despite the changing geopolitical circumstances on the European continent.

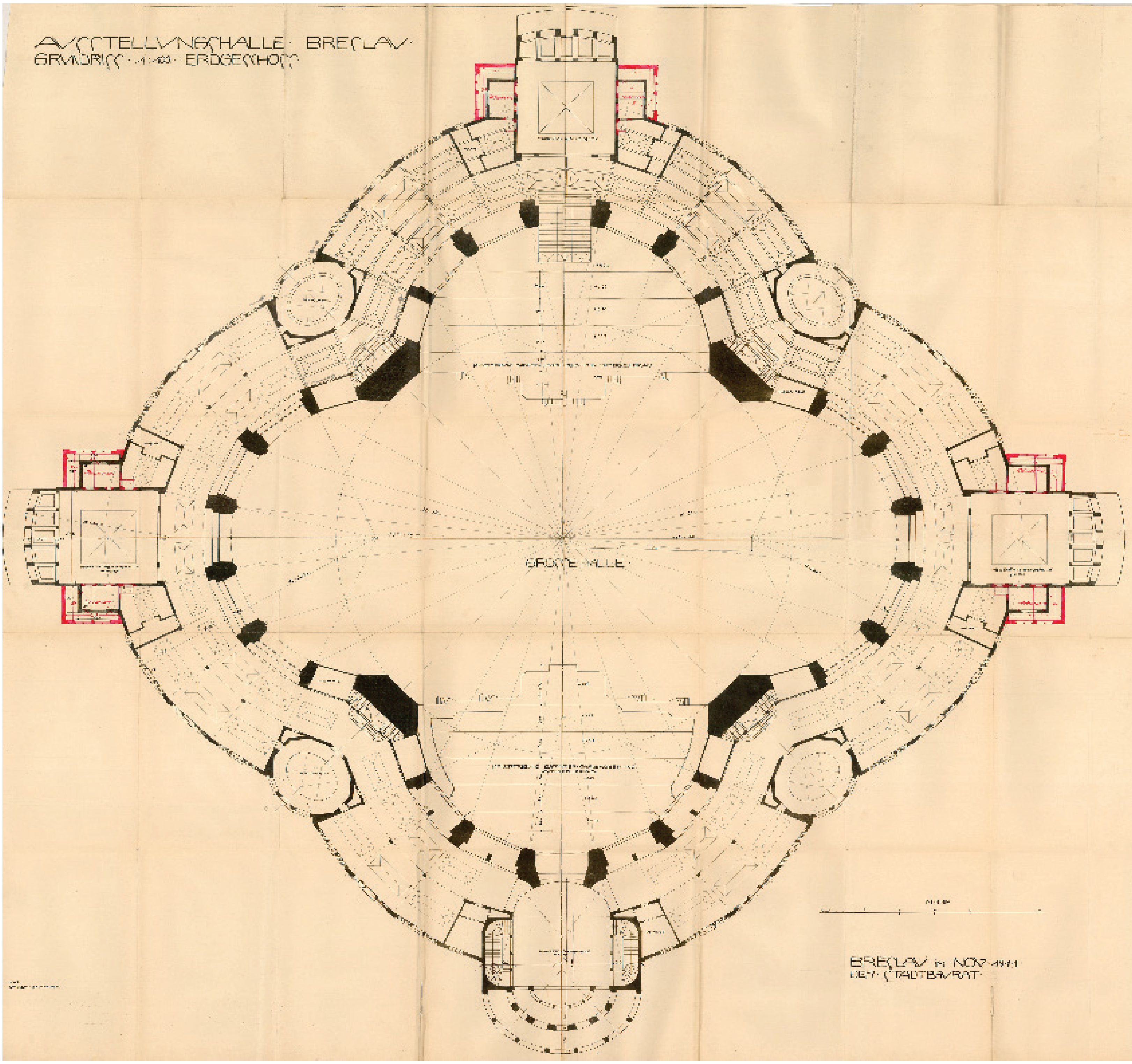
2.5.2. Description of the Centennial Hall

The Centennial Hall was erected in the north-eastern part of the city in the area of Szczytnicki Park, on the site of the former horserace track, as part of the Exhibition Grounds complex adjoining the Zoological Garden which was established in the 1860's. It was the principal and central feature of the Exhibition Grounds designed by Max Berg and Hans Poelzig in 1912–1913. Its principal axes of symmetry defined the composition of the entire complex. The Centennial Hall has been laid out on a symmetrical quatrefoil (tetrakonchos) plan with a circular central space into which four semicircular apses forming four "lobes" open. The quatrefoil unified space is surrounded by a repetition of its outline – its width approximate to the radius of the apses. Like most churches, the Centennial Hall is orientated, meaning that the stage is situated in its eastern section. The entrances to the Centennial Hall are situated on two perpendicular axes (north-south and east-west). The main entrance is preceded by a Doric colonnade laid out on a section of circle, covered with a coffered ceiling. The collonade and Imperial Hall over the are the only elements of the building referencing historical forms, that is Prussian Neo-Classicism ca. 1800.

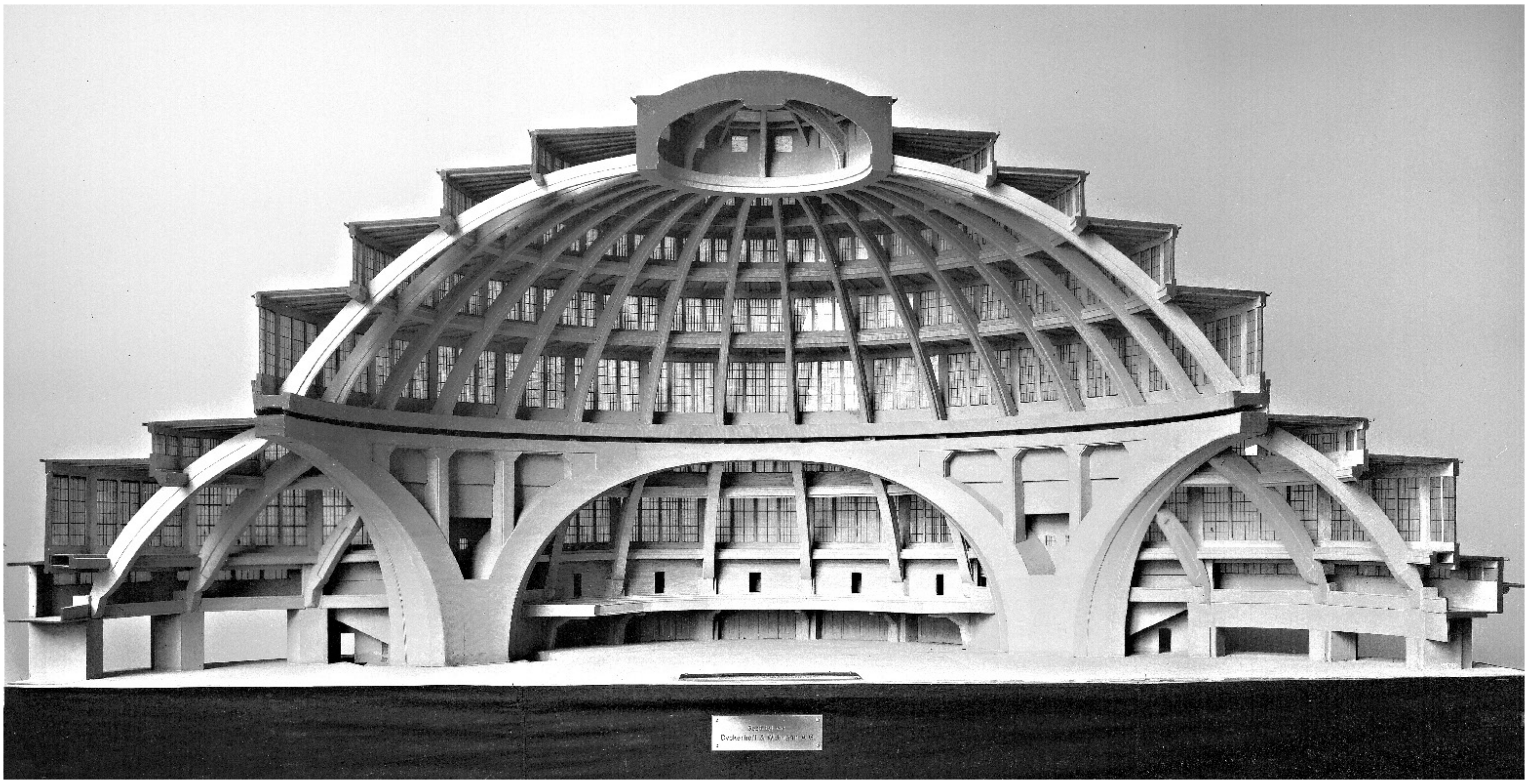
The floor plan of the Centennial Hall is based on the module equal to the diameter of the dome (and of the quatrefoil's inner circle which corresponds to the dome). The size of the other elements has been determined by the system of overlapping equilateral triangles circumscribed about the circle corresponding to the base of the dome and defining the arrangement of six-point stars and thus determining the proportions of the layout approximate the "golden rule". The same principle seems to define Centennial Hall's architecture. It is based on the module where the diameter of the dome's base is equal to and at the same time the arm of the equilateral triangle which has been multiplied to form the system of a six-point star. The result is a building of harmonious volumes whose monumentality is not overpowering.

The Centennial Hall's reinforced-concrete structure comprises of two self-supporting complementary structural systems: the 19-metre-high cylindrical base (span of 41.2 metres, height of 16.7 metres), consisting of four massive arcades (acting as reduced pendentives) opening into the apses and topped with a massive ring which has been divided up into sections for structural reasons; and the 23-metre-high ribbed dome placed on a drum. The dome, of a slightly flattened shape, consists of 32 ribs resting on a stretched ring with a diameter of 65 metres which is held together by a compressed ring with a diameter of 14.4 metres. The ribs are stabilized by means of three concentric rings arranged at regular intervals and at different heights; these form the base of the four tiers of glazed walls in a terraced arrangement covered by a ceiling. The dome is topped with a lantern composed of four stiff frames and has the form of a small dome of steel and glass with side windows (invisible from the inside) and a glazed ceiling built of large glass blocks. Light can enter the interior directly through the roof and the side windows. A similar arrangement of windows has been used above the four arcades, with the tiers of windows placed between the concentric rings holding the ribs of the dome together to support the ceiling above each respective level. The two structural systems (dome and base) are connected by means of 32 brass bearings. In order to counteract the "twisting" of the structure, Berg devised a system of 24 buttresses – the ribs of the four apses which also relieve the structure of the dome. Each of the four monumental arches holds a load of about 1200 tons.

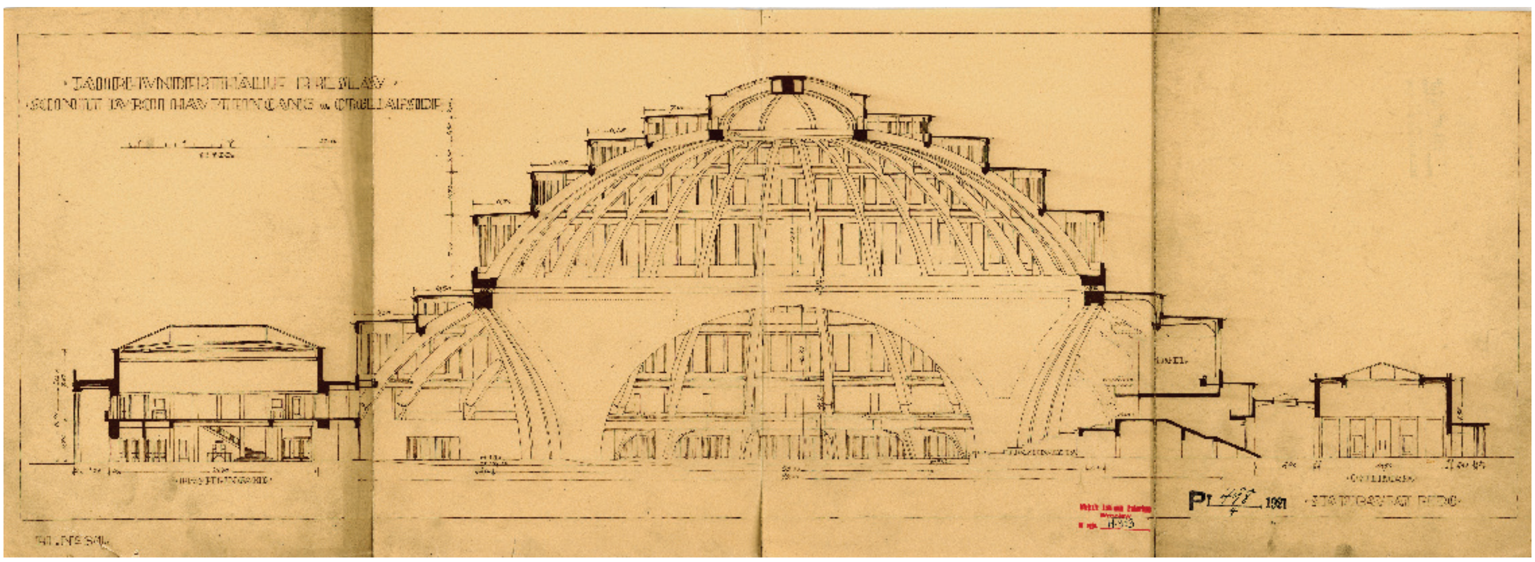
70 Bird's eye view of the Exhibition Grounds, 2012. Photograph by Stanisław Klimek



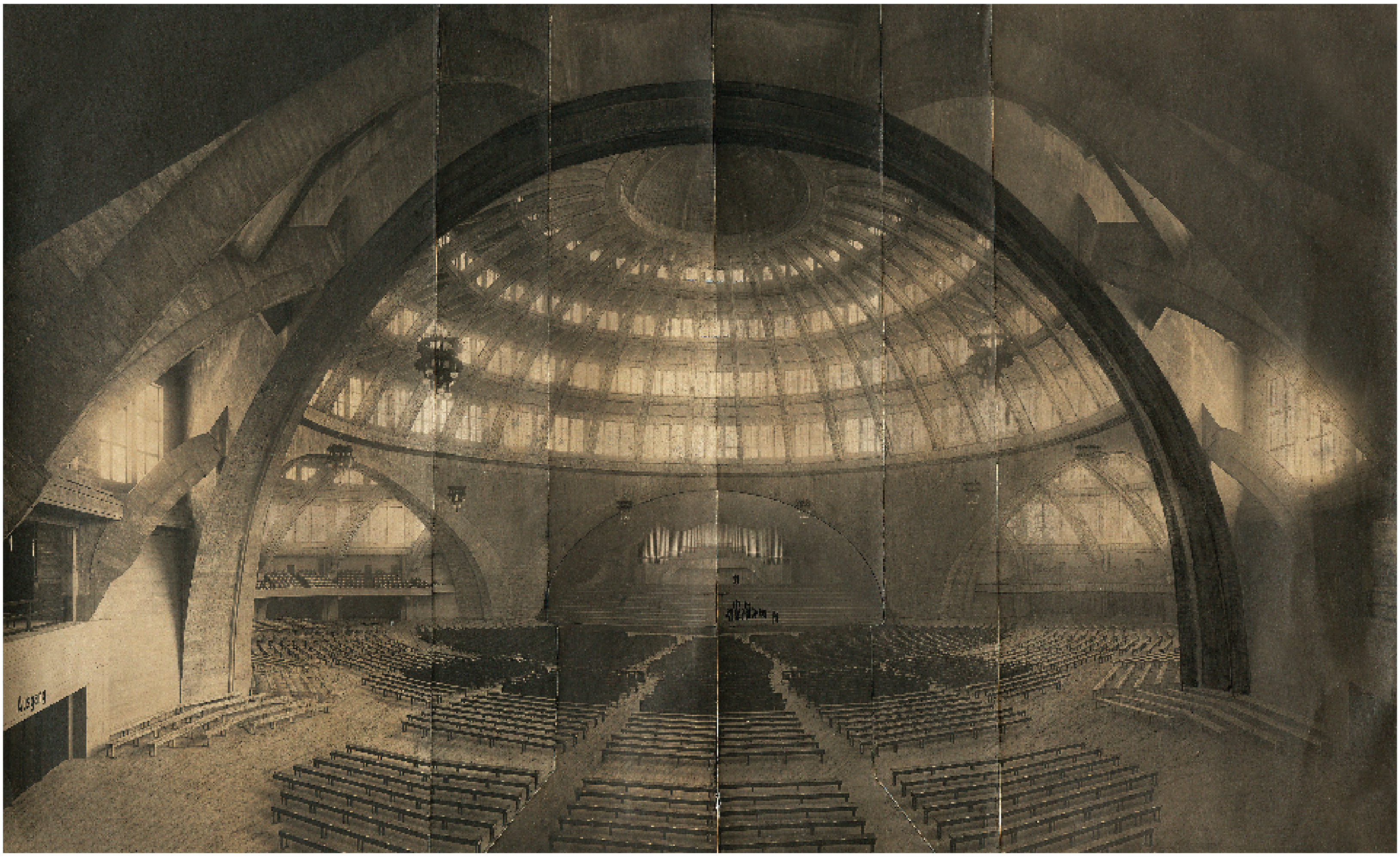
71 Max Berg, Centennial Hall, design with indicated changes in side entrances, November 1911.
Museum of Architecture in Wrocław – Building Archive of the City of Wrocław



72 Model of Centennial Hall made in the 1930's. Deutsches Museum in Munich



73 Maks Berg, Centennial Hall, design, section, 1921. Museum of Architecture in Wrocław – Building Archive of the City of Wrocław



74 Centennial Hall, interior, photograph, 1913. Deutsches Museum in Munich, archive, legacy of Max Berg

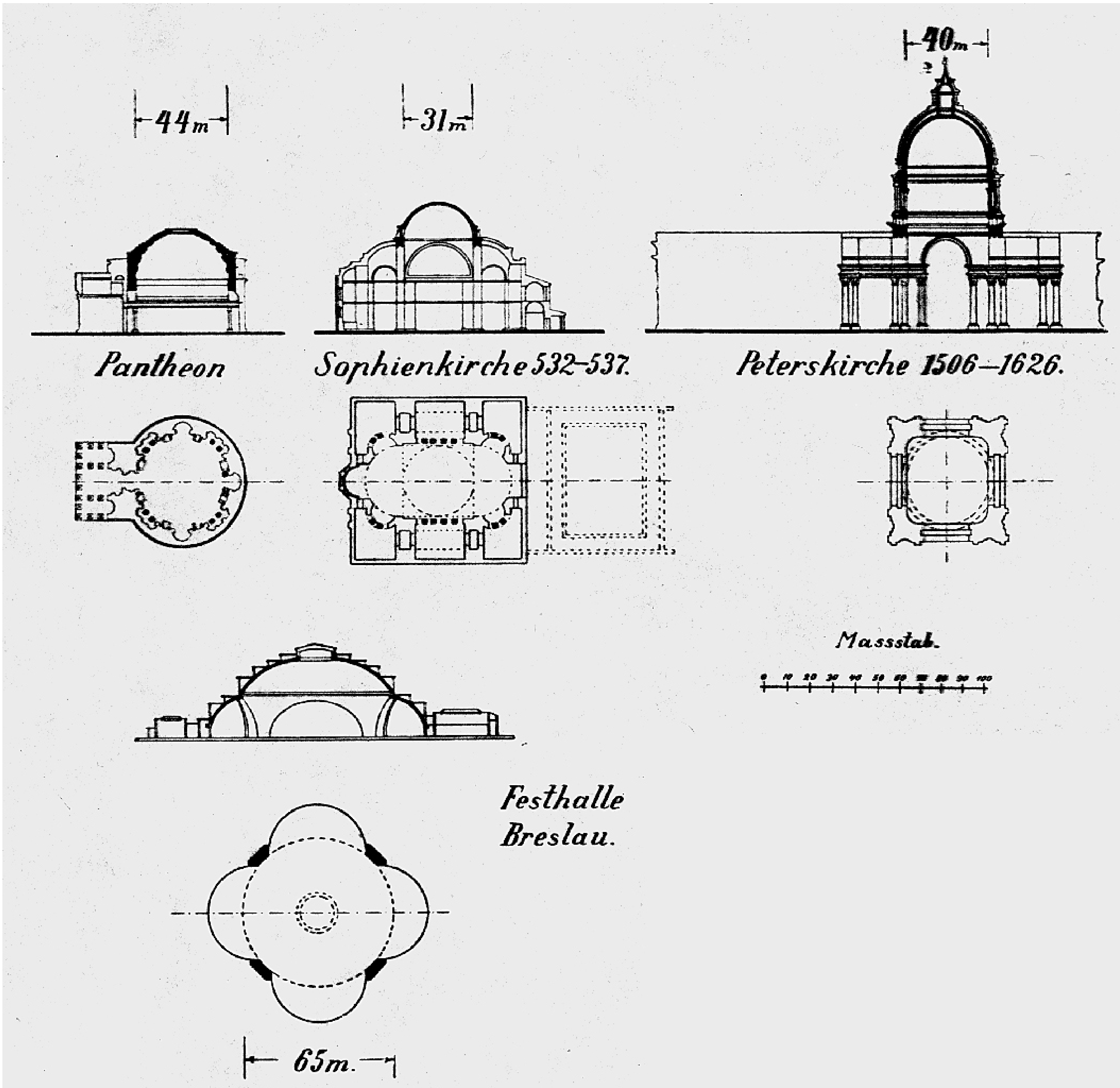
2.5.3. The Centennial Hall and architectural tradition

Designing the Centennial Hall, Berg referred to Antiquity and the Pantheon, the domed Byzantine churches and particularly the exquisite Hagia Sophia (with its dome of comparable scale), and the centrally planned Renaissance structures. There are analogies to the designs of Bramante and Michelangelo for St Peter's Basilica in Rome. Certain elements of Centennial Hall's floor plan resemble the church of Santa Maria della Consolazione at Todi and the Early-Christian San Lorenzo in Milan. Berg's design for the Centennial Hall reflected his search for harmony of the "grand style" that would define a new approach to architecture which rejected both 19th century architecture and the ephemeral Art Nouveau while inspiring the emerging avant-garde. The search for simplicity and the "truth of the material" was the order of the day, advocated by both the proponents of Neo-Biedermeier and those rejecting Historicism. Berg pursued the utopian "absolute form" based on the principle of proportions and in his quest he referred to Classical Antiquity and architecture of other historical periods and traditions. The stepped contour of the Centennial Hall's dome is reminiscent of the architecture of ancient Egypt and Mexico. The building's silhouette alludes to the iconography of the Tower of Babel. Berg was not isolated in his pursuits: the first decade of the 20th century saw heated debates on art and the emergence of new, revolutionary ideas, exemplified by Hermann Finsterlin's "Nine architectural types" presented in *Das Stilspiel*.

In the Berg Archive at the Deutsches Museum in Munich there is an interesting conception drawing – a study of Centennial Hall's proportions elucidated by means of geometric figures superimposed onto its cross section. The drawing proves that Berg's design was based on numerical as well as geometrical proportions. The principal ratios calculated from the drawing show that the numerical values basically conform to the golden section. Max Berg attached great weight to noble proportions. In the 1930s he wrote a study devoted to proportions and art. Presumably, the drawing was made in connection with his text which was probably intended to present the author's position on Theodor Fischer's work on the subject. 19th-century Germany studies on proportions were advanced by Viollet-le-Duc's followers and proponents of Neo-Gothics Friedrich Hoffstadt and August Reichensperger, among others, who studied Mediaeval design methods: quadratura and triangulation. In the 1890s a group Dutch architects: Jan Hessel Groot, Karel Petrus de Bazel, Eduard Cuypers, Petrus Berlage, Johannes Ludovicus and Mattheus Lauweriks, focused on the application of geometrical principles and proportions in architectural design. Their approach was based on mysticism, theosophy, and social utopias. Lecturing in Germany in 1904 and 1907, Berlage referred to the Amsterdam Stock Exchange to elaborate on its underlying geometric proportions based on the "Egyptian triangle". In Germany, Berlage's ideas were promoted by Lauweriks who was invited by Peter Behrens in 1907 to teach at the Academy of Crafts in Düsseldorf.

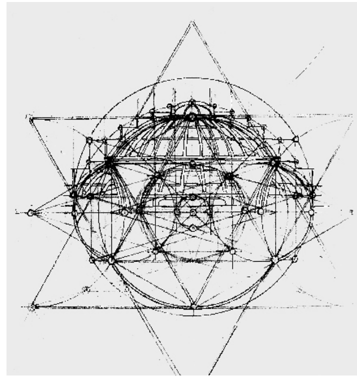
Theodor Fischer's approach to geometry and proportions differed from his Dutch counterparts because his goal was to "imitate the nature of plants". He published his ideas, which mainly referred to the work of his teacher August Thiersch, in two articles in 1934. The articles provoked many architects, including Max Berg, to respond. Berg's opinion is illustrated by the following passage: "I can still remember the thrill I had experienced as a student listening to lectures explaining the forms of Classical Antiquity. Looking at the models of Greek architectural orders, one could acquire a certain feel for art even if one had no special talent. During my art history classes, I saw that the composition of the most beautiful masterpieces of paintings could be explained by referring to the principles of quadratura and triangulation." Drawing from the theories of Theodor Fischer and the aforementioned Dutch architects, Berg insisted that proportions reflect the harmony of nature and spirit and had a fundamental significance for culture, society and man, finding spiritual fulfilment in civilization.

Initially, like Hugo Häring, Berg was against geometrical proportions. Arguing with Fischer, he maintained that – as opposed to "organic design" – geometry blocked creative invention and excluded "spirituality" and believed that it was a mistake to identify proportions with Classicism hence Gothic architecture, for example, had



75 Comparison drawing: Domes of the Pantheon in Rome, Hagia Sophia in Constantinople, St. Peter's Basilica in Rome, and the Centennial Hall.
Günther Trauer, Willy Gehler, *Die Jahrhunderthalle in Breslau*, Berlin 1914

also been formulated by sublime systems of proportions. He became convinced that a good artist is capable of discovering the right proportions intuitively and that "geometric science of harmony could become to architecture what harmony is to music". Berg regarded proportions as presenting no threat to "organic design" since the "anatomy of forms" – as he referred to proportions – did not tell anything about the "spirit" as it was not its objective. "It could be said that stone has no soul either and thus a work executed in stone is soulless." In this context, he referred to his Wrocław masterpiece: "I have examined the proportions of the floor plan and cross sections of my Centennial Hall, I was stunned by the precision of various proportions underlying the structure, my amazement was no smaller than that inspired by the analysis of Pretorius' drawing because, like most architects, I started to design by making a sketch using no circle nor set square. Both the floor plan and cross sections have been executed according to the eye's measure, that is imprecise, and yet they have revealed quadraturas and triangulations. This fact has strengthened my belief that the systems of proportions underlying Classical buildings had originated in the same way." To Berg, proportions assumed a nature close to the esoteric science of Pythagoras and the proponents of neo-Pythagoreanism. He wrote "All these mathematical revelations are magical symbols of truth and beauty in connection with faith and religion. [...] The magical world of symbols, which lives on in Mediaeval cathedrals, was adapted by Christianity through the mystical and esoteric Greek and Egyptian tradition."



76 Maks Berg, study of proportion of the Centennial Hall, ca. 1930. Deutsches Museum in Munich, archive, legacy of Max Berg

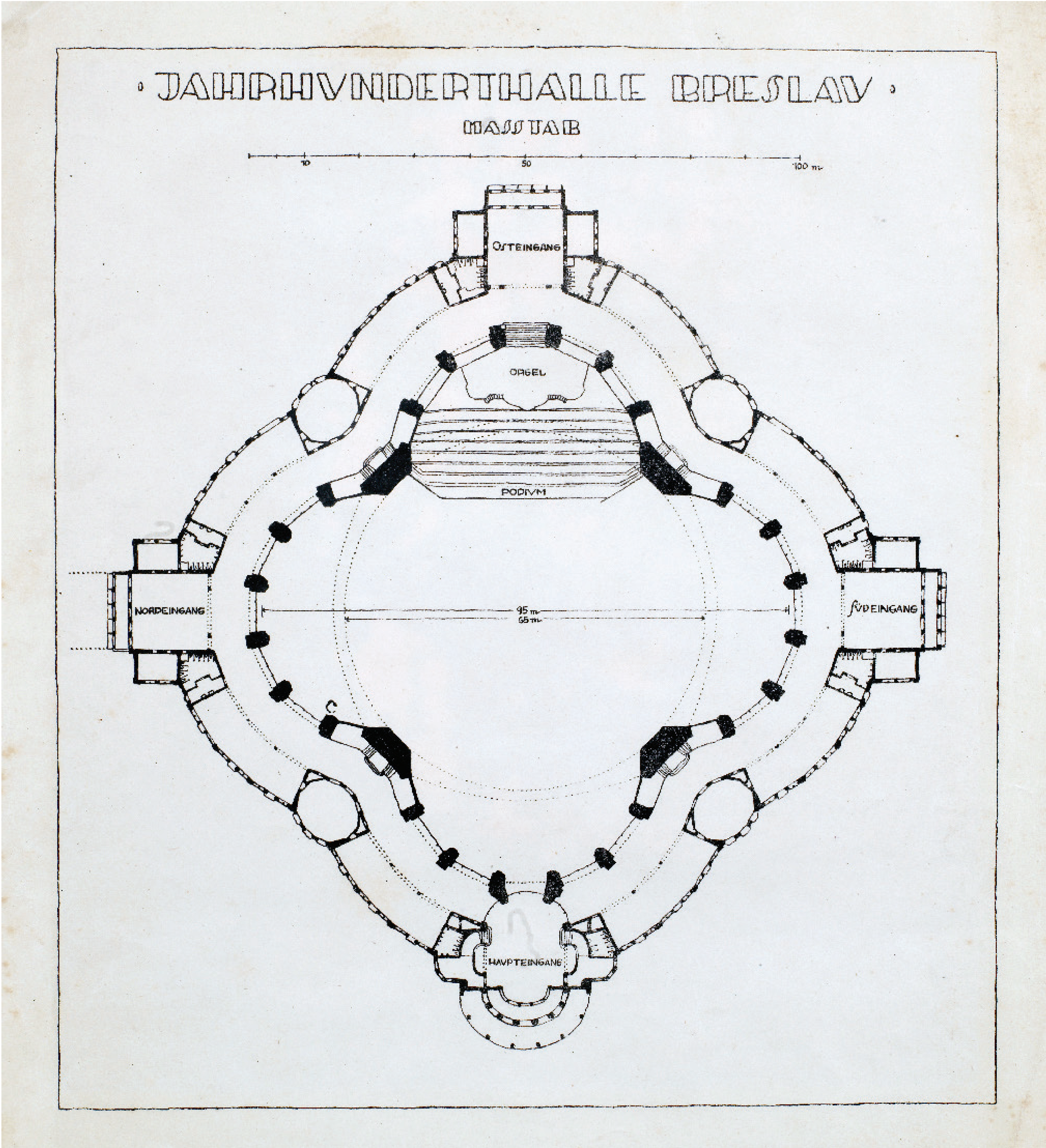
Berg's approach to architectural design as outlined by a geometric module and his search for ideal proportions also point to his connection with the aforementioned group of Dutch architects, Lauweriks in particular, and also with the mysticism of Schoenmakers. According to Lauweriks, architecture reflects the mathematical model of the cosmic order and in turn effects the order of human society. The equilateral triangle employed by Berg symbolizes the alchemical number "Trias" and thus points to the architect's interest in mysticism and theosophy. This is confirmed in the aforementioned letter to Sesselberg, in which Berg refers to the spiritual transformation he underwent during the period when he worked on the Centennial Hall, and in his treaty on proportions contained within the following passage "Employing proportions is not about either-or, yes-or-no; it is about the equilibrium between the spirit and the soul. [...] Great art originates from the faith in one's inner mission; it is a tool guided by a supreme force." Once a proponent of rationalism and positivism, he turns to theosophy and his new convictions get strengthened under the influence of his wartime experience and his encounter with the Silesian mystic Karl Welkisch. Berg repeats after Emanuel Swedeborg "The whole cosmic and earthly existence is analogous to the existence and history of the spiritual world. The Earthly wisdom refers to the pretended world. Each work of art is, to a higher or lesser degree, created to animate within ourselves the beauty of the spiritual world."

In Berg's fascination with noble proportions, the golden section, symmetry, simple geometrical figures and numerology are indicative of his pursuit of permanent principles in both the aesthetic and ethical sense. Berg reaches to Plato's idealist philosophy. According to Plato, regarded as beautiful are the things that assume a rectangular or circular form thanks to a compass, rope and line. The Centennial Hall's arrangement as a domed building laid out on a quatrefoil referred to the architect's platonic view of symmetry as a "cosmic, eternal and sacred principle of nature". Despite the materiality of its principal building material (reinforced concrete), the Centennial Hall falls within the aesthetic system defined by Günther Bandmann. The materials have been subjected to artistic form carrying certain ideas related to the fact that the building was addressed to a new type of user. From this perspective, concrete is an ideal material – simple and streamlined. The specific character of the material has been combined with the architectural form of a domed structure whose tradition harks back to Antiquity. Although in the course of centuries this building type has lost its divine references. Berg has deliberately returned to its original and universal meaning echoing Plato's philosophy. The dome of the Centennial Hall reflects the harmony of cosmic order and happiness of Heavenly Jerusalem. The monument was constructed

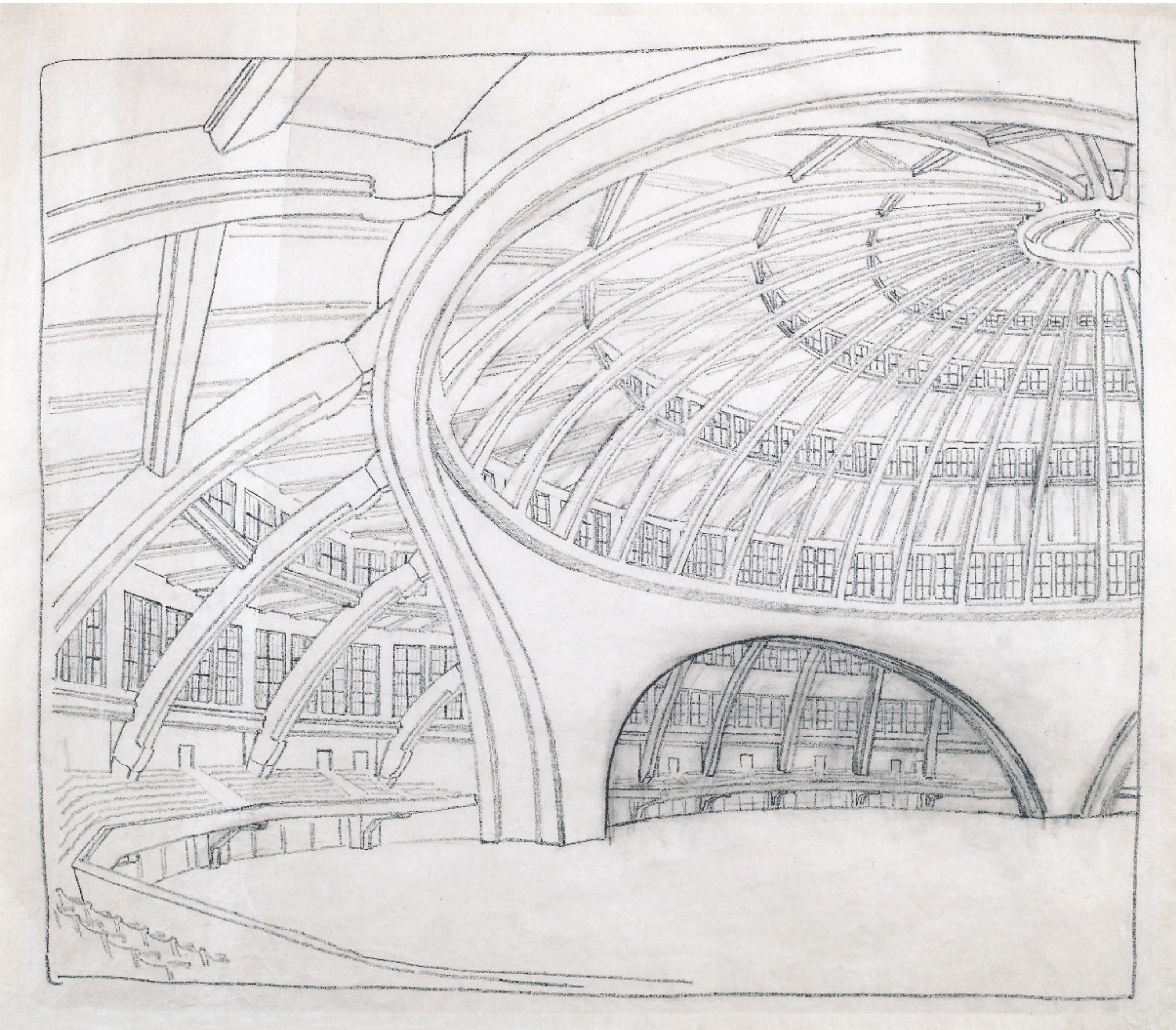
– like a church – to echo the structure of the universe and become a medium for carrying sacred ideas. This is not a realistic rendering but an image "structural in the sense that it re-creates the universe's inner and mathematical structure". The Centennial Hall's circular dome and its base constructed of the four arcades supported by square pillars correspond to the primeval forms of the circle and square. These symbols express divine perfection in two aspects. "The circle and square, whose points are equally distanced from the center which has neither a beginning nor an end, represent the boundless Oneness of God, His Infinity and Perfection, while the square and the cube, which are static forms, are representations of Divine Permanence and Eternity. On the lower level, in the cosmological order, these two symbols encompass the whole created by Nature in its essence and dynamics." The building's sacred aspect is emphasised by its oriented arrangement instructing the placement of entrances and in particular of the organ and the stage: located in the eastern apse they clearly allude to the High Altarpiece, a symbol of the "centre of the universe" and "axes of the universe". Berg was greatly concerned with the Hall's intended function of a concert hall and theatre. Bruno Taut once observed that "both music and architecture are abstract and the relationship between them is the purest harmony". Earlier Johann Wolfgang von Goethe called architecture a "silent art of tones" – ("Verstummte Tonkunst".) These statements relate to the tradition of Pythagoreanism and Platonism on harmony. In *Timaeus* Plato states that universal harmony expresses the equilibrium of musical and architectural proportions. The principles underlying the cosmic order are revealed through numbers, musical harmony and architectural proportions. At the Goetheneum at Dornach designed by Rudolf Steiner, this world of sounds remains inaudible for the "physical" ear as it belongs to the realm of "superior reality". Music and musical harmony have inspired many a modern architect to study numerical proportions and to create spaces in which sound and architecture merge in immanent unity. In this pursuit they have been supported by musicians, for example by the composer Alexander Scriabin who designed a domed "multimedia temple" in 1914. Inspired by Plato's concept of numbers and brought up in a musical tradition, Le Corbusier developed *Le Modulor*, his own system of proportion based on the golden section and on the male human figure. Max Berg intuitively employed a similar system of proportion in his design for the Centennial Hall.

Like Berlage's theories, the individualist and romantic themes in Berg's views on art reflect his fascination with Gothic architecture. To Berg, who studied under Karl Schäfer, a leading advocate of Neo-Gothic architecture in 19th-century Germany. Gothic means the "Paradise Lost" the last grand style. Paraphrasing Ernest Cassirer words "Modern architect often looks up to the mystic eras, "divine" or "heroic", like to the paradise lost", Berg appreciates Gothic architecture for its approach to space. In a letter written towards the end of his life, Berg explained the ideas and concepts underlying the architecture of the Centennial Hall: "I wanted to give the structure, built of a modern material, an appropriate spatial form, a shape imbued with the Gothic spirit." Earlier, in an article published in the "Deutsche Bauzeitung", he wrote: "Departing from the usual arrangement of the dome supported by four arches over a square, set in perpendicular planes [...] in this case, I have placed the dome over a cylinder. [...] Thus, the monumental arches have become three-dimensional curves. In order to counteract the structure's tendency to twist off towards the outside, I have employed large and strong buttresses inside the apses to transfer the load to the foundation. The function of these buttresses is the same as with Gothic buttresses. They support the four monumental arcades that carry the load of the dome and, in terms of construction stability, to balance out forces between the load-carrying arches and the buttresses was the greatest structural challenge."

Presenting his design in a number of articles written in connection with the Centennial Exhibition, Berg emphasized functionalism as its underlying principle. According to the doctrine of Jean Nicolas Louis Durand "which saw the fundamental criteria of perfection in architecture in its being useful to society and profitable



77 Centennial Hall, plan, ca. 1913. Leibniz Institute for Research on Society and Space in Erkner near Berlin



78 Max Berg, Centennial Hall, interior design, 1911. Leibniz Institute for Research on Society and Space in Erkner near Berlin

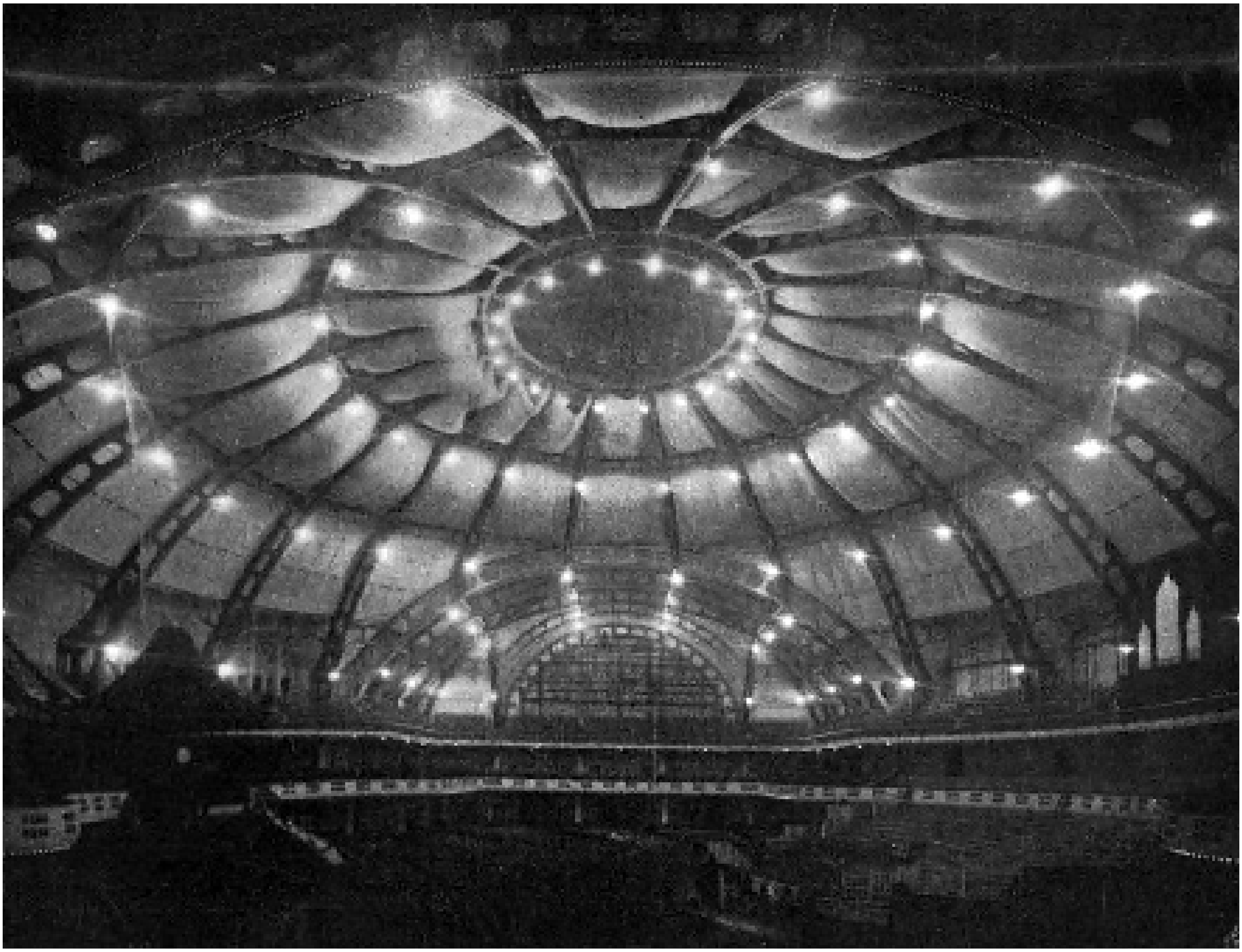
in construction", Berg's approach was based on economics and rationality of design. According to the original conception, the building was to serve two principal functions; as an exhibition venue and as a public assembly hall. According to the objectives first specified by the City Executive Board, the Centennial Hall was to accommodate the Centennial Exhibition's principal event – the Historical Exhibition. The decision to have a separate pavilion built for the Historical Exhibition (after Poelzig's design) was made as late as February 1912 that is when the work on the Centennial Hall had already reached an advanced stage. Of course, Berg wanted to solve the problem of reconciling the two principal functions in a rational and economic manner but in a sense these appeared mutually exclusive as he himself stated "Public assemblies require a centrally-planned space while an elongated layout is more suited to exhibitions. In Frankfurt-am-Main a compromise solution was employed because of the same program: the Ceremonial Hall plan combined the features of an elongated and central layout [...] However, I have opted for a centrally-planned space, more suited to public assemblies: a circle with four apses, as the most appropriate layout for the aforementioned purposes. [...] Exhibitions require plenty of light which is not essential for assemblies. Full overhead illumination, which opens the space upwards, is inappropriate and distracting. In Frankfurt the glazed dome is the principal source of illumination. This arrangement may be considered appropriate when there are inner galleries and the aim is to accommodate the largest possible number of people. However, galleries take up much light making a large part of the floor surface useless. Notwithstanding the lantern, which in the Centennial Hall is employed to hold the structure together tectonically rather then to illuminate the interior. Light does not enter from above but through the sides of the structure's upper section. In order to let in as much light as possible, the walls have been filled with windows." Elsewhere, referring to the Centennial Hall's exterior, Berg observed that "the gradation (Staffelung) of the dome has resulted from its having been divided into two systems: the supporting rib structure and the glazed rings of windows (Fensterringen) with ceilings. [...] This has given the hall its characteristic and symbolic silhouette which currently appears on postal stamps as a symbol of Breslau in the same way as the Mediaeval spire of the Town Hall was featured earlier."

Robert Breuer, a contemporary critic from Berlin, having failed to grasp Berg's idea, criticized the Centennial Hall's architecture as insufficiently monumental in relation to its monumental interior. He did not notice that it reflected Berg's approach to designing the building "from the inside out" and that the walls were "dematerialized" and replaced with glazing intentionally. Berg's contemporaries were probably more receptive to the massive concrete hall built in 1913 after Wilhelm Kreis' design for the exposition in Leipzig which reflected the Wilhelmian proclivity for monuments of aggressive, powerful character.

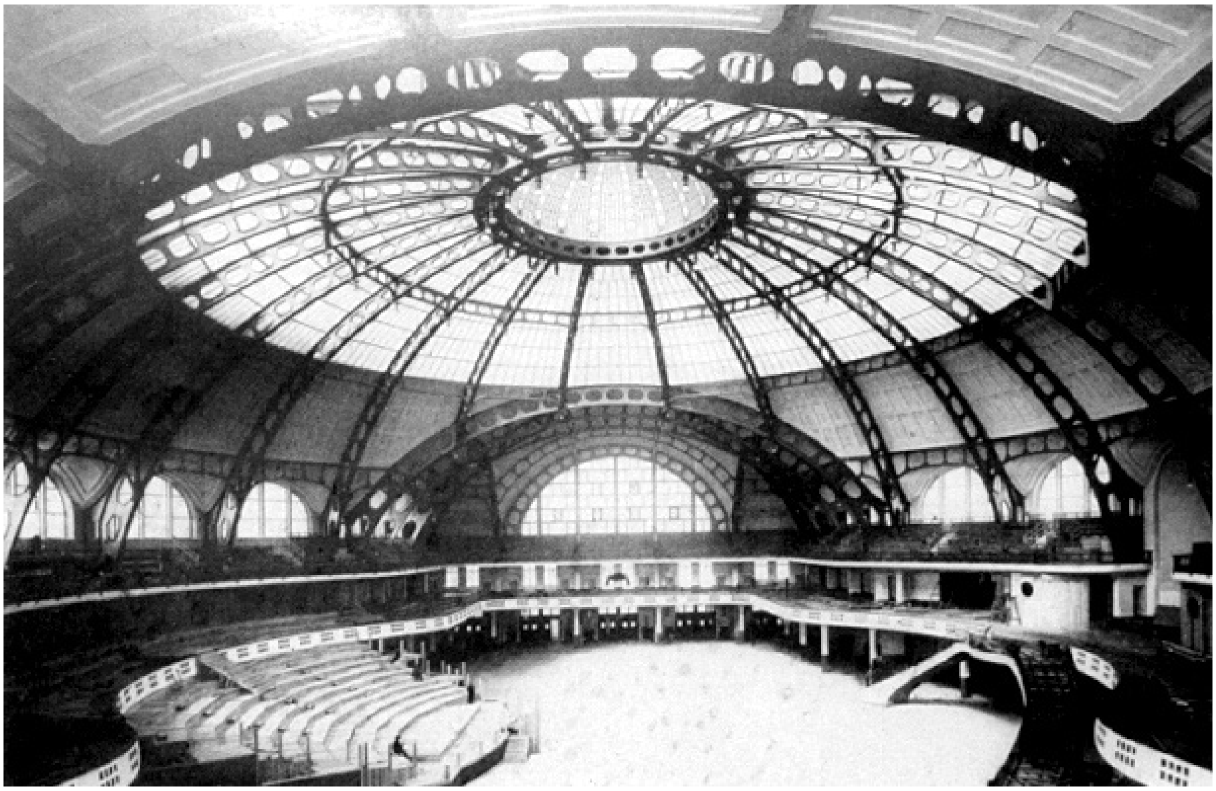
Berg's approach, comprised of taking the interior as the departure point and primary consideration, his designing "from the interior and for the interior" and his interest in the rational shaping of space seems analogous to Petrus Berlage's architectural theory presented in his 1908 *Grundlagen und Entwicklung der Architektur* (1908) where he noted that "The architect's art consists of creating space and not in designing facades." His famous Amsterdam Stock Exchange exemplified the plan developed "from the inside out". His "organic" approach in a sense links Berlage with Wright or the group of architects gathered round Hugo Häring after World War I. Berlage also advocated "simplicity" and "objectivity" and beauty achieved not only by means of decoration but through "the relation between space and volumes". The affinity between Berlage and Berg also reflected their similar outlook. Berlage thought that the French Revolution had cut off the tradition of "spiritual unity". The period during which Berg designed the Centennial Hall sees to show a dramatic change in his outlook in and about 1910. Hitherto a materialist and positivist, advocate of man's limitless potential to be realized through the scientific and technological progress, he became a proponent of individualism and idealism. In 1920, in a programmatic text on the future of architecture, he wrote: "We know that the materialist world view dominated in the previous century has defined a certain way of thinking continuing through to today. Taking science

79 Centennial Hall, interior, photograph, 1913. Deutsches Museum in Munich, archive, legacy of Max Berg

80 Centennial Hall, interior, photograph, 1913. Deutsches Museum in Munich, archive, legacy of Max Berg



81 Friedrich von Thiersch, exhibition and convention hall in Frankfurt-am-Main, interior, with covered dome. “Deutsche Bauzeitung”, 1909, vol. 43, no. 53

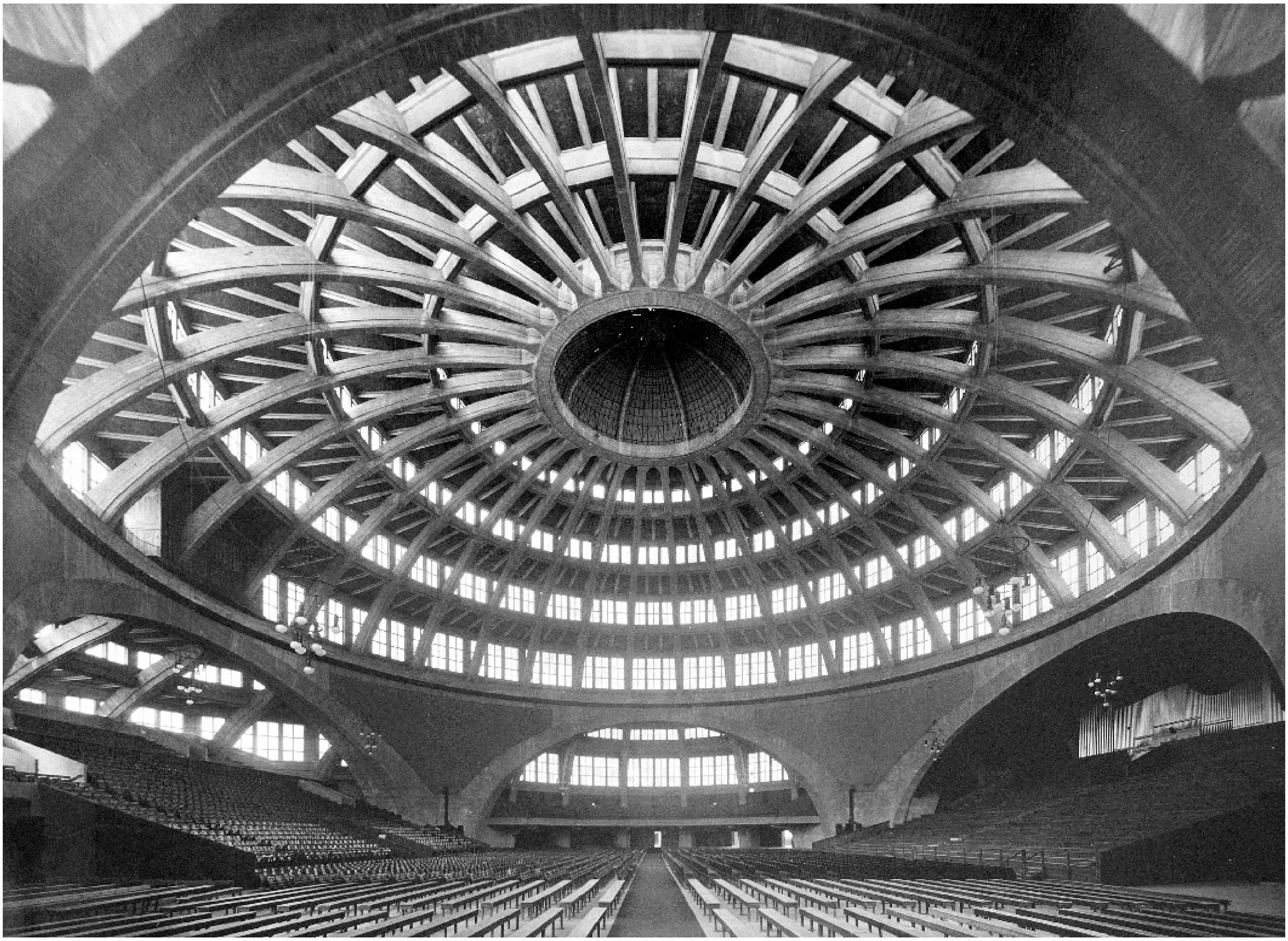


82 Friedrich von Thiersch, exhibition and convention hall in Frankfurt-am-Main, interior, with uncovered dome.
G.A. Platz, *Die Kunst der neuesten Zeit [Propyläen Kunstgeschichte]*, Berlin 1927

and technology as a guide which controls the material of nature, it is aimed at violating the same nature. [...] This worldly view was accompanied by the dwarfing and callousness of feeling."

Berg attached great weight to the problem of acoustics as the building was to function as a concert hall fitted with the largest organ in the world. According to the architect, this aspect had not been studied extensively and the intuitive approach dominated among builders at the time. Berg emphasized that "the huge interior serves more than a single function and therefore it is necessary to walk a fine line" in order to reconcile the function of a theatre, an Opera House, and an assembly hall. Each one of them requiring a different approach to acoustics. The architect was well aware of the challenge presented by the domed interiors which are usually over-acoustic. The problem was exacerbated by the use of such a "springy" material as reinforced concrete. In order to counteract this effect, Berg relied on "pronounced articulation (deep coffers, protruding ribs, etc.) and other appropriate materials." Berg reported that "the emphasis on acoustics was the base for the design of the floor plan and cross-sections. The source of sound would be located in a monumental apse from where it would be uniformly distributed in all directions", adding that "acoustics will be improved thanks to the division of the dome into zones of support ribs on which the horizontal ceilings and vertical glazed walls would rest: they will disperse and absorb sound and partially resonate."

Despite these efforts and the employment of cork lining on the ceilings and sound-absorbing wall screens, the final effect proved below the architect's expectations. In fact, acoustics presented a major challenge for architects designing monumental interiors intended for mass audiences. The experience gained by Hans Poelzig during his collaboration with Berg on the Centennial Hall made him address this problem in his later conversion of the Schumann Circus in Berlin into the Great Playhouse (Grosses Schauspielhaus) where he employed the

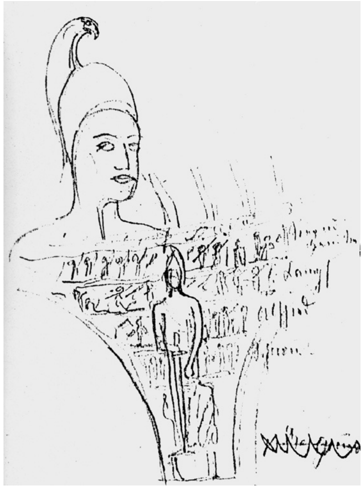


83 Centennial Hall, interior, photograph, 1913. Deutsches Museum in Munich, archive, legacy of Max Berg

84 Centennial Hall, view from the north-west, photograph, 2014. Photo by Mirosław Łanowiecki. Museum of Architecture in Wrocław

85 Centennial Hall, interior, photograph, 1913. Deutsches Museum in Munich, archive, legacy of Max Berg

86 Centennial Hall, interior – ambulatory (foyer), photograph, 1913. Deutsches Museum in Munich, archive, legacy of Max Berg



87 Max Berg, sketch of Centennial Hall interior decoration. Deutsches Museum in Munich, archive, legacy of Max Berg

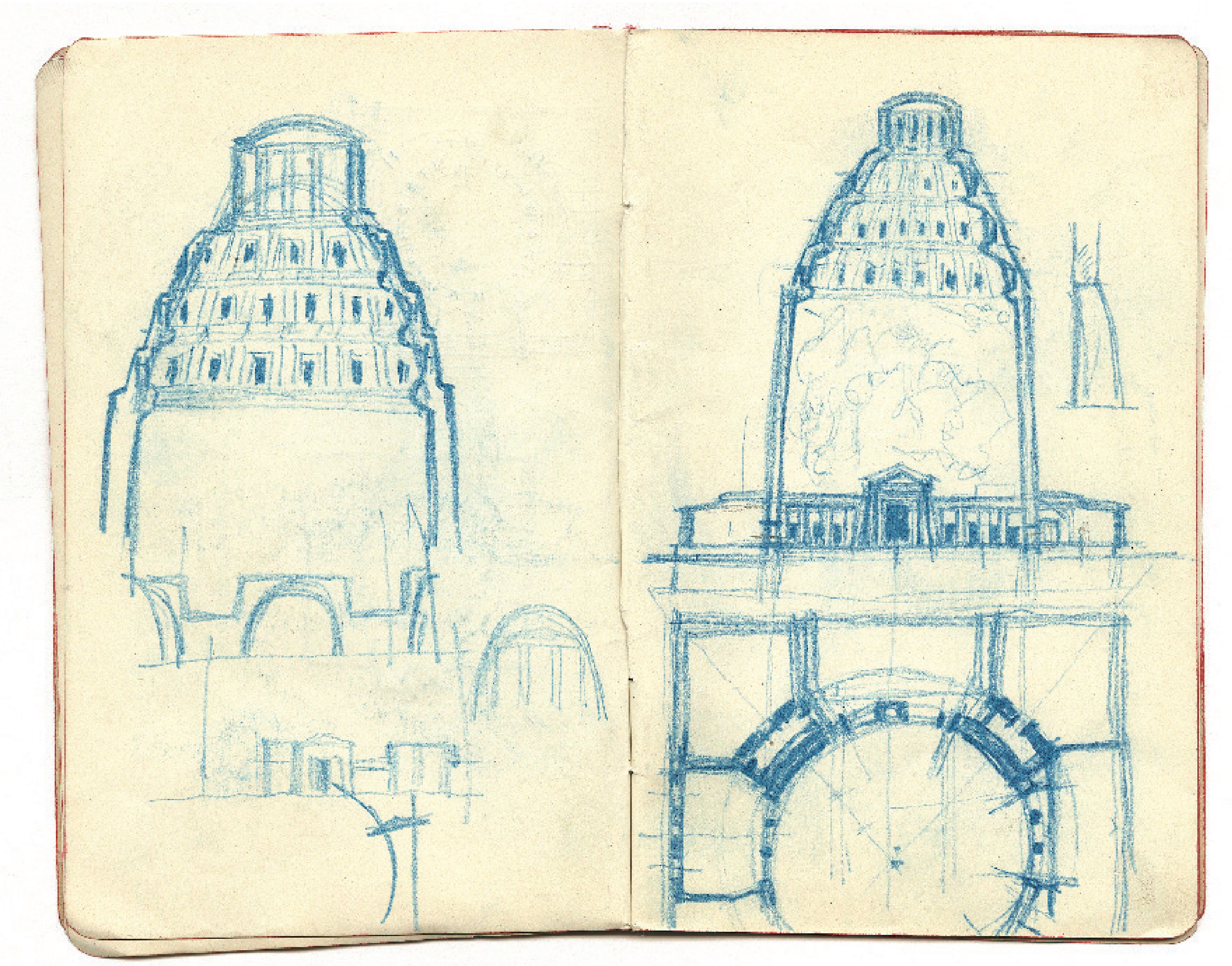
graduated dome and stalactite vaults in the auditorium. Many have interpreted the stalactites as the manifestation of the architect's fancy and Expressionist leanings. In fact, they radically improved the auditorium's acoustics and Poelzig even tried to obtain a patent for his method.

Berg's emphasis on acoustics reflected his fine sensitivity to music. Explaining the ideology for his design of the Centennial Hall, he wrote: "A man incapable of thinking in musical terms may find it difficult to solve acoustic problems." Elsewhere he added: "In the same way as the delicate rhythm of proportions between the members of the violin and the grace of its curvilinear soundboard clearly have an effect upon the beauty of sound, so does the immanent musicality of the rhythm. Spatial proportions and curves of its floor plan and cross-section play a crucial role in the beauty and resonance of an interior." Berg repeatedly referred to music stating that "unifying the art of proportions with artistic activity, as it is often accomplished in contemporary music, is also the task of architecture." He largely owed his passion for and knowledge of music to his pianist wife and his contacts with musicians of Berlin and Vienna. It also seems that his references to music were expressive of the spirit of the time. The musical phraseology to which Berg referred in the context of art and architecture was probably inspired by his contacts with the group of painters in Munich gathered around Kandinsky and also by Kandinsky's seminal publication *Über das Geistige in der Kunst*. Centennial Hall's musical connections also reflect Wagner's idea of the total work of art (*Gesamtkunstwerk*) and its reception in the architecture of the late 19^{th} early 20^{th} century.

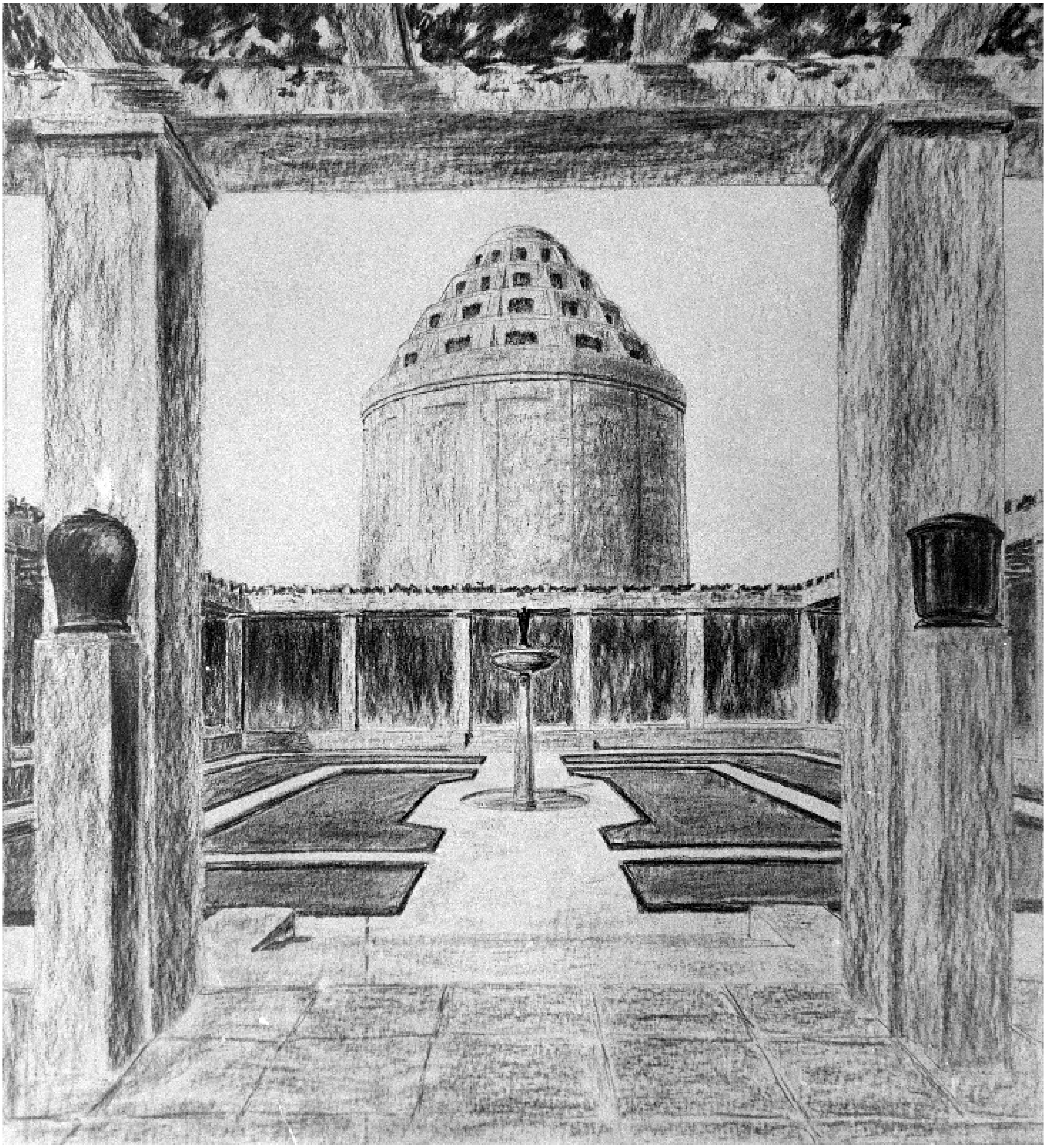
Like Berlage and later Adolf Loos, Berg rejected ornamentation and in the Centennial Hall left the reinforced-concrete structure unplastered and exposed, revealing the characteristic pattern of planking impressed into wet concrete. After the opening of the Centennial Exhibition, a critic wrote that the whole complex was liberated from "the chaos of historical styles and in the principal structure [Centennial Hall] the functional style of purposeful, noble forms is clearly manifested, emphasized by the severity and wonderful plasticity of concrete. [...] The imposing role played by this building material may be described as triumphal." In 1912, Professor Müller of Berlin Technical University, a leading authority in structural design, declared the Centennial Hall "A milestone in the history of construction" and emphasised that it was the first reinforced-concrete structure ever built whose dome span reached 65 metres. Also, for the first time its reinforced concrete shell had been left just as it left its mold, without any attempt to obliterate "the material's severity."

Berg's radical rejection of decoration and insistence on the "truth of the material" corresponds to the so-called Bekleidungstheorie formulated by Gottfried Semper who insisted that "form is dependent upon the material in which it manifests itself". As Günther Bandmann has proved, the architects of the early 20^{th} century made only partial use of Semper's theory; moreover the theory itself was rooted in tradition and not as revolutionary as it may have appeared. They accepted these elements which were congruent with the emerging 20^{th} century aesthetic "relishing the primitive and the primeval; the joy inspired by the diverse structures of the material." Hermann Muthesius declared that the material proudly revealed a proclamation of the inner truth, putting an end to false pseudo-aristocratic art. Like the early Modernists, Berg – in a sense – advocated the cult of the material. Unlike them, he did not stop at formulating theories but actually practiced what he preached. This does not imply that he was against any decoration: he envisioned the Centennial Hall's interior like a Gothic cathedral furnished with sculptures, stained-glass windows and frescoes. Paradoxically, while embodying the modern aesthetic of the Pure Form, the Centennial Hall expressed symbolic meanings in the spirit of Plato's metaphysical doctrine. This reflected on the one hand Berg's rational attitude and on the other his impressive erudition and conscious references to tradition; this intertwining of rationalism and innovation with tradition was the trademark of Berg's approach.

Sources show that the architect envisioned the interior complete with frescoes, stained-glass windows and sculptures. The idea did not come to fruition due to financial constraints. The City Council giving its approval



88 Max Berg, sketches of Wrocław's crematorium, sections, schematic arrangement of a fresco by Oskar Kokoschka, ca. 1913. Deutsches Museum in Munich, archive, legacy of Max Berg



89 Max Berg, Wrocław crematorium design, view of the columbarium, façade, ca. 1916.
Deutsches Museum in Munich, archive, legacy of Max Berg

for the project hoped to obtain financial support from the Prussian government or even of the Emperor himself but these plans failed. Had this utopian project been presented after World War I, in all probability it would have shared the fate of Berg's designs of the never-built skyscrapers. Even in the times of prosperity it presented a colossal financial burden overstretching the Municipal budget. Time constraints also contributed to the reduction of Centennial Hall's artistic program. The architect's drawings as well as his articles and correspondence confirm his intentions to expand the artistic conception of the Centennial Hall. In a letter to Sesselberg he wrote: " It was my intention to imbue the whole structure with the symbolism of human spirituality through color design and the introduction of sculpture." In another letter, to Paul Heim, he declared: "While designing the Centennial Hall, I thought of emphasizing the color scheme by introducing stained-glass windows and polychrome pendentives on the dome." Berg's likely motivation was the wish to enhance the structure's aesthetic appeal through an appropriate color scheme: such approach was advocated by reformers as a desirable departure from the despised blandness of tenement houses. In 1901 Fritz Schumacher insisted that color design was an integral part of the design process and not an afterthought. However, the question remains open as to Berg's conception of Centennial Hall's decoration. Documents preserved at the Deutsches Museum in Munich concerning the designs for the crematorium on which Berg and Oskar Kokoschka collaborated in 1911–1916 shed some light on the issue.

In September 1914, in a letter written to Kurt Wolf, publisher of Expressionist writers and poets, Kokoschka recalls: "Before the outbreak of the war, I was commissioned by Berg from Breslau to prepare design sketches for a series of murals to grace a newly-built crematorium; he also indicated that there may be a chance for me to decorate the local Centennial Hall." Had Kokoschka carried out the decoration, it would have comprised of paintings and stained-glass windows in an Expressionist style. The stained-glass windows would have presumably replaced window panes while the polychromes would have graced the pendentives of the monumental arches and the ceilings of the dome's terraced storeys. Berg's drawing on the margin of his manuscript concerning the acoustics of the Centennial Hall and some sketches by Kokoschka also confirm these plans. It must be kept in mind that the building's structural membranes were deliberately left exposed revealing the impresses of the planking. The decoration was to be limited to the windows and those elements which had been covered with acoustics-enhancing material.

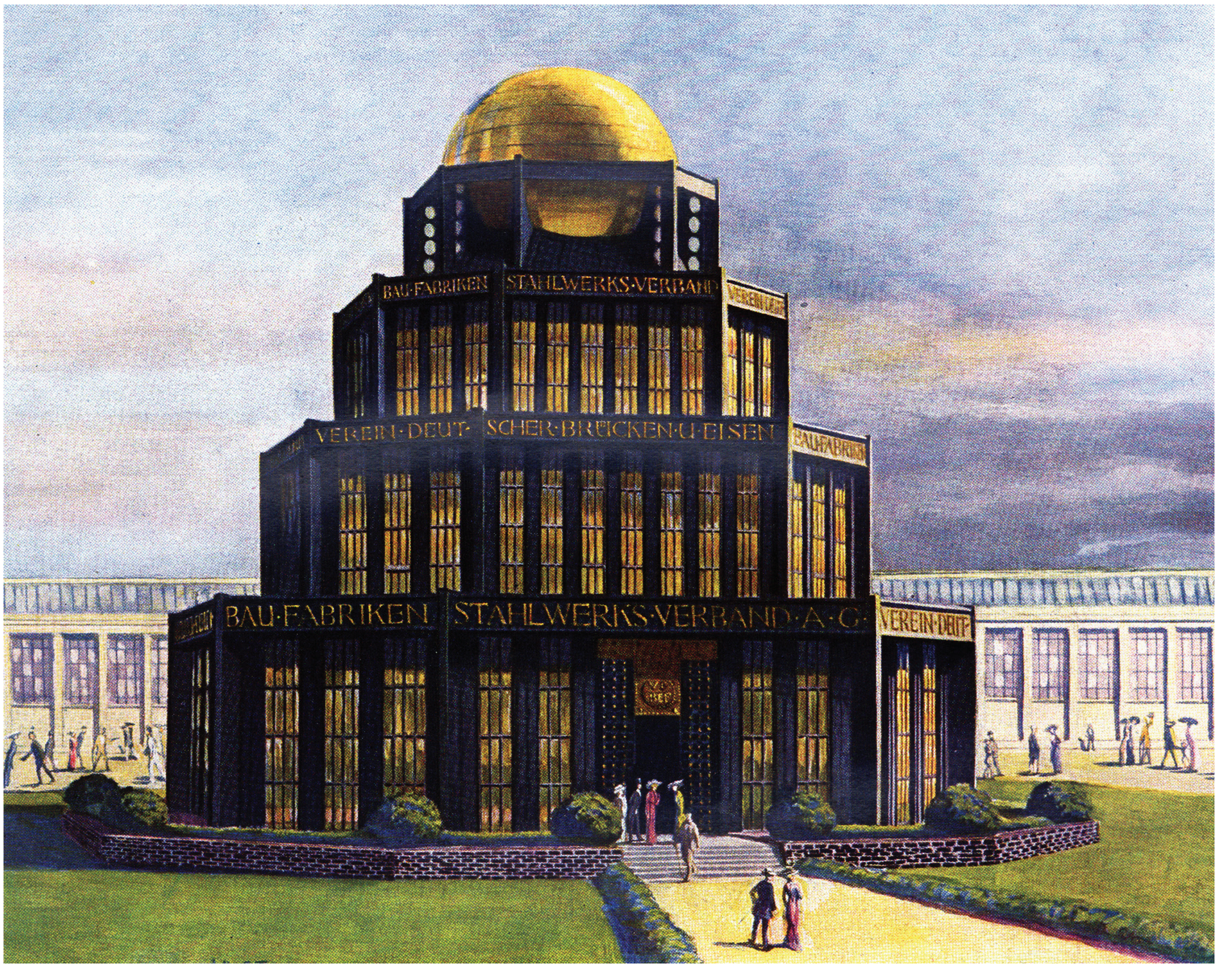
In 1911–1912 Berg maintained close contacts with the artists congregating around the Berlin art journal "Der Sturm", which was instrumental in promoting Modern Art in Germany. It was probably through its publisher Herwarth Walden that he made acquaintance with Oskar Kokoschka and perhaps also with the architects later connected with the "Gläserne Kette" and Paul Scheebart, the visionary advocate of "glass houses".

In April 1912, in a letter to Walden, Kokoschka mentioned a commission related to some of Berg's projects. The painter did not specify what commission it was, perhaps he already referred to it as the crematorium. It seems more probable, however, that he was in fact referring to their collaboration on the Centennial Hall. Its construction had already begun (August 1911) and by April 1912 the formwork for concreting the dome's ribs was ready. At this point Berg was probably elaborating on the interior's color scheme. In a letter written to Alma Mahler in May 1914, Kokoschka mentions a letter he had just got from Berg, asking him to paint a view of the Hall measuring 3 x 3 m to present at an exhibition in San Francisco. In 1912–1913 Kokoschka collaborated with Berg on two projects: the Centennial Hall and the crematorium.

The conception of Centennial Hall's polychrome decoration also relied on the use of glass and stained glass. Harmonizing with exposed reinforced concrete, clear and colored glass was to contribute to the aesthetics of the new architecture. The motif of glass architecture had already appeared in the poems of Scheerbart: the transparency of glass recalled the crystalline structure the architects of Modernism found so fascinating. To Peter Behrens, crystal symbolized the metamorphosis of "rough and chaotic life into an orderly and beautiful

90 East German Exhibition in Poznań in 1911 (Ostdeutsche Ausstellung Posen 1919), Upper Silesian (Oberschlesische) Tower at night, postcard. Nordostdeutsches Kulturwerk Lüneburg Archives

91 Centennial Hall at night, 2004. Photography by Stanisław Klimek

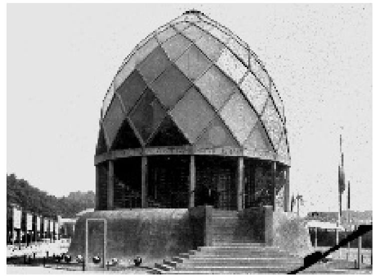


92 Iron Monument, pavilion at the Building Trades Exhibition in Leipzig in 1913, designed by Bruno Taut. "Der Profanbau", 1913

existence", it was a "symbol of new life" – new art, that is. To the architects of Berg's generation the famous Crystal Palace built by Joseph Paxton of iron and glass for the first World Exhibition in London in 1851 was an inspiration, a glorious symbol of the departure from historical styles towards the dematerialised architecture pursuing "pure form". The Crystal Palace embodied the "idea of absolute mastery over nature" and faith in the limitless potential of technology. This fascination with crystalline structures also contributed to the renewed interest in the "crystalline lines of Gothic Architecture". Bruno Taut writes "the Gothic cathedral is a prelude to the architecture of glass." He also emphasises that the Gothic cathedral's space with its characteristic light leads people to God and that modern technology may help transform it into "The Cathedral of the future" where one will be able to experience the cosmos reflected in the colorful helix of the glass dome.

Gothic ecclesiastical architecture was viewed as a model for the crystalline form and light effects of the glass house. Both Max Berg and Hans Poelzig, the latter connected with the Neo-Gothic school of Karl Schäfer, were familiar with these theories and also with Paul Scheerbart's visionary architecture of glass and light published in the 1890s that came long before his 1914 *Gläserne Architektur*. Paul Scheerbart also contributed to the "Der Morgen" magazine published by Werner Sombart, a member of the local group of intellectuals gathered around Albert and Toni Neissers and Carl Hauptmann. Max Berg also belonged to this group. Paul Scheerbart's leanings to Mysticism might have inspired the interest of Berg, Poelzig and Hauptmann. It seems likely that the group also discussed the ideas of glass architecture.

Almost simultaneously with the Centennial Hall, Hans Poelzig built his famous Water Tower and Exhibition Hall (Upper-Silesian Tower) in Poznań, likewise inspired by the imaginative architecture of glass. Poelzig was able to utilize the idea of employing colored glass where as Berg was forced to abandon it at the Centennial Hall. "The architecture of glass implemented in the structure of the Centennial Hall and Upper-Silesian Tower which is clearly visible in the evocative nocturnal views of both monuments. The tower, in daytime a landmark of the East-German Exhibition, at night metamorphosed into some kind of a lighthouse that is additionally illuminated by a spotlight installed on the dome. It can therefore be said that Paul Scheerbart's vision of "spotlights on all glass towers" materialized.



93 Brunon Taut, Glass pavilion (Pavilion of German Glass Industry) at the Werkbund Exhibition in Cologne, 1914. © Bildarchiv Foto Marburg

Both the Upper-Silesian Tower and the Centennial Hall influenced two structures designed by Bruno Taut. The idea of glass architecture could also be found in the Steel Industry Pavilion at the International Building Trades Exhibition in Leipzig (1913) and the polygonal Glass Pavilion at the Werkbund Exhibition in Cologne (1914) with its dome-like roof constructed of a space-frame with diamond-shaped glass panels. At night, the illuminated pavilion resembled a gigantic lantern built of steel and glass.

The glazed structure of the Centennial Hall evokes similar associations and had it been decorated according to the architect's original idea, it would have also gleamed with colors like Taut's pavilions as suggested by the form of the lantern whose structure resembles that in Taut's pavilion in Cologne. It is worth emphasising that, unlike the buildings of Poelzig and Taut, the Centennial Hall embodies the idea of glass architecture in an exposed reinforced-concrete structure.

Inspired by Semper's idea of the unity of the arts and Wagner's Gesamtkunstwerk, Berg explored the connection between architecture and other disciplines, such as theatre and music. During the Centennial Exhibition, the Centennial Hall was reserved for staging monumental theatrical productions and concerts. Envisioning them, Berg had a monumental organ installed and devoted much care to the interior's acoustics. Alongside the Historical Exhibition presented at Poelzig's Four Dome Pavilion, the Centennial Exhibition's main artistic event was the production of the drama by Gerhart Hauptmann (winner of the Nobel Prize for Literature in 1912) titled *Commemoration Masque* (*Festspiel in deutschen Reimen*). The play referred, in a symbolic form, to the war of liberation. It was directed by Max Reinhardt and the music was composed by Einer Nielsen. Max Berg designed the architecture of the stage and the auditorium while the sets were designed by Ernst Stern. At the Centennial Hall Reinhard's idea of the "Theatre for Five Thousand" took form. Actually, about 6000 guests saw the premiere on May 13, 1913. The viewers arrived from Berlin and other cities by special trains. The premiere was a huge success and the press hailed it "a production the city had never seen before."

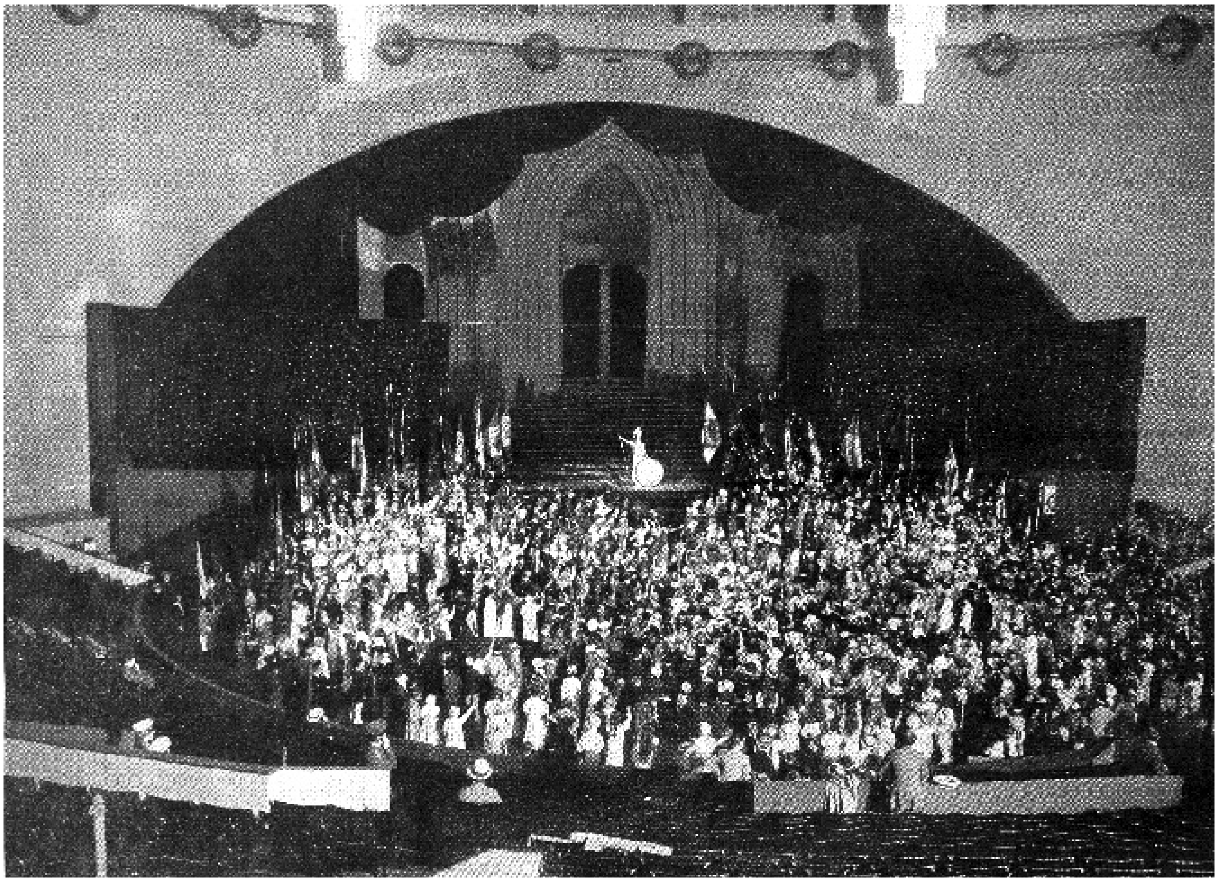
Immediately after its premiere, Hauptmann's play inspired a heated discussion. A local newspaper's correspondent observed that "the social-democratic and liberal press approves of it while the nationally-minded press is against it". Arthur Westphall wrote in the "Welt am Sonntag", "This whole play is simply an offence; I am ashamed that this hokus-pokus was shown to accompany the anniversary of the year 1813. I am ashamed as a German, a writer, and a civilized man." The conservative press criticized the production arguing that "for all patriotic enthusiasts Hauptmann's play is not patriotic enough. His drama condemned the war of liberation instead of glorifying it and it apotheosized peace." The premiere of *Commemoration Masque* (*Festspiel in deutschen Reimen*) was staged shortly before the outbreak of World War I during the period marked by the rise of German nationalism not only among the bourgeoisie but also the working class. The violent reaction of the press was stirred by a letter of protest addressed to Hauptmann by the Prussian war veterans of the Provinzial Kriegesverband and published in the "Schlesische Zeitung". Liberals, leftists, and first of all artists and intellectuals came to the playwright's defense. Among them was Max Berg who voiced his opinion in the press "Comments pertaining to Hauptmann's play may have suggested that he only has opponents in Silesia so we feel obliged to explain […] that we see in it neither an apotheosis of Napoleon nor mockery of patriotic

94 Poster and title page of the souvenir programme of the play of Gerhart Hauptmann's *Commemoration Masque* (*Festspiel in deutschen Reimen*), 1913. University Library in Wrocław, Silesiaca and Lusatica Collection

sentiments [...] Despite holding such views, we aspire to be patriots." *Commemoration Masque* (*Festspiel in deutschen Reimen*) was performed 11 times instead of the contracted 15 spectacles. Hauptmann himself told the City Council that "This whole affair, connections and intrigue have their source in Berlin." The scandal however echoed throughout Europe. The conflicts accumulating in the process of Centennial Hall's construction and production of Hauptmann's play revealed the discord between the expectations of the ancient régime and the artists who no longer saw in art and architecture instruments to glorify the ruling power and ruling classes. On the contrary, art and architecture were to express sentiments and concerns of society. Works of art and architecture were being addressed to the masses and should be made accessible to them.

In 1922, in an article on "The Gerhart Hauptmann Festival – the way to the people's theatre", Berg wrote "I recall with joy my first impressions from Reinhardt's stage production almost twenty years ago. I was surprised with the simplicity of the stage." In the same article Berg presented his reflections on the art of drama: he distinguished between its two varieties: recitation (*Wortdrama*) and spectacle (*Schaudrama* or *Schauspiel*). Traditionally, the word has been at the centre of the theatrical event "The perception of drama, poetry has been primarily focused on the sense of hearing. The "spectacle" unfolds through the development of the drama of the word." A dramatic performance properly directed may appeal to the broad masses. Dramatic plays should be presented in simple sets so that the word may complement the visual image of the stage, like in Medieval mystery plays. Berg's opinions indicated that he must have been familiar with the ideas of Georg Fuchs who, in collaboration with Peter Behrens, wanted to show a new type of theatre at Mathildenhöhe in connection with the exhibition at Darmstadt in 1901. Fuchs also wanted to eliminate the "theatre of private boxes" with its social hierarchy. Hauptmann's play referred to Ancient Greek drama, the semicircular amphitheater designed by Berg referred to the Greek *cavea*. From the very beginning, Berg envisioned it as a temporary structure built especially for the production of Hauptmann's drama and the opening ceremony of the Centennial Exhibition. It also referred to Richard Wagner's idea of *Gesamtkunstwerk* and the employment of the stage arrangement drawn from Classical Antiquity at the Festspielhaus at Bayreuth. Both Wagner and the architects of the Festspielhaus who expounded the Modern Style advocated the aesthetic of simplicity. "The boxes had been eliminated and the lights in the auditorium were turned off during the spectacle. These two factors encouraged the public to behave in a new way, in terms of interactions between the viewers and their attitude towards the spectacle. The changed arrangement of the auditorium forced the viewers to focus their attention on the stage and watch the spectacle. Another innovation was the introduction of the orchestra pit hidden from the view so it would not deter spectators from what was happening on the stage." These developments implied a more democratic character of the auditorium's space.

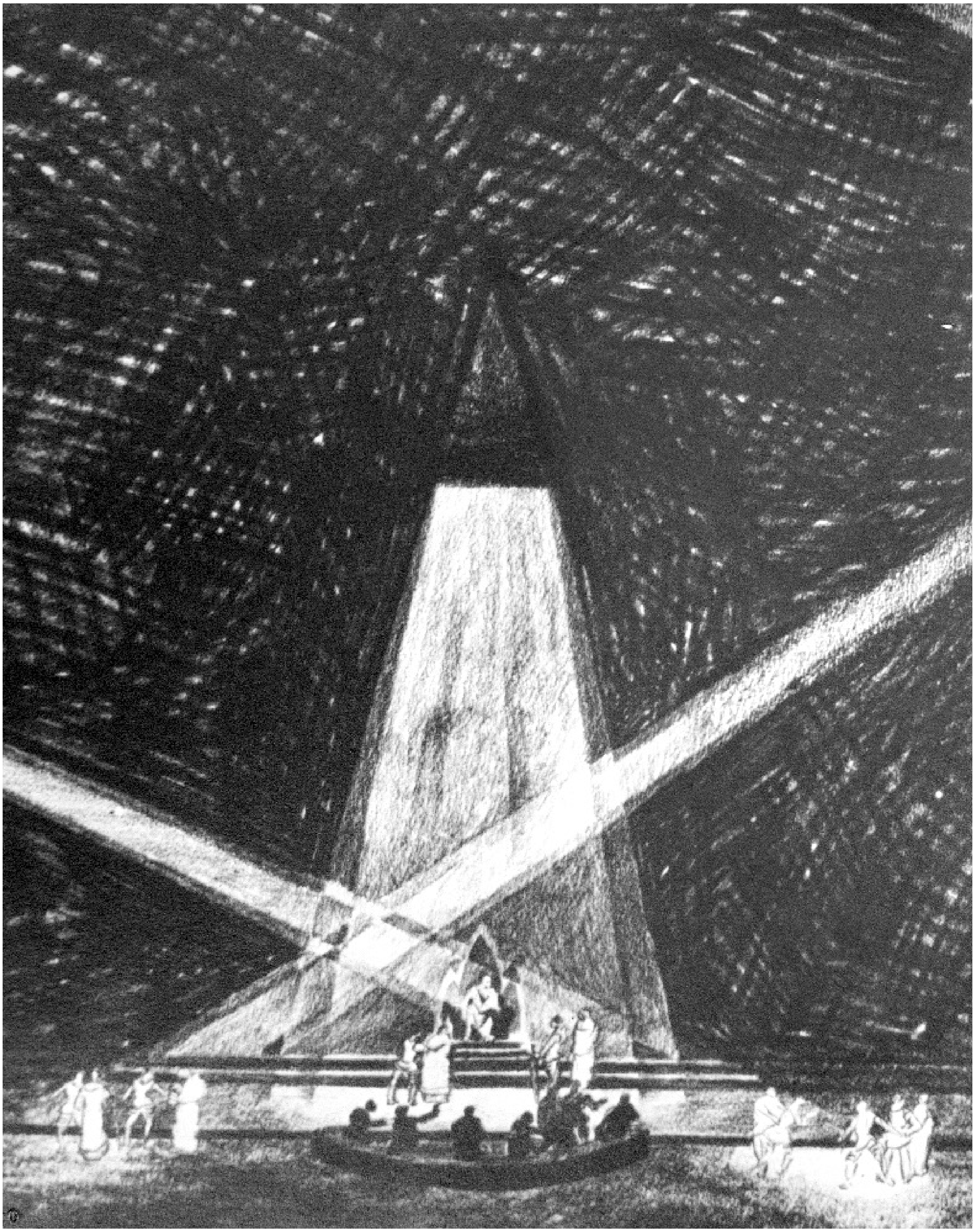
Around 1900, Peter Behrens (in connection with the Mathildenhöhe exhibition in Darmstadt) and then Bruno Taut, inspired by Behrens, employed the amphitheater in order to merge the auditorium with the stage and thus foster a partnership between the viewer, the artist, and the actor. Adolphe Appia urged "Let's stop being viewers." Relying on new technology, the reformers changed the stage and the use of light as the most important instrument of creation. To Edward Gordon Craig, "Light is as important to the stage as the bow is to the violin." For a Dalcroze production at Hellerau, Adolphe Appia created a system of multiple bulbs that allowed him to change spatial perception and was "capable of transforming and uniting the viewers and actors under one roof making it The Cathedral of the Future." For Hauptmann's production at the Centennial Hall lighting was designed and employed by Rudolf Dworski of the Deutsches Theater in Berlin. New theatre, came to be seen as a cultural symbol, that addressed the ideal community in a society inspired by monumental productions staged for the masses. Sophocles' *Oedipus* directed by Max Reinhard, staged at the Musikfesthalle in Munich in 1910 and later transferred to the Schumann Circus in Berlin could accommodate 5000 viewers. In 1911 Polish *Tygodnik Ilustrowany* (a weekly newspaper) published a review tellingly titled "A future people's stage".



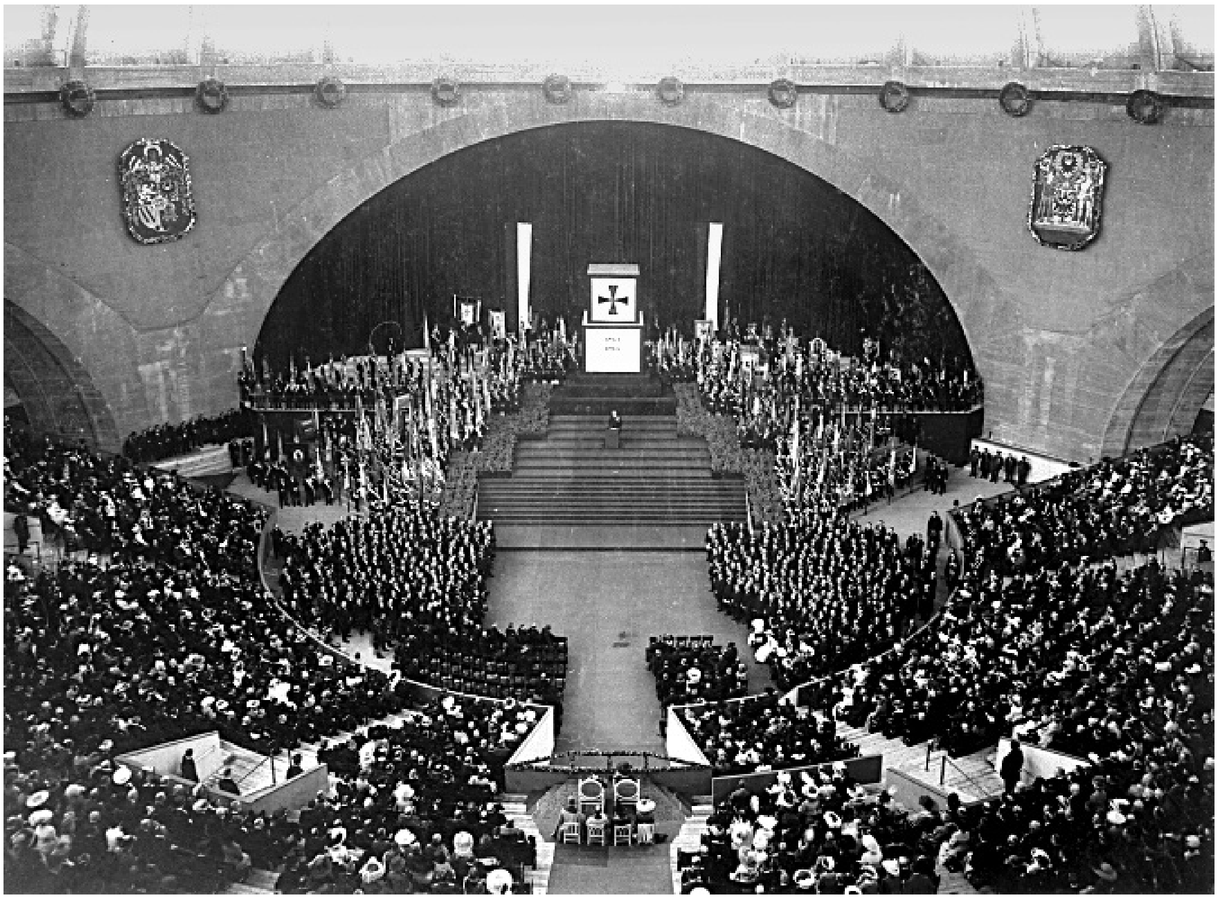
95 Final scene of Gerhart Hauptmann's *Commemoration Masque* (*Festspiel in deutschen Reimen*), Germany-Athena glorifies peace and the actors unite with the audience, photograph, 1913. "Schlesische Zeitung. Sondernummer", 1913

The author wrote that "The auditorium and the stage create a single, organically unified whole. [...] In his production of *Oedipus* Reinhard has shown what is the crowd of extras in the dramatic spectacle. The crowd of extras makes the whole drama enfold." The second monumental production Karl Vollomoeller's *Das Mirakel* was staged at the Olympia Hall in London in 1910 with music composed by Engelbert Humperdinck. The production inspired by Mediaeval mystery plays tells the story of the Virgin. These monumental productions were usually shown in spaces temporarily adapted and therefore unsuited to accommodate such large audiences. For this reason Reinhard decided to present his spectacles in the open: for example, his *Jedermann* after Hofmannstahl was staged in front of the Salzburg Cathedral. Only after World War I did Reinhard's collaboration with Poelzig result in the conversion of the former Schumann Circus Building in Berlin into the Grosses Schauspielhaus in 1919–1920, which was specifically designed for staging spectacles for the broad masses. Several years earlier Reinhard presented his third monumental spectacle at the Centennial Hall. Max Berg wrote of this production of Hauptmann's drama "This stage production has clearly shown the path to a more profound and internal experience and perception of poetical ideas. It has proven that this path leads to the goal which is the people's theatre."

At the Centennial Hall the Expressionist idea of "The Theatre for Five Thousand" advocated by Reinhard surfaced. In the final scene of Hauptmann's drama the actors and audience united on the stage. What Berg had initiated in his hall-cum-theatre became the quest of many artists leaning towards Expressionism as well as



96 Hans Leistikow, set design sketch for Gerhardt Hauptmann's play in the Centennial Hall, 1922.
Deutsches Museum in Munich, archive, legacy of Max Berg



97 Opening reception of the Centennial Exhibition staged at the Centennial Hall on May 20, 1913, photograph reproduction. Leibniz Institute for Research on Society and Space in Erkner near Berlin

those connected with the Bauhaus, like Gropius and Piscator with their "total theatre". Ironically, the Modernist experiment may have inspired the staging of the mass events filmed by Leni Riefenstahl.

Another attraction of the Centennial Exhibition was the performance of Mahler's Symphony No. 8. The local press commented "The colossal structure of the Centennial Hall provides an appropriate setting for Mahler's monumental work." During the closing ceremony on October 26, 1913 Beethoven's 9th Symphony was performed. During the Centennial Exhibition Max Reinhardt also staged another monumental production, *Das Mirakel*, with a choir and 2000 extras. It was intended to compensate the local community and municipal authorities for the scandal caused by his production of Hauptmann's drama.

Unlike 19th century exhibitions, typically staged in pavilions presenting a motley of architectural styles, the Centennial Exhibition with the dominating accent of the Centennial Hall reverberating in the architecture of other structures was a coherent aesthetic and architectural creation incorporating music, visual arts, and garden design. The comprehensive vision of Max Berg and Hans Poelzig extended beyond the idea of Gesamtkunstwerk – they succeeded in creating a "total environment."

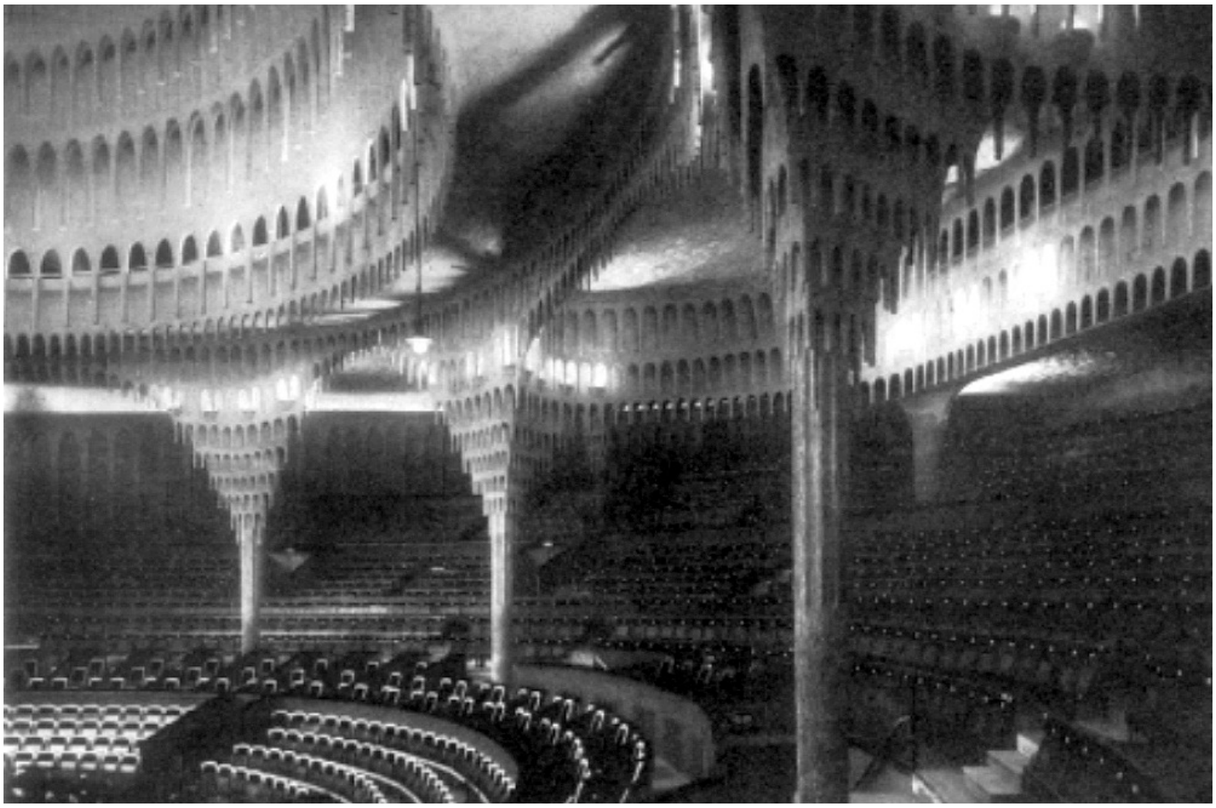
Shortly after the end of World War I in a programmatic text on the future of urban development of Breslau (Wrocław) as an expression of an emerging new culture Max Berg wrote, "Along with the development of democracy monuments will be erected that will make ideas and works of art accessible to everyone. There will be halls and small auditoriums to organize performances, concerts and academic conferences. Enormous costs involved in the staging of dramas or music performances must result in the simplification of stage design and

98 Poster of the Centennial Exhibition final concert. University Library in Wrocław, Silesiaca and Lusatica Collection

theatrical sets according to Ancient Greek tradition in order to educate the broad masses. Already before the war, Breslau built its "Cathedral of Democracy" and called it the Centennial Hall". The "Cathedral of Democracy" also points to the idea of the "people's house", very popular in the period before World War I. Berg's political views, despite his early social-democratic sympathies, may be defined as "apolitical socialism." The essence of this kind of political thinking was described by Bruno Taut "There is a word to which both rich and poor men respond, which reverberates everywhere and promises Christianity in a new form [...] To feel solidarity with all humanity [...] socialism in a non-political or supra-political sense, far from any form of power, as a simple and mutual union between humans, transcends the divide between warring states and nations, unites people with people. If there is anything today that may crown the city, it is first of all an expression of this idea." To Taut, this idea was best expressed in the symbolical vertical accent dominating the cityscape (Stadtkrone). In Berg's view, monumental assembly halls were especially well suited to "unite people with people".

Kathleen James in her study on the Centennial Hall showed that it was one of the earliest examples of architecture addressed to the mass audience in Wilhelmian Germany whose society was undergoing the process of democratization. She argued that the forces hostile to democratization had tried to use mass culture to strengthen and promote social harmony and national unity from the end of the 19^{th} century. The political situation in Germany was getting increasingly complex in the period preceding World War I. In 1912 the Social Democrats became the biggest party in the Reichstag and the electorate's preferences turned to the left so significantly that it threatened the status quo in the Reichstag hitherto characterized by an equilibrium between the liberal and conservative forces representing the bourgeoisie and the aristocratic faction connected with the imperial court. In this situation, the formation of a new government became problematic. On the other hand, the election results revealed deep conflicts between different classes of society and shook the myth of national unity and converging interests of various segments of society. James maintained that the political situation towards the end of the Wilhelmian era made the elites aware of the possibility of their losing control over national politics and the economic system due to the increasing role of the working class. At the same time employers were aware of their employees' spending power and their ability to absorb mass-produced goods and thus their instrumental role in supporting the level of production which could not have been supported by the spending of richer consumers alone. The working class consumer also aspired to culture and entertainment in the form of cinema, radio and theatre. Founded by progressive manufacturers and architects, the Deutscher Werkbund aimed at improving the aesthetic quality of mass-produced goods and industrial design, and was seen as an instrument essential to achieve this goal. Already prior to World War I, the ideas of the Deutscher Werkbund were addressed to the broad masses.

Berg and the City Council tried to win popular support for Centennial Hall's construction and make the idea appeal not only to the well-educated bourgeois elite dominating the city's political and cultural life. The Centennial Hall was originally planned to accommodate up to 10 000 people irrespective of their social status. They would be able to participate in the same aesthetic experience and form an assembly in which no apparent social barriers existed. The architect's intention corresponded to sociological theories promoted in Germany at that time, in particular to Max and Alfred Weber, Georg Simmel, Werner Sombar, and first of all Ferdinand Tönnies as presented in his book *Gemeinschaft und Gesellschaft. Grundbegriffe der reinen Soziologie*. Tönnies distinguished between community (Gemeinschaft) and association (Gesellschaft) referring to the different types of relationships characteristic of small-scale and large-scale societies, respectively. In the village or small community, the patriarchal family and church are instrumental in sustaining a clearly defined set of beliefs and values and co-operative relationships flourish based on personal ties and group solidarity. These communal ties dissolve into contractual and impersonal relationships as the division of labour becomes more complex in the



99 Hans Poelzig, Great Theater in Berlin [Großes Schauspielhaus]. G.A. Platz, *Die Baukunst der neusten Zeit*, Berlin 1930, p. 345

mechanical organization of urban life in modern nation-states. Tönnies regretted the loss of communal life and spirit following Marx in his criticism of contemporary capitalism and looked back with nostalgia to pre-industrial forms of social life. He dreamt of reconstructing the mythical communities by eliminating social divisions. In connection with the idea of political reform, rooted in the tradition of German Romanticism of the late 18th century, art was viewed as a form of social reflection. Like art, architecture was also expected to perform a social function. Social harmony was pursued through references to pre-industrial communal life. This pursuit of harmony was expressed through the historical styles adopted with all symbolic meanings attached to the centrally planned Renaissance church or Gothic cathedral. It was only in the late 19th century that this approach started to be revised and the genesis of architecture became linked with form, structure, and geometry rather than with the succession of historic styles. Kathleen James ascertains that as a result of this process "the fusion of aesthetic and political theories with experimental architecture" emerged around 1910. In this context, the centrally planned Centennial Hall was viewed by its contemporaries as a perfect response to the needs of the new consumer – that is the broad masses, as the interior's spatial unity symbolized social harmony. Buildings like the Centennial Hall symbolically reconstructed "organic" communities whose present divisions were considered incidental and temporary." The experimental theatre in Germany (like Max Reinhardt's staging of Hauptmann's drama at the Centennial Hall) addressed the same issues. In France however, experimental art was intended for the civilized and educated elite. The avant-garde artists in Germany appealed to the mass audience, first of all to the working class. Envisioned primarily as a venue for concerts and theatrical productions, the Centennial Hall through its innovative architecture rendered in exposed cast concrete expressed the idea of new, democratic society.

The Centennial Exhibition and Centennial Hall exerted a great influence upon the later work of both Max Berg and Hans Poelzig. The objective in this project of uniting drama and music and creating a monumental architectural space suitable for staging mass events would later inspire Poelzig to elaborate on the idea. Thanks to him the idea later became the leitmotif of the Expressionist phase in the history of architecture. The Centennial Hall anticipated Poelzig's later achievements – like the Grosse Schauspielhaus and Sports Center in Berlin or the Festspielhaus in Salzburg – and in this sense the first mature architectural work of Expressionism. After World War I Berg also continued to elaborate on the idea of monumental architecture for the broad masses in a number of design sketches of a concert hall planned on today's Powstańców Śląskich Street which in turn shows a clear connection with Poelzig's designs.

3.

Heritage and conservation status

3. Heritage and conservation status

3.1. Legal contexts and limitations (Polish and International)

3.1.1. Polish Law

The Centennial Hall and its accompanying historic buildings and the Exhibition Grounds are protected by law: this protection results from it being inscribing on the list of historic monuments and having the status of a historic monument. The owner's relevant obligations towards historic monuments, limitations of property rights and the principles for issuing permits to conduct overhauls, repairs and conservation works are regulated by the following legal acts:

- Law on the protection of historic monuments and care for historic monuments enacted on July 23, 2003 (Ustawa z dnia 23 lipca 2003 roku o ochronie zabytków i opiece nad zabytkami) Dz.U. 2003, No. 162, item 1568 with amendments, uniform text published on September 10, 2014 – Dz.U. 2014, item 1446. The Law defines the object, scope, forms of protection and care of historic monuments and also the institutional system of dedicated organs and agencies. On the basis of this Law, Ministerial decrees define the principles of conducting conservation, restoration, and construction work concerning historic monuments.
- Decree of the Minister of Culture and National Heritage issued on July 27, 2011 concerning conservation, restoration, and construction work, conservation and architectural surveys and other actions concerning a listed historic monument and archeological surveys (Rozporządzenie Ministra Kultury i Dziedzictwa Narodowego z dnia 27 lipca 2011 roku w sprawie prowadzenia prac konserwatorskich, prac restauratorskich, robót budowlanych, badań konserwatorskich, badań architektonicznych i innych działań przy zabytku wpisanym do rejestru zabytków oraz badań archeologicznych, Dz.U. 2011, No. 165, item 987).
- Decree of the Minister of Culture and National Heritage issued on March 13, 2015 changing the Decree concerning conservation, restoration, and construction work, conservation and architectural surveys and other actions concerning a listed historic monument and archeological surveys (Rozporządzenie Ministra Kultury i Dziedzictwa Narodowego z dnia 13 marca 2015 roku zmieniające rozporządzenie w sprawie prowadzenia prac konserwatorskich, prac restauratorskich, robót budowlanych, badań konserwatorskich, badań architektonicznych i innych działań przy zabytkach wpisanych do rejestru zabytków oraz badań archeologicznych, Dz.U. 2015, item 383).

- Decree of the Minister of Culture issued on June 6, 2005 concerning dedicated government grants to finance conservation, restoration and construction work concerning a listed historic monument (Rozporządzenie Ministra Kultury z dnia 6 czerwca 2005 roku w sprawie udzielania dotacji celowej na prace konserwatorskie, restauratorskie i roboty budowlane przy zabytku wpisanym do rejestru zabytkówł Dz.U. 2005, No. 112, item 940).
- Decree of the Minister of Culture issued on May 26, 2011 concerning the maintenance of a list of historic monuments as well as a national, provincial and communal registry of historic monuments and a national registry of historic monuments stolen or illegally transferred abroad (Rozporządzenie Ministra Kultury z dnia 26 maja 2011 roku w sprawie prowadzenia rejestru zabytków, krajowej, wojewódzkiej i gminnej ewidencji zabytków oraz krajowego wykazu zabytków skradzionych lub wywiezionych za granicę niezgodnie z prawem; Dz.U. 2011, No. 113, item 661).

The protection of listed monuments is also addressed in the following legal acts concerning building law and planning which require the need to obtain permission of the relevant Inspector of Historic Monuments for construction work if and when changing the form of use of a site under conservation protection:

- Law – Building law enacted on July 7, 1994 (Ustawa z dnia 7 lipca 1994 roku – Prawo budowlane, unified text Dz.U. 1994, No. 89, item. 414 with amendments).
- Law on planning and spatial development enacted on March 27, 2003 (Ustawa z dnia 27 marca 2003 roku o planowaniu i zagospodarowaniu przestrzennym; unified text Dz.U. 2003, Nro.80, item 717 with amendments).
- Law on public access to the environment and environmental protection information, public involvement in environmental protection, and assessment of environmental impact enacted on October 3, 2008 (Ustawa z dnia 3 października 2008 roku o udostępnianiu informacji o środowisku i jego ochronie, udziale społeczeństwa w ochronie środowiska oraz o ocenach oddziaływania na środowisko; Dz.U. 2008, No. 199, item 1227 with amendments).

3.1.2. International Law

The Centennial Hall and the Exhibition Grounds site were inscribed on the UNESCO World Heritage List in 2006. The legal basis for inscribing as well as monitoring and supervision by an executive organ (World Heritage Center) is provided by:

- The Convention Concerning the Protection of World Cultural and National Heritage adopted by The General Conference of UNESCO in November 1972, ratified by Poland in 1976 (Dz. U. 1976, No. 32, item 190)
- Operational Guidelines for the Implementation of the World Heritage Convention issued on July 8, 2015 (WHC.15/01).

3.2. Heritage status

3.2.1. List of historic monuments

On the basis of the decision of the Voivodship Inspector of Historic Monuments issued on April 24, 1962, the Centennial Hall was inscribed on the list of historic monuments as item A/5291/198 and received legal protection as a historic monument of significant artistic, historical, and scientific value whose preservation is in public interest.

The decision issued on April 15, 1977 (item A/5259/343/Wm) extended the area under protection over "The Complex of the Centennial Hall and former Exhibition Grounds" comprising of: the Centennial Hall, the Four Dome Pavilion, the Restaurant Pavilion (formerly Main Terrace Restaurant), the Pergola, the Colonnade, and the Iglica spire.
The decision issued on April 19, 2013 (item A/5867) extended protection to the former Pavilion of Industry of the Exhibition of the Reclaimed Territories, presently the seat of the Institute of Power Systems (Instytut Automatyki Systemów Energetycznych, IASE).
The decision issued on June 12, 2014 (item A-5926) extended protection to the former children's sanatorium and later one of the pavilions of the Exhibition of the Reclaimed Territories.
The decision issued on February 28, 2015 (item A/5953) extended protection to the so-called Hall of States, an exhibition pavilion which is currently the seat of the Center of Audiovisual Technology (Centrum Technologii Audiowizualnych, CeTA).

3.2.2. The Monument of History enacted in 2005

The status of the Monument of History is granted by the President of the Republic of Poland to listed monuments – material and non-material – of special historical, scientific and artistic value, well established in collective consciousness and significant for the cultural heritage of Poland. The Centennial Hall was granted the Monument of History status in the decree of the President of the Republic of Poland issued on April 13, 2005 (Dz. U. 2005, No. 64, item 570). The document stated that the goal of protecting the Monument of History "Wrocław – the Centennial Hall" is "preserving, for the sake of its special architectural and spatial value, a building regarded as one of the most important architectural works of the 20th century."

3.2.3. Inscribed on the UNESCO World Heritage List in 2006

Retrospective Statements of Outstanding Universal Value
Poland: Centennial Hall in Wrocław
WHC-14/38.COM/8E Doha, Quatar 15–25 June 2014.

Brief synthesis

The Centennial Hall in Wrocław, a milestone in the history of reinforced concrete architecture, was designed by the architect Max Berg and built in 1911–1913. The hall has a symmetrical quatrefoil ground plan with a huge circular central space covered by a ribbed dome topped with a lantern. It can accommodate up to 10 000 people.
The Centennial Hall is an outstanding example of early Modernism and the innovative use of reinforced concrete structures in the building industry. At the time of its construction, it was the largest ever reinforced concrete dome in the world. It played a significant role in the creation of a new technological solution of high aesthetic value, which became an important point of reference in the design of public spaces and in the further evolution of this technology. Drawing on historical forms, the building was a pioneering design responding to emerging social needs, including an assembly hall, an auditorium for theatre performances, an exhibition space and a sports venue. The building is a significant watershed in the history of Modern architecture.
The Exhibition Grounds, designed jointly by Max Berg and Hans Poelzig feature the Centennial Hall, which stand at the intersection of its principal axes, constituting an integral spatial whole. On the west side of Centennial Hall is a monumental square modelled on the ancient forum, which is preceded by the colonnade of the main entrance (built in 1925). To the north of the square stands the pavilion of the Historical and Artistic Exhibition,

now known as the Four Dome Pavilion, built in 1912–1913 according to a design by Hans Poelzig. In the northern part of the Exhibition Grounds the concrete Pergola encloses a pond. It is separated from the Centennial Hall by a building housing a restaurant with an open terrace.
The design of the Exhibition Grounds combined new elements with the southern part of the 19th-century Szczytnicki Park, which was used as the setting for thematic garden exhibitions, such as the Japanese Garden, as well as for the temporary Exhibition of Cemetery Art, a current reminder of which is the 18th-century wooden church relocated from Upper Silesia in 1912.

Criterion (i)**:** The Centennial Hall in Wrocław is a creative and innovative example in the development of construction technology in large reinforced concrete structures. The Centennial Hall occupies a key position in the evolution of methods of reinforcement used in architecture, and represents one of the climactic points in the history of the use of metal in structural consolidation.

Criterion (ii)**:** The Centennial Hall is a pioneering work of Modern engineering and architecture, which exhibits an important interchange of influences in the early 20th century, becoming a key reference in the later development of reinforced concrete structures.

Criterion (iv)**:** As part of the Exhibition Grounds in Wrocław, the Centennial Hall is an outstanding example of Modern recreational architecture that served a variety of purposes, ranging from hosting conferences and exhibitions to concerts, theatre and opera.

Integrity

The Exhibition Grounds, together with the Centennial Hall, have retained their compositional integrity within the boundary of the property. As a whole, they have retained their structural integrity and views on the property. Also, the use of the grounds is compatible with the originally intended functions.
Since the time of its construction, the Hall has remained a fully complete and unique facility in terms of structure and materials used. The building has undergone a series of renovations in order to maintain its structural condition and to replace installations in accordance with obligatory safety standards for public use buildings.
The property's boundaries include the entire existing central part of the Exhibition Grounds. After the end of the Centennial Exhibition in 1913, temporary architectural features and seasonal garden plantings were removed. Some permanent structures, such as the roof of the colonnade of the main entrance and the restaurant building with its open terrace, were destroyed during Second World War.
Despite some losses, the most important features situated on the two main axes of the Exhibition Grounds survive to this day: The Centennial Hall, the Four Dome Pavilion, the colonnade of the main entrance and the Pergola with its pond. The Japanese Garden and the wooden Baroque church have also survived.
In 1948, the composition of the Exhibition Grounds was supplemented with a steel spire designed by Stanisław Hempel, which was placed in the middle of the 'forum'.
All investment plans in the property and its buffer zone need to be assessed carefully to avoid adverse impacts on its Outstanding Universal Value.

Authenticity

The Centennial Hall and Exhibition Grounds within the boundaries of the inscription have retained their unique cohesive spatial layout and permanent compositional features. The Centennial Hall is a fully authentic building in terms of architectural form, specific construction technology and materials. The building is in good condition

100 UNESCO Director – General Koichiro Matsuura and the Mayor of Wrocław Rafał Dutkiewicz holding the certificate of Centennial Hall entry on the UNESCO World Heritage List in 2006, photograph, June 4, 2007. Museum of Architecture in Wrocław

following the completion of renovation work addressing its conservation as well as functional and technical modernization.
The structural condition of other features within the exhibition complex is varied, as is the state of preservation of their historic fabric. The property is used in accordance with its original intended functions.

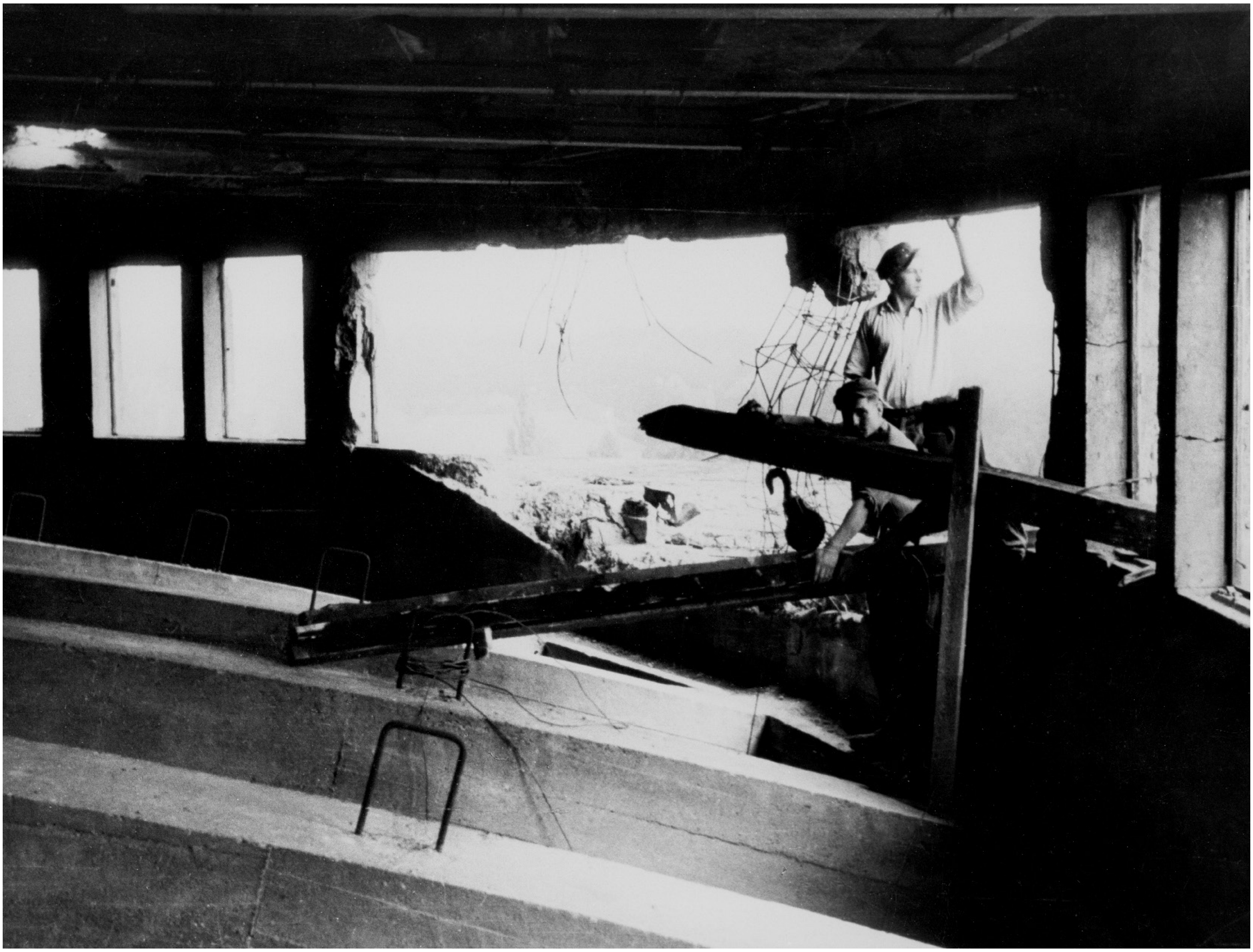
Protection and management requirements
The entire property (36.69 ha) is legally protected under regulations governing the protection of monuments, which are implemented by national and local conservation services.
The system of legal protection pertaining to the property has been supplemented by the perennial efforts of the local government, which has led to the entire area within the buffer zone (189,68 ha) being covered by local spatial development plans protecting the property at the level of by-laws in accordance with the provisions of the spatial planning and development act.
All conservation and investment works are preceded by pertinent historical studies and research as well as environmental analyses, taking into consideration the spatial context. Each operation requires that the proposed work be approved and relevant permission obtained from conservation services.
Responsibility for the property is shared by several legal entities with various profiles of activity, hence individual buildings and spaces are used for different functions. The main part of the Centennial Hall complex serves as an exhibition and conference centre and as a widely accessible recreational area, in keeping with its original intended purpose.
All investment plans in the property and its buffer zone must be subordinate to the protection of the Outstanding Universal Value, and the preservation of its character and historical spatial context.
Fulfilment of this objective will be through the implementation of a Management Plan for the area inscribed on the World Heritage List. The aim of this document is to coordinate activities related to the management and monitoring of the Centennial Hall complex and its buffer zone. The plan will ensure the sustainable use and functioning of the entire complex, taking into account social, environmental and economic issues, as well as the full use of its tourism potential and the landscape values of the property and its surroundings.

3.3. Conservation history and current state

3.3.1. Overhauls and changes at Centennial Hall in 1945–2007

Except for the last overhaul conducted in 2009–2011, the yearly dates indicate the time of the job's completion or the dates appearing on the design documentation preserved in the relevant files while the actual work might have been done later. It is also not certain whether all planned jobs were actually done. In many cases, there was no post-completion documentation. In most cases, the results of jobs completed prior to 2009 are no longer visible.
The list does not include the changes to the wiring system, plumbing, central heating, gas and fire protection systems, ventilation and acoustic systems, telephone and television systems if they did not involve construction work altering the building's architecture.

101 War damage to the Centennial Hall, photograph, 1945. Ossolineum, Wrocław



102 War damage to the Centennial Hall, photograph, 1945. Ossolineum, Wrocław

1946–1948

First, the building was temporarily secured and then the process of repairing war damages began. These repairs involved repairing the locally damaged terrace roofs of the dome, repairs and reconstruction of the damaged pillars of the dome's drum on the southern side. Replacement of yellow window glazing with colorless glass and repairing window frames. The organ was dismantled and transferred to the cathedral in Wrocław.

1960

Remodeling of office space (involving some construction work, wiring and central heating systems).

1972

Changing the color of the windows: planned but never completed.

1974

Overhaul of the skylights in the foyer. The documentation comprised of stocktaking and technical design/specification.

1978

Replacement of the reinforced-concrete elements of the ground floor attic. The design documentation by architect J. Stasiunkiewicz (1976) comprised of stocktaking, technical assessment of renovation methods, statistical calculations, design of the mold to cast the prefabricated elements of the attic.

1980

Conversion of some rooms for sports purposes (locker rooms, restrooms, showers). The technical specification comprised of construction work as well as changes to the wiring, ventilation, central heating, and plumbing systems.

1983–1984

Remodeling of some spaces into utility rooms to serve events organized at the Centennial Hall. The technical specification comprised of construction work as well as changes to the wiring and plumbing systems.

1985

New stairs built behind stage.

1985

Suspended ceiling and reinforced concrete stairs installed in three rooms whose original height was 5.93 meters.

1985–1987

Modernization of the principal reception room of the former "Below the Spire" café (kawiarnia "Pod Iglicą") and its food and beverage facilities (at present the Imperial Hall). The technical specification comprised of construction work and changes to the wiring, central heating, plumbing, ventilation, and fire protection systems.

1993

Replacement of three exterior doors with doors altered to conform to the design of the original ones.

103 Centennial Hall, interior, photograph, 1980. Museum of Architecture in Wrocław

104 Centennial Hall, interior, photograph, 1980. Museum of Architecture in Wrocław

1994

Partial replacement of the dome's windows (16 in the uppermost tier, 64 in the second tier from the top, 96 in the third tier from the top), overhaul of window frames in the three tiers.

1996–1997

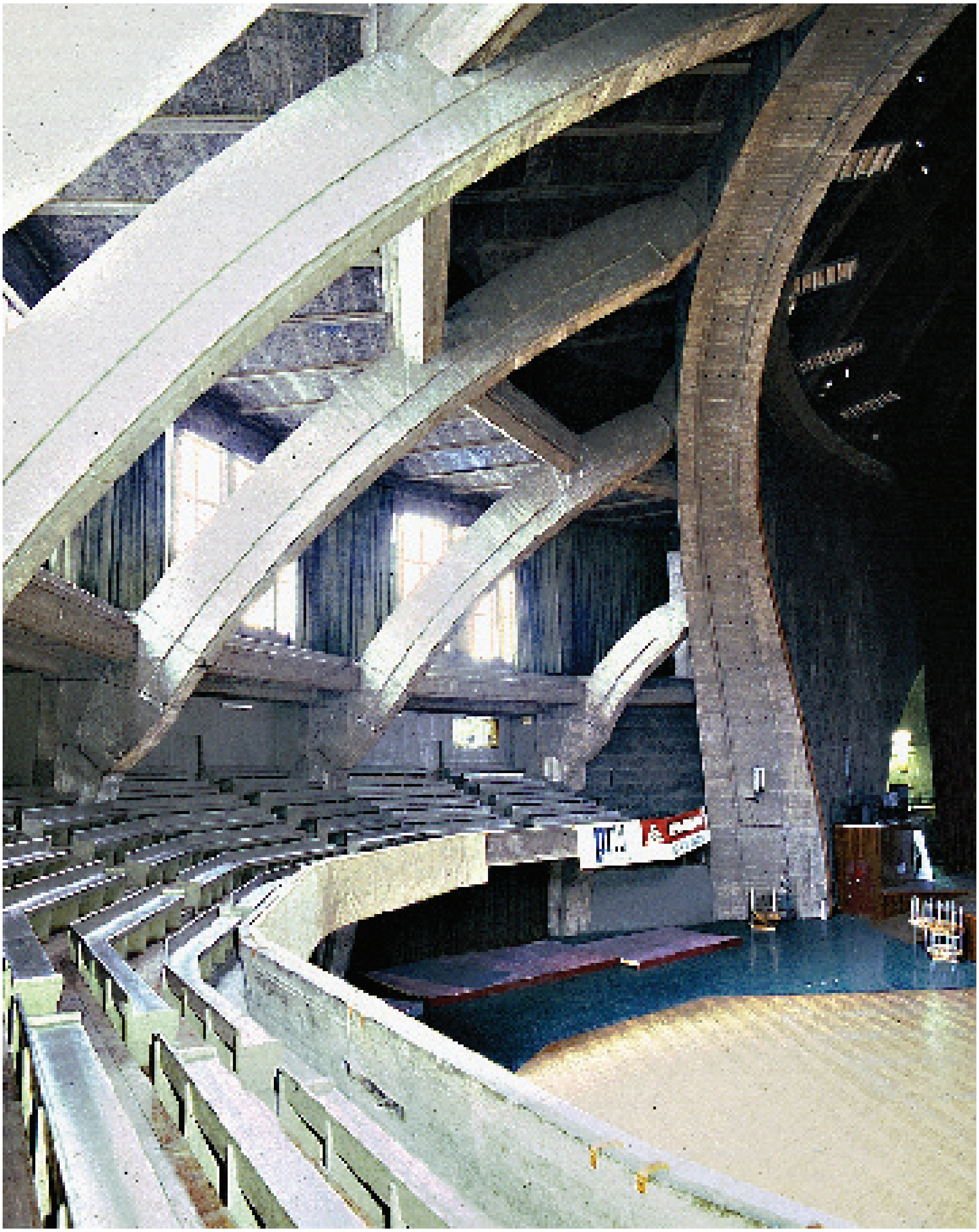
The interior of the Centennial Hall was modernized by Leszek Konarzewski whose designs won the competition for the conservation and modernization of Centennial Hall's interior. The jury was chaired by Hubert Jan Hanket, Dutch architect and President of DOCOMOMO-International Working Party for Documentation and Conservation of Buildings Sites and Neighborhoods of the Modern Movement. Work was done in the main hall under the dome, the main entrance hall, foyer, and on the roof of the building. The technical specification comprised of changing the interiors' color design, construction work, and changes to the sanitary, wiring, electroacoustic, television, ventilation, fire protection and audio-visual systems.

The Main hall

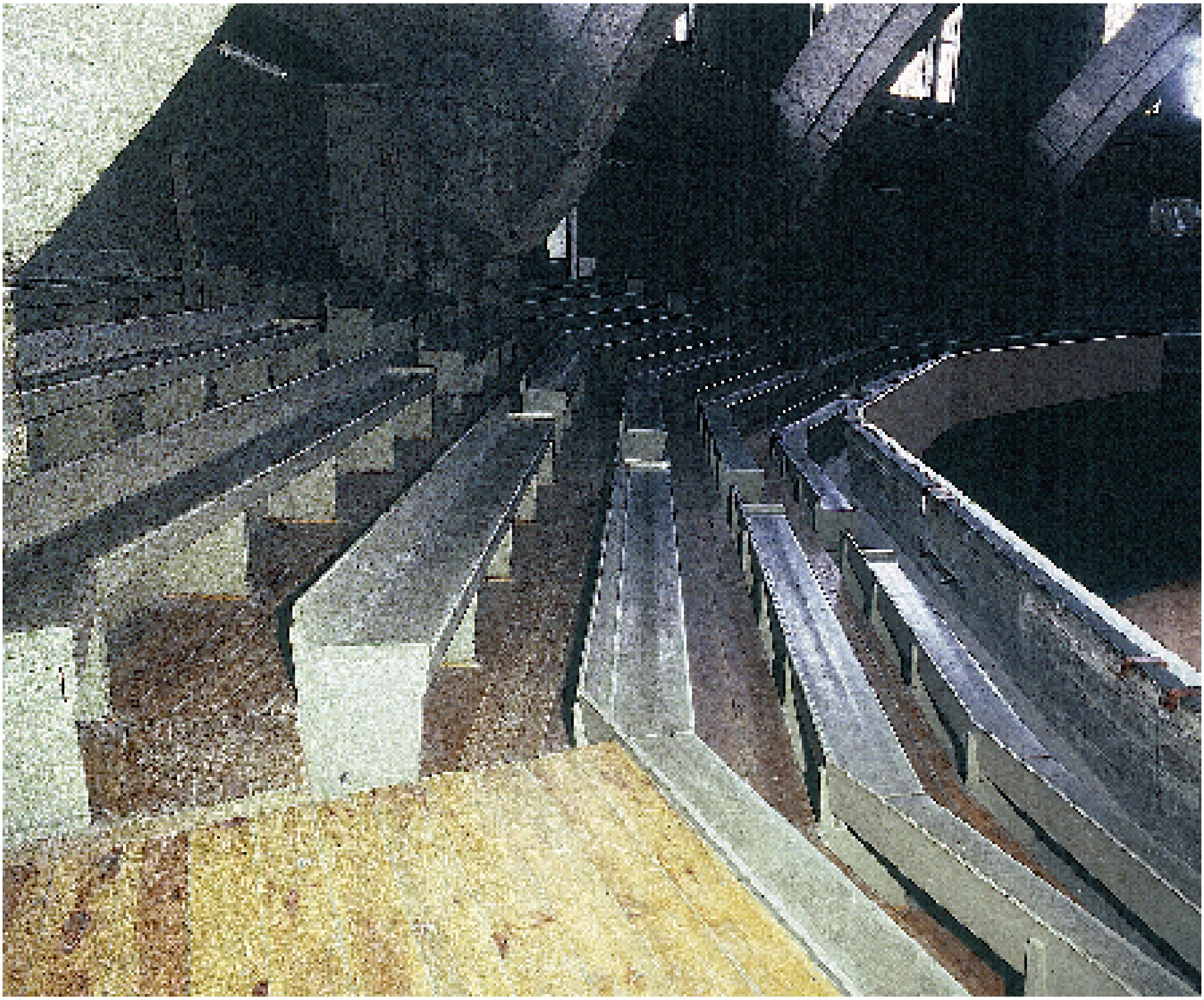
- injectable reinforcement of the auditorium and stage foundations (item 183, list A),
- rebuilding of the arena (lowering the floor level by 1.20 m),
- rebuilding of the eastern apse (stage): new reinforced concrete plate on the stand behind the stage, underground level: foundations, stairs, cable duct, screen channels,

105 Centennial Hall, view from the south, 2004. Photograph by Stanisław Klimek

106 Centennial Hal, view from the west, main entrance, 2004. Photograph by Stanisław Klimek



107 Centennial Hall, interior – main hall, 1998. Photograph by Waldemar Borski, Museum of Architecture in Wrocław



108 Centennial Hall, interior – main hall, 1998. Photograph by Waldemar Borski, Museum of Architecture in Wrocław

109 Centennial Hall, interior – main hall, 1998. Photograph by Waldemar Borski, Museum of Architecture in Wrocław

110 Centennial Hall, interior – main hall, 2004. Photograph by Stanisław Klimek

111 Centennial Hall, interior – main hall, 2004. Photograph by Stanisław Klimek

- rebuilding of the western (auditorium) apse including: the main entrance hall (overhaul of the reinforced concrete stand from the level of 0.00 to the level of + 5.94 m and construction of the reinforced concrete stand from the level of 6.29 upwards), balustrades and handrails,
- balconies of the southern and northern apses: an elevator and cargo lift, helical lift, platforms of steel grids, cable passages and vaults, acoustic screens and absorbers, removable platforms for the disabled in the galleries, and a balustrade on the exterior ramp for the disabled,
- installation of new seats in the western apse auditorium and balconies over the southern and northern apse,
- overhaul of the stairs leading from the foyer to the auditoriums on the southern and northern balconies,
- building of a ramp for trucks leading to the main hall

Roofs:
- new roofing and thermal insulation of the foyer roof
- replacement of skylight glazing in the foyer with organic glass

Foyer:
- overhaul of the restrooms (outside of the main entrance hall),
- overhaul of the polygonal rooms,
- overhaul of the flooring,
- overhaul of the window frames and metal furniture,
- partial replacement of the foyer windows,
- painting of the walls in accordance with the results of Jacek Żelbromski's stratigraphic tests to reconstruct their original color design,
- remodeling of the restaurant's interior.

1996
Modernization of the bar in the foyer and turning it into a restaurant offering a limited culinary selection.

1998
Adapting the main hall to accomodate boxing matches. Overhaul of the roof over the main hall.

1999
Installation of blinds in the dome's windows.

2000–2001
Adapting the mobile stands in the main hall for the needs of sports and stage events, with a new system of seat numbering. New ventilation system installed in the polygonal rooms. Overhaul of the four public restrooms (male and female facilities) and lavatories by the wardrobes in the back section of the foyer.

2004–2005
Modernization and overhaul of the foyer:
- remodeling of the four restroom complexes in the foyer,
- remodeling of the two restroom complexes in the foyer,

- air conditioning in the polygonal room, electrical and telephone wiring systems,
- replacing the exterior main entrance doors returning to the original form,
- revalorization of the internal doors in the vestibule of the main entrance hall,
- revalorization of the flooring and pillars in the main entrance hall,
- revalorization of the foyer walls in the space under the main auditorium in the western apse,
- revalorization of the walls of the southern side entrance hall,
- replacement of the flooring in the main entrance hall,
- revalorization of the stairs leading from the foyer to the auditorium,
- revalorization of the reinforced concrete portico columns,
- painting of the walls and ceilings in the main entrance hall, the southern and eastern side entrance halls and the Imperial Hall in accordance with the new findings regarding the original color design,
- replacement of the external doors in the northern, southern and eastern side entrances
- replacement of the external evacuation doors in the foyer,
- replacement of the windows in the foyer on the ground floor,
- revalorization of the internal doors of the side entrances, the polygonal rooms and the remaining doors leading to the utility rooms,
- revalorization of external door between the south side entrance and the south-east polygonal room entrance,
- revalorization of the side doors between the main hall and the foyer,
- revalorization of the stonework in the south-west polygonal room,
- painting of the walls and ceilings of the foyer's left section, north side entrance hall, the north-west and north-east polygonal rooms, and the bottom sections of the skylights,
- construction work in the foyer between the north-east polygonal room and the east entrance hall,
- overhauls of the cold water piping in the basement,
- air conditioning and heating in the north-west polygonal room,
- ventilation of the right section of the foyer in the main entrance,
- ventilation of the left section of the foyer in the main entrance,
- replacement of the wiring system in the south side entrance hall,
- replacement of the wiring system in the north side entrance hall and the north-west and north-east polygonal rooms,
- tele-technical wiring systems in north side entrance hall and the north-west and north-east polygonal rooms,
- remodeling of the restaurant and adapting it for an art gallery.

2006–2007

Modernization of the bar (Bar Max) in the foyer's south-western section. Overhaul of the roof (including skylights) in the foyer zone: replacement of the thermal insulation, skylights and new lighting rods. Repairing the attic over the foyer and its mounting. Repairing the main entrance portico columns.

3.3.2. Overhaul and conservation of Centennial Hall in 2009–2011

2009

Revalorization of the façade, window frames, and roofing; reinforcing the dome's lower ring.

The revalorization of the building's concrete façades was preceded by a technical assessment and stratigraphic tests of the concrete surfaces. The following jobs were completed in this phase of the project:

112 Centennial Hall, interior – main hall renovation, 2011. Photograph by Mirosław Łanowiecki, Museum of Architecture in Wrocław

113 Centennial Hall, interior – main hall renovation, 2011. Photograph by Mirosław Łanowiecki, Museum of Architecture in Wrocław

- cleaning of the façades using a safe jet-stream wet sanding method in two stages: the first stage involved a delicate washing and cleaning of the whole concrete surface to prevent damages to the original texture of the wood formwork impressed in the wet concrete; the second stage involved a more intense cleaning of the areas requiring repair,
- repairing damaged areas (taking steps to protect the steel reinforcement), reconstructing the original texture effects to match the adjoining areas,
- reinforcing concrete structures by impregnating them with a vapor permeable solution,
- applying thin translucent layers of paint to mimic the original color of concrete and unify its appearance.
- revalorization of the window frames (except for the windows in the foyer's ground floor which had already been replaced during the previous overhauls in 1997–2006) – altogether 613 windows and three doors in the dome, and 33 windows and two doors in the basement.

The conservation program was based on a detailed assessment of the condition and conservation needs done in 2007. The following jobs were completed:

- taking down the window frames and casements, marking them and transporting to the workshop in special crates,
- cleaning the frames (after removing glass and furniture) using a thermal and mechanical method, then polishing and repairing (filling in) damaged areas,
- replacing window frame elements biologically or mechanically damaged beyond repair, replacing windows damaged by more than 50% with faithful reconstructions,
- impregnating and painting,
- glazing the windows with yellow ornamental glass,
- mounting the windows in their original openings.
- revalorization of the window frames of the foyer's ground floor: the windows replaced in 1997–2006 were altered to conform to the appearance of the original windows.

The project involved:

- replacing the internal mounting bars with external bars,
- adding wooden drip molds to window casements.

Revalorization of the building's roof:

- thermal insulation of the flat roofs on all levels of the dome,
- covering with roofing paper and copper sheeting,
- revalorization of steel elements: foldable flagpole, octagonal grid platform around the flagpole, external ladders, balustrade on the staircase's roof.

Reinforcing the bottom ring of the dome.
Following the technical assessment of the ring's structure, the decision was made to install additional reinforcements in the form of steel cables stretched over the ring's surface, which protected against fire and corrosion: 27 ropes of zinc-covered wires in lubricant-filled HDPE (high-density polyethylene) tubing with a diameter of 15.7 mm, making up nine cables in plastic tubing (50 mm diameter) filled with concrete. The reinforcement covered with a layer of low contraction concrete matched the texture and color of the façade.

2011
Overhaul of the interior.
The project involved construction work and the total replacement of the plumbing, central heating, ventilation,

114 Centennial Hall, interior – foyer renovation, 2011. Photograph by Mirosław Łanowiecki, Museum of Architecture in Wrocław

115 Centennial Hall, interior – foyer renovation, 2011. Photograph by Mirosław Łanowiecki, Museum of Architecture in Wrocław

116 Centennial Hall, interior – north side entrance hall renovation, 2011. Photograph by Mirosław Łanowiecki, Museum of Architecture in Wrocław

117 Centennial Hall, interior – main entrance hall renovation, 2011. Photograph by Mirosław Łanowiecki, Museum of Architecture in Wrocław

118 Centennial Hall, view from the north, 2014. Photograph by Mirosław Łanowiecki, Museum of Architecture in Wrocław

air conditioning, wiring, telecommunication, low-voltage wiring, fire protection, computer, and security systems. The following jobs were completed:

The main hall

- rebuilding of the floor: raising the floor to its original level while expanding the underground zone and descending to –3.70 meters,
- rebuilding of the stands and replacing seats; taking down the concrete auditorium built in 1996 and installing a reinforced concrete understructure for telescopic steel stands,
- installing ventilation units and artificial ventilation ducts in ceiling voids and under the auditorium,
- replacing the “Heraklith” absorbing cladding on the four pillars supporting the dome and in the auditorium,
- placing new thermal insulation on the underside of the ring floor over the auditorium,
- installing smoke flaps in the dome’s uppermost ring,
- reinforcing the lantern’s structure with carbon fiber tapes,
- replacing metal window shutters with fully automatic inflammable textile blinds.

In the foyer:

- placing new concrete flooring (in connection with the need to make a channel to accommodate plumbing and heating systems), reconstructing the original dilatation system from 1913 obliterated by previous overhauls,
- replacement of all installation systems,
- refurbishing the entrances: removing the non-original stone slab facing installed in 1936–1937, removing the suspended ceiling in the western side entrance hall, completely uncovering the original architectural structure of the raw concrete walls in the western side entrance hall and partially in the southern and northern side entrances halls, cleaning the concrete using a closed circuit water stream with detergent, repairing damaged areas, reconstructing the original texture and color to the concrete walls,
- remodeling the rooms accessed from the foyer: four locker rooms for sports teams, rooms for coaches, and service rooms,
- dismantling all office and utility rooms in the foyer put in after 1913,
- arranging a new utility room (partition walls) to the east of the south-eastern polygonal room,
- enlarging the restrooms.

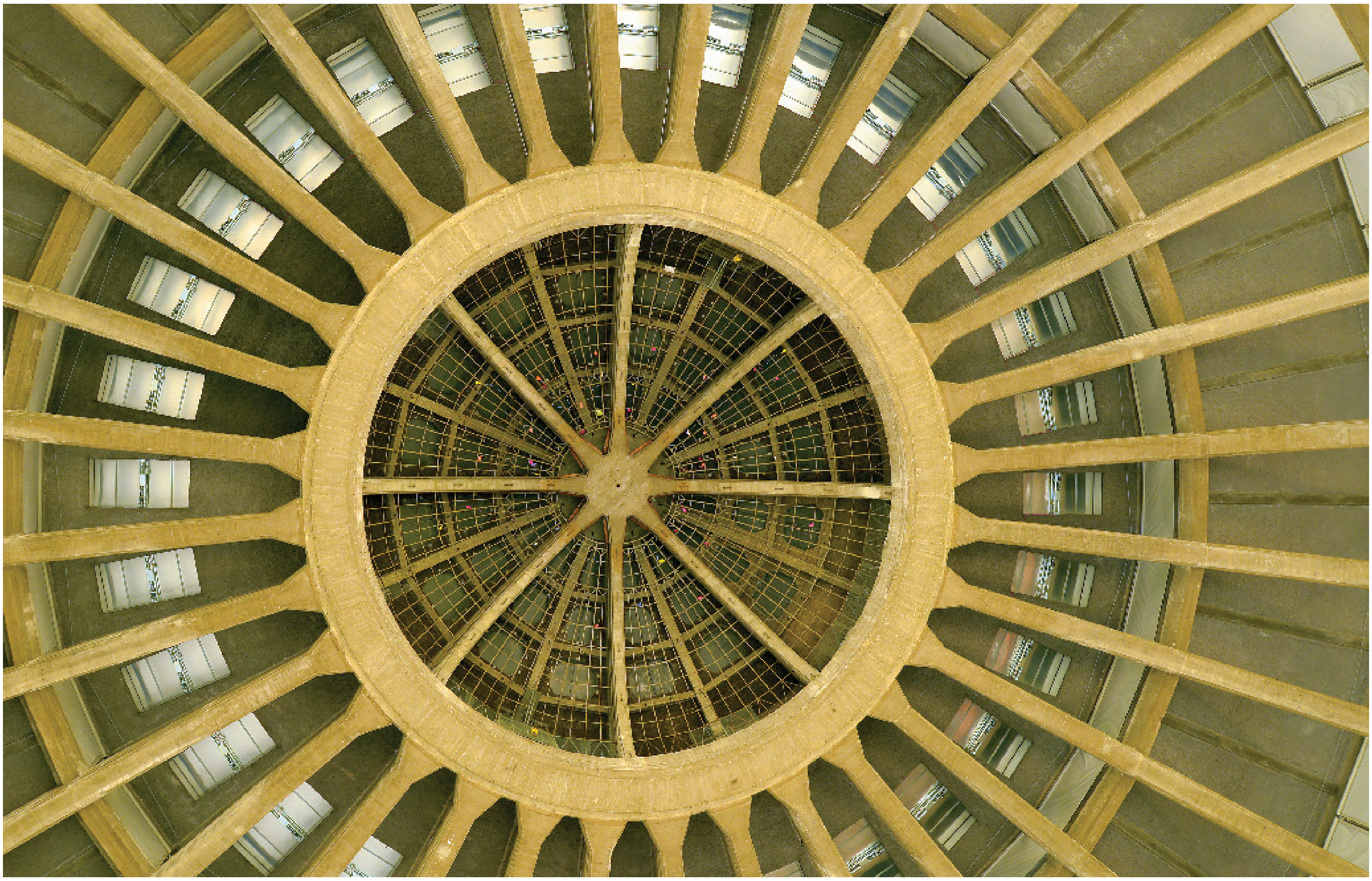
In the Imperial Hall:

- implementing stratigraphic tests to reconstruct the original wall finishings and color design,
- installing new hardwood flooring and painting the walls,
- installing an air conditioning system,
- modernization of the adjoining utility space.

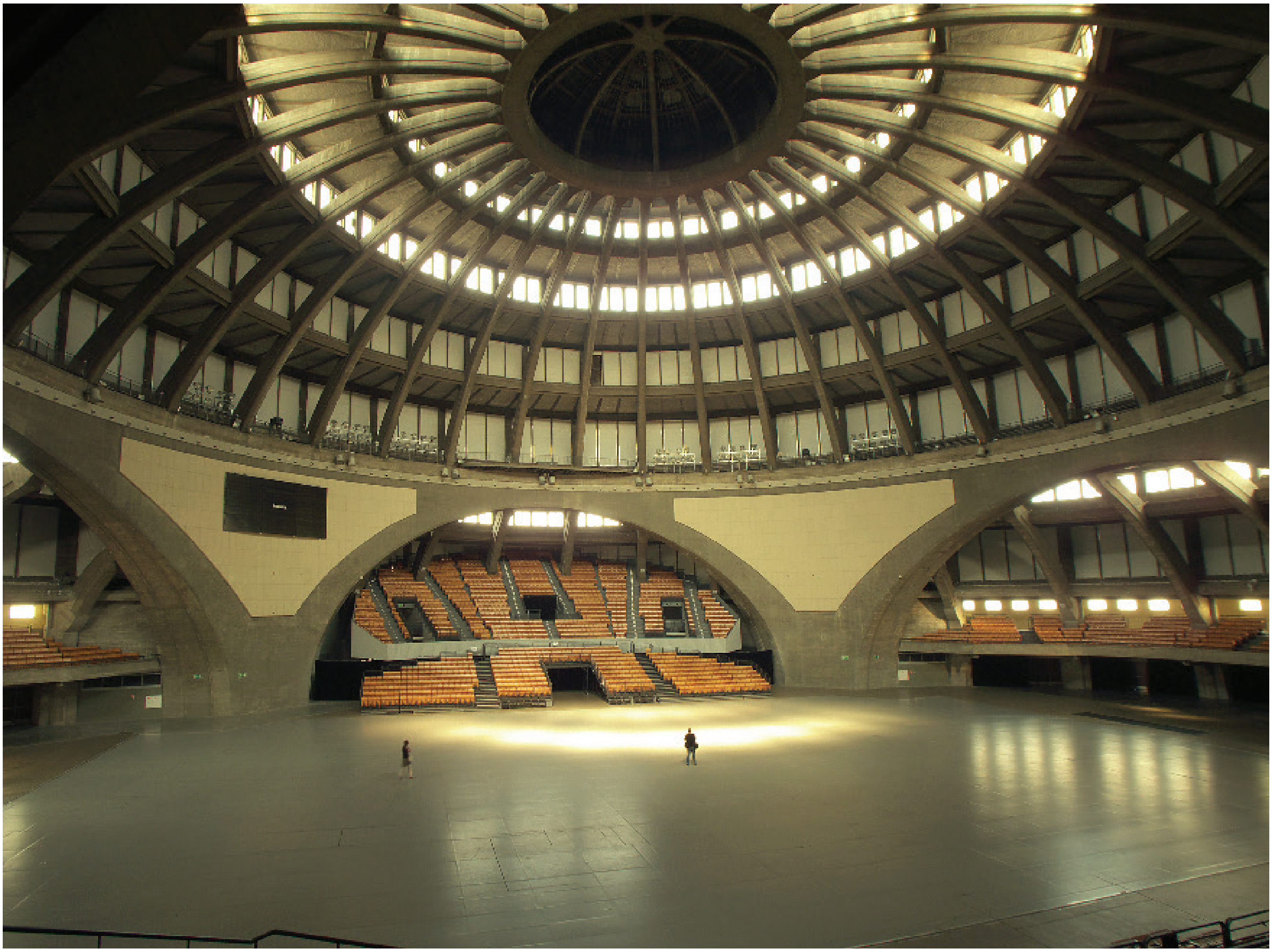
2011–2012

In the foyer’s south-western section, a museum exhibition called Centrum Poznawcze (“Learning Center”) was installed. It is devoted to the history of the Centennial Hall and Modernistic Movement in Wrocław, Germany, the world as well as the Modernist buildings inscribed on the UNESCO World Heritage List.

119 Centennial Hall, view from the west, main entrance, 2015. Photograph by Mirosław Łanowiecki, Museum of Architecture in Wrocław



120 Centennial Hall, interior, dome ribs, 2015. Photograph by Mirosław Łanowiecki, Museum of Architecture in Wrocław



121 Centennial Hall, interior – main hall, 2015. Photograph by Mirosław Łanowiecki, Museum of Architecture in Wrocław

122 Centennial Hall, interior – foyer, 2015. Photograph by Mirosław Łanowiecki, Museum of Architecture in Wrocław

3.3.3. State of preservation

The Centennial Hall's state of preservation is good as conformed by the technical inspection conducted in the process of developing the CMP. The overhauls and conservation work carried in 2009-2011 were aimed at preserving the authenticity of originally used building materials using technologies consistent with their historic character. Contemporary standards required of public buildings were met according to the principle of adding systems to the existing structure, without affecting the original structural elements. The new elements were integrated into the building's aesthetic expression as at the time of its completion in 1913. Because of budgetary constraints and cost involved, the restoration of the original appearance of the main entrance hall and the foyer with the polygonal rooms was only partial.

The state of preservation of the remaining buildings and structures on the Exhibition Grounds is as follows:

- The Main Terrace Restaurant: good condition, following an overhaul and extension,
- The colonnade of the Pergola: fair condition, locally visible deflection of the columns, testing and development of a repair method is necessary,
- The IASE building: good condition following an overhaul and partial remodeling; the adjoining site of the no longer existing Messehalle (exposition hall) of 1925 is now used as a parking lot,
- The Four Dome Pavilion: good condition following an overhaul and partial remodeling to adapt the building for the Contemporary Art Museum, with its branch of the National Museum in Wrocław,
- The former Hall of States, at present Center of Audiovisual Technology CeTA (Centrum Technologii Audiowizualnych): fair condition, the building is in the need of an overhaul,
- Building of the Children's Sanatorium (the so-called Pavilion "Under the Bears"); bad condition, the building needs a major overhaul,
- House on Zygmunta Wróblewskiego Street 2a: bad condition, the building needs a major overhaul,
- Greenery on the Exhibition Grounds: good to fair condition. The trees need more extensive care.

4.

Key issues

4. Key issues

4.1. Ownership and management of Centennial Hall and the Exhibition Grounds

History of ownership and management of the building:

- From 1913, the Centennial Hall built on the plot owned by the City of Wrocław was managed by the dedicated Magistrate Department,
- From 1925, the Centennial Hall and Exhibition Grounds were managed by Breslauer Messee G.m,b.H., a limited liability company in which the City of Wrocław was the majority shareholder,
- In 1945, the Centennial Hall and Exhibition Grounds became the property of the State Treasury,
- In 1948, the State Treasury entrusted the management of the property to the Municipality of Wrocław but the property rights to the land were not transferred. Until 1982, the Centennial Hall was under the management of Municipal agency responsible for the management of parks, green areas and recreational facilities in the city (Zarząd Terenów Zielonych Miasta Wrocławia) and functioned as Wrocław's Park of Culture and Recreation (Wrocławski Park Kultury i Wypoczynku),
- In 1982, the management of the property was transferred to the Office of the Voivodeship,
- In 2000, the Minister of the State Treasury enacted the transformation of the state enterprise WP People's Hall Ltd. (Wrocławskie Przedsiębiorstwo Hala Ludowa Sp. z.o.o.) into a commercial limited company, and at the same time taking over 100% of its shares,
- In 2005, the State Treasury transferred 75% of its shares to the Voivodship of Lower Silesia and by the end of the year, the partners – State Treasury and Voivodship of Lower Silesia – agreed for a third partner, the Municipality of Wrocław (Gmina Wrocław), to join the company,
- From 2006, the Municipality of Wrocław (Gmina Wrocław) successively took over the company shares reducing the shares of the other partners (Voivodeship of Lower Silesia, State Treasury and the company's employees who had, in the meantime, acquired shares in the process of the company's commercialization),

By the end of 2015, the ownership structure was as follows:

- Gmina Wrocław: 97,87%
- Voivodship of Lower Silesia: 2,03%
- Employees: 0,10%

At present, the Municipality of Wrocław (Gmina Wrocław) owns the majority stake in Centennial Hall's ownership structure, decisions concerning its future are in the hands of the local government. This consolidation of ownership and consequently of responsibility and the decision-making process, is an important factor facilitating the management of the heritage site. It must be emphasized, though, that the situation of the Exhibi-

123 Centennial Hall, European Culture Congress, 2011.
Archives of Wrocławskie Przedsiębiorstwo Hala Ludowa Sp. z o.o.

124 Centennial Hall, European Culture Congress, 2011.
Archives of Wrocławskie Przedsiębiorstwo Hala Ludowa Sp. z o.o.

125 Centennial Hall, European Culture Congress, 2011. Archives of Wrocławskie Przedsiębiorstwo Hala Ludowa Sp. z o.o.

126 Centennial Hall, European Culture Congress, Krzysztof Penderecki and Jonny Greenwood concert, 2011.
Archives of Wrocławskie Przedsiębiorstwo Hala Ludowa Sp. z o.o.

127 Centennial Hall, European Culture Congress, Krzysztof Penderecki And Jonny Greenwood concert, 2011. Archives of Wrocławskie Przedsiębiorstwo Hala Ludowa Sp. z o.o.

tion Grounds as a whole is different. Here, ownership is dispersed which makes the protection of the historic complex more difficult.

4.2. Target groups: scopes of interest of external stakeholders/subjects

On the basis of the collected data regarding various interest groups and their actual influence upon the decision-making process concerning the building, two target groups may be distinguished:

First Degree Group: comprising of the stakeholders who have direct influence upon construction projects carried out in the area of the Centennial Hall and possessing the rights and competences in the area of conservation.

Second Degree Group: subjects with no direct influence over conservation decisions but relevant and important because of their interests in the direct geographical and social ambience of the Centennial Hall.

According to this classification, the First Degree Group comprises mostly of individuals holding management rights in the area covered by the present study: the Municipality of Wrocław (Gmina Wrocław), the Mayor of Wrocław (Prezydent Wrocławia), the City Council (Rada Miejska), the Municipal Inspector of Historic Monuments (Miejski Konserwator Zabytków), the Planning Bureau of the City of Wrocław (Biuro Rozwoju Wrocławia), the City Architect (Architekt Miejski) and two companies controlled by the Municipality of Wrocław: the state enterprise WP People’s Hall Ltd. (Wrocławskie Przedsiębiorstwo Hala Ludowa Sp. z.o.o.) and Management of Urban Greenery (Zarząd Zieleni Miejskiej). The group also includes other institutions which have influence over the decision-making process with regards to the heritage site’s management: the local government of the Voivodeship of Lower Silesia, Marshall of the Voivodship of Lower Silesia (Marszałek Województwa Dolnośląskiego), the Assembly of the Voivodeship of Lower Silesia (Sejmik Województwa Dolnośląskiego), as well as national institutions: the Ministry of Culture and National Heritage (Ministerstwo Kultury i Dziedzictwa Narodowego), National Heritage Institute (Narodowy Instytut Dziedzictwa), UNESCO Committee (Komitet do spraw UNESCO), Voivodeship of Lower Silesia (Województwo Dolnośląskie), Voivode of Lower Silesia (Wojewoda Dolnośląski), and Inspector of Historic Monuments of the Voivodship of Lower Silesia (Wojewódzki Konserwator Zabytków). Various private and public entities also belong to the group that uses the Centennial Hall, including organizers and participants in various projects and events, tourists, and entrepreneurs.

The Second Degree Group comprises of holders of property rights in the Exhibition Grounds area and its immediate surroundings, in particular:

- Center of Audiovisual Technology (Centrum Technologii Audiowizualnych – CeTA),
- The National Museum in Wrocław (Muzeum Narodowe we Wrocławiu),
- The Institute of Power System Automation Ltd. (Instytut Automatyki Systemów Energetycznych Sp. z o.o. – IASE),
- Municipal Department of Road Management and City Maintenance (Zarząd Dróg i Utrzymania Miasta),
- Local community boards,
- The Zoological Garden (ZOO Wrocław),
- Residents of the former WUWA housing development,
- The Lower Silesian Chamber of Architects (Dolnośląska Okręgowa Izba Architektów),
- The National Labor Inspectorate (Państwowa Inspekcja Pracy),
- The Academy of Physical Education (Akademia Wychowania Fizycznego),
- The Polish Academy of Sciences (Polska Akademia Nauk),
- University of Wrocław (Uniwersytet Wrocławski),
- Schools and preschools,
- Local businesses,

- Citizens of Wrocław,
- Non-government organizations, including Szczytnicki Park Initiative (Akcja Park Szczytnicki), Beautifying the City of Wroclaw Society (Towarzystwo Upiększania Miasta Wrocławia), and the Friendly Island Association (Stowarzyszenie Przyjazna Wyspa).

4.3. Visitor and public access

Visitor and public access to the Centennial Hall has always required coordination enabling two different groups of visitors access to the building: those visiting the building because of its architectural value and those organizing and attending various events. The task often proved very challenging. In 2012, following the completion of the long revitalization process, the Learning Center opened in the foyer of the Centennial Hall making it possible to learn about Centennial Hall's history even when other events took place on the premises. It is also possible to enter the main hall when no events are staged there. This solution has very much improved the conditions for visiting the Centennial Hall.

The main hall has continued to serve mostly in the participation of mass events regularly staged at the Centennial Hall. Following the revitalization program, the Centennial Hall has a modern system of reservations and event organizations and a much broader commercial offer, first of all thanks to the improvement and modernization of the infrastructure supporting the organization of cultural and business events. In addition to the revitalization of Centennial Hall's building and equipping it with modern multimedia systems, the opening of Wrocław's Convention Center (Wrocławskie Centrum Kongresowe) in the former Terrace Restaurant has played a major role. Another key factor is the dynamic growth of the number of recreational visitors to the Exhibition Grounds as a result of the comprehensive revitalization of the complex, including the installation of the Multimedia Fountain in the area of the historic Pergola and the construction of an underground parking garage.

4.4. SWOT analysis of conservation with respect to Centennial Hall's management

Strong points	Weak points
• completed revitalization process • consolidation of ownership and management • organized system of the building's use	• no permanent solution regarding the building's conservation process in accordance with the standards and requirements regarding the protection of historic monuments holding the highest level of protection • dispersed ownership in the Exhibition Grounds' area • low level of social awareness regarding the need to implement proper conservation principles and practices
Chances	**Risks**
• possibility of implementing clear conservation procedures • involvement of experts in various disciplines for consultations and promotion • developing and implementing good practices	• risk of completed projects is not in accordance with the CMP • inconsistencies in conservation policies implemented at various levels

4.4.1. Strong points

Completed revitalization process

The experience gained in connection with the long and complex revitalization process completed in 2013 facilitates adequate planning of future actions related to revalorizations. With the costly overhaul completed, the focus may now shift to proper maintenance and the needed repairs.

Consolidation of ownership and management

The present consolidated ownership situation is conducive to establishing the building's management, maintenance and exploitation procedures.

Functionality

Having completed Centennial Hall's revitalization, procedures were implemented to regulate the use of the building and its adjoining structures. To ensure control over the increased flow of visitors using the infrastructure, procedures were devised to ensure proper use of the building as well as to minimize any potential wrongdoing.

4.4.2. Weak points

Lack of a permanent solution regarding the building's conservation process in accordance with standards and requirements of protection of historic monuments containing the highest level of protection.

At present, there is no permanent solution for the building's conservation process which would take into account special conservation standards governing Centennial Hall and its status as a historic monument with the highest level of protection. During the recent revitalization project of 2007–2011, this problem was solved by establishing a Conservation Advisory Board to act as an agency of the Executive Board at WP The People's Hall Ltd. (Wrocławskie Przedsiębiorstwo Hala Ludowa Sp. z o.o.) which was responsible for supervision and had the capacity to oversee the revitalization project.

Dispersed ownership in the area of the Exhibition Grounds

Presently the Exhibition Grounds – a site inscribed on the UNESCO World Heritage List – is the property of several public institutions. This situation (on many occasions criticized by UNESCO) has caused problems with ensuring the conservation protection of the whole site and the implementation of good practices developed in the revitalization process of the Centennial Hall.

Low level of social awareness regarding the need to implement proper conservation principles and practices

At present, target groups have insufficient knowledge regarding the value of Centennial Hall and the necessity to implement proper conservation procedures and practices. In a building of this stature, it is essential to preserve as much of the original fabric as possible. The CMP should provide the basis for the necessary educational programs.

4.4.3. Chances

Possibility of implementing clear conservation procedures

The present document (CMP) should be the source of guidance for the use and conservation of the Centennial Hall in the future. It can also serve as a model with regard to other historic buildings and structures on the Exhibition Grounds.

Involvement of experts in various disciplines for consultations and promotions
The present situation – having undergone a comprehensive revalorization the Centennial Hall along with its management collaborate with a large group of Polish and international experts – making it possible to establish a permanent advisory board whose members act as ambassadors of the Centennial Hall and its conservation and promotional projects. The CMP may serve as an instrument assisting such activities.

Developing and implementing good practices
As a pioneering project in Poland, the CMP can serve as a good example and model not only for the structures in Centennial Hall's surroundings but also for other monuments in Poland by introducing a new quality to conservation management.

4.4.4. Risks

The risk of carrying out projects not in accordance with the CMP
A potential risk in the process of the building's use in the future may result in the company's management being pressured to increase profits at the cost of the building's historic fabric. The CMP presents a comprehensive state of knowledge regarding the Centennial Hall from the time of its construction until the present day and should be the only basis assisting future conservation decisions to prevent any harmful and irreversible actions.

Inconsistencies in conservation policies implemented at various levels
Because different levels of protection apply to the Centennial Hall and the Exhibition Grounds, both of which are inscribed on the UNESCO World Heritage List, there is the potential risk that the lower protection levels might be applied with regard to projects carried out in the future. The CMP introduces the principles that will ensure the proper level of conservation protection is employed.

5.

Conservation recommendations and action plan

5. Conservation recommendations and action plan

5.1. General conservation recommendations for the Centennial Hall

The conservation recommendations precisely define the scope of protection of the values that provided the basis for inscribing the Centennial Hall and Exhibition Grounds on the UNESCO World Heritage List in 2006. These values are defined in the Retrospective Statement of Outstanding Universal Value (RSOUV) issued in 2014. Protecting the values of the Centennial Hall as specified in the RSOUV: its authentic architectural form, specific building techniques and materials, should govern the choice of methods to carry out revalorizations and conservation work. All modernization projects must be guided by the principle of preserving the OUV and must always take precedence over the needs of the contemporary user. This requires that each conservation and/or construction project must be preceded by relevant detailed historic studies, technological tests, and first of all an analysis of the potential impact of the project upon the Outstanding Universal Value. According to the Operational Guidelines for the Implementation of the World Heritage Convention, before the final decision is made the documentation should be sent by the investor to the National Heritage Institute (Narodowy Instytut Dziedzictwa) which may turn to the UNESCO World Heritage Center for an opinion.
According to the RSOUV, Centennial Hall's original 1913 features include: its plan, architectural form and façades including window and door frames, interiors, their original décor and furnishings and are subject to absolute protection.

Based on the analysis of the original spatial conception of the Exhibition Grounds and the buffer zone, the guidelines for any future development projects have been defined in accordance with the same principles stipulating the precedence of the features specified in the RSOUV over any contemporary development projects. Also in this case, the design process should be preceded by historical studies and a detailed analysis of the project's potential impact upon the original spatial conception of the Exhibition Grounds.

As required by law, any conservation and revalorization work undertaken in the area of the Exhibition Grounds must be carried out under close heritage conservation supervision and in accordance with the obtained con-

servation permit and documentation that was approved by the relevant Inspectorate of Historic Monuments. It is also recommended that prior to issuing any decisions concerning conservation work, new development projects or extensions of existing buildings, the Inspector of Historic Monuments should be contacted to provide expert opinions of specialists in the history and protection of Modernist architecture.
A periodic technical condition check that is required by the construction law regulations should be performed according to the detailed conservation recommendations specified in the CMP.
In the case of the buildings which total roof surface exceeds 1000 m^2 (under the construction law from 7.07.1994) the technical condition check needs to be performed twice a year, until 31 of May and until 30 of November. The range of the check includes: building and installation parts exposed to the destructive influence of weather and the elements, including, for example: outer wall parts (attic, pillars, cornices, balconies, loggias, balustrades) windows, doors, roofing, flashing, general condition of the indoor installations, basement, staircases, gutters and downspouts.

5.2. Detailed conservation recommendations for Centennial Hall

Defining the levels of conservation protection.

Three levels of the conservation protection of the Centennial Hall have been defined:

SIGNIFICANT – concerning some utility spaces arranged within the building's original structure in connection with the construction of the eastern and western auditorium in 2011, all technical, utility, and sanitary areas located in the underground level that were constructed in 2011 and are located under the principal interior.

HIGH SIGNIFICANCE – constituting the remaining utility and technical spaces from 1913, partially remodeled in 1937 or 2011.

VERY HIGH SIGNIFICANCE – comprising of the main hall, Imperial Hall, foyer with polygonal rooms and the four entrances with their vestibules. These are the interiors in which most of the original elements have been preserved. Likewise, the highest level of conservation protection applies to the façades as well as the windows and door frames.

In accordance with the above principles, the following scope of protection and guidelines are set:

5.2.1. Centennial Hall building

The building is in good state. In 2009, conservation of the façades and windows was conducted and doors were repaired. In 2011, the interior was overhauled and the technical rooms were built under the main hall.

OBLIGATORY

- The building plans and architectural shape of Centennial Hall cannot by altered by any remodeling or extensions.
- The authenticity of structural elements must be preserved.
- The layout of the building's interior should be preserved in its present form, including the monumental main hall covered with a ribbed dome, the foyer, polygonal rooms, the four entrances, the Imperial Hall over the main entrance hall and the utility rooms.

- Annual detailed inspections of the state of preservation of the building's original elements must be carried out by conservation agencies.
- In the case of revalorization work planned in areas where conservatory research was previously not conducted, such tests should be supplemented, by stratigraphic tests of painted surfaces.

RECOMMENDED

All technical systems must fit into the current design of the Centennial Hall, and preferably accommodated in the basement and technical channels under the foyer's floor. Any interventions into the building's original structure in order to make new channels for technical systems are unacceptable. Regarding the new technical systems required by special regulations concerning public buildings, legal options should be considered for departing from the standards or individual solutions to preserve the aesthetic expression of the interiors to which the highest level of conservation protection applies.

5.2.1.1. The main hall of Centennial Hall

An overhaul was carried in 2011. The original structure from 1913 has been preserved in its entirety. In 2011, the non-original paneling was removed from the walls of the four pillars supporting the dome and the original raw concrete wall uncovered. Likewise, the non-original lining boards were removed from the underside of the terrace roofs of the ribbed dome uncovering the original structure. The two auditoriums (eastern and western) are new elements built in 2011. They have replaced the non-original structures erected in the 1930s that were remodeled several times. The original flooring from 1913 has been preserved.

OBLIGATORY

- The ground floor level in the main hall, which corresponds to the original from 1913, must be preserved. It is very important to preserve the interior's original proportions designed by Max Berg.
- It is not acceptable to remodel or add any permanent elements to the existing eastern and western auditoriums and balconies of the southern and northern galleries. It is permissible to install temporary structures for the duration of sporting events or sets for spectacles and cultural events.
- It is vital that the original surface treatment of the reinforced concrete internal walls, deprived of any painted layer and showcasing the imprints of wooden formwork in wet concrete, is preserved. Consequently, the walls, pillars supporting the dome, and the dome's ribs cannot be used for hanging any temporary decorations or structures intervening into the building's historic fabric.
- The only acceptable method of conserving the walls is washing them with water and detergents purpose-selected by specialist in conservation. Only larger missing fragments can be filled-in with mortar whose structure matches the original concrete structure and then the fillings should be treated to make their texture match the original wall surface.

RECOMMENDED

- If the replacement of the acoustic screens installed in 2011 on the pendentives over the four main pillars supporting the dome is undertaken, their bottom section should be corrected in correspondence with the original design from 1913. Moreover, the color should correspond with the original color of the concrete wall after it has been cleaned.
- The spatial arrangement of the southern and northern galleries should be left unchanged.
- It is recommended that the color of the external walls of the passage behind the seats on the galleries'

balconies should be converted from the present yellow to grey, corresponding as closely as possible with the original color of the adjoining concrete elements. The paint should be selected with no additives changing the texture of the painted surface. An alternative solution is to uncover the concrete walls' original surface with the textural effects of the wooden formwork impressed in wet concrete.

- The balcony of the second organ, placed on the western side on the level of the dome's bottom ring, requires an overhaul which must preserve the original structural elements, including the metal balustrade.
- The original open-work steel dust screen structure in the dome's lantern should be preserved.
- If the replacement of the absorbing plaster on the underside of the dome's terrace roof is undertaken, the thickness of the new layer should be such that the ribbed structure of the roof remains visible and its color matches the color of concrete (as it was done during the 2011 overhaul).

SUGGESTED

- It is acceptable to reconstruct the skylights in the lantern's cupola which were covered by the existing roof structure in the early 1930s.
- To properly display the aesthetic values of the interior of Centennial Hall it is important to make the system controlling the inner window blinds fully operational. Presently, technical problems with the system result in the passage of light being almost permanently obscured. This technical dysfunction is inconsistent with Berg's idea of the role of light in architecture and his design of the Centennial Hall.

5.2.1.2. Foyer and polygonal rooms at the Centennial Hall

a) Foyer

The foyer underwent an overhaul in 2011. The original spatial arrangement of the foyer encircling the main hall has been preserved. It is laid out on a quatrefoil plan with polygonal rooms at the ends of each quarter. Additionally, four entrances are located, respectively, on the quarters' axes of symmetry: they are adjoined by symmetrically arranged utility rooms, most of them accommodating restrooms. The interior is covered with an exposed concrete coffered ceiling with skylights. In 2011, only two changes were introduced to the interior's original layout: a partition was built to create the exhibition space for the Discovery Center (Centrum Poznawcze) in the south-western section of the foyer and a small utility room was built east of the southern side entrance. The original 1913 staircases have been preserved: four staircases with dog-legged stairs leading from the foyer along the external side of the pillars supporting the dome to the auditorium in the main hall, with original wooden balustrades, one staircase with straight stairs, in the foyer's eastern section, leading to the former organ balcony, with the original metal balustrade preserved.

OBLIGATORY

- The foyer's present original form of an open interior covered with a coffered ceiling with skylights must be preserved.
- The present original form of staircases must be preserved, including the stair treads and wooden handrails.

RECOMMENDED

- All technical systems must fit into the present design of the Centennial Hall, preferably accommodated in the basement and technical channels under the foyer's floor. Any interventions into the building's original structure in order to make new channels for technical systems is unacceptable. Regarding the new technical systems required by special regulations concerning public buildings, legal options should be considered for departing from the standards or individual solutions should be sought to preserve the aesthetic expression of the interiors to which the highest level of conservation protection applies.

- If repainting of the walls is undertaken, it is recommended that the present rough texture be replaced with a smooth texture.
- It is recommended that the casements containing electrical equipment hung on the non-original walls be embedded into the walls to make them less intrusive (this does not apply to the original walls from 1913).
- The non-original partition walls making up the utility room adjoining the south-eastern polygonal room on its eastern side should be taken down and the space re-integrated into the foyer.

SUGGESTED

- If and when the Discovery Center (Centrum Poznawcze) is dismantled or remodeled, the partition walls separating its exhibition space from the foyer should be dismantled to restore the original spatial arrangement from 1913.
- The non-original plaster of the foyer's walls should be removed to restore their original textured surface with the impressed wooden formwork. The color of the walls should be corrected in accordance with the results of stratigraphic tests of paint layers (cost permitting): the suggested solution would be to restore the first color applied after the walls were plastered.

b) Polygonal rooms

The polygonal rooms are located in the foyer's outer ring on the axes of the pillars supporting the dome. Their walls feature simple grid-like structure with a wide cornice. The interiors are covered with coffered ceilings with a polygonal skylight in the center. During the 2011 overhaul, in three of the polygonal rooms (south-eastern, north-eastern, and north-western), air conditioning ducts were installed. In the south-western hall, the Learning Center's exhibition was installed employing a temporary structure.

OBLIGATORY

- The original external doors from 1948 should be restored their original arrangement of three external doors corresponding to three doors leading to the foyer in each respective hall.

RECOMMENDED

- During the next overhaul of the interiors, removing or at least reducing the size of the air conditioning ducts installed in 2011 is recommended since they distort the original refined grid-like structure of the walls.

SUGGESTED

- The non-original plaster of the walls should be removed to restore their original textured surface with impressed wooden formwork. If it this is not viable, the color of the walls should be corrected in accordance with the results of the stratigraphic tests of paint layers: the suggested solution would be to restore the first color applied after the walls were plastered.

5.2.1.3. The Entrances of Centennial Hall

a) The main entrance hall-western

The main entrance hall is laid out on a rectangle, its western side is joined to a semi-circular vestibule. On the rectangle's longer sides symmetrically arranged stairs lead to the Imperial Hall. During the 2011 overhaul, the original raw concrete coffered ceiling was exposed. The original stairs and balustrades have been preserved.

OBLIGATORY

- The exposed and conserved original surface of the reinforced concrete walls and coffered ceiling must be preserved.
- The fan-shaped stairs leading to the Imperial Hall, including the linoleum-covered threads and metal balustrade, must be preserved.

RECOMMENDED

- Removing all systems, especially multimedia projectors and information totems, except for those required by safety regulations.

SUGGESTED

- Continue to uncover and expose the original reinforced concrete surface of Centennial Hall's western wall. The ducts, trays and channels accommodating various systems installed in 2011 should be reduced to a necessary minimum or their layout reconsidered.

b) Southern and northern side entrances halls

The southern and northern side entrance halls are laid out on a rectangular plan and preceded by vestibules of a lower height. The interiors are unified, covered with a coffered ceiling with a rectangular skylight. The original entrance doors from 1913 and somewhat younger ones from the side of the foyer have been preserved. During the 2011 overhaul, the non-original limestone cladding was removed and the original raw concrete texture of the walls was uncovered and exposed from the floor up to the middle of the wall's height: the non-original plaster covering the walls' upper section was not removed.

OBLIGATORY

- The exposed and conserved original surface of the bottom section of the reinforced concrete walls together with the wooden frames of the ticket boxes' windows, glazed doors, and the utility rooms' paneled doors must be preserved.

RECOMMENDED

- In the future, the original surface of the concrete walls in their upper section should be uncovered, exposed and conserved.

c) Eastern side entrance hall

The eastern side entrance hall is laid out on a rectangular plan and preceded by a vestibule of lower height. The interior is unified, covered with a coffered ceiling with a rectangular skylight. The original entrance doors from 1913 and somewhat younger ones from the side of the foyer have been preserved. During the 2011 overhaul, the plaster applied to the walls in 1937 and the decoration of the ceiling beams were not removed.

OBLIGATORY

- The side eastern hall should be preserved in its present form dating to 1937 as a testimony to the changes to the Centennial Hall introduced during that period.

- The plaster of the walls with its restrained structure and the coffered ceiling with the glazed skylight should be preserved.

5.2.1.4. The External façade of Centennial Hall

Having undergone comprehensive conservation in 2009, the external façade is in good condition. The original raw concrete surface with impressed wooden formwork was painted over with a protective thin layer of water-glass. Conservation, as much as possible, was based on the preservation of the façade's original raw concrete structure. The diverse types of concrete used for the façade as well as the original surface treatment of the windows, cornices, and hoods over the drain pipes' ports are still visible. The color is close to that assumed by the decades that have passed since its application. The new element – the 8-centimeter-wide encasement of the additional reinforcement to the dome's ribbed bottom ring – has been aesthetically integrated into the façade.

OBLIGATORY

- The present structure and color of Centennial Hall's external façade must be preserved. During any future overhauls, the following conservation procedure should be repeated: cleaning, repairing damaged areas with fillers matching the original surface's structure and color making the filler's texture match the adjoining area followed by impregnation.
- The window frames and doors throughout the Centennial Hall require special care, including the windows of the ticket boxes in the main entrance hall, and the original lamps over the north, south and east side entrances.
- The window frames of the ribbed dome, the apses of its base, and the Imperial Hall should be conserved and repaired in accordance with guidelines formulated by Professor Jan Teichmann's team of experts. All repairs should consist of conservation and not replacement in cases where the damage is below 50% of the original state. The same or similar kind of wood should be used. Introducing double glazing or replacing original furniture is not acceptable. Original elements or new elements modeled on original ones should be used. To repair the reconstructed glazing, the same kind of glass should be used as the one introduced in 2011.
- The windows of both ticket boxes located in the main entrance hall should be preserved in their present form. If the degree of damage to the original frames precludes their further use, the replacements should be altered to conform to the originals.
- The lamps over the south, north and east side entrance should be preserved and conserved. They are the original lamps from 1913 and the only original lighting fixtures that still exist. This is a very urgent task as the lamps' condition is poor.
- The original granite thresholds in the entrances to the foyer, polygonal rooms and vestibules of the entrances should be preserved.

RECOMMENDED

- The assessment of the state of preservation of the majority of the windows in the curtain walls conducted in 2015 has shown that the principal cause of damage to the conserved and repaired window frames was due to improper use. Necessary repairs and reinforcements should be done as soon as possible, preferably in the next work season in 2016.
- At the same time, the user should make annual maintenance inspections and first of all, employees as

well as external contractors should be instructed on how to properly and carefully operate the opening system of the dome's windows. Legal provisions must be included in all relevant contracts concerning following proper procedures with financial responsibility being sought for incurred damages to the window frames.

- Any damages to the internal and external doors throughout Centennial Hall should be repaired with replacement frame elements and furniture altered to conform to the design of the originals.

SUGGESTED

- The external façades of Centennial Hall's foyer are overgrown with creepers which must be regularly clipped to limit the expansion of greenery over the building's walls.

5.2.2. The Immediate surroundings of Centennial Hall

a) Greenery

Historical and botanical studies have established that the Linden alleys and lawns surrounding the Centennial Hall were designed by Max Berg and planted after 1918, probably in 1919–1920. The architect envisioned the building surrounded by four triangular lawns outlined with Linden alleys.

OBLIGATORY

- The original layout of pathways must be preserved as well as their original planting with formed Lindens. It is essential that any necessary replacements are Linden trees of the same type that are already formed to match the other trees (the tree-top base should be at the same level).

RECOMMENDED

- The relatively few replacements for which a different type of Linden has been used should be substituted with specimens of the same Linden type.
- All triangular areas between the Linden alleys should be preserved or restored as lawns (parking lots in the complex's north-eastern quarter should be re-converted into lawns).
- The plantings of trees and shrubs in the southern section need correcting as they have been done at various times and quite chaotically. It is recommended that based on the topical study prepared under the CMP project the self-sown plants be removed and trees and shrubs obscuring the view of Centennial Hall from the south re-planted.

b) Architecture

OBLIGATORY

- With regard to the connecting building between the Centennial Hall and the former Terrace Restaurant (at present the Convention Center), the entire structure should be preserved in its present form and in particular the under-side of the reinforced concrete ridge roof with the original texture and color of the concrete surface dating back to 1913.

RECOMMENDED

- The recent repairs done to the columns need aesthetic corrections. In particular, their surface treatment must be refined to convey the diverse textures of the columns' bases. Shafts, capitals and the color should be corrected to better match the color of the original impregnating layer. Hanging any advertisements or information boards in this area is not acceptable.

5.2.3. The pond and the colonnade of the Pergola

OBLIGATORY

- The parabolic pond must be preserved in its present form, including the concrete lining of the water reservoir built in 1978.
- The present layout of pathways and stairs between the colonnade and the pond and the lawns' outline must be preserved. No permanent structures or landscape design elements should be introduced in this area.

RECOMMENDED

- The visible cracks in some of the columns and their deflection from the vertical line suggest that some form of technical intervention may be needed in the future whose scope should be defined by experts. This project should provide an opportunity for improving surface finishes in order to restore the original diversified surface treatment of the columns' bases, shafts, and capitals.
- Replacing asphalt pavement with another kind of pavement, preferably gravel, is recommended.

5.2.4. The Terrace Restaurant (at present the Convention Center)

OBLIGATORY

- The central hall with pillars supporting the upper floor terrace, the original reinforced concrete stairs in front of the building's south façade and terrace stairs in front of its northern façade must be preserved.

RECOMMENDED

- The building's present form is the result of the major overhaul and extension carried out in 2010. It is recommended to construct some architectural feature referencing the original glazed dome supported on a tall drum and stepped base of the Terraced Restaurant that was dismantled in 1924. The new structure should not attempt a reconstruction of the original dome.

5.2.5. The Courtyard in front of Centennial Hall's western façade

OBLIGATORY

- The present layout of the square, surrounded by Linden alleys in the southern and northern side planted in 1919-1920, should be preserved.

SUGGESTED

- For compositional reasons it is advisable to move the Iglica (steel spire) erected in 1948 westwards and out of the courtyard, as it has already been postulated in earlier urban planning studies.

5.2.6. The Four Dome Pavilion, (at present the Museum of Contemporary Art, a branch of the National Museum in Wrocław)

RECOMMENDED

- The building's original form from 1913, restored as a result of the overhaul completed in 2015, should be preserved.

SUGGESTED

- The removal of the glazed roof introduced over the inner courtyard should be considered. This functional solution, often introduced in historic buildings serves the purpose of a museums. This case proved controversial and has not been approved by the experts of the World Heritage Center.

5.2.7. Pavilion of Industry (at present The Institute of Power System Automation [Instytut Automatyki Systemów Energetycznych – IASE])

OBLIGATORY

- The building's present form resulting from its partial reconstruction in 1948 and the 1998 overhaul should be preserved.

RECOMMENDED

- On the site of the Exhibition Hall burnt down in 1945 a new building referencing the original structure should be erected. Its architectural form should be consistent with the axial symmetry of the Four Dome Pavilion, its volume and scale harmoniously blending into the surroundings of the Centennial Hall and other buildings on the Exhibition Grounds. This project is essential for filling in the southern side of the courtyard in front of the Centennial Hall.

5.2.8. The Hall of States (at present the Center of Audiovisual Technology [Centrum Technologii Audiowizualnych – CeTA])

OBLIGATORY

- The building's present form, including the 1954 extension, should be preserved.

RECOMMENDED

- Concerning both the IASE and CeTA buildings, the goal should be to unify the texture and color of the plaster and window frames.

5.2.9. The Colonnade of the Exhibition Grounds' Main Entrance

OBLIGATORY

- The reinforced concrete columns require technical conservation.

RECOMMENDED

- The original coffered wood ceiling over the main entrance should be reconstructed.

5.2.10. Children's Sanatorium building

OBLIGATORY

- The building's present external form dating to 1948 should be preserved as an example of exhibition architecture from the period of the exhibition of the Reclaimed Territories.

RECOMMENDED

- Changes to the interior are acceptable.

5.2.11. Wooden Church of St. John of Nepomuk

OBLIGATORY

- Because of the building's materials that are extremely vulnerable to the elements, the church must be systematically conserved in accordance with the principles of preventive conservation, as was done during the 2015 overhaul.
- The self-sown plants which now obscure the view of the church created in 1913 should be removed.

5.2.12. Residential building of a model farm

OBLIGATORY

- The building located on Wróblewskiego 2A Street in its present form should be listed on the Register of Historic Monuments.
- An overhaul consistent with conservation principles is necessary.

5.2.13. The remainder of the Exhibition Grounds next to the Centennial Hall and related fragments of Szczytnicki Park

OBLIGATORY

- **Former historic and topical gardens of the Exhibition Grounds**: a plan for the area's revalorization should be developed following a historical study and dendrological stock taking. However, reconstructing of the Belvedere would not be justified.
- **Japanese Garden** located north-west of the Pergola surrounding the Eichborn Pond: its present form, dating to 1997–1999 and created by Japanese gardeners, should be preserved. The asphalt pavement left on a pathway in the garden's reception section should be removed.
- **Underground parking garage** located east of the Centennial Hall: the present arrangement of the parking lot's upper plate should remain unchanged. The tree-tops of the newly-planted Linden alley separating the parking lot from the immediate surroundings of the Centennial Hall should be formed.
- **Summer Theater** located north-east of the Pergola and the Children's Sanatorium (Pavilion "Under the Bears"): The Summer Theater in its 1913 form should be reconstructed which requires the revalorization of the embankment and reconstruction of the auditorium and stage.
- **Diana's Garden** (fragment of Szczytnicki Park at the crossroads of Mickiewicza and Wróblewskiego Streets, separated from the Exhibition Grounds by Wystawowa Street, called Skwer Cybulskiego): its present layout should be preserved, particularly the wide pathway continuing the principal east-west compositional axis of the Exhibition Grounds. If the decision is made to remove the Iglica steel spire from the courtyard, this is its preferred new location.
- **William's Garden** (fragment of Szczytnicki Park between A. Mickiewicza Street and the Exhibition Grounds): the revalorization program for this fragment of Szczytnicki Park should be developed taking into consideration that the greenery provides an acoustic barrier from the side of A. Mickiewicza Street.
- **Göppert's Groove** (southern section of Szczytnicki Park within the boundaries of the area inscribed on the UNESCO World Heritage List, functionally connected with the Exhibition Grounds near the Centennial Hall, but separated from it by Dąbska Alley): the greenery revalorization program should be developed for this fragment of Szczytnicki Park. No building structures or recreational equipment, even temporary, should be planned or installed in this area.

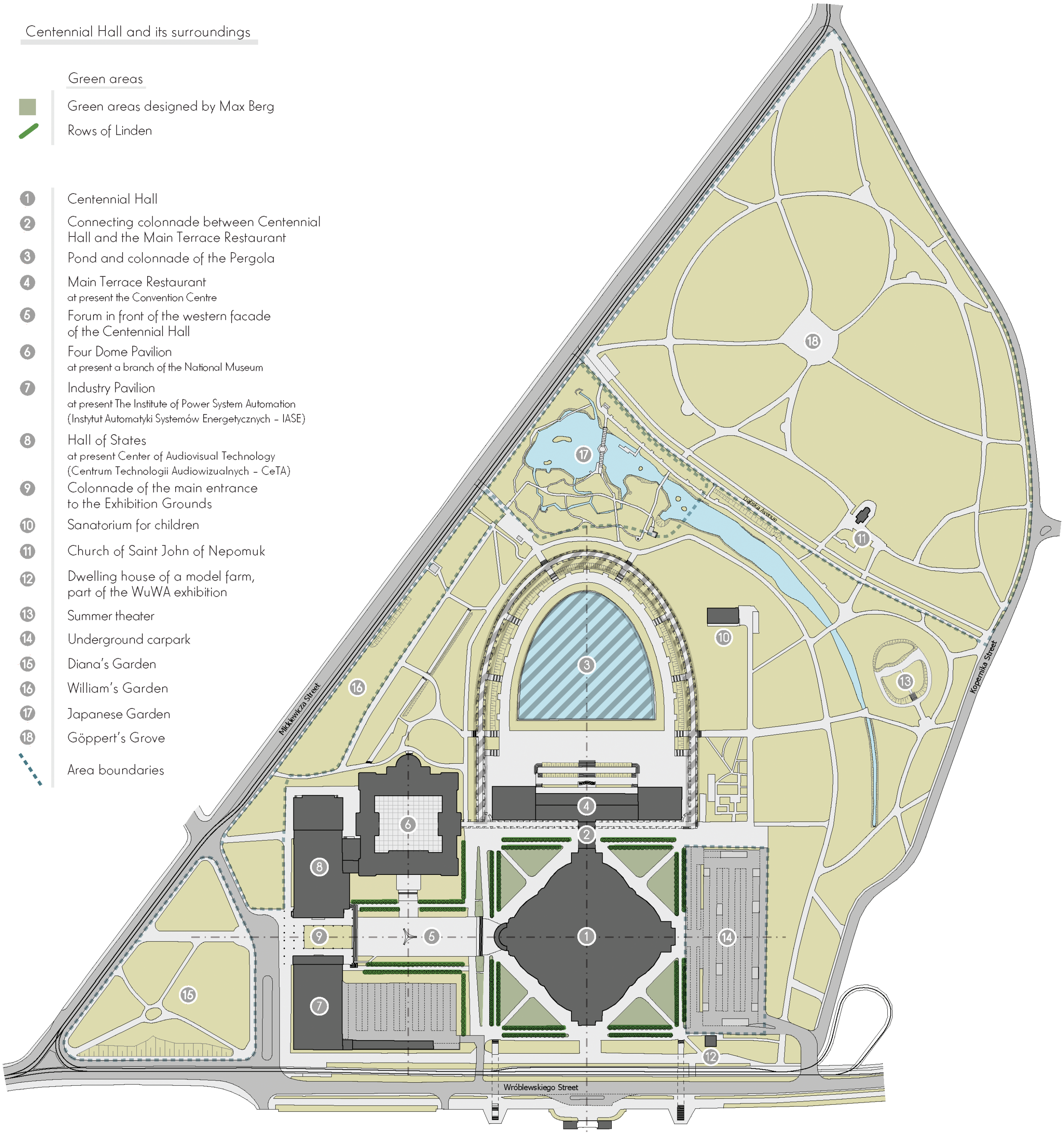
Centennial Hall and its surroundings

Green areas

- Green areas designed by Max Berg
- Rows of Linden

1. Centennial Hall
2. Connecting colonnade between Centennial Hall and the Main Terrace Restaurant
3. Pond and colonnade of the Pergola
4. Main Terrace Restaurant
   at present the Convention Centre
5. Forum in front of the western facade of the Centennial Hall
6. Four Dome Pavilion
   at present a branch of the National Museum
7. Industry Pavilion
   at present The Institute of Power System Automation (Instytut Automatyki Systemów Energetycznych – IASE)
8. Hall of States
   at present Center of Audiovisual Technology (Centrum Technologii Audiowizualnych – CeTA)
9. Colonnade of the main entrance to the Exhibition Grounds
10. Sanatorium for children
11. Church of Saint John of Nepomuk
12. Dwelling house of a model farm, part of the WuWA exhibition
13. Summer theater
14. Underground carpark
15. Diana's Garden
16. William's Garden
17. Japanese Garden
18. Göppert's Grove

- Area boundaries



Chronology

■	1913	■	1948
■	1919	■	1954
■	1925	■	2010
■	1929	■	2014
■	1938	■	2015

Main axis of the layout

Boundaries of the green areas

Area boundaries:

1. Diana's Garden (1875-1877)
2. William's Garden (1875-1877)
3. Moritz-Eichborn's Pond (1877)
4. Göppert's Grove (1885)

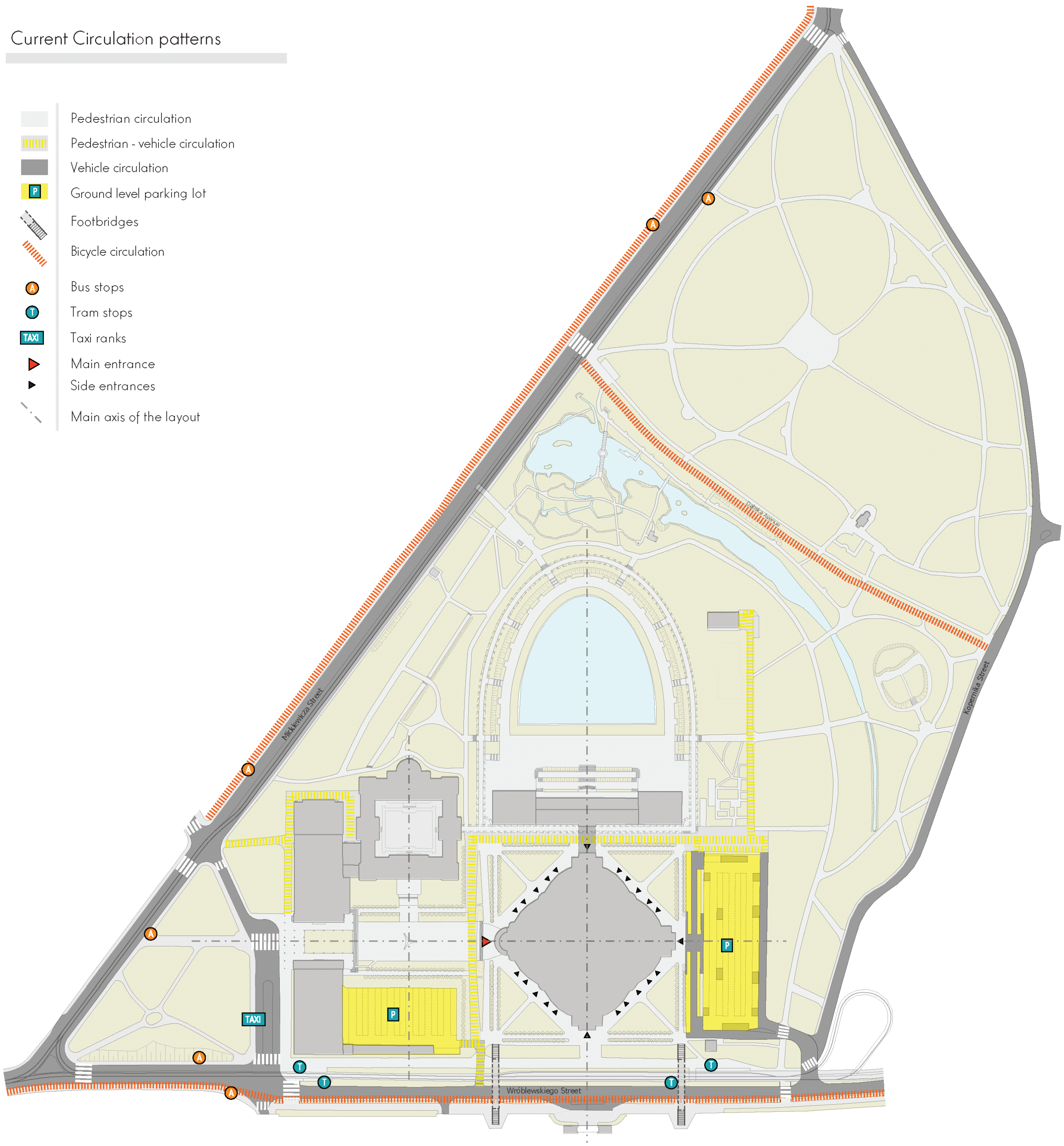
Japanese Garden (1913, 1997)

Horserace track (1832-1907)

Rows of Linden (1919)

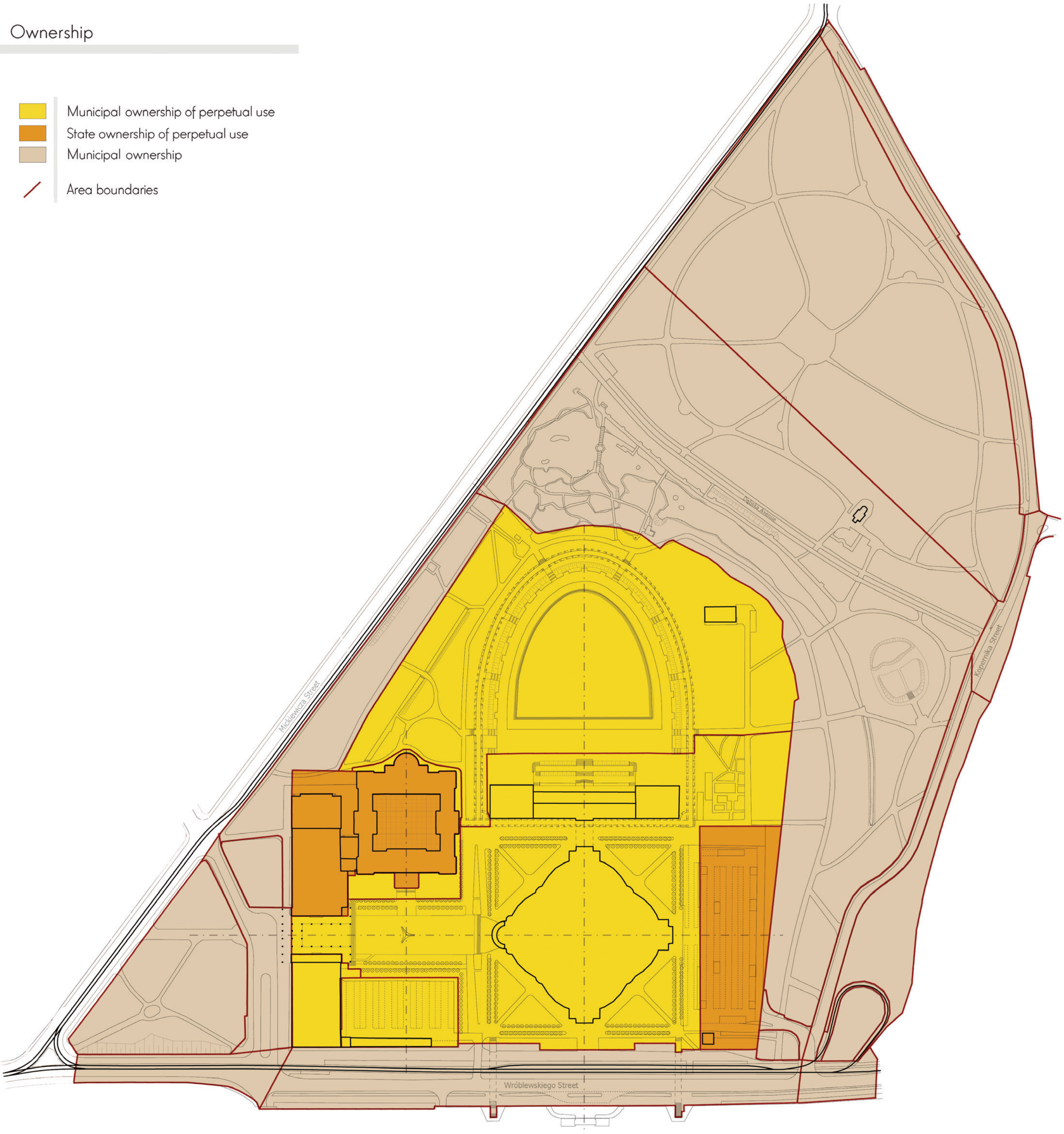
Exhibition Grounds (1913)

Current Circulation patterns



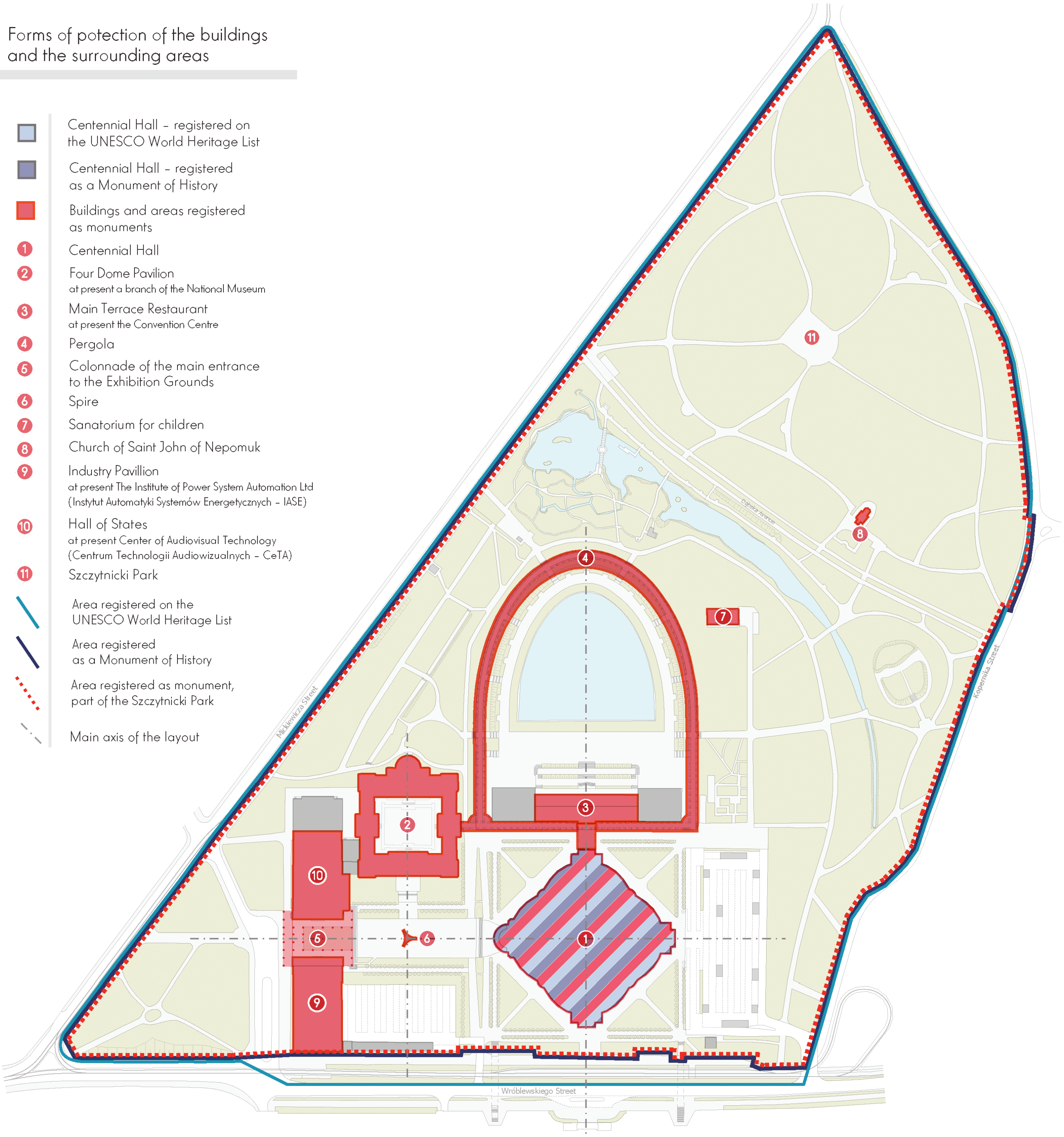
Ownership

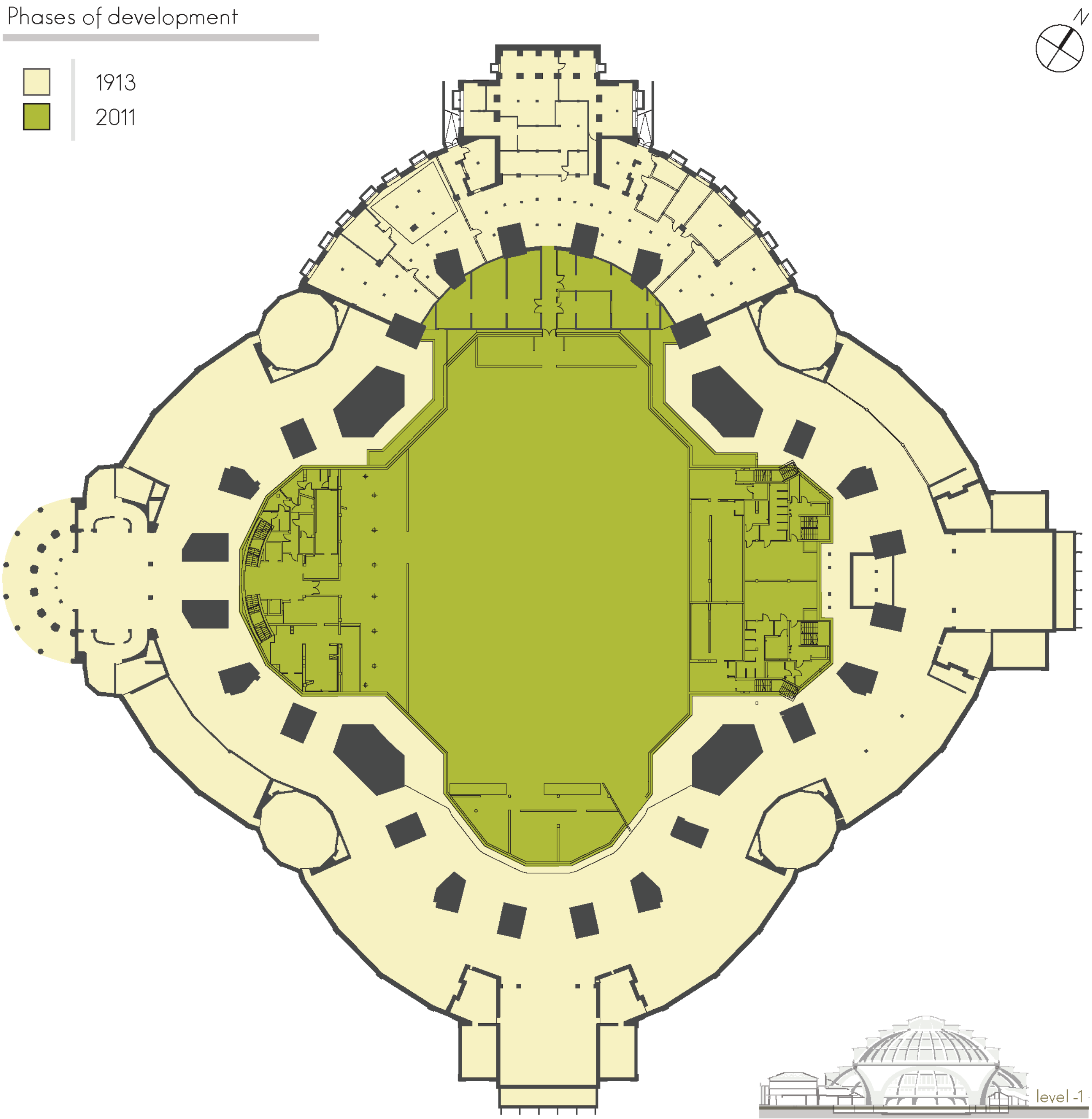
- Municipal ownership of perpetual use
- State ownership of perpetual use
- Municipal ownership
- Area boundaries

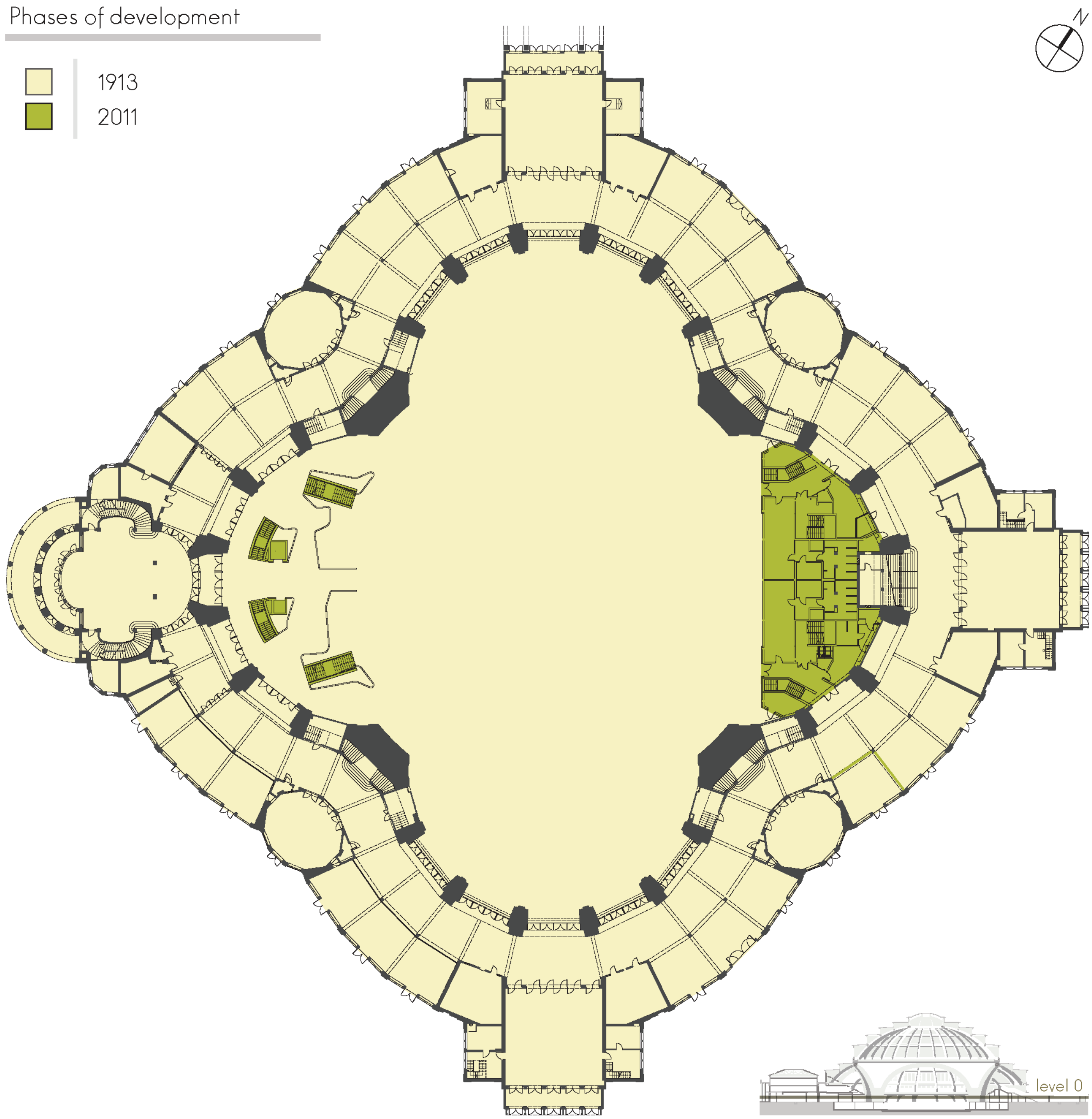


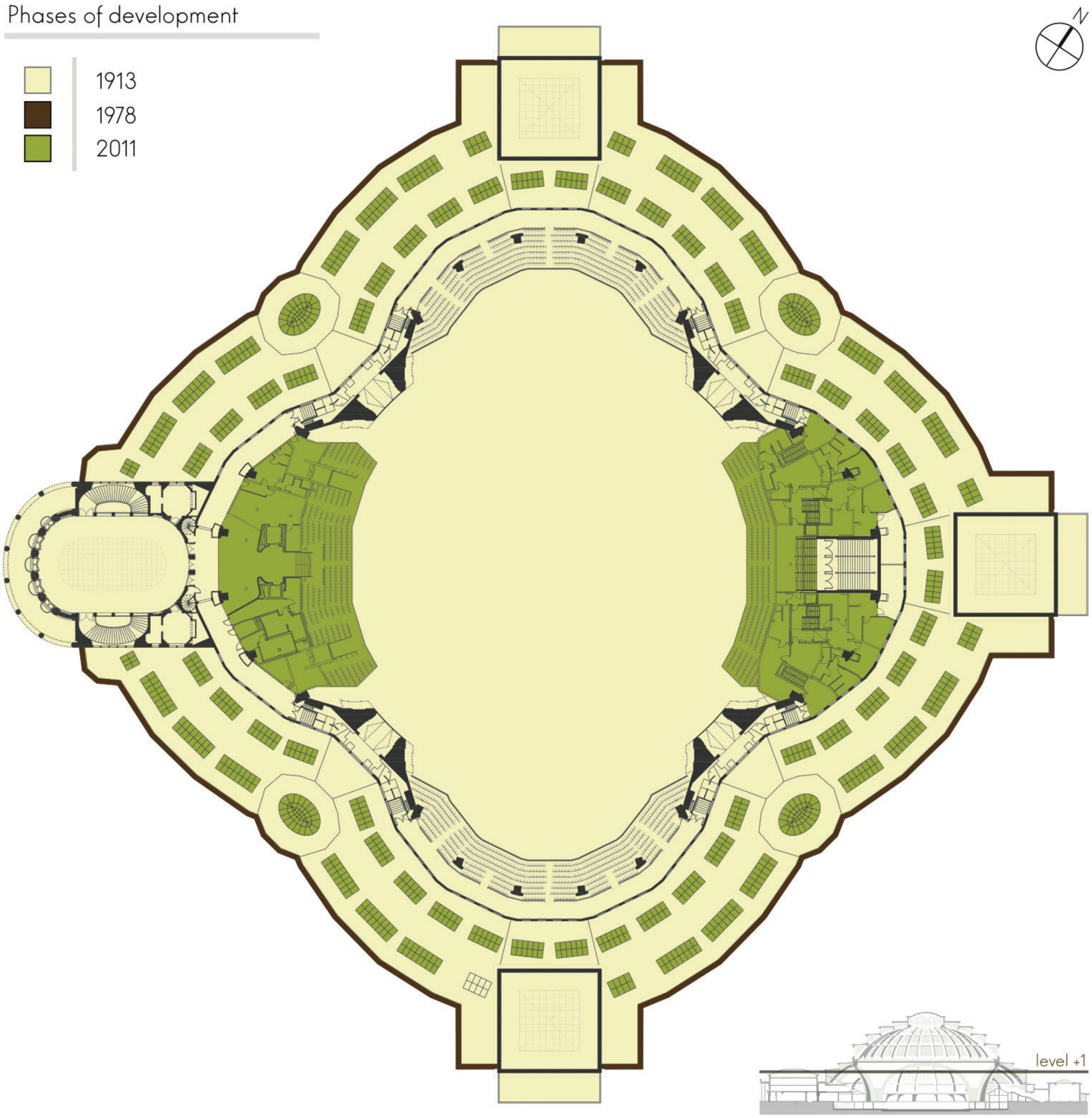
Forms of potection of the buildings and the surrounding areas

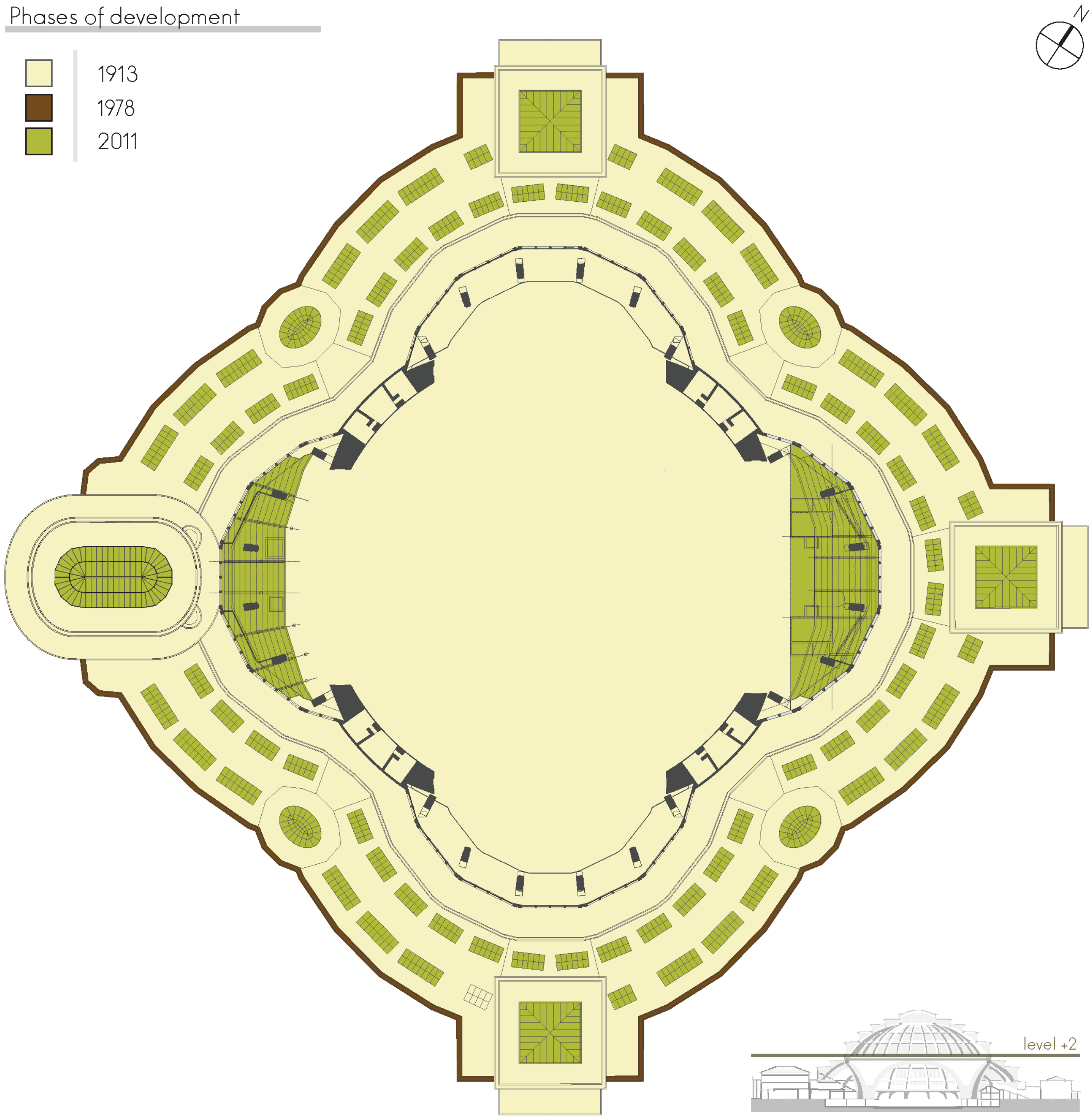
- Centennial Hall – registered on the UNESCO World Heritage List
- Centennial Hall – registered as a Monument of History
- Buildings and areas registered as monuments
- 1 Centennial Hall
- 2 Four Dome Pavilion at present a branch of the National Museum
- 3 Main Terrace Restaurant at present the Convention Centre
- 4 Pergola
- 5 Colonnade of the main entrance to the Exhibition Grounds
- 6 Spire
- 7 Sanatorium for children
- 8 Church of Saint John of Nepomuk
- 9 Industry Pavillion at present The Institute of Power System Automation Ltd (Instytut Automatyki Systemów Energetycznych – IASE)
- 10 Hall of States at present Center of Audiovisual Technology (Centrum Technologii Audiowizualnych – CeTA)
- 11 Szczytnicki Park
- Area registered on the UNESCO World Heritage List
- Area registered as a Monument of History
- Area registered as monument, part of the Szczytnicki Park
- Main axis of the layout

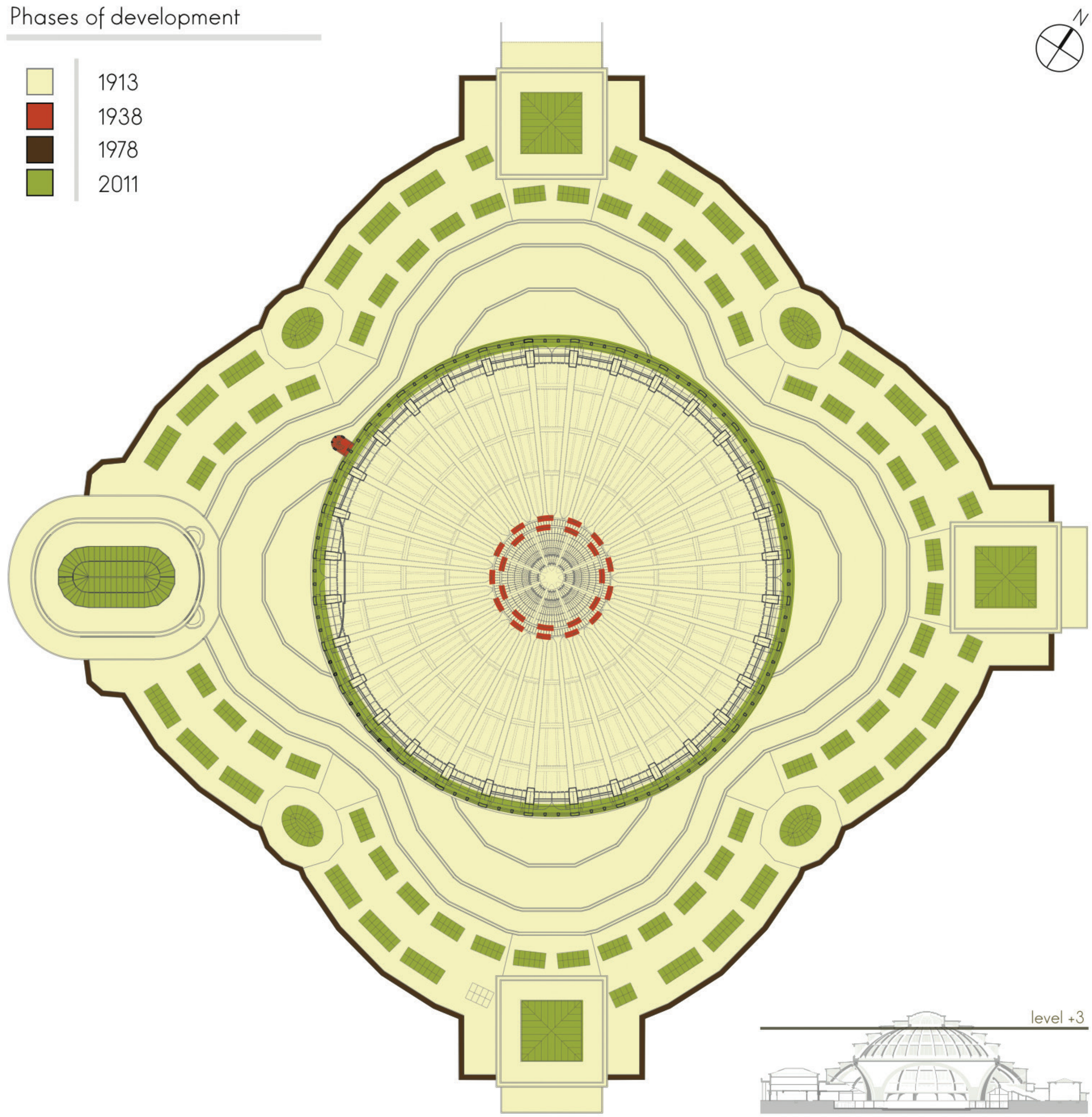



Phases of development
1913
2011
N
level -1


Phases of development
1913
2011
N
level 0

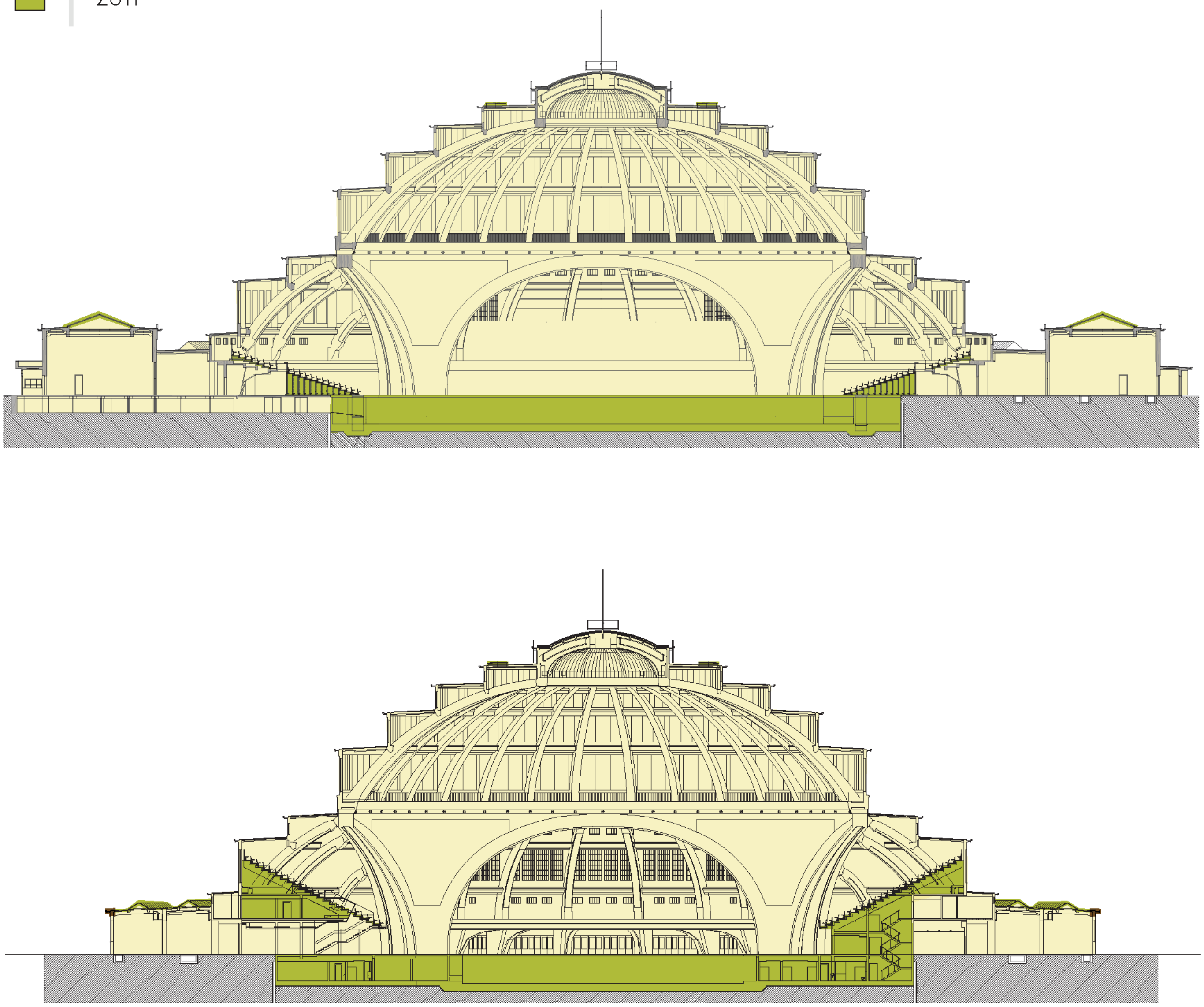

Phases of development
1913
1978
2011
N
level +1

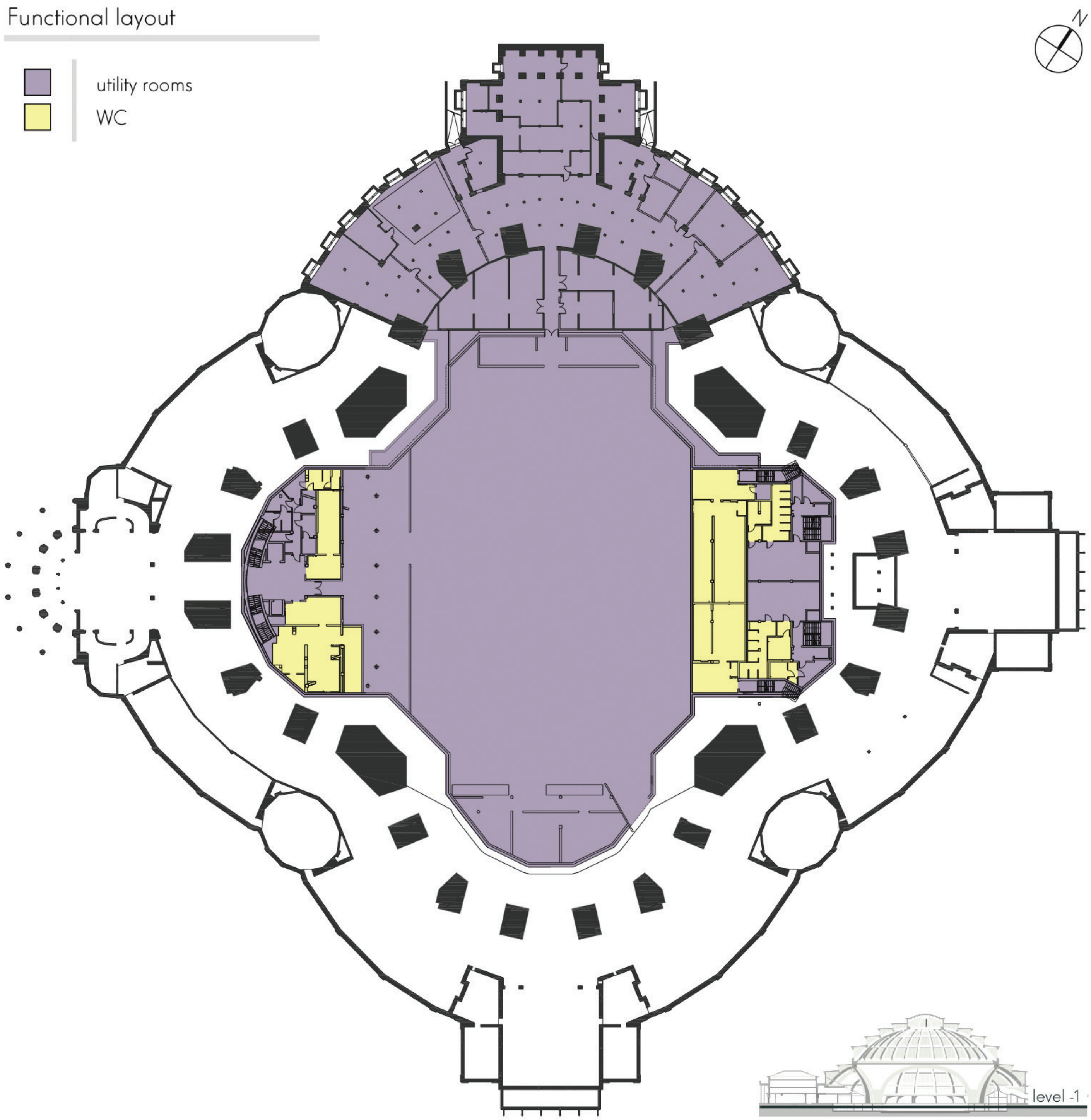

Phases of development
1913
1978
2011
N
level +2

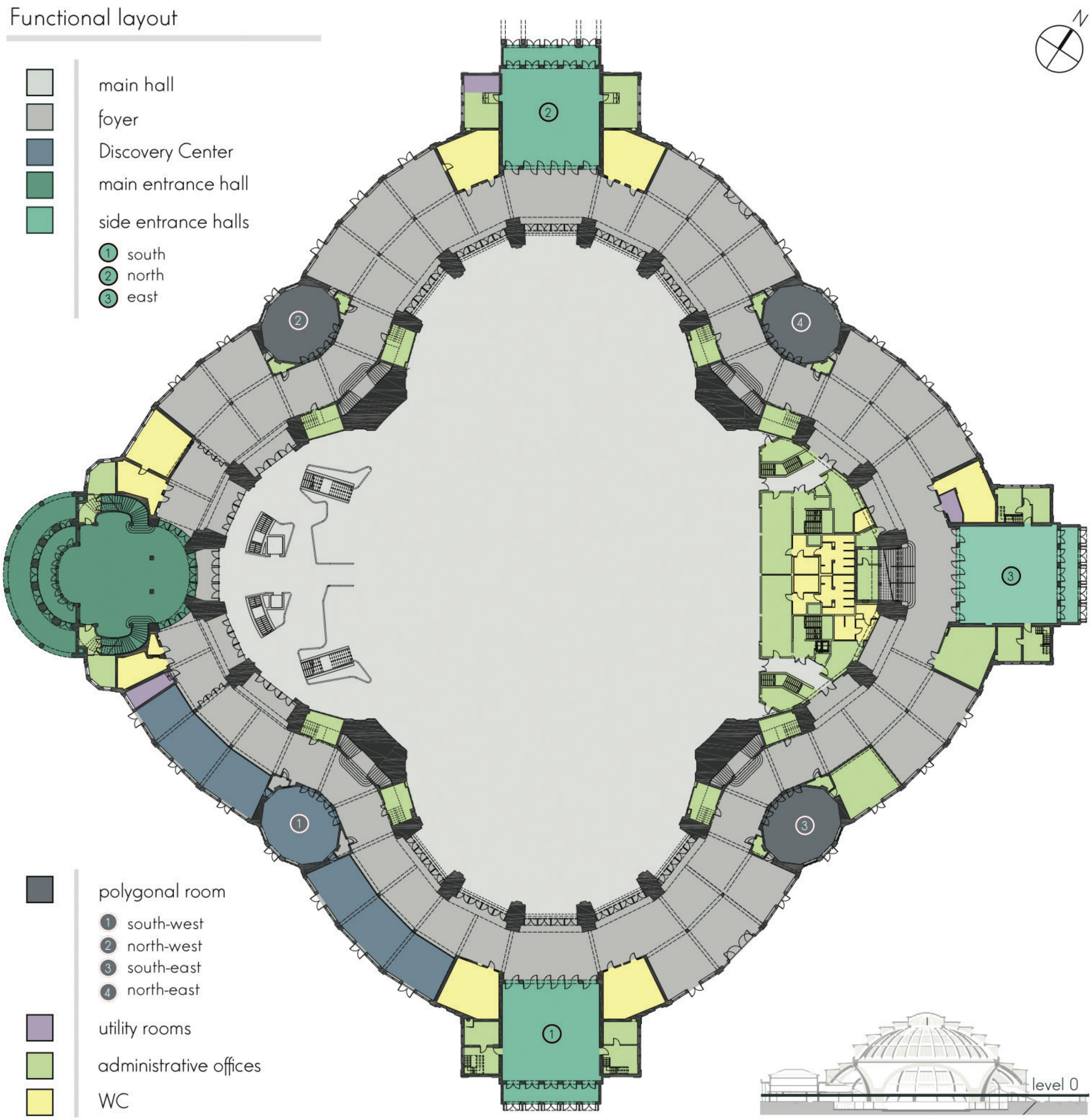

Phases of development
1913
1938
1978
2011
N
level +3

Phases of development

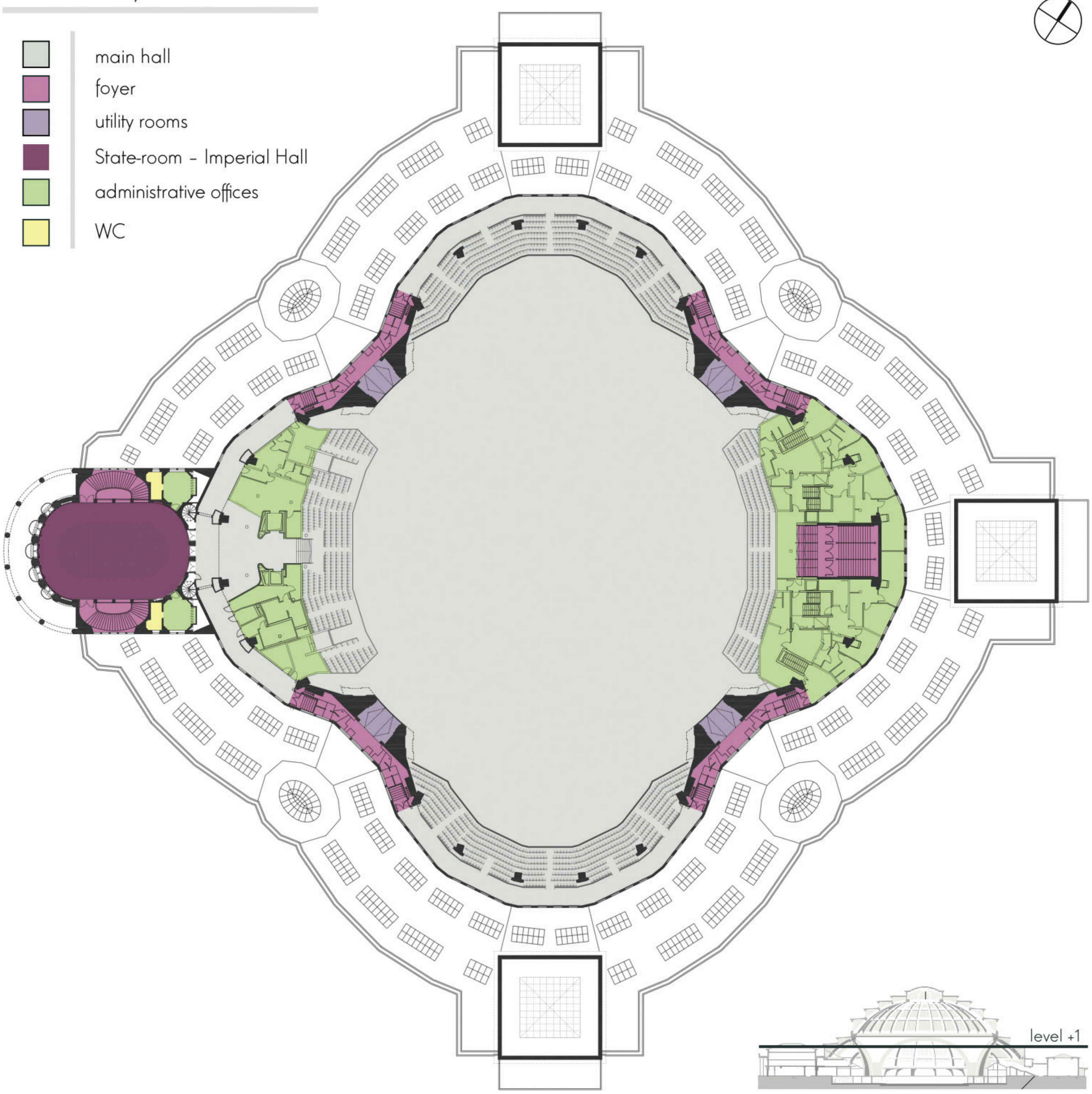
1913
1978
2011




Functional layout
utility rooms
WC
N
level -1

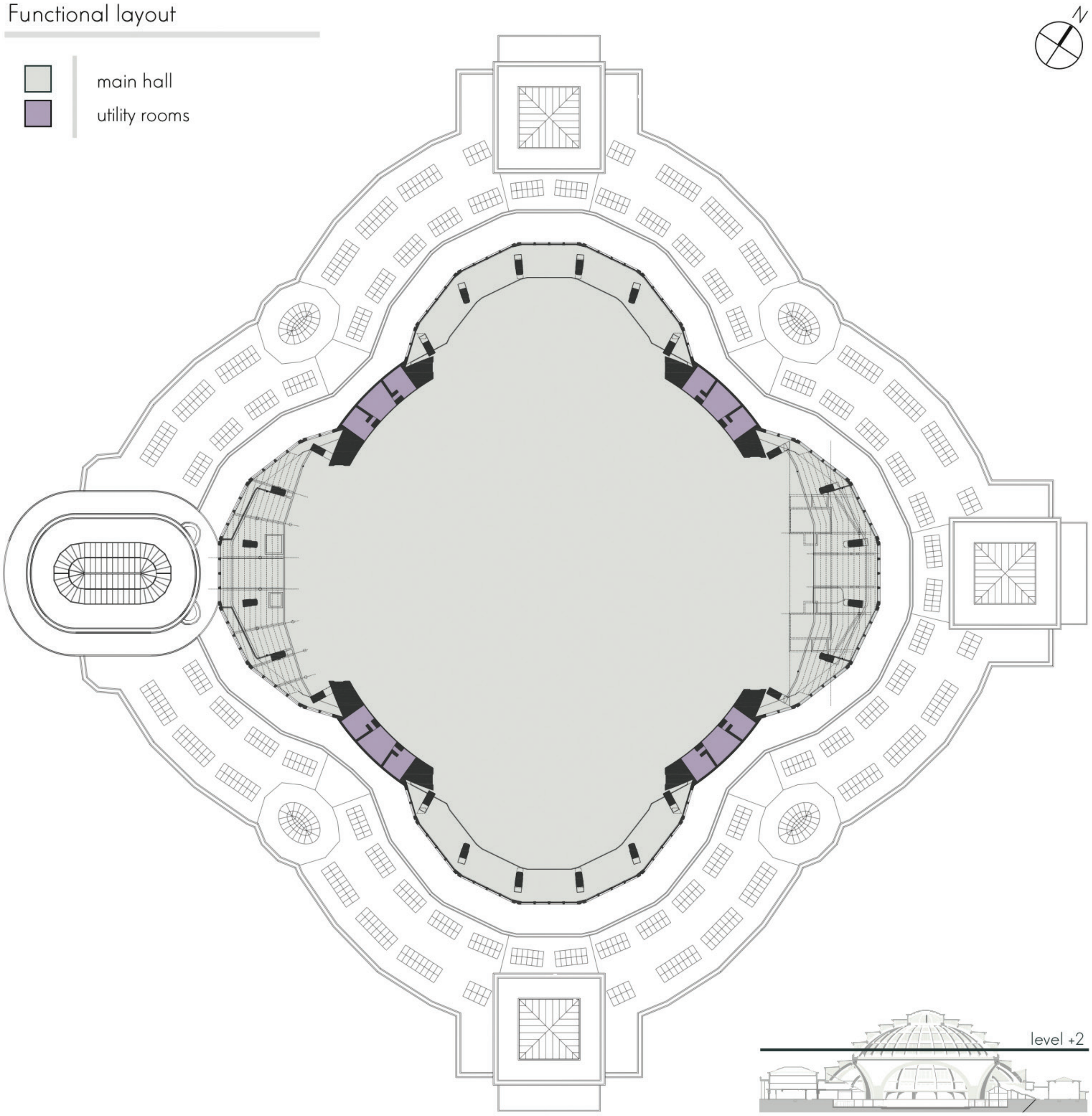

Functional layout
main hall
foyer
Discovery Center
main entrance hall
side entrance halls
1 south
2 north
3 east
polygonal room
1 south-west
2 north-west
3 south-east
4 north-east
utility rooms
administrative offices
WC
N
level 0

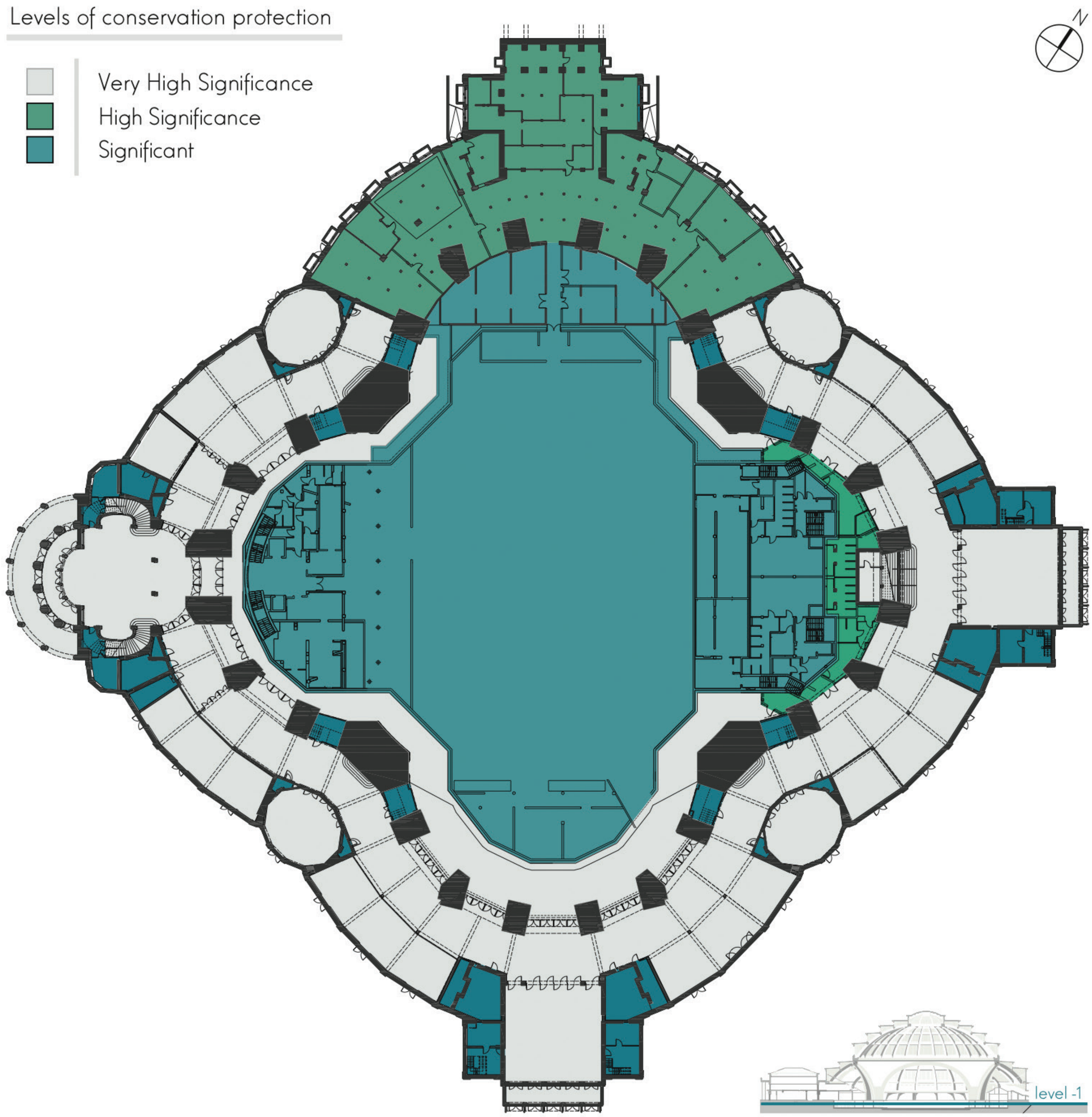
Functional layout

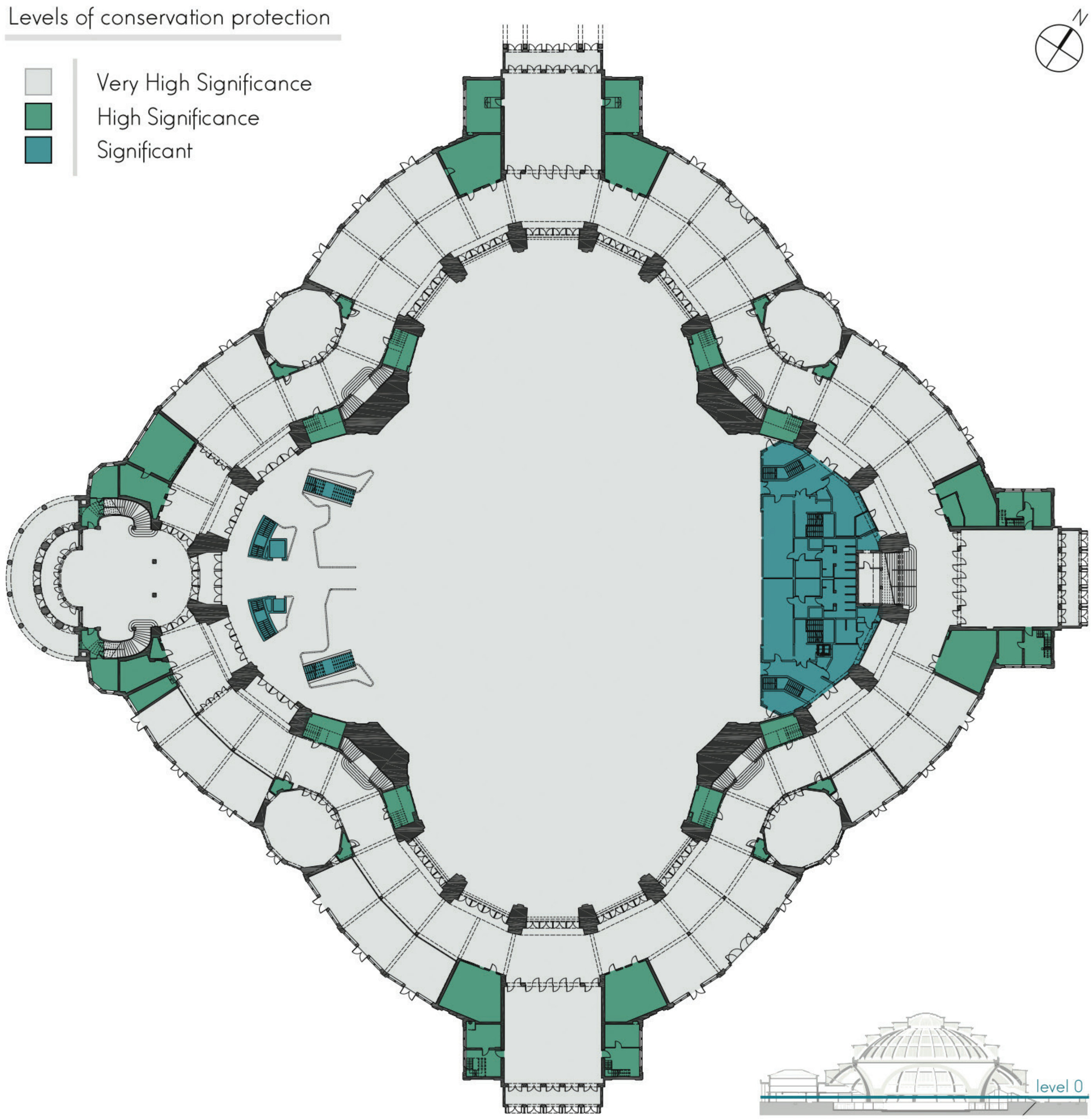


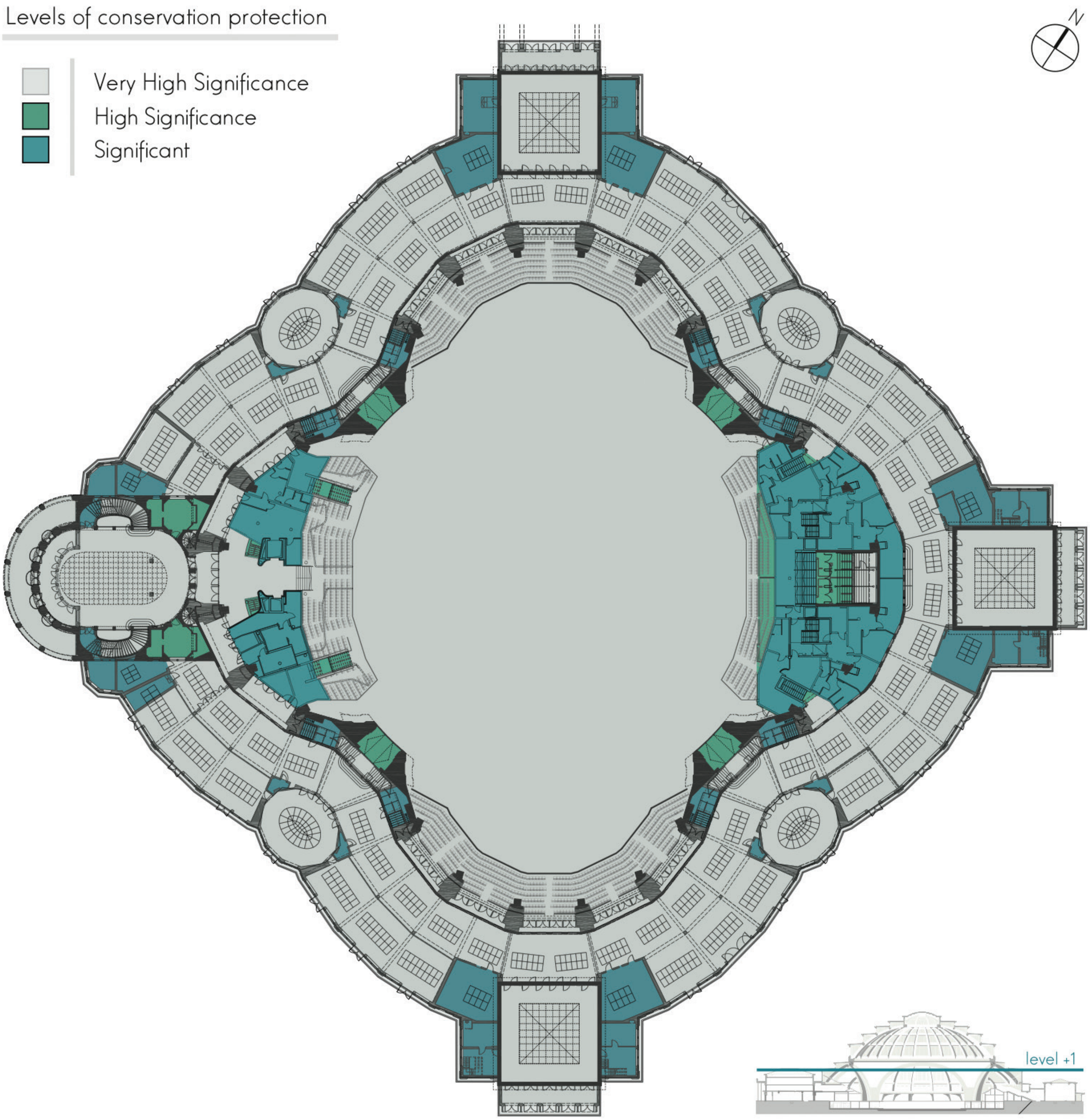
Functional layout

main hall
utility rooms



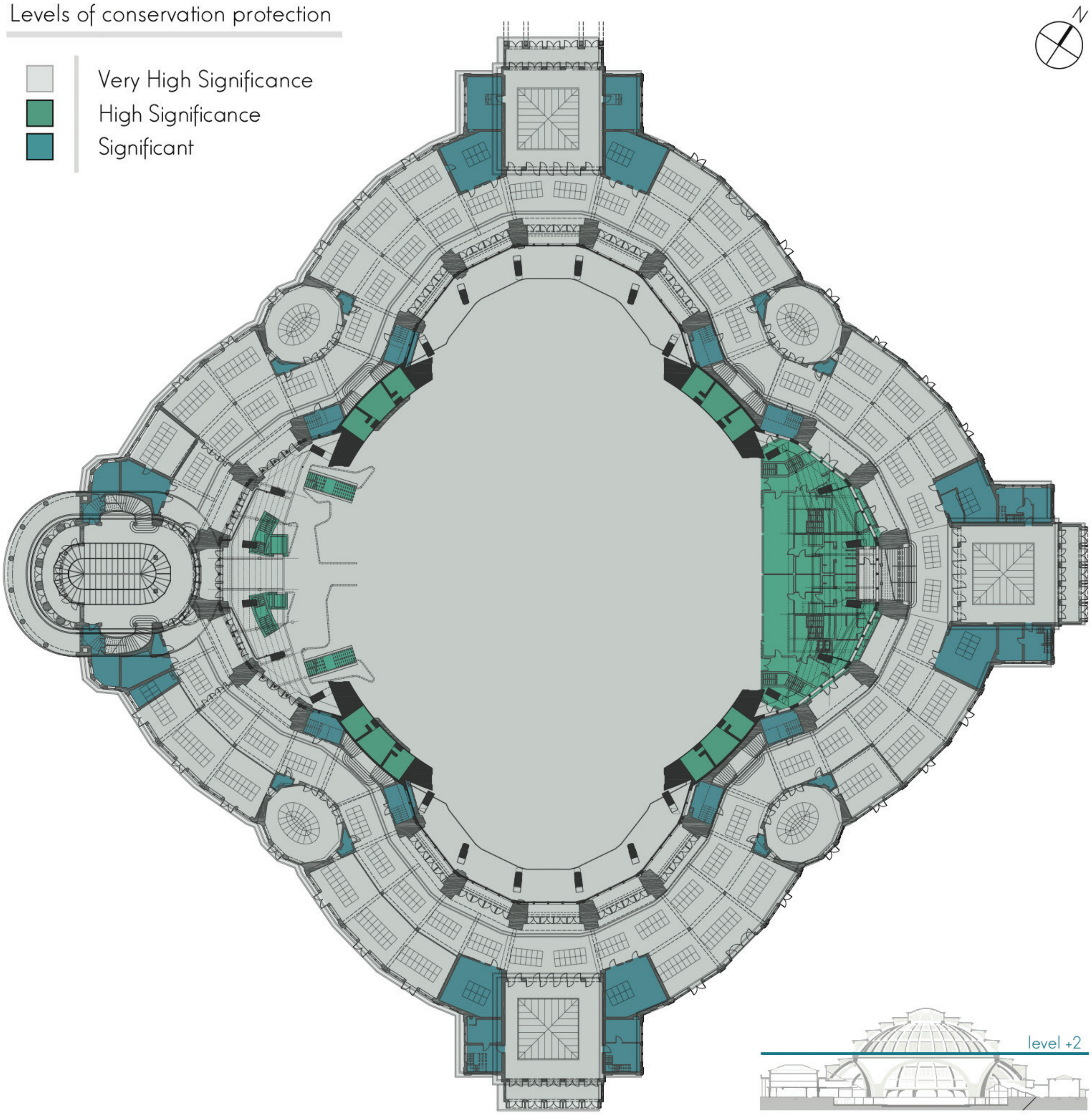

Levels of conservation protection
Very High Significance
High Significance
Significant
N
level -1

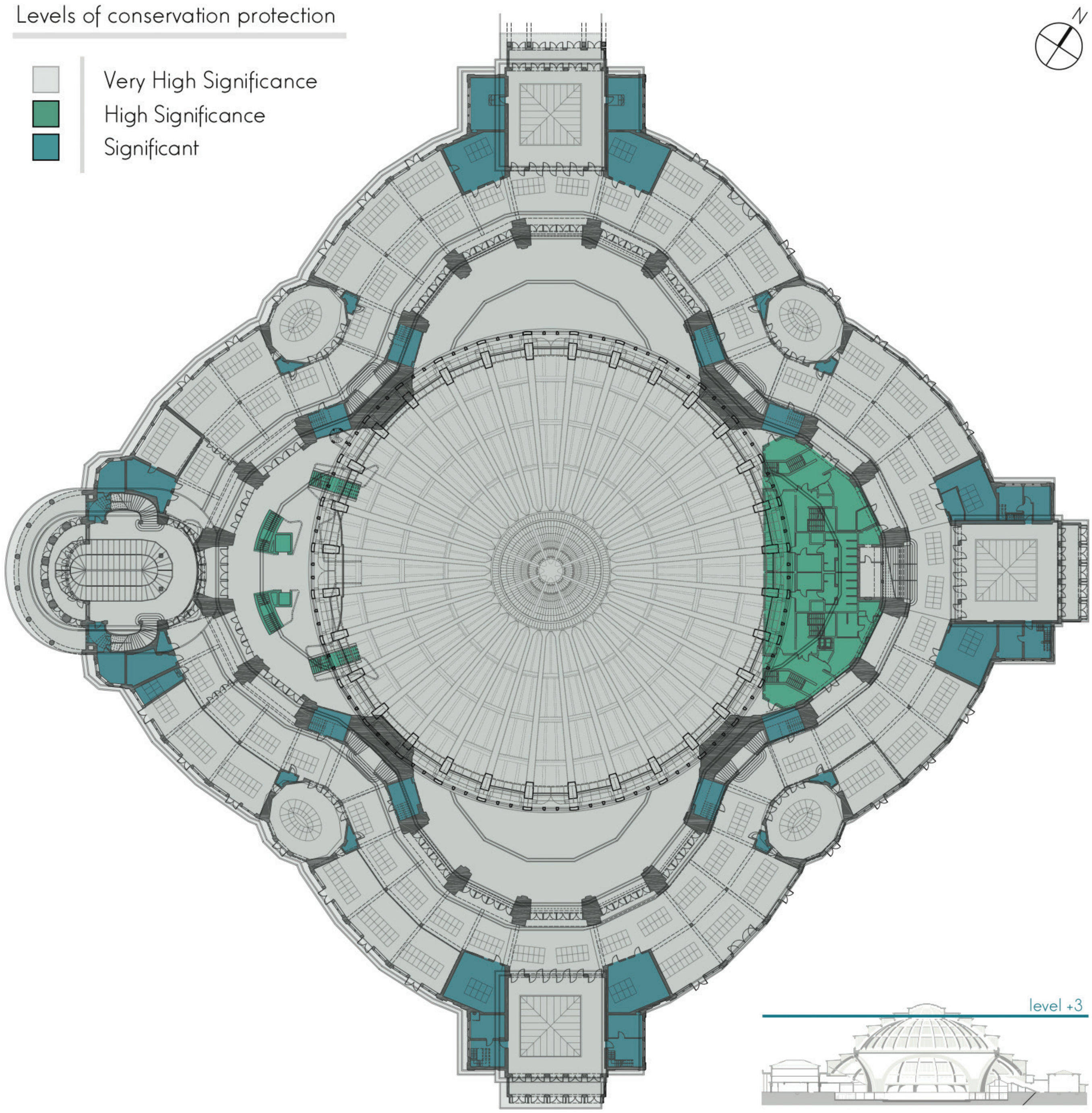

Levels of conservation protection
Very High Significance
High Significance
Significant
N
level 0


Levels of conservation protection
Very High Significance
High Significance
Significant
N
level +1

Levels of conservation protection

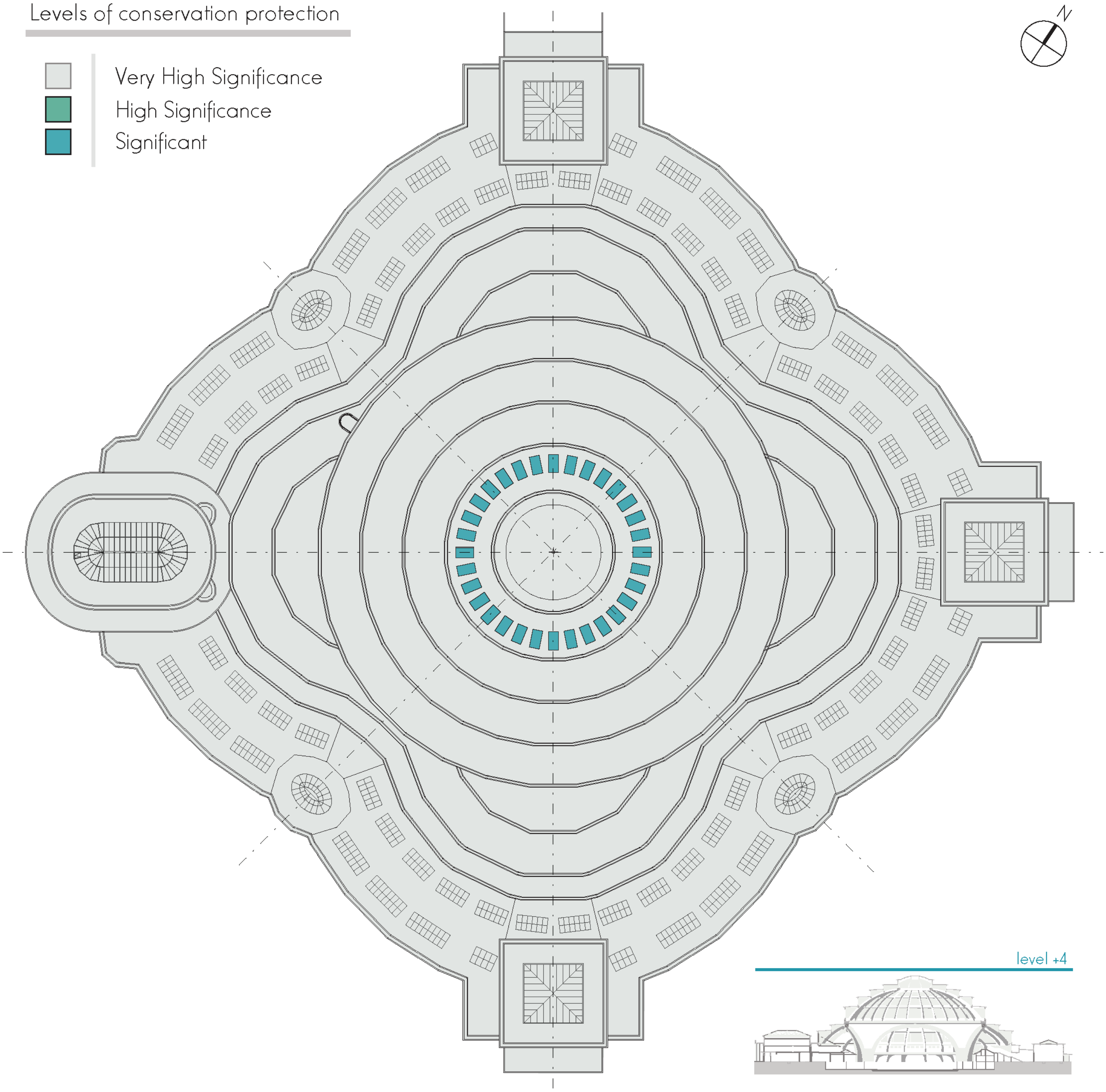
- Very High Significance
- High Significance
- Significant




Levels of conservation protection
Very High Significance
High Significance
Significant
N
level +3

Levels of conservation protection

- Very High Significance
- High Significance
- Significant



5.3. Implementation and Action Plan

The Action Plan concerns four basic areas defined on the basis of the analysis conducted in the process of developing the Conservation Management Plan (CMP).

Institutional framework for the Conservation Management Plan
Since the CMP for the Centennial Hall is the first document of this kind in Poland, there are no set procedures for its implementation in practice. Therefore, the methods and principles for its implementation should be developed which would incur the relevant institutions emphasizing their position as the basis for conservation.

Unifying the ownership and/or Conservation Management of the Exhibition Grounds
The present fragmented ownership of the buildings located on the Exhibition Grounds is one of the principal threats and barriers to proper conservation and protection. Since ownership unification of the Exhibition Grounds presents a major challenge, it is essential to make at least the conservation management of the Exhibition Grounds unified and consistent. The Municipal Inspectorate of Historic Monuments is instrumental in the project. The establishment of a body representing all institutions active in the area, for example the Owners Board, is necessary.

Appointing the Expert Conservation Advisory Board
The establishment of an Expert Conservation Advisory Board seems essential to advise the Owners' Board on matters related to planning, overhauls, development projects and all other actions and projects concerning the Exhibition Grounds.

Publication of the Conservation Management Plan for the Centennial Hall in Wrocław
The public should have full access to the information contained in the Conservation Management Plan for the Centennial Hall in Wrocław. To this purpose, the document's text will be published online (open access format) and printed. The plan's principal issues and conclusions will be publicized during public presentations and meetings. The document will be sent and presented to target groups comprising of the principal institutions concerned with the monument's protection and conservation.

6.

Documentation

6.1.

The Centennial Hall in Wrocław

UNESCO World Heritage Site

Structural analysis, materials analysis, monitoring of the structural security and conservation condition of the building

The research work for this Report involved cooperation with the Museum of Architecture in Wroclaw. The work was funded by a J. Paul Getty Foundation grant for the project: 'Preparation of a conservation management plan for Max Berg's Centennial Hall in Wroclaw, Poland' as part of the 'Keeping It Modern' initiative.

The project team:
- Prof. PhD. Eng. Jerzy Jasieńko – Team Leader
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- Prof. PhD. Eng. Dariusz Łydżba,
- PhD. Eng. Andrzej Moczko
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- MSc. Eng. Piotr Organek
- MSc. Eng. Anna Pawlik
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- MSc. Eng. Marcin Szyszka

The Report draws also on earlier research related to the Hall carried out, inter alia, by:
- PhD. Grzegorz Grajewski
- PhD. Jerzy Ilkosz
- Prof. PhD. Eng. Jan Biliszczuk
- MSc. Ewa Bożejewicz
- MSc. Eng. Renato Dżugaj
- MSc. Eng. Zenon Jasiński
- PhD. Eng. Arch. Leszek Konarzewski
- MSc. Eng. Arch. Marek Konarzewski
- PhD. Eng. Jerzy Laska
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- PhD. Ulrich Schaff
- Prof. Jan Tajchman
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and others.

Contents

1. Introduction. The goal and scope of the report

The Report was prepared as part of a project entitled: ‘Preparation of a conservation management plan for Max Berg's Centennial Hall in Wroclaw, Poland’ as part of the ‘Keeping It Modern’ initiative. The project was funded with a grant from the J. Paul Getty Foundation and was realised in cooperation with the Museum of Architecture in Wroclaw.
The project involved the following:

– Analysis of the physical and mechanical properties of the building materials used in the construction of the building structure of the Centennial Hall,
– Laser measurement of the structure of the Hall and creation of a 3D model of the building as a basis for digital modelling,
– BIM (Building Information Model) and FEM (Finite Elements Method) modelling was used to assess the technical condition and conservation condition of the structure of the Hall,
– Conceptual basis for a plan for monitoring the structural security and consevation condition of the building

1.1. The goal of the study

The main goal of the study was to develop research materials for evaluating the current technical condition of the structure and building materials of the Hall which can serve as a baseline for regular assessment of the building in line with a proposed monitoring plan.

1.2. The scope of the study

The scope of the study included monitoring of the structural security and technical condition of the Hall, taking into account the deterioration of building materials. Thus, the scope of research work comprised the following:

– Analysis of the technical condition of the structure and building materials of the Centennial Hall,
– Analysis and assessment of the technical condition of the steel reinforcement,
– Analysis and assessment of the technical condition of bearings,
– Analysis of physical, chemical and mechanical properties of concrete,
– Assessment of the watertightness properties of the concrete,
– Identification of sites of corrosion hazard,
– Assessment of the integrity of sections of concrete elements,
– Development of an interactive digital model of the Centennial Hall based on three primary modelling approaches: FEM (Finite Elements Method) model for structural calculations, BIM (Building Information Modelling) model as a benchmark to allow for updating of information concerning the building’s infrastructure and for project purposes, LMS (Longterm Monitoring System) model for ongoing processing of data collected from sensors installed inside the building and in its immediate surroundings.

A detailed description of the structural security of the Hall and the technical condition of building materials and a programme for monitoring building condition over time provides a scientific and technical basis for monitoring changes in structural security over time.

2. Historical background - the structure

2.1. Description of the structure of the Hall

The structure of the Hall [3] comprises a central dome, measuring 42 m in height with an internal span of 65 m. Four semi-circular apses adjoin the dome on its main axes. The maximum width of the space free of structural elements is 95 m along the main axes of the building. The surface area of this space is 5.500 m^2. The central part of the Hall is surrounded by single-storey side lobbies, comprising rooms which can be used as additional exhibition spaces. The entrances to the building are located along the main axes of the structure. The west entrance faces the centre of Wroclaw and was built as the main entrance. A reception hall with the access to the Emperor's Stand, is located over the entrance space. Originally, the artists' gallery and a two hundred stop organ, which was the largest built in the world at the time, were to be found directly opposite the Emperor's Stand. The Hall was designed to provide seating space for nearly 6.000 people or standing space for 10.000. The dome had a form which was very different from the generally accepted standards of the time. The surface surrounding the interior of the Hall is not spherical in shape but consists of descending horizontal circular terraces and vertical cylindrical window walls. As the vertical window surfaces are not strongly affected by external weather conditions, they admit a great deal of natural light. The same feature was used in the apses. Only the groundfloor side lobbies make use of skylights, which were shaped in forms popular at the time.
According to [4], The Centennial Hall comprises four main structural components.

- **A lantern**, which crowns the ribbed dome. The lantern is supported by a keystone compression ring, which braces the 32 main arches of the dome at a height of approximately 36 m. The structure of the lantern consists of four rigid frames, which cross in the keystone block (fig. 2.1). The frames are firmly mounted in the compression ring, which has an internal diameter of 14.4 m and a cross-section of 150 cm (width) and 110 cm (height).

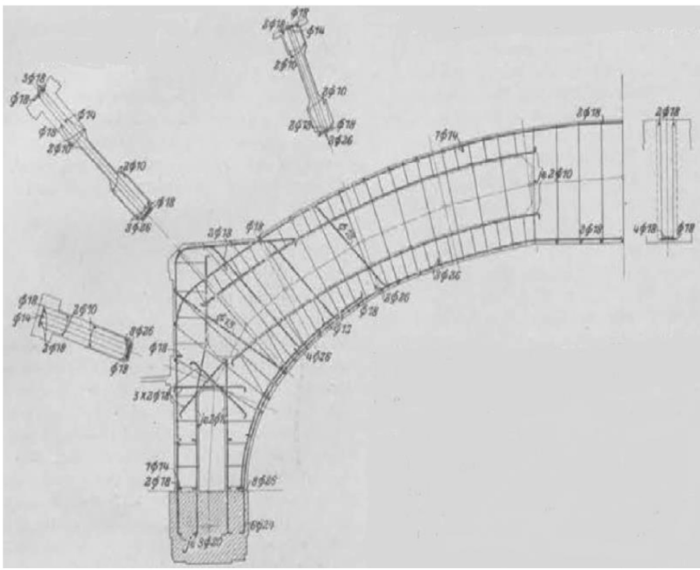

Fig. 2.1. The arrangement of reinforcing bars in the frames of the lantern according to [3].

- **A ribbed dome** (fig. 2.2), consisting of 32 arches (fig. 2.3, 2.4), inserted into the keystone ring at the top and anchored in the tension ring at the bottom. The main arches are divided into four segments with circumferential transoms along their length between the tension ring and the compression ring. The transoms stiffen the ribs of the dome and prevent them from torsion or buckling out of plane. They serve at the same time as supports for window walls and supports for ring ribs of the flat roofs. Terraced-glazed facade walls were placed on each of the transom rings.
- **A cylinder,** which forms the base for the dome. It is 19 m high, with an internal diameter of 65 m, and walls varying in thickness (stiffness). Four arcades of apses were cut into the cylinder symmetrically on its axes. Each arcade is 16.7 m high with a span of 41 m (fig. 2.5). Each apse consists of six supporting arches, which carry two window walls and two terraced flat roofs.
- **Side lobbies,** which constitute the external part of the groundfloor, which surround the arcades and the cylinder.

Fig. 2.2. The ribbed structure of the dome of the Centennial Hall.

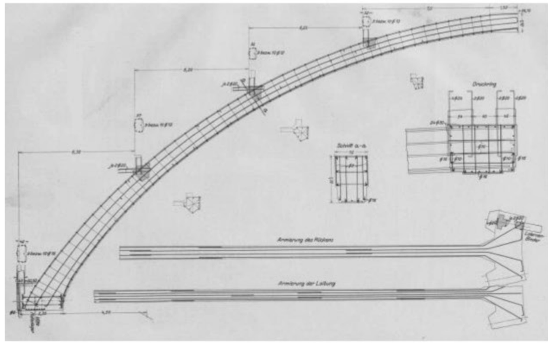

Fig. 2.3. Arrangement of the reinforcing bars in the dome rib according to [3].

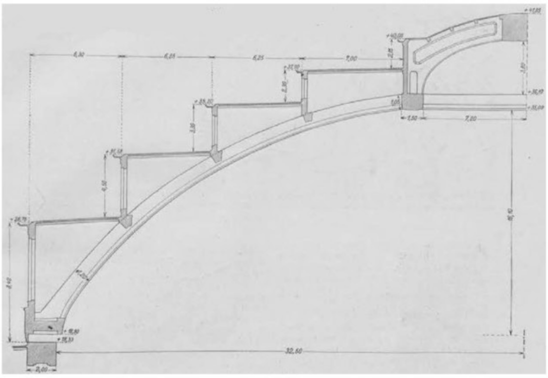

Fig. 2.4. Cross-section of the dome structure according to [3].

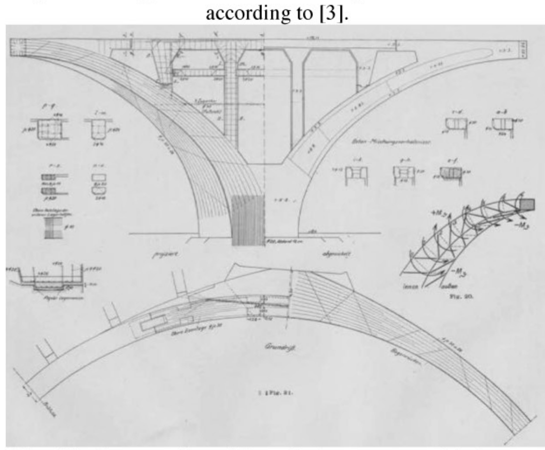

Fig. 2.5. Cross-section of the cylinder structure with the apse arcades cut out symmetrically on the axes of the cylinder according to [3].

According to [3], the dome was divided into two distinctly separated structural components: the dome proper with an internal span of 65 m and a height of 23 m (fig. 2.6) and a 19 m high dome base (fig. 2.7).

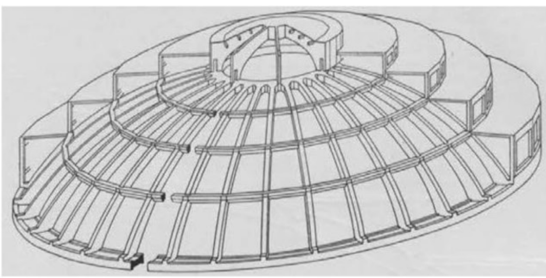

Fig. 2.6. The structure of the upper part of the Hall according to [3].

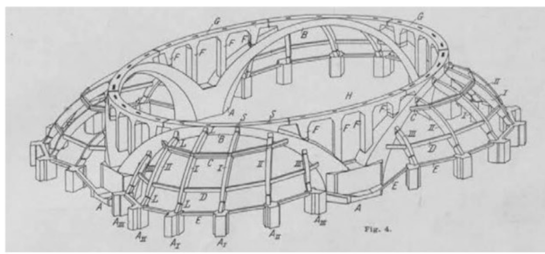

Fig. 2.7. The structure of the lower part of the Hall according to [3].

The load bearing structure of the dome consists of 32 ribs, which are braced at the top with a compression ring with an internal diameter of 14.4 m and supported at the bottom with a tension ring. The compression ring carries the load of the 5.75 m high lantern, which consists of four crossing trusses. The dome rests on a base by means of 32 bearings with tangent balancing mechanisms, which move in the radial direction (fig. 2.8) and is not influenced by horizontal forces, which would have occurred as a consequence of disassembly of scaffolding and as a result of changes in the thermal load, if the dome had been permanently fixed to its base. The radial arrangement of rollers allows for the wind load to be transferred to the base in a tangential direction, in which the load-carrying capacity for horizontal forces of the dome is the highest. From the static behaviour point of view, the structure of the base is very complex and is susceptible to unanticipated loading. For this reason, a number of elements additional to the bearings were introduced to support the overall stiffness of the structure.

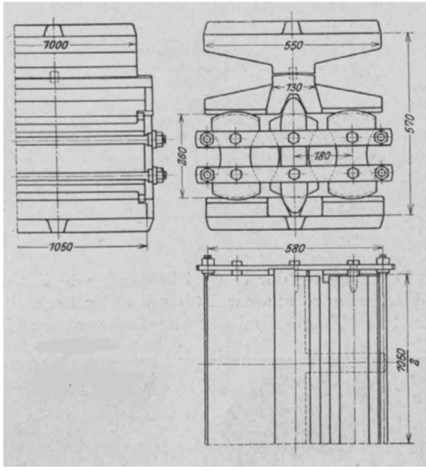

Fig. 2.8. The structure of a bearing according to [3].

Despite its simple form and a uniform distribution of vertical loads, the load-bearing structure of the dome is very complex due to the multiple indeterminability of the static scheme. Most probably the lower tension ring provides only minor resistance against the torsion of the dome trusses at the top, due to the small dimensions of its cross-section in relation to the diameter of the dome and due to the use of the bearings [3].

2.2. Description of building materials

The authors who carried out analysis of the conservation condition of the Hall, e.g. [4], claim that building documentation was modified, amended and updated also during the construction of the Hall. This observation concerns mainly the structure of the terraced roofs and facade walls, where significant discrepancies have been identified. They relate mainly to the arrangement of reinforcement, the length of lap joints and anchorage of reinforcing bars, and also to the density, homogeneity and structure of concrete. Archive information that the structural ceiling slabs and structural elements of the facade walls were prefabricated were not confirmed. The assumption is that only window posts and some of the lintels with small cross-sections were prefabricated. The remaining structures were made on-site and built using formwork. The principles of arranging reinforcement to assure homogeneity regimes and concrete density were not observed. The steel reinforcement is arranged at random and the quality of concrete (even within a single element) is highly variable.

2.2.1 Concrete elements

According to [3], the gravel concrete of the foundations consists of 1 part concrete to 7 parts gravel in the lower parts of the foundations, and 1 part concrete to 5½ parts gravel in the upper parts. The proportion used for the sections with anchored steel rods is 1:4. The pillars were built with crushed stone concrete consisting of 1 part concrete to 6 parts sand-gravel to 8 parts fine granite aggregate. Concrete was compacted with compressed air in all foundations and low-reinforced pillars with large sections.
The proportion of the concrete mix used for setting steel elements on the surface of the arches was as follows: 1 part concrete, 3 parts sand-gravel and 3 parts fine granite aggregate, whereas for the internal concrete core without steel fill, the loads carried were as follows: the proportion of 1:6:8 in the lower part, 1:5:6½ in the middle part and 1:4:5½ in the upper part. In the part at the very top of the dome measuring 1 m in length, the proportion was 1:2½:2½ and in the adjoining sections measuring 2.5 m the proportion was 1:3:3.
The reinforced concrete elements adjoining the cast-steel plate of the bearing were reinforced with three layers of reinforcing bars, each with a diameter of 12 mm, arranged in two crossing directions with grid slots of 5 cm with the proportion of concrete mix equaling 1:2½:2½. The strength of concrete cubes with the ridges of 30 cm were equal to 260 kg/cm^2 after 28 days. However, when the compressed surface was limited to a quarter, i.e. to a square of dimensions of 15 cm x 15 cm, then the breaking load related to a surface unit of the smaller compressed surface increased on average to 567 kg/cm^2 for unreinforced concrete samples and to 927 kg/cm^2 – also after 28 days – for samples reinforced with steel bars. After one year, the value increased to 1,089 kg/cm^2, which is why it was possible to adopt a compressive strength of concrete amounting to 1,000 kg/cm^2.
In the case of straining arches, it was necessary to use a concrete mixture with proportions of 1:3:3 with an increased moisture content, as application of concrete was possible only from the top as the sides were covered with formwork.
The concrete used in formation of the load-bearing structure of the dome was relatively dry in order to ensure appropriate density of these elements, which undergo compression, and to prevent accidental ‘flowing down’ of concrete mixture, which could be the case if the concrete had been more liquid.
The technical parameters of the concrete produced for the construction of the Hall were not good. This resulted in numerous defects in the reinforced concrete elements, which have had to withstand the destructive impacts of unfavourable weather conditions.
According to [3], the concrete used for the construction of the Hall could be classified as B12.5 (which translates to the contemporary C8/10 to C12/15 class), and of lower class in various places. According to contemporary sources, e.g.: [4], [8], [9] the class of the structural concrete can in places be much higher and reach values equivalent to the C30/37 class.

2.2.2. Steel reinforcement

According to [3], the percentage of reinforcement in the section of elements at the top of the dome is 0.32% with the surface area of reinforcement measures 3.0 cm^2, whereas at the abutments, the percentage of reinforcement in the section of elements is only 0.06% with the surface area of reinforcement equal to 21.0 cm^2. The small percentage of the steel reinforcement applied indicates that in the case of such structural elements, reinforced concrete is a suitable building material, and more cost-effective than steel structures. Several lateral bars were added in the planes of arches because of low value torsional stress. As the large sections did not require the use of common stirrups, the steel bars were anchored on the internal arch faces with 50 cm long 'S' shaped stirrups, which served to prevent delamination of the concrete layer from the steel reinforcement.

2.2.3 Metal elements

According to [3], 32 bearings upon which the dome rests were each calculated to bear a pressure of a force equal to 200 t. Tests were carried out to determine their sizes and detailed properties.

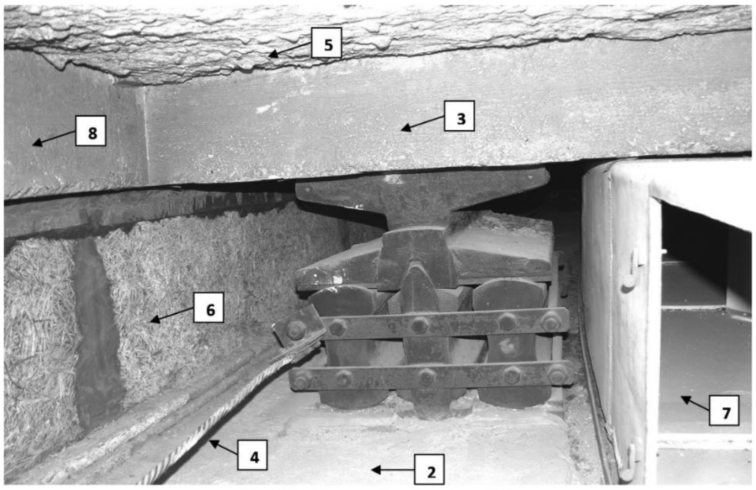

Fig. 2.9. The rocker bearing, [4].

Fig. 2.9 [4] presents a tension ring which rests on 32 steel bearings. A rocker bearing (1) is placed under each of the arches, which allows movement only along the radius of the ring. The bottom plate of the bearing is situated on reinforced concrete elements of the dome's base (2) and on the top plate there is a reinforced concrete cushion (thicker element) (3) comprising a concrete casing of steel lattice-work which make up the tension ring. A steel wire cable (4) is laid along the bearing duct to links all the bearings together and is connected in four places to the lightning protection system of the building. The intrados of the bearing duct consists of a concrete slab with a rough surface (5), which is separated from the solid section of the concrete casing of the lattice-work by a space that is approximately 5 cm wide. The external reinforced concrete wall of the duct has been covered on the internal side with cement-bonded woodchip tiles (6), whereas the internal wall consists of the casing of the ventilation duct (7), which is made mainly of asbestos and concrete tiles. The upper part of the external wall of the bearing duct consists of a reinforced concrete 'T' section ledge which constitutes also the casing for the lattice-work, (8).

According to [3], the tension ring comprised two rivet-joined lattice girders placed one on top of the other, with a total weight of 130 t (fig. 2.10). A great deal of attention was paid to careful and precise construction of the tension ring, which in a way serves as a thrust bearing for the dome and which transfers bending loads caused by wind. The tensile force was equal to 500 t for steel where the maximum permissible stress of 1,250 kg/cm^2 is the least favourable case. A tensile cross-bracing was used to join the two girders where there is potential for buckling, in addition to 10 horizontal anchors in each of 32 locations on each girder. Concrete elements of specified dimensions were produced and placed in specific locations to ensure an appropriate horizontal and vertical setting during the installation of the tensile ring. The 'S' shaped stirrups were used on the external surfaces of the girders to ensure an appropriate connection between the rivet-joined girder and the concrete elements.

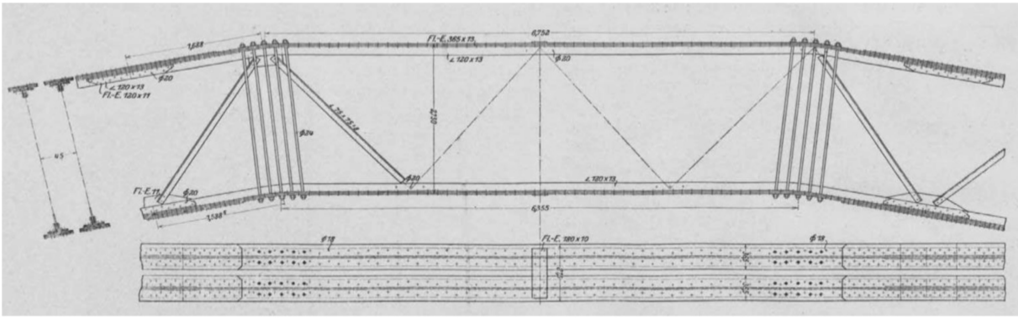

Fig. 2.10. The structure of the lattice girders of the bottom ring, [3].

2.2.4. Wooden elements

The single casement windows with rebates are the only original wooden elements remaining in the Centennial Hall. The windows were installed from the outside and open outwards [32]. They are made of so-called ironwood (*Casuarina* wood) imported from Australia, which is characterised by a rust-reddish colour [35].
A detailed description of window woodwork and an inventory of all the window-types in the Hall were prepared by prof. Tajchman in 2007 [32], [33], [34]. Bożejewicz prepared detailed drawings for each type of window [33], including external and internal views and all relevant sections. In addition, documentation has been prepared for all profiles of window frames (head, sill and side jambs, trim boards), window sashes (top rails, hanging stiles, weatherboards, muntin bars) and steel window fittings (hooks, knobs, corners, hinges), including specification of all relevant dimensions.

2.2.5. Analysis of damage, cracking and defects

The structure of the Hall comprises more than two thousand reinforced concrete elements, which were intended to perform a number of static, structural and functional tasks. It is only natural that the structural elements of the Centennial Hall, which were built over a hundred years ago when reinforced concrete construction was still being developed, display a number of defects, anomalies, irregularities and damage resulting from building use. The present condition of the building has also been influenced by the lack of sufficient renovation work following World War Two, [4].
Several thousand cubic meters of reinforced concrete structures were fabricated during less then eleven months. According to [4], the damage to the Hall's elements is widespread and highly varied. A study [4], covering the years 2007 and 2008, provides more detailed information on the range of damage and defects found in the building prior to the renovation work, which was carried out in the Hall's interior and exterior in subsequent years.
Describing the irregularities and anomalies of the structural solutions used in the Centennial Hall construction, the authors of [4] emphasised that, it is important to bear in mind that the Hall is one of the first buildings built at such a scale in Europe. It was designed and built in the years 1912 – 1913, when the theory of reinforced concrete construction was still being developed and a significant part of the design and planning decisions were made on the basis of the designers' intuition. Despite the fact that, at the time, calculation methods regarding the statics of the building based on advanced mechanics of the building were available, the designers used simplified models for calculations, which often generated results at odds with the actual situation. Graphic methods were an important element in reviewing and revising the static calculations. Such methods were also used by the designers of the Centennial Hall. It is important to remember that at the time, there were no analytical procedures for assessing the support (shearing) zone with stirrups. Designers were not familiar with the principles of reinforcing beams for torsion. They also neglected the role of stirrups in designing building structures. As a consequence, assessment of the structure of the Centennial Hall should take into consideration all the circumstances discussed above. The relatively small number of anomalies and defects in the building structure attests to the skill and intuition of the professionals who designed and built the Hall.
Some insignificant mistakes which were made during the construction of the Hall and some design shortcomings were observed shortly after the completion of the building. Fig. 2.11 presents locations, in which dilatations were planned to be introduced to counteract cracks, which appeared on the external walls.

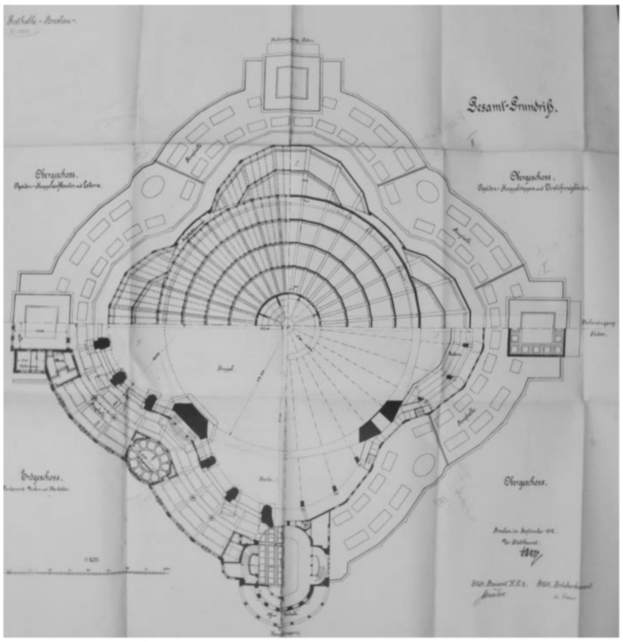

Fig. 2.11. Locations (marked in red) where dilatations were planned to be introduced due to cracks which appeared on the external walls of the Hall.

According to [4], the anomalies of the reinforced concrete structure of the Centennial Hall and their impact on the buildings overall safety can be listed as follows:

– Lack of additional regular reinforcement in the bottom tension ring of the dome, which would make the element a homogenous reinforced concrete structure and prevent excessive cracking of concrete. Lack of such reinforcement results in a high number of fissures and cracks in the concrete of the ring, decreasing its stiffness and facilitating corrosion of lattice-work which forms the rigid reinforcement (the extent of the corrosion was eventually determined to be insignificant),
– Lack of near-surface reinforcement in other elements of the large sections, which in the case of contemporary concrete could result in contraction cracking. Such cracking was not observed in the reinforced concrete elements analysed, which might have been caused by the application of types of concrete which generate lower hydratation heat during the process of setting and curing,
– Application of stirrups with the wrong geometry, i. e. single-shear stirrups with hooks at the ends,which are poorly anchored in the concrete and not able to embrace the whole section. What is more, the designers did not provide spacing dimensions for the stirrups in their drawings, which resulted in uneven spacing of this type of reinforcement in the structural elements,
– Varying thickness of the concrete casing in the secondary elements and casing too thin in places, which facilitated corrosion of the reinforcement,
– Lack of homogeneity of concrete in the element sections, as well as localised cavities, which translate into lower quality and decreased strength of concrete,
– Wrong assumptions for the reinforcement of the posts in the frames of the lantern resulted most probably in application of an erraneous calculation scheme for the structure, causing cracking in the internal branches of the frame posts. Collapse was a real threat as a result. But this was recognised before World War 2 and effective strengthening of the lantern structure was carried out, enabling the Hall to function on an ongoing basis.

The authors of [4] suggest that the Centennial Hall's designers disregardedsomewhat the bottom tension ring, which constitutes a very important structural element. They did recognise its critical role in providing for the overall structural security of the building. This element was one of only a few cases in which, not only did the design not allow an appropriate safety margin for the load-bearing capacity of the element, but it was also found to be deficient in its load-bearing capacity as has been demonstrated by computer calculations [4]. This deficiency resulted from the application of simplified static schemes. This, along with the other defects describee, may call for strengthening of the ring structure.

A specific characteristic of the design of the Centennial Hall is the high variability of safety margins adopted for different elements. Arches of the dome are, for example, characterised by high safety margins, whereas the tension ring and bearings of the main dome are characterised by low safety margins.

Localised damage in the connection areas of elements, which are made of different materials or separated from each other with dilatations, has been caused by thermal factors, which can seldom be prevented. Such damage can generate cracking in the adjoining elements, e.g. structural ceiling slabs or walls. Appearance and development of such damage may have also resulted from vibrations caused by the operation of various machines or equipment, such as ventilation fans. Mistakes in design, contruction and building use are the most frequent causes of damage to the concrete casing, the corrosion of steel reinforcement and localised damage to areas of unreinforced concrete.

The authors of [4] found that the design mistakes, which resulted in damage to the concrete, especially the concrete casing and corrosion of reinforcement,, correlated with the level of knowledge of reinforced concrete at the beginning of the twentieth century,

especially in the years 1911 – 1913, which was when the Hall was designed and built. Their findings took into account also the level of technological development at the time.
The design errors, which resulted in damage, were identified as follows:

- The application by the designer of low class concrete classified as B12.5 (currently classified as falling in between C8/10 and C12/15 classes), and even lower in places,
- The lack of necessary guidelines and information on the thickness of concrete casing in the design of facade elements.

It was concluded, however, that the causes listed above cannot be blamed on the structural designers of the Hall, as they reflected the state of knowledge of concrete and reinforced concrete construction which prevailed at the time. This refers in particular to the problems of corrosion of reinforced concrete structures and prevention of corrosion advancement. The B12.5 class concrete was regarded at the time as structural concrete and so its application in the Centennial Hall designed in the years 1911 – 1912 did not generate any reservations. The thickness of the concrete casing was not a design parameter, but rather a result of the building construction process. Structural concrete was regarded as an extremely durable material, not prone to corrosion and thus providing a sufficient protection for the steel reinforcement. There was no detailed analysis of the role of the concrete casing and the impact of the building's external surroundings.
Contemporary knowledge on the subject indicates that weak concrete undergoes the process of carbonisation faster and so, provides poor protection for the steel reinforcement from external factors, thus facilitating corrosion of steel elements. This is why an appropriate thickness of the concrete casing and its integrity are highly significant.
The low class and quality of the concrete in comparison to modern standards, which was referred to earlier, is a result of not only design parameters, but also in part the result of the quality of building work. It is important to consider also the level of concrete technology, which was much less developed at the time. The contractor building the Centennial Hall took measures to meet the technical parameters of concrete required by the designer by using basalt crushed-stone aggregate, but did not prevent the creation of localised discontinuities and cavities in concrete connections. The importance of concrete homogeneity was also not recognised (i.e. even aggregate content, especially with respect to coarse grain), nor the importance of assuring appropriate concrete density.
The following features of the reinforced concrete structures analysed promote damage to the concrete casing and steel corrosion and result from low quality construction work:

- Excessive porosity of concrete, including the presence of numerous pores visible to the naked eye as well as cavities. This kind of concrete structure allows penetration of gases and liquids, including aggressive substances. Concrete with high absorbability is not resistant to freezing.
- Varying thickness of the concrete casing covering the reinforcement (the casing thickness ranged from 0.5 cm to 4 cm), found to be insufficient in many places.

The analysis of concrete samples and damaged areas indicated that the concrete in monolithic elements was typically characterised by a lower density, whereas the prefabricated wall elements (e.g. window posts) had better parameters.
A significant cause of corrosion damage of the reinforced concrete facade elements arises during the ongoing functioning of the building, where the building's facade is subjected to external impacts, such as precipitation, aggressive gases and liquids, as well as freezing. The low quality of concrete magnifies these impacts by allowing penetration into the interior of the element sections. The impact of so called acid rain has caused damage to the surface of the Hall's façade by turning it into a powdered form.
Several interventions have been undertaken to protect some of damaged fragments of the external walls above the level of the side lobbies during the years the Hall has been in use. These included reprofiling and filling in cavities and covering repaired fragments with various protective coats. The repairs were carried out incorrectly as the corroded reinforcement was not cleared of corrosive deposits in a proper way and the substrate was not prepared appropriately. The wrong reprofiling materials were used. This resulted in further reinforcement corrosion and concrete damage.
The overall advance of corrosion of the reinforced concrete structural elements of the Centennial Hall has been facilitated by the lack of proper protection and maintenance repairs of the external elements, which have been the most exposed to the influence of aggressive external conditions.
The limited mechanical damage, visible in the upper parts of the Hall's façades, is the result of shelling during military operations in the last War. Mechanical damage visible in the lower parts of the building results also from vehicles, machines and other equipment hitting the façades or are the result of intentional work to cut or drill wall openings etc.
The accelerated surface corrosion of the groundfloor walls has been facilitated by the growing on the walls. In considerable areas of the facade surfaces, vegetation cover penetrates into the pores and fissures in the concrete, causing dampness and splitting the near-surface layers.
Cracks and fissures visible on the surface of the concrete can be attributed to a variety of causes:

- Cracks and fissures appearing along reinforcing bars resulting from reinforcement corrosion processes,
- Cracks and fissures in external walls, as well as in some lintels and cornice beams, which run almost vertically, as well as cracks appearing around window and door openings, are usually caused by the process of concrete contraction. They indicate insufficient care during the early stages of concrete curing and should be regarded as a deficiency on the part of the building contractor. This type of damage can be also influenced by changes in the external temperature, especially in places where there are large distances between dilatations or there is poor reinforcement of the walls. The archived static calculation documentation indicates that the Hall designers did not take into account thermal impact on the internal forces in the structural elements. Vertical cracks, as well as cracks running in different directions can be found on the Hall's facade walls where edges of the structural elements meet the monolithic walls of lower stiffness, which were built at the same time with poor reinforcement or without reinforcement altogether. This design defect is caused by differences in deformation of elements which carry heavy loads and elements which carry only their dead load, where there is no reinforcement joining them together,
- Some of the cracks (fissures) which can be found on the groundfloor walls in the northern part of the building may indicate localised of uneven settlement of soil substrate and foundations. There are cellars under the northern apse and side lobbies of the Hall. This would suggest a deficiency in design (assessment of the soil substrate), as well as in construction work

(analysis of soil substrate conditions). The nature of these deficiencies indicates that they originated a long time ago – most definitely prior to the flood of 1997.

The façade elements include relatively numerous spots which indicate that the breaks in the laying of the concrete were incorrectly executed – leading to cracks and fissures in these spots, separation of concrete, extensive concrete surface discontinuities and even cavities. Some of the dilatations planned by the designers were carelessly implemented and their edges have sustained damage over time.

Cracks and fissures where prefabricated facade elements (lintels, pillars) and monolithic elements (walls under window sills, cornice beams) meet are a consequence of the way the prefabricated elements were installed (rigid or flexible joints were not used at the time).

Infiltration spots of calcium hydroxide (from concrete corrosion from leaching) can be found in many places on the cornice beams. They appear much more frequently on the ceilings of terrace flat roofs above the level of the groundfloor. The calcium hydroxide leached from reinforced concrete flat roof slabs has migrated through cork tiles and the cement-bonded woodchip tiles. This is visible on the lower surfaces of tiles, suspended from the flat roofs.

The causes of this deficiency include leaks in the roof covering and the faulty operation of precipitation drainage systems prior to renovation and repair. They are the result of incorrect maintenance and functioning of building in past years.

2.3. Rebuilding, repair and conservation work

In a historical perspective, World War Two should have been the most difficult time for the Centennial Hall. But the building did not suffer during the bombing campaign in 1945, even though some of the other Max Berg designed buildings in the Exhibition Grounds were destroyed. Both the Hall and the Exhibition Grounds have functioned continuously right up to the present day.

There have been only a few changes in the structure of the Centennial Hall since it was built. The most important changes include:

- 1937 – construction of an external service staircase for the organ, renovation of the interiors and the roof terrace, installation of chipboards and cement boards to improve the acoustics of the Hall. This was a temporary solution, which was implemented due to the lack of funds for a more permanent solution;
- 1947 – 1948 – repair of war damage, roof repair, installation of transparent glass panes, disassembly of the damaged organ, removal of roof covering, renovation of damaged skylights over the passage way, replacement of electric and heating installations;
- 1996 – renovation of the Hall auditorium,, including seat replacement;
- 2009 – 2011 – the most comprehensive renovation of the Hall since it was built.

The renovation work completed in the years 2009 – 2011, was preceded by preparatory work, which included securing financing and carrying out several analyses and surveys to assess the technical condition of the building as a whole and its constitutent elements. Several reports were prepared, including: conservation documentation for the window woodwork, expert opinion on the technical condition of the building structure, dendrological analysis concerning the vegetation covering the building façades and the requirements for temporary protection of the vegetation during renovation work of the facade, assessment of the conservation condition and analysis of the colour scheme of the external walls, technical opinion concerning the strengthening of the main tension ring, metallographic examination of the condition and parameters of steel lattice-work elements of the tension ring, comprehensive assessment of the mechanical properties of the concrete in the tension ring, documentation relating to the conservation condition and exposed excavations in the Emperor's Room. The documents and reports listed above and consultations with a group of outstanding experts in heritage monument conservation, history of art and construction, provided the basis for developing designs and plans for the renovation of the Centennial Hall and for obtaining the planning permission required. Renovation work was divided into two stages due to the specific character of the financial support secured. The first stage involved renovation of the building's façades, whereas the second stage was related to the renovation and modernisation of the interiors, [1].

Stage one – the renovation of the façades began in February 2009, when planning permission was granted for renovation of the façades, window woodwork and the roof covering the Hall. The work started in March 2009 by ensuring protection for the vegetation growing next to the building walls so as to allow the process of cleaning the concrete façade surface. At the same time, windows were disassembled for comprehensive conservation in a specialist woodworking workshop and layers of roof covering were removed.

The original façade was repaired using concrete prepared on-site in wooden formwork. The pattern of formwork used, included varied heterogeneous texture with aggregates of various sizes, which allowed application of concrete varying in strength. The façade had sustained damage and was dirty with a layer of grime from exposure to destructive weather conditions.

The concrete façade had numerous cracks and fissures. The defects and cavities were the result of concrete degradation. The concrete casing of the steel reinforcement had lost its protective properties, causing corrosion of steel elements, which brought about further cracking and delamination of concrete fragments in window posts. The whole surface of the façade was in need of comprehensive conservation and renovation work.

The renovation work of the façades involved cleaning all the concrete elements, carrying out all necessary repairs to the damaged concrete and reinforcement, reprofiling of concrete cavities, injections of fill to secure cracks and fissures in the concrete structure, which had sustained damage from rain and wind.

Renovation work of concrete surfaces was completed as follows:

- the whole concrete surface of the façade was cleaned using low-pressure streaming of fine-grained abradent (quartz dust) protected by a water mist in accordance with the JOS method;
- cavities, honeycombing and corrosion delamination were repaired (reprofiled), and the corroded reinforcing bars were replaced;
- in the case of large cavities and delaminations, the missing surface was recreated in line with adjoining surfaces or surfaces of similar elements;

– small cavities and defects resulting from washing-out of the concrete texture were left without reprofiling, where they did not stand out from the adjoining surfaces or other elements of similar character, and where they did not affect concrete strength;
– injections of material to fill all cracks and fissures to secure the internal concrete structure;
– the concrete surface of the façade was secured with a water vapour-permeable impregnating agent.

The renovation work carried out included a securing of the main structural element, which is the bottom tension ring situated below the ribbed dome (fig. 2.12 – 2.14). The length of the ring perimeter is 218 m and the element is located 19 m above ground level. Intervention was necessary because the lighting and sound system equipment used for public events held in the Hall would have to be temporarily suspended from the structural ribs of the dome. The general contractor suggested securing the tension ring by surrounding the element on the outside with unbonded cords (27 cords, each with a diameter of 15.5 mm), grouped into nine cables, and each one comprising three cords. Cables were placed in PEHD tube covers and were laid on the external surface of the tension ring of the dome with a spacing of 140 mm between them. Prior to anchoring, the cables were also tightened using an even force equal to 15% of the load-bearing capacity of the cords, which ensured proper functioning of the anchors. After tightening, the cords were injected with cement paste and secured from their external side with a layer of low-shrinkage mineral mortar with a texture and colour compliant with recommendations of the heritage conservation officer and similar to that used on the other surfaces of the Hall's façade, [1], [5].

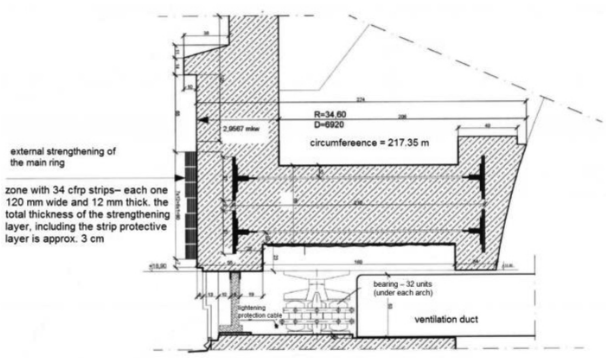

Fig. 2.12. Proposal for strengthening of the bottom tension ring with the application of C-FRP strips which had been considered earlier, [4].

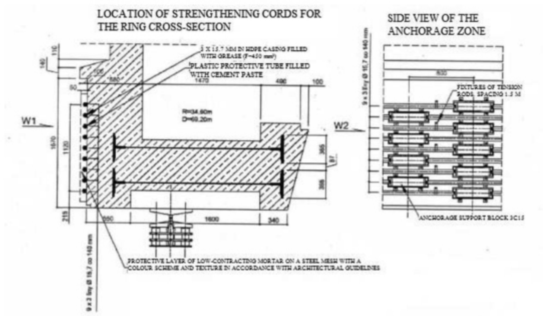

Fig. 2.13. Proposal for strengthening of the bottom tension ring with the application of cables, [6].

Fig. 2.14. Strengthening of the bottom tension ring –laying cables, [1].

The circumferential securing of the main structural element of the Centennial Hall with the application of an external prestress system is the largest strengthening intervention of this type in Poland.

Work on the Hall's façades was undertaken. After the façade surfaces had been cleaned, it was decided to test different colour hues of the paint coatings that were to be applied. An additional conservation assessment was conducted in order to determine the right colour scheme for the external walls: photographic documentation was prepared, places for extracting samples for laboratory testing were selected, and analysis of the preservation of tested fragments was carried out together with the analysis of the impact of destructive agents on the original colouring. Samples were extracted and specialist laboratory and stratigraphic tests were carried out, followed by analysis of the material gathered and test results. The final colour scheme for the façade walls was determined on the basis of these test results

The tests which were carried out indicated that the oldest ochre colour coating of paint had been applied directly onto the concrete surface. In addition to the ochre, the coating was found to contain an unidentified white. No organic binder or carbonates were found in the samples. The paint layers were brittle. Most probably, the original binder had disintegrated as a result of weather impacts. Light yellow paint layers were visible on the surface of five samples. These were all well connected to the substrate and some of them were shiny. The pigment used for this paint was also ochre, most probably with a silicate binder.

The overall colour scheme of the façade was varied and depended on several factors. Weather conditions have influenced the colouring of the paint coatings in various places. Rainfall has washed out pigments, whereas strong sunshine has turned natural ochre into a burnt ochre colouring, additional salt precipitation and repainting of some layers has resulted in a colour drizzle effect.
This effect resulted also from adding various types of aggregate to the concrete paste (basalts, granites, gravel and sand) and the application of different arrangements of formwork boards, accentuating individual elements of the façades. Most repair and secondary filling of cavities differed significantly from the original, both in terms of colour and in the technology applied. They turned out not to be durable and badly preserved.
The original colour scheme of the façades was difficult to identify as a result of several factors, such as soiling, damage and cavities, repainting, repairs, destruction of window paint coats and re-glazing of all the windows.
In the final analysis, it was concluded that it was not possible to identify unambiguously one colour for the whole surface of the façade. This was because the paints used originally had been applied in relatively thin layers and glazed in a particular way. The final decision on colour selection was preceded with several tests, which were carried out on clean concrete surfaces to assist in selecting the right paint coating. The basic colour selected was the S 0520-Y20R colour in accordance with the NCS colour classification model or colour number 35 H 54 (Farbreihe 35 Goldocker) in the KEIM historisch colour model.
Colour testing was carried out on specially prepared surfaces of the façade. The test results were assessed by a team of conservation experts, designers and contractors. The colour experimental testing led to the decision to use a non-standard colour. The colour of the paint and its concentration was determined through individualised test applications.
KEIM paints were used in order to ensure the integrity of the colour scheme. First of all, surfaces were grounded with a primer containing a sol-silicate binder. Then a glazing coat of a sol-silicate paint was applied. The glazing coat consisted of a diluted mix of four base colours. The colour composition obtained in this way was marked as 27/9 HS.
The overall perception of the colour scheme of the façades depends not just on the colouring of concrete surfaces, but also on the colours of window woodwork. Windows comprise two different types of materials – wood which constitutes the window structure and glass which fills the structure. The colour of the paint used for window woodwork had been selected earlier, during the renovation of window and door woodwork in the side lobbies of the Centennial Hall. The S 4050-Y80R colour was chosen in accordance with the NCS colour model.
The renovation of all windows was recommended, including replacement of all damaged elements of frames and restoration of missing elements. Iroko wood was identified as the most suitable material for the window renovation work.
No fragments of the original glazing have survived for use as a reference. There was no historical documentation describing types and colours of glass used in the original glazing of the dome windows. The only information discovered in documents from the years 1913 – 1914, which are stored in the State Archive in Wroclaw, is a reference to a delivery of ten boxes of textured yellow-green opalescent glass in May 1913. There is also confirmation that Berg accepted the colour of the first batch of textured glass which was marked with the number 21, with an adnotation that the colour of the sample is acceptable but required the texture to be that of sample number 23. The relief structure of glass was to improve the acoustics of the Hall, whereas the colour of glass and its structure were chosen to limit the intensity of the sunlight, which otherwise might have dazzled the audience.
The experts identified that the glass for window glazing came from the glassworks in Pirna, a town not far from Dresden in Germany. Efforts were made to recover the original catalogues and samplers of glass produced at that time by the glassworks. Unfortunately, the factory was closed down and the buildings have been demolished. The local town hall did not posess any documents related to the glassworks and the local museum had no artefacts from the factory or glass produced in it. Through the support and help of some enthusiasts, the experts were able to identify the name and address of the last manager of the glassworks, who happened to be also a utility glass collector. His collection comprised an original sampler and catalogue of window glass produced in the factory in the years 1913 – 1914. The catalogue included also a sample identified as number 21 (a photograph of the sample was attached). This was the type of glass named in the documents found in the State Archive in Wroclaw. This is the only sample of glass with the colour identical to the original window glazing, but it has a slightly different texture pattern.
The glass sample, which was discovered, served as a reference in the search for glass production with a close resemblance to the original. More than a dozen window glass samples were obtained and assessed by the team of conservation experts, designers and contractors and the decision was made to use an ornamented tempered glass in ochre.
All façade renovation works were carried out without limitating the normal use and operation of the Hall in any way, with mass events organised both inside the building and in the surrounding grounds, [1], [7].
The second stage – renovation work of the interiors began in January 2011 and was completed in August of the same year. It was a very short period of time for a complex renovation intervention.
The aim of the renovation was to adapt the building to the modern requirements which have to be met by any sports and entertainment arena. As a result, the Hall could be still used for the purposes it had originally been designed for. Work essential for allowing the Hall to serve as a venue for concerts, sport events, conferences and congresses, artistic performances, trade fairs and exhibitions, which was carried out, included:

- a complete replacement of the auditorium with a new one, which provides seating for a maximum number of seven thousand people or standing room for ten thousand. On a temporary basis (as in the case of sports events) up to ten thousand people can be seated, if the moving floor is lowered to the level of (–) 2.7 m;
- four dressing room complexes were built for teams participating in sports events, along with rooms for trainers and team support staff;
- all office and ancillary rooms in the side lobbies were dismantled;
- the bathrooms were extended to accommodate theincreased number of Hall users;
- a Discovery Centre was organised in a separated part of the side lobbies (in the south west part of the building) and the space was adapted to its needs;
- the window jalousies made of metal were replaced with contemporary ones made of non-flammable textile material, with fully automatic opening and closing systems;
- the flooring in the side lobbies was replaced;
- the Emperor's Room and its back rooms were modernised;

– tthe acoustic cladding of the performance hall was replaced;
– the suspended ceiling in the hallway of the main entrance was disassembled, uncovering the original reinforced concrete coffer ceiling;
– the concrete surfaces inside the Hall were cleaned using a closed system water streaming method, which included detergent additive;
– the stone cladding of walls, which had been added in the rooms next to the southern and northern entrances was dismantled and the original look of these rooms was restored.

As financial resources were limited, mechanisms for installing the movable floor were not completed and the audience galleries at -1 level were not built. This meant that the ten thousand seat capacity for hosting international sporting events is not yet available. However, the building is technically ready for the relevant fittings to be installed.

The following structural work was also carried out in the building:

– removal of reinforced concrete audience galleries and flooring of the performance hall which had been installed in 1996;
– the floor of the performance hall was lowered to the level of – 3.70 in order to install a movable floor,
– the structure of the lantern was secured and strengthened using carbon fibre C-FRP strips,
– construction of a reinforced concrete structure of the permanent auditorium and steel telescopic audience galleries,
– repair (reprofiling) of structural reinforced concrete elements inside the Hall,
– installation of a duct for heating and water and sewage systems under the floor of the side lobbies.

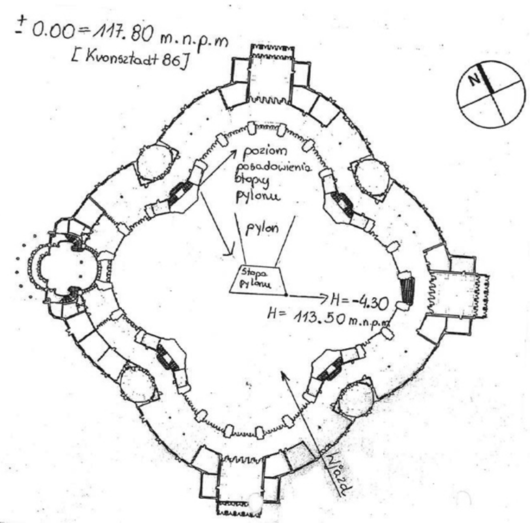

Fig. 2.17. A sketch of the foundation constructed for the movable floor in the performance hall.

A movable floor was designed for the performance hall, to be operated between the 0.00 to -2.75m levels. A 1 m high space was reserved for the mechanism of the floor and a 1 m thick reinforced concrete foundation slab with a heavy waterproofing insulation was to be placed in the space below (fig. 2.17). Two sewage pumping stations were planned in the area of the excavation at a depth of -6.00 m below the level of the flooring. To achieve this, a deep excavation had to be undertaken with the bottom reaching approximately 1.50 m below the block foundations of the arcade pillars (–4.30 m below the level of the flooring) and 3.0 m below the groundwater table. The geological layers below are not complex but are extremely unfavourable for any excavations carried out below the depth of 1.50 m below ground (flooring) level. The top geological layer is 12.0 to 13.0 m thick, comprised of various types of sand. A layer of glacial till lies under the sand. In order to proceed with deeper excavations in such conditions, it was necessary to install a slurry wall (anchored in the water proof clay layer) to protect the excavation from the inflow of groundwater and to prevent washing out of sand from beneath the block foundations.

Slurry walls were used to prevent an uncontrolled settlement of the foundations. They were prepared using Deep Soil Mixing technology and Solicrete Jet Grouting technology. The sides of the deep excavation were secured with a palisade consisting of DSM columns with a diameter of 70 cm and Solicrete columns with a diameter of 80/200 cm, which sealed the load-bearing elements. The DSM columns were reinforced with IPE 360 and IPE 450 steel profiles. The slurry walls were constructed as so called lost elements. No additional strengthening or securing of block foundations of the pillars was applied.

All existing electricity installations, water and sewage systems, heating and ventilation systems, sound systems, fire protection systems, IT installations and security systems were replaced in the building.

The work in the Centennial Hall was carried out in accordance with the recommendations of heritage conservation experts who had been consulted on the subject, which required the following:

– the model for the interior design to be in the original décor from 1913;
– the pillars of the arcades not to be covered with permanent elements of the audience galleries. As a consequence, mobile (folded-in) galleries were designed for these locations. The two-level (LD type) galleries can be disassembled, or used temporarily during international sporting events;
– the acoustics to be improved. Modern technology was used to replace the old cement bonded woodchip boards (heraklit boards) on the arcade pillars with new types of cladding;

- ventilation fans in the arcade pillars to be replaced with more efficient ones;
- asbestos ventilation ducts located at the level of the first main tension ring to be replaced with ducts conforming to contemporary legal requirements. External ducts to be replaced with long-range nozzles on the the condition that the colour scheme of the nozzles is similar to the colour of the concrete;
- all heritage staircases with railings to be preserved;
- the suspended ceiling in the hallway of the main entrance to be disassembled;
- the stone cladding of walls in the square rooms to be dismantled to uncover the original natural surface of reinforced concrete walls;
- All audience galleries to be dismantled, along with their support structures to floor level, except for those dating back to 1913: seats and other elements of interior design installed in the new galleries to refer to the original materials of the Hall;
- electricity installation in the side lobbies to run along the longitudinal axis of the lobbies in a casing under the ceiling;
- air supply openings and ventilation outlets in the Emperor's Room to be placed in the external wall;
- ventilation central units and mechanical ventilation ducts to be located in the ceiling spaces or under the audience galleries;
- elements of the alarm system can be visible but should not clash with the interior design of the Hall.

The Discovery Centre has been organised in a separated part of the side lobbies. It is equipped with modern audio-visual technology and comprises a multimedia exhibition on the history of the Centennial Hall and the grounds that surround it, [1].

3. Structure and material testing

A number of structural and material tests have been carried out in the Centennial Hall. The tests relate to the building's static behaviour, mechanical, physical and chemical properties of materials and to the building's façades. The following section presents the the tests carried out to date, including the most recent tests carried out in 2015.

3.1 Structural concrete – earlier tests

The following tests of the concrete used in construction of the Centennial Hall were carried out for structural, architectural and conservation purposes, [4], [8], [9].

3.1.1 Compressive strength tests of concrete

Eleven boreholes were made with a ∅80 drill I (fig 3.1) as described in [4] in order to determine strength parameters and assess the absorbability of structural concrete. Core samples were extracted in selected locations in the Centennial Hall structure.

Fig. 3.1. Core samples, [4].

Localised damage (cavities, delamination, honeycombing and cracking) made it impossible to test some of the extracted samples in a testing press and so the number of tested samples does not allow for an accurate assessment of the concrete class, and so the result should be treated as an overestimate.
The macroscopic evaluation of the concrete indicates that the following types of aggregate were used in the structural concrete of the Hall: granites (locally with a small amount of haematite) and feldspars dominate, with smaller amounts of marble, quartzite, basalt and slate. The maximum diameter of the aggregate grain is more than 20 mm. The aggregate composition was selected in a careless manner, which is evidenced by the low content of the small aggregate fraction. The H7 and H8 boreholes were drilled on purpose through clearly visible cavities. These were were found during drilling in the solid sections and blocks, and provided core fragments unsuitable for preparing samples for strength (compression) tests.

Table 3.1. Results of compression tests, [4].

No.	Laboratory identification of samples (LOK)	Sample dimensions		Maximum load at failure F [kN]	Compressive strength f_c [MPa]	Compressive strength $f_{c.cube} = 1.05\ f_c$ [MPa]
		Diameter	Height			
1.	LOK-926/H1	74.6	74.5	174.3	40.0	42.0
2.	LOK-926/H2a	74.7	74.4	144.6	33.0	34.7
3.	LOK-926/H3b	74.4	75.5	110.5	25.5	26.8
4.	LOK-926/H4a	74.6	74.4	99.5	23.0	24.2
5.	LOK-926/H5	74.4	75.0	231.6	53.5	56.2
6.	LOK-926/H6a	74.6	74.4	246.9	56.5	59.3
7.	LOK-926/H9	74.6	74.7	118.5	27.0	28.4
8.	LOK-926/H10b	74.6	74.8	39.5	9.0	9.5
9.	LOK-926/H11	74.5	73.5	94.9	22.0	23.1

Compressive strength values higher than 30 MPa obtained in testing (tab. 3.1) should be regarded as overestimates, as they do not reflect the generally low strength of the structural concrete of the Hall. The concrete used for the construction of structural elements is characterised by high heterogeneity, varied grain and aggregate composition. Lack of proper density of concrete (cavities, honeycombing, cracking) has been identified in the central parts of the solid sections. In the case of some long core samples (40-50 cm), the ends crumbled before they were extracted from the borehole.

Field testing of the concrete perimeter ring presented in [8] included precise assessment of the current compressive strength of the concrete, based on the evaluation of core samples, accounting for the direction of the laying of the concrete and the variability in this characteristic within the thickness of the analysed structure. The research programme involved carrying out all planned measurements in ten selected locations, distributed evenly on the perimeter of the analysed ring. Some of the measurements were carried out only on the external side of the ring (perpendicular to the direction of the laying of concrete) and some were carried out both on the external and top sides of the ring (parallel to the direction of laying of the concrete). The precise location of measurement points is shown in fig. 3.2. The numbers refer to the specific arches, making up the structure of the dome, which is supported by the tested ring. Thus the measurement locations were marked as follows:

– measurement point no 1 – fragment of the ring between arches no 30 and 31,
– measurement point no 2 - fragment of the ring between arches no 5 and 6,
– measurement point no 3 - fragment of the ring between arches no 8 and 9,
– measurement point no 4 - fragment of the ring between arches no 11 and 12,
– measurement point no 5 - fragment of the ring between arches no 14 and 15,
– measurement point no 6 - fragment of the ring between arches no 16 and 17,
– measurement point no 7 - fragment of the ring between arches no 18 and 19,
– measurement point no 8 - fragment of the ring between arches no 21 and 22,
– measurement point no 9 - fragment of the ring between arches no 24 and 25,
– measurement point no 10 - fragment of the ring between arches no 27 and 28.

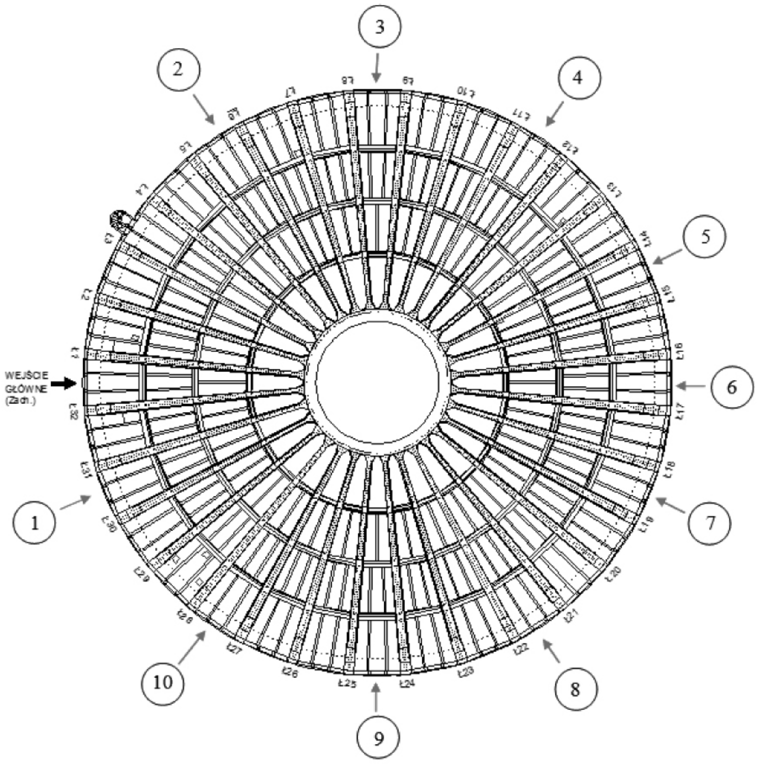

Fig. 3.2. Location of measurement points [8].

Twenty core samples, each with a diameter of approximately 100 mm, were extracted from the ring using a crown drill to obtain information on the strength parameters of the concrete. The core samples were cut into specimens of dimensions h≈ϕ≈100mm and tested in a testing press.

As two boreholes were drilled at each of the measurement points – one from the top of the ring and the other in its external side – a rule was adopted to mark them in an unambiguous way. The rule specified that the number of a borehole drilled along the direction of the laying of concrete (in the top side of the ring) would be the same as the number of a given measurement point. The number of a borehole drilled at the same point but perpendicular to the direction of laying of concrete would be the number of the measurement point plus 10. Thus, for example, if a given borehole is marked as number 12, it means that it was drilled at the measurement point

number 2, perpendicular to the direction of laying of concrete.
Individual specimens for strength testing were marked in the same way as the boreholes, including also information on the depth at which the specimen was extracted, for example:

- specimen **O-2/A** – is a concrete specimen extracted from borehole **no 2** and marked as **A,** meaning it came from the external concrete layer, which is about 10 cm thick.
- specimen **O-2/B** - is a concrete specimen extracted from borehole **no 2** and marked as **B,** meaning it was extracted from a depth of approximately 10 to 20 cm from the external surface of the ring,
- specimen **O-2/C** - is a concrete specimen extracted from borehole **no 2** and marked as **C** meaning it was extracted from a depth of approximately 20 to 30 cm from the external surface of the ring.

The face surfaces of specimens were adjusted for testing by capping with sand tips in order to ensure they were parallel to each other.
The following assumptions were adopted while processing the results obtained from compressive strength tests of the concrete specimens with dimensions of $h \approx \phi \approx 100$mm:

- in accordance with Bukowski [10], it was assumed that the relation between compressive strength determined for cube-shaped specimens with the dimension 'a' is equal to compressive strength determined for cylinder-shaped specimens with the height and diameter equal to 'a', multiplied by 1.12,
- thus the following relation can be assumed as true:

$$\mathbf{R_{cube}}(a=100\ \text{mm}) = \mathbf{1.12\ R_{cylinder}}(h=\phi=100\ \text{mm})$$

- additionally, the following relation was adopted in accordance with [11]:

$$\mathbf{R_{cube}}(a=150\ \text{mm}) = \mathbf{0.9\ R_{cylinder}}(a=100\ \text{mm})$$

- as a result, the following relation was obtained:

$$\mathbf{R_{cube}}(a=150\ \text{mm}) = \mathbf{1.12\ x\ 0.9\ R_{cylinder}}(\phi=100\ \text{mm})$$

and thus:

$$\mathbf{R_{cube}}(a=150\ \text{mm}) \approx \mathbf{R_{cylinder}}(\phi=100\ \text{mm})$$

The visual inspection of extracted samples indicated that the analysed concrete comprised granite aggregate with an addition of natural aggregates and is characterised by a good grain-size (fig. 3.3). Its average weight by volume is 2,236 kg/m^3.

Fig. 3.3. Structure of the analysed concrete as exemplified by a sample from borehole no 10, [8].

The results of compressive strength tests obtained for concrete specimens cut from core boreholes allowed the mean compressive strength, minimum strength value, coefficient of strength variation and weight by volume of concrete to be determined for each of the specimens.
The strength class of the analysed concrete was determined based on the results obtained in accordance with the European Standard [12], with the assumption that the characteristic strength of the analysed concrete, corresponding to the strength determined for cube-shaped specimens of dimensions of 150 x 150 x 150 mm ($f_{ck,is,cube}$), is the lower value of the two presented below:

$$f_{ck,is,cube} \leq f_{cm(n),is} - k \quad \text{and} \quad f_{ck,is,cube} \leq f_{is,lowest} + 4 \qquad (1)$$

where:

$f_{ck,is,cube}$ - the characteristic compressive strength of concrete in structures, equal to the strength of concrete determined for cube-shaped specimens with the side length of 150 mm

$f_{cm(n),is}$ - the mean value of compressive strength of concrete in the structure, obtained from **'n'** test results

$f_{is,lowest}$ - the lowest of determined values of compressive strength of concrete in structures

k - variable dependent on the number of strength test results (n), equal **5** when n=10-14, equal **6**, when n=7-9 and equal **7** for n=3-6

A correction factor equal to 0.85 takes into account the widespread view that the strength of concrete in structures is generally lower than the strength determined for standard samples and was taken into account in the analysis in accordance with [12] and [13]. Examples of strength test results, obtained for the external 10 cm thick layer of concrete, in line with the direction of laying of concrete, are presented in table 3.2. Results for concrete extracted from a depth of 10 to 20 cm, perpendicular to the direction of laying of concrete are presented in table 3.3.

Tab. 3.2. Results of strength tests for the external 10 cm thick layer of concrete in the direction of laying of concrete, [8].

Specimen number	Diameter F [mm^2]	Force P [kN]	Weight by volume [kg/m^3]	Compressive strength [MPa]
specimen **O-1/A**	6962	269	2283	**38.7**
specimen **O-2/A**	6960	235	2191	**33.8**
specimen **O-3/A**	6968	280	2237	**40.2**
specimen **O-4/A**	6983	240	2217	**34.4**
specimen **O-5/A**	6945	197	2222	**28.4**
specimen **O-6/A**	6936	300	2268	**43.2**
specimen **O-7/A**	6944	177	2204	**25.6**
specimen **O-8/A**	6945	307	2284	**44.3**
specimen **O-9/A**	6944	245	2273	**35.3**
specimen **O-10/A**	6953	244	2249	**35.1**

Tab. 3.3. Results of strength tests for concrete extracted at a depth of 10 to 20 cm, perpendicular to the direction of laying of concrete, [8].

Specimen number	Diameter F [mm^2]	Force P [kN]	Weight by volume [kg/m^3]	Compressive strength [MPa]
specimen **O-11/B**	6975	200	2250	**28.7**
specimen **O-12/B**	6964	185	2180	**26.6**
specimen **O-13/B**	6963	232	2239	**33.3**
specimen **O-14/B**	6954	136	2165	**19.6**
specimen **O-15/B**	6968	146	2226	**21.0**
specimen **O-16/B**	6987	224	2303	**32.1**
specimen **O-17/B**	6975	217	2236	**31.1**
specimen **O-18/B**	6982	197	2281	**28.2**
specimen **O-19/B**	6980	249	2243	**35.7**

Table 3.4 presents mean values of parameters obtained from test results for individual sections of the concrete ring with the aim of presenting the overall distribution of strength of the tested concrete.

Tab. 3.4. Mean values of strength parameters of the tested concrete, [8].

Tested section	Mean strength [MPa]	Minimum strength [MPa]	Coefficient of variation [%]	Weight by volume [kg/m^3]
Near surface layer (up to a 10 cm depth) in the direction of layind of concrete	**35.9**	25.6	16.6	2243
Layer at depth (at a depth of approx.. 10 to 20cm) in the direction of laying of concrete	**28.9**	21.4	18.4	2257
Layer at the depth (at a depth of approx 20 to 30 cm) in the direction of laying of concret	**28.2**	21.0	17.3	2210
Near surface layer (up to 10 cm depth) perpendicular to the direction of laying of concrete	**38.5**	32.1	10.2	2232
Layer at depth (at a depth of approx 10 to 20 cm) perpendicular to the direction of laying of concrete	**28.5**	19.6	19.0	2236

3.1.2 Concrete absorbability testing

Table 3.5 contains detailed results of the concrete absorbability tests, [8]. It has to be stressed that the results presented are astonishing as the obtained values of absorbability are very low, ranging between **3.9%** and **4.8%**, which is a result difficult to achieve even today, with the availability of much more advanced concrete technologies.

Tab. 3.5. Results of concrete absorbability for specimens extracted from the tested ring form a depth of 10 to 20 cm.

Specimen number	Saturated specimen weight [g]	Dry specimen weight [g]	Absorbability [%]
specimen **O-2/B**	1483	1416	**4.70**
specimen **O-4/B**	1526	1469	**3.90**
specimen **O-6/B**	1498	1440	**4.00**
specimen **O-9/B**	1489	1430	**4.10**
specimen **O-11/B**	1494	1426	**4.80**
specimen **O-15/B**	1510	1449	**4.20**
specimen **O-17/B**	1516	1454	**4.30**

It has to be emphasised that the tests were carried out on specimens extracted from a depth of approximately 10 cm to 20 cm in the tested ring, which practically excludes the possibility that the surface sealing with soluble glass applied during construction of the Hall had any potential influence. It should be noted that the coefficient of variation for the absorbability of the tested concrete is approximately **8.0%**, which indicates a high homogeneity of this parameter. The values of absorbability obtained in [4] are presented in Table 3.6.

Tab. 3.6. Results of concrete absorbability testing, [4].

No.	The Laboratory identification of samples (LOK)	Concrete absorbability [%]
1.	LOK-926/H1	3.0
2.	LOK-926/H2b	4.3
3.	LOK-926/H3a	4.3
4.	LOK-926/H4b	5.3
5.	LOK-926/H6a	4.0

6.	LOK-926/H9	4.3
7.	LOK-926/H10a	5.9
8.	LOK-926/H11	5.5

3.1.3 Sclerometric measurement of compressive strength of concrete

Sclerometric measurements described in [4] were carried out with the N type Schmidt hammer certified by the Swiss PROCEQ SERVICE company. Damaged and uneven places on the concrete surface were cleaned and polished prior to testing.

The class of concrete was estimated on the basis of the rebound number of the sclerometer using the correlation relations described in [15]. Additionally, the requirements of standards [16], [17] were taken into consideration.
The static parameters of the rebound number for each element were obtained from the following formulae:

- Mean value of the rebound number:

$$\overline{L} = \frac{\sum L_i}{n} \tag{2}$$

where: L_i – average, reduced value of the rebound number in a given location,
n – number of measurement locations.

- Standard deviation of the rebound number:

$$s_L = \sqrt{\frac{\sum (L_i - \overline{L})^2}{n-1}} \tag{3}$$

- Coefficient of variation of rebound numbers:

$$\nu_L = \frac{s_L}{L} \tag{4}$$

The static parameters of the compressive strength of concrete, referenced to standard cube-shaped samples, were determined using the following formulae:

- Mean compressive strength of concrete:

$$\overline{R} = k_1 k_2 \overline{L}\left[0.0356\overline{L(\nu_l^2+1) - 0.795 + \frac{6.4}{\overline{L}}}\right] \tag{5}$$

- Standard deviation of concrete strength:

$$S_R = k_1 k_2 \overline{L}\nu_L \sqrt{0.00254\,\overline{L}^2(\nu_L^2+2) - 0.1134\,\overline{L} + 0.633} \tag{6}$$

- Coefficient of variation of concrete strength:

$$\nu_R = \frac{s_R}{\overline{R}} \tag{7}$$

- Minimum guaranteed strength:

$$R_b^G = \overline{R} - t_{\min} * S_R \tag{8}$$

where $t_{min} = 1.64$,

- Concrete homogeneity factor:

$$k_R = \frac{R_b^G}{\overline{R}} \qquad (9)$$

A reduction related to the age of the structure was accounted for (concrete carbonation factor value of 0.6 was adopted) in determining the strength of the concrete.

Measurement results of rebound numbers for selected structural elements of the Centennial Hall, as well as concrete strength parameters and concrete class results, obtained through sclerometric testing, are listed in an appendix to [4]. It is important to note, the high heterogeneity of structural concrete and the presence of areas of extremely low strength – below the old B10 class (present-day C8/10 class). The reduced strength can be explained by concrete surface erosion and the considerable heterogeneity of the material.

3.1.4. Concrete strength testing with the pull-off testing method

The tensile (pull-off) strength of concrete was tested with the pull-off testing method, in accordance with [14]. The tests were carried out with a DYNA device made by the Swiss Proceq company, using 50 mm diameter metal discs.

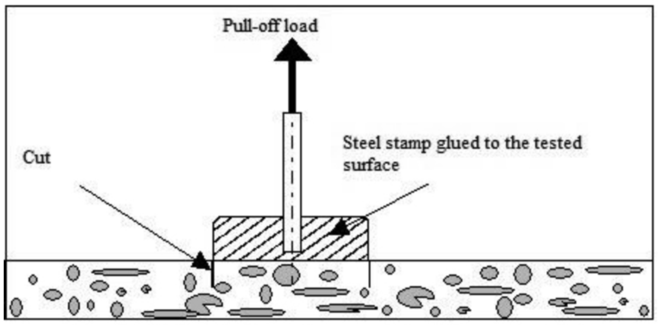

Fig. 3.4. Pull-off testing – the essentials of the method, [8].

In accordance with recommendations regarding requirements which have to be fulfilled by a concrete surface for it to undergo modern surface repairs, e.g. using PCC type materials, it was determined that the following conditions have to be met:

- mean compressive strength of concrete should be no less than 25 MPa,
- mean pull-off strength, determined in a given measurement location for all measurements carried out, should be no less than 1.5 MPa,
- the minimum value of a single measurement should be no less than 1.0 MPa.

The measurements [8] were carried out on the external surface of the tested ring in ten locations, which had been selected earlier in the vicinity of the core boreholes.

The essence of the pull-off testing method involves the measurement of the load which pulls off a metal disc with a specified surface area, glued to the surface which is being tested, (fig. 3.4). A centric cut 10 – 15 mm deep is made around the disc. The registered value of the pull-off load, divided by the surface area to which the load is being transferred, gives the value of concrete tensile strength, which is also known as pull-off strength.

Detailed results of the concrete tensile (pull-off) strength measurements are presented in Table 3.7.

Tab. 3.7. Results of concrete tensile (pull-off) strength testing using the pull-off testing method, [8].

	Direct reading of the pull-off load [kN]	Pull-off strength [MPa]
Measurement location **B-1**	9.10	**4.64**
Measurement location **B-2**	6.00	**3.06**
Measurement location **B-3**	7.80	**3.97**
Measurement location **B-4**	5.60	**2.85**
Measurement location **B-5**	8.10	**4.13**
Measurement location **B-6**	4.40	**2.24**
Measurement location **B-7**	5.50	**2.80**
Measurement location **B-8**	8.70	**4.43**

Measurement location **B-9**	7.40	**3.77**
Measurement location **B-10**	8.50	**4.33**

The results discussed in [4] are presented in Table 3.8.

Tab. 3.8. Results of concrete tensile (pull-off) strength testing using the pull-off testing method, [4].

No	Element	Pull-off strength	Mean pull-off strength	Minimum pull-off strength	Type of failure
		[MPa]	[MPa]	[MPa]	
1	North side external wall – level +1.4m	0.9	1.49	0.70	P
2	East side external wall– level +0.5m	1.0			P
3	South side external wall– level +0.8m	0.7			P
4	West side external wall – level +0.9m	1.2			P
6	East side external wall (rib 15) – level +18.5m (ring 3A)	2.1			P
7	South side external wall (rib 24) – level +18.5m (ring 3A)	1.8			P
8	West side external wall (rib 31) – level +18.5m (ring 3A)	1.5			P
9	North side external wall (rib 7) – level +27.3m (ring 4)	2.2			P
10	East side external wall (rib 15) – level +27.3m (ring 4)	1.4			P
11	South side external wall (rib 23) – level +27.3m (ring 4)	1.6			P
12	West side external wall (rib 30) – level +27.3m (ring 4)	1.9			P

13	East side external wall (rib 16) – level +32.0m (ring 5)	2.1			P
14	South side external wall (rib 24) – level +35.6m (ring 6)	1.8			P
15	East side external wall (rib 17) – level +38.0m (ring 7)	1.5			P

3.1.5 Concrete carbonation depth measurement

The range of carbonation of the surface concrete layer was assessed using phenolphthalein and Rainbow tests. In both cases, testing is carried out on surfaces of core samples, immediately after extracting them from a structure. The phenolphthalein test method is well known in contrast to the Rainbow test method, which requires some explanation. The test involves spraying the surface of the tested concrete with a solution composed of specially selected chemical reagents, capable of identifying various pH values ranging from 5 to 13 (fig. 3.5).

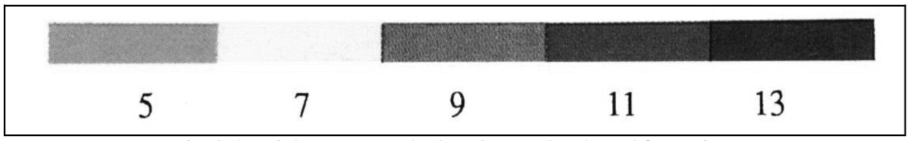

Fig. 3.5. Rainbow Test method –colour scale adopted for testing.

The pH reaction of 11 is commonly regarded as a border value, below which the natural capacity of concrete for passivation of reinforcement decreases and corresponds to the concrete staining purple. If the stain colour is green (pH = 9) it represents a pH being lower than the border value and indicates potential corrosion of reinforcement.
According to [8] tests, which were carried out, demonstrated that the near-surface layer of concrete had been significantly carbonated and its pH reaction was approximately equal to 9. In the majority of tested locations, the thickness of the carbonated area is no less than 35 mm, although in a number of locations it was found to be much thicker (fig. 3.6).
It has to be noted that the tested ring contains localised areas where concrete, despite its age (approximately 100 years) has not yielded to this process and has managed to preserve its natural alkaline reaction (pH ≥ 13) – fig. 3.7 and 3.8.

Fig. 3.6. Core sample O-5 – carbonation range - approximately 63 mm, [8].

Fig. 3.7. Core sample O-13 – no carbonation (pH≥13), [8].

Fig. 3.8. Core sample O-10 – no carbonation (pH≥13), [8].

Table 3.9 presents results of carbonation testing obtained in [4].

Tab. 3.9. Results of carbonation testing of structural concrete of the Centennial Hall in Wroclaw carried out on core samples, [4].

No.	Location	Depth of carbonation	Average depth of carbonation	Maximum depth of carbonation
		[mm]	[mm]	[mm]
1	Core borehole H1	72	85	105
2	Core borehole H2	81		
3	Core borehole H3	86		
4	Core borehole H4	89		
5	Core borehole H5	74		
6	Core borehole H6	71		
7	Core borehole H9	93		
8	Core borehole H10	105		
9	Core borehole H11	96		

The differences in the range of carbonation are primarily caused by the type and condition of the structure of concrete (strength and integrity) and depend also on the location of a given measurement point.

3.1.6 Chemical testing of concrete for damaging salt content

Salts which are damaging to building materials and can most frequently be found in building structures include sulphates, chlorides and nitrates. Water serves as an agent, essential to facilitating the migration of salts into a building structure. Water containing salts penetrates inside concrete to enable destructive chemical processes. The presence of salts is indicated by efflorescence, staining, damaged surface structure, flaking etc.,on the surface of building elements. The presence of salts in a material results from increased moisture absorption of the material, which in turn leads to pressures arising from crystallization processes of expanding salt crystals and the process of hydratation. These pressures exceed strength of concrete, [4].
It is assumed that a choride content greater than 0.15% of concrete by weight is detrimental to concrete strength and a content of 0.056% of concrete by weight (for an amount of approximately 350 kg/m^3 of cement) is damaging to steel reinforcement. In the case of nitrates, content is harmful when it is more than 0.15 % of concrete by weight and for sulphates, content is harmful when it is more than 0.5 % of concrete by weight.
Chemical tests [4] were carried out on concrete samples extracted from structural elements of the Centennial Hall, selected at random, and included:

– Determination of the value of the pH indicator,
– Identification of the percentage content of sulphates, chlorides and nitrates in the building material.

The Merckquant 10019 and 10020 indicators and the Chlorid-Aquamerck 11106 test kits were used to determine the presence and concentration of chlorides. Dedicated formulations from the OMBRAN and MERCK test kits for chemical testing of building materials were also used. The results obtained from tests are presented in Table 3.10.

Tab. 3.10. Results of chemical testing of concrete samples extracted from façade wall structures of the Centennial Hall in Wroclaw. Tests for the content of chlorides, sulphates, nitrates and nitrites, [4].

No	Location of sample extraction	pH	Chlorides		Sulphates		Nitrates		Nitrites
			qualitatively	[%] m/m. of sample	qualitatively	[%] m/m. of sample	qualitatively	[%] m/m of sample	qualitatively
1	North side external wall – level +1m	7.5	+	0.009	+	0.3	+	0.025	-
2	East side external wall – level +0.3m	7.0	+	0.010	+	0.4	+	0.050	+
3	South side external wall – level +0.6m	6.5	+	0.008	+	0.4	+	0.025	-
4	West side external wall – level +0.3m	7.0	+	0.008	+	0.3	+	0.050	+
5	North side external wall (rib 7) – level +18.5m (ring 3A)	7.0	+	0.007	+	0.3	+	0.010	-
6	East side external wall (rib 15) – level +18.5m (ring 3A)	7.0	+	0.008	+	0.2	+	0.010	-
7	South side external wall (rib 24) – level +18.5m (ring 3A)	7.5	+	0.007	+	0.3	+	0.020	-
8	West side external wall (rib 31) – level +18.5m (ring 3A)	6.5	+	0.008	+	0.4	+	0.025	-
9	North side external wall (rib 7) – level	7.0	+	0.008	+	0.5	+	0.010	-

	+27.3m (ring 4)								
10	East side external wall (rib 15) – level +27.3m (ring 4)	6.5	+	0.007	+	0.2	+	0.020	-
11	South side external wall (rib 24) – level +27.3m (ring 4)	7.0	+	0.008	+	0.3	+	0.020	-
12	West side external wall (rib 31) – level +27.3m (ring 4)	6.5	+	0.009	+	0.2	+	0.010	-
13	East side external wall (rib 16) – level +32.0m (ring 5)	6.5	+	0.008	+	0.5	+	0.010	-
14	South side external wall (rib 25) – level +35.6m (ring 6)	7.0	+	0.007	+	0.3	+	0.025	-
15	East side external wall (rib 17) – level +38.0m (ring 7)	6.5	+	0.008	+	0.2	+	0.010	-

The results of chemical tests of concrete samples did not indicate the presence of chlorides and nitrates at a concentration which could be damaging to the structural materials of the reinforced concrete elements of the Centennial Hall. The presence of sulphates amounting to 0.5% of concrete by weight was identified in two samples (no 9 and no 13), which were extracted from the façade walls of the building.

3.1.7. Conclusions

The following conclusions were formulated on the basis of the tests performed, [4], [8]:

– A high variability was found in the physical and chemical properties of the concrete, which was related to the distance from the external surface of concrete elements. The concrete layer near the external surface is characterised by an apparently high density, low overall porosity and low absorbability. Layers of concrete increase in porosity and absorbability with increasing distance from the external surface. This is a consequenceof the carbonation process. Concrete samples differ also in relation to the aggregate content. The content of granite aggregate and the larger grain-size fraction is higher closer to the external surface.
– 1 m^3 of concrete contains 1,941.5 kg of aggregate and 215.0 kg of cement. The ratio of aggregate to cement is approximately 9:1. Thus, the amount of cement is relatively low.
– The composition of cement in the tested concrete differs significantly from the oxide composition of Portland cement (lower content of CaO, higher content of SiO_2) and has a composition more like Roman cement or blast-furnace cement. The colour of the cement paste (cream) of the tested concrete differs considerably from the colour of Portland cement paste. This may indicate that the cement used in construction of the Hall was produced with the addition of metallurgical slags.

- The sieve analysis indicated that all of the tested aggregate complies with the recommended content of aggregate grain-size of dimensions of less than 32 mm. The tested aggregate consists of crushed granite. Grain-size fractions of 31.5 ÷ 16 mm comprise more than 92 % granite, which in more than 47% consists of elongated and flat grains. The smaller the grain-size of the aggregate, the lower the content of granite and irregular grains. The fraction of 4 -2 mm contains approximately 50 % granite, whereas the remaining part consists of natural quartz aggregate or other additives.
- Small wood intrusions and black blast-furnace slag with structures of frothed glass were identified in the aggregate fraction of less than 8 mm, occuring mainly in the fraction of less than 4 mm. The assumption is that these additives were introduced intentionally to improve the moisture conditions during the process of setting and curing the concrete.

3.2. Structural concrete – current testing (year 2015)

3.2.1. Testing of concrete in the dome ribs

Field tests of concrete in the dome ribs were carried out in April and May 2015. They included the following:
- Assessing compressive strength of concrete by means of laboratory testing of core samples,
- Assessing compressive strength of concrete by means of the non-destructive pull-out testing method,
- Assessing tensile strength of concrete by means of the non-destructive pull-off testing method,
- Determining weight by volume and laboratory assessment of concrete absorbability,
- Analysis of the depth of carbonation of the surface layer of concrete,
- Evaluation of watertightness of concrete by means of the non-destructive GWT method.

The dome rib testing programme involved non-destructive compressive strength tests of concrete, using the pull-out testing method. Seventeen measurement locations were selected at random, and marked in accordance with the numbering of individual ribs, which had been adopted for the building (fig. 3.9). The locations were assigned the following numbers:

C-1 → rib no Ł1 **C-16** → rib no Ł16 **C-27** → rib no Ł27
C-2 → rib no Ł2 **C-17** → rib no Ł17 **C-28** → rib no Ł28
C-5 → rib no Ł5 **C-20** → rib no Ł20 **C-29** → rib no Ł29
C-7 → rib no Ł7 **C-22** → rib no Ł22 **C-30** → rib no Ł30
C-11 → rib no Ł11 **C-23** → rib no Ł23 **C-32** → rib no Ł32
C-13 → rib no Ł13 **C-26** → rib no Ł26

Irrespective of the measurements carried out with the pull-out testing method, ten core boreholes were drilled in the tested ribs using an HILTI drilling device (fig. 3.10), in accordance with [69]. In each of the ten selected ribs (ribs no. 1, 2, 5, 7, 13, 17, 20, 23, 28 and 29), a borehole was drilled with a diameter of approximately 100 mm and a length of approximately 15 cm, and was marked as follows:

O-1 → core sample extracted from rib Ł1 **O-7** → core sample extracted from rib Ł7
O-2 → core sample extracted from rib Ł2 **O-13** → core sample extracted from rib Ł13
O-5 → core sample extracted from rib Ł5 **O-17** → core sample extracted from rib Ł17
O-20 → core sample extracted from rib Ł20 **O-28** → core sample extracted from rib Ł28
O-23 → core sample extracted from rib Ł23 **O-29** → core sample extracted from rib Ł29.

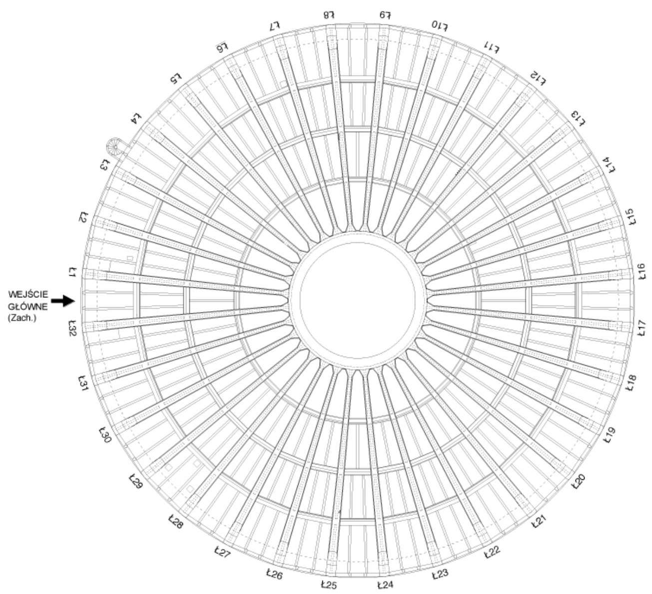

Fig. 3.9. The number identification of individual ribs in the Hall.

Fig. 3.10. Drilling device used for extracting core samples.

3.2.1.1 Determining compressive strength of concrete by means of laboratory testing of core samples

Strength tests were carried out in the Laboratory of the Faculty of Civil Engineering at the Wroclaw University of Technology. Tests were performed in accordance with [70], using concrete specimens of dimensions of φ≈h≈100mm, which were cut from core samples. A calibrated ZD 100 strength testing press was used. The face surfaces of specimens were adjusted for testing, in accordance with [70], by capping them with sand tips in order to ensure that they were parallel to one other (fig. 3.11).

The following assumptions were adopted in analysing the results obtained from compressive strength failure tests of concrete specimens with dimensions of h≈ϕ≈100mm:

- in accordance with [10], it was assumed that the relation between compressive strength determined for cube-shaped specimens with the dimension ‘a’, is equal to the compressive strength determined for cylinder-shaped specimens with a height and diameter equal to ‘a’, multiplied by 1.12,
- therefore, the following relation was assumed to be true:

$$\mathbf{R_{cube}}(a=100\text{ mm}) = \mathbf{1.12}\ \mathbf{R_{cylinder}}(\varphi=h=100\text{ mm})$$

- additionally, the following relation was adopted, in accordance with [11]:

$$\mathbf{R_{cube}}(a=150\text{ mm}) = \mathbf{0.9}\ \mathbf{R_{cube}}(a=100\text{ mm})$$

- as a result, the following relation was obtained:

$$\mathbf{R_{cube}}(a=150\text{ mm}) = \mathbf{1.12 \times 0.9}\ \mathbf{R_{cylinder}}(\varphi=100\text{ mm})$$

and thus:

$$\mathbf{R_{cube}}(a=150\text{ mm}) \approx \mathbf{R_{cylinder}}(\varphi=100\text{ mm})$$

Fig. 3.11. One of specimens adjusted for strength testing with ‘capping’.

The following parameters of the tested concrete were determined for each specimen based on laboratory testing and relevant calculations:

- mean compressive strength of concrete $f_{cm,is}$
- minimum value of strength determined $f_{c,is,lowest}$
- standard deviation of strength s
- strength coefficient of variation v
- concrete weight by volume ρ

Next, based on the results of strength testing, the strength class of concrete was estimated in accordance with the construction standard [71] and an amendment added to it two years later, which conformed the Polish Concrete Construction standard with the new standard [21].
The strength class of concrete was determined in accordance with the standard [72]. It has to be stressed that this standard, when compared to the specifications of the assessment standard of concrete quality formulated in the concrete standard [21], lists slightly different compliance criteria for concrete strength, when these are determined on the basis of core sample testing. The specifications used for determining the characteristic compressive strength value of concrete in structures, includes two cases: case '**A**' can be applied in a situation in which test results are available from at least 15 core samples. Case '**B**' applies to a situation where test results are available for 3 to 14 samples.

Case 'A'

The characteristic value of concrete compressive strength in structures, determined for a given location, is the lower value of the two listed below:

$$f_{ck,\,is} = f_{m(n),\,is} - \mathbf{k_2} \times \mathbf{s} \quad \text{or} \quad f_{ck,\,is} = f_{is,lowest} + 4$$

where:

$f_{ck,\,is}$ - characteristic compressive strength of concrete in structures,
$f_{m(n),\,is}$ - mean value of compressive strength of concrete in structures obtained from 'n' measurements,
$f_{is,lowest}$ - the lowest of determined values of the compressive strength of concrete in structures,
s - standard deviation of results, but no less than 2.0 N/mm^2,
$\mathbf{k_2}$ - value determined in a national supplement, but if this does not exist, then the value is assumed to be equal to 1.48.

Case 'B'

The value of characteristic compressive strength of concrete in structures, determined for a given measurement location, is the lower value of the following two:

$$f_{ck,\,is} = f_{m(n),\,is} - \mathbf{k} \quad \text{or} \quad f_{ck,\,is} = f_{is,lowest} + \mathbf{4}$$

The variable '**k**' depends on the number of test results obtained. Its value has to be adopted accordingly, as specified in Table 3.11.

Tab. 3.11. Variable 'k' for a small number of test results.

Number of results	Value of variable 'k'
10 to 14	5
7 to 9	6
3 to 6	7

In both cases, the compressive strength class of concrete must be identified in accordance with Table 3.12, on the basis of the value determined as being characteristic compressive strength of concrete in structures. It has to be underscored, however, that in the case of the Centennial Hall, it is possible to observe a significant decrease in the minimum values of the characteristic compressive strength of concrete, which are required for individual concrete strength classes, in accordance with the standard [21]. The standard [72] introduced a correction factor equal to 0.85, which takes into account a general conviction that the strength of concrete in structures is usually lower than the strength determined for standard samples extracted from the same batch of concrete. This is partly due to the process of drilling, which may cause minor damage to the core sample material. Another reason for the difference is the fact that concrete curing conditions are usually much less favourable on the building site than in the laboratory.

Tab. 3.12. Minimum values of the characteristic compressive strength of concrete in structures, which correspond to strength classes of concrete, in accordance with [21].

Concrete compressive strength class, in accordance with EN 206-1	Ratio of the characteristic strength of concrete in structures to the characteristic strength of standard samples	Minimum characteristic compressive strength of concrete in structures [N/mm^2]	
		$f_{ck,\,is,\,cyl}$	$f_{ck,\,is,\,cube}$

C8/10	0.85	7	9
C12/15	**0.85**	10	13
C16/20	0.85	14	17
C20/25	**0.85**	17	21
C25/30	0.85	21	26
C30/37	**0.85**	26	31
C35/45	0.85	30	38
C40/50	**0.85**	34	43
C45/55	0.85	38	47
C50/60	**0.85**	43	51
C55/67	0.85	47	57
C60/75	**0.85**	51	64
C70/85	0.85	60	72
C80/95	**0.85**	68	81
C90/105	0.85	77	89
C100/115	**0.85**	85	98

Laboratory specimens were cut from core samples taken from the boreholes in the structure. The specimens had dimensions of $h \approx \phi \approx 100$mm, and their identification numbers corresponded to the numbering of the boreholes. Specimens were subjected to strength testing. Concrete weight by volume, concrete absorbability and carbonation range for specific concrete sections were also determined.

A visual inspection of extracted core samples indicated that the tested concrete was based on granite aggregate with an addition of natural aggregate, in amounts which vary in individual ribs of the dome. In the majority of cases, the granite aggregate dominates, with a small addition of natural aggregate (fig. 3.12 and 3.13). But in some elements, the content of both types of aggregate is similar (fig. 3.14), or the same, as in the case of the Ł17 rib, in which the natural aggregate dominates the composition (fig. 3.15). It should be noted that overall, the aggregate composition of the tested ribs is well-grained.

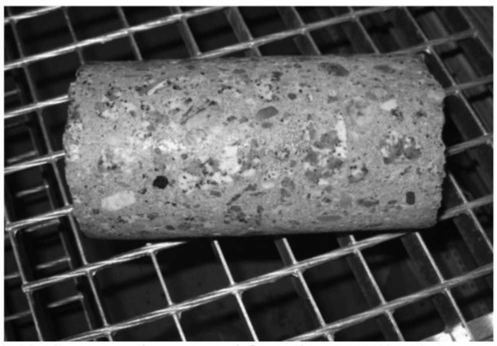

Fig. 3.12. Core sample extracted from the Ł 17 rib (high content of granite aggregate).

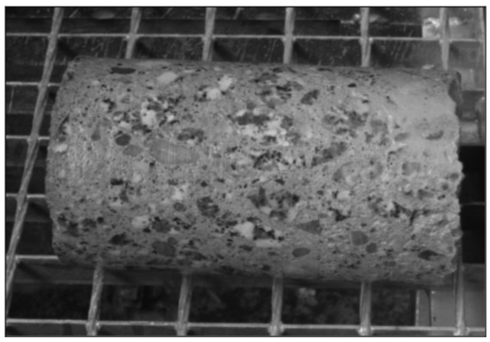

Fig. 3.13. Core sample extracted from the Ł 29 rib (high content of granite aggregate).

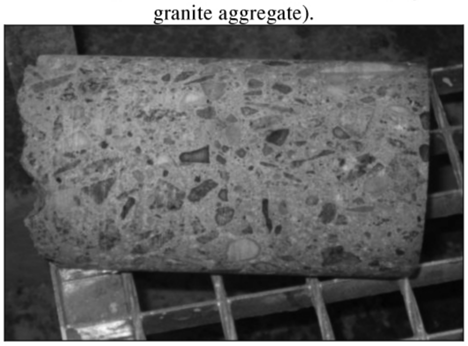

Fig. 3.14. Core sample extracted from the Ł 7 rib (similar content of granite and natural aggregates).

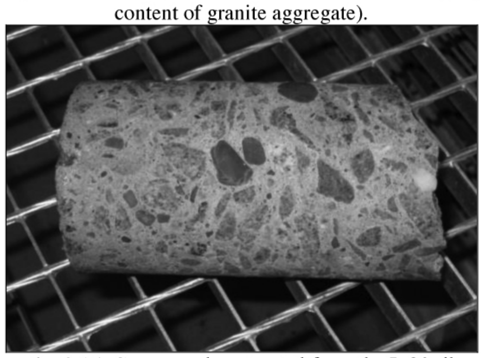

Fig. 3.15. Core sample extracted from the Ł 20 rib (composition dominated by natural aggregate).

The detailed results of the strength tests which were carried out, are presented in Table 3.11.

Tab. 3.11. Results of concrete compressive strength testing of core samples extracted from the dome ribs.

Sample number	Section F [mm²]	Force P [kN]	Apparent density [kg/m³]	Compressive strength [MPa]
sample **O-1**	7020	220	2267	**32.1**
sample **O-5**	7006	242	2260	**34.5**
sample **O-7**	7007	210	2267	**30.0**
sample **O-17**	7035	252	2300	**35.8**
sample **O-20**	6985	166	2220	**23.8**
sample **O-28**	7010	210	2257	**30.0**
sample **O-29**	7035	238	2253	**33.8**

The results obtained are characterised by the following parameters:

- mean compressive strength of concrete $f_{cm(core)}$ = **31.4 MPa**
- the lowest obtained strength value $f_{core,lowest}$ = **23.8 MPa**
- standard deviation of strength s = **4.00 MPa**
- strength coefficient of veriation ν = **12.8 %**
- mean value of apparent density ρ = **2261 kg/m³**

It was assumed that, in accordance with the standard [72], the characteristic strength of the tested concrete, corresponding to the strength determined for cube-shaped samples with dimensions of 150 x 150 x 150 mm ($f_{ck,is,cube}$), constitutes the lower value of the two given below:

$$f_{ck,is,cube} \leq f_{cm(core)} - k \quad \text{and} \quad f_{ck,is,cube} \leq f_{core,lowest} + 4$$

where:

$f_{ck,is,cube}$ – characteristic compressive strength of concrete in structures, corresponding to the strength determined for cube-shaped samples with a side length of 150 mm

$f_{cm(core)}$ – mean value of compressive strength of concrete in structures obtained in '**n**' testing results

$f_{core,lowest}$ – the lowest of determined values of compressive strength of concrete in structures

k – variable dependant on the number of strength testing results (n), in the case when n=7, it has been assumed that ***k*=6**

$$f_{ck,is,cube} \leq 31.4 - 6 = \mathbf{25.4\ MPa} \quad \text{and} \quad f_{ck,is,cube} \leq 23.8 + 4 = \mathbf{27.8\ MPa}$$

Based on the results obtained, the value of the characteristic strength of the tested concrete can be determined as being no higher than **25.4 MPa** and, estimated as equivalent to the **C20/25** strength class, in accordance with the standard [72].

3.2.1.2. Determining compressive strength of concrete by means of the non-destructive pull-out testing method

Compressive strength of reinforced concrete structural arches was tested on-site using the pull-out testing method. The CAPO – Test kit was made by a German Instruments company from Denmark (fig. 3.16) and was used for testing.
Pull-out testing involves measurement of the load necessary to pull out a steel anchor from concrete, consisting of a steel ring which had been expanded within a specially cut groove (fig. 3.17).
The first stage of the test, once the reinforcement has been located (fig. 3.18) and the edges have been smoothed, involves drilling a hole in the tested structure. A special groove is cut inside the hole at a depth of 25 mm. A special ring, constituting the head of an anchor, is then expanded in the groove.
The load is transmitted via a hydraulic actuator (fig. 3.19). The actuator transmits a pull-out load onto the stem of the anchor but at the same time it compresses the surface of concrete with a centric thrust ring. Due to an appropriate configuration of proportions and dimensions relating to the depth of the anchor location and its dimensions, the ring induces a state of complex stress, which leads to failure and is characterised by a close correlation between the registered anchor pull-out load concrete compressive strength.

Fig. 3.16. The CAPO-Test kit.

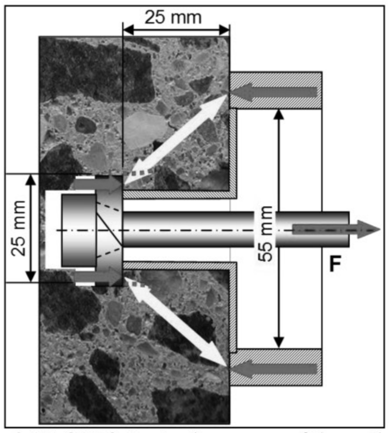

Fig. 3.17. CAPO-Test – the essence of the method.

Fig. 3.18. The 'Cover-Master' (CM52 type) device used for locating reinforcing bars.

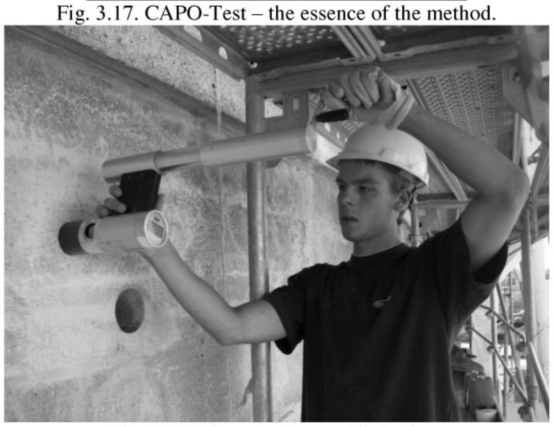

Fig. 3.19. The actuator used in testing.

Th correlation stays true overall. This means it is not dependant on the material and technological parameters, such as the w/c ratio, curing conditions, concrete age, content of possible additives – silica, dusts or various types of fibre. The only exception relates to concrete produced from light aggregates and concrete with aggregate grains larger than 32 mm. The correlation is presented in fig. 3.20.

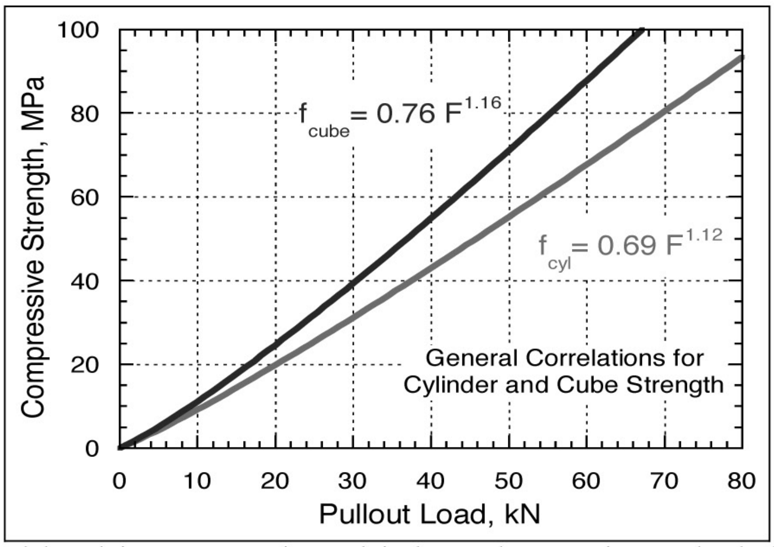

Fig. 3.20. Recommended correlation curves, presenting correlation between the compressive strength and pull-out load, for cube and cylinder strength, respectively.

The extremely strong correlation between the registered value of the pull-out load and concrete compressive strength, which was determined for standard laboratory samples (e.g. cubes with a side length of 150 mm) can be explained by the fact that the localised damage in the area of anchor pull-out is dominated by compression of concrete between the anchor head and the thrust ring, which is pressed to the concrete surface by a hydraulic actuator.
The reliability of this method for determination of compressive strength of concrete has been confirmed by its inclusion in standard regulations, such as: the American standard [73] and the European standard [74], as well as Polish regulations [75].
The evaluation of concrete compressive strength was carried out of the results of pull-out tests, indepdently of analysis of core samples. The detailed results of these tests are presented in Table 3.12. The strength class of the tested concrete was estimated in accordance with the concrete standard [72].
The results obtained from the correlation equation cannot be regarded as absolutely reliable in the case described, as the concrete surface layer carbonation which was detected, impacts the concrete strength. The carbonation range exceeds 25 mm in all analysed samples, which means that the pull-out testing was carried out entirely in the carbonated layer of concrete. The results obtained are significantly higher than the results obtained from testing core samples in the laboratory, for which the potential impact of carbonation was eliminated as the 30 mm thick external layer of concrete was cut off from the samples.
For this reason, an experimental correction factor (**Δ**) was determined, which is understood as a relation between the mean compressive strength of concrete obtained in tests of core samples, and mean compressive strength of concrete obtained in pull-out testing in locations next to the boreholes from which the core samples had been extracted.

$$\Delta = f_{cm(core)} / f_{cm(CT)} = 31.4 / 60.8 = \mathbf{0.52}$$

The concrete fractures obtained confirmed that the concrete used for the dome ribs was based on granite aggregate (fig. 3.21 – 3.22).

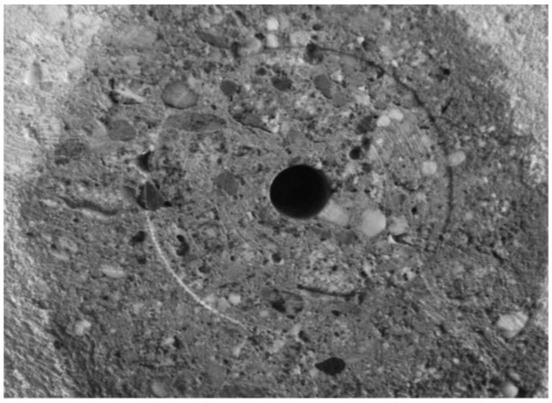

Fig. 3.21. The surface of the tested concrete after polishing (with granite aggregate grains clearly visible).

Fig. 3.22. The structure of the tested concrete in the location of one of the Capo-Tests.

Tab. 3.12. Results of pull-out compressive strength testing of concrete in the dome ribs.

Measurement location	Direct reading of the pull-out load [kN]	Actual pull-out load [kN]	Cube strength [MPa]	Strength after modification (× **0.52**)
C-1 (rib Ł1)	31.9	31.6	41.7	**21.7 MPa**
C-2 (rib Ł2)	50.2	49.9	70.9	**36.9 MPa**
C-5 (rib Ł5)	38.9	38.6	52.6	**27.4 MPa**
C-7 (rib Ł7)	40.2	39.9	54.7	**28.4 MPa**
C-11 (rib Ł11)	42.0	41.7	57.6	**30.0 MPa**
C-13 (rib Ł13)	55,2	54.9	79.2	**41.2 MPa**
C-16 (rib Ł16)	57.7	57.4	83.4	**43.4 MPa**
C-17 (rib Ł17)	55.3	55.0	79.4	**41.3 MPa**
C-20 (rib Ł20)	41.3	41.0	56.4	**29.3 MPa**

C-22 (rib Ł22)	57.0	56.7	82.2	**42.7 MPa**
C-23 (rib Ł23)	46.4	46.1	64.7	**33.6 MPa**
C-26 (rib Ł26)	55.3	55.0	79.4	**41.3 MPa**
C-27 (rib Ł27)	34.1	33.8	45.1	**23.5 MPa**
C-28 (rib Ł28)	49.8	49.5	70.2	**36.5 MPa**
C-29 (rib Ł29)	50.2	49.9	70.9	**36.9 MPa**
C-30 (rib Ł30)	43.2	42.9	59.5	**30.9 MPa**
C-32 (rib Ł32)	46.1	45.8	64.2	**33.4 MPa**

All values of the concrete compressive strength obtained using the pull-out testing method were recalculated with the correction factor (Δ=0.52). As a result, the strength values obtained for the concrete in the dome ribs of the Centennial Hall were characterised by the following parameters:

- Mean compressive strength of concrete $f_{cm(CT)}$ = **34.0 MPa**
- The lowest obtained value of strength $f_{CT,lowest}$ = **21.7 MPa**
- Strength standard deviation of the stength s = **6.8 MPa**
- Strength coefficient of variation v = **19.9 %**

In accordance with [72], it was assumed that the characteristic strength of the tested concrete, corresponding to strength determined for cube-shaped samples with dimensions of 150 x 150 x 150 mm ($f_{ck,is,cube}$), is the lower value of the two values given below:

$$f_{ck,is,cube} \leq f_{cm(CT)} - 1.48 \times s \quad \textbf{and} \quad f_{ck,is,cube} \leq f_{CT,\mathbf{lowest}} + 4$$

where:

$f_{ck,is,cube}$ – characteristic compressive strength of concrete in structures, corresponding to concrete strength determined for cube-shaped samples with side length of 150 mm

$f_{cm(CT)}$ – mean value of compressive strength of concrete in structures, obtained from '**n**' results of tests

$f_{CT,lowest}$ – the lowest of obtained values of compressive strength of concrete in structures

$$f_{ck,is,cube} \leq 34.0 - 1.48 \times 6.8 = \mathbf{23.9\ MPa} \quad \text{and} \quad f_{ck,is,cube} \leq 21.7 + 4 = \mathbf{25.7\ MPa}$$

Based on the test results, the value of the characteristic strength of the tested concrete can be assumed to be no higher than **23.9 MPa** and thus the concrete strength class can be estimated as **C16/20** in accordance with the standard [21].

3.2.1.3 Determining tensile strength of concrete by means of the non-destructive pull-off testing method

Tensile (pull-off) strength of concrete was tested in accordance with [14] using the 'pull-off' method. The tests were performed with a DYNA device made by the Swiss Proceq company (fig. 3.23) using 50 mm diameter metal discs. The measurements were carried out on the surfaces of 10 ribs, which had been selected at random.

In summary, the 'pull-off' testing method involves measuring the load needed to pull off a metal disc with a specified surface area, glued to the surface being tested (fig. 3.4). A centric cut 10 – 15 mm deep is made around the disc. The registered value of the pull-off load, divided by the surface area to which the load is being transferred, gives the value of concrete tensile strength, which is also known as pull-off strength.

In accordance with requirements for concrete surfaces, which specify conditions for modern surface repairs and renovations, e.g. use of PCC type materials, the following conditions need to be met for the concrete structure being analysed:

- Mean compressive strength of concrete should be no less than 25 MPa,
- Mean value of pull-off strength, determined for a given measurement location for all measurements carried out, should be no less than 1.5 MPa,
- Minimum value of an individual measurement should be no less than 1.0 MPa.

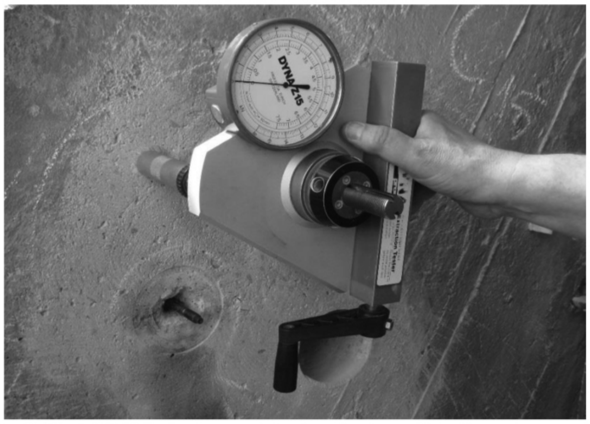

Fig. 3.23. A DYNA device used for tensile strength testing of concrete.

The concrete tensile strength tests using the pull-off testing method were carried out in 10 measurement locations. The measurement locations were marked, as in previous tests, based on the identification numbers of individual ribs in the structure (fig. 3.9). The following identification numbers were assigned:

B-1 → rib no Ł1 **B-17** → rib no Ł17
B-2 → rib no Ł2 **B-20** → rib no Ł20
B-5 → rib no Ł5 **B-23** → rib no Ł23
B-7 → rib no Ł7 **B-28** → rib no Ł28
B-13 → rib no Ł13 **B-29** → rib no Ł29.

Tensile (pull-off) strength of concrete was assessed using the pull-off testing method, involving application of 50 mm diameter metal discs. A centric cut approximately 15 mm deep was made around each disc (fig. 3.20). The test results are presented in Table 3.13.

Tab. 3.13. The results of pull-off strength of concrete in the ribs of the dome, obtained with the pull-off testing method.

Measurement location	Direct reading of pull-off load [kN]	Pull-off strength [MPa]
B-1 (rib Ł1)	11.10	**5.66**
B-2 (rib Ł2)	11.25	**5.73**
B-5 (rib Ł5)	10.05	**5.12**
B-7 (rib Ł7)	8.75	**4.46**
B-13 (rib Ł13)	8.20	**4.18**
B-17 (rib Ł17)	9.00	**4.59**
B-20 (rib Ł20)	5.90	**3.00**
B-23 (rib Ł23)	6.95	**3.54**
B-28 (rib Ł28)	7.30	**3.72**
B-29 (rib Ł29)	6.05	**3.08**

- mean pull-off strength: $f_{tm(BT)}$ = **4.31 MPa >> 1.5 MPa**
- mean compressive strength**:** $f_{cm(core)}$ = **31.4 MPa >** $f_{cm,min}$**= 25 MPa**

The concrete fully meets the conditions for possible surface repair and renovation work.

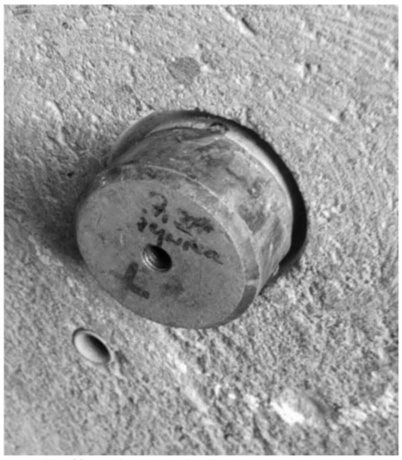

Fig. 3.24. A metal disc prepared for the pull-off testing method measurement (a concentric cut around the disc glued to the concrete surface is visible).

As carbonation was discovered to be significant in the surface layer of concrete (at least 25 mm), it was decided that the test results of the pull-off testing method should be treated only as an indication of the feasibility of using PCC repair materials for possible renovation of the concrete surface. It was also accepted that the test results obtained should not be treated as reliable for assessment of actual tensile strength of concrete in tested structural sections, as they are valid only for the concrete layer affected by carbonation.
Additional measurements of concrete strength were carried out using the Brazilian test (fig. 3.25), in accordance with [76]. This was to provide experimental verification for the limitation discussed above. For the purposes of testing, 3 specimens were cut out from core samples, which had been extracted from the Ł2, Ł13 and Ł23 dome ribs of the Centennial Hall. An approximately 30 mm thick external layer of concrete was removed in order to eliminate any potential influence of carbonation processes on the results of the tests performed.
The calculations of the value of the concrete tensile strength (tensile failure – Brazilian test) were carried out in accordance with the following formula:

$$f_t = 2 \times F / \pi \times L \times d \qquad (10)$$

where:
f_t – tensile strength at the point of tensile failure of the concrete [MPa],
F – maximum load [N],
L – length of the interface of the specimen [mm],
d – cross section dimension [mm].

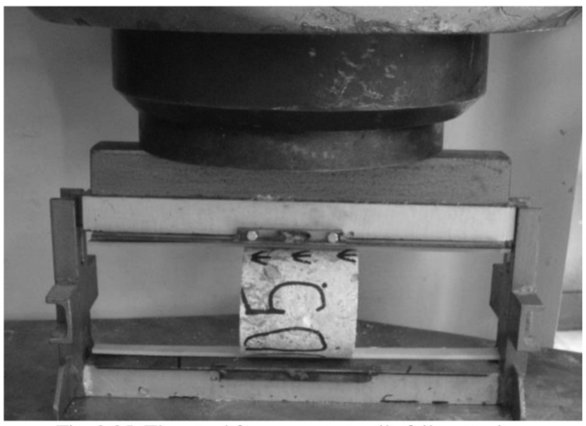

Fig. 3.25. The stand for concrete tensile failure testing.

The test results are presented in Table 3.14.

Tab. 3.14. Test results from the Brazilian test for tensile strength of concrete in the dome ribs.

Specimen number	Value of loading at point of failure [N]	L [mm]	d [mm]	f_t [MP]

O-2 (rib Ł2)	23500	94.12	93.75	**1.70**
O-13 (rib Ł13)	32500	94.50	94.38	**2.32**
O-23 (rib Ł23)	29500	94.50	94.35	**2.11**

The Brazilian test results presented above indicate that the mean tensile strength of concrete in the structural sections of the dome ribs can be estimated as approximately 2.0 MPa. This value of tensile strength is considerably lower than the value determined by means of the pull-off testing method for the carbonated near-surface layer (4.31 MPa).

3.2.1.4. Determining the absorbability of the tested concrete

Testing was carried out on specimens cut from core samples, which had been extracted from the structural elements under investigation. The tests were carried out in accordance with provisions of point 6.4.2. of the standard [11], using the following relation:

$$n_w = \frac{G_2 - G_1}{G_1} \cdot 100\ \% \qquad (11)$$

where: G_1 – dry specimen weight,
G_2 – water saturated specimen weight
n_w – absorbability
Detailed test results are presented in Table 3.15.

Tab. 3.15. Test results of concrete absorbability for specimens extracted from dome ribs.

Specimen number	Saturated specimen weight [g]	Dry specimen weight [g]	Absorbability [%]	Mean absorbability value [%]
specimen **O-1/A** (rib Ł1)	248.80	238.73	4.22	
specimen **O-1/B** (rib Ł1)	267.21	256.60	4.13	**4.17**
specimen **O-1/C** (rib Ł1)	249.95	237.68	5.16	
specimen **O-2/A** (rib Ł2)	271.94	262.12	3.75	
specimen **O-2/B** (rib Ł2)	250.54	241.90	3.57	**4.13**
specimen **O-2/C** (rib Ł2)	357.41	340.18	5.06	
specimen **O-5/A** (rib Ł5)	206.05	197.96	4.10	
specimen **O-5/B** (rib Ł5)	219.03	210.97	3.82	**4.21**
specimen **O-5/C** (rib Ł5)	458.71	438.04	4.72	
specimen **O-7/A** (rib Ł7)	246.87	237.69	3.86	
specimen **O-7/B** (rib Ł7)	254.90	245.46	3.84	**4.42**
specimen **O-7/C** (rib Ł7)	318.58	301.83	5.55	
specimen **O-13/A** (rib Ł13)	363.45	348.65	4.24	
specimen **O-13/B** (rib Ł13)	126.01	121.57	3.65	**4.28**
specimen **O-13/C** (rib Ł13)	353.73	337.03	4.95	
specimen **O-17/A** (rib Ł17)	220.77	212.87	3.71	
specimen **O-17/B** (rib Ł17)	322.54	310.67	3.82	

specimen **O-17/C** (rib Ł17)	422.75	403.74	4.71	**4.08**
specimen **O-20/A** (rib Ł20)	275.00	259.96	5.78	**5.45 > 5.0**
specimen **O-20/B** (rib Ł20)	188.76	181.25	4.14	
specimen **O-20/C** (rib Ł20)	303.52	285.16	6.43	
specimen **O-23/A** (rib Ł23)	182.30	174.05	4.74	**5.07 > 5.0**
specimen **O-23/B** (rib Ł23)	338.05	323.82	4.39	
specimen **O-23/C** (rib Ł23)	439.90	414.63	6.09	
specimen **O-28/A** (rib Ł28)	196.29	186.80	5.08	**5.27> 5.0**
specimen **O-28/B** (rib Ł28)	244.83	232.40	5.35	
specimen **O-28/C** (rib Ł28)	267.21	253.59	5.38	
specimen **O-29/A** (rib Ł29)	248.80	238.73	4.22	**4.50**
specimen **O-29/B** (rib Ł29)	267.21	256.60	4.13	
specimen **O-29/C** (rib Ł29)	249.95	237.68	5.16	

The concrete absorbability values obtained in testing range from 4.08% to 5.45% with the absorbability coefficient of variation equal to 11.2%, which indicates a high homogeneity of this parameter of concrete. The accepted maximum value of absorbability, which according to the standard [11] is 5.0%, has been exceeded in only 3 cases (ribs number Ł20, Ł23 and Ł28). The mean value of absorbability for the tested concrete is approximately **4.6 %**, which is below the maximum value (5.0%) deemed acceptable in accordance with the standard [11].

3.2.1.5 Determining the extent of concrete carbonation

The extent of carbonation of the surface concrete layer was assessed using phenolphthalein and Rainbow tests (fig. 3.26). In both cases, testing was carried out on fresh concrete fractures, which were taken from tested samples damaged in the testing press, as well as from locations where measurements of concrete strength had been carried out using the CAPO testing method.

Fig. 3.26. Rainbow and phenolphthalein tests.

The phenolphthalein test involves spraying an alcoholic solution of phenolphthalein on the surface of a fresh concrete fracture. Interpretation of results is very straight forward, as the phenolphthalein changes the red colour to neutral when pH is equal to 8.5 – 9.5. The discoloured layer of concrete is thus regarded as being equivalent to the carbonated layer, which has lost its steel reinforcement passivation capabilities.
The Rainbow testing method involves spraying the surface of tested concrete with a solution of a composition of specially selected chemical reagents, capable of identifying pH values ranging from 5 to 13. The pH reaction of 11 is commonly regarded as a border value, below which the natural capacity of concrete for passivation of reinforcement decreases. In this situation, the surface stains purple. If the stain colour is green (pH = 9), the pH is lower than the border value and corrosion of the reinforcement is possible.

The tests performed indicate that the thickness of the carbonated near-surface concrete layer differs for individual ribs. Depth ranges from approximately 22 mm to approximately 42 mm. The test results are presented below.

RIB Ł1 → averaged thickness of the carbonated layer is approximately **25 mm**

- core sample **O-1** → thickness of the carbonated layer: approximately 25 mm
- Capo-Test **C-1** → thickness of the carbonated layer: approximately 25 mm

RIB Ł2 → averaged thickness of the carbonated layer is approximately **30 mm**

- Core sample **O-2** → thickness of the carbonated layer (fig.24): approximately 20-30 mm
- Capo-Test **C-2** → thickness of the carbonated layer: approximately 35 mm

RIB Ł5 → averaged thickness of the carbonated layer is approximately **25 mm**

- Core sample **O-5** → thickness of the carbonated layer: approximately 20 mm
- Capo-Test **C-5** → thickness of the carbonated layer: approximately 30 mm

RIB Ł7 → averaged thickness of the carbonated layer is approximately **28 mm**

- Core sample **O-7** → thickness of the carbonated layer: approximately 25-30 mm
- Capo-Test **C-7** → thickness of the carbonated layer (fig.25): approximately 25 mm

RIB Ł11 → averaged thickness of the carbonated layer is approximately **35 mm**

- Capo-Test **C-11** → thickness of the carbonated layer: approximately 30-40 mm

RIB Ł13 → averaged thickness of the carbonated layer is approximately **40 mm**

- Core sample **O-13** → thickness of the carbonated layer (fig.26): approximately 45-55 mm
- Capo-Test **C-13** → thickness of the carbonated layer: approximately 30 mm

RIB Ł16 → averaged thickness of the carbonated layer is approximately **24 mm**

- Capo-Test **C-16** → thickness of the carbonated layer: approximately 24 mm

RIB Ł17 → averaged thickness of the carbonated layer is approximately **30 mm**

- Core sample **O-17** → thickness of the carbonated layer: approximately 35 mm
- Capo-Test **C-17** → thickness of the carbonated layer: approximately 25 mm

RIB Ł20 → averaged thickness of the carbonated layer is approximately **33 mm**

- Core sample **O-20** → thickness of the carbonated layer: approximately 20-25 mm
- Capo-Test **C-20** → thickness of the carbonated layer: approximately 40-45 mm

RIB Ł22 → averaged thickness of the carbonated layer is approximately **22 mm**

- Capo-Test **C-22** → thickness of the carbonated layer: approximately 20-24 mm

RIB Ł23 → averaged thickness of the carbonated layer is approximately **25 mm**

- Core sample **O-23** → thickness of the carbonated layer: approximately 24-28 mm
- Capo-Test **C-23** → thickness of the carbonated layer: approximately 25 mm

RIB Ł26 → averaged thickness of the carbonated layer is approximately **27 mm**

- Capo-Test **C-26** → thickness of the carbonated layer: approximately 25-30 mm

RIB Ł27 → averaged thickness of the carbonated layer is approximately **42 mm**

- Capo-Test **C-27** → thickness of the carbonated layer: approximately 40-45 mm

RIB Ł28 → averaged thickness of the carbonated layer is approximately **28 mm**

- Core sample **O-28** → thickness of the carbonated layer: approximately 20-25 mm
- Capo-Test **C-28** → thickness of the carbonated layer: approximately 35 mm

RIB Ł29 → averaged thickness of the carbonated layer is approximately **35 mm**

- Core sample **O-29** → thickness of the carbonated layer (fig.27): approximately 30-40 mm
- Capo-Test **C-29** → thickness of the carbonated layer: approximately 35 mm

RIB Ł30 → averaged thickness of the carbonated layer is approximately **30 mm**

– Capo-Test **C-30** → thickness of the carbonated layer: approximately 30 mm

RIB Ł32 → averaged thickness of the carbonated layer is approximately **25 mm**

– Capo-Test **C-32** → thickness of the carbonated layer: approximately 25 mm

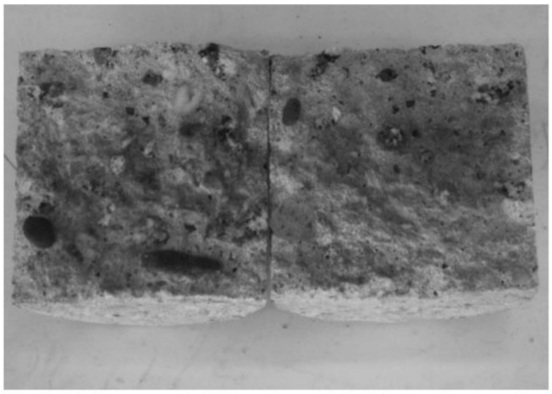

Fig. 3.27. Core sample O-2 – phenolphthalein test (carbonation depth ranging from 20 mm to 30 mm).

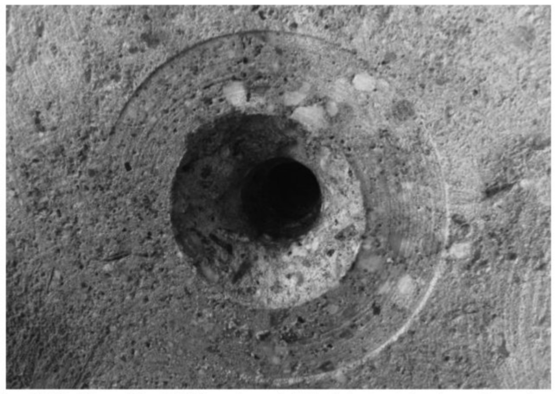

Fig. 3.28. Capo Test C-7 – phenolphthalein test (carbonation depth from 25 mm).

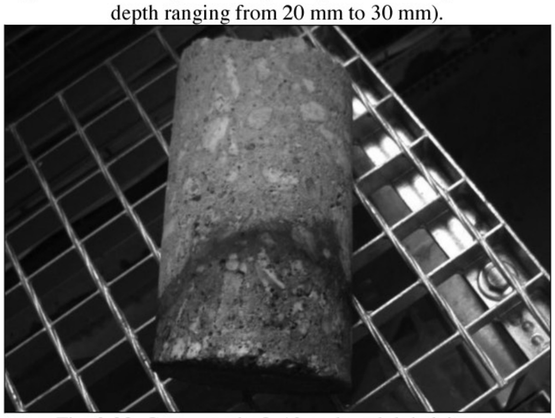

Fig. 3.29. Core sample O-13 – phenolphthalein test (carbonation depth ranging from 45 mm to 55 mm).

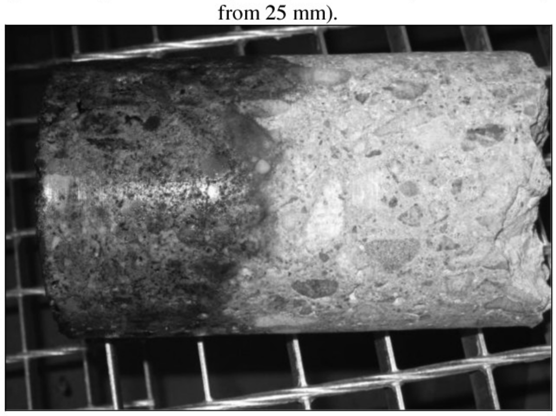

Fig. 3.30. Core sample O-29 – Rainbow test (carbonation depth ranging from 30 mm to 40 mm).

3.2.1.6. Non-destructive assessment of concrete watertightness by means of the GWT method

The research programme adopted for the Hall included an *in situ* non-destructive assessment of water permeation of the tested concrete using the GWT method (Germann Water Permeation Test). Testing was carried out in 6 locations selected at random, which were assigned the following identification numbers:

G-1 → rib no Ł1 **G-18** → rib no Ł18
G-7 → rib no Ł7 **G-24** → rib no Ł24
G-11 → rib no Ł11 **G-26** → rib no Ł26

The GWT non-destructive water permeation test of concrete was carried out using a GWT pressure chamber made by the Danish company Germann Instruments (fig. 3.31). The value of '*liquid flux*' ***(q)***, describes the speed of the forced water penetration into the tested material, which was adopted as the criterion for assessing the watertightness of the concrete. The value of q=0.660 μm/sec was adopted as the maximum acceptable value for the required W8 watertightness level in accordance with the standard [11]. The GWT testing method is a non-destructive research method which enables direct assessment of concrete watertightness *in situ*. The method involves application of water under a preselected pressure to the tested surface. The water is contained in a specially designed pressure chamber (fig. 3.32).

Fig. 3.31. GWT pressure chamber in operation.

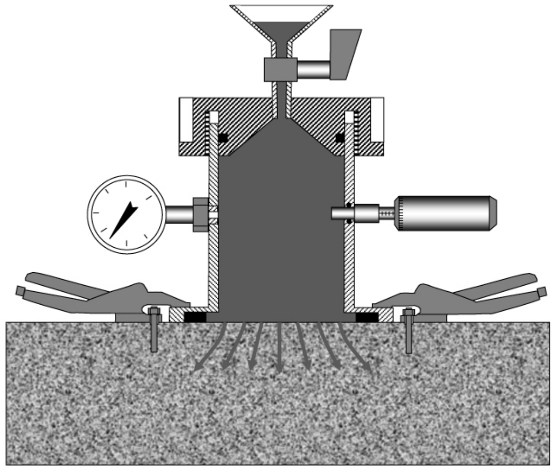

Fig. 3.32. GWT water permeation testing.

As the water permeates into the tested surface, a micrometric screw controls water loss in the pressure chamber. The screw allows a constant, preselected pressure to be maintained in the chamber, ranging from 0 to 0.6 MPa. This is because its rotation is coupled with movement of the piston, which regulates the water pressure acting on the surface of the concrete being tested.
The value of '*liquid flux*' ***(q)***, describes the speed of the forced water penetration into the tested material and was adopted as a criterion for assessing concrete watertightness. The value of q=0.660 μm/sec was adopted as the maximum acceptable value required for attaining the W8 watertightness level in accordance with the standard [11].

$$\mathbf{q} = \frac{B(g_1 - g_2)}{A \cdot t} \tag{12}$$

where:

- q – liquid flux, in [mm/sec]
- B – surface area of the micrometric screw piston, which controls the pressure in the chamber (78,6 mm^2)
- A – surface area of concrete, to which the water pressure is applied (3018 mm^2 with the diameter of 62 mm)
- t – duration of the test, in [sec]
- g_1 – reading on the dial of the micrometric screw at the beginning of the test, in [mm]
- g_2 – reading on the dial of the micrometric screw at the end of the test, in [mm]

For the purposes of testing, the value of pressure which induces water penetration into the material was adopted at the level of 0.1 MPa. It was also assumed that the basic time measurement unit would be 600 seconds.
In total, 6 measurements were carried out on surfaces of selected dome ribs. The first measurement, indicated as **G-1** (rib Ł1), ended in failure as it was impossible to maintain the preselected pressure even for a short period of time. A rapid pressure drop occurred immediately on initiating the test, which was due to a very intense penetration of water into the concrete. This indicates unequivocally that defects are present in the interior of the tested section, which most probably resulted from incorrect concrete compression during the process of constructing the element. A similar result was obtained in the **G-26** measurement location (rib Ł26), where the maximum measurement range of the device was reached after only 3 minutes following test initiation. Even though 3 intermediate measurements had been successfully carried out, the results indicate the presence of structural discontinuities in the tested section. These discontinuities are responsible for rapid penetration of water into the concrete structure. In other cases, the measurements were successfully completed and the results allowed the value of '*liquid flux*' ***(q)*** to be determined.
The detailed results of tests are presented in Table 3.16.

Tab. 3.16 Watertighness measurement logbook – the GWT testing of dome ribs.

Measurement number	Reading on the micrometric screw dial			
	G-7	**G-11**	**G-18**	**G-24**
measurement no 1 (initial reading – $\mathbf{g_0}$)	23.00	23.00	23.00	23.00
measurement no 2 (reading after 1 minute – $\mathbf{g_1}$)	20.30	21.10	20.95	20.80
measurement no 3 (reading after 2 minutes – $\mathbf{g_2}$)	18.30	19.90	19.25	19.23
measurement no 4 (reading after 3 minutes – $\mathbf{g_3}$)	16.75	18.90	17.95	17.73
measurement no 5 (reading after 4 minutes – $\mathbf{g_4}$)	15.45	18.05	16.65	16.48
measurement no 6	14.15	17.25	15.50	15.28

(reading after 5 minutes – g_5)				
measurement no 7 (reading after 6 minutes – g_6)	12.90	16.60	14.30	14.08
measurement no 8 (reading after 7 minutes – g_7)	11.60	15.95	13.40	13.08
measurement no 9 (reading after 8 minutes – g_8)	10.40	15.40	12.50	12.03
measurement no 10 (reading after 9 minutes – g_{10})	9.25	14.83	11.55	11.08
measurement no 11 (reading after 10 minutes – g_{11})	8.15	14.23	10.75	10.18

The ***liquid flux (q)*** value was determined on the basis of the results presented above for each of the measurement locations. This parameter was then adopted as the criterion for watertightness assessment for the tested concrete (tab. 3.17). The analysis of results indicated that the tested concrete can be regarded as watertight in accordance with the standard specified in [11] (the level of watertightness in not less than W8).

Tab. 3.17. The liquid flux values as indicators of watertightness of tested concrete in dome ribs under investigation.

Measurement location number	**Duration of the test** [sec]	**Micrometric screw dial reading** ($\Delta g = g_0 - g_n$) [mm]	**Liquid flux value** [μm/sec]
G-7	600	12.82	**0.556 < 0.666**
G-11	600	8.77	**0.380 < 0.660**
G-18	600	12.25	**0.531 < 0.666**
G-24	600	14.85	**0.644 <0.660**

3.2.2. Analysis of concrete in supporting pillars

In situ testing of concrete pillars, which constitute the main supporting structure for the dome, were carried out in May and June 2015. The investigation concentrated on the following aspects:

- Determining concrete compressive strength on the basis of laboratory testing of core samples,
- Determining concrete tensile strength (tensile failure) using the Brazilian test,
- Determining weight by volume and laboratory assessment of the absorbability of the tested concrete,
- Examining the depth of carbonation of the surface layer of concrete.

The testing programme for concrete pillars, constituting the main supportive structure for the dome of the Centennial Hall, included evaluation of compressive strength of concrete by means of laboratory strength tests on core samples. In accordance with [69], a total of 8 core samples were extracted, 2 from each of the four pillars. Each had a diameter of approximately 100 mm and a length ranging from 12 cm to 35 cm. The core samples received the following identification numbers:

O-A1 – Core sample extracted from the side of the pillar **A** (pillar located between sections A and B)
O-A2 – Core sample extracted from the side of the pillar **A** (pillar located between sections A and B)
O-B1 – Core sample extracted from the side of the pillar **B** (pillar located between sections B and C)
O-B2 – Core sample extracted from the side of the pillar **B** (pillar located between sections B and C)
O-C1 – Core sample extracted from the face of the pillar **C** (pillar located between sections C and D)
O-C2 – Core sample extracted from the side of the pillar **C** (pillar located between sections C and D)
O-D1 – Core sample extracted from the side of the pillar **D** (pillar located between sections D and A)
O-D2 – Core sample extracted from the side of the pillar **D** (pillar located between sections D and A).

Laboratory specimens with dimensions of $h \approx \phi \approx 100$mm were then cut from core samples extracted from the structural elements. The specimens were assigned identification numbers in accordance with the identification of core samples. The specimens were then subjected to strength tests. Concrete weight by volume and absorbability were determined, as well as the extent of carbonation in the concrete sections.

3.2.2.1 Analysis of concrete in the core samples

A visual assessment of control core samples (fig. 3.33) indicated that the structure of concrete in the tested pillars is highly diverse. In the majority of cases, the aggregate composition is well-grained, and comprises both, extremely large granite aggregate grains and natural aggregate, which constitutes a well-matched supplement by volume (fig. 3.34 – 3.35).

Fig. 3.33. Core samples extracted from supporting pillars.


Fig. 3.34. The **O-B1** core sample, extracted from pillar B (well-grained aggregate composition visible).

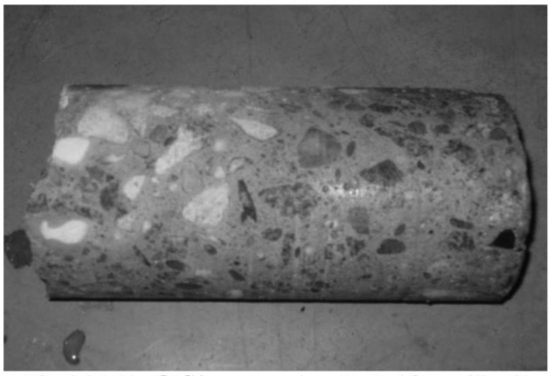
Fig. 3.35. The **O-C1** core sample, extracted from pillar C (well-grained aggregate composition visible).

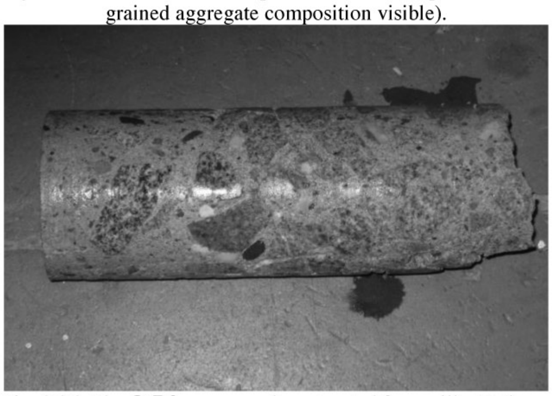
Fig. 3.36. The **O-B2** core sample, extracted from pillar B (large granite grains and fine natural aggregate visible).


Fig. 3.37. The **O-C2** core sample, extracted from pillar C (large granite grains and fine natural aggregate visible).

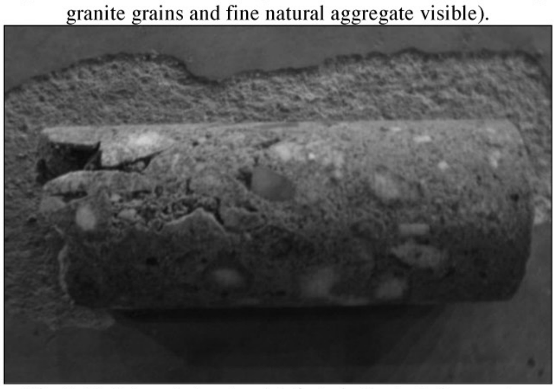
Fig. 3.38. Internal structural defects in the tested concrete, resulting from incorrect size distribution of the aggregate composition.

At the same time, the concrete structure was extremely heterogeneous in some cases (fig. 3.36 - 3.37). These were characterised by presence of both granite aggregate with very large grains and natural aggregate with disproportionally fine grains. Fill aggregate with grains ranging from 8 mm to 24 mm was absent.

It should be noted that there are two very different types of concrete structure present in the same supporting pillar, depending on the location of the borehole from which a given core sample was extracted.

The incorrect size distribution of the aggregate composition is in these cases the source of significant localised heterogeneity of the tested concrete structure. This causes numerous internal defects which resulted from difficulties during compression of the concrete mix (fig. 3.38) and high diversity of concrete compressive strength values.

Detailed results of strength tests are presented in Table 3.18.

Tab. 3.18 Results of concrete compressive strength tests, obtained from core samples extracted from supporting pillars.

Specimen number	Section F [mm^2]	Load P [kN]	Apparent density [kg/m^3]	Compressive strength [MPa]

specimen **O-A1**	7982	236	2243	**29.6**
specimen **O-A2**	7986	342	2260	**42.8**
specimen **O-B1/1**	8592	354	2250	**41.2**
specimen **O-B1/2**	8589	360	2270	**41.9**
specimen **O-B2**	8577	176	2130	**20.5**
specimen **O-C1**	8533	400	2310	**46.9**
specimen **O-D1**	7847	270	2310	**34.4**

The results obtained are characterised by the following parameters:

- Mean compressive strength of concrete e $f_{cm(core)}$ **= 36.7 MPa**
- Minimum strength value obtained $f_{core,lowest}$ **= 20.5 MPa**
- Standard deviation of strength s **= 9.2 MPa**
- Strength co-efficient of variation v **= 25.0 %**
- Mean value of apparent density ρ **= 2252 kg/m³**

In accordance with [12], it was assumed that the characteristic strength of the tested concrete, corresponding to the strength determined for cube-shaped samples with dimensions of 150 x 150 x 150 mm ($f_{ck,is,cube}$), is the lower value of the two given below:

$$f_{ck,is,cube} \leq f_{cm(core)} - \boldsymbol{k} \quad \text{and} \quad f_{ck,is,cube} \leq f_{core,lowest} + 4$$

where:

$f_{ck,is,cube}$ – characteristic compressive strength of concrete in structures, which corresponds to the strength of concrete determined for cube-shaped samples with a side length of 150 mm

$f_{cm(core)}$ – mean value of compressive strength of concrete in structures obtained from '**n**' test results

$f_{core,lowest}$ – the lowest of determined values of compressive strength of concrete in structures

$\boldsymbol{k}$ – variable dependent on the number of strength test results (n), when n=7, then ***k*=6** should be adopted

$$f_{ck,is,cube} \leq 36.7 - 6 = \mathbf{30.7\ MPa} \quad \text{and} \quad f_{ck,is,cube} \leq 20.5 + 4 = \mathbf{24.5\ MPa}$$

Based on the test results obtained, the characteristic strength value of the tested concrete should be assumed as being no higher than **24.5 MPa** and, according to [12], the concrete class should be estimated as **C20/25**.

3.2.2.2. Determining tensile failure of concrete (Brazilian test)

As carbonation of a significant range (from 25 mm to 70 mm) was found in the near surface layers of the concrete, it was decided that a Brazilian test would be used to determine tensile strength of the concrete (fig. 3.39) in accordance with [76]. For the purposes of testing, 4 specimens were cut from the core samples extracted from supporting pillars, with one specimen for each pillar under investigation.

The tensile failure of the tested concrete (Brazilian test) was calculated in accordance with the following formula:

$$f_t = 2 \times F / \pi \times L \times d \qquad (13)$$

where:

f_t – tensile strength at the tensile failure of concrete [MPa],
F – maximum load [N],
L – length of the interface of the specimen [mm],
d – cross section dimension [mm].

Fig. 3.39. Specimen **O-A1/1** after tensile failure.

Results are presented in Table 3.19.

Tab. 3.19. Results of tensile strength of concrete in the tested pillars as determined by the Brazilian test.

Specimen number	Value of load at point of failure [N]	L [mm]	d [mm]	f_t [MP]
O-A1/1 (pillar A)	42000	100.92	100.86	**2.63**
O-B1/3 (pillar B)	57500	105.03	104.62	**3.33**
O-C2 (pillar C)	37500	104.30	104.30	**2.18**
O-D2 (pillar D)	42000	103.81	104.61	**2.46**

The results presented above indicate that the mean tensile strength of concrete in the tested structural sections of pillars by means of the Brazilian test is equal to 2.65 MPa.

3.2.2.3. Determining concrete absorbability

Testing was carried out on specimens cut from core samples, which had been extracted from dome supporting pillars in the Centennial Hall. The detailed results of tests are presented in Table 3.20.

Tab. 3.20. Results of absorbability tests for specimens cut from core samples extracted from supporting pillars.

Specimen number	Weight of saturated specimen [g]	Weight of dry specimen [g]	Absorbability [%]	Absorbability mean value [%]
specimen **O-A1/A** (pillar A)	196.08	187.56	4.54	**4.99**
specimen **O-A1/B** (pillar A)	130.37	123.62	**5.46 > 5.00**	
specimen **O-A1/C** (pillar A)	630.27	600.32	5.00	
specimen **O-A1/1** (pillar A)	872.26	831.00	4.96	

specimen **O-B1/1/A** (pillar B)	259.03	248.97	4.04	**4.15**
specimen **O-B1/1/B** (pillar B)	757.96	726.63	4.31	
specimen **O-B1/2** (pillar B)	289.43	277.86	4.16	
specimen **O-B1/3** (pillar B)	977.04	938.57	4.10	
specimen **O-C1/A** (pillar C)	245.33	235.95	3.97	**4.42**
specimen **O-C1/B** (pillar C)	350.81	336.75	4.17	
specimen **O-C1/C** (pillar C)	1007.07	967.93	4.04	
specimen **O-C2** (pillar C)	668.80	633.85	**5.51> 5.00**	
specimen **O-D1/A** (pillar D)	254.49	245.41	3.70	**3.71**
specimen **O-D1/B** (pillar D)	245.43	236.73	3.67	
specimen **O-D1/C** (pillar D)	479.65	463.58	3.47	
specimen **O-D2** (pillar D)	971.44	934.19	3.99	

The concrete absorbability values obtained, range between **3.47 %** and **5.51 %** with the absorbability coefficient of variation equal to **12.4%**, which indicates high homogeneity of the tested concrete.The absorbability value deemed acceptable according to the standard [11] is 5.0%. This was exceeded only in 2 specimens.
The mean absorbability value of the investigated concrete is approximately **4.3 %**, which is lower, than the acceptable value (5.0%) adopted in accordance with the standard [11].

3.2.2.4 Determining the extent of concrete carbonation

Tests indicated that the extent of the carbonated near-surface concrete layer was considerable. It ranged in thickness between 25 mm and 70 mm. The results are presented below.

PILLAR A → the averaged thickness of the carbonated layer is approximately **28 mm**

- Core sample **O-A1** → thickness of carbonated layer: approximately 25 mm
- Core sample **O-A2** → thickness of carbonated layer (fig. 3.40): approximately 30 mm

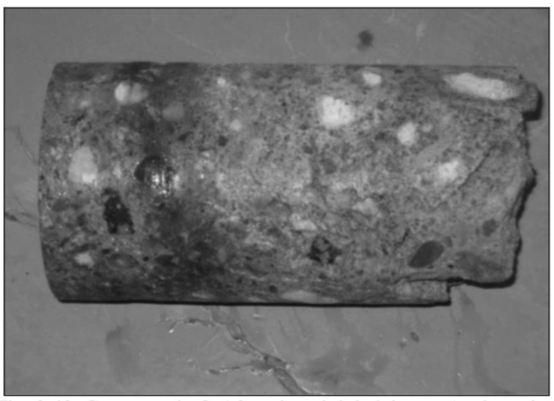

Fig. 3.40. Core sample O-A2 – phenolphthalein test (carbonation depth 30 mm).

Fig. 3.41. Core sample O-B2 – phenolphthalein test (carbonation depth 70 mm).

PILLAR B → the averaged thickness of the carbonated layer is approximately **65 mm**

- Core sample **O-B1** → thickness of carbonated layer: approximately 60 mm

– Core sample **O-B2** → thickness of carbonated layer (fig. 3.41): approximately 70 mm

PILLAR C → the averaged thickness of the carbonated layer is approximately **52 mm**

– Core sample **O-C1** → thickness of carbonated layer (fig. 3.42): approximately 35-40 mm
– Core sample **O-C2** → thickness of carbonated layer (fig. 3.43): approximately 60-70 mm

Fig. 3.42. Core sample O-C1 – phenolphthalein test (carbonation depth 35-40 mm).

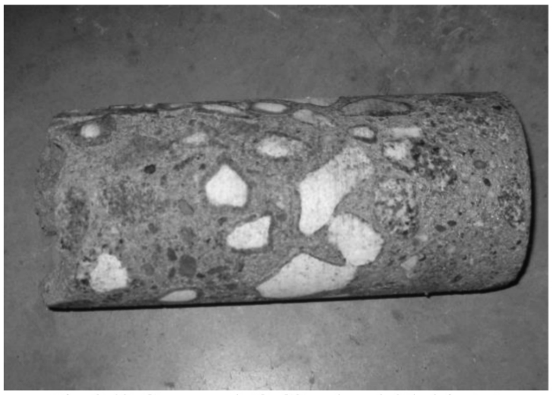

Fig. 3.43. Core sample O-C2 – phenolphthalein test (carbonation depth 60-70 mm).

PILLAR D → averaged thickness of the carbonated layer is approximately **34 mm**

– Core sample **O-D1** → thickness of carbonated layer: approximately 40-45 mm
– Core sample **O-D2** → thickness of carbonated layer: approximately 25 mm

3.2.3 Conclusions

Based on the tests, the following conclusions were formulated:

A. Concrete in the dome ribs

– Concrete was based on granite aggregate with the addition of natural aggregate in proportions which varied for individual ribs of the dome. In most cases, the granite aggregate dominates with a small addition of natural aggregate, but for some ribs it was determined that the proportion of both types of aggregate was similar. In the case of rib no Ł17, the natural aggregate was found to dominate the composition. Overall, the aggregate composition of the tested ribs was found to be well-grained.
– The value of the characteristic strength of the tested concrete can be taken to be no greater than **25.4 MPa** and can be estimated as **C20/25** concrete class in accordance with the standard [72].
– Based on the results of pull-out tests, the value of the characteristic strength of the tested concrete can be estimated as no greater than **23.9 MPa** and can be estimated as **C16/20** concrete class in accordance with the standard [21].
– The concrete meets the strength requirements and necessary conditions for the carrying out of surface repair interventions.
– The mean value of tensile strength of the concrete as determined by the Brazilian test for the structural sections of dome ribs is approximately **2.0 MPa**. This value is significantly lower than the tensile strength of concrete as determined by the pull-off testing method for the carbonated near-surface layer of concrete (**4.31 MPa**).
– The values obtained for concrete absorbability range from 4.08% to 5.45% with the absorbability coefficient of variation equal to 11.2%, which indicates a high homogeneity of this parameter of concrete. The acceptable value of absorbability, which according to the standard [11] is 5.0%, was exceeded in only 3 cases (for ribs number Ł20, Ł23 and Ł28). The mean absorbability of the tested concrete is approximately **4.6 %**, which is lower than the 5% acceptable value adopted in accordance with the standard [11].
– The tests indicate that the thickness of the carbonated near-surface layer of the tested concrete varies for individual dome ribs. The value ranges from approximately 22 mm to 42 mm.
– The analysis of results indicates that the tested concrete can be regarded as watertight, as specified in the standard [11] (watertightness level no less than W8).

B. Concrete in the supporting pillars

– The value of the concrete characteristic strength can be assumed to be no greater than **24.5 MPa** and estimated as **C20/25** concrete class in accordance with the standard [72],
– The mean tensile strength, determined for the structural section of pillars by means of the Brazilian test is **2.65 MPa**.
– The values obtained for concrete absorbability range from 3.47% to 5.51% with the absorbability coefficient of variation equal to 12.4%, which indicates a high homogeneity of this parameter of the concrete. The acceptable absorbability value (5%) as specified in the standard [11] was exceed in only 2 cases. The mean value of absorbability of the tested concrete is approximately 4.3%, which is lower, than the value adopted as acceptable (5.0%) in accordance with the standard [11].
– The tests completed indicate that the thickness of the carbonated near-surface layer of the tested concrete is significant. Values range from approximately 25 mm to 70 mm.

3.3. Assessing continuity of concrete element sections, microstructure and concrete composition analysis

This chapter discusses the results of chemical and physical analysis of concrete in the bottom circumferential ring of the dome in the Centennial Hall in Wroclaw. The tests were carried out in the second half of 2009 and in the first half of 2015. Additionally, the analysis of the concrete microstructure was carried out using a computer tomograph and on the basis of results of a series of nano-indentation tests carried out by means of a nano-indentation tester. The SkyScan 1172 micro-tomograph made by the Bruker company and the TTX-NHT nano-indentation tester made by the CSM company were used in the tests.
Tests carried out to date to determine mechanical properties of concrete in the structures of the Centennial Hall (compressive strength, tensile strength using the pull-off testing method, absorbability and others) are discussed in [8]. Depending on the measurement location in the structure, the compressive strength values ranged from 28 MPa to 38 MPa, and the tensile strength values ranged from 2.8 MPa to 4.5 MPa. The absorbability tests resulted in values from 3.9 % to 4.8%, with the coefficient of variation equal to 8%, which indicates a high homogeneity of the tested concrete. The strength values obtained in these tests did not vary significantly for concrete samples extracted from the structure both along the direction of laying of concrete and perpendicular to this direction.
Data available in the literature and other documents suggest that concrete for the construction of the Hall was made from a special cement from the Silesia cement mill in Opole. The highest quality Strzegom granite was used for the aggregate. Concrete mixing stations and aggregate grinding mills were located on the construction site of the Centennial Hall, [77].
Analysis of the phase composition was carried out on a sample extracted with a crown drill from the concrete in the bottom tension ring of the dome. The sample was 143 mm in diameter and 230 mm in length was cut out along the direction of the laying of the concrete, (fig. 3.44). The sample was then cut into 5 slices. The external surface with traces of weathering was 25 mm thick, the remaining 4 slices were each approximately 50 mm thick. The discs were assigned numbers from 1 to 4, with the disc number 1 being the most distant from the external surface.
The following tests were carried out:
- Concrete phase composition in accordance with [19, 20],
- Oxide composition of concrete and its HCl soluble and insoluble fractions,
- Metal content using Atomic Absorption Spectroscopy (AAS),
- Aggregate grain analysis with the assessment of respective fractions,
- Concrete density, density by volume and porosity,
- Concrete microstructure was analysed – the shape, size and dimensions of pores were determined.

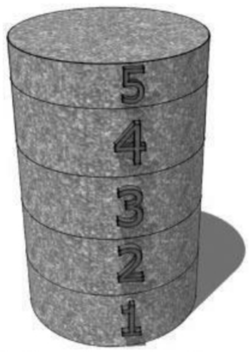

Fig. 3.44. Concrete sample with numbers of discs, [9].

3.3.1. Test results

3.3.1.1. Physical properties – density, density by volume and porosity

Concrete density by volume and absorbability were determined in 2009 by means of the hydrostatic method (discs 1 – 4). The total porosity and closed porosity were also calculated. Concrete density was determined using a crushed sample of concrete in a Le Chatelier flask. The density for disc number 2 (2009 tests) was equal to 2560 kg/m^3, [9]. A similar value was obtained in 2015 for disc number 4 equal to 2520 kg/m^3. The density by volume for disc 4 obtained in 2015 was 2203 kg/m^3. Additionally, concrete porosity was calculated as equal to 12.6%. The results of tests obtained in 2009 for discs 1 – 4 are presented in Table 3.21.

Tab 3.21. Physical properties of the tested concrete, [9].

Disc number	Density by volume [kg/m^3]	Total porosity [%]	Closed porosity [%]	Absorbability by volume [%]	Absorbability by weight [%]
1	2180	14.02	5.02	9.20	4.22
2	2220	13.12	4.77	8.36	3.76
3	2250	12.11	4.50	7.61	3.38
4	2300	9.96	3.82	6.14	2.66

3.3.1.2 Composition of the tested concrete

The concrete composition assessment was carried out in accordance with Building Research Institute guidelines [19] for the concrete sample disc number 4. The method involves determining concrete density by volume, the quantity of fractions insoluble in HCl (1:3) and the content of components which attach during the processes of hydrolysis, hydratation and carbonation of the cement binder. The data is used to carry out calculations. The calculations are presented in Table 3.22. The ratio of aggregate in concrete was 9:1 for disc number 2 and approximately 8:1 for disc number 4. These differences in the volume ratio of aggregate and concrete may result from the method of laying of the concrete which had been used during the construction of the Hall. The difference is not great and may be regarded as insignificant.

Tab. 3.22. Composition of concrete samples, discs number 2 and 4.

Concrete component	Content [kg/m^3], disc 2 (2009)	Component [kg/m^3], disc 4 (2015)
Aggregate	1941.5	1895
Cement	215	240

The assessment of mineral content of the tested concrete was carried out based on the results of the oxide composition analysis. The content of the following oxides: CaO, SiO_2, Al_2O_3, Fe_2O_3, MgO, Na_2O, K_2O, was determined using Atomic Absorption Spectroscopy (AAS) method. The composition of the tested binder differed from the oxide composition of Portland cement. Its oxide composition was similar to the composition of Roman cement or blast-furnace cement on account of a lower content of CaO, Table 3.23.

Tab. 3.23. Oxide composition of the tested concrete sample (disc no 4).

Components	Content [%]	Determination method
CaO	32.2	AAS
SiO_2	24.3	AAS
Al_2O_3	6.1	AAS
Fe_2O_3	6.3	AAS
MgO	1.2	AAS
Na_2O	0.2	AAS
K_2O	1.0	AAS
CO_2	5.9	Roasting losses
H_2O	16.4	Roasting losses
SO_3	0.8	Gravimetric analysis

Analysis of the mineral composition of the tested concrete was carried out using X-ray diffraction and thermal methods. The results are reported in [9]. The presence of calcium carbonate in the form of calcite and crystal phase in the form of portlandite $Ca(OH)_2$ was discovered in tested samples of cement paste, which had been separated out. The X-ray diffraction analysis did not indicate any presence of hydrated calcium aluminium sulphate in the form of ettringite C_6AH_{32}, calcium mono-sulphate C_4AH_{12} and hydrated calcium silicates C-S-H, which occur in an amorphous form, fig. 3.45. The presence of the C-S-H phase was determined by means of thermal analysis (DTA, DTG, TG), (fig. 3.46). In specific temperature ranges, endothermic effects were observed, such as: dehydration of hydrates of silicates, aluminium silicates and calcium aluminium sulphates (temp. 50-350°C), $Ca(OH)_2$ dehydroxylation (490-510°C), disintegration of $CaCO_3$ resulting from the process of carbonation (795-815°C), disintegration of remaining $CaCO_3$ (temp. 800-900°C), [9].

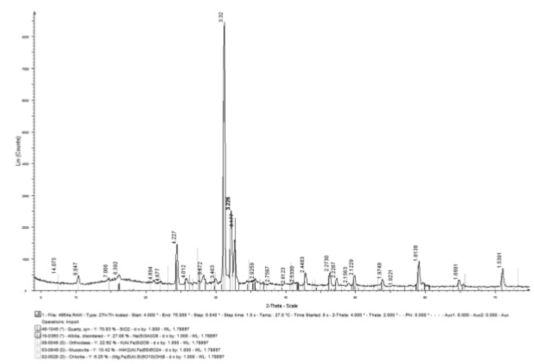

Fig. 3.45. Phase analysis of the tested concrete – X-ray diffractometry, [9].

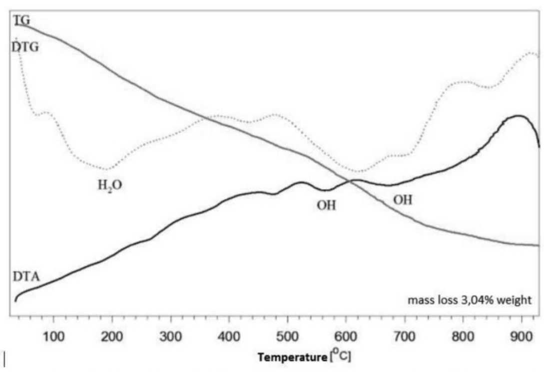

Fig. 3.46. DTA, DTG, TG thermal analysis of the tested concrete, [9].

3.3.1.3. Aggregate grain composition

The curve of grain size for the aggregate was determined in tests (disc 3, 2009 tests) and for disc 4 – tests in 2015. Test results are presented in Table 3.24.

Tab. 3.23. Aggregate grain composition.

Sieve	Remaining on the sieve [%]		Passing through the sieve [%]	
	disc 3	disc 4	disc 3	disc 4
31.5	0	0	100	100
16	2.8	17.35	97.2	82.65
8	26.6	25.7	70.6	56.95
4	16,5	10.87	54	46.08
2	10	6.1	44	39.98
1	6.5	6.27	37.5	33.71
0.5	8,9	16.14	28.6	17.57
0.25	23	13.58	5.7	3.99
0.125	3.7	2.86	2	1.13
less	2	1.13	0	0

The tested aggregate can be classified as 'well-grained' in line with the recommended grain size of less than 32 mm. In both discs, fine grains were found to constitute approximately 40% of the aggregate. It can be assumed that the aggregate was enriched through addition of stone dust. The aggregate in the tested discs comprised mainly crushed granite. For the fraction of 2 – 4 mm, half of the aggregate in both discs was granite, Table 3.25. The smaller the fraction of the aggregate, the lower the content of granite. This tendency was however not repeated for the 31.5 – 16 fraction in disc 4. It can be assumed that this situation resulted from technological processes used in laying the concrete mix during the construction of the Hall.

Tab. 3.25. Content of granite aggregate in 2 – 31.5 mm fractions.

Aggregate fraction [mm]	Content of granite aggregate in the fraction [%]	
	disc 3	disc 4
31.5 - 16	92.79	45.9
8 - 16	88.77	79.6
4 - 8	83.45	69.5
2 - 4	50.5	47

In aggregate fractions lower than 8 mm, the presence of high porosity slag and wood chip inclusions was observed, (fig. 3.47). Slag was mainly observed in fractions lower than 4 mm. The presence of fine black inclusions was also confirmed by images taken with the TTX-NHT nano-indentation tester, (fig. 3.48). It can be assumed that the slag was intentionally added to the concrete mix in order to improve concrete mechanical properties. High concentration of the C-S-H phase, which is a product of the process of hydration of slag and reaction of calcium hydroxide with silicate anions resulting from the slag hydration, is responsible for a much lower content of calcium hydroxide and higher concentration of the C-S-H phase in the hardened cement paste. The high content of the C-S-H phase, in the form of a dense gel, results in a very dense concrete microstructure. This leads to lower capillary porosity of the hardened cement paste, which obstructs diffusion of aggressive agents into the cement matrix. This in turn translates into a smaller content of portlandite and calcium aluminates, which are not resistant to corrosion. The described changes to microstructure of slag cement pastes are responsible for the fact that slag cements are characterised by a number of more favourable properties than Portland cements without additives. This was confirmed by research reported in [8]. Slag may have been added to the concrete also in order to improve moisture conditions in the process of concrete setting and curing, [9].

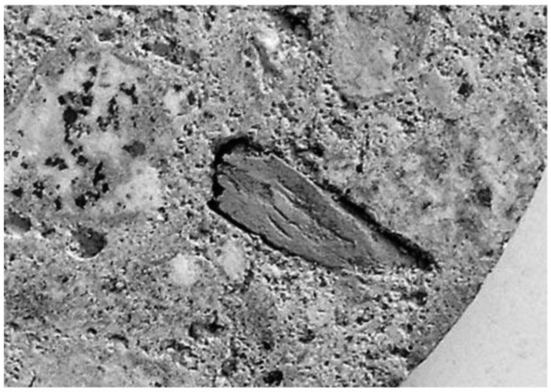

Fig. 3.47. Wood inclusions in concrete, [9].

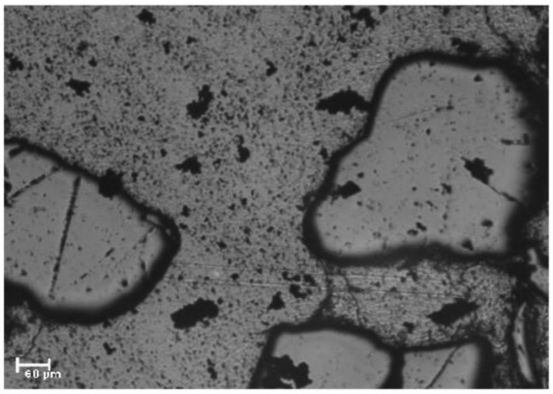

Fig. 3.48. The tested concrete – image obtained with the TTX-NHT nano-indentation tester.

Microscopic analysis of grain composition was reported in [9]. The content of aggregate with grains larger than 2 mm was investigated along 6 straight lines. They constituted the diameter of a flat surface and the angle between two immediate lines was 30°. The test results are presented in Table 3.26.

Tab. 3.26. Analysis of aggregate content on the surface of concrete sample discs, [9].

Disc number	Aggregate [%]	Granite [%]	Other aggregate [%]
1	46.8	35.7	11.1
2	49.4	35.8	13.6
3	54.4	48.6	5.8
4	61.6	53.7	7.9

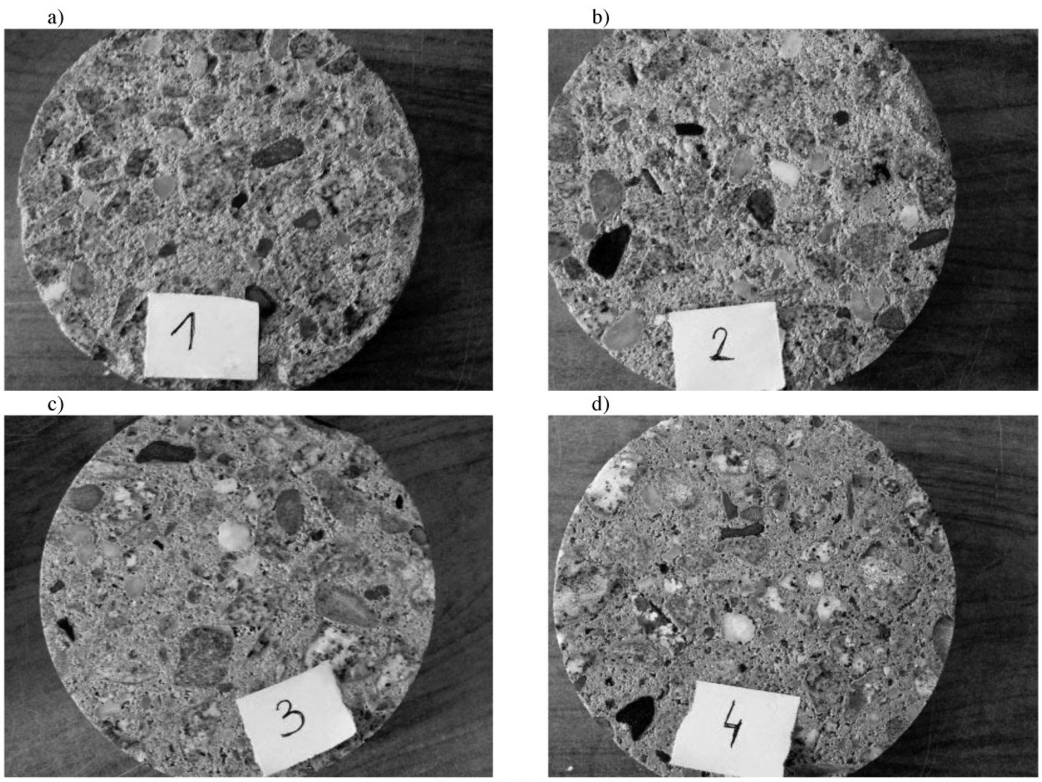

Fig. 3.49. Sample disc cross-sections: a) disc no 1, b) disc no 2, c) disc no 3, d) disc no 4, [9]

3.3.1.4. Analysis of concrete microstructure

Analysis of porosity was carried out using the X-ray micro-CT method, which provides for a sharp contrast between the solid phase and air. The method involves a 3D reconstructed image of a tested element, which is based on two-dimension projections obtained through X-ray scanning of the specimen. The source of radiation is usually an X-ray tube which comprises two electrodes: cathode and anode, made of material with a high atomic number. A beam of rays passes through the specimen placed on a mobile hoist. Images are registered by a scintillator, which transforms the energy of radiation molecules into visible light. The scintillator is connected to the matrix of the Charge Coupled Device (CCD), which transforms light into a digital signal. The result of scanning is a set of images (projections) which can be subsequently reconstructed into a series of specimen sections. On the basis of this data, a 3D visualisation of the material can be obtained.

The Skyscan 1172 device with a 11 Mp resolution camera (fig. 3.50) was used for testing. All scans were carried out with maximum lamp voltage (100 kV) and a constant power of the source of 10 W. An Al+Cu (aluminium – 1 mm, copper – 0.05 mm) screen was used for scanning all elements due to the properties of samples (high density material). The individual rate of specimen rotation was equal to 0.15°. The images were reconstructed with the NRecon software using the Feldkamp algorithm. The test resulted in a series of images with a resolution of 6.8 μm per 1 pixel.

Fig. 3.50. Testing station - SkySkan 1172 micro-CT made by the Bruker company.

Four specimens of concrete, marked as A, B, C and D were taken from disc 4 for testing. Results enabled analysis of the patterns, shape, size and diameter of pores. The images of specimens analysed with the micro CT device are presented in Figs. 3.51 – 3.54. In the pictures, the distribution of pores is marked in red for each tested specimen. They are uniformly spread in the volume of the tested concrete.

The results of the analysis of sphericity of pores in the tested samples are presented in Fig. 3.55. The results obtained for all samples were comparable. The most frequent value of the pore sphericity is 0.6-0.7, which means that the pores shape is not close to spherical but slightly elongated

a) b)

Fig. 3.51. 3D images of concrete specimen A obtained with micro-CT; a) image of the specimen solid reduced by pore space, b) isolated pore space.

a) b)

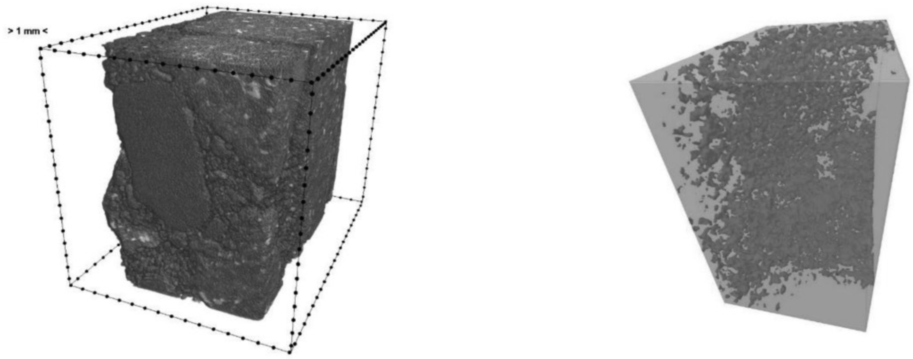

Fig. 3.52. 3D images of concrete specimen B obtained with micro-CT; a) image of the specimen solid reduced by pore space, b) isolated pore space.

a) b)

Fig. 3.53. 3D images of concrete specimen C obtained with micro-CT; a) image of the specimen solid reduced by pore space, b) isolated pore space.

a) b)

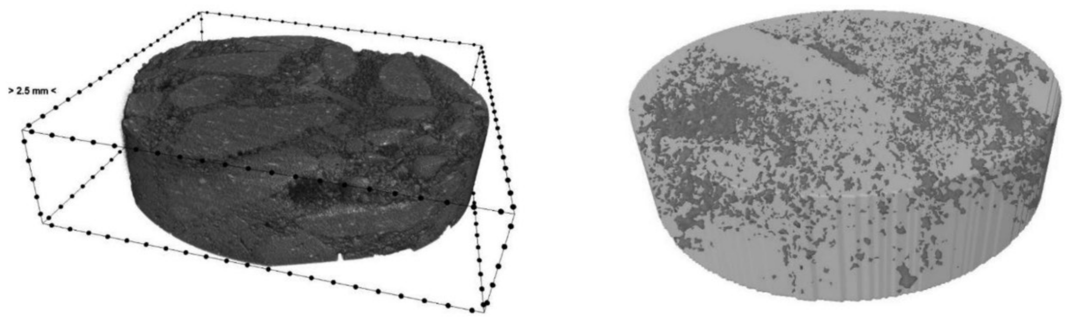

Fig. 3.54. 3D images of concrete specimen D obtained with micro-CT; a) image of the specimen solid reduced by pore space, b) isolated pore space.

Concrete properties depend on the following: total volume of pores, spread of their sizes, uniformity of distribution and shape. The air pore structure can be characterised by the following parameters: total air content, specific surface area of the air pore system, spread of the air pore sizes and the content of micropores <300μm.

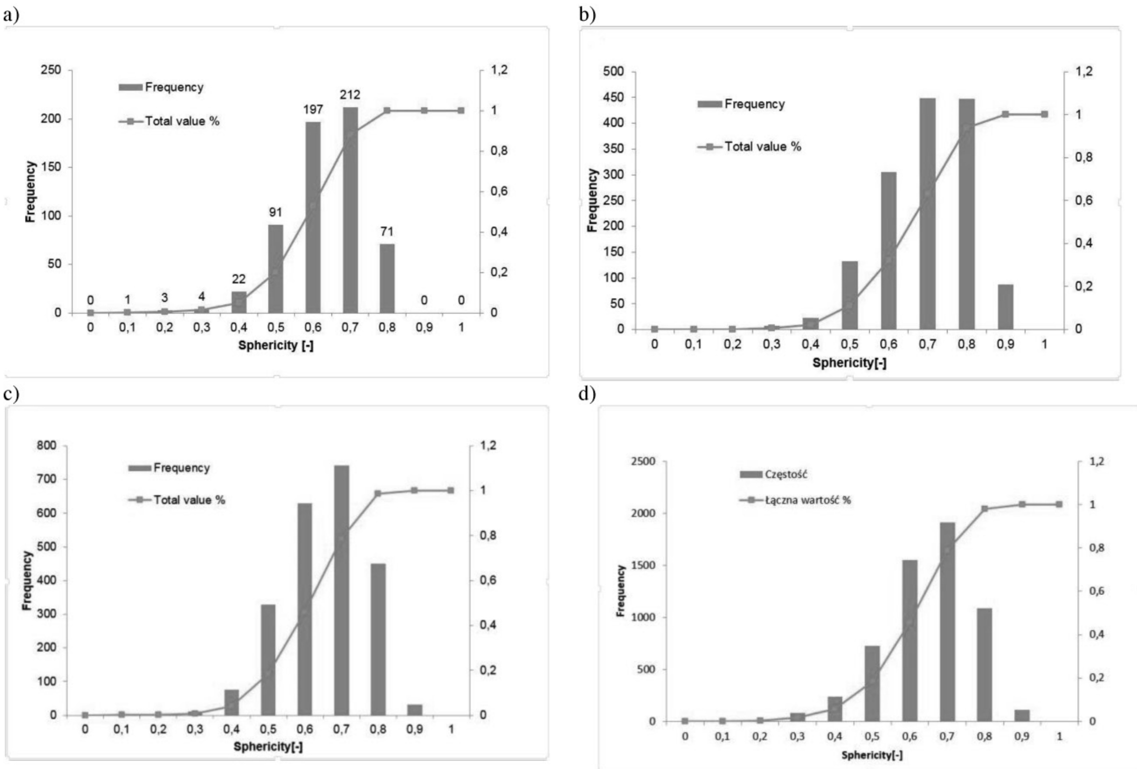

Fig. 3.55 Pore shape spread in samples: a) specimen A, b) specimen B, c) specimen C, d) specimen D.

Porosity structure, pore size, shape and distribution influence concrete properties such as: thermal conductivity, frost resistance, absorbability and percolation, capillarity and strength. Sizes of pores in the tested concrete have been presented in Fig. 3.56, and the spread of pore diameters in Fig. 3.57. Based on the graphs presented, it can be concluded that fine-sized capillary pores prevail in the tested concrete.

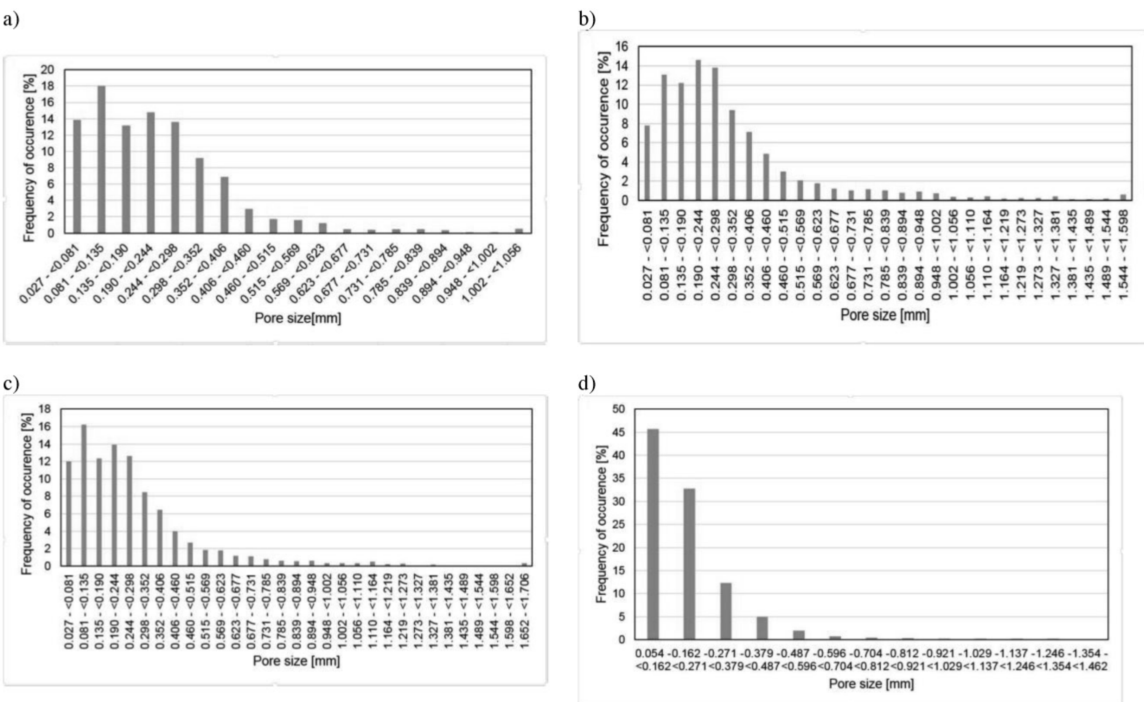

Fig. 3.56. Pore size spread in samples: a) specimen A, b) specimen B, c) specimen C, d) specimen D.

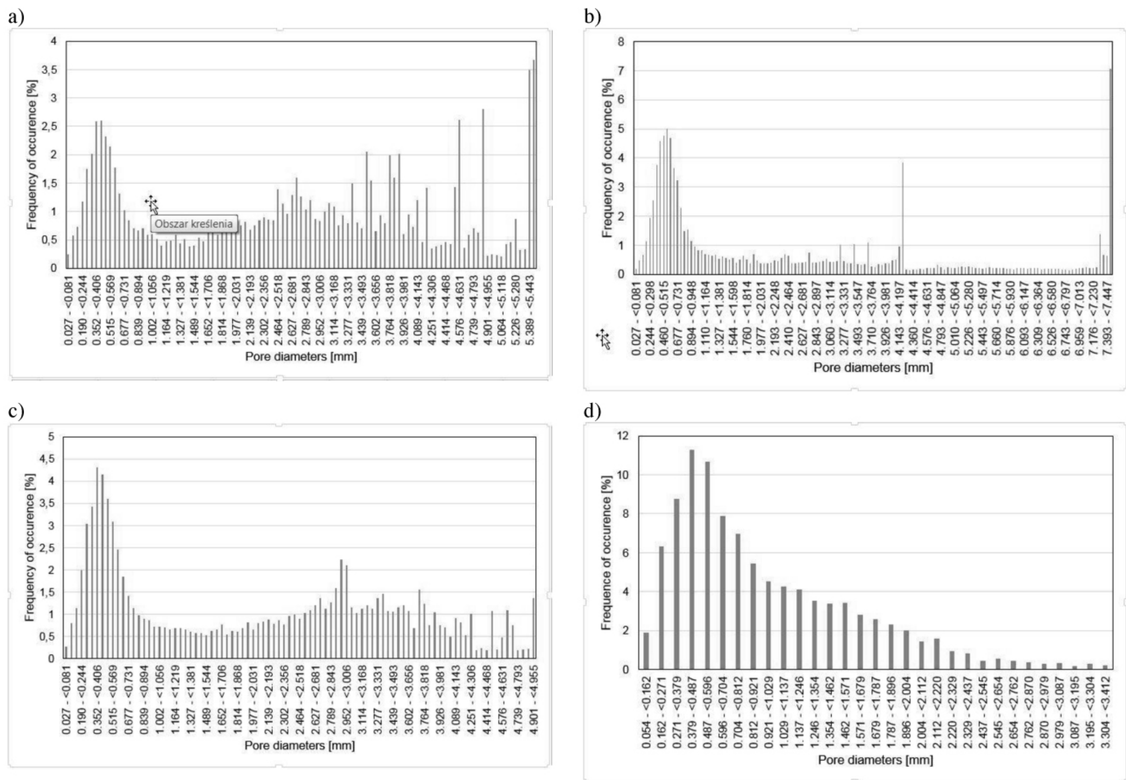

Fig. 3.57. Pore diameter spread in samples: a) specimen A, b) specimen B, c) specimen C, d) specimen D.

Table 3.27 presents the results of porosity tests carried out for specimens A, B, C and D. In the case of specimens B-D, the total air content was approximately 10%, but it was half of this value for specimen A. The specific surface area of the air pores system in all tested specimens amounted to approximately 40 mm^2/mm^3. Fine-sized, regularly distributed air pores with dimensions ranging between 10μm and 300μm improve the frost resistance properties of concrete. They are visible to the naked eye.

Tab. 3.27. Concrete porosity (specimens A-D).

	A	B	C	D
Total air content [%]	5.82	10.15	9.36	10.84
Specific surface area of the air pores system [mm^2/mm^3]	41.73	32.87	45.42	37.65
Micropores < 300μm content [%]	73.45	61.53	67.12	90.68

3.3.1.5. Determining hardness and modulus of elasticity of the tested concrete by means of the indentation method

The indentation method is a common technique used to measure the mechanical parameters of a material. It enables determination of the hardness and modulus of elasticity of a tested material, based on generating a ‘stress-strain’ curve. The TTX-NHT nano-indentation tester made by the CSM company was used in testing, fig. 3.58.

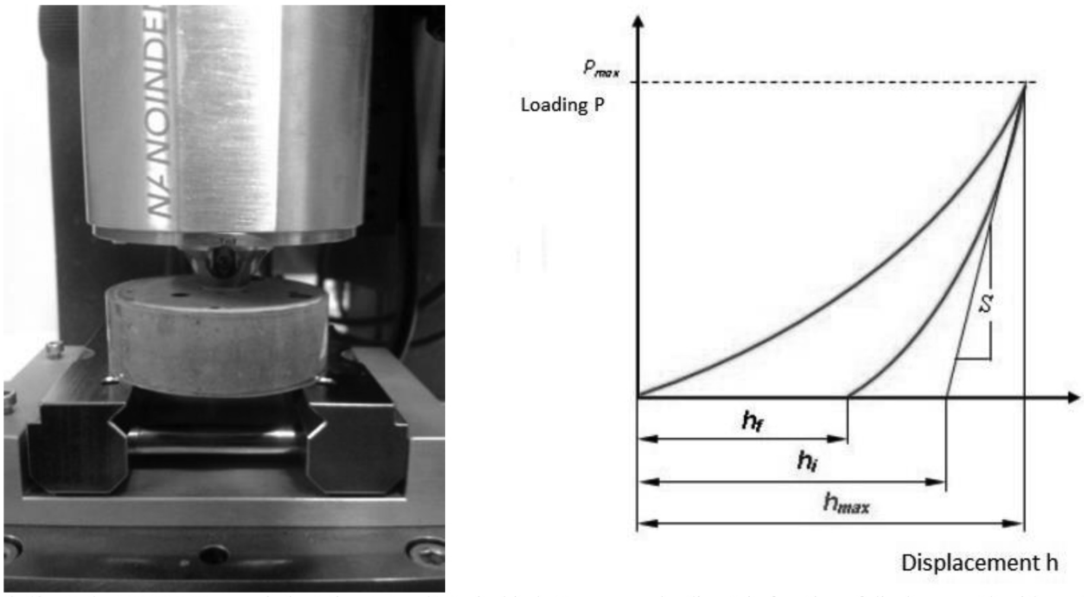

Fig. 3.58. a) The TTX-NHT nano-indentation tester, b) typical indenter curve – loading P in function of displacement h with marked parameters: h_f - remaining indentation, h_i – depth of contact, h_{max} – maximum indentation, S – total stiffness, [78].

The nano-indentation method involves penetrating a specimen with a hard diamond tip of an indentation tester, with a specified geometry (in this case - a pyramid). Loading is increased until it reaches a specified limit value P_{max}, which depends on the type of material being tested. As a result, the strain in the function of the load curve is obtained and is used to determine the maximum strain h_{max} and stiffness (based on the curve S = dP/dh), fig. 3.58 b.

$$\mu H = \frac{P_{\max}}{A}, \tag{14}$$

$$S = \beta \frac{2}{\sqrt{\pi}} E_{eff} \sqrt{A}, \tag{15}$$

where: μH – micro-stiffness, A is the surface area of contact between the tip of the indentation tester and the specimen, β is a non-dimensional parameter which considers the asymmetry of the tip of the indentation tester, E_{eff} is the effective modulus of elasticity, E is the modulus of elasticity of the material, υ is the Poisson's ratio, and E_i and υ_i elasticity parameters of the tip of the indentation tester [79]. Knowing the Poisson's ratio of the material, it is possible to determine the modulus of elasticity using the equation:

$$\frac{1}{E_{eff}} = \frac{1-\nu^2}{E} + \frac{1-\nu_i^2}{E_i}, \tag{16}$$

The analysis presented above allowed determination of the micro-hardness of the tested concrete which was found to be 1.8 GPa and modulus of elasticity, E = 33 GPa. Referring to the classic Mohs scale or extended Ridgwey's scale, the micro-hardness of concrete was determined to have a value 4, Table 3.28. The upper part of the Mohs scale was modified in 1933 by Ridgwey, who extended it to cover 15 grades in order to emphasise differences between the hardest minerals. The modulus of elasticity obtained for the specimen 4 of the circumferential ring of the dome meets the requirements for the C30/37 strength class as defined by the concrete standard, [21].

Tab. 3.28. Hardness of abrasive materials, [80].

Micro-hardness	Ridgwey's scale		Mohs scale	
HV [GPa]	standard	scale	standard	scale
98.7	diamond	15	diamond	10
54.9 – 56.9	boron carbide B_4C	14		
26.0 – 29.5	black silicon carbide SiC	13		
20.1 – 21.6	corundum	12	corundum	9
12.8	zirconium oxide ZrO_2	11		

11	topaz	10	topaz	8
10.3	garnet	9		
9.8	quartz	8	quartz	7
8.6 – 9.8	silica glass	7		
5.9 – 7.4	orthoclase	6	orthoclase	6
4.1	apatite	5	apatite	5
1.5	fluorite	4	fluorite	4
1.2	calcite	3	calcite	3
0.35	gypsum	2	gypsum	2
0.2	talc	1	talc	1

3.3.2. Conclusions

Analysis of the concrete in the bottom tension ring of the Centennial Hall's dome carried out to date confirms high concrete quality [9], [19]. Depending on the location of the sample extraction in the structure, the compressive strength values were found to range between 28 MPa and 38 MPa, and tensile strength values were found to range from 2.8 MPa to 4.5 MPa. Low absorbability of the concrete, being less than 5%, together with a low coefficient of variation equal to 8%, attests to the high structural homogeneity of the tested concrete. The hardened cement paste in the tested concrete demonstrates excellent adhesion to crushed granite aggregate. It is characterised by a dense structure, with low absorbability. Low infiltration of the cement paste obstructs carbonation and diffusion of chlorides, providing a protective barrier for the steel reinforcement of the concrete. Micro-hardness of the tested concrete was determined to equal 1.8 GPa and the modulus of elasticity, E = 33 GPa. When the value of micro-hardness obtained was referred to the classic Mohs scale or the extended Ridgwey's scale, it was found to have a value of 4. The modulus of elasticity obtained for the concrete of the tested circumferential ring (specimen 4) meets the requirements for the C30/37 strength class as specified by the concrete standard, [21].

The analysis conducted confirmed that the physical properties of concrete change with the distance from the external surface of the material. The density by volume increases and the porosity and absorbability of concrete decrease. This phenomenon is caused by the process of carbonation of concrete. Concrete samples differ with respect to composition and quantity of aggregate. The closer to the external surface of the material, the lower the content of aggregate in concrete which results in higher content of cement. The ratio of aggregate to cement for tested samples was 9:1 and 8:1, which can be regarded as relatively low.

The analysis of grain composition of the aggregate indicated that the curve derived from the results for sieve testing, places the aggregate in the 'well-grained' category of aggregates with a fraction below 31.5 mm. Quartz aggregate along with crushed granite aggregate was found in the aggregate composition. The content of crushed granite aggregate increases for higher fractions of aggregate. It also increases closer to the external surface of the tested concrete. The presence of fine wood chip inclusions was discovered in aggregate with a fraction below 8 mm, [9].

A lower amount of CaO in the oxide composition of the cement and presence of fine black inclusions indicate that blast-furnace cement may have been used for construction purposes. Introduction of slag into the concrete mix resulted in a dense microstructure of the concrete. A high concentration of C-S-H phase is a product of slag hydration and reaction of calcium hydroxide with silicate anions coming from slag hydration. The amount of calcium hydroxide decreases, resulting in the presence of a C-S-H phase as a dense gel. This leads to lower capillary porosity of the hardened cement paste, which in turn obstructs the diffusion of aggressive agents to the cement matrix. The amount of portlandite and calcium aluminates, which are not resistant to corrosion, is lower in the cement paste. These changes to the microstructure of cement paste based on blast-furnace cement mean that such cements are characterised by a number of more favourable properties than Portland cements without additives.

Analysis of the microstructure allowed for porosity assessment of the material, as well as the structure and dimensions of pores. Porosity was determined with a micro-CT device for the tested samples, and found to be approximately 10%. The pores in the material are fine-sized, with a sphericity of 0.6-0.7. The majority are micropores smaller than 300µm. Such porosity of the tested concrete is responsible for its low absorbability (less than 5%) and permeability, and high mechanical properties (compressive strength and tensile strength [8]), as well as good frost resistance.

3.4. Steel reinforcement

The paper [4] reports on chemical and metallographic tests carried out on 3 samples of steel reinforcement extracted from the structure of the Centennial Hall.

The chemical analysis indicated that samples no 1, 2, 3 are made of a material with composition similar to that of St0S general purpose structural carbon steel, classified in accordance with [18]. Microscopic and chemical composition analysis indicated that the tested bars no 1, 2, 3 were made of weldable steel. This piece of information is important in case welding is needed to repair or partly replace some of the corroded reinforcing bars or stirrups.

In 2015, an inventory and evaluation of the technical condition was carried out for the reinforcement of the main ring supporting the dome of the Centennial Hall in Wroclaw and for the reinforcement of the reinforced concrete ribs, which constitute the structure of the dome.

The reinforcing elements were identified, their arrangement was localised and the thickness of the concrete casing was determined, using a non-destructive electromagnetic method, with the application of a 'Cover-Master' CM52 device (fig. 3.14). Additionally, the

results from non-destructive testing were verified with exposure of reinforcing elements in several locations. These exposures allowed also assessment of the degree of corrosion of reinforcing bars in concrete.
The Rainbow test and the phenolphthalein test were used to assess the extent of carbonation in the near-surface layers of the concrete, (fig. 3.22). The tests were carried out on fresh concrete fractures, in locations where reinforcements were exposed.
The Rainbow testing method involves spraying the surface of tested concrete with a solution of a composition of specially selected chemical reagents, capable of identifying various pH values ranging from 5 to 13. The pH reaction of 11 is commonly regarded as a border value below which the natural capacity of concrete for passivation of reinforcement decreases. In this situation, the concrete stains purple. If the stain colour is green (pH = 9), the pH value is lower than the border value and corrosion of the reinforcement is possible.
Assessment of the extent of carbonation in the near-surface layer of concrete with the phenolphthalein test involves spraying an alcoholic solution of phenolphthalein on the surface of a fresh concrete fracture. Interpretation of results is straight forward as phenolphthalein changes the red colour to neutral where pH is equal to 8.5 – 9.5. A discoloured layer of concrete is thus regarded as a carbonated layer, which has lost its steel reinforcement passivation capabilities.
Tests carried out on the dome ribs and exposed reinforcing elements (fig. 3.59, 3.60) indicated that the main longitudinal reinforcement of the dome ribs consists of plain bars with the diameter of 32 mm (fig. 3.61) with spacing of approximately 42 cm. The crosswise spacing of the reinforcing bars has been determined to be approximately 15 cm (fig. 3.62). The concrete casing of the bars is 90 to 100 mm from the top and 35 mm to 45 mm on the sides.

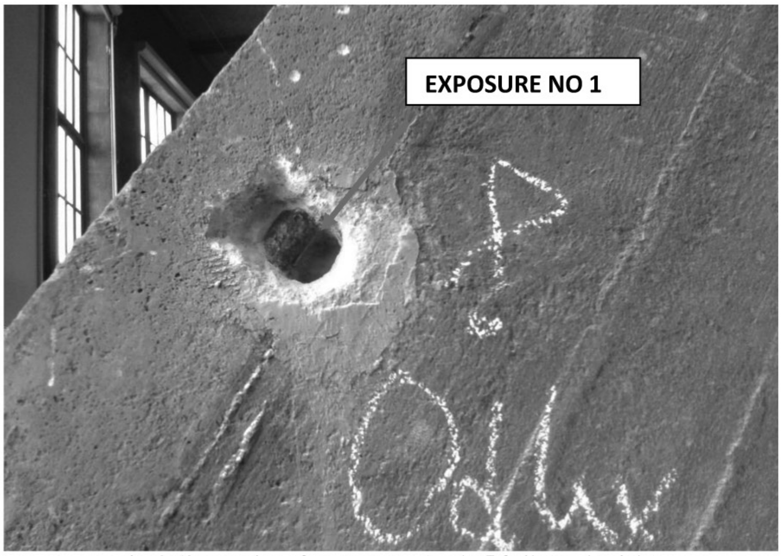

Fig. 3.59. Location of exposure no 1 – the **Ł3** rib (on the right).

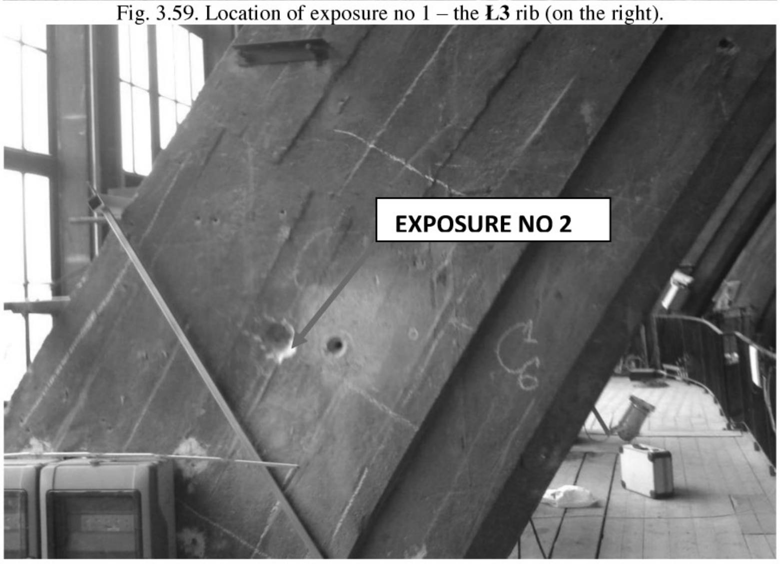

Fig. 3.60. Location of exposure no 2 – the **Ł32** rib (on the right).

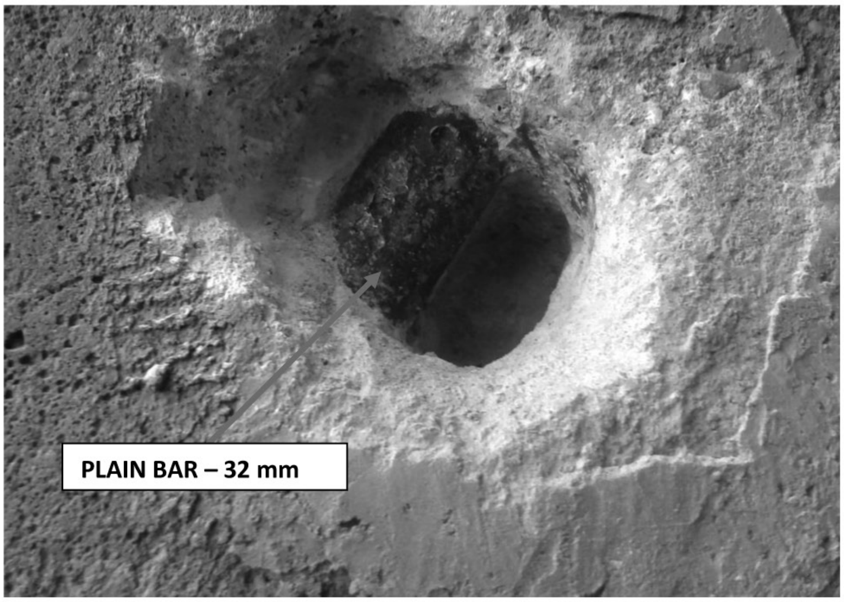

Fig. 3.61. Exposure no 1 – the main reinforcement of the rib consisting of plain bars with a diameter of 32mm.


Fig.3.62. Spacing of the main reinforcing bars crosswise.

A visual inspection of the exposure no 2 (fig. 3.63) indicated that the rib stirrups have been made of plain bars with a diameter of 8 mm and with a spacing of approximately 50 - 60 cm. The thickness of their concrete casing ranges from 27 mm to approximately 37 mm.

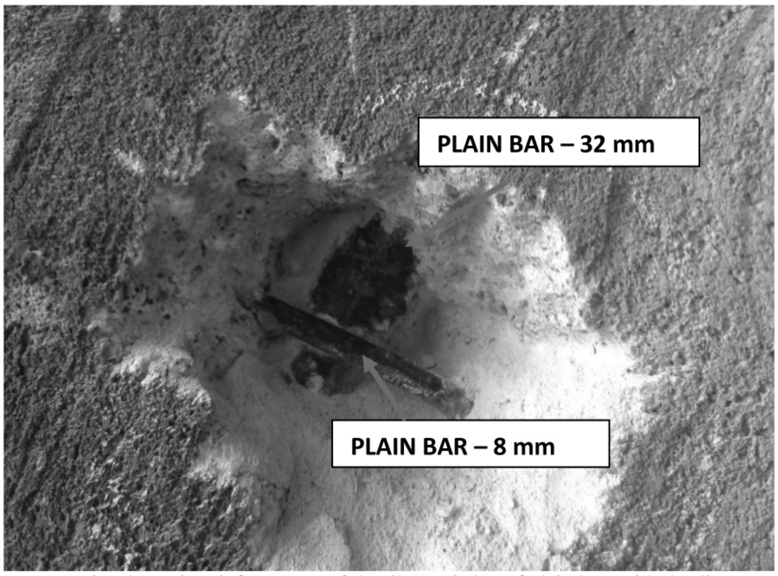

Fig. 3.63. Exposure no 2 – the main reinforcement of the rib consisting of plain bars with the diameter of 32mm and stirrups consisting of plain bars with a diameter of 8mm.

The visual inspection of the exposures which had been made in elements did not indicate any significant corrosion risk for the reinforcing steel elements, despite the fact, that some small corrosion pitting could be seen on the surface of the main bars. However their character indicated that they most probably had been present before the bars were built into the structure of the ribs.
Tests carried out in order to measure the extent of carbonation of the concrete casing at the locations of exposures indicated that the carbonated layer was approximately 25 mm thick.

3.5. Metal structural elements

Assessment of the condition of steel elements of lattice-work and bearings of the main tension ring of the dome was carried out for planning purposes in the years 2008 and 2009. The results of these analyses are reported in [30] and [31]. In line with requirements, 4 samples were extracted for metallographic testing from the main steel elements of the ring supporting the dome. The ring constitutes one of the key elements of the whole structure of the Hall. Available information suggested that the ring structure has not been subjected to any analysis following its construction (a hundred years ago) and the data regarding the steel used in its construction was fragmentary and unclear (lack of documentation concerning the so called 'zero' condition of the materials). The condition of the material (steel) a hundred years after it had been manufactured was unknown. A hundred years of use must have affected the steel condition as a result of material ageing and corrosion processes. Damaged concrete of the ring indicated such a possibility.
The results of the tests constituted part of a comprehensive assessment of the condition of the Centennial Hall and were used to verify calculations. It was assumed that all other (not subject to testing) steel elements of the ring had a similar microstructure and similar properties as the sampled elements. This was because they were produced at the same time and most probably by the same manufacturer.
The tests were considered to be non-destructive, even though they required extracting samples from the structure. Non-destructive metallographic tests carried out using replicas could not be used in this case due to the surface characteristics. Surface testing of steel characterised by considerable differences in volume could provide incorrect information, especially where the steel was manufactured over a century ago.

Samples were extracted using a pin-cutting drill with an external diameter of 15 mm, which was correlated with the dimensions of the structural elements under investigation. The intention was not to decrease significantly their load-bearing capability so as to ensure there would be no influence on the safety related to the functioning of the building. Access to the steel elements (reinforcement of the ring) was granted in locations where the concrete surface was damaged (cracks). These places could have been subjected for many years to corrosion enhancing agents and would now have to be repaired with modern strengthening and sealing technologies. The drilling equipment was mounted onto the concrete wall using a special device.
Four samples were extracted from areas subject to a variety of functional conditions:

- The external side of the main ring (external belt), characterised by lower sun access – the belt in the axis of the arch no 4, within the riveted joint of elements – samples no 1 and 2 (from two elements joined with rivets, sample no 1 extracted closer to the external surface – in accordance with the drilling sequence),
- The opposite external side of the main ring (external belt), with more sun access – the belt between the arches no 20 and 21 – sample no 3,
- Inside the building - a cross-bracing which links the external and internal belts together, between the arches no 30 and 31 – sample no 4 – fig. 3.64.

Fig. 3.64. Location of extraction of sample no 4 from the cross-bracing, [30].

The material testing included measurement of hardness and thickness, and microstructure analysis of the samples.
Hardness measurement was carried out on coated and polished metallographic sections. The hardness was measured using a laboratory ZWICK 321 hardness tester with a loading of 10 kG (98.070 N). The results were reported in relation to Vickers' scale as the mean value of a minimum of three measurements.
The samples subjected to microstructure analysis (fig. 3.65) were first coated in epoxy resin and then abraded using sandpapers with grains of 100 to 1000, and then polished using the water suspension of aluminium oxide and etched with 3% Nital. The laboratory analysis of the microstructure was carried out with a light microscope, using a magnification of up to 800X. A magnification of 500X was used for the purposes of documentation.
Thickness was measured on polished metallographic sections using a calliper with 0.1mm accuracy. The results were presented along with photomicrographs of the structures.

Fig. 3.65. Samples for testing, [30].

The microstructures of the samples extracted are presented in fig. 3.66 – 3.74. The results of hardness and thickness measurements are provided along with descriptions of the microstructures.

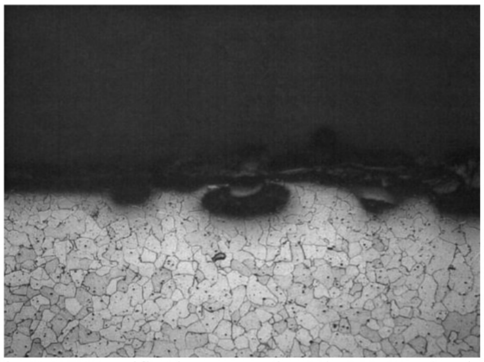

Fig. 3.66. Magnification: approximately 100 X – showing corrosive cavities and microstructure of the material in the external belt of the main ring (1). Hardness - 106 HV; thickness – 13.1 mm.

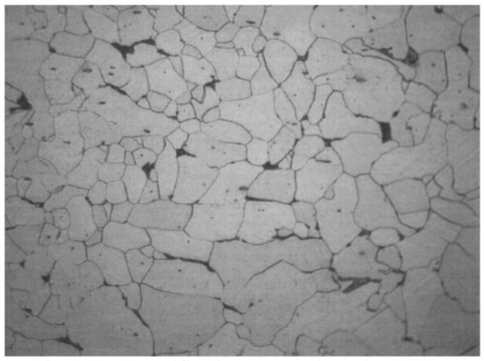

Fig. 3.67. Magnification: approximately 200 X – microstructure of the material in the external belt of the main ring (1) the middle section

A significant level of contamination was discovered in steel sample 1 prior to etching, comprising non-metallic inclusions, mainly sulphides and oxides. But overall, inclusions were tiny though individual large inclusions were also present. These were distributed unevenly and were more numerous in the middle layers of the material. Corrosion pitting was found to be of a uniform character and highly localised (approximately 0.1 mm deep).

The microstructure of the sample after etching was found to be ferritic and pearlitic with a very small amount of lamellar pearlite located on the boundaries of ferrite grains. Tiny individual precipitation locations of tertiary cementite were also found on the boundaries of these grains.

A significant level of contamination of steel with non-metallic inclusions, mainly sulphides and oxides, was discovered in sample 2 prior to etching. The inclusions were tiny and distributed unevenly. They were more numerous in the middle layers of the material. The sample surfaces were covered with well-adhering thin layers of corrosion products and individual corrosion pitting, which had a localised character and depth of around 0.1mm.

The microstructure of the sample after etching was found to be ferritic and individual fine grains of lamellar pearlite were located on the boundaries of ferrite grains. Numerous precipitation locations of iron carbides and nitrides were discovered inside the ferrite grains. Individual precipitation locations of tertiary cementite were also found on the boundaries of these grains.

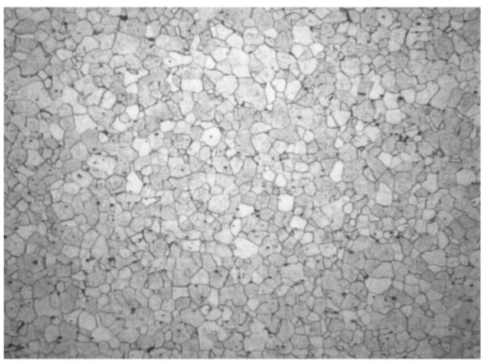

Fig. 3.68. Magnification: approximately 100 X – the microstructure of the second layer of the external belt of the main ring (2) in the middle section. Hardness -109 HV; thickness -13.0 mm.

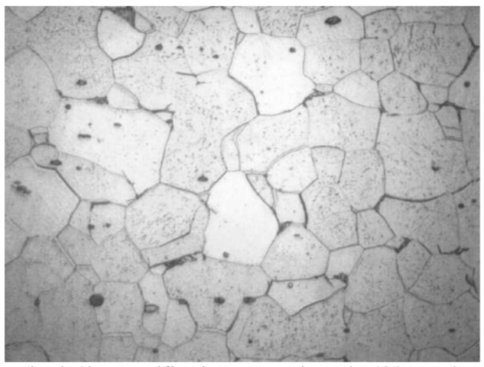

Fig. 3.69. Magnification: approximately 400 X – the microstructure of the material of the second (joined with rivets) layer of the external belt of the main ring (2) in the middle section.

A significant level of contamination of the steel with non-metallic inclusions, mainly sulphides and oxides, was discovered in sample 3 prior to etching. The inclusions were tiny but individual larger ones were also present. They were distributed unevenly and were more numerous in the middle layers of the material. The sample surfaces were covered with well-adhering thin layers of corrosion products and individual corrosion pitting had a localised character and depth of around 0.1mm.

The microstructure of the sample after etching was found to be ferritic with individual fine grains of lamellar pearlite located on the boundaries of the ferrite grains. Numerous precipitation locations of iron carbides and nitrides were discovered inside the ferrite grains. Iron nitrides were present in large amounts in the near-surface areas, up to the depth of approximately 0.5 mm. Individual precipitation locations of tertiary cementite were also found on the boundaries of these grains.

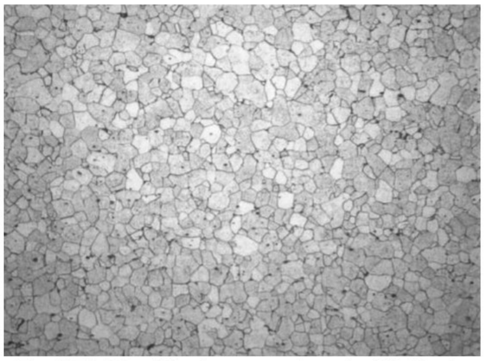

Fig. 3.70. Magnification: approximately 100 X – the microstructure of the external belt material of the main ring (3) near surface. Hardness - 100 HV; thickness – 12.9 mm.

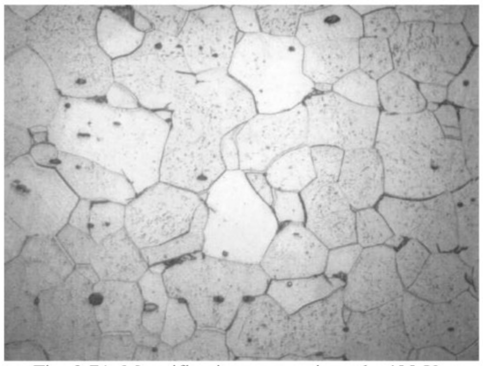

Fig. 3.71. Magnification: approximately 400 X – microstructure of a layer of the external belt material of the main ring (3) in the middle section.

A significant level of contamination of steel with non-metallic inclusions: slag, sulphides and oxides, was discovered in sample 4 prior to etching. Fine inclusions were numerous. Larger inclusions were also present, but these were less numerous and localised in groupings. They are distributed unevenly, mainly in the middle layers of the material. The sample surfaces were covered with well-adhering thin layers of corrosion products and individual corrosion pitting had a localised character and a depth of around 0.1mm.
The microstructure of the sample after etching was found to be ferritic with individual fine grains of lamellar pearlite located on the boundaries of ferrite grains. Individual precipitation locations of iron carbides and nitrides were discovered inside the ferrite grains. Individual precipitation locations of tertiary cementite were also found on the boundaries of these grains.

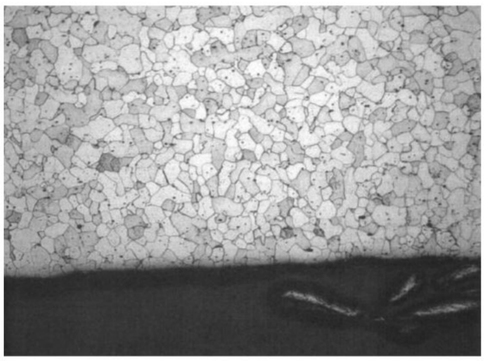

Fig. 3.72. Magnification: approximately 100 X – the microstructure of the cross-bracing material of the main ring (4) near surface. Hardness -133 HV; thickness – 8.1 mm.

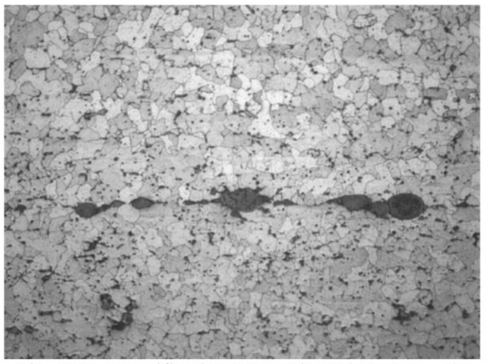

Fig. 3.73. Magnification: approximately 100 X – the microstructure of the cross-bracing material of the main ring (4) in the middle.

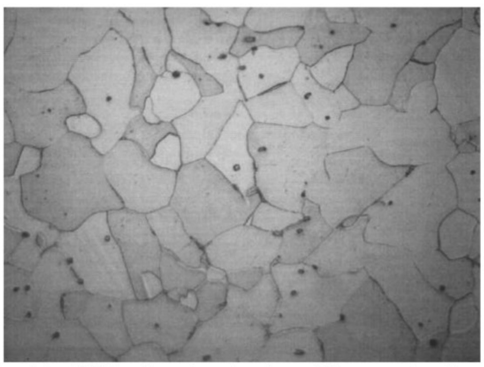

Fig. 3.74. Magnification: approximately 400 X – the microstructure of the cross-bracing material of the main ring (4) near surface.

The following conclusions were formulated on the basis of test results:

– The visual inspection of the surface condition of the steel elements in the main ring exposed for testing indicated that the elements are in good condition – with no corrosion pittings significant from the functional point of view. It is likely that corrosion products located on the surfaces of the elements date back to the time of Hal construction. The thickness of the tested elements indicates no significant differences when compared to the original documentation.

– Hardness of the tested elements does not indicate any significant differences. The differences identified are a result of heterogeneity of materials connected to the metal forming processes (localised content of carbon, non-metallic impurities and inclusions).
– The microstructure is typical of steel elements, which had been produced a hundred years earlier. The inclusions of carbides and nitrides identified can appear with the aging of material (over a hundred years of use), but could have also appeared already during the steel-making processes. These are responsible for decreasing of ductile properties of steel (impact strength, elongation, reduction in area).

The lack of homogeneity of steel discovered during testing could appear within one type of steel and even within one steel cast. There is no basis for attributing the unfavourable properties of the structure to the functioning of the Hall (no documentation is available on the original, so called 'zero' condition of the material). However, these features are a normal part of the aging processes of this type of steel.

The number of non-metallic inclusions and their considerable segregation can be regarded as typical for steel produced at the time of Hall construction, when rivets were widely used (these are characterised by a higher content of sulphur and phosphorus than in modern steel).

A comparison of the thickness measurements of the tested elements to the data contained in documentation from the time of the construction of the Hall indicates that the steel elements of the reinforcement of the main ring (in the tested locations) have not corroded over the past 100 years. The corrosion pitting discovered dates back to installation of the elements during Hall construction.

Tests of the bottom tension ring of the dome carried out in 2015 confirmed that the two steel lattice structures, located horizontally one above the other and covered with concrete, constitute the principal element of the main ring, which carries tensile loads from the dome ribs (fig. 3.75, 3.76). The exposure made in the ring indicated that the steel of the lattice-work elements is in good technical condition. No traces of corrosion were detected. The tests indicated that the structure of the main ring itself is made of concrete. There was no sign of soft reinforcement.

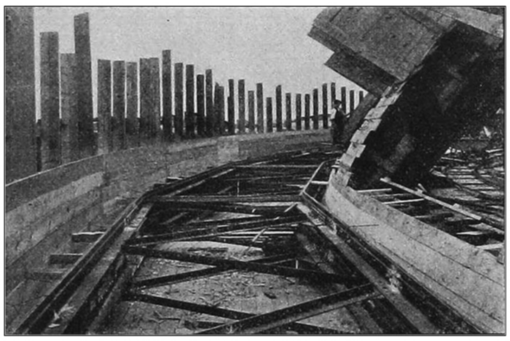

Fig. 3.75. Lattice structures which carry the tensile loads – archive photo

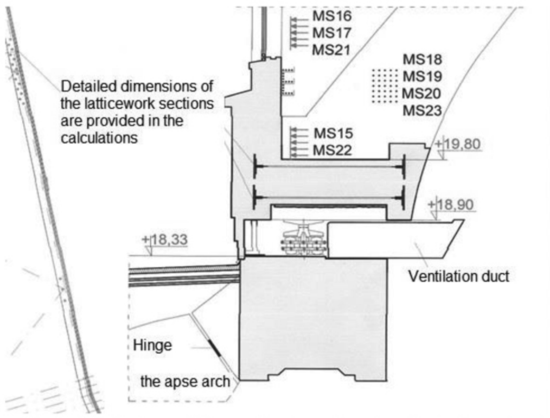

Fig. 3.76. Section of the main ring, showing the lattice structures carrying the tensile loads.

In 2015, tests and analyses were carried out to determine the design strength of the steel used to manufacture the support bearings of the bottom ring of the dome of the Centennial Hall. The bearings had been designed to be located in places where the meridional ribs rested on the ring (fig. 3.77). Thus the total number of bearings is 32. They are placed along the circumference of the dome, under its bottom ring, which is located approximately 0.6m above the structural ceiling of the supporting structure. The height of the bearings is approximately 0.5m. It is possible to access them from the roof, via several hatchways along the circumference of the structure. One of these is shown in fig. 3.78.

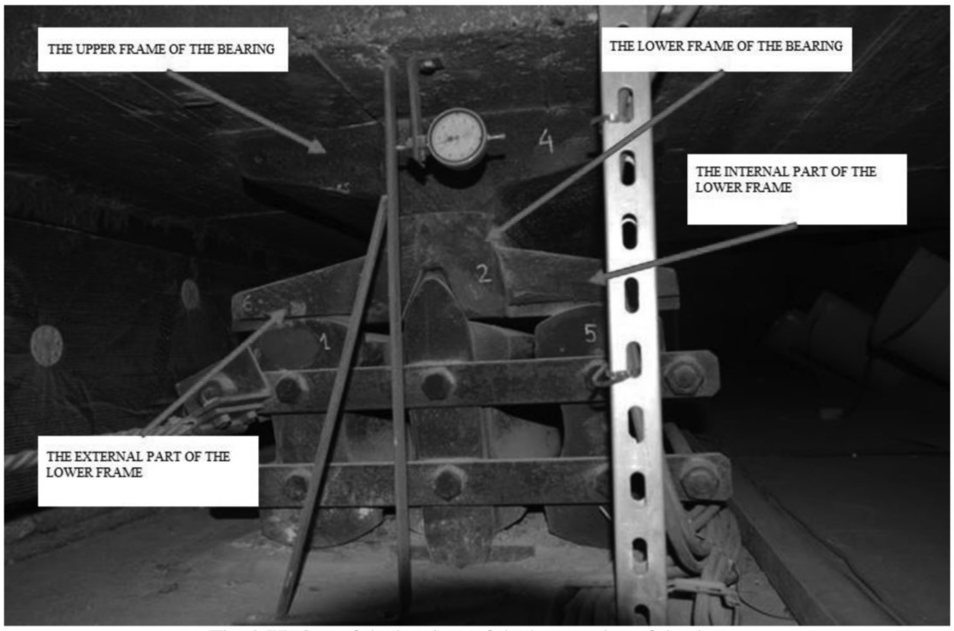

Fig. 3.77. One of the bearings of the bottom ring of the dome.

Fig. 3.78. One of the hatchways allowing access to the bearings.

The bearings were manufactured at the beginning of the twentieth century, using steel or cast-steel of an unknown sort. It is essential to determine the design strength of this structural material so as to enable monitoring of the structural condition of the Centennial Hall.
As it was not possible to sample the material from the frame of the bearings in an amount sufficient for preparing specimens for destructive tensile strength tests, it was decided to assess the strength parameters of the material on the basis of extensive, non-destructive Brinell hardness tests [22], [23], [24], using the mobile Brinell tester and the Poldi hammer. Testing was carried out in locations with easy access, where the internal stress condition due to loading was close to zero [23]. In all, 43 measurements of hardness were carried out on the structure of 3 bearings using the Brinell test and 19 measurements were carried out on samples extracted for chemical analysis from frames of 2 bearings (including 9 measurements using the stationary Brinell tester).
A PZ-3 mobile Brinell tester produced by a German company ZWICK was the main device used for testing. The device was used to carry out 40 measurements on site on the 3 bearings. The measurements were carried out using the expansion method, which required construction of a special shackle consisting of 140 channel sections and M16 threaded pins (fig. 3.79). A 5 mm diameter ball made of self-bonded carbides was used as an indenter, driven with a standard force of 7.355 N (750 kG) (see: [23], [25]). The diameters of the indentations were measured with an electronic microscope. Following chemical analysis, the same hardness tester was used with the clamping method to carry out 10 measurements on the samples.

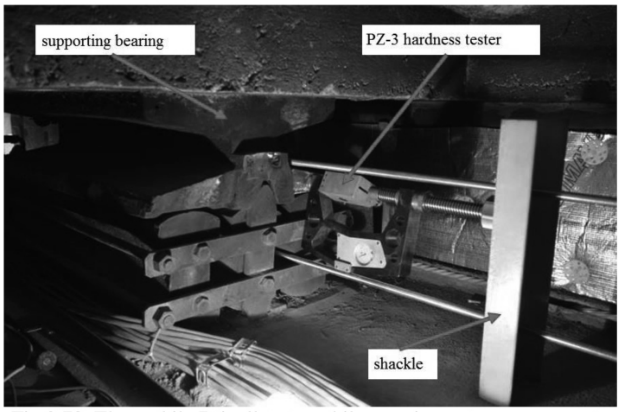

Fig.3.79. The mobile Brinell tester while carrying out measurements.

Three trial measurements for Brinell's hardness were conducted on one of the bearings using the Poldi hammer [23] with a 10 mm diameter steel ball. The results obtained were within the same range as those obtained using the mobile Brinell tester. But only one measurement could be qualifed as complying with standard measuring requirements due to the lack of sufficient space for delivering a strong enough blow with the hammer of standard weight of 0.5 kg. Further testing with the Poldi hammer was abandoned for this reason.

Small material samples were extracted from two bearings (one from each) for the purposes of chemical analysis. The analysis was performed in the Laboratory of Emission Spectroscopy of the Alucast Wroclaw company. The chemical composition analysis was used to determine the type of material (cast-steel, cast-iron) used for casting the bearing frames. Following the chemical analysis, 10 additional hardness measurements were carried out on the samples using the mobile Brinell tester. To verify the results, 9 measurements were carried out on the samples using the stationary Brinell tester. The results obtained were found to be within the same range as results obtained from the mobile tester.

Hardness tests of the material of the bearing frames enabled a statistical determination of the minimum hardness HBW_{min} at a statistically significant level, made possible by the numerous tests performed. The design value was thus calculated on the basis of the experimental tests, with the assumption of a normal distribution, the level of significance to be $\alpha = 0.05$ and defective percent $\omega = 0.135\%$, which correspond to the global tolerance factor $k_\infty = 3.0$ [24]. A slightly different defective percent value of $\omega = 0.1\%$ has been adopted in European standards, with a global tolerance factor $k_\infty = 3.04$ (see e.g. [26], [27]).

The design value of minimum hardness can be determined using the formula:

$$HBW_{\min} = \overline{HBW} - k_n \cdot s_{HBW} \tag{17}$$

where:

$\overline{HBW}$ - hardness mean value,

s_{HBW} - empirical standard deviation,

k_n - tolerance factor dependant on the n number of samples in the set of results.

Based on the HBW_{min} value, it is possible to determine the adequate yield strength $R_{e\,min}$, and immediate tensile strength $R_{m\,min}$, using the following formulae:

$$R_{e\,\min} = 2.3 \cdot HBW_{\min}, \qquad R_{m\,\min} = 3.2 \cdot HBW_{\min} \tag{18}$$

which are important for analysing historical low-carbon steel (see [24]).

The design parameters of the cast-steel or cast-iron, which were used for casting the bearing frames, can now be calculated as follows [27]:

$$f_y = \frac{R_{e\,\min}}{\gamma_{M0}} \tag{19}$$

where γ_{M0} is a partial safety factor, equal to 1.0.

Table 3.29 presents the chemical composition of samples extracted from the frames of the 2 bearings selected, and Table 3.30, provides a comparison with the chemical composition of modern unalloyed (carbon) cast-steel.

Tab. 3.29. Chemical composition (mass %) of the tested samples.

Sample	C	Mn	Si	P	S	Cr	Ni	Mo	V	Cu	Ti	A l
Ł1 (the lower frame of the bearing no 3)	0.205	0.862	0.363	0.083	0.036	0.0	0.046	0.007	0.002	0.139	0.003	0. 0
Ł2 (the lower frame of the bearing no 1)	0.277	0.674	0.113	0.066	0.047	0.0	0.042	0.004	0.001	0.115	0.003	0. 0

Tab. 3.30. Chemical composition and mechanical properties of structural carbon cast-steel types of regular quality according to [82].

Type of cast-steel	Chemical composition, %					Mechanical properties				
	C max	Mn max	Si max	P max	S max	$R_{e,\,min}$ MPa	R_m MPa	A_{min} %	Z_{min} %	KV_{min} J
200-400	0.25	1.00	0.60	0.035	0.035	200	400-550	25	40	30
230-450	0.25	1.20	0.60	0.035	0.035	230	450-600	22	31	25

The carbon content in the tested samples suggests (tab. 3.29), that the frames of the tested bearings have been made from cast-steel, as cast-iron, being an alloy of iron and carbon, should contain more than 2.0% carbon [28]. A comparison of the chemical composition presented in Table 3.29 to the one presented in Table 3.30 indicates that the cast-steel used in manufacturing of the bearings is of a much lower quality than modern cast-steel. Carbon content is much too high, as well as that of phosphorus and sulphur, whereas manganese and silicon content is too low. This is not surprising as the cast-steel was manufactured at the beginning of the twentieth century. It can thus be concluded that the strength parameters must be worse than those presented in Table 3.30.

The final results of the statistical calculations of minimum hardness $HBW_{\min}$ for the the tested cast-steel bearing frames are presented in Table 3.31. Calculations of the respective strength parameters $R_{e\,min}$, $R_{m\,min}$ and the design strength f_y – are presented in Table 3.22. Tables 3.31 and 3.32 present calculations based both on the assumptions from the paper [24] (ω = 0.135% and an appropriate statistically determined k_n), and on the European standards [26], [27] (ω = 0.1% and k_n value taken from the appropriate table in [26]). The results were based both on the full set of results of Brinell hardness measurements and for a limited set of results, from which the ten highest values have been excluded.

Tab. 3.31. The results of statistical calculations of minimum hardness of the tested bearings.

Assumptions as in	Set of results	n	$\overline{HBW}$	s_{HBW}	k_n	$HBW_{\min}$
paper [24]	full	59	155.20	21.03	3.55	80.5
paper [24]	limited	49	148.52	15.22	3.62	93.4
standards [26, 27]	full	59	155.20	21.03	3.09	90.2
standards [26, 27]	limited	49	148.52	15.22	3.10	101.3

Tab. 3.32. The results of calculations of strength parameters of the cast-steel in the tested bearings.

Assumptions as in	Set of results	n	$HBW_{\min}$	$R_{e\min}$ [MPa]	$R_{m\min}$ [MPa]	f_y*[MPa]
paper [24]	full	59	80.5	185.15	257.60	**185**
paper [24]	limited	49	93.4	214.82	298.88	215
standards [26, 27]	full	59	90.2	207.46	288.64	207
standards [26, 27]	limited	49	101.3	232.99	324.16	233

*) design strength f_y determined for $\gamma_{M0} = 1.00$.

3.5.1. Conclusions

1) The comparison of the results presented in Tables 3.30 and 3.32 confirms that the strength parameters of the cast-steel used in the manufacture of the bearings, are worse than those of modern cast-steel. This refers primarily to the minimum tensile strength value, which is much lower than 400 MPa, even with the most favourable estimates.
The chemical analysis of the samples extracted from the the lower frames of the bearings indicated that the frames were cast at the beginning of the twentieth century with low-carbon cast-steel. However, the chemical composition of this cast-steel differs considerably from the chemical composition of modern low-carbon cast-steel.
The non-destructive Brinell hardness tests carried out on the unknown type of cast-steel, which had been used to cast the bearings located under the bottom ring of the Centennial Hall's dome, enabled determination of the cast-steel design strength. This strength value is essential for monitoring of the structural condition of the Centennial Hall. The authors' experimental test results were used [24], and served to develop generalized formulae describing the relation between Brinell hardness of the historical steel and its yield strength and immediate tensile strength. Respective formulae (18) refer to low-carbon steel. The tested cast-steel is also low-carbon, which was confirmed in the chemical analysis of the extracted samples.

2) Taking all the above into consideration, the design strength f_y of the cast-steel used to manufacture the bearings, can be assumed with a margin of safety to be as follows:

– analysis in accordance with the standard [27] – f_y **= 185 MPa** (see tab. 3.32),

– analysis in accordance with the standard [29] – $f_d = f_y / \gamma_m$ **= 185/1.15 = 160 MPa.**

3) The design strength values, referred to above, can be used to monitor of the structural condition of the Centennial Hall and to assess the boundary states of load-bearing capacity in accordance with accordance with standards [27] or [29] (respectively).

3.6. Wooden elements – window woodwork (2015)

With respect to the window woodwork, an analysis of the tests carried out to date [32], [33], [34] was conducted along with assessment of the technical condition of 606 original and replacement windows situated from level II to level IX (fig. R1) in the Centennial Hall in Wroclaw.
The description of the window woodwork was prepared using the terminology from papers [33] and [2].
Single casement windows with rebates have been installed from the outside and swing outwards [32]. They are made of the so called ironwood (*Casuarina* wood) imported from Australia, which was characterised by rust-reddish colour, [35].
A detailed description of window woodwork and an inventory of all window types in the Hall were prepared by prof. Tajchman in 2007 [32], [33], [34]. Bożejewicz prepared detailed drawings for each type of a window [33], including external and internal views and all essential sections. In addition, all profiles of window frames (head, sill and side jambs, trim boards), window sashes (top rails, hanging stiles, weatherboards, muntin bars) and steel window fittings (hooks, knobs, corners, hinges) were presented in terms of their actual dimensions.
Window frames consist of rectangular jambs with notches, measuring 36×58/65 mm. Trim boards (11×21 mm) have been installed on the sides and at the top to cover the gap between the window frame and the concrete structure of the wall. They also cover the flat bars (5×20×83 mm) used for fixing the windows to the walls. Dual windows contain rectangular, vertical mullions with notches and measure 35/36×72/75 mm. Multilevel windows contain one or two rectangular transom bars with notches and measure 66×72/75 mm. Window sashes, which swing outward, comprise rails with notches, and measure 36×55 mm. Some of the rails have bevelled external edges. Bottom rails (weatherboards) are made as a single unit, including a drip. Crossing muntin bars are 28÷32 mm thick. They are 6÷11 mm wide on the internal side, and 24÷26 mm wide on the external side next to the window pane, which gives the muntin bars a trapezoidal cross-section when viewed from the inside [32].
The windows were glazed with ornamental ochre-coloured glass instead of ordinary window glazing. No fragments of original window glazing have been preserved and so no reference was available for glass selection. No historical documentation has survived relating to the types and colours of glass used originally for the glazing of the windows in the dome. Some documents have been found in the State Archives in Wroclaw, which refer to sample number 21 as acceptable with respect to its colour, but wih a note that the texture of sample number 23 is required. The relief texture of the glass was to improve the acoustics of the Hall, whereas the colour and texture of the glass were chosen to limit the intensity of the sunlight, which might otherwise have dazzled the audience. It was discovered that glass for glazing the windows was made by the glassworks in Pirna, a town not far from Dresden in Germany, but the factory no longer exists. The last manager of the glassworks, who happened to be a utility glass collector, had an original sampler and catalogue of window glass produced in the factory in the years 1913 – 1914 in his collection, [6].
The windows which required restoration have been repaired since the tests described in [32], [33], [34] were reported.
Note:
Cards number 21 and 21a in [33] do not concern the windows on level VI.
Cards number 18 and 18a in [33] do not concern the windows on level V.
Cards number 12 and 12a in [33] do not concern the windows on level III.

3.6.1. Analysis of the condition of wood in window woodwork using the resistance drilling method

3.6.1.1. The subject, goal and scope of testing

The analysis focused on timber elements of window woodwork of the Centennial Hall in Wroclaw.
The resistance drilling method (the resistographic method) was used to determine the condition of the timber material in the window woodwork.

The scope of the work covered:

– Description of the method used to assess the condition of the timber material,
– Test results,
– Conclusions.

3.6.1.2 Resistance drilling testing - description of the method

The resistance drilling tests are used to assess the condition of timber material in structural elements. The tests were carried out using the IML RESI F-400S drilling device (fig. 3.80), which registers measurements to an accuracy of 0.1 mm.
The device measures resistance encountered by a drilling needle, which rotates with a constant speed of approximately 1500 rotations per minute. The diameter of the needle is from 1.5 to 3 mm at its end and it is up to 400mm long (fig. 3.81). Drilling indicates subsequent annual growth zones and changes to the density of timber material, resulting from, inter alia, biological degradation. The diameter of the drill-hole in the timber element resulting from the test is no larger than the exit holes of wood pests (approximately 3 mm). For this reason, the method can be regarded as quasi non-destructive.

The shape of the resistance drilling graph in sound timber material is strictly related to the difference in density of earlywood and latewood [36], the structure of annual growth rings and the angle of drilling. Application of drilling resistance methods enables localising internal damage and discontinuities in timber elements without affecting their functional properties, which is of particular importance in the case of historical monuments [37], [38], [39], [40].

Fig. 3.80. The IML RESI F-400S device used for resistance drilling tests.

Test results are presented as graphs depicting the relation between the amplitude of resistance and the depth of drilling. Graph peaks indicate high resistance and high density. The shape of the resistance drilling graph in sound material is strictly related to the difference in density of earlywood and latewood, the structure of annual growth rings and the angle of drilling. Troughs and low points indicate low resistance and low density. Timber subjected to complete disintegration offers no drill resistance. In such a situation, the graph is a flat horizontal line. The preliminary evaluation of the timber condition can be carried out using the description in Table 3.33

The results of resistographic tests enable assessment of the range of potential damage to the wood material and a preliminary evaluation of its strength.

The HARD timber hardness setting for deciduous wood was used for testing.

The location of measurement spots has been presented in Table 3.33.

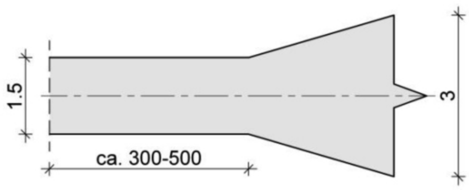

Fig. 3.81. Shape and dimensions of the drilling needle, [mm].

Tab. 3.3.3. Assessment of the condition of timber, depending on the resistance drilling amplitude.

Description	Characteristic features, additional remarks
Entrance/ exit zone during drilling in the tested element.	The measurement in this zone is faulty as some time is necessary for the proper arrangement of the drill and for the device to reach the required rotation speed. The graph most frequently has the form of a curve – gradually ascending or descending. A long entrance zone may also indicate a high decay of surface layers of wood.
Sound wood with high strength parameters.	If the mean amplitude of drilling resistance of wood is greater than 50% along a section of more than 1cm, it is assumed that the wood in this zone has high strength parameters. If the section is short, it can indicate that the drill has encountered a knot. If the section is long and covers most of the graph, the tested wood is of very high quality.
Sound wood with medium	If the mean amplitude of drilling resistance of wood ranges between 25 and 50% along a

strength parameters	section of more than 1cm, it is assumed that the wood in this zone is sound and has retained strength parameters close to those of modern medium quality wood.
Wood with low strength parameters	If the mean amplitude of drilling resistance of wood is below 25% along a section of more than 1cm, it is assumed that the wood in this zone has low strength parameters. This may be caused by biological decay of wood but also by using low quality timber with low structural parameters.
Decayed wood	A flat shaped graph indicates very low resistance to drilling. If the graph is flat along a long section it indicates almost complete decay of timber material. A short section may indicate a localised crack inside the element which does not exclude the element from further use.

Attempts to link resistographic tests with strength tests have been undertaken, in order to assess strength parameters of wood in structures. Test results presented in the form of graphs depicting the relationship between the relative resistance (*RA*) and the drilling depth (*H*) enable assessment of timber parameters through correlation between the value of mean Resistance Measure (*RM*) with density, strength and modulus of elasticity [37], [41] in accordance with the formula (20):

$$RM = \frac{\int_0^H RA \cdot dh}{H} \tag{20}$$

However, the estimated parameters of wood, using the *RM* value, have to be regarded only as approximate. *RM* values obtained from tests on one sample of timber, depending on inclusions present and the slope of grain, may vary considerably.

3.6.1.3 Results of resistance drilling tests

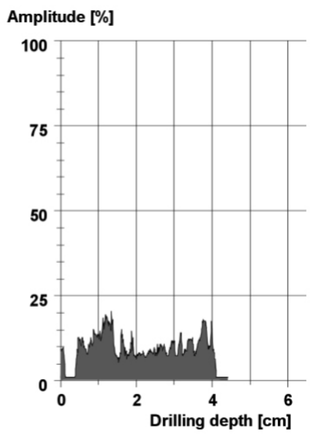

Fig. 3.82. Measurement spot no 1.

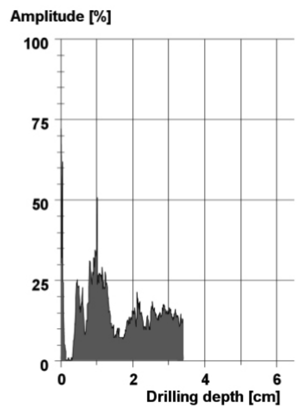

Fig. 3.83. Measurement spot no 2.

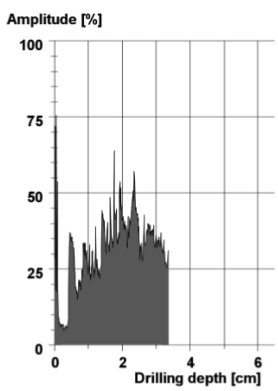

Fig. 3.84. Measurement spot no 3.

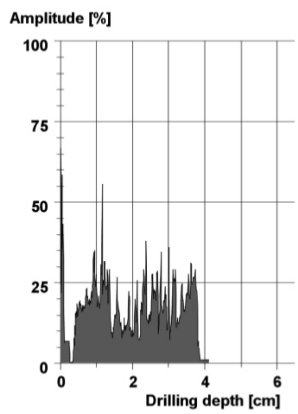

Fig. 3.85. Measurement spot no 4.

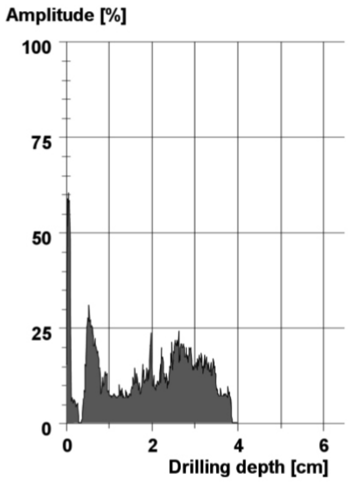

Fig. 3.86. Measurement spot no 5.

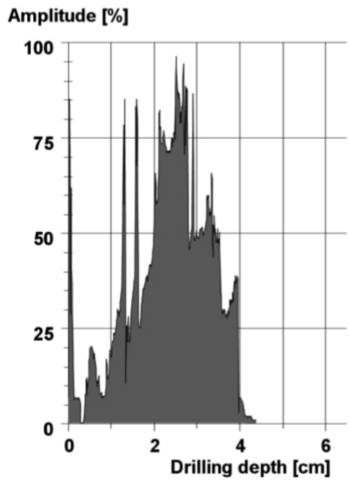

Fig. 3.87. Measurement spot no 6.

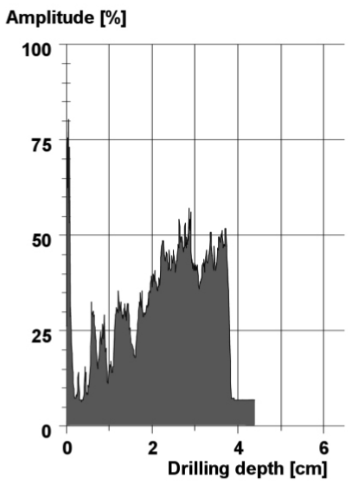

Fig. 3.88. Measurement spot no 7.

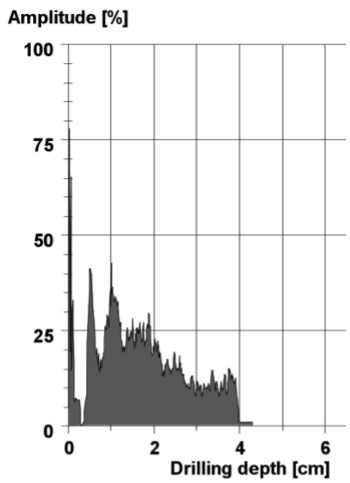

Fig. 3.89. Measurement spot no 8.

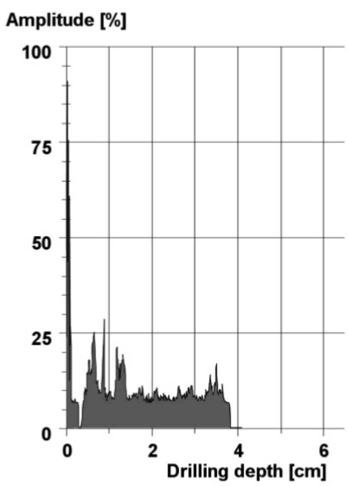

Fig. 3.90. Measurement spot no 9.

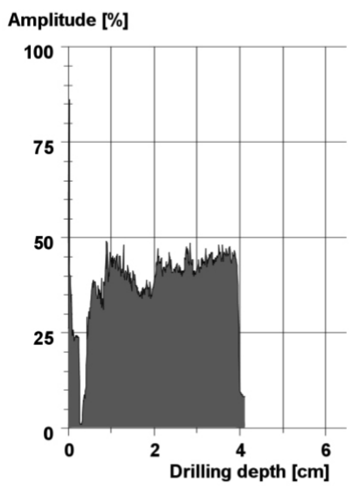

Fig. 3.91. Measurement spot no 10.

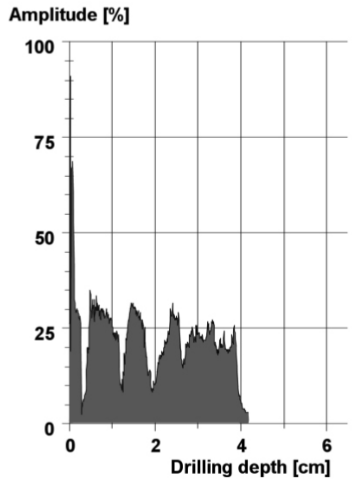

Fig. 3.92. Measurement spot no 11.

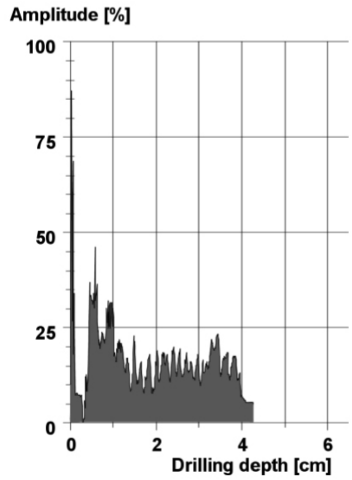

Fig. 3.93. Measurement spot no 12.

Tab. 3.3.4 Resistance drilling results.

Measurement number	Resistance drilling ***RM*** [%]	Location of measurement spot
1	**9.5**	level VI, window 36 (bottom), left side jamb
2	**14.9**	level VI, window 8 (bottom), right side jamb
3	**31.1**	level VI, window 4 (bottom), sill
4	**17.9**	level VI, window 86 (bottom), left stile of the right sash
5	**13.1**	level VI, window 72 (bottom), right jamb
6	**41.2**	level VI, window 48 (bottom). left stile of the left sash
7	**33.2**	level VI, window 39 (bottom), left side jamb
8	**17.8**	level IV, window 24, right stile of the right sash
9	**10.4**	level IV, window 25, left stile of the left sash
10	**38.5**	level IV, window 30, left stile of the left sash
11	**23.1**	level IV, window 31, right stile of the right sash
12	**16.8**	level IV, window 31, left stile of the left sash
Number of tests	**12**	
Mean value ***RM*** [%]	**22.3**	
Standard deviation [%]	**11.0**	
Coefficient of variation [%]	**49.4**	
Minimum value [%]	**9.5**	
Maximum value [%]	**41.2**	
Median [%]	**17.8**	

3.6.1.4 Conclusions

The resitographic tests conducted do not provide a basis for evaluation of the class of wood (the strength parameters of wood). They can be used as basis for a preliminary qualitative assessment. No biological decay was discovered inside sections of window woodwork elements (frames and sashes) in places where resistance drilling tests were carried out. Surface identification of biological decay was not possible due to paint coats which cover the tested elements. A high value of the coefficient of variation (nearly 50% - tab. 3.34) in the tests calls into question the possibility of estimating wood density based on resistance drilling measurements.

3.6.2. Analysis of the condition of wood in window woodwork using the stress wave method – description of the method and test results

Testing included carrying out stress wave propagation measurement in wooden elements of window woodwork. The tests were carried out with a Fakopp Microsecond Timer device (fig. 3.94) which uses the method of a stress wave induced by a single tap with a hammer, [42]. The device enables measurement of the time of stress wave propagation in wood, between two transducers (emitter and receiver) [43], [44]. A direct method of placing the transducer heads (parallel to the grain) was used in testing. The heads of the Fakopp Microsecond Timer device are mounted directly on special metal spikes which have to be embedded in the wood undergoing testing.

Fig. 3.94. The Fakopp Microsecond Timer device for stress wave testing.

The velocity of the acoustic wave propagation was calculated using the formula (21), which accounts for a time correction for the Fakopp Microsecond Timer device, [42].

$$V = 1000 \cdot distance/(FAKOPP\ read\ out - 4.5) \tag{21}$$

where: V – velocity of stress wave propagation [m/s];
distance – the distance between transducers [mm];
FAKOPP read out – time reading on the FAKOPP device [µs].

According to data available in the literature, the density of ironwood (*Casuarina* wood) ranges from approximately 800 kg/m^3 [45] to approximately 900-1000 kg/m^3 [46]. The wood density of 900 kg/m^3 was adopted for the rough calculations below. Knowing the wood density ρ and velocity of the acoustic wave propagation V in individual elements, the dynamic modulus of elasticity (MOE_{dyn}) could be calculated based on the formula (22). The results are presented in Tables 3.35 and 3.36.

$$MOE_{dyn} = V^2 \rho \tag{22}$$

Tab. 3.35. Results of stress wave testing.

Measurement number	Element	Time of wave propagation [µs]	Average time of wave propagation after correction [µs]	Length [mm]	Velocity of wave propagation [m/sec]	Wood density [kg/m^3]	E_d [MPa]
1	Window number 36, level VI, the	138 138	132.5	550	4151	900.0	15507

	right stile of the right sash	135					
2	Window number 48, level VI, the right stile of the right sash	164 162 162	158.2	655	4141	900.0	15435
3	Window number 45, level VI, the left stile of the left sash	168 169 170	164.5	735	4468	900.0	17967
4	Window number 12, level III, the left stile of the left sash	154 156 153	149.8	655	4372	900.0	17199
5	Window number 64, level III, the right stile of the right sash	104 103 102	98.5	445	4518	900.0	18369
6	Window number 53, level II, the left stile of the left sash	111 111 112	106.8	465	4353	900.0	17050

Tab. 3.36.The mean value of the dynamic modulus of elasticity.

Number of measurements	6
The mean value of the dynamic modulus of elasticity E_d [MPa]	16921
Standard deviation [MPa]	1224
Coefficient of variation [%]	7.2
Minimum value [MPa]	15435
Maximum value [MPa]	18369
Median [MPa]	17125

Stress wave measurements were carried out only for 6 window elements (hanging stiles) due to the semi-destructive character of this testing method. The metal spikes of the device have to be inserted directly into the tested wood, which breaks the structure of the wood surface. The results should be regarded as estimates only because of the small number of measurements taken. A low value of the coefficient of variation for the dynamic modulus of elasticity indicates a homogeneous structure of the tested elements and their similar parameters. The mean value of the dynamic modulus of elasticity E_d=16.9 GPa (tab. 3.36) has to be regarded as an estimated one, because the wood density was not measured, as it would have required extracting wood samples from the window elements. However, the obtained value is close to the value of the static modulus of elasticity of the ironwood available in the literature (inter alia in [81]).

3.6.3. Assessment of the condition of window preservation

The assessment of the technical condition of window preservation was carried out based on a visual investigation of all the windows from levels II to IX. The windows had numbers assigned to them according to [34]. The numbers of photographs taken are presented in fig. R1. Selected photographs are presented below in the next section of the chapter 3.6.3. All photographs (indicated in fig. R1) are attached in digital format on a CD.

Tab. 3.37. Windows at level IX.

Window number	Photo number.	Comments
1	-	-
2	-	-
3	4, 5, 6	The lower part of the left hanging stile damaged, the paint coat of the weatherboard damaged in its left corner - as a result of banging on the concrete structure.
4	7	Smoke vent
5	-	-
6	-	-
7	1	The window pane covered with black adhesive film. The paint coat of the weatherboard damaged in its left corner - as a result of banging on the concrete structure..

8	-	-
9	-	-
10	-	-
11	2, 3	The window pane covered with black adhesive film. Visible damage of the sill caused by workers passing through the window during maintenance and repair work at altitude
12	-	-
13	-	-
14	-	-
15		The window pane covered with black adhesive film
16	-	-
		General remarks: Slight damage to the weatherboard paint coating on the side of the hinges visible in all windows. Damaged paint coatings of sills caused by work at altitude carried out by workers passing through the windows.

Tab. 3.3.8. Windows at level VIII.

Window number	Photo number	Comments
1	-	-
2	42	The corner of the right side jamb damaged.
3	-	-
4	43	The right side jamb damaged in the area of the bottom hinge location.
5	-	-
6	44	The left side jamb damaged in the area of the bottom hinge location, damaged paint coating – a fragment glued in.
7	45	A corner of the window head damaged.
8	-	-
9	-	-
10	46, 47	The left side jamb damaged in the area of the bottom hinge location
11	-	-
12	48	The window sill cracked.
13	-	-
14	49, 50	The right side jamb damaged in its middle part.
15	-	-
16	51	Near-surface decay of a fragment glued in near the left bottom hinge.
17	-	-
18	-	-
19	-	-
20	52	A fragment of the sill damaged as a result of a faulty instalment of the window sash.
21	-	-
22	53	The window sash replaced with a smartply board (OSB) fastened with screws
23		
24	54	The bottom left corner – careless and negligent repair work of the side jamb near the bottom hinge – glue visible.
25	-	-
26	55	The window sash replaced with a smartply board (OSB) fastened with screws.
27	56, 57	Staples and remains of plastic film in the window rails and stiles.
28	9, 10	Damaged window sill as a results of high altitude maintenance work by workers
29	11, 12	The top hinge damaged, a distorted window sash.
30	13, 14	The left part of the side jamb near the hinge – decay, damaged seal.
31	-	-
32	15	Insufficiently glued seal.
33	-	-
34	16	Pain coating of the window sill damaged.
35	17	The edge of the window head damaged in the right corner.
36	-	-
37	-	-
38	-	-
39	18, 19	The right side jamb damaged hear the hinge.
40	20	The window sash replaced with a smartply board (OSB) fastened with screws.
41	-	-
42	-	-
43	21	The right hanging stile differs in colour from the remaining elements of the window.

44	22, 23	The hanging stile fastened to the side jamb with black screws, missing hinges.
45	24 - 28	The right hanging stile damaged near the top and bottom hinges. The right trim board damaged near its top and bottom corners. A screw driven aslant into the left corner. The weatherboard damaged on the left side.
46	-	-
47	-	-
48	29, 30	A trim board installed improperly. The bottom turn button damaged – it turns without the handle.
49	31	The surface of the left side jamb damaged.
50	32 - 34	The left hanging stile replaced – hinge fastening screws visible. Some missing screws in the internal steel corners (top and bottom). A fragment of the top rail damaged.
51	35	The right side jamb damaged near the bottom hinge.
52	-	-
53	36	The right side jamb damaged near the bottom hinge.
54	-	-
55	-	-
56	-	-
57	37, 38	The window sash replaced with a smartply board (OSB) fastened with screws.
58		
59	-	-
60	39	Cracks and gaps in the left side jamb filled with polyurethane foam.
61	-	-
62	40, 41	The top turn button and handle missing. The upper fixture of the bottom hook damaged.
63		
64		
		General remarks: The fixtures of hooks in all windows have to be checked and repaired if necessary. Paint coating of window sills damaged as a result of maintenance work at high altitude, which involved workers passing through the windows.

Tab. 3.3.9. Windows at level VII.

Window number	Photo number	Comments
1	-	-
2	108	The bottom turn button damaged.
3	109	The left side jamb cracked near the bottom hinge.
4	-	-
5	-	-
6	-	-
7	110, 111	The corner of the left side jamb damaged near the top and bottom hooks.
8	-	-
9	112	The top turn button missing, a makeshift fastener used.
10	113	The edge of the left side jamb damaged.
11	-	The fixture of the top hook broken.
12	114, 115	The edges of the window sill and the right side jamb damaged.
13	-	-
14	116	The paint coating of the window sill damaged in several places.
15	-	-
16	-	-
17	-	-
18	117	The left hanging stile cracked near the bottom hinge.
19	-	-
20	-	-
21	118	The window sill edge damaged. Problems with unlocking and locking the top turn button. The fixture of the top hook broken. Problems with opening the window – a distorted sash.
22	-	-
23	-	-
24	-	-
25	-	-
26	-	-
27	-	-
28	119	The edge of the window sill damaged. The top turn button turns without the handle.
29	120	The edge of the left side jamb damaged.
30	121	The left hanging stile cracked near the left hinge.
31	122	The edge of the hanging stile damaged near the bottom metal corner.

32	123	Localised damage of paint coating of the left side jamb and hanging stile.
33	124	The edge of the window sill damaged in the right bottom corner.
34	-	-
35	125-127	Localised damage of the paint coating of the right hanging stile. A fragment of the right hanging stile damaged on the interior side.
36	-	-
37	128-130	The bottom and top hinges broken (a lowered pivot and a missing pivot). The hanging stile damaged near the bottom hinge.
38	131	The fixture of the top turn button broken.
39	132	The left hanging stile cracked near the bottom hinge.
40	133	The paint coating missing on the wood plug in the right side jamb near the bottom hinge.
41	134	Staples in the rails and stiles.
42	-	Staples in the rails and stiles.
43	58	The paint coating of the weatherboard damaged as a result of banging on the concrete structure.
44	-	-
45	59	The left hanging stile cracked near the bottom hinge.
46	60	The fixture of the top hook broken. A screw missing. The sash does not close properly.
47	-	-
48	-	-
49	-	-
50	61, 62	The fixture of the hook broken. A fragment of the right hanging stile differs significantly in colour from the remaining elements of the window.
51	63	The hinge location was originally situated in the incorrect spot in the left side jamb.
52	-	-
53	-	-
54	-	-
55	-	-
56	64, 65	Wood decay at the location of the joint linking the window sill and the left side jamb. A pivot missing from the hinge.
57	66	The fixture of the bottom hook broken.
58	67-69	All hinges destroyed – **do not open the window! Immediate repair necessary**.
59	-	-
60	-	-
61	70	The hanging stile cracked near the bottom hinge.
62	71, 72	The hanging stile cracked near the bottom hinge. The edge of the right hanging stile damaged.
63	73, 74	The hook missing from the top turn button. The fixture of the bottom hook broken. The window does not close properly.
64	75 - 77	The edge of the window head damaged. The hanging stile cracked near the bottom hinge. The fixture of the bottom hook broken.
65	78	The bottom hook missing.
66	79	The bottom hook missing.
67	-	-
68	80, 81	Loose fixture of the bottom hook. The bottom hinge installed too close to the trim board and obstructs opening the window.
69	82, 83	The hanging stile cracked near the bottom hinge. Surface damage to the fragments of the side jamb near the top hook.
70	84-86	The right hanging stile damaged along its whole length, near each hinge. The sash fastened to the window with four screws.
71	87	Wood decay at the location of the joint linking the window sill and the left side jamb.
72	88, 89	Screws missing from the top and bottom metal corners. One of the window panes (near the left hanging stile, at mid-height of the sash) differs from the other panes.
73	90, 91	Loose bottom hinge, the hanging stile cracked. The surface of the stile damaged as a result of the wrong shape of the handle.
74	92, 93	The side jamb cracked near the top hinge. The edges of the right side jamb damaged.
75	-	-
76	94,95	The edges of the left side jamb damaged. The left trim board installed in a wrong way.
77	-	-
78	96, 97	The stile cracked near the bottom turn button. The edge of the right side jamb damaged.
79	-	-
80	98	Localised damage to the paint coating.
81	99	The right trim board installed in a wrong way.
82	100, 101	The fixtures of the top and bottom turn buttons broken.
83	-	-
84	102	Incorrect fixture of the bottom turn button – wrong placing of screws, which are visible when

		the window sash is opened.
85	103	Wood decay at the location of the joint linking the window sill and the right side jamb.
86	104	The left hanging stile differs in colour from the remaining elements of the window.
87	-	-
88	105	The left jamb damaged near the hooks (top and bottom).
89	-	-
90	-	-
91	-	-
92	106	The bottom hinge broken.
93	-	-
94	107	The right hanging stile cracked near the bottom hinge.
95	-	-
96	-	-
		General remarks: The fixtures of hooks in all windows have to be checked and repaired if necessary. Paint coating of window sills damaged as a result of maintenance at high altitudes, which involved workers passing through the windows.

Tab. 3.40. Windows at level VI.

Window number	Photo number	Comments
1	161, 162	Damaged paint coating of the hanging stiles in the area of the top handle of the bottom window. The fixture of the knob in the left sash broken – the top screw is missing.
2	160	Damaged paint coating of the hanging stiles in the area of the knob.
3	159	The fixture of the bottom turn button broken.
4	158	Wood decay in the location of the joint linking the window sill and the left side jamb.
5	157	The connecting link of the top handle fixture is missing in the top window.
6	-	-
7	156	Incorrect, too loose fixture of the turn button of the bottom window.
8	155	Wood decay at the location of the joint linking the window sill and the side jamb.
9	-	-
10	-	-
11	-	-
12	-	-
13	154	The bottom handle of the top window is missing, a makeshift fastener used.
14	-	The bottom handle installed in a wrong way – impossible to open the window.
15	152, 153	The bottom turn button installed in a wrong way. The bottom turn button of the top window missing.
16	151	The nail fastening the cover plate of the handle obstructs its use.
17	-	-
18	-	-
19	150	The window sashes mounted unevenly – at different levels. This defect can be observed in many of the windows.
20	149	The top handle of the bottom window is mounted with replacement screws.
21	-	-
22	-	-
23	-	-
24	-	Loose bottom hinge of the right sash of the bottom window.
25	-	-
26	148	Surface damage of the left hanging stile (the left sash).
27	-	-
28	-	-
29	147	Peeling paint coating of the right hanging stile of the left sash along its whole length.
30	-	-
31	-	-
32	-	-
33	145, 146	Damaged (cracked) paint coating of the right hanging stile of the left sash in the bottom window. The bottom handle of the bottom window broken.
34	144	Loosened fittings and the top turn button of the bottom window.
35	143	Slight cracking of the rails and stiles of the top window.
36	138	Small damage to the rails and stiles of the bottom window near turn buttons and the knob.
37	137	No access to the window as it was covered with a curtain.
38	136	The fixture of the turn button of the bottom window damaged.
39	135	Peeling paint coating of the rail in the right sash of the bottom window.

40	231	The right trim board mounted in a wrong way.
41	230	Damaged right corner of the weatherboard of the bottom window.
42	-	Loose fixture of the top turn button of the bottom window.
43	-	-
44	229	Peeling paint coating of the left hanging stile of the right sash. Loose top turn button of the bottom window.
45	-	The left sash does not close properly.
46	-	Loose connection between the middle mullion and the window head and sill – the bottom window.
47	228	Damaged fixture of the bottom turn button of the top window.
48	-	-
49	227	Damaged paint coating of the rail near the knob.
50	226	The bottom turn button and handle are missing in the bottom window.
51	222-225	The edge of the mullion damaged. Loose fixture of the bottom window turn buttons. The top right sash does not close properly. The right corner of the weatherboard of the left sash damaged. Staples visible in the left side jamb.
52	-	-
53	221	The edge of the mullion damaged.
54	-	-
55	220	Surface damage of the weatherboard of the bottom window.
56	219	Loosened fixture of the bottom turn button.
57	218	The fixture of the top turn button broken and the stile damaged near the turn button. The fixture of the bottom turn button damaged.
58	-	-
59	-	-
60	217	Surface damage (cracking) of the weatherboard of the bottom window.
61	-	The fixture of the top turn button of the bottom window broken.
62	215, 216	The top turn button is missing, a makeshift fastener used. The fixture of the bottom turn button of the bottom window broken.
63	214	The fixture of the top turn button damaged.
64	-	-
65	-	-
66	213	The fixture of the top turn button of the bottom window damaged. Peeling paint coating of the left sash of the top window.
67	212	The bottom turn button of the top window is missing, a makeshift fastener used
68	210, 211	The right hanging stile is cracked near the bottom hinge – the right sash of the top window. Surface damage near handles.
69	208, 209	Surface damage of the hanging stile near the top handle. The fixtures of the middle and bottom turn buttons damaged.
70	206, 207	The fixture of the bottom handle broken. The left hanging stile of the left sash differs in colour from the remaining elements of the window – no paint coating.
71	203-205	Significant peeling of the paint coating of the left hanging stile of the right sash in the bottom window. The fixture of the bottom turn button broken. Deep defects of the surface of the left hanging stile of the left sash in the top window.
72	200-202	The fixture of the bottom turn button damaged. Surface damage of the weatherboards. Surface damage of the stile near the top handle.
73	-	-
74	198, 199	The fixture of the bottom turn button broken. The edge of the stile near the bottom handle of the right sash damaged. The surface of the weatherboard of the right sash damaged.
75	197	Damaged paint coating of the left weatherboard, the weatherboard cracked.
76	194-196	Damaged paint coating of the weatherboard of the right bottom window. The wood of the hanging stile cracked considerably near the weatherboard. Surface damage of the stiles near handles.
77	193	The wood insert of the weatherboard of the top left window made without a drip.
78	192	The fixtures of the bottom and top turn buttons broken.
79	190, 191	The cover plates of the bottom and top handles damaged.
80	-	-
81	189	The fixture of the top turn button of the bottom window damaged.
82	187, 188	Damaged paint coating of the weatherboard of the left sash. The original weatherboard and the replaced one differ in shape (difference in the depth).
83	182-186	Damaged paint coating of the weatherboard of the right sash. The fixtures of the top turn button and knob damaged. Some remains of the polyurethane foam on the hinge.
84	179-181	Surface damage of the weatherboard of the left sash. The drip is missing from the wood insert in the weatherboard.
85	-	-

86	177, 178	Peeling surface of the hanging stile of the right sash.
87	174-176	Damaged paint coating of the weatherboard of the left bottom window. Considerable peeling of the paint coating of the hanging stile in the left top window. Surface damage of stiles near handles of the bottom window.
88	171-173	The corner of the weatherboard of the bottom window damaged. The connection between the left hanging stile and the weatherboard of the left sash damaged – **to be repaired immediately.** Considerable peeling of the paint coating of the left hanging stile of the left sash in the top window.
89	169, 170	The fixtures of the top and bottom turn buttons damaged.
90	168	The paint coating of the left and right hanging stiles peeled off.
91	-	The fixture of the bottom turn button loosened.
92	167	The left sash of the top window does not close properly. The fixture of the bottom turn button damaged.
93	165, 166	The fixture of the bottom turn button damaged. A makeshift fixture of the top turn button (the third screw).
94	164	The middle mullion loosened. Paint coating of the stiles near handles of the bottom window damaged.
95	163	Paint coating of the stiles near handles of the bottom window damaged.
96	-	-
		General remarks: Top windows are in a better condition as they are not opened and their window sills are not stepped on. The seals in all the windows have to be inspected and repaired if necessary. Nearly all fixtures of the turn buttons have to be repaired. Problems with proper closing of some of the windows.

Tab. 3.41. Windows at level V (note: the condition of the windows from the interior side is described)

Window number	Photo number	Comments
1	-	-
2	-	-
3	-	-
4	-	-
5	-	-
6	-	-
7	-	-
8	-	-
9	-	-
10	-	-
11	-	-
12	-	-
13	-	-
14	-	-
15	-	-
16	-	-
17	-	-
18	-	-
19	-	-
20	-	-
21	-	-
22	-	-
23	-	-
24	-	-
25	-	-
26	-	-
27	-	-
28	-	-
29	-	-
30	-	-
31	-	-
32	-	-
33	-	-
34	246	The left sash corner damaged.
35	-	-

36	-	-
37	245	A negligent installation of a seal in the bottom and middle windows.
38	-	-
39	-	-
40	-	-
41	244	The window sash does not fit into the window frame properly – The left sash of the bottom window.
42	-	-
43	-	-
44	-	-
45	-	-
46	-	-
47	-	-
48	-	-
49	-	-
50	-	-
51	-	-
52	243	The right sash of the bottom window does not close properly.
53	242	A drooping bottom seal of the right window sash.
54	-	-
55	-	-
56	-	-
57	-	-
58	-	-
59	-	-
60	-	-
61	-	-
62	-	-
63	-	-
64	241	-
65	-	-
66	-	-
67	240	The right sash of the middle window does not close properly.
68	-	-
69	239	Plastic film fragments jammed in the window elements.
70	-	-
71	-	-
72	238	The left sash does not close properly.
73	-	-
74	-	-
75	-	-
76	-	-
77	-	-
78	237	The left sash of the middle window does not close properly – a gap visible.
79	-	-
80	-	-
81	-	-
82	236	Distorted frame of the left sash, the sash does not close properly.
83	-	-
84	-	-
85	-	-
86	235	Discontinuity of the seal – the left bottom corner of the right sash of the bottom window.
87	-	-
88	-	-
89	234	-
90	-	-
91	-	-
92	-	-
93	-	-
94a	232, 233	Discolouration of the bottom frame and damaged paint coating.
94b	-	-
94c	-	-
95	-	-
96	-	-

		General remarks: Considerable lack of accuracy at the stage of making the windows – numerous cracks resulting in the lack of tightness of the windows. Window seals installed in a careless and negligent way.

Tab. 3.42. Windows at Level IV.

Window number	Photo number	Comments
1	247	The fixture of the bottom turn button broken.
2	-	-
3	-	The bottom handle turns hard.
4	-	-
5	-	The top handle turns hard.
6	-	-
7	248	The bottom handle does not close
8	-	-
9	-	-
10	249	The bottom part of the right hanging stile of the right sash damaged.
11	-	-
12	-	-
13	-	-
14	-	-
15	250	-
16	-	-
17	251	Paint coating of the left weatherboard damaged.
18	-	-
19	-	-
20	-	-
21	252	Slight damage near the weatherboard of the left sash.
22	-	-
23	253	A wooden insert is applied wrongly near the top handle.
24	-	-
25	-	-
26	-	-
27	254	Loosened cover plates of the bottom handle.
28	-	-
29	-	-
30	-	-
31	255-257	The fixture of the bottom turn button loosened. Paint coating of the stile damaged near the handle. Paint coating of the weatherboard cracked. Putty applied in a negligent way near the bottom hinge of the right sash.
32	258	The right hanging stile of the left sash cracked.
33	259	The right sash opens only partly as it is blocked by the weatherboard.
34	260	Loosened fixture of the bottom turn button.
35	261	The edge of the hanging stile of the right sash damaged near the top handle.
36	-	-
37	-	-
38	262	The seals installed in a negligent and careless way. Loosened hinges of the top and bottom turn buttons.
39	-	-
40	-	-
41	-	-
42	263	The edge of the window head of the left sash damaged.
43	-	-
44	-	-
45	264	The fixture of the knob loosened.
46	-	-
47	-	-
48	-	-

Tab. 3.43. Windows at level III.

Window number	Photo number	Comments

1	280	Paint coating of the weatherboard damaged.
2	-	Ventilator
3	-	-
4	-	-
5	-	-
6	-	-
7	279	Wood decay of the left side jamb. The wood insert in the bottom corner of the window fastened using screws.
8	-	-
9	277, 278	The bottom window repaired in a negligent and careless way using wood plug fastened with screws.
10	275, 276	The edge of the hanging stile of the right sash in the bottom window damaged. The weatherboard damaged.
11	-	-
12	-	-
13	-	-
14	-	-
15	-	-
16	272	The edge of the sill of the bottom window damaged.
17	-	-
18	271	Slight damage to the hanging stile of the right sash in the bottom window in the area of the bottom hinge repaired with a wood plug.
19	270	The hanging stile of the right sash in the bottom window lopsided.
20	269	The corner of the weatherboard of the left sash in the bottom window cracked.
21	268	The fixture of the bottom handle in the middle window damaged.
22	-	-
23	267	A big crack resulting from incorrect mounting of the right sash of the bottom window.
24	-	-
25	266	The weatherboard of the right sash lopsided.
26	265	
27	-	-
28	-	-
29	-	-
30	-	-
31	304	The right hanging stile cracked near the bottom hinge.
32	-	-
33	-	-
34	-	-
35	303	The hanging stile of the right sash in the bottom window cracked.
36	302	The pivots are missing from the hinges in the left sash of the middle window.
37	-	-
38	-	-
39	301	The pivot of the top hinge in the right sash of the bottom window installed incorrectly.
40	-	-
41	300	Numerous surface cracks on the weatherboard of the bottom window.
42	-	-
43	-	-
44	-	-
45	299	The right hanging stile of the right sash in the top window damaged.
46	-	-
47	-	A wooden block under the bottom handle of the bottom window.
48	-	-
49	-	-
50	298	Surface damage of the right hanging stile of the right sash in the bottom window.
51	-	-
52	-	-
53	-	-
54	-	-
55	297	The weatherboard of the right sash in the bottom window differs in colour from the remaining elements of the window (no paint coating).
56	-	-
57	-	-
58	-	-
59	-	-

60	-	-
61	296	The middle knob of the left sash in the middle window missing.
62	-	-
63	295	The edge of the weatherboard of the right sash in the bottom window damaged.
64	-	-
65	-	-
66	294	The hanging stiles of the right and left sashes of the middle window damaged near the bottom hinges.
67	293	The left hanging stile of the left sash of the bottom window differs in colour from the remaining elements of the window.
68	292	The hanging stile of the right sash of the middle window damaged near the bottom hinge.
69	290, 291	The fixture of the knob in the right sash of the window broken. The left stile of the left sash of the middle window differs in colour from the other elements of the window.
70	288, 289	The paint coating of the rail and stile in the bottom right corner of the top window. The left stile of the left sash of the top window differs in colour from the other elements of the window.
71	287	Installations
72		
73		
74		
75	-	The fixture of the top turn button of the middle window broken. The bottom handle of the bottom window mounted on a wooden block.
76	285, 286	The bottom handle of the bottom window mounted on a wooden block. The fixture of the bottom handle of the middle window broken.
77	284	The window sill of the bottom window damaged (damage resulting from workers frequently passing through the window).
78	-	-
79	283	The fixture of the bottom turn button of the bottom window broken.
80	-	-
81	-	Some remains of black plastic film.
82	-	Some remains of black plastic film
83	282	Some remains of black plastic film
84	281	The handle and the bottom turn button of the bottom window are missing, a makeshift fastener used.

Tab. 3.44. Windows at level II.

Window number	Photo number	Comments
1	-	‘grille’
2	-	-
3	-	‘grille’
4	-	‘grille’
5	-	-
6	-	-
7	-	-
8	-	-
9	-	-
10	-	-
11	-	-
12	-	-
13	-	-
14	-	-
15	-	-
16	-	-
17	-	-
18	-	-
19	-	-
20	308	A general photograph. Damage to the weatherboard near the corner.
21	-	-
22	-	-
23	-	-
24	-	-
25	-	-
26	-	-
27	-	-

28	-	‘grille’
29	-	-
30	-	‘grille’
31	307	A general photograph presenting the so called ‘grille’.
32	-	-
33	-	-
34	-	-
35	-	-
36	-	-
37	-	-
38	-	-
39	-	-
40	-	-
41	-	-
42	-	-
43	-	-
44	306	The muntin bars differ significantly in colour from the other elements of the window.
45	-	-
46	-	-
47	-	-
48	-	-
49	-	-
50	-	-
51	-	-
52	-	-
53	305	Surface damage of the left sash weatherboard.
54	-	‘grille’
55	-	‘grille’
56	316	A screw is missing from the fixture of the knob in the left sash of the window.
57	-	‘grille’
58	-	‘grille’
59	-	-
60	-	-
61	-	-
62	-	-
63	-	-
64	-	-
65	-	-
66	-	-
67	-	-
68	-	-
69	-	-
70	-	-
71	314, 315	The window pane mounted using screws.
72	-	-
73	-	-
74	-	-
75	-	-
76	-	-
77	-	-
78	-	-
79	-	-
80	-	-
81	-	‘grille’
82	-	‘grille’
83	312, 313	The fixture of the cover plate of the handle broken. The bottom hinge of the right sash damaged.
84	-	‘grille’
85	-	‘grille’
86	-	-
87	-	-
88	-	-
89	-	-
90	-	-

91	-	-
92	-	-
93	-	-
94	-	-
95	-	-
96	-	-
97	-	-
98	-	‘grille’
Other	309	Windows situated above the main entrance to the Hall, which were not included in the drawings presenting the identification numbers assigned to individual windows of the Hall contained in [2]. There are 8 windows on each side. The edge of the weatherboard is damaged (photo 309)
	310	
	311	

The numbers on the photographs presented below refer to the numerical identification used in fig. R1 attached to the report in electronic format.

Photo 1 Window number 7, level IX.

Photo 2 Window number 11, level IX.

Photo 6 Window number 3, level IX.

Photo 9 Window number 28, level VIII.

Photo 14 Window number 30, level VIII.

Photo 25 Window number 45, level VIII.


Photo 36 Window number 53, level VIII.


Photo 34 Window number 50, level VIII.


Photo 37 Windows number 57 and 58, level VIII.


Photo 43 Window number 4, level VIII.


Photo 46 Window number 10, level VIII.


Photo 48 Window number 12, level VIII.


Photo 49 Window number 14, level VIII.


Photo 52 Window number 20, level VIII.

Photo 53 Windows number 22 and 23, level VIII.

Photo 54 Window number 24, level VIII.

Photo 56 Window number 27, level VIII.

Photo 17 Window number 35, level VIII.

Photo 60 Window number 46, level VII.

Photo 61 Window number 50, level VII.

Photo 64 Window number 56, level VII.

Photo 65 Window number 56, level VII.


Photo 73 Window number 63, level VII.


Photo 75 Window number 64, level VII.


Photo 76 Window number 64, level VII.


Photo 78 Window number 65, level VII.


Photo 84 Window number 70, level VII.


Photo 85 Window number 70, level VII.


Photo 88 Window number 72, level VII.


Photo 93 Window number 74, level VII.

Photo 95 Window number 76, level VII.

Photo 96 Window number 78, level VII.

Photo 100 Window number 82, level VII.

Photo 102 Window number 84, level VII.

Photo 106 Window number 92, level VII.

Photo 107 Window number 94, level VII.

Photo 112 Window number 9, level VII.

Photo 121 Window number 30, level VII.


Photo 128 Window number 37, level VII.


Photo 130 Window number 37, level VII.


Photo 137 Window number 37, level VI.


Photo 144 Window number 34, level VI.


Photo 148 Window number 26, level VI.


Photo 150 Window number 19, level VI.


Photo 153 Window number 15, level VI.


Photo 155 Window number 8, level VI.


Photo 159 Window number 3, level VI.


Photo 164 Window number 94, level VI.


Photo 166 Window number 93, level VI.


Photo 171 Window number 88, level VI.


Photo 172 Window number 88, level VI.


Photo 174 Window number 87, level VI.


Photo 180 Window number 84, level VI.


Photo 182 Window number 83, level VI.


Photo 186 Window number 83, level VI.


Photo 188 Window number 82, level VI.


Photo 190 Window number 79, level VI.

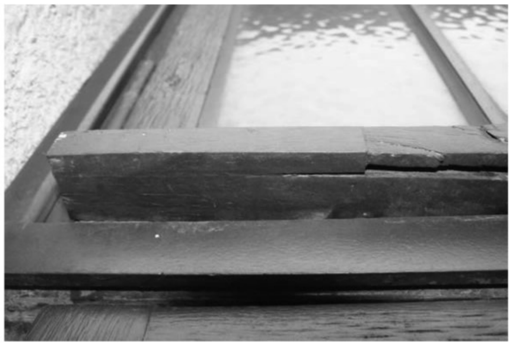
Photo 193 Window number 77, level VI.


Photo 201 Window number 72, level VI.


Photo 202 Window number 72, level VI.


Photo 205 Window number 71, level VI.


Photo 210 Window number 68, level VI.

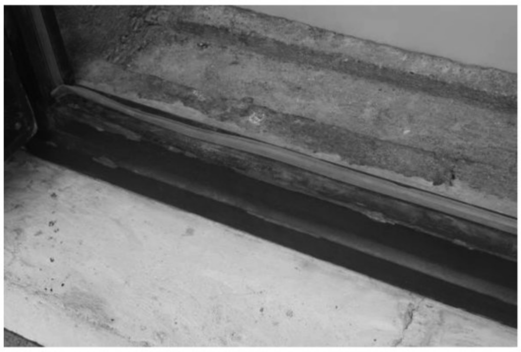

Photo 223 Window number 51, level VI.

Photo 225 Window number 51, level VI.

Photo 231 Window number 40, level VI.

Photo 232 Window number 94a, level V.

Photo 233 Window number 94a, level V.

Photo 236 Window number 82, level V.

Photo 238 Window number 72, level V.

Photo 239 Window number 69, level V.

Photo 243 Window number 52, level V.

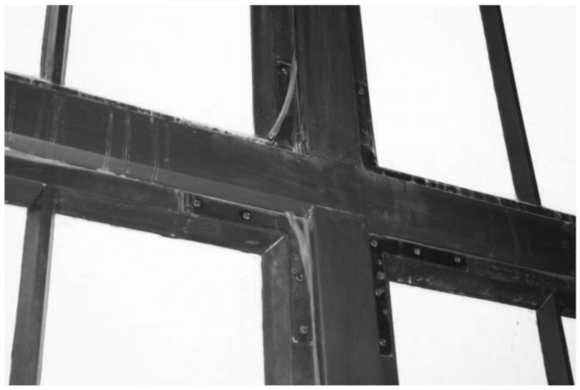

Photo 245 Window number 37, level V.

Photo 249 Window number 10, level IV.

Photo 253 Window number 23, level IV.

Photo 255 Window number 31, level IV.

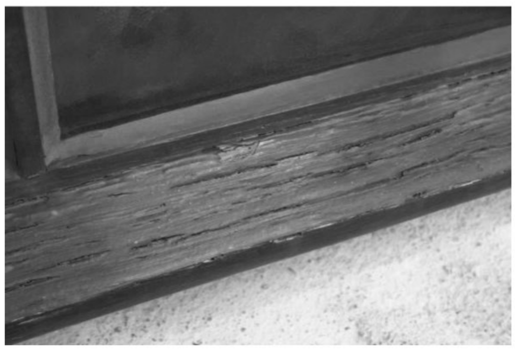

Photo 256 Window number 31, level IV.

Photo 257 Window number 31, level IV.

Photo 259 Window number 33, level IV.


Photo 262 Window number 38, level IV.


Photo 264 Window number 45, level IV.

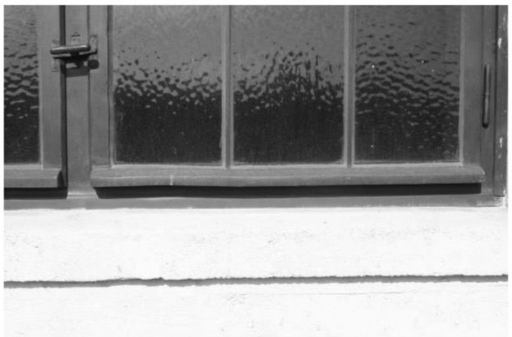
Photo 266 Window number 25, level III.


Photo 269 Window number 20, level III.


Photo 271 Window number 18, level III.

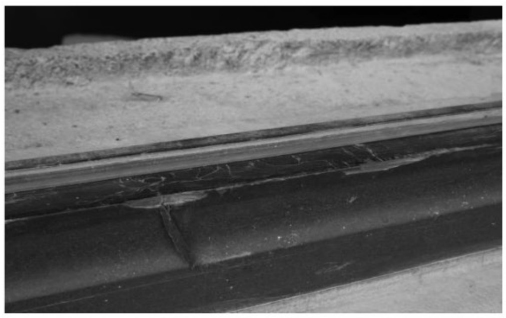
Photo 272 Window number 16, level III.


Photo 277 Window number 9, level III.


Photo 280 Window number 1, level III.

Photo 281 Window number 84, level III.

Photo 282 Window number 83, level III.

Photo 283 Window number 79, level III.

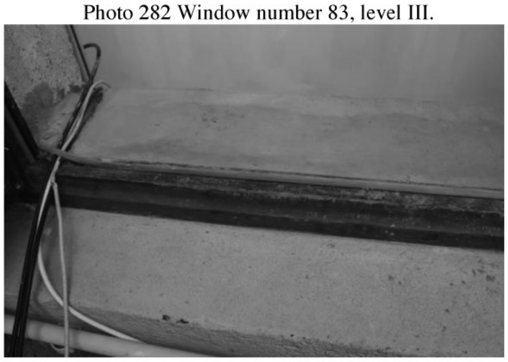

Photo 284 Window number 77, level III.

Photo 286 Window number 76, level III.

Photo 288 Window number 70, level III.

Photo 292 Window number 68, level III.

Photo 299 Window number 45, level III.

Photo 300 Window number 41, level III.

Photo 302 Window number 36, level III.

Photo 303 Window number 35, level III.

Photo 304 Window number 31, level III.

Photo 305 Window number 53, level II.

Photo 309 “Other” window, level II.

Photo 310 “Other” window, level II.

Photo 312 Window number 83, level II.

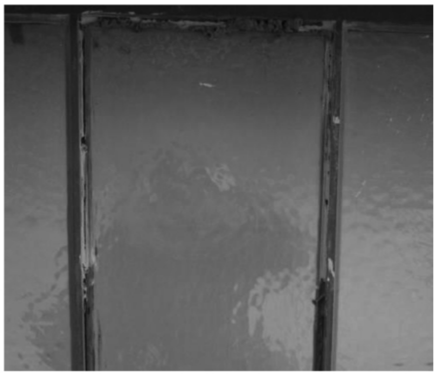
Photo 314 Window number 71, level II.


Photo 315 Window number 71, level II.

3.6.4. Conclusions

A detailed inventory of the Hall's window woodwork was carried out in 2007 (preceding renovation work). On the basis of the inventory, the technical condition of the windows was assessed and a conservation programme was developed [32], [33], [34].
The analysis was carried out in May and June 2015 and indicated that the paint coating on many windows (especially weatherboards and sills) as well as jamb edges was damaged as a result of opening of the windows and the weatherboards banging against the concrete structure. The mechanical damage observed in the woodwork of the windows resulted also from people stepping onto the window sills. It is recommended that stepping on the window sills be forbidden and windows should not be left open in ways that allow the weatherboards to bang on the concrete structure in windy conditions (the windows have not been equipped with wind stops).
Many windows have damaged surfaces. Continuous monitoring of the paint coating of window woodwork is recommended, as any damage may facilitate water penetration into the interior sections of the wooden elements.
The seals in many windows have been installed in an inappropriate and careless way and require careful reinstallation.
Numerous fixtures of turn buttons with handles and fixtures of knobs have been damaged and are in need of repair.
In some windows, window sashes have been distorted, which prevents the window from being closed properly. Regulation of hinges is recommended in windows which are opened frequently.
In addition to visual inspection, analysis of the condition of the material of selected windows was tested using the resistance drilling method (resistographic method) and the stress wave method. No biological degradation was discovered inside sections of window woodwork elements in places where the tests were carried out

3.7. Conclusions, analysis of original solutions, past structural and material testing in relation to tests carried out today (in 2015).

The tests carried out indicate that the structural elements of the Hall are in good technical condition, despite the building being a hundred years old. The strength parameters of concrete comply with the contemporary requirements for the **C20/25** strength class (minimum value of strength obtained in testing was 20.5 MPa), which has to be seen as a surprisingly good result considering the level of concrete technology at the beginning of the twentieth century.
The concrete was made using a high quality granite aggregate with the addition of natural aggregate and its average weight by volume was found to be 2,236 kg/m^3 (the minimum value of the weight by volume obtained in testing was 2,180 kg/m^3). The data available in the literature suggests that a special type of cement made by the Silesia cement mill in Opole was used for the concrete production, together with the highest quality Strzegom granite.
The strength tests carried out identified significant differences in strength parameters for concrete at the near-surface layer (approximately 10 cm deep) when compared to deeper layers (from 10 to 30 cm). The compressive strength values were highest for the concrete from the near-surface layer and subsequently lower for layers located deeper. This refers to tests carried out along the direction of laying of concrete, as well as perpendicular to this direction.
The results of 'pull-off' tests described in [4], which were performed at randomly selected locations, indicate that the structural concrete is strong enough for structural repairs to be carried out. The worst results (ranging between 0.7÷1.2 MPa) were obtained for external surfaces of the façade walls at the level of the groundfloor. The low value of the 'pull-off' strength in this location is mainly caused by the surface corrosion of concrete.
The tests carried out to date on the concrete of the bottom tension ring of the dome confirm that a high quality of concrete was used [8, 9]. Depending on the location in the structure, the compressive strength values ranged from 28 MPa to 38 MPa, and the tensile strength values ranged from 2.8 MPa to 4.5 MPa. The low value of concrete absorbability, below 5%, together with a low coefficient of variation equal to 8%, indicate high structural homogeneity of the tested concrete. The hardened cement paste of the tested concrete adheres well to the crushed granite aggregate. Its structure is dense, thick and characterised by low absorbability. Low permeability of the cement paste obstructs carbonation and diffusion of chlorides, and thus constitutes a protective barrier for the steel reinforcement. The micro-hardness of the tested concrete was found to be 1.8 GPa and its modulus of elasticity E = 33 GPa. When compared to the classic Mohs' scale or the extended Ridgwey's scale, the micro-hardness of the tested concrete was determined to be 4. The modulus of elasticity determined for the concrete sample number 4, extracted from the tested circumferential supporting ring complies with requirements corresponding to the **C30/37** strength class, as described in the standard, [21].

Based on the tests which were conducted, it was determined that the physical properties of the concrete change with the distance from the external surface of the element. The higher the density by volume of the concrete, the lower the porosity and absorbability. This is a result of carbonation of the concrete. The composition and amount of aggregate varies for individual concrete specimens. The closer to the external surface, the lower the content of aggregate in concrete and the higher the content of cement. The ratio of aggregate content to the content of cement for the tested concrete specimens is 9:1 and 8:1, and should be regarded as relatively low.

The analysis of grain composition of the aggregate indicated that the curve derived from the results for sieve testing, places the aggregate in the 'well-grained' category of aggregates with a fraction below 31.5mm. Quartz aggregate along with crushed granite aggregate was found in the aggregate composition. The content of crushed granite aggregate increased for higher fractions of aggregate. It also increased closer to the external surface of the tested concrete. The presence of fine wood chip inclusions was discovered in aggregate with a fraction below 8 mm, [9].

A lower amount of CaO in the oxide composition of the cement and presence of fine black inclusions with the structure of frothed glass indicates that blast-furnace cement may have been used for construction purposes. Introduction of slag into the concrete mix resulted in a dense microstructure of the concrete. The high concentration of C-S-H phase is a product of slag hydration and reaction of calcium hydroxide with silicate anions originating from slag hydration. The amount of calcium hydroxide decreases, resulting in the presence of a C-S-H phase as a dense gel. This leads to lower capillary porosity of the hardened cement paste, which in turn obstructs the diffusion of aggressive agents to the cement matrix. The amount of portlandite and calcium aluminates, which are not resistant to corrosion, is lower in the cement paste. These changes to the microstructure of cement paste based on blast-furnace cement mean that such cements are characterised by a number of more favourable properties than Portland cements without additives.

Analysis of the microstructure allowed for porosity assessment of the material, as well as the structure and dimensions of pores. Porosity was determined with a micro-CT device for the tested samples, and found to be approximately 10%. The pores in the material are fine-sized, with a sphericity of 0.6-0.7. The majority are micropores smaller than 300µm. Such porosity of the tested concrete accounts for its low absorbability (less than 5%) and permeability, and high mechanical properties (compressive strength and tensile strength [8], as well as good frost resistance).

The results of tests which analysed the range of carbonation of concrete demonstrate that the near-surface layer of the tested concrete has been considerably carbonated. For the majority of tested samples, the range of carbonation was no less than 35 mm, but a number of locations have been identified with a much thicker layer of carbonated concrete. It has to be underscored, that in a number of cases, the concrete carbonation range tests, carried out on core samples extracted perpendicular to the direction of laying of concrete, indicated that the tested concrete had not been affected by the process of carbonation despite a hundred years of use and had managed to retain its full passivation capacity with respect to the reinforcing steel.

The microscopic and chemical composition analysis carried out, indicated that the tested reinforcing bars:

- are made of a material with a composition similar to that of St0S structural carbon steel for general use, as classified according to [18],
- reinforcing bars were made of weldable steel,
- tests carried out on the dome ribs and exposed reinforcing elements indicated that the main longitudinal reinforcement of the dome ribs consists of plain bars with the diameter of 32 mm with spacing of approximately 42 cm; the crosswise spacing of the reinforcing bars has been determined to be approximately 15 cm; the concrete casing of the bars is 90 to 100 mm from the top and 35 to 45 mm on the sides,
- the rib stirrups have been made of plain bars with a diameter of 8 mm, with the spacing of approximately 50 - 60 cm; The thickness of their concrete casing ranges from 27 to approximately 37 mm,
- the visual inspection of the exposures made in elements, did not indicate any significant corrosion risk for the reinforcing steel elements, despite the fact, that some small corrosion pitting could be seen on the surface of the main bars. However, their character indicated that they were most probably present before the bars were built into the structure of the ribs; tests carried out to measure the extent of carbonation of the concrete casing at the locations of exposures indicated that the carbonated layer was approximately 25 mm thick.

The tests of metal reinforcing elements of the bottom ring of the dome indicated that:

- the differences between the tested elements can be regarded as negligible – such differences could be expected in one type of steel produced around a hundred years ago; the differences in the microstructure are mainly related to the steel-making processes at the beginning of the twentieth century,
- despite the lack of documentation as to the zero condition, it can be concluded that the changes to the microstructure connected to the functioning of the building (caused by the aging of the material) are small,
- the weldability of the tested steel has to be regarded as limited due to a significant amount of concentrated non-metallic inclusions (including sulphides) and material contamination; if welding proved necessary, special welding technology would have to be developed.

The tests carried out confirmed that the strength parameters of the cast-steel used to manufacture the bearings are inferior to those of modern cast-steel. This finding refers primarily to the minimum tensile strength value, which is much lower than 400 MPa, even when the most favourable estimations are taken into consideration. The chemical analysis of the samples extracted from the lower bearing frames confirmed that the frames were cast at the beginning of the twentieth century using low-carbon cast-steel. However, the chemical composition of this cast-steel differs considerably from the chemical composition of modern low-carbon cast-steel. The non-destructive Brinell hardness tests were carried out on the unknown type of cast-steel, which had been used to cast bearings located under the bottom ring of the Centennial Hall's dome. These enabled determination of the design strength of the cast-steel in the bearings. This strength value is needed to enable appropriate monitoring of the structural condition of the Centennial Hall. The tested cast-steel is low-carbon, which was confirmed by a chemical analysis of the extracted samples.

Taking all the above into consideration, the design strength f_y of the cast-steel used to manufacture the bearings, can be assumed with a margin of safety to be as follows:

- analysis in accordance with the standard [27] – f_y **= 185 MPa**,
- analysis in accordance with the standard [29] – $f_d = f_y / \gamma_m$ **= 185/1.15 = 160 MPa.**

The analysis of the condition of window woodwork indicated that many windows have damaged surfaces. The seals in many windows have been installed in an inappropriate and careless way and require careful reinstallation. Numerous fixtures of turn buttons with handles and fixtures of knobs have been destroyed and are in need of repair.

In some windows, window sashes have been distorted, which prevents the window from being closed properly. Regulation of hinges is recommended in windows which are opened frequently.

No biological degradation was discovered inside sections of window woodwork elements in places where tests were carried out.

Continuous monitoring of the paint coating of window woodwork is recommended, as any damage may facilitate water penetration into the interior sections of the wooden elements.

4. Concept for monitoring structural safety and the condition of the Hall

The term 'monitoring' refers to various methods and techniques which are used to assess the condition of a building. Monitoring activities can be classified according to different criteria, e.g., the goal of monitoring, the type of measurements carried out (static, dynamic), the character of tests (destructive, quasi-destructive and non-destructive), the time of monitoring, etc. According to [47] the most important monitoring techniques can be classified as assessing static or dynamic behaviour of a structure over time. The most effective solution, at least for heritage buildings, seems to be a hybrid system, linking several of these technologies into one comprehensive system, capable of tracking changes to the geometry of the structure (which result also from delayed actions), together with non-destructive testing of structural materials. Geometry monitoring technologies include: tacheometry, laser scanning, global positioning system (GPS), photogrammetry and technologies based on remote sensing. The range and types of non-destructive testing which can be performed are very wide and include: infrared thermography, ground-penetrating radar tests, tomography, X-ray tests, flat-jack tests, ultrasonography and many others.

In the case of the Centennial Hall, the research focused on monitoring the Hall's geometry due to the size of the building and a lack of significant damage. An additional argument related to the lack of earlier detailed digital data related to the structure's geometry and displacement of its individual elements.

The digital documentation which was produced is a valuable and useful tool in preservation of cultural heritage. The models based on the digital data which had been gathered, were used to assess the condition of the structure, as well as to identify the agents which can facilitate its destruction. The same procedures have been used for other buildings, e.g. St. Anne's church in Ząbkowice Śląskie [83].

Displacement and development of cracks in three-dimensional elements can be detected by repeating 3D scanning and overlaying the respective scan images. This is an effective tool for monitoring of the behaviour of the structure, which does not require physical access to the structural elements of the building. This technology can assure millimetre accuracy and can be used to register the degradation process of surfaces, such as, concrete surfaces.

A 3D scan of the structure of the Centennial Hall was carried out and BIM (Building Information Modelling) models were developed along with numerical structural analysis of the building in order to obtain reliable preliminary data. The data which will be collected in the future to monitor the technical condition of the Hall will be used to update the models developed and to verify the data used in calculations.

4.1. 3D modelling

The 3D laser scanning of the Centennial Hall carried out in 2015 was based on the work and experience described in [48], [49], [50]. Work related to collecting geometric data of the Hall's structure was necessary to develop numerical models (FEM – Finite Element Method), BIM models and for further structural analysis of the building.

A number of tools are available which can be used for carrying out distance measurements for the purposes of a building inventory. A 3D spatial scanner is a perfect tool for a detailed inventory of a structure. A FARO X330 scanning device (fig. 4.1, 4.2, 4.3, 4.4) was used during measurements of the Centennial Hall. The device enables development of a comprehensive and detailed 3D documentation of buildings, including heritage structures, which is extremely useful for conservation and renovation work, as well as for scientific analysis aimed at preservation of heritage buildings and developing virtual presentations of historic sites.

Selecting the date for the measurements, one has to take into consideration the following:

– The necessity to restrict access to the site being scanned to all unauthorized persons,
– The weather, as rain, snow or strong wind may make scanning impossible,
– Lingering snow, which causes additional stress in the structure, which results in slight deformation of the structure,
– The atmospheric temperature and pressure, which have impact on air transparency and – as a consequence – on the laser ray used by the scanning device,
– Removal of all furnishing elements contaminating scan images such as bags, waste bins, cars, ropes, curtains etc.

Fig. 4.1. 3D laser scanning device inside the Centennial Hall during measurement.

Fig. 4.2. 3D laser scanning device outside the Centennial Hall during measurement.

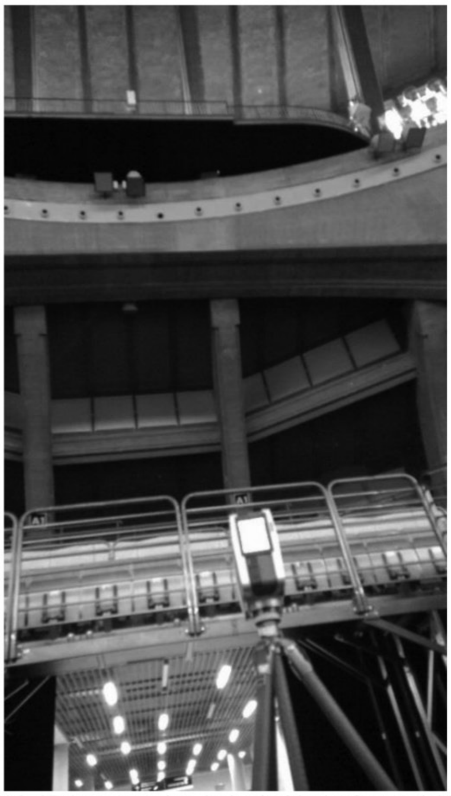

Fig. 4.3. 3D laser scanning device inside the Centennial Hall, under its dome, during measurement

Fig. 4.4. 3D laser scanning device inside the Centennial Hall, under its dome, during measurement

A camera was integrated with the scanner to enable immediate development of actual 3D pictures. The device produces a cloud of points, which, after being processed, gives an accurate three-dimensional picture of the building, (fig. 4.5 – 4.8). Clouds of points saved in individual files were merged into a single large cloud. Reference spheres and discs were used to enable an exact positioning of scans with reference to one another. Spherical objects with a known diameter had been placed in locations common to subsequent scans, before the process of scanning began. The reduction of cloud density was necessary due to limitations of the computational capacity of programming software.

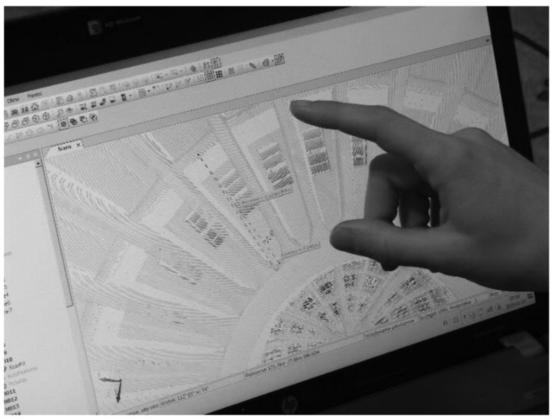

Fig. 4.5. A cloud of points being processed – the dome.

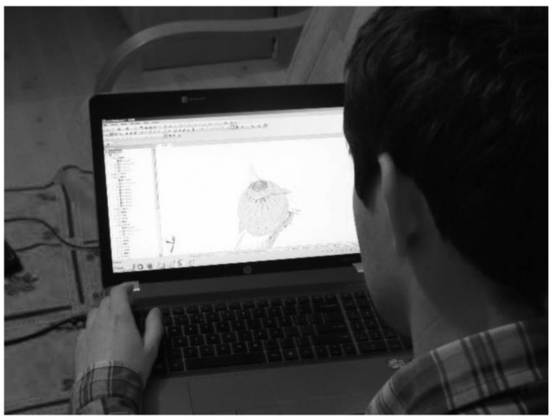

Fig. 4.6. A cloud of points being processed.

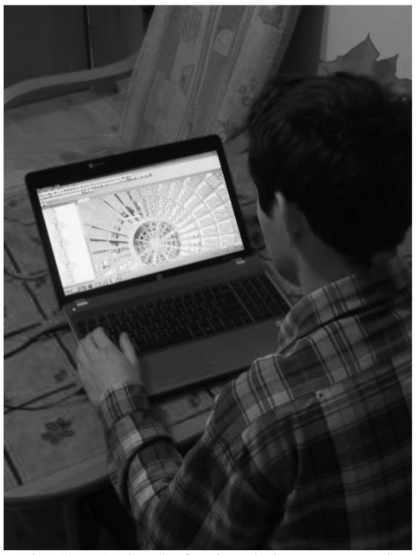
Fig. 4.7. A cloud of points being processed.

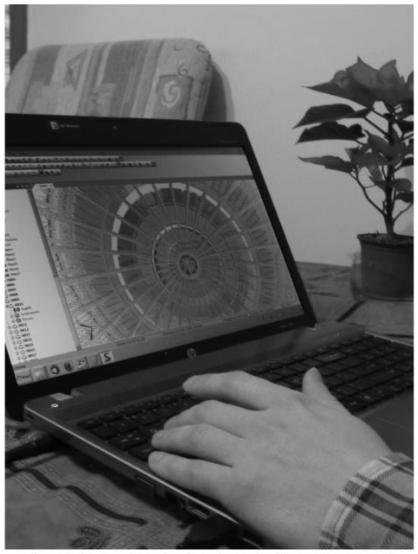
Fig. 4.8. A cloud of points being processed.

Spherical coordinates for points located at some distance from the measurement station were obtained in this way. The inventory obtained in this way can be used for further numerical analysis and design work.
More than 50 scans were made inside and outside the Centennial Hall in Wroclaw. Along with numerous spherical photographs in grey scale, (fig. 4.9 – 4.12).

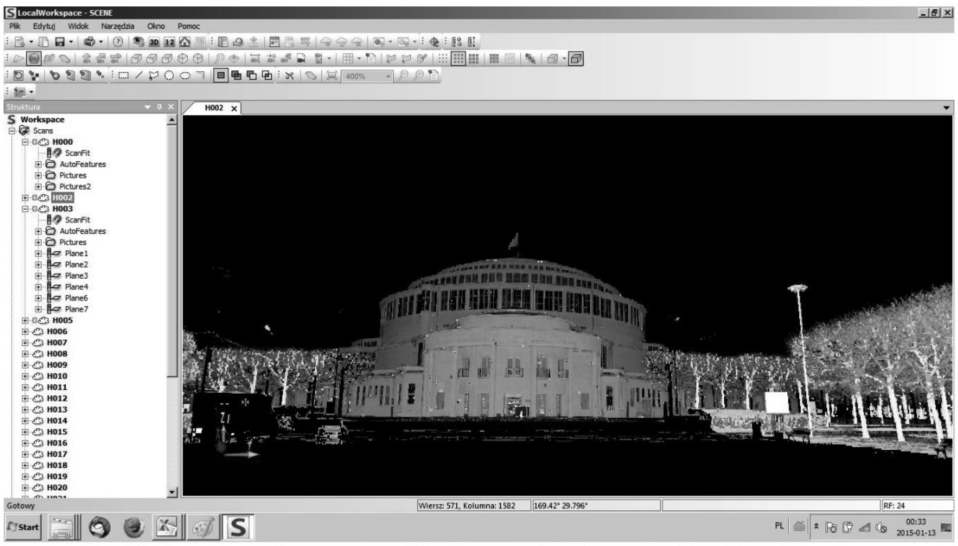

Fig. 4.9. A cloud of points – a view of the Centennial Hall from the side of the Iglica statue.

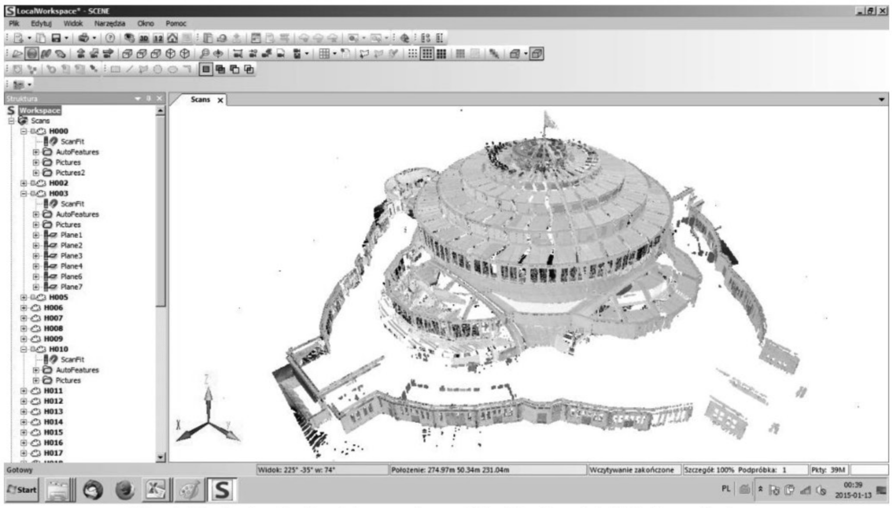

Fig. 4.10. A cloud of points – a view of the Centennial Hall from the top.

Fig. 4.11. A cloud of points – a view of the interior of the Hall.

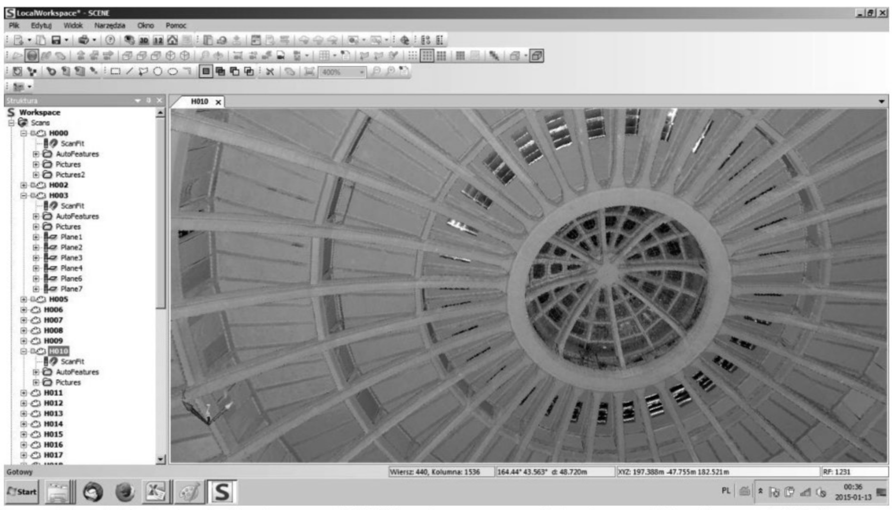

Fig. 4.12. A cloud of points – a SCENE software scan of the dome of the Centennial Hall.

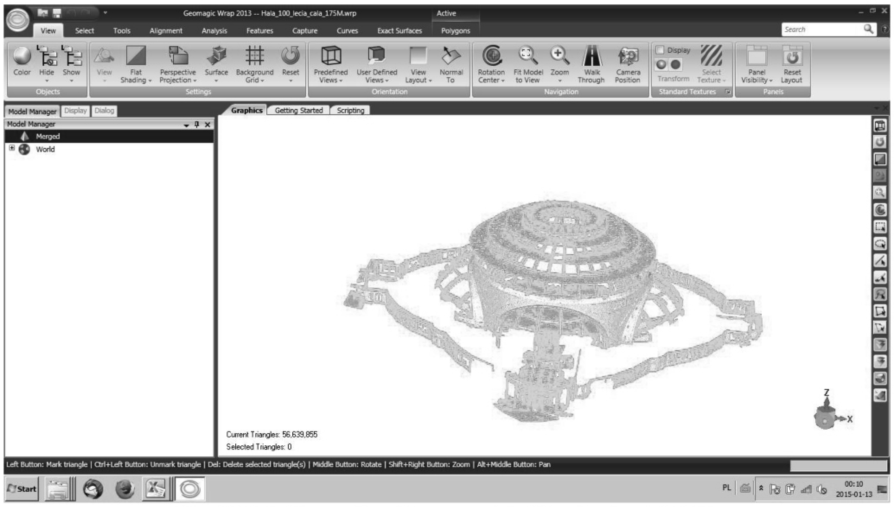

Fig. 4.13. A Geomagic software model of the Centennial Hall.

Further work involved transforming ordinates from a spherical to an orthogonal form using SCENE system software for interpreting scanning data. The specialist software Geomagic (fig. 4.13) was used to measure the distance between individual points in the cloud and identify basic surface areas, i.e. slabs, pipes, planes, spheres and lines. It is possible to describe individual elements and export them into formats required by other software programmes. In generating technical drawings, it is helpful to describe the characteristic curves for plain distortion and profile outlines for the purposes of exporting them to the CAD environment. The software provides considerable capability for reviewing and visualising clouds of points, enabling for example virtual walks along scanned locations.

4.2. BIM (Building Information Modelling)

A model of a building generated using the BIM technology presents all possible parameters of the actual building. This enables analysis of more information than in the case of a 2D design. What is more important, a 2D design can be interpreted by people only on the basis of their experience and knowledge, whereas a BIM model introduces additional support in the form of various programmes and reports facilitating interpretation of images.

A benchmark (a constant and unchanging point located preferably outside the building) is necessary for carrying out measurements of geometry changes of the building in order to monitor the condition of the Hall. All subsequent 3D scans of the building will be positioned with reference to the benchmark for monitoring of the changes to the structure's geometry.

The information contained in the BIM model will enable fast and faultless prediction where and which structural and operational elements will need to be strengthened or replaced in the nearest future. Access to such new possibilities will definitely improve the structural safety of the building and the monitoring of its actual technical condition. But it will also reduce the costs connected to building maintenance. BIM simulations will also enable assessment of the impact of planned repairs and modernisations of individual elements on the whole load-bearing structure or the environment.

The BIM models of the Centennial Hall have been generated on the basis of 3D scanning results. The stages of developing documentation based on the clouds of points have also been presented. The models have been generated using two specialist software programme families. Development of two BIM models demonstrates that there are different methods for generating a model which can be used in further analysis, e.g. numerical. The two models - BIM I and BIM II – have been generated using different groups of compatible software programmes.

The following software was used for BIM I development:

– Autodesk ReCap software for processing clouds of points,
– Autodesk AutoCAD software for generation of vector drawings,
– Autodesk Revit software for generation of BIM models,
– Meshlab software for processing of mesh objects.

Information on other software programmes facilitating processing of clouds of points in the Revit environment has also been included, along with a review of the benefits of BIM model generation based on 3D scanning.

The following software was used for BIM II development:

– 3D FARO Scane – software dedicated to, inter alia, the Faro Focus 3D scanner, which facilitates browsing, measurements and editing of clouds of points,
– Geomagic Design X – software based on putting together three independent programmes in order to simplify and increase effectiveness of the process of 'reverse engineering',
– RhinoCeros – a pioneering software using modelling surfaces with 'iso-curves'; the functional description of curves and surfaces has been adapted for many well-recognised and widely used CAD/CAM programmes in this way.

4.2.1. BIM I

The model was generated on the basis of a cloud of points containing approximately 170 million objects. Additionally, archive documentation was analysed, inter alia [4], [7]. The BIM model was generated using the Autodesk Revit 2015 software.

3D laser scanning of the building resulted in a cloud of points consisting of a set containing from several to several dozen million points. Each of the points is characterised by its own coordinates X, Y, Z and information on the RGB colour and the intensity of the reflected ray. Such data format enables a faithful and exact projection of the objects being scanned. Special software programmes are devoted to processing clouds of points. Every manufacturer of 3D scanning devices offers a software dedicated to processing 3D scan images. The Autodesk ReCap is a software for processing 3D scan images prepared by the Autodesk company. This software enables the opening of clouds of points in most available saving formats used by 3D scanner manufacturers and text files.
The ReCap programme saves clouds of points in the default *.rcp '*Autodesk ReCap project*' format, which can consist of a number of individual scans. Additionally, the Autodesk environment comprises its own format for saving 3D scan images *.rcs '*Autodesk ReCap Scan*' – which can later be imported to a *.rcp file.
Depicting the side of the whole building in just one 3D scan is not possible from a technical point of view, which is why it is necessary to merge several clouds of points into a single system of coordinates. Such an operation is called a registration of clouds of points. 36 scan images of the Centennial Hall were delivered in the *FLS format and did not require registration.
The ReCap programme enables registration of scans, although it was not necessary in the case of the Hall. The process involves identifying the same points in different scans. These can take the form of measurement signals prepared in advance, such as checkerboards placed on building elements. The registration accuracy, and as a consequence, the accuracy of the final cloud of points, depends on a number of factors, such as the number of selected common points (at least 3), the distance between them and their location in different planes. Selecting points located on the edges should be avoided due to the possibility of selecting points located on different planes.
The next stage involved indexing, which means merging all scans into a single cloud of points, after which it is possible to process the cloud of points using specialist software.

Fig. 4.14. Autodesk ReCap interface for 3D scan indexing.

ReCap offers several display modes for points which facilitate processing.

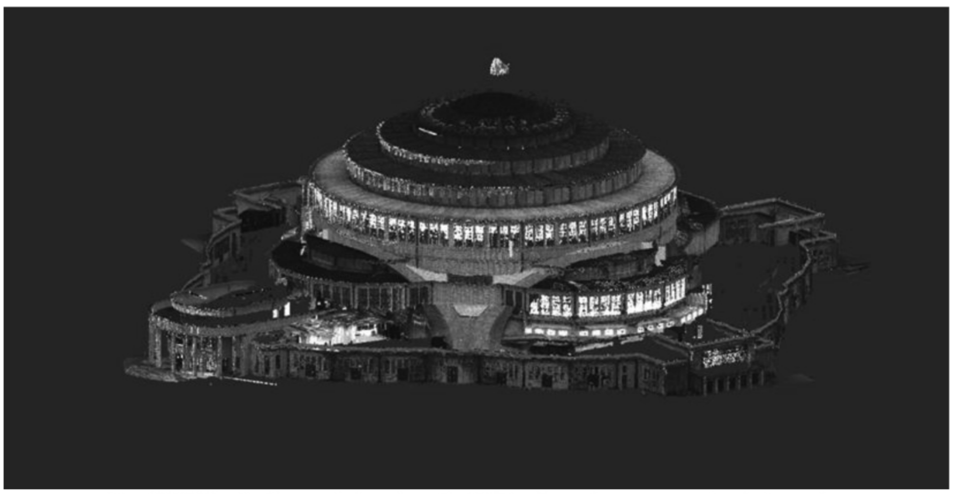

Fig. 4.15. The display mode based on the RGB colours from panoramic photographs.

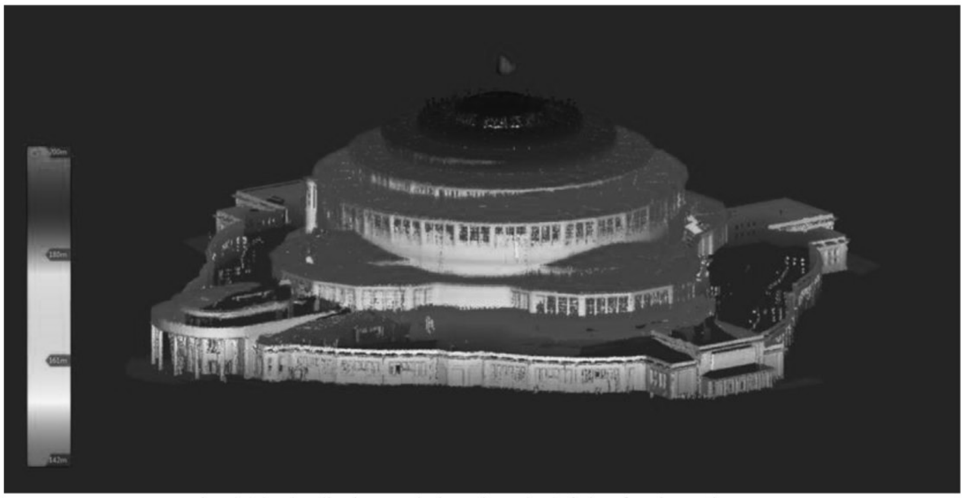

Fig. 4.16. The display mode based on the height of a given element.

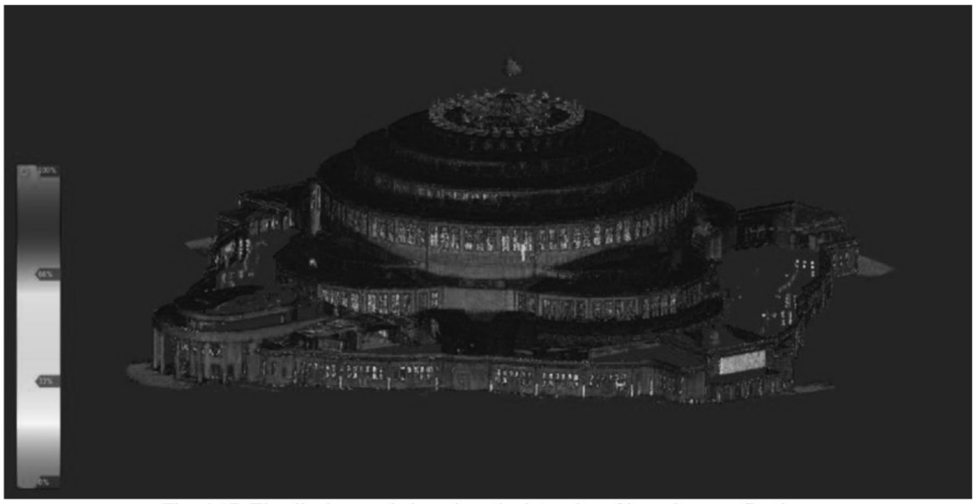

Fig. 4.17. The display mode based on the intensity of laser beam reflection.

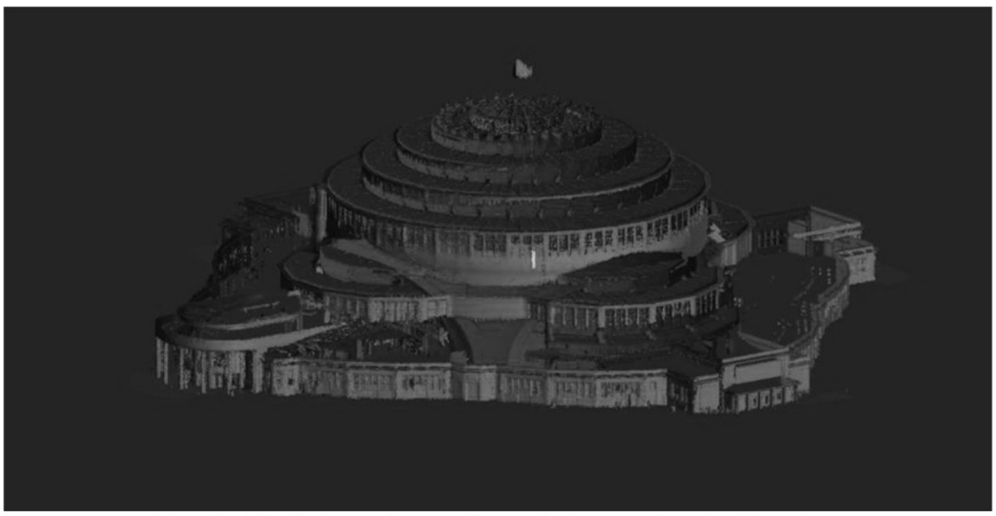

Fig. 4.18. The display mode presenting standard vectors for each of the points.

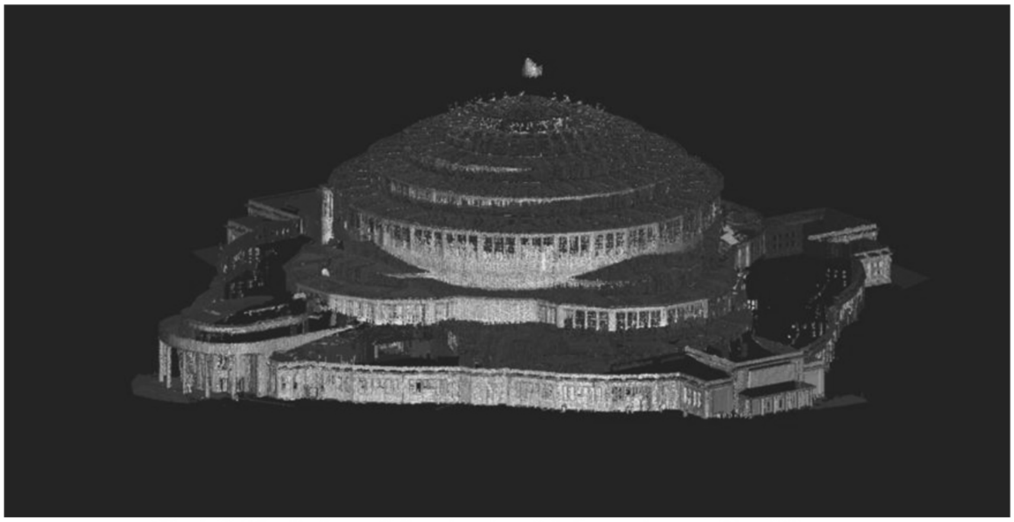

Fig. 4.19. The display mode based on the attributing a given point to a 3D scan. .

The first stage of processing a merged cloud of points involved removing so called 'artefacts' – false points, resulting from technological inaccuracies (e.g. mirror-like surface reflections) and points which are not building elements: people, vehicles and other objects found near the building at the time of scanning.

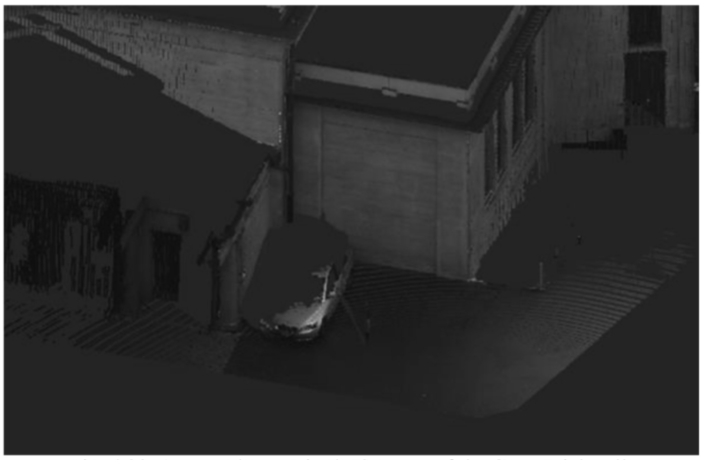

Fig. 4.20. A car and a man in the 3D scan of the Centennial Hall.

The main goal of processing the cloud of points using the ReCap software was to group together points which belong to the same elements. This allows display only of the points that are needed for documentation of a specific element in programmes such as Revit or AutoCAD. The following groups of points, called regions, have been isolated in the cloud of points for the Centennial Hall:

- The cylinder, constituting the base of the dome (a pendentive),
- Arcade supporting ribs,
- The tension ring,
- The ribs of the dome,
- The circumferential transoms,
- The compression keystone ring,
- The lantern ribs,
- The walls and structural ceilings of respective building levels.

Exporting a given group of points to a separate *.rcs file and deleting permanently the exported points from the project file is an alternative for working with regions.

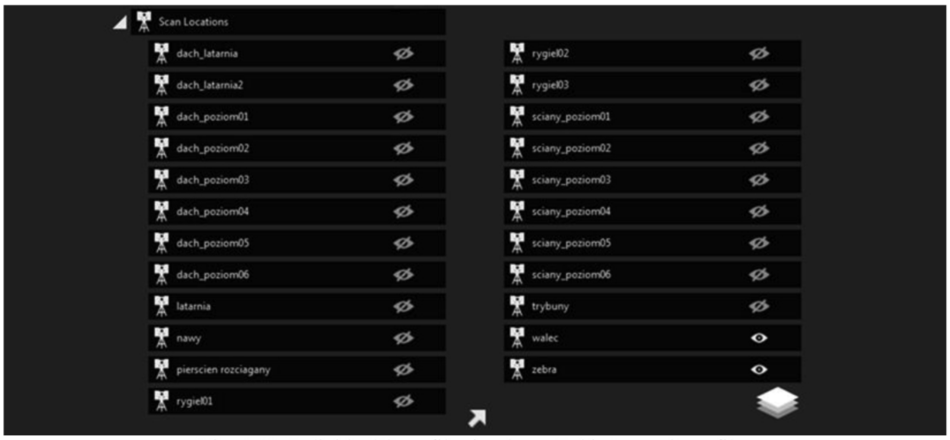

Fig. 4.21. Individual *.rcs files implemented into one *.rcp file.

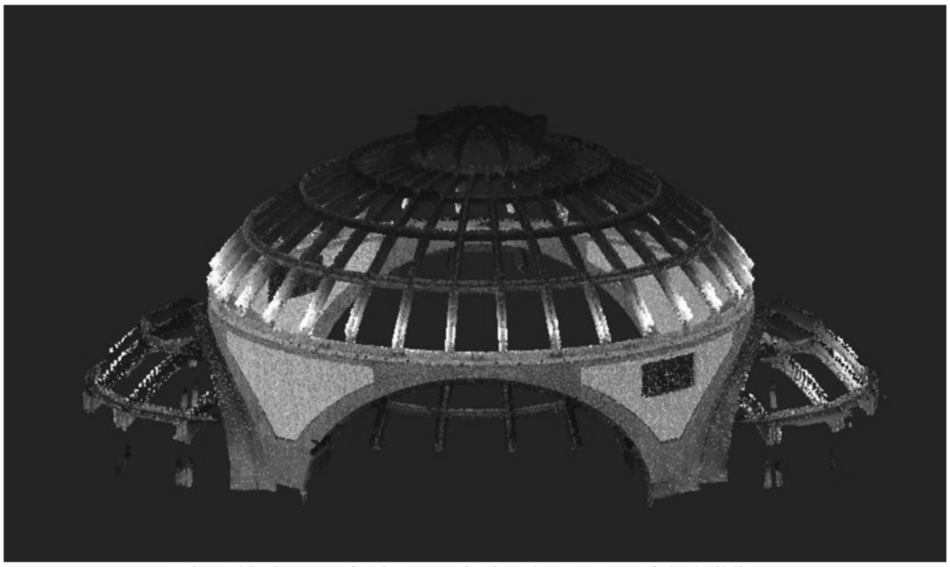

Fig. 4.22. Groups of points constituting the structure of the building.

Two reference planes, intersecting at right angles, which determine the theoretical centre of the Centennial Hall, have been introduced during preparations of BIM files. All *.dwg files and clouds of points refer to this theoretical centre of the Hall. One of the planes (the 'NW-SE' plane) runs through the main entrance. The other one (the 'NE-SW' plane) runs through the entrance on the side of Wróblewski Street.

32 structural axes have been generated, which spread in a radial way from the point of intersection of the two planes - the 'NW-SE' plane and the 'NE-SW' plane. The angle between the axes is 11.25°, and the angle between the first axis and the 'NW-SE' plane is 5.625°.

In addition, some basic reference levels were introduced:

– 'central slab' -1.20 m
– 'level 0' 0.00 m
– 'top of the cylinder' 18.33 m
– 'tension ring' 20.00 m
– 'compression ring' 36.10 m.

The following stage involved uploading clouds of points in the *.rcs format to the Revit software and positioning them correctly in relation to the adopted reference planes, reference levels and structural axes. Next, the position of the cloud of points was blocked with the 'Pin' tool. While uploading subsequent *.rcs files, the 'Auto – Origin to Last Placed' option was selected from the 'Positioning' bookmark. The 'Pin' tool was used to block their position.

An archive documentation saved in *dwg format was used while generating the BIM model of the Centennial Hall, [7]. The documents were extremely useful in the modelling of elements scanned with low resolution (e.g. lantern ribs) or covered at the time of scanning.

The *.dwg file was uploaded using the 'Link CAD' tool. This function enables reloading of the base design, if any changes are introduced to it. After uploading the file in the proper viewing mode, it is correctly positioned in relation to other elements which have already been in the project file. The geometric centre of the Centennial Hall and the ‘Pin’ tool are used to prevent any potential shifting of the base design.

The Revit programme enables switching off and deleting unnecessary layers from the *.dwg file. The ‘Delete Layers” or ‘Object Styles’ tools in the ‘Manage’ bookmark enable these operations. It is also possible to switch some layers off only in one viewing mode, using the ‘Visibility/Grafics Override’ option in the view properties.

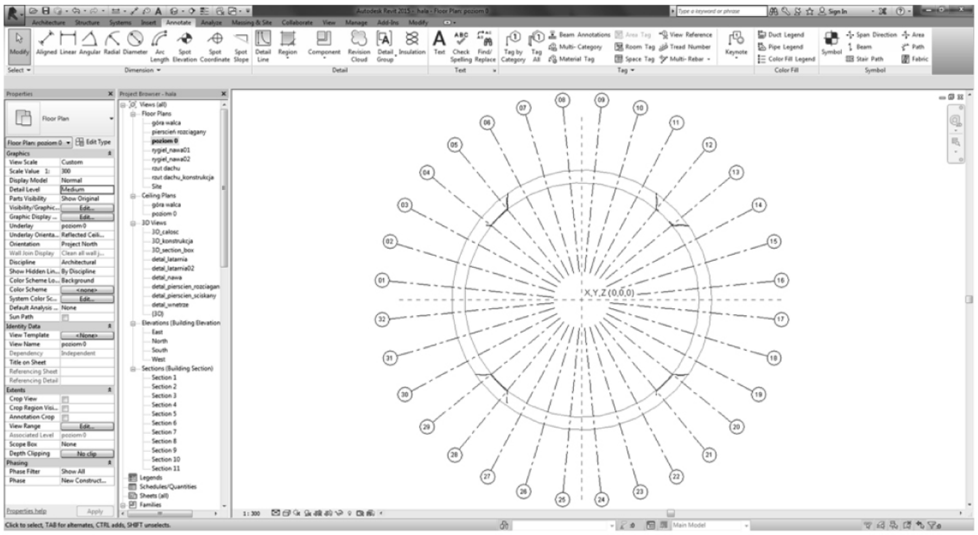

Fig. 4.23. Structural axes and the cloud of points in the Revit software.

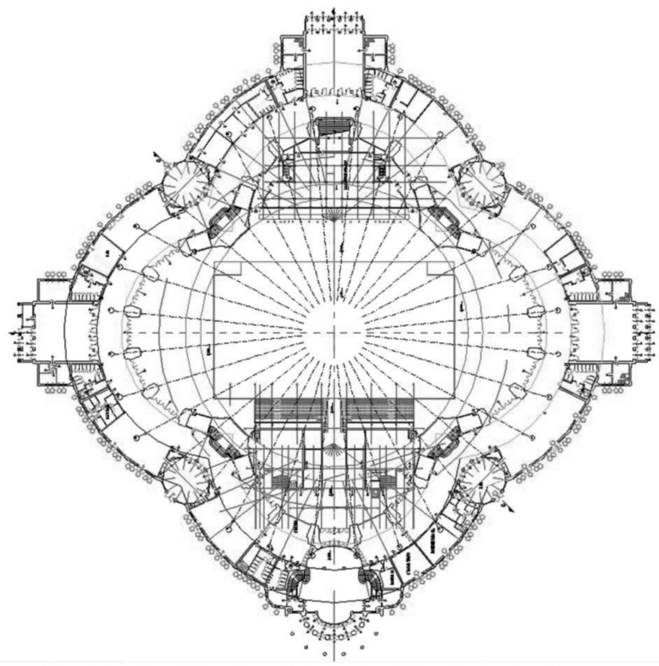

Fig. 4.24. The *.dwg base-design uploaded to the Revit software.

The following standard elements have been used in generating the BIM model of the Centennial Hall:

– Walls - 410 mm, 340 mm and 300 mm thick;
– Roofs for subsequent levels;
– Lantern roof (volume modelled as a dome shape).

‘Metric Structural Framing - Beams and Braces’, ‘Metric Structural – Column’ and ‘Metric Window’ structural templates were used in modelling structural elements of the Hall. If the selected template for a given family turns out to be wrong, it can be changed while editing the family in the ‘Family Category and Parameters’ bookmark.

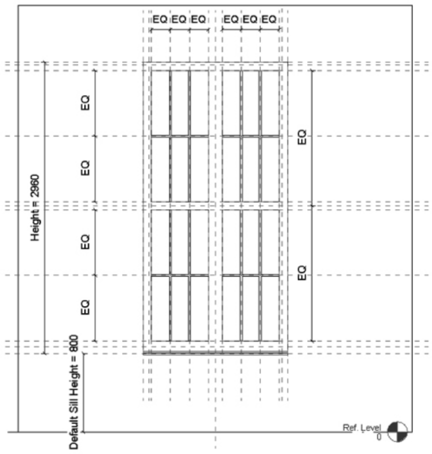

Fig. 4.25. Parameter family of a window used in generating the BIM model.

The family editor in the Autodesk Revit software does not provide for importing clouds of points, hence, depending on the structural element, different methods for importing clouds of points to the family template have been applied. One of these methods uses the 'MeshLab' programme to transform a cloud of points into a mesh and then to save it in the *.dxf format, which can be then imported to the family editor. Another method involves obtaining a base design from a cloud of points using the Revit software, saving it as a *.dwg file and then importing it to the family file.
A cloud of points has been prepared using the ReCap programme prior to its processing in the MeshLab programme, as a mesh created using too many points can impede effective work.

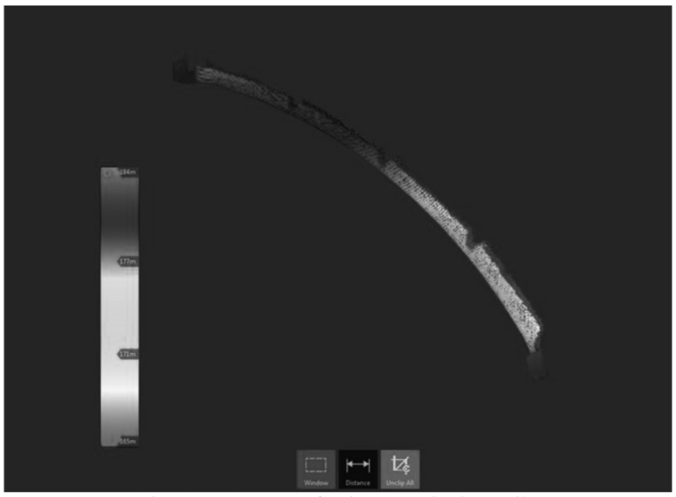
Fig. 4.26. A group of points constituting a rib.

Next, the points were exported to a file with the *.pts extension, subsequently changing the extension to *.asc. The file was then ready to be uploaded to the MeshLab software.
The first stage of MeshLab processing involved calculating standard vectors for the imported cloud of points. Then, the cloud was transformed into a mesh using the 'Surface reconstruction: Poisson' tool. The result of the function operation was then improved using the 'Vertex Attribute Transfer' algorithm, which projects the original cloud of points onto the mesh generated. Next, all unnecessary planes resulting from applying the algorithm were removed. Finally, the mesh was exported to a *.dxf file and uploaded to the family template in the Revit software. The disadvantage of this method is the lack of possibility of cutting with planes the cross-sections of imported elements and of adjusting the viewing range.

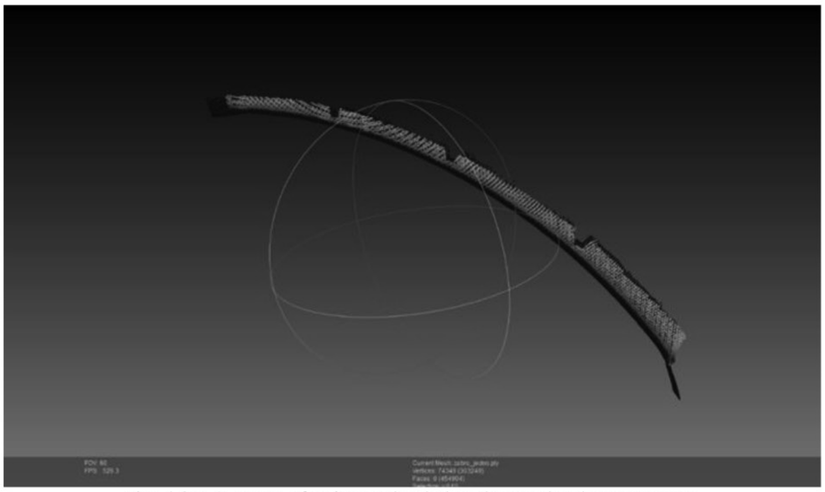

Fig. 4.27. A group of points uploaded to the MeshLab programme.

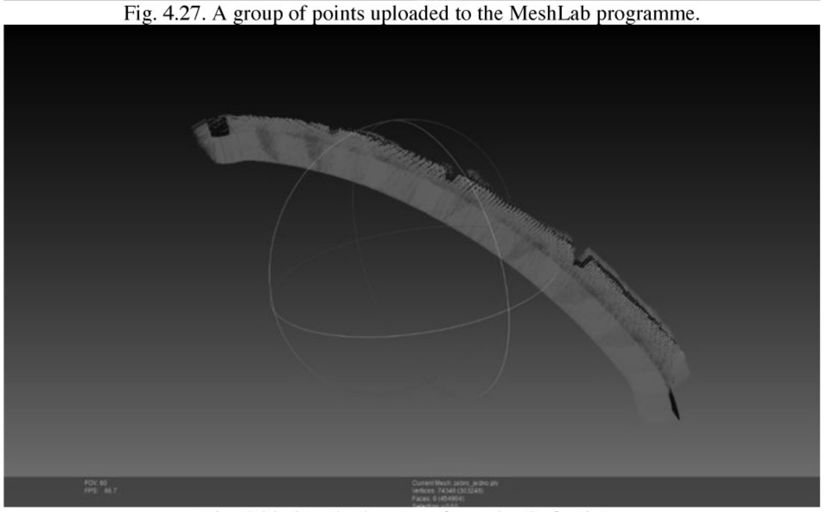

Fig. 4.28. Standard vectors for a cloud of points.

Fig. 4.29. The results of the use of the ‘Surface reconstruction: Poisson’ function.

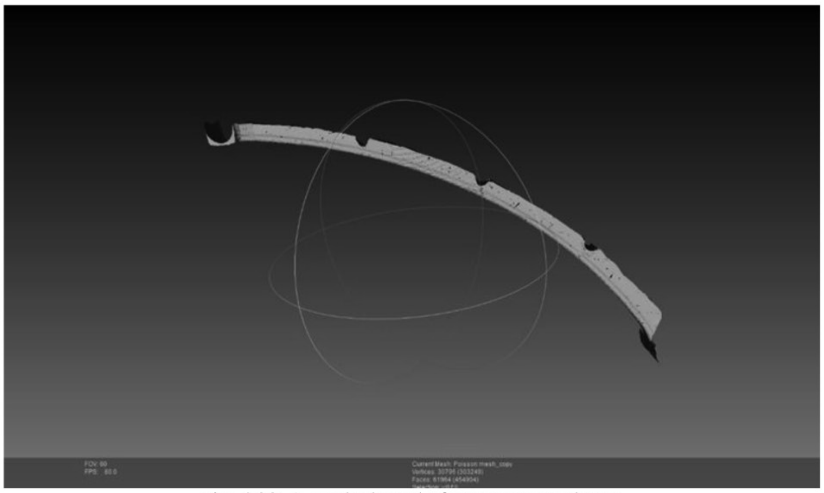

Fig. 4.30. A mesh cleared of unnecessary planes.

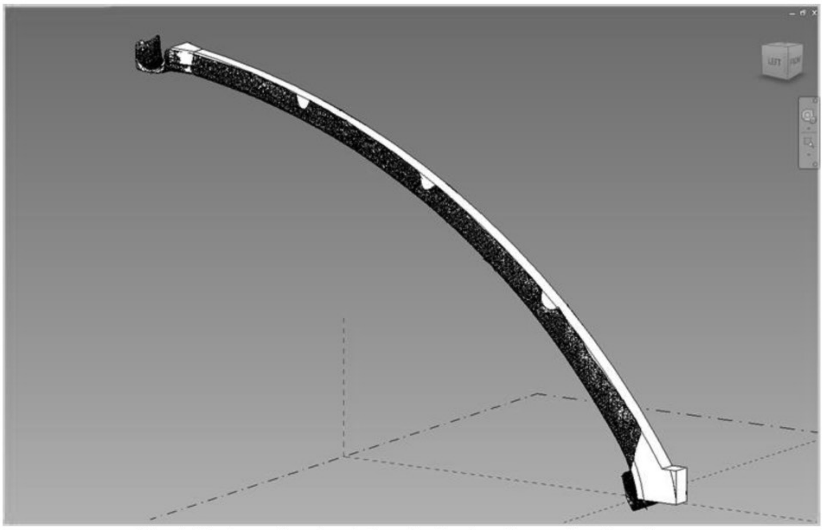

Fig. 4.31. A mesh uploaded to the Revit software family editor.

Another method for working with clouds of points in a family editor involves creating a base-design is the main Revit file and exporting the view as a *.dwg file in order to upload it into the family template. To begin, an adequate view was selected – a cross-section in this case – and then, the visibility of the view was set by adjusting the depth of the view in such a way that it was not obscured by unnecessary points. Next, an outline of the element was prepared using the 'Detail Line' tool and the view was exported to a *.dwg file.

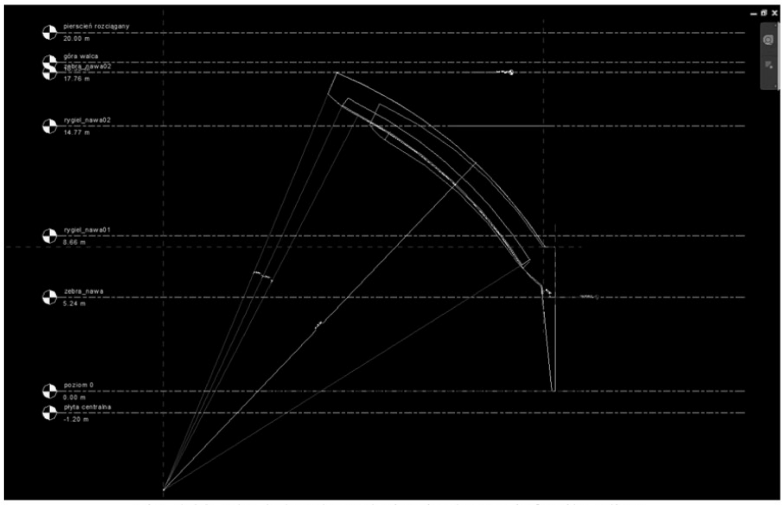

Fig. 4.32. The *.dwg base design in the Revit family editor.

The ‘In Place Component’ function was used for modelling of the supportive cylinder of the Hall because of its complex geometry. The thickness of the element decreases as its height increases and additionally there are four openings in the shape of a half of an ellipse in the cylinder.
The ‘Wall’ family category was chosen as the category for this element. The cylinder was modelled using the ‘Swept Blend’ function, which enables generating solids with two different bases along a defined curve. Next, elliptic openings were cut in the cylinder along the ‘NW-SE’ and ‘SW-NE’ planes.

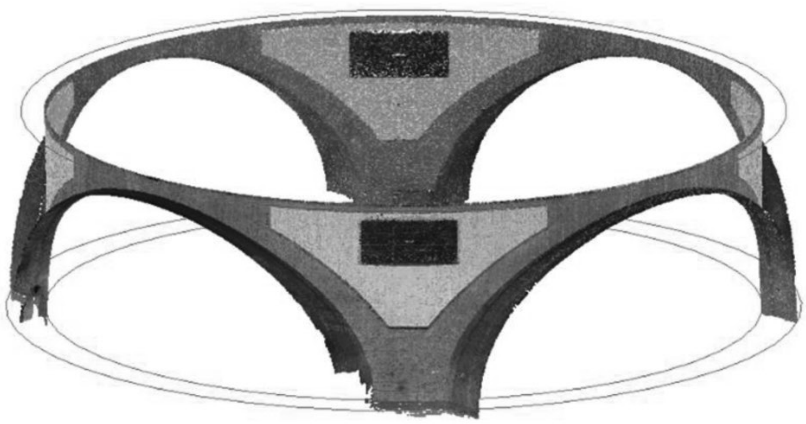
Fig. 4.33. The cloud of points with auxiliary lines

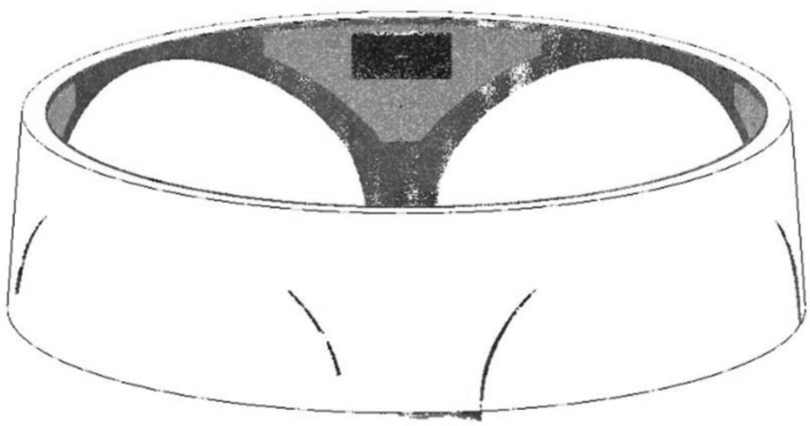
Fig. 4.34. The cylinder created with the ‘Swept Blend’ tool.

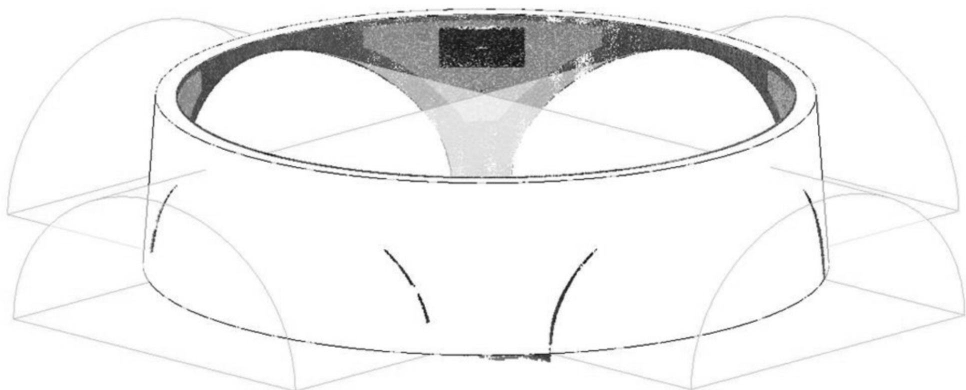

Fig. 4.35. Two half-pipes used for cutting openings in the cylinder.

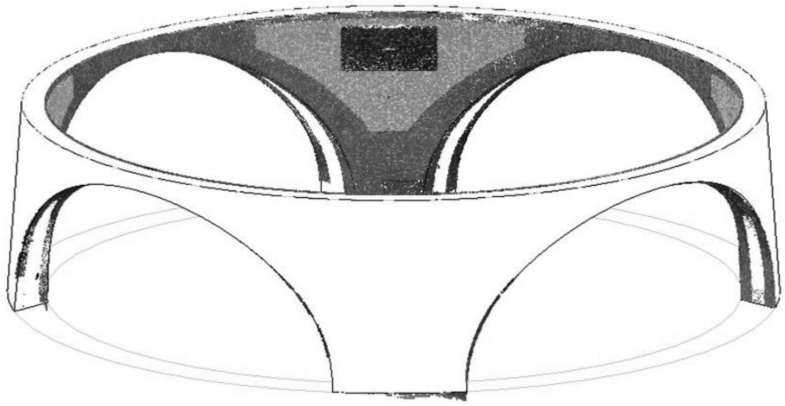

Fig. 4.36. The complete cylinder with openings.

The BIM models comprise a large amount of information on the structure and so can be used for several purposes. They can be used to produce cost calculations, statements and analysis for more efficient design processes. As a BIM model covers the building as a whole, it is possible to depict each detail of the structure or generate additional sections or 3D images for complex elements.

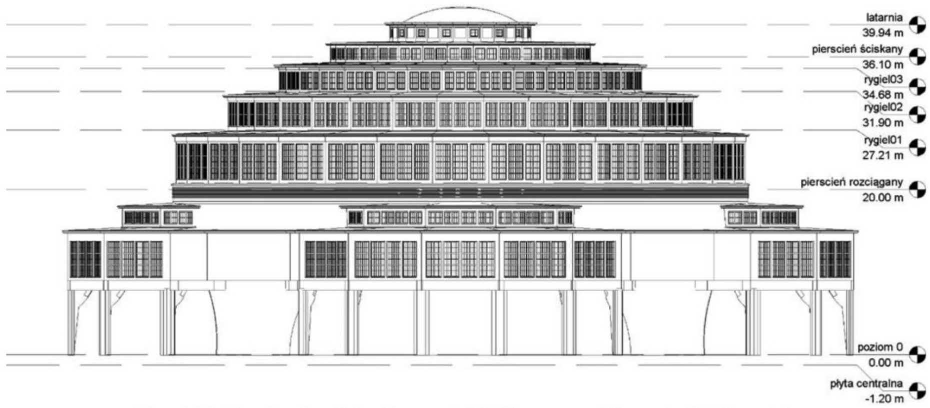

Fig. 4.37. The façade of the Centennial Hall generated from the BIM model.

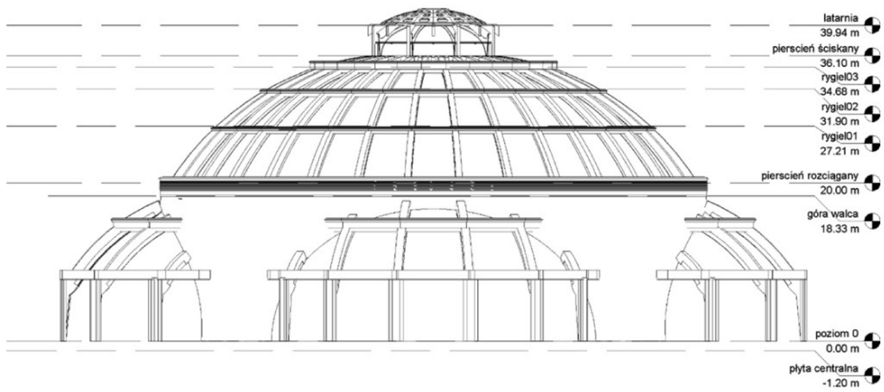

Fig. 4.38. A view of the structure generated from the BIM model.

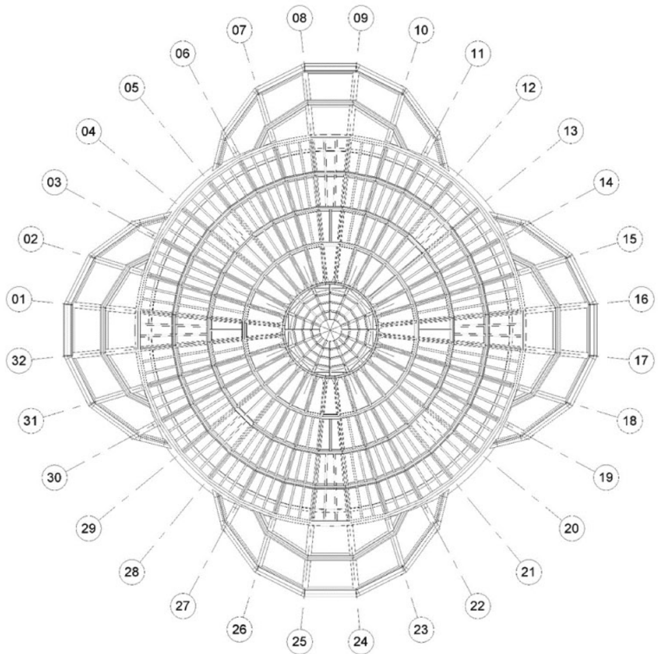

Fig. 4.39. A floor plan of the structure of the Centennial Hall generated from the BIM model.

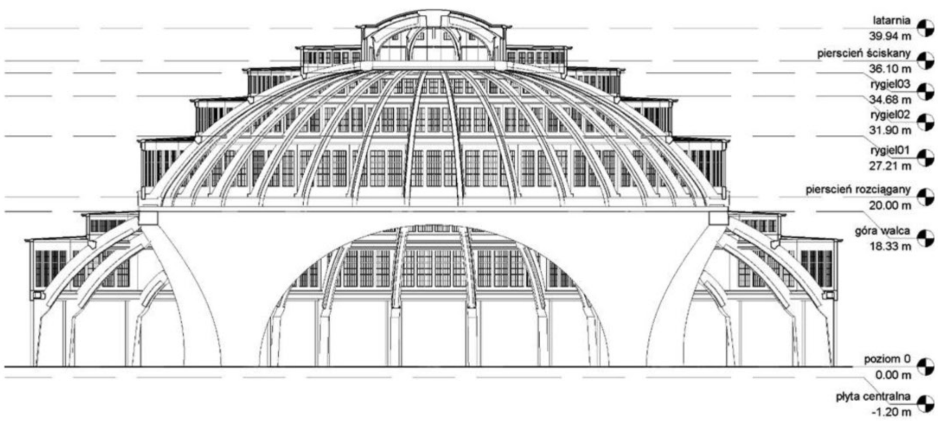

Fig. 4.40. The NW-SE section of the Centennial Hall.

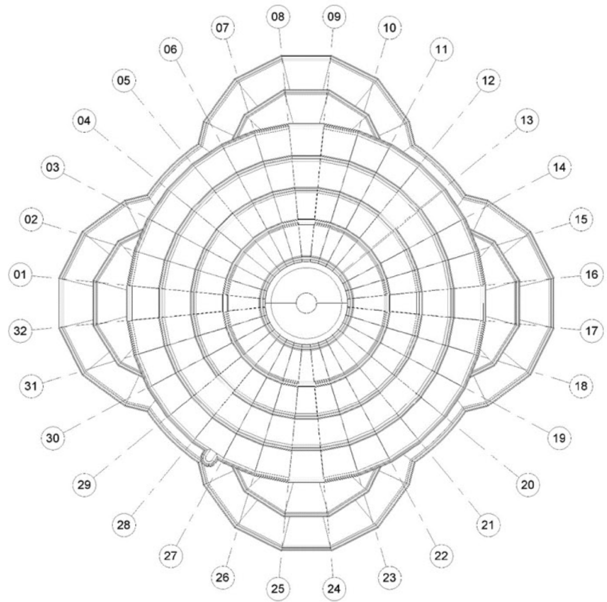

Fig. 4.41. The floor plan of the roof structure of the Centennial Hall generated from the BIM model.

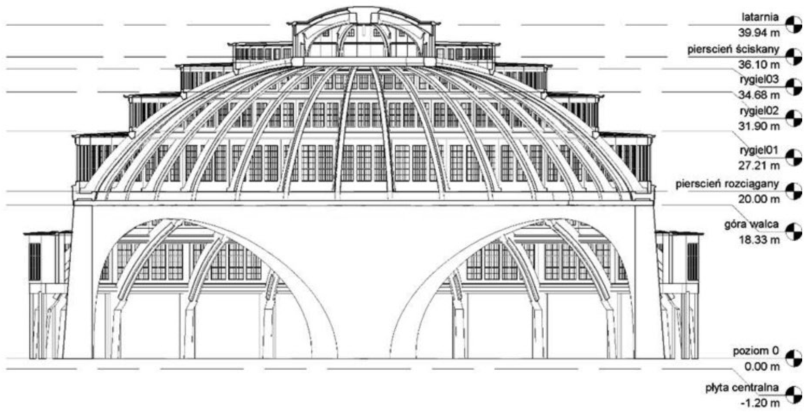

Fig. 4.42. Cross-section of the Centennial Hall generated from the BIM model.

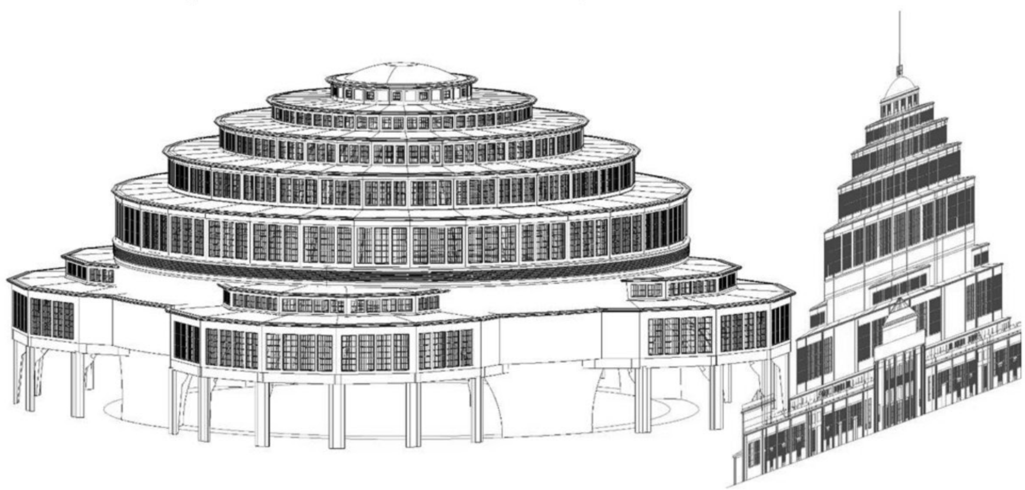

Fig. 4.43. The BIM model of the Centennial Hall with the *.dwg base-design uploaded.

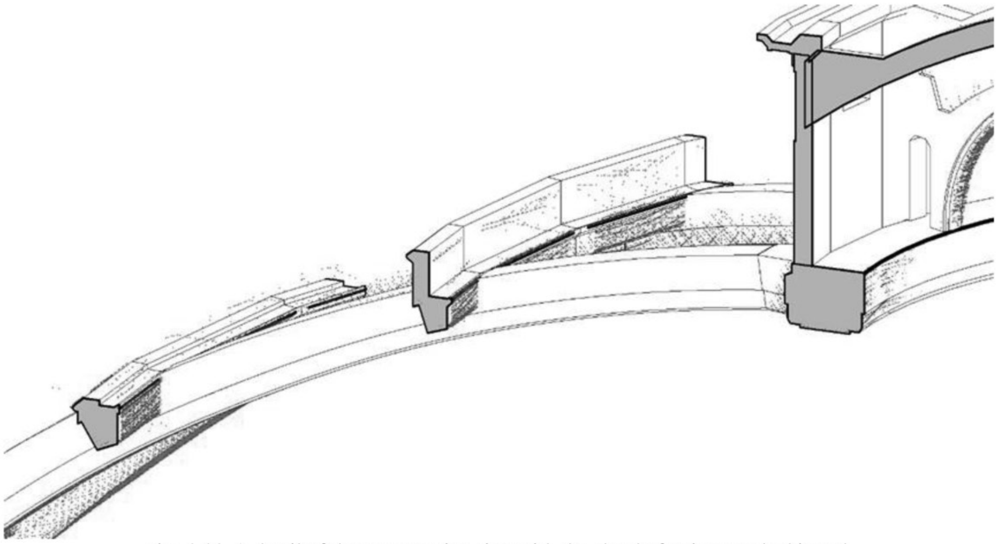

Fig. 4.44. A detail of the compression ring with the cloud of points marked in red.

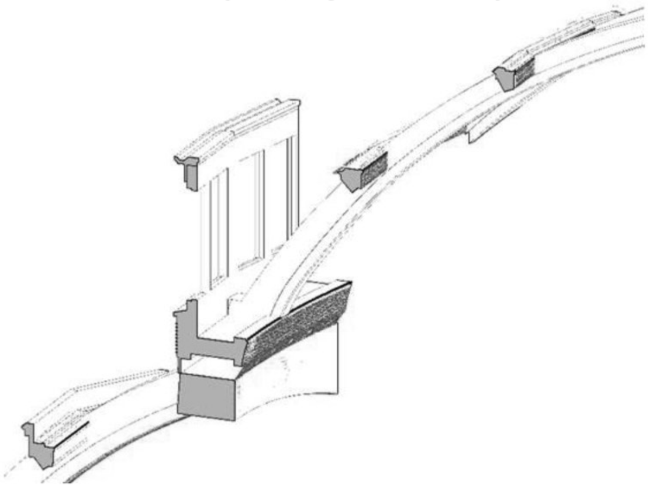

Fig. 4.45. Detail of the tension ring with the cloud of points marked in red.

The BIM model was generated to include analysis of the properties of its components, and so enables export of the analytical model to calculation programmes (such as Robot Structural Analysis, Ansys, or others). Geometric elements were introduced in the process of creating new families, which were subsequently adapted for inclusion in the analytical model in the form of slabs and bars.

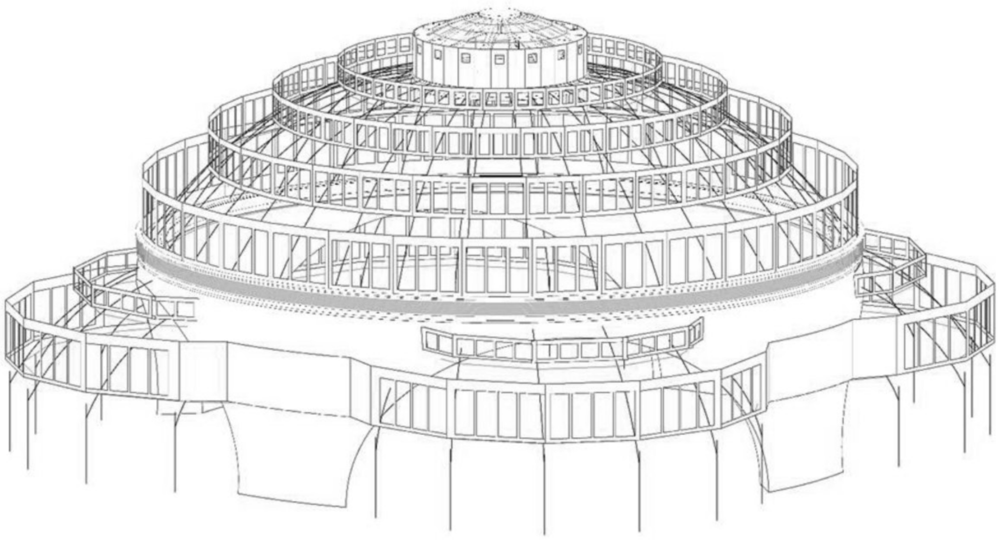

Fig. 4.46. Analytical model generated on the basis of the BIM model.

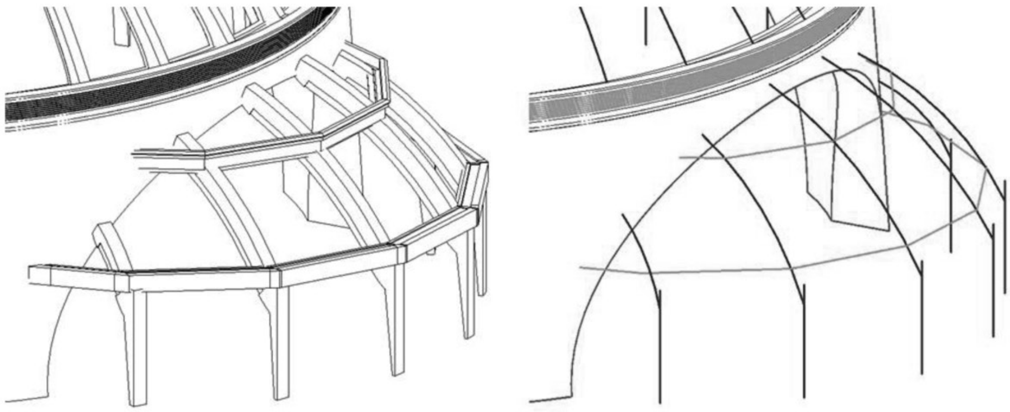

Fig. 4.47. The BIM model (on the left) and the analytical model (on the right) compared.

The BIM model with its analytical model for static and strength calculations, was generated based on images obtained from 3D scanning. This allows assessment of the strain of the structure in relation to its present geometry. In the case of structures with high universal value (e.g. UNESCO World Heritage sites) a programme of ongoing monitoring over time is recommended involving, inter alia, repeated scanning of the building. That is why it was necessary to select a bench mark – a constant geodetic point - to which all subsequent scans can be referred. After importing the subsequent scan and creating *.rcs files, it will be possible to import the results of repeated scans to the BIM model (as a *.rvt file). Measurements of displacement can be carried out using an applet written using the C# or VB.Net language, which takes into account the following functions:

1) Calculating standard vectors for each of the points in the cloud based on adjacent points.
2) Projecting points onto the geometry in the Revit software along a standard vector.
3) Measuring the distance between the original point and the one projected onto the geometry.
4) Data displayed as a 3D diagram.

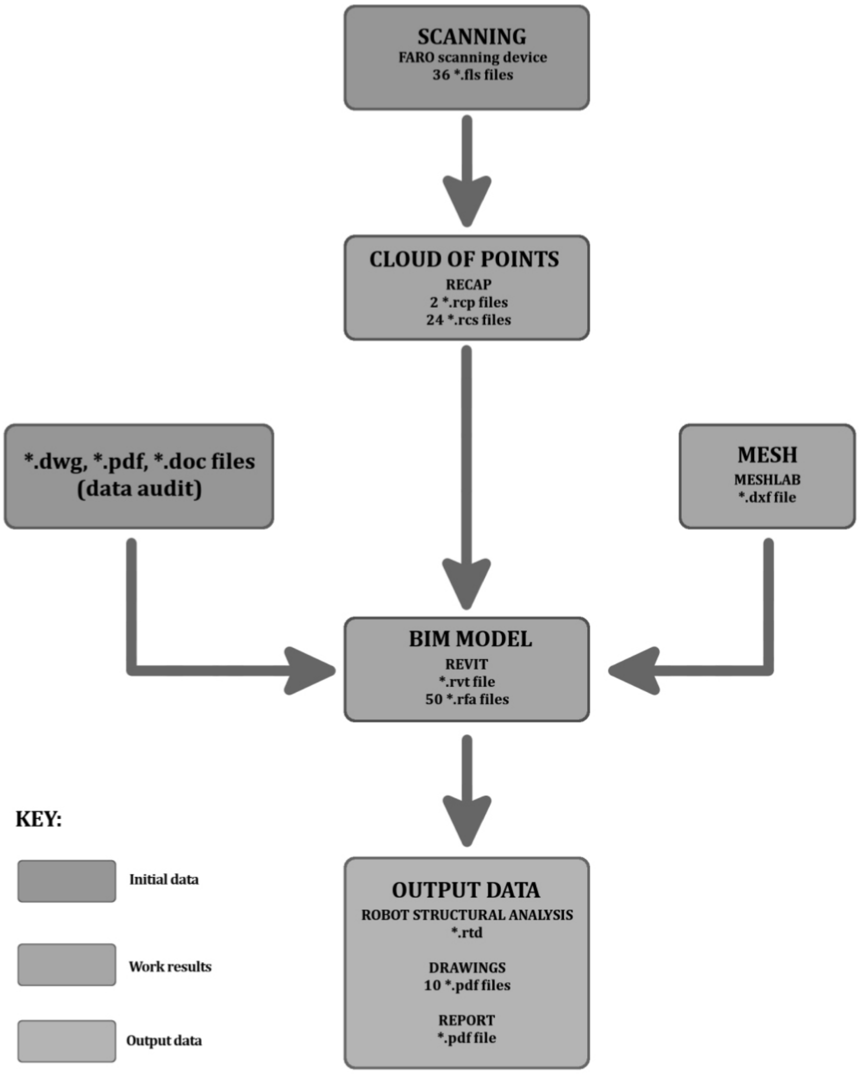

Fig. 4.48. Schema describing creation of a BIM model from a cloud of points

Summing up:

1) It is possible to generate BIM models with Revit software for processing clouds of points.
2) There are applets for the Revit software which facilitate processing clouds of points. They enable, inter alia, automatic generation of working planes based on selected points and importing clouds of points to family templates. Some of them can work with programmes dedicated to processing 3D scanning images, which makes importing clouds of points to the Revit software easier.
3) A benchmark is necessary for measuring changes in the geometry of a building. Repeat 3D scans should then be carried out with reference to the benchmark to allow monitoring of deformations and changes to the geometry of the building etc.
4) An applet written using the C# or VB.Net language is necessary for measuring the distance between the cloud of points and the BIM model.
5) Changes to the *.dwg documentation enable monitoring of changes in the building and updating of the BIM model.

4.2.2. BIM II

The aim of BIM modelling is to obtain an accurate and faithful projection of the geometry of structural elements of the Hall in a computer generated model, which is based on the spatial scanning completed. This section compares using the results of scanning of the building for twonmodelling approaches in order to indicate to what extent the models generated can be useful and how they can be used in the future.

The study dealt with generating a computer model of the following structural elements of the Centennial Hall:

1. the lantern,
2. the top ring,

3. ribs of the dome,
4. the bottom ring,
5. the arcades,
6. the cylinder,
7. the side lobbies.

The spatial BIM model comprises individual elements of the structure of the Centennial Hall.

1) The lantern – the axis of the lantern was positioned using the interpolation of cylindrical surfaces. The support points for the lantern ribs were determined on the top ring. A surface of a sphere was interpolated and inscribed in the bottom surface of the ribs.
2) The top ring – the axis of the ring was determined as a result of interpolation of the surface of the internal ring. Next, the plane of the axis was determined. The section of the ring was plotted. The section was rotated about the axis, generating a solid.
3) The ribs of the dome – the surfaces limiting a rib (walls) were determined. A cylinder was inscribed in the bottom arches and top ribs. As a result of the operation on planes, a rib was generated.
4) The bottom ring – using the cylindrical surfaces, the axis of the ring was interpolated. The plane of the axis was determined and the cross section of the ring was outlined. The surfaces of the ring were generated with a rotation around its axis.
5) The arcades – too many defects and shortcomings in the cloud of points prevented effective generation of solids.
6) The cylinder – the axis of the internal surface of the cylinder was determined.
7) The side lobbies – The horizontal surface was determined, the external floor plan was outlined and drawn up to the level of the side lobbies.

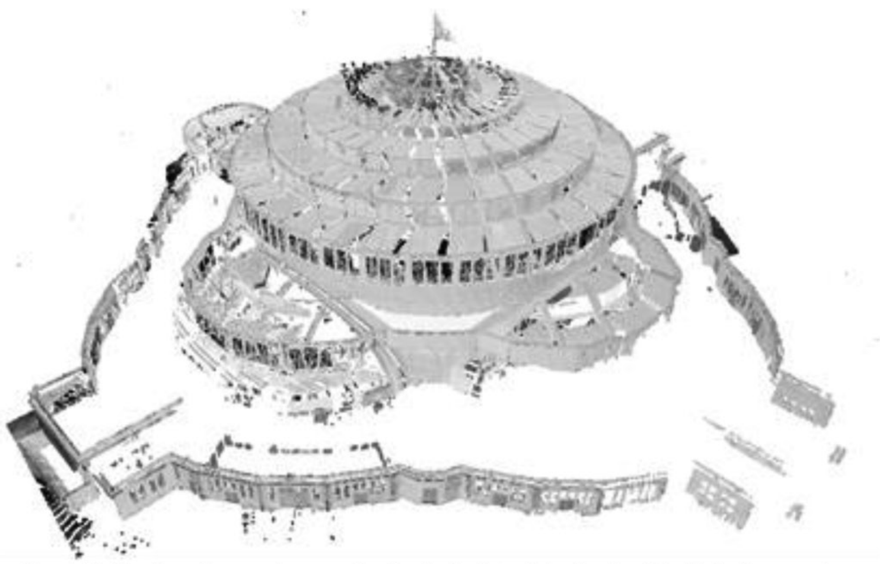

Fig. 4.49. The Faro Scane software – the cloud of points of the façade of the Hall after merging.

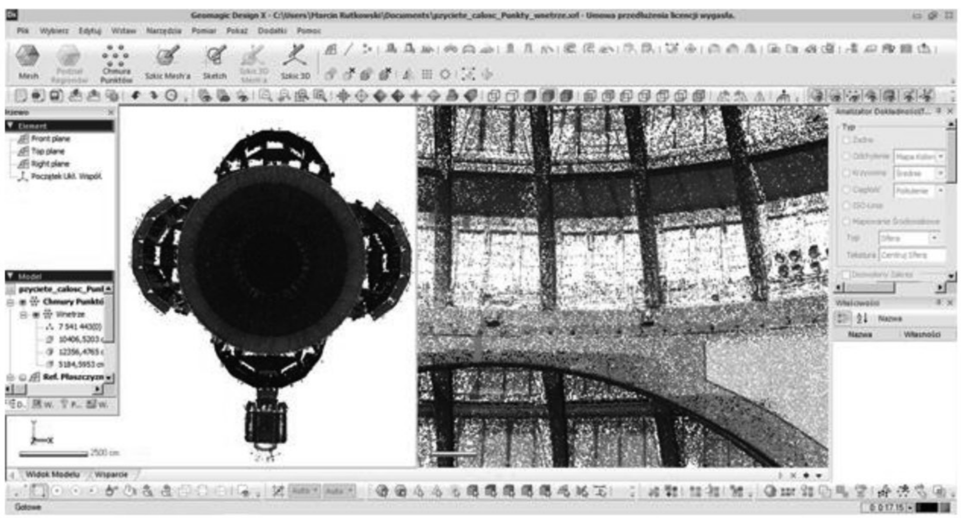

Fig. 4.50. The Geomagic Design X software – the cloud of points of the interior of the Hall after merging, removing unnecessary data and reduction.

The individual files of the cloud of points were positioned in relation to one another using the Faro Scan software. This process is called registration. It can be facilitated with marking tokens (such as plates, spheres) placed in the object being scanned or GPS devices used in the process of scanning. In the case of the Hall, checkerboards stuck to the walls of the building were used.

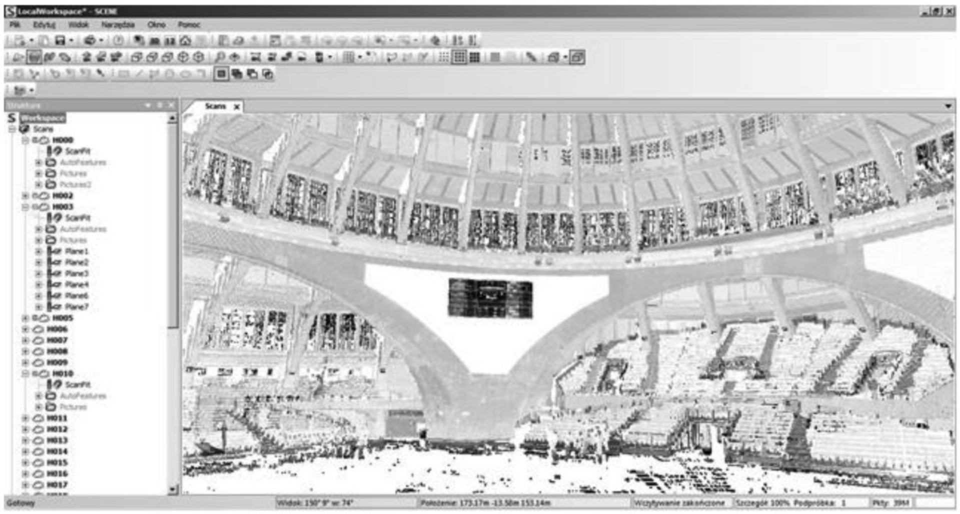

Fig. 4.51. The Faro SCANE software – the cloud of points after registration.

The individual files of the cloud of points were uploaded, cleared of any unnecessary material and reduced to match the computational cabilities of the equipment, the needs and the experience of persons involved in processing data. The basic assumption used in clearing data was to remove points located at a long distance from the scanning station and to remove all elements irrelevant for the observation (i.e. waste bins, benches, posts, vehicles etc.). The number of points on flat planes was also reduced.

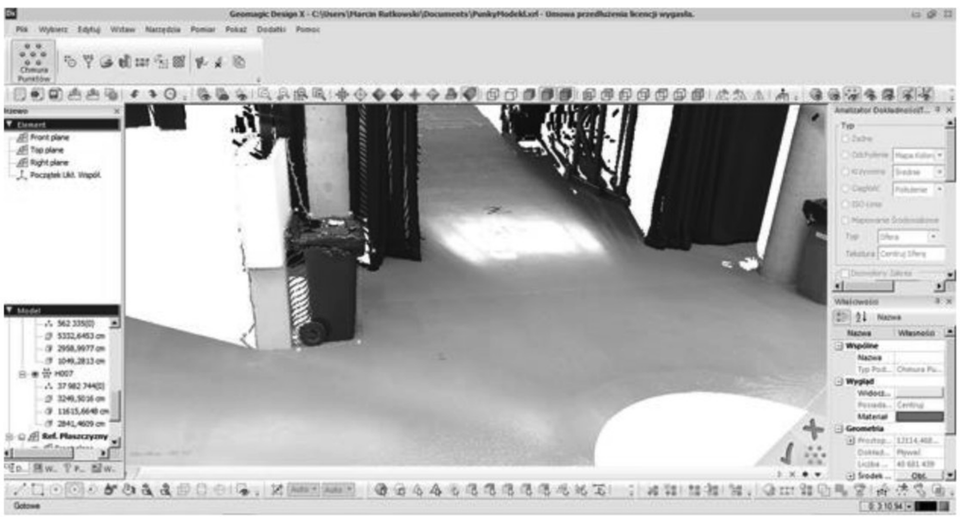

Fig. 4.52. The Geomagic Design X software – an irrelevant element to be deleted – a waste bin. Most of such elements could have been removed before scanning, which would have reduced the time needed for data processing.

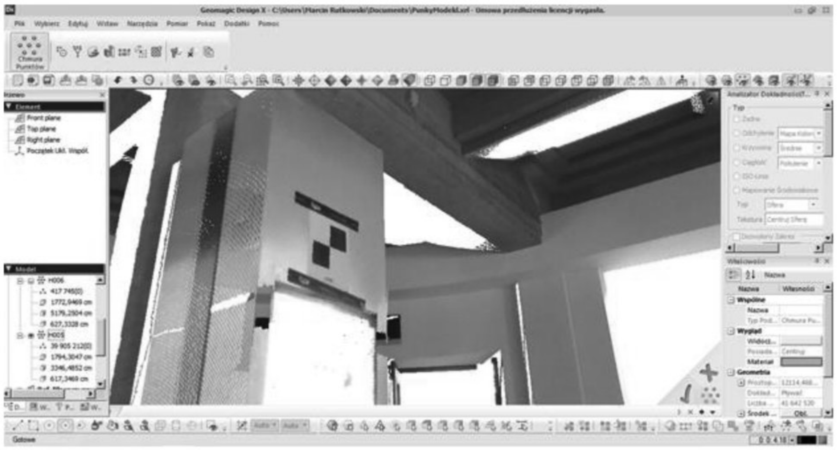

Fig. 4.53. The Geomagic Design X software – a cloud of points before sampling. A plate for scan registration.

Individual elements to be analysed were separated from the cloud of points, which was divided into smaller clouds. The models of the following elements were generated:

1) the cylinder (its internal surface);
2) the arcades (ribs);
3) the bottom ring (its internal surface);
4) the ribs of the dome;
5) the top ring;
6) the lantern;
7) the side lobbies (irrelevant for the results of the study, excluded from modelling).

The individual clouds of points were used to generate a grid of triangles. The surface of the triangles adhering to each other was divided into areas of a similar geometry, e.g. fragments of: a sphere, pipe, cylinder, flat or wavy surfaces. Each of the basic geometries comprised its own characteristic points or axes. On the basis of this feature, solids and planes were interpolated for selected grids and used to generate a faithful and accurate model. Each solid can be referred to a grid of triangles or a cloud of points in order to obtain information on deviations.

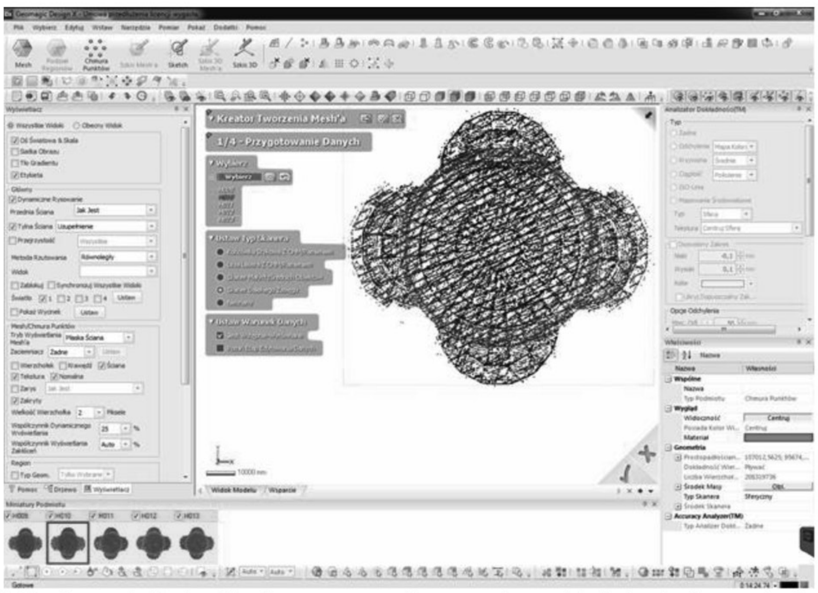

Fig. 4.54. The Geomagic Design X software – creator for generating a grid of triangles from a cloud of points.

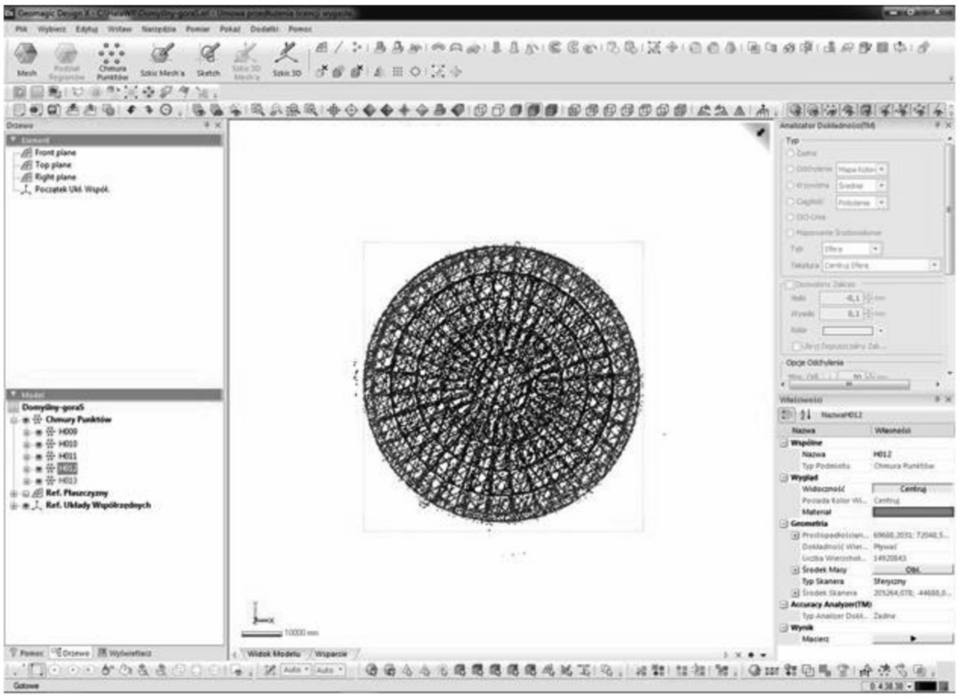

Fig. 4.55. The Geomagic Design X software – a reduced cloud of points prepared for modelling of the ribs, the top ring and the lantern.

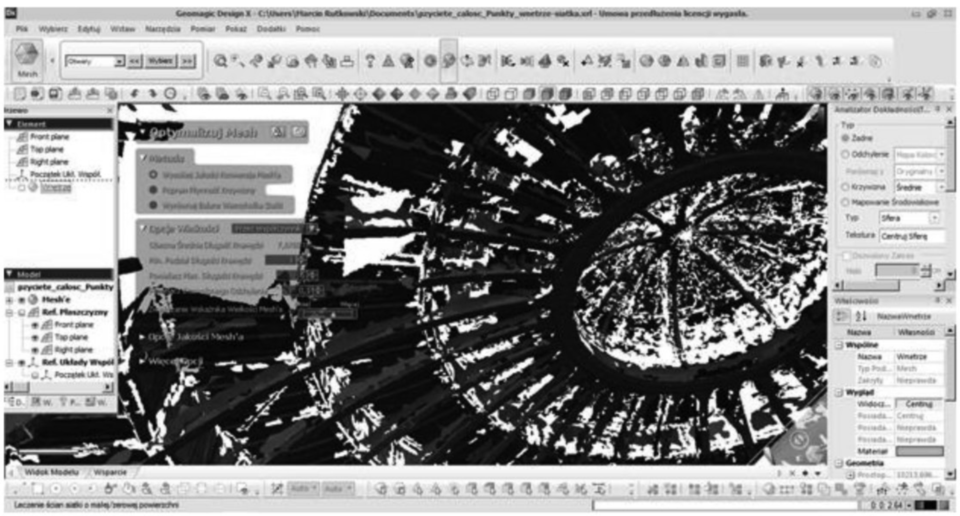

Fig. 4.56. The Geomagic Design X software – the grid of triangles (with an overly sparse cloud of points).

The spatial BIM model comprises individual elements of the structure of the Centennial Hall.

1) The lantern – the axis of the lantern was positioned using the interpolation of cylindrical surfaces. The support points for the lantern ribs were determined on the top ring. A surface of a sphere was interpolated and inscribed in the bottom surface of the ribs.
2) The top ring – the axis of the ring was determined as a result of interpolation of the surface of the internal ring. Next, the plane of the axis was determined. The section of the ring was plotted. The section was rotated about the axis, generating a solid.

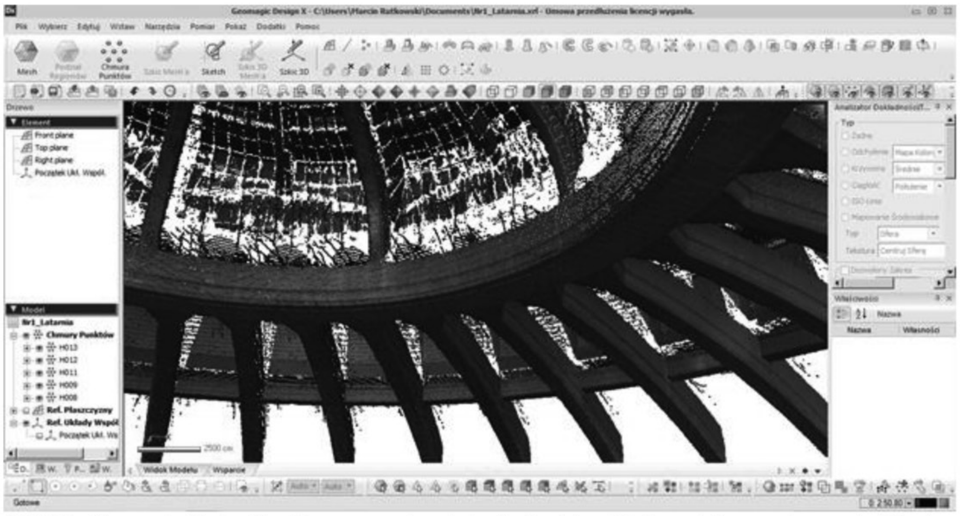

Fig. 4.57. The Geomagic Design X software – a reduced cloud of points of high resolution – a fragment of the top ring.

Fig. 4.58. The Geomagic Design X software – the grid of triangles generated from the high resolution cloud of points.

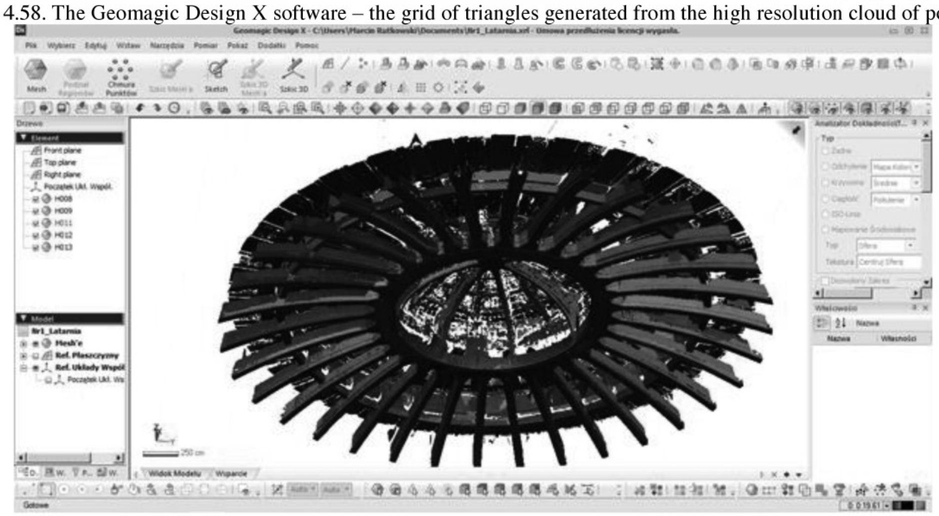

Fig. 4.59. The Geomagic Design X software – division of the grid of triangles into surfaces which can be recognised by the software (flat, spherical, cylindrical or wavy).

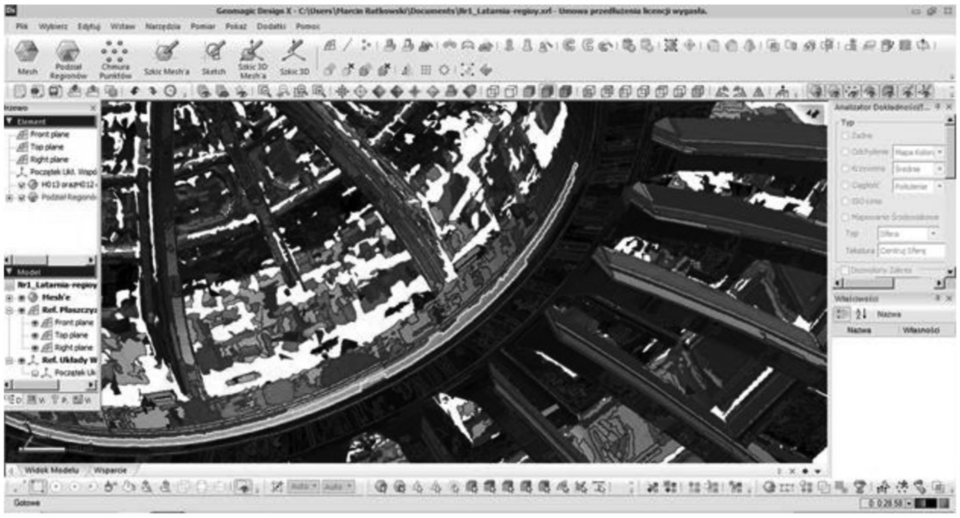

Fig. 4.60. The Geomagic Design X software – the highlighted surface fragment has a centre of rotation, which enables interpolation of the centre of the top ring.

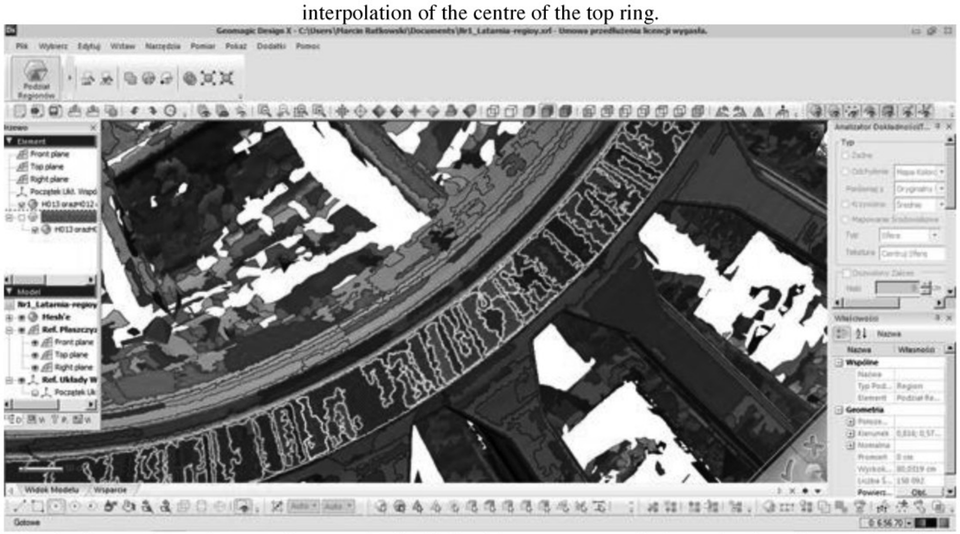

Fig. 4.61. The Geomagic Design X software – the highlighted fragments are added together in order to reduce the number of separate elements.

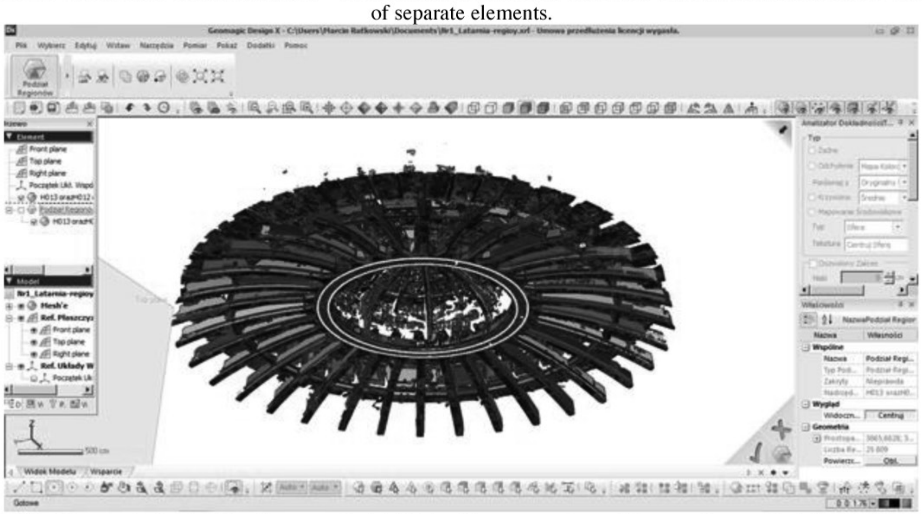

Fig. 4.62. The Geomagic Design X software – the highlighted bottom surface of the top ring resulted from adding together fragments of surfaces

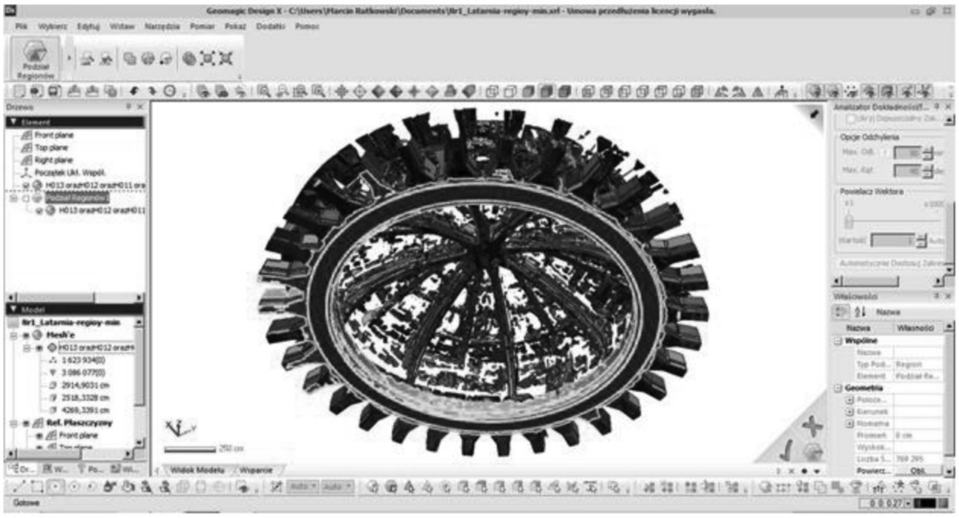

Fig. 4.63. The Geomagic Design X software – the highlighted fragments of the surface of the top ring.

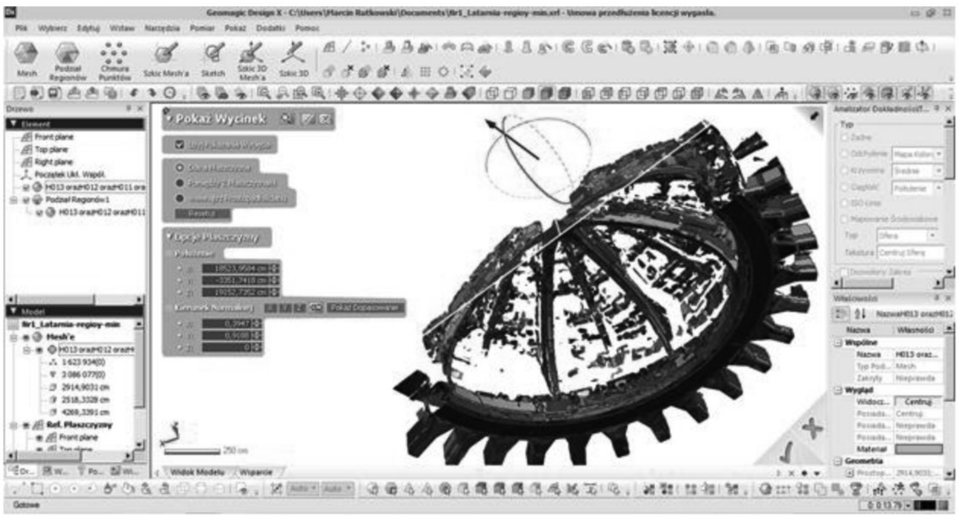

Fig. 4.64. The Geomagic Design X software – the cross section of the lantern.

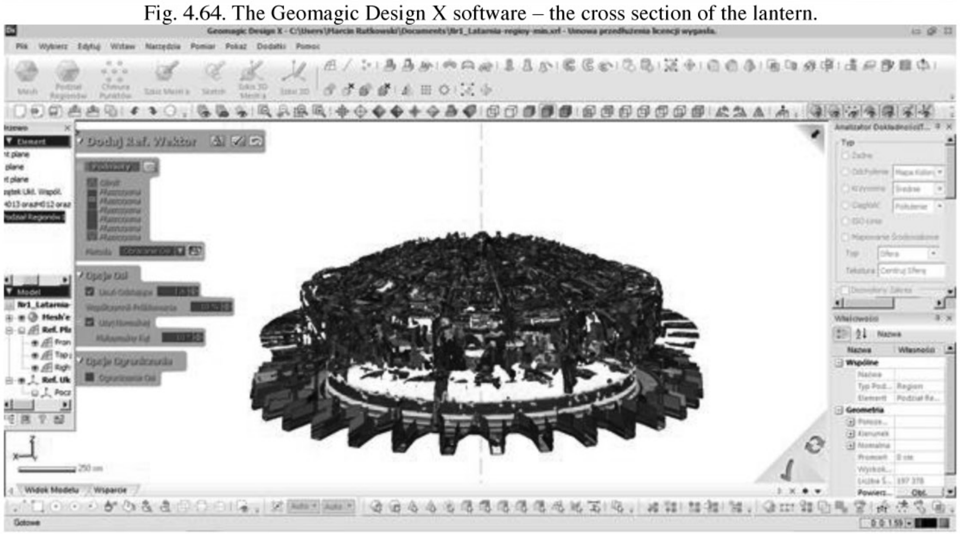

Fig. 4.65. The Geomagic Design X software – interpolation of the surface rotational axis vector for the surfaces making up the top ring

.

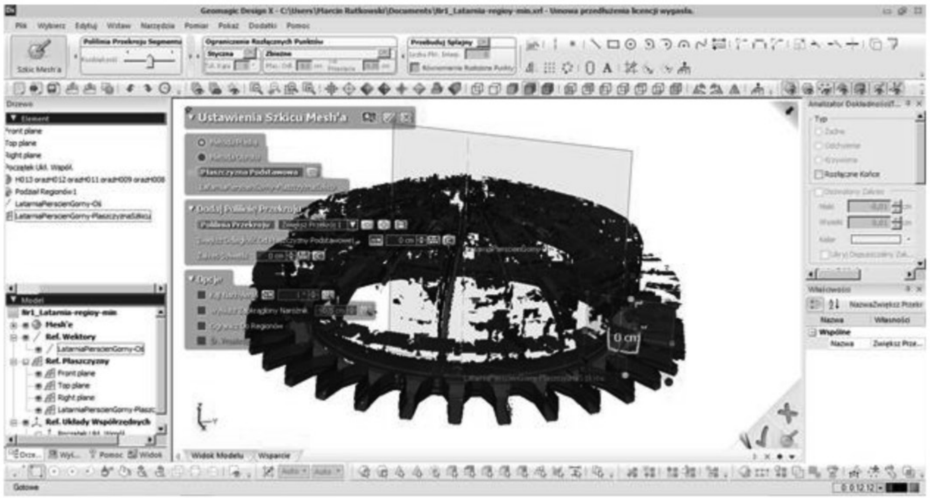

Fig. 4.66. The Geomagic Design X software – defining the surface and the cross-section of the top ring using a grid of triangles

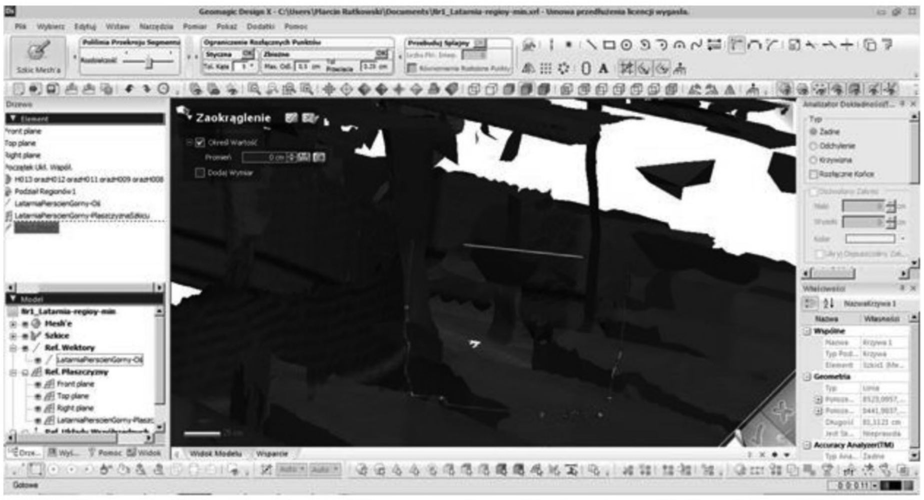

Fig. 4.67. The Geomagic Design X software – The cross section of the top ring and interpolation of the segments of the outline.

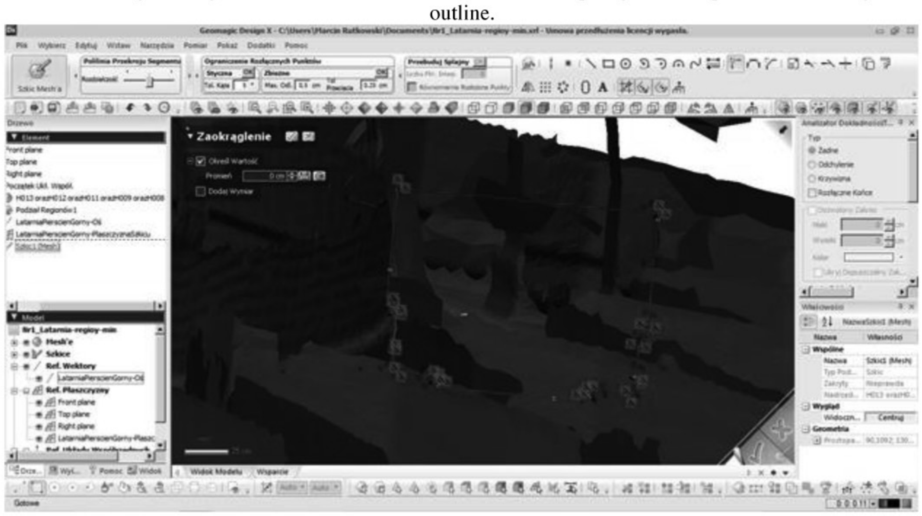

Fig. 4.68. The Geomagic Design X software – merging, appropriate phasing of an element cross-section

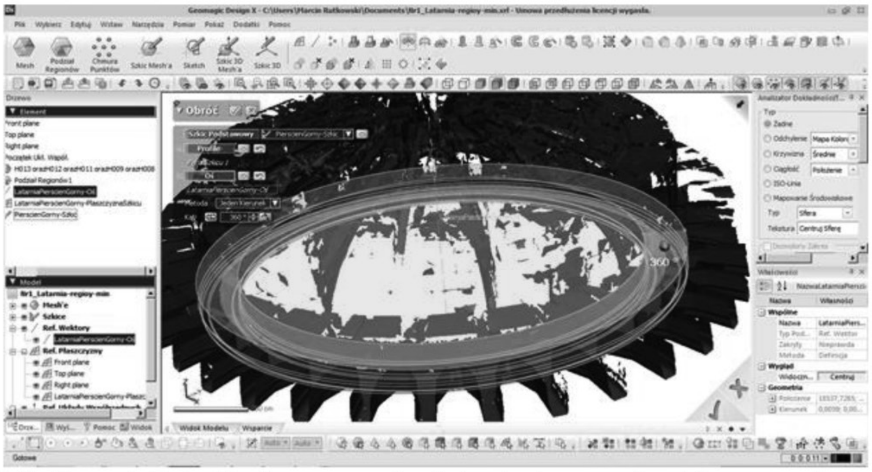

Fig. 4.69. The Geomagic Design X software – generating the top ring by means of a rotating cross-section around the reference vecor

Fig. 4.70. The Geomagic Design X software – superimposing the element generated on a cloud of points in order to correct the largest differences in the model

3) The ribs of the dome – the surfaces limiting a rib (walls) were determined. A cylinder was inscribed in the bottom arches and top ribs. As a result of the operation on planes a rib was generated.

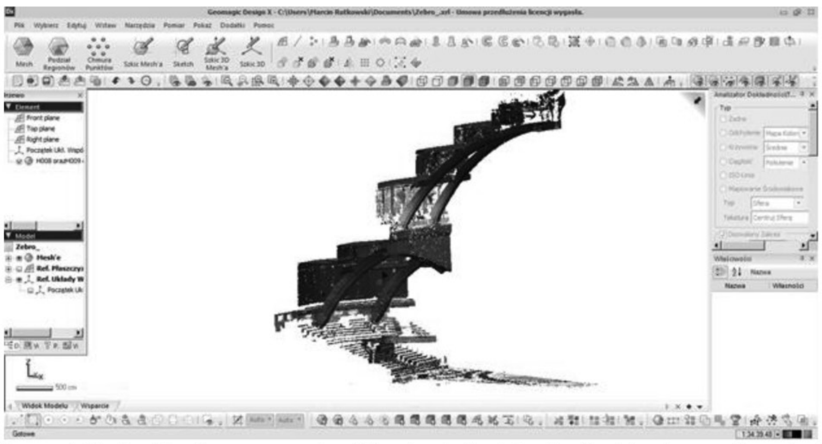

Fig. 4.71. The Geomagic Design X software – a sector of the cloud of points of a rib of the dome and arcades in an isometric view.

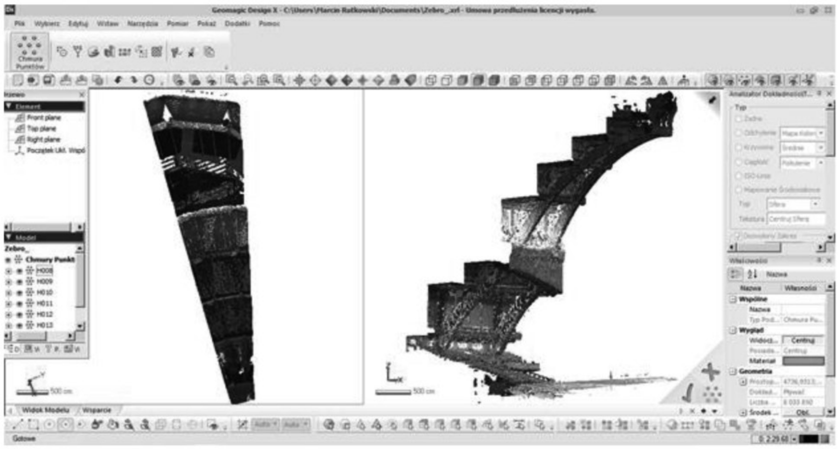

Fig. 4.72. The Geomagic Design X software – a sector of the cloud of points of a rib of the dome and arcades.

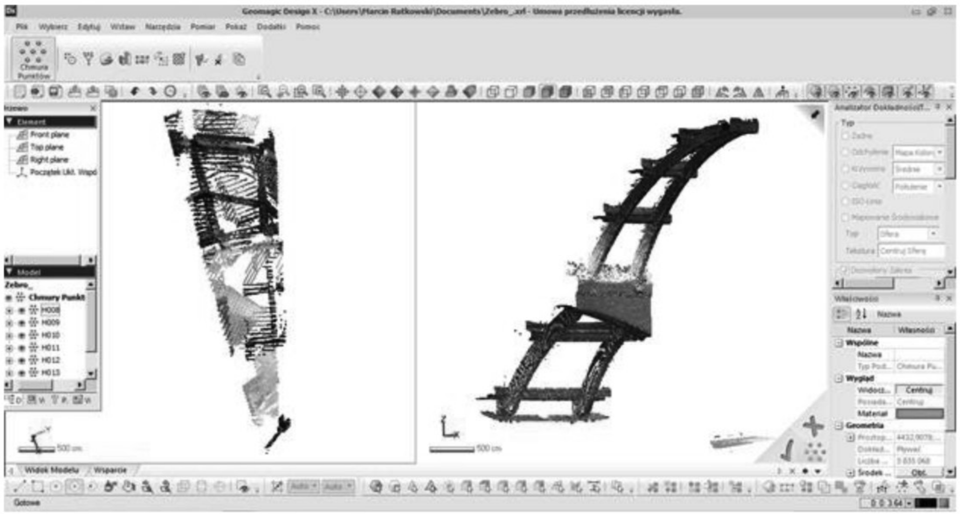

Fig. 4.73. The Geomagic Design X software – clearing of a sector of the cloud of points for a rib.

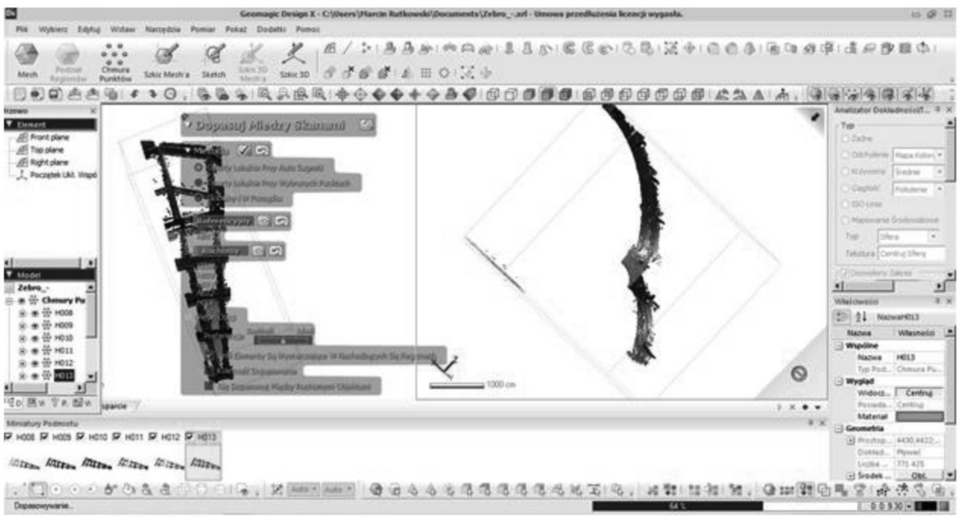

Fig. 4.74. The Geomagic Design X software – correcting scans superimposed upon one another.

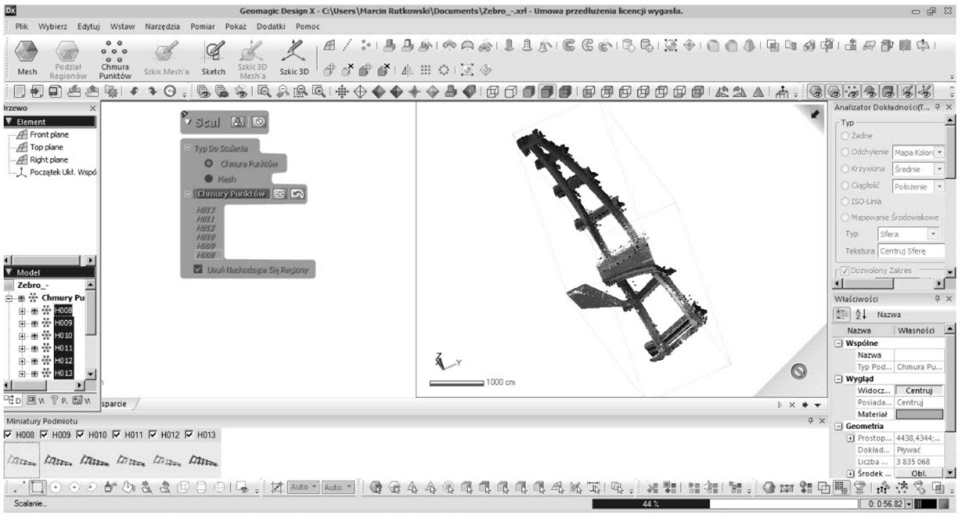

Fig. 4.75. The Geomagic Design X software – merging of matching scans.

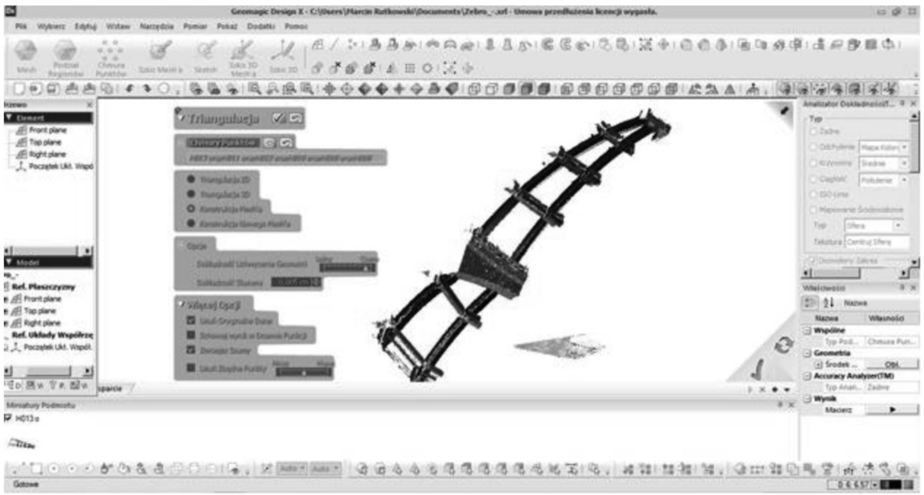

Fig. 4.76. The Geomagic Design X software – generation of a grid of triangles for a fragment of the cloud of points of high resolution.

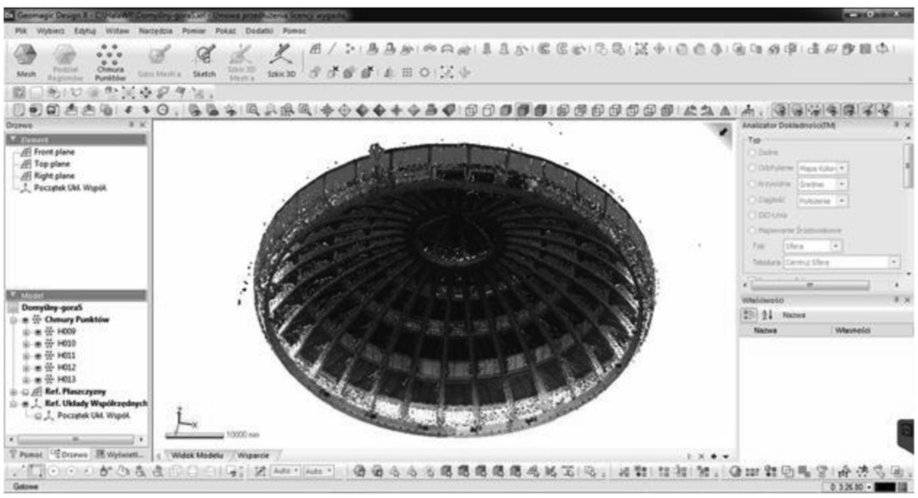

Fig. 4.77. The Geomagic Design X software – the cloud of points for the bottom ring, ribs, the top ring and the lantern.

4) The bottom ring – using the cylindrical surfaces, the axis of the ring was interpolated. The plane of the axis was determined and the cross section of the ring was outlined. The surfaces of the ring were generated with a rotation around its axis.
5) The arcades – too many defects and shortcomings in the cloud of points prevented effective generation of solids.
6) The cylinder – the axis of the internal surface of the cylinder was determined.

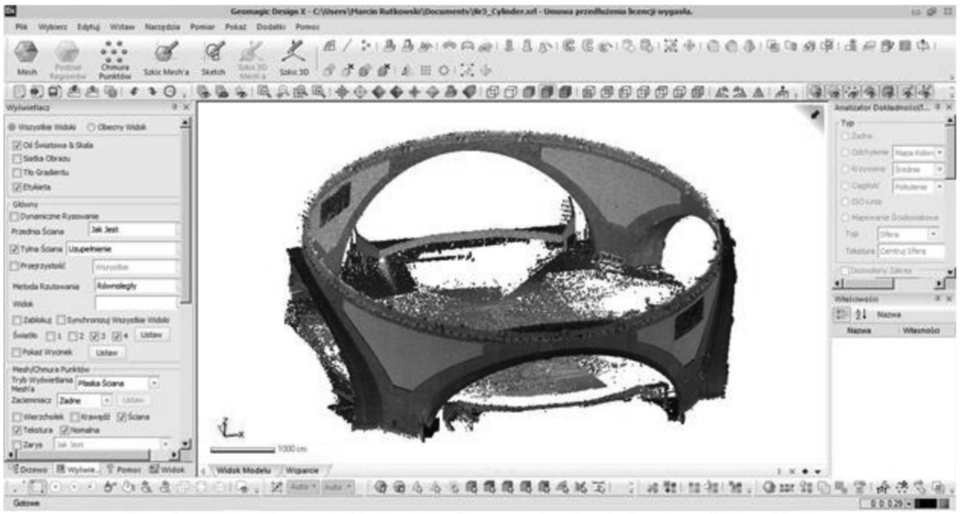

Fig. 4.78. The Geomagic Design X software – the cloud of points of the cylinder.

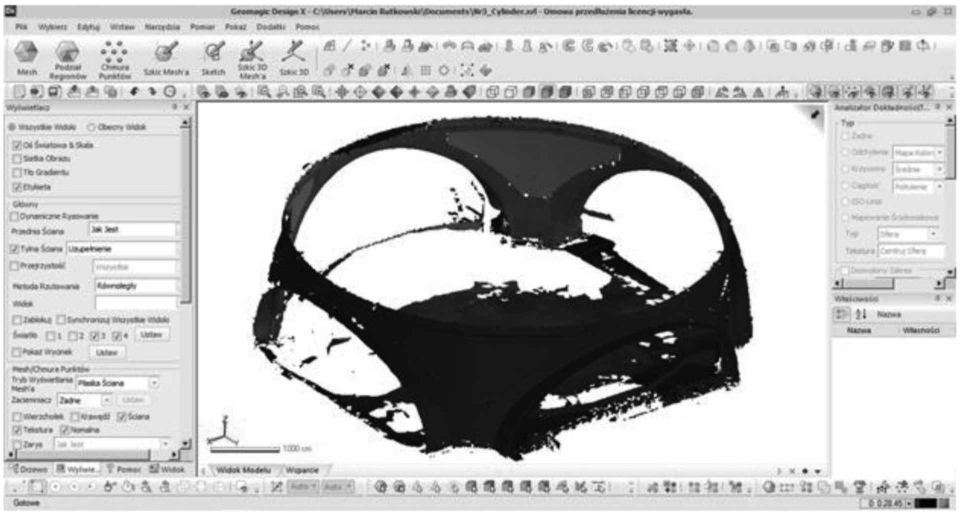

Fig. 4.79. The Geomagic Design X software – the grid of triangles of the cylinder with the textures added.

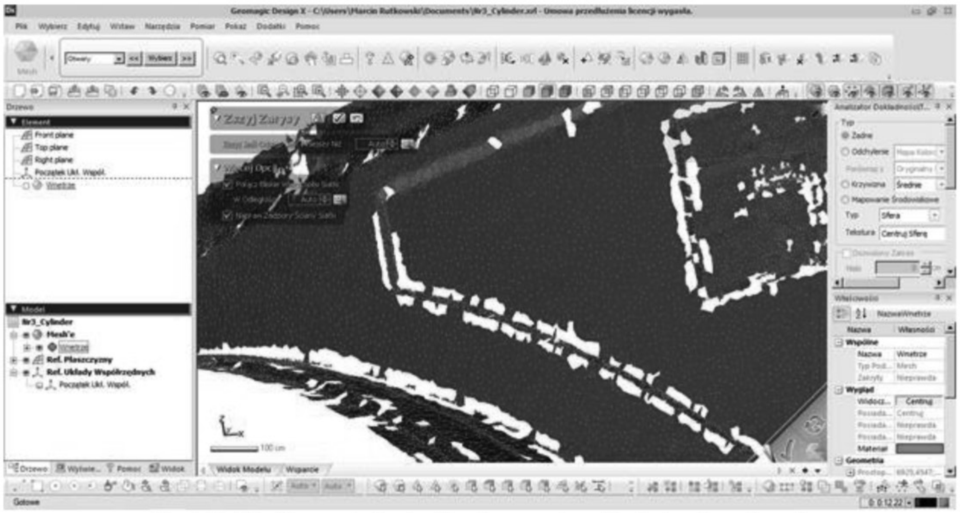

Fig. 4.80. The Geomagic Design X software – the grid of triangles enlarged.

Fig. 4.81. The Geomagic Design X software – the grid of triangles without the textures.

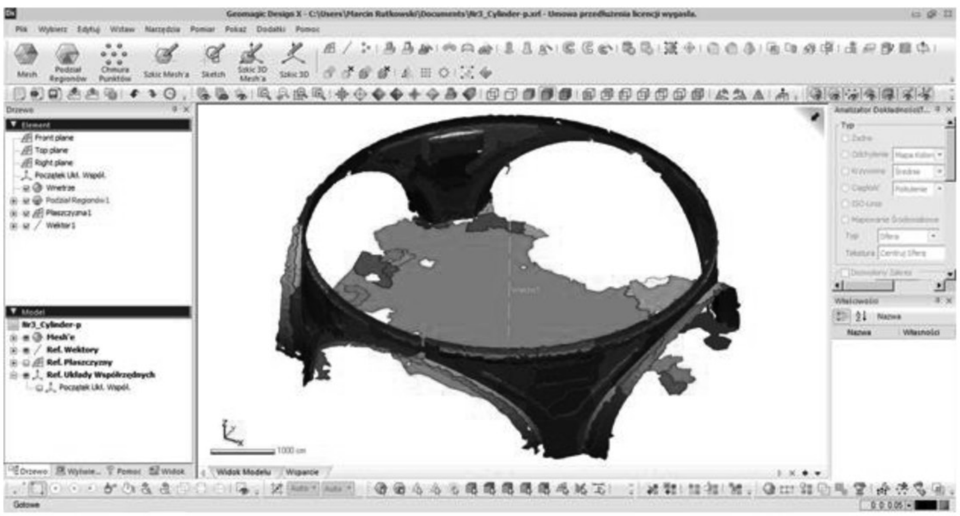

Fig. 4.82. The Geomagic Design X software – the division of the grid of triangles into definable fragments.

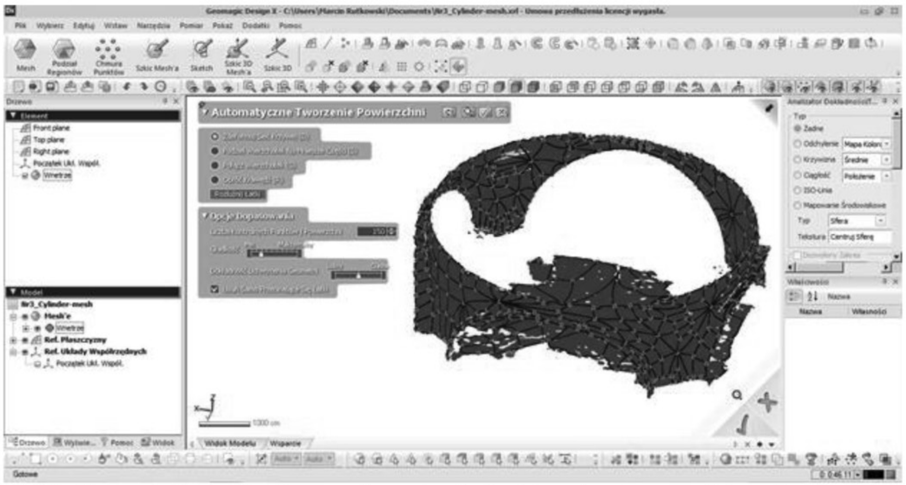

Fig. 4.83. The Geomagic Design X software – the results obtained from the generator of the surface from the grid of triangles.

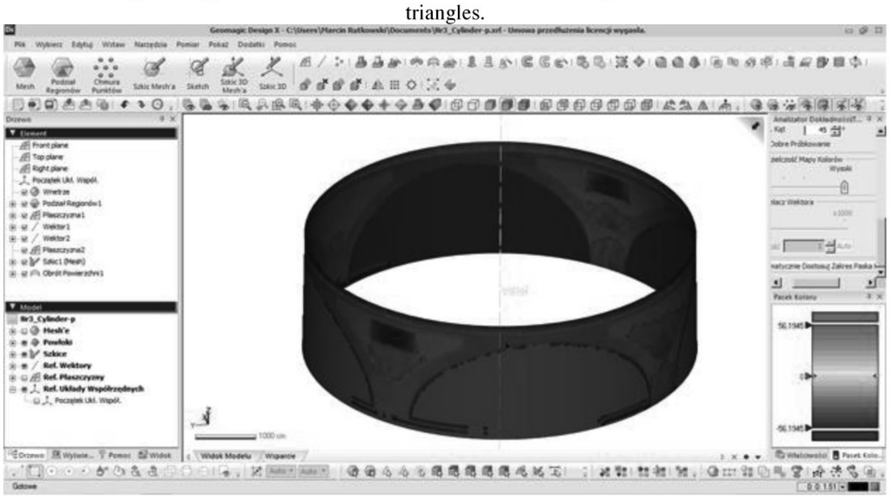

Fig. 4.84. The Geomagic Design X software – plotting of the cylinder and checking for differences in relation to the original cloud of points.

7) The side lobbies – The horizontal surface was determined, the external floor plan was outlined and drawn up to the level of the side lobbies.

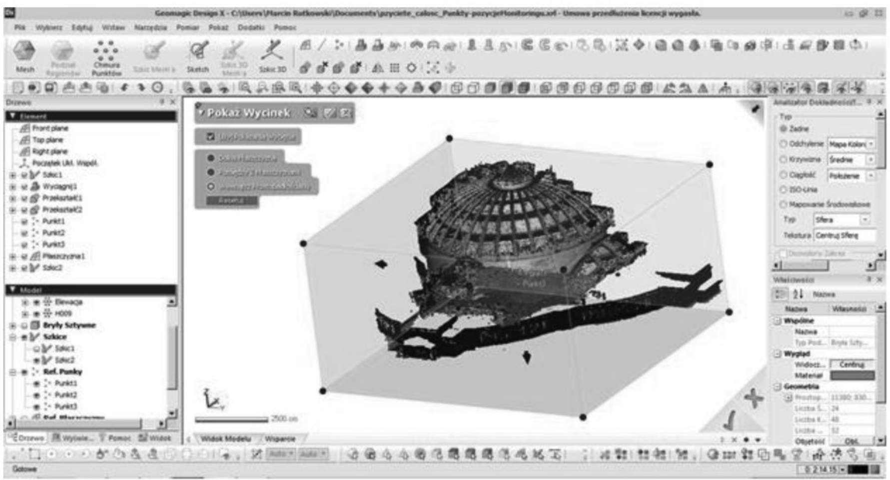

Fig. 4.85. The Geomagic Design X software – presentation of a selected sector enclosed in a solid

.

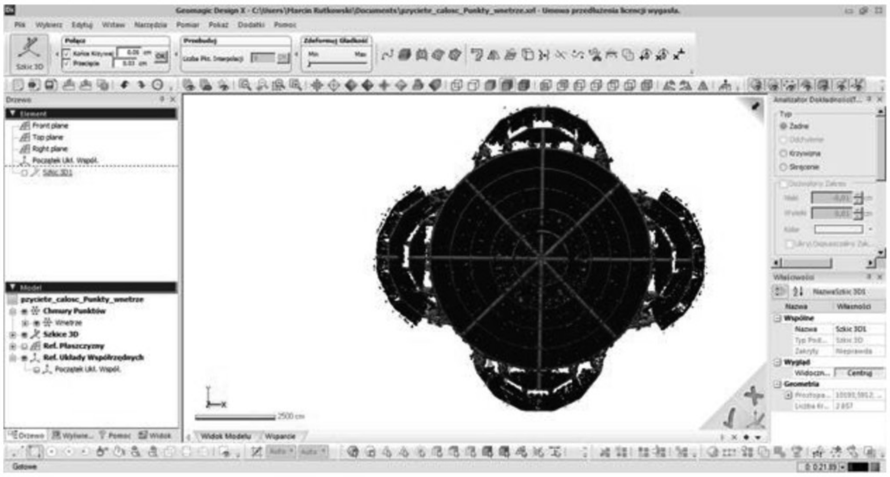

Fig. 4.86. The Geomagic Design X software – presentation of sections plotted using the 3D Sketch tool.

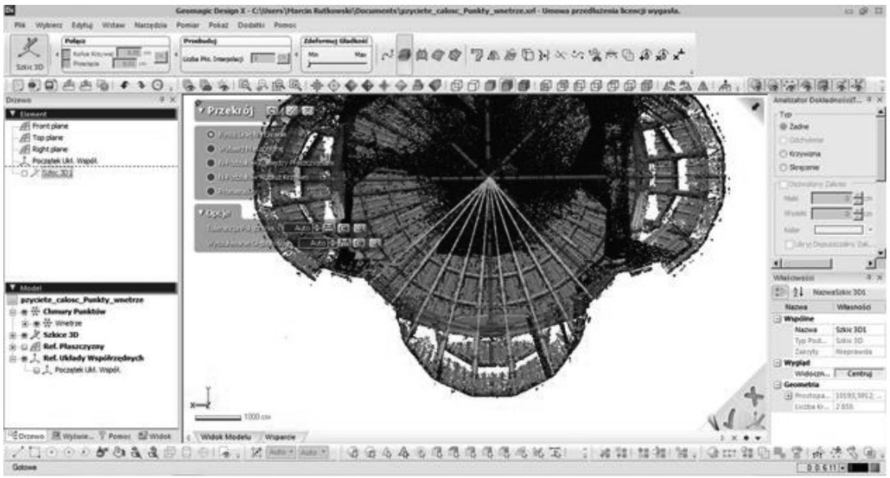

Fig. 4.87. The Geomagic Design X software – sections of ribs for a replicable segment of the Hall.

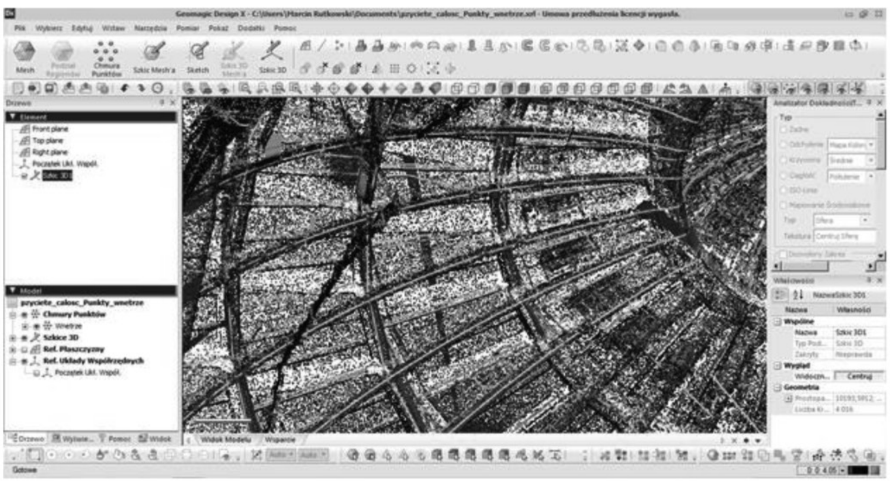

Fig. 4.88. The Geomagic Design X software – sections of the cloud of points.

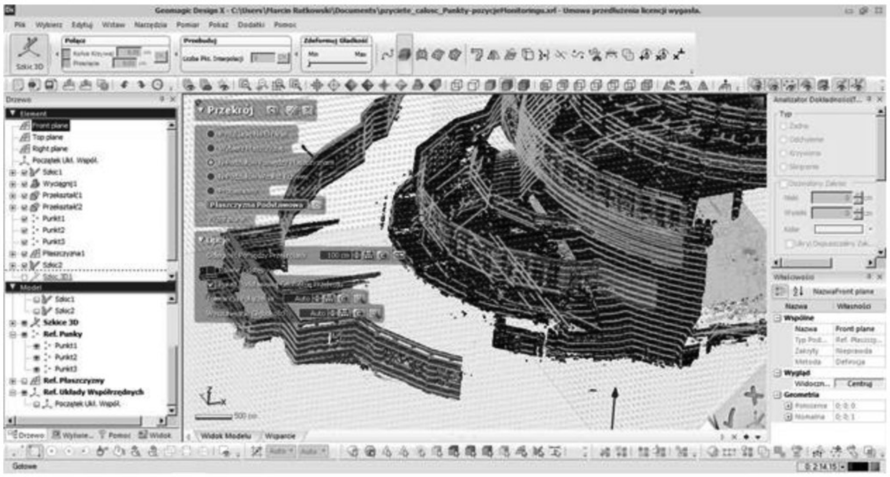

Fig. 4.89. The Geomagic Design X software – horizontal sections of the Hall with a constant spacing of 1.00m generated using the 3D Sketch tool.

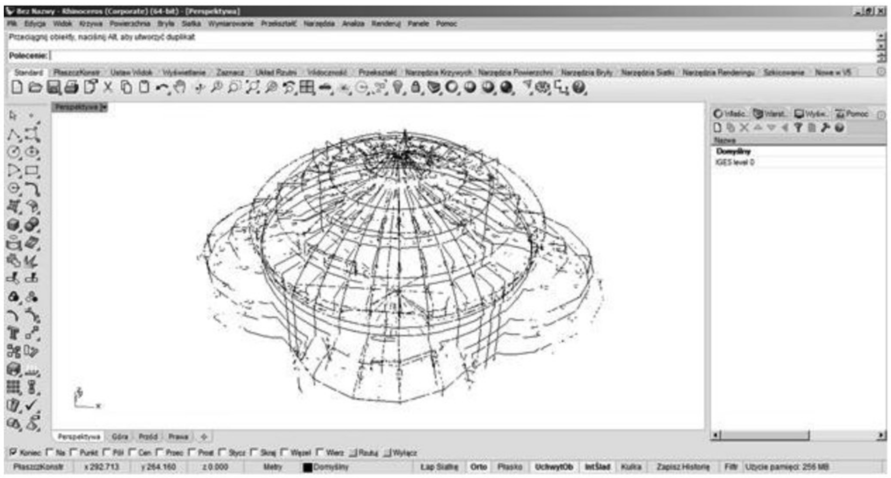

Fig. 4.90. The RhinoCeros software – the sections of the cloud of points imported from the Geomagic Design X software.

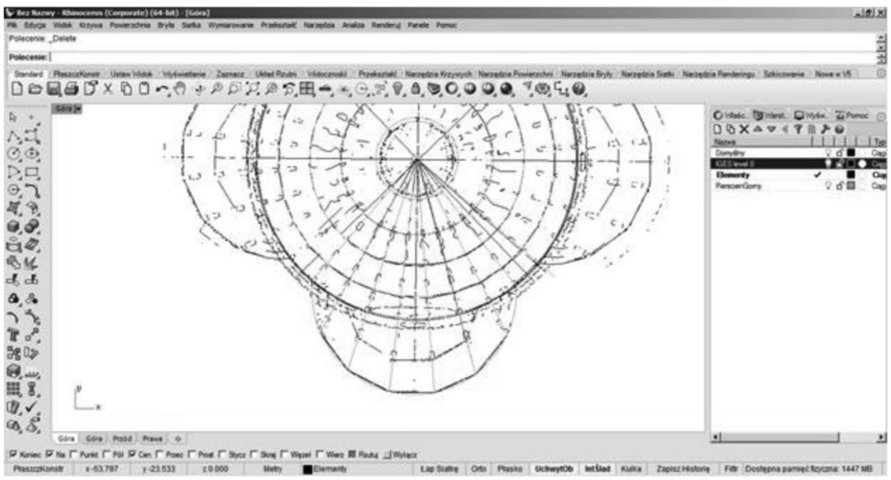

Fig. 4.91. The RhinoCeros software – plotting of the Hall's axes.

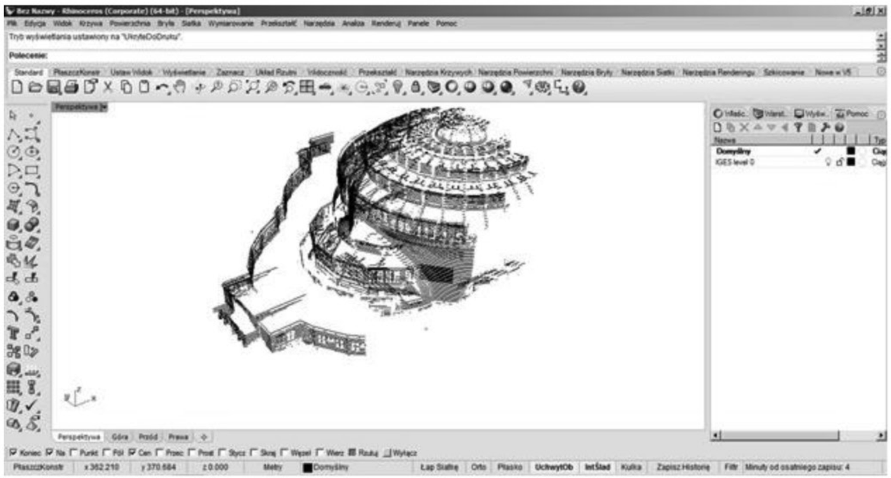

Fig. 4.92. The RhinoCeros software – importing the sections of the cloud of points generated by Geomagic Design X software.

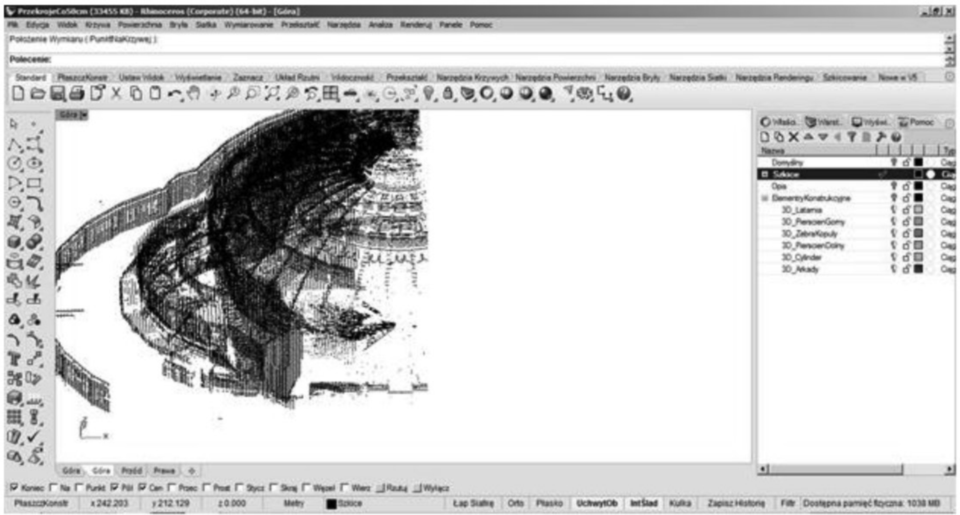

Fig. 4.93. The RhinoCeros software – a view of the grid of a section of the cloud of internal and external points of the Hall.

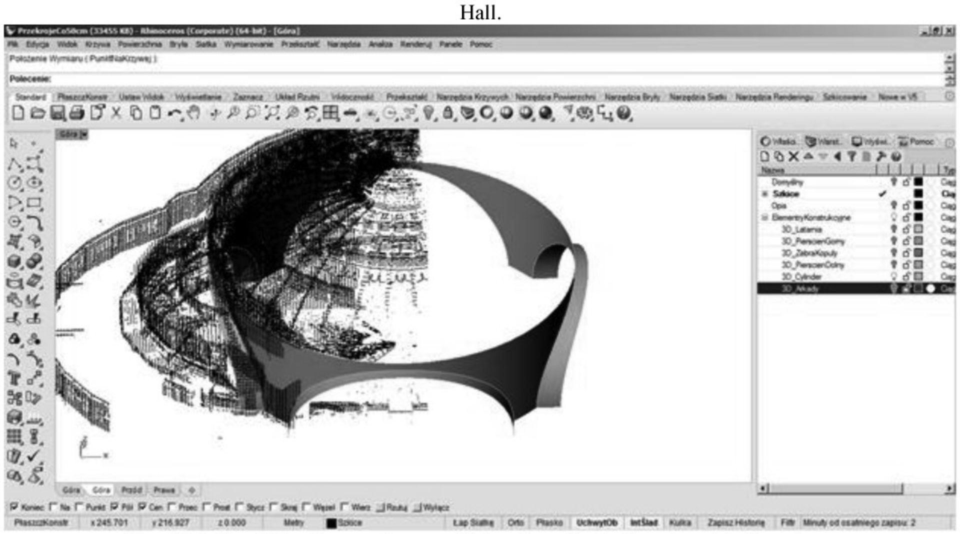

Fig. 4.94. The RhinoCeros software – fitting the cylinder into the grid of sections.

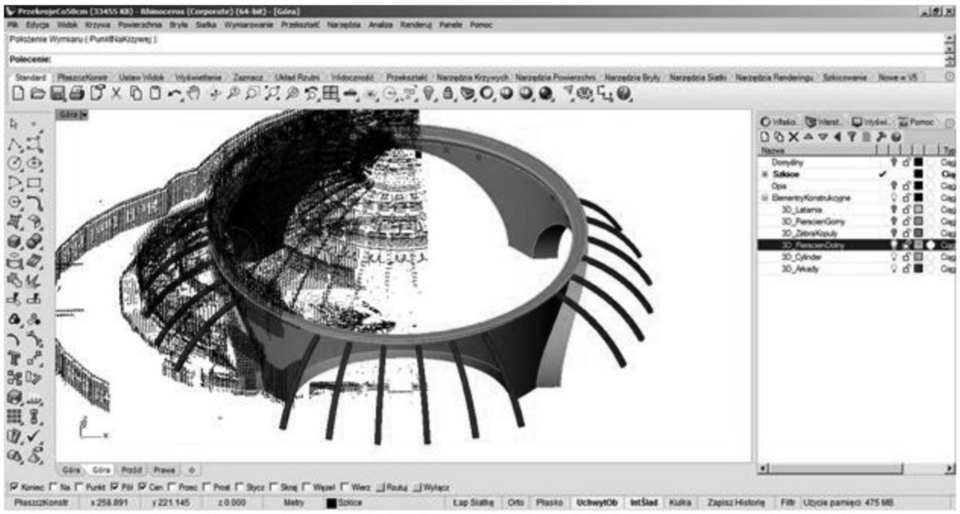

Fig. 4.95. The RhinoCeros software – fitting the arcade ribs and the bottom ring into the grid of sections.

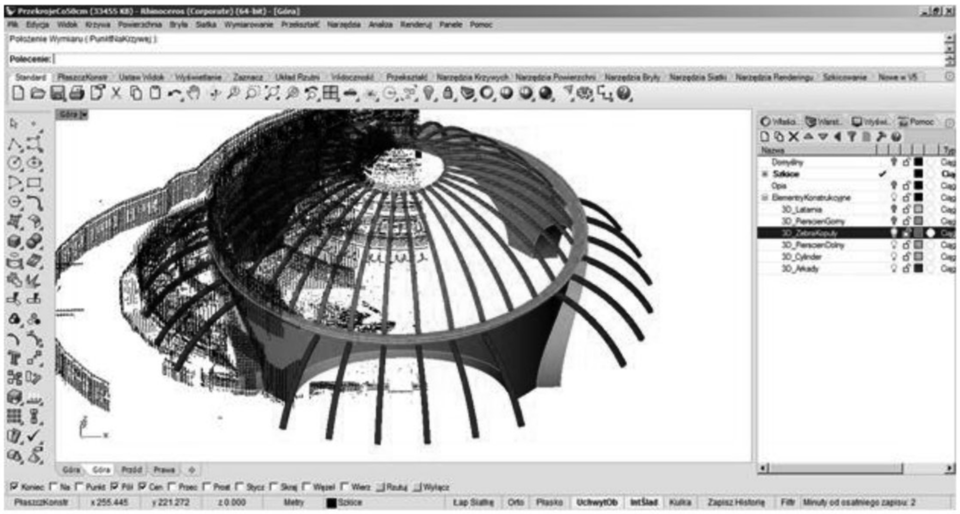

Fig. 4.96. The RhinoCeros software – fitting the ribs of the dome into the grid of sections.

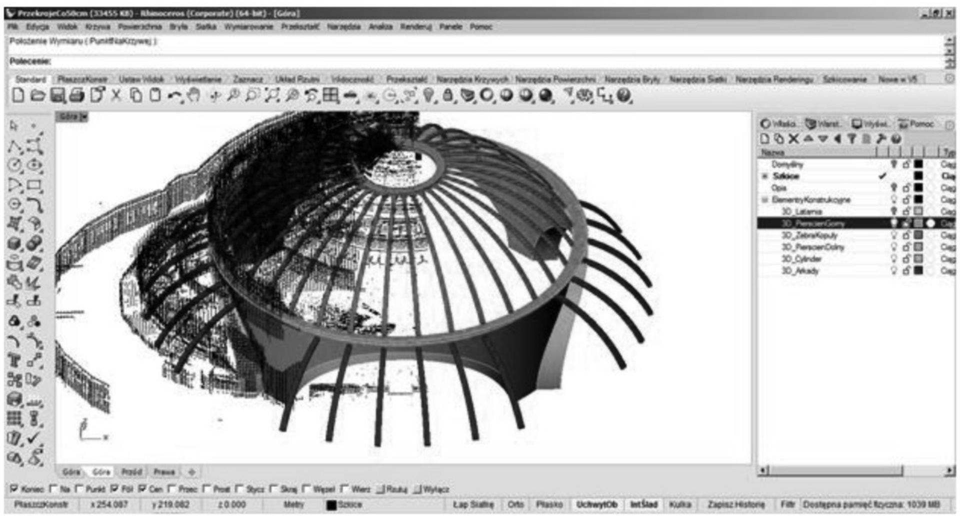

Fig. 4.97. The RhinoCeros software – fitting the top ring into the grid of sections.

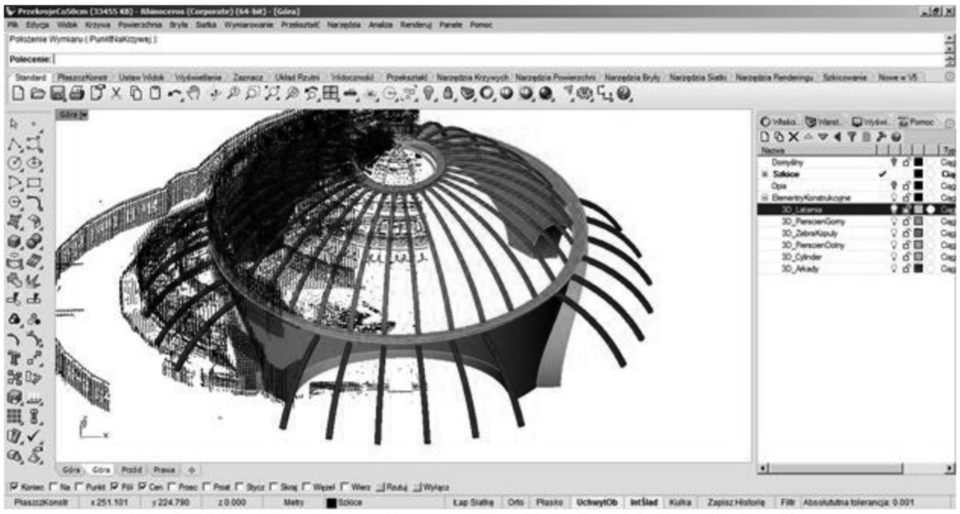

Fig. 4.98. The RhinoCeros software – fitting the lantern into the grid of sections.

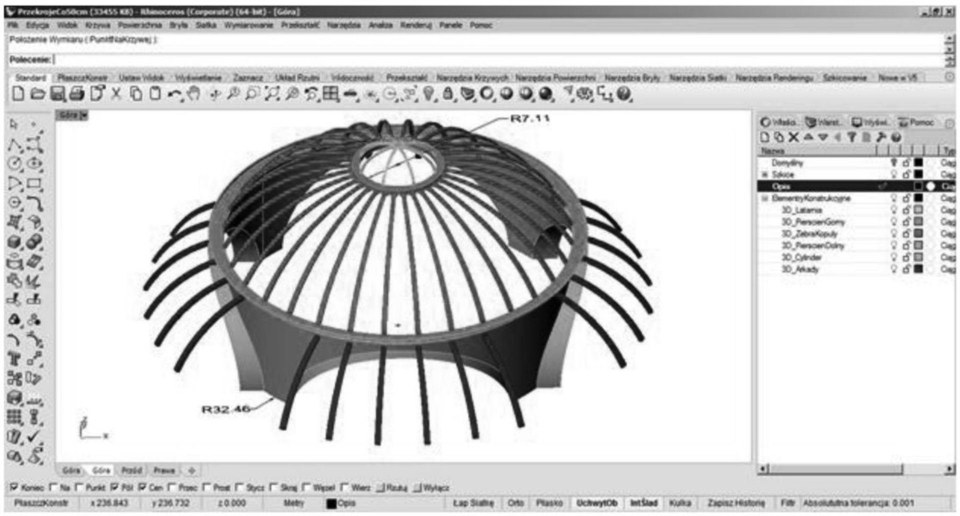

Fig. 4.99. The RhinoCeros software – the geometric model of the structural elements of the Hall.

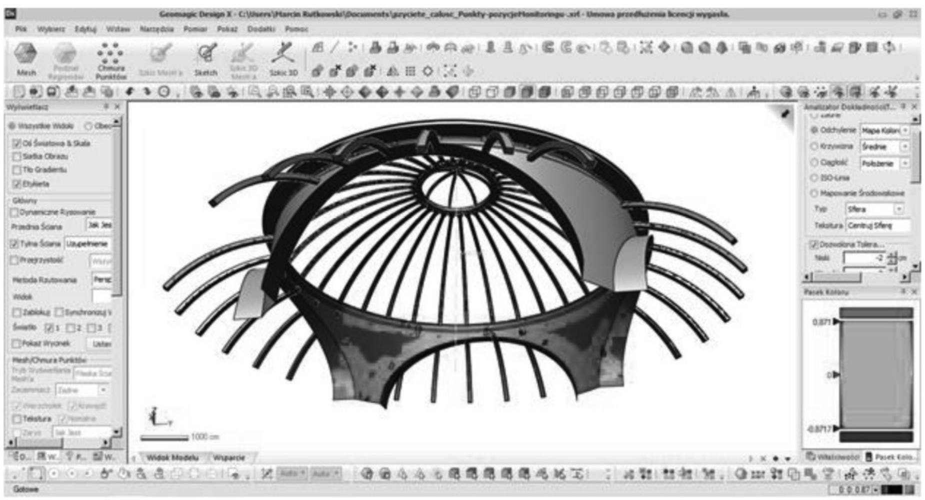

Fig. 4.100. The Geomagic Design X software – the map of deviations with respect to the cloud of points superimposed on the model.

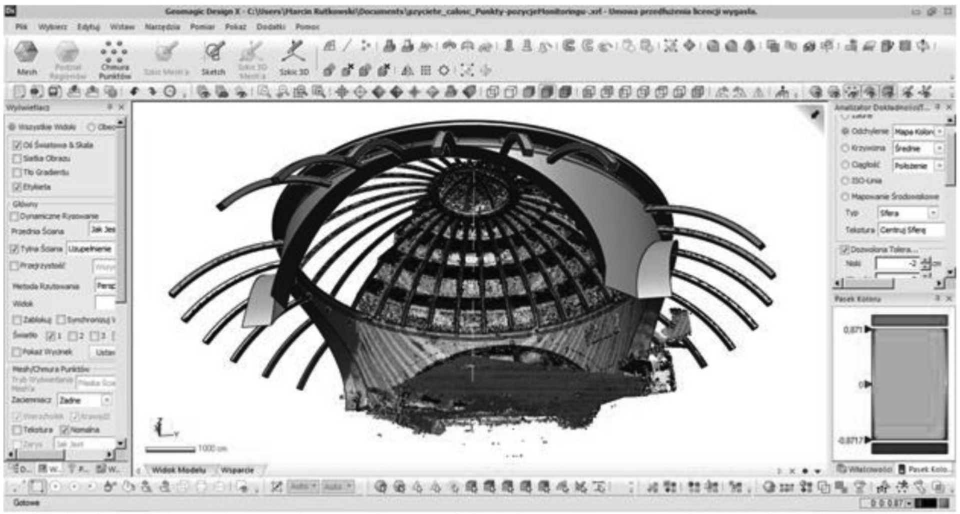

Fig. 4.101. The Geomagic Design X software – the map of deviations with respect to the cloud of points superimposed on the model with the view of the cloud of points.

The study was used to model the structural elements of the Centennial Hall. The elements which were modelled, had been selected as being critical for the analysis of the static behaviour of the building and due to a good knowledge of their structural materials. The results can be used in other research work on the Hall.

The software used in the study can be successfully applied in the process of modelling buildings. The scanned images can be reprocessed using other available programmes, as they evolve and are being developed constantly, allowing for yet faster processing to attain expected results.

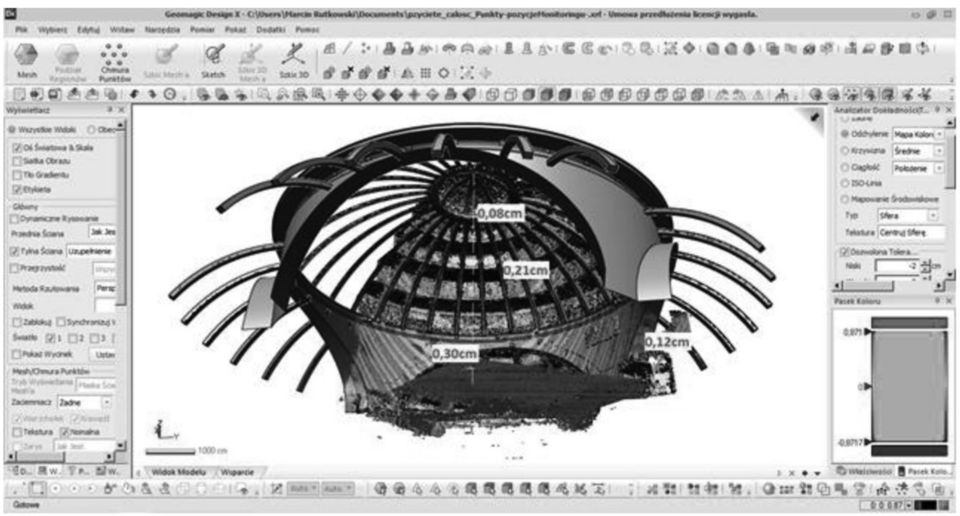

Fig. 4.102. The Geomagic Design X software – determination of average deviation for selected structural elements.

Summing up the work on the BIM II model of the Hall, it can be concluded that:

1) the model demonstrates differences of the idealised model and can be used for calculations of the actual situation,
2) it is possible to generate the model which presents the condition of the building on the day when the spatial scanning was carried out,
3) it is possible to determine the deviations of the geometry from the cloud of points,
4) it is possible to reuse the cloud of points in the future for another analysis and for monitoring changes,
5) it is necessary to place some reference points for future measurements and ensure ongoing or periodic monitoring of these points, e.g. using a tacheometre.

4.3. FEM numerical model – analysis of the static behaviour of the structure

The FEM (Finite Element Method) numerical model generated for the Centennial Hall is related to the static behaviour and strength analysis of the load-bearing structure of the dome. The flat roof and the shielding walls which cover the ribs and the load-bearing

rings have been used in the design to transfer the load. The model enables determination of the deformation, strain and the high risk spots of the structure.
A numerical model of a structure is always only an approximation. The process of transition from an actual structure is strictly defined and determined by a number of variable factors depending on the problem under analysis. In order to avoid any mistakes, the operational procedures need to be selected and delivered correctly, [51]. The first step involves identification of the problem – indication of a physical phenomenon, acting forces, material properties, answers which are being searched for. The analysis of these issues is crucial for selecting an adequate structural model and calculation method – at this stage, a correctly carried out process of collecting and processing data is of extreme importance. The calculation method selected for the project is the Finite Element Method (FEM). The numerical method is not applied to an actual problem, but to its conceptual model (which is a simplified model of the problem, from which any irrelevant features have been removed). The term 'irrelevant features' has been used to denote, e.g. a detailed geometry, which is excluded from the model as its impact on the final result is negligible. However, each decision regarding any simplifications has to be taken in an informed way and should be justified. The next stage, after developing the conceptual model, involves defining a structural model, consisting of three basic elements: geometry (points, lines, planes, solids), mathematical description of the physical phenomenon being analysed (usually in the form of a system of partial differential equations) and description of materials and loading. In the project, the modelling of the ribs of the domes was carried out using the general 3D elastic- plastic theory, although a 1D beam element technology could have also been used. If the wrong conceptual or structural models are selected, then the whole process which follows will also be incorrect, regardless of the numerical accuracy. The next step involves application of FEM, using a computer code. In the project, the Ansys Classic and Ansys Workbench programmes were used. After selecting the code, quantitative data is fed into the code (materials, boundary conditions, etc.). Again, data bases play a crucial role at this stage (here: information obtained from the Architectural Archives in the Museum of Architecture in Wroclaw and from experimental testing). This is followed by a process of discretisation (the grid dimensions, selection of elements) which results in generation of the desired analytical model.
In an ideal situation, solving a physical problem, especially an engineering one, is possible using closed solution differential equations. Unfortunately, the number of such problems is very limited, both in relation to solvability of the system of equations and to their size. For this reason, a number of numerical methods are used, which enable generating approximate solutions, but the accuracy of these approximations is satisfactory and reliable enough to use such methods in science and engineering. These methods include the finite difference method, parametric methods and the boundary element method, [52]. The Finite Element Method is regarded as the most effective, [53]. Two key issues linked to this method involve the calculus of variations and discretisation (dividing the whole problem into elements). One of the creators of FEM is Olgierd Zienkiewicz, an Englisman of Polish origins.

4.3.1. Conceptual model

All concrete elements of the load-bearing structure of the dome have been modelled using 3D solid type elements, meaning that they have physical shape and volume. Steel reinforcement inside concrete elements and the lattice-work in the tension ring have been modelled using 1D link elements. The flat roof and shielding walls (with the majority of surface area taken up by windows) have been modelled using shell elements. These shell elements serve only to determine the reaction to the load-bearing structure. The shielding elements have been separated on purpose from structural elements – their precise stiffness is difficult to determine without detailed analysis. This issue would require a separate study. That is why the stiffness of these elements has been ignored – which is a conservative approach. Reactions resulting from loading the shell elements with dead load, wind and snow are then transferred to the load-bearing structure. Because of the symmetrical character of the problem, only ¼ of the dome has been modelled. This means that 8 out of 32 ribs and 2 out of 8 lantern posts have been modelled.

4.3.2. Geometry

The data on the geometry of the building gathered from a number of sources (e.g. 3D scans) enabled generation of an integrated model of the object, which can be subjected to further processing. A comprehensive system for monitoring of the building's safety can be created by linking geometrical and measurement data. When the results of measurements are interpreted using, e.g. FEM, a model is generated, which enables identification of critical elements and description of various phenomena which occur during the building's use (e.g. extreme, unaccounted for loading or vibrations).
Information on geometry, reinforcing elements, the characteristic features of the structure and structural changes introduced to the Centennial Hall, comes from original structural drawings made available by the Architectural Archives of the Museum of Architecture in Wroclaw [54] and construction designs prepared by the MBM Consulting, Design, Research and Construction Company [4] and 'MOSTY – Wroclaw' Research Project Team [55] for the last major renovation of the Hall. The BIM models generated with the digital models obtained from 3D scans have also been used.
The geometry of the whole structure was created using the Design Modeller module of the ANSYS Workbench software.
Three separate models have been generated:

a. The load-bearing structure (1/4),
b. The flat roof and shielding walls in a ¼ version
c. The flat roof and shielding walls in a 1/32 version.

Two versions of the shell have been modelled in relation to various loading conditions. The shell of the lantern has been ignored, as its impact has been included directly in the load-bearing structure. The geometry is presented in the photographs that follow.

Fig. 4.103. The geometry of the load-bearing structure (a).

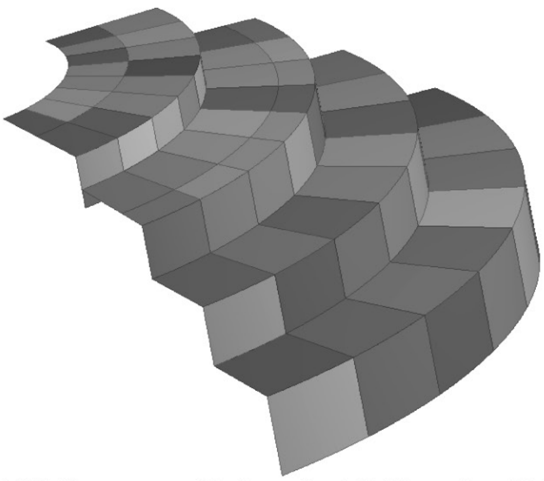

Fig. 4.104. The geometry of the flat roof and shielding walls – 1/4 (b).

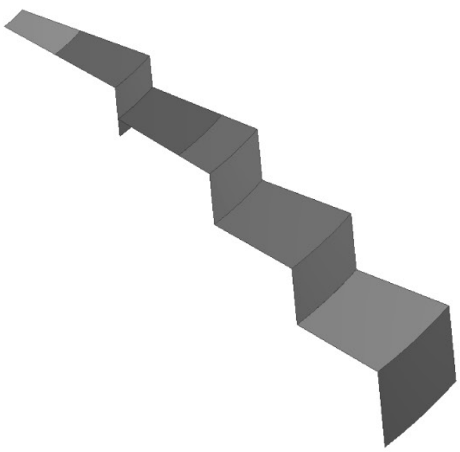

Fig. 4.105. The geometry of the flat roof and shielding walls – 1/32 (c).

When introducing the geometry, the following issues were taken into consideration: the way loading is applied, boundary conditions and the discretisation process. For this reason, knowledge of the whole course of action and anticipated potential problems is needed already at this early stage of the process. Relevant sections using planes have been introduced in places where a coherent grid of elements is required. Such sections have also been made at the locations of reinforcing bars. The software limitations (in relation to the dimensions of the model) have not allowed for the whole grid to be coherent – contact elements have been introduced. For the same reason, the number of reinforcing bars has been reduced and replaced with a smaller number, but with the same total surface area, which is justified in the relation to the scale of the model. This issue will be discussed in more detail further on in the paper. The tie rods introduced in the 1930s between the lantern posts were modelled at this stage of the process (contrary to the reinforcing bars and lattice-work) -– fig. 4.106.

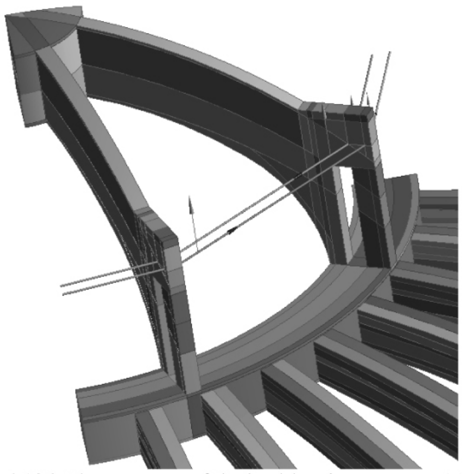

Fig. 4.106. The geometry of the load-bearing structure (a).

4.3.3. Discretisation

When the geometry data was introduced, the model was transferred to the Mechanical module of the software, where a grid of finite elements was superimposed onto it. This process required an appropriate approach and the right sequence for the grid to be superimposed on the individual elements because of the size of the problem and the complex character of its elements. Mistakes in the process of discretisation may result in the lack of a grid on fragments of the structure or in generation of a degenerated grid. The latter situation may be particularly dangerous as it may lead to numerical mistakes difficult to detect, which may significantly change the final results of the analysis.

The shell of the dome has been discreted using shell type elements of a lower order, which means that each of the nodes in the element has six degrees of freedom – three translational and three rotational. The fragment corresponding to 1/32 of the shell comprises 465 nodes and 409 elements. The model representing a quarter of the flat roof comprises 7,244 nodes and 7,091 elements, also of a lower order. In both cases, the grid consists of quadrilateral elements (quads) in 98%. The remaining 2% are triangle elements (tris). Fig. 4.107 presents discretisation of one of the shells.

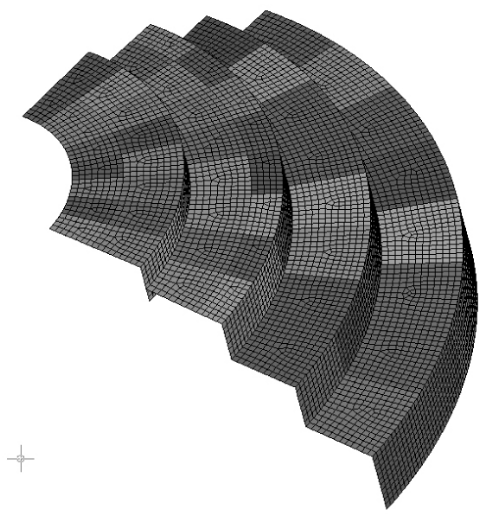

Fig. 4.107. The grid of finite elements on the quarter of the flat roof.

The discretisation process of the load-bearing structure has been much more complex and demanding. It was necessary to introduce locally forced divisions of the grid and to use dedicated grid algorithms. The anticipation of critical places and stress concentration locations was necessary. The grid has been made denser in these locations. Due to the excessive dimensions of the problem, it was not possible to generate a coherent grid at the link between the ribs and the rings. Generation of a stiff link between these elements required the use of contact elements. Since the lantern of the Hall – the highest level of the load-bearing structure, comprising 8 frame posts linked with a keystone – cracked soon after the Hall was constructed, precautions had to be taken to ensure coherence of the grid between the posts and the keystone, as well as between the posts and the top ring.

Fig. 4.108. The grid of finite elements on the load-bearing structure.

In fig. 4.108, each of the tie rods is presented as one element as they do not have flexural stiffness. Each of the nodes needs to have all the degrees of freedom defined. Six 1D elements of the tension rod type were included at this stage in the model. The number of solid elements in the model is 189,910. They have been positioned across 242,349 nodes. These are the primary elements. 85 % of these elements are cubic, octonodal (hexa) – the remaining elements are tetranodal (tetra) or hexanodal (prism).

4.3.4. The analytical model

The analytical (discrete) model is equivalent to a mathematical model of the building structure, which defines the arrangement of the nodes and enables identification of critical elements threatening the safety of the structure.

Elements and material models

The grid created in the Ansys Workbench software was transferred to the Ansys Classic programme. It is worth noting that only a grid is transferred – as no geometrical values (lines, surfaces, volumes) can be exported within the strategy selected. This causes a slight complication, which demands several crucial decisions at this first stage of modelling. When the grid is imported to the Ansys Classic, the elements of desired technology (methods of integration or capability to represent cracking) must be assigned.

The flat roof and shielding walls

The shell models described use the SHELL181 element, [56]. This element can work in accordance with the membrane – bending theory (having both the translational and rotational degrees of freedom) or the membrane theory (only translational). The first option was applied in the static diagram used in the project. The element enabled multi-layer sections to be defined. It was possible to define thickness, material, orientation and the number of integration points in the thickness of the layer for each of the individual layers of the element. The number of integration points may be equal to 1, 3, 5, 7 or 9. The default number of integration points is 3, but if the element consists of only one layer of plastic material, the algorithm automatically switches the element to 5 points of integration.
Elements comprising 5 sections – 3 concrete and 2 steel – were used in modelling the flat roof and shielding walls. Two out of three concrete sections constitute the casing, which according to [55] was at least 5mm thick. The two steel sections represent reinforcement (bars with a diameter of 6 mm, evenly spaced in both directions, 6 bars per 1m) – fig. 4.109. The layers have been adopted as isotropic and the material properties as linear – elastic. The Young Modulus of 205 GPa, and Poisson's ratio of 0.3 were adopted for the steel; whereas for concrete, the parameters were 30 GPa and 0.2 respectively. Since the structural role of these elements is negligible, their role in the analysis relates only to determine reactions as their plastic properties do not need to be taken into account.

The shielding walls were modelled in exactly the same way as the flat roof. The same strategy was adopted because it is difficult to assess their stiffness due to the large number of windows and window posts with an unknown reinforcement. For this reason, the shells have been separated out from the load-bearing structure – the positive input of the shielding walls to the overall stiffness of the structure can be safely ignored. This is a more reliable option than considering this factor without sufficient knowledge. Fig. 4.110 depicts the arrangement of layers in the SHELL181 element. Their total thickness is 100 mm, in accordance with the actual situation.

Fig. 4.109. Reinforcement of the flat roof, [55].

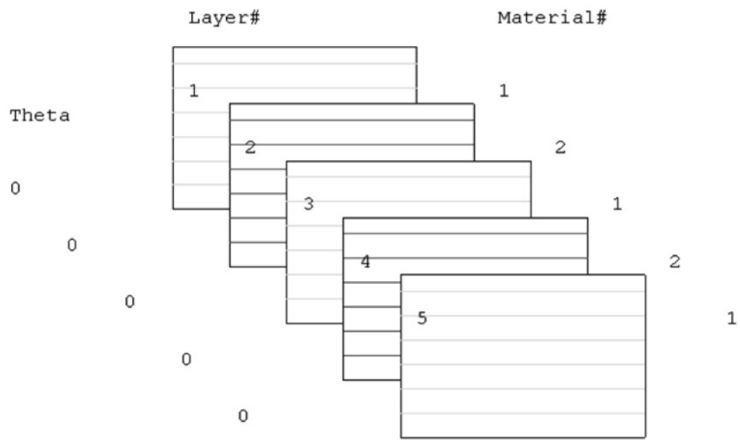

Fig. 4.110. The arrangement of layers in the shell elements.

Concrete in the load-bearing structure

The volume grid of concrete was described using the SOLID65 element, in which it is possible to apply reinforcement scattered in three dimensions. The element is capable of cracking in tension and of crushing in compression. For this reaons, this seems to be the right choice for modelling the behaviour of concrete. In an ideal situation, the element would be defined by 8 nodes. Each of them has three translational degrees of freedom. Hexanodal and tetranodal versions are acceptable, although not recommended - fig. 4.111.

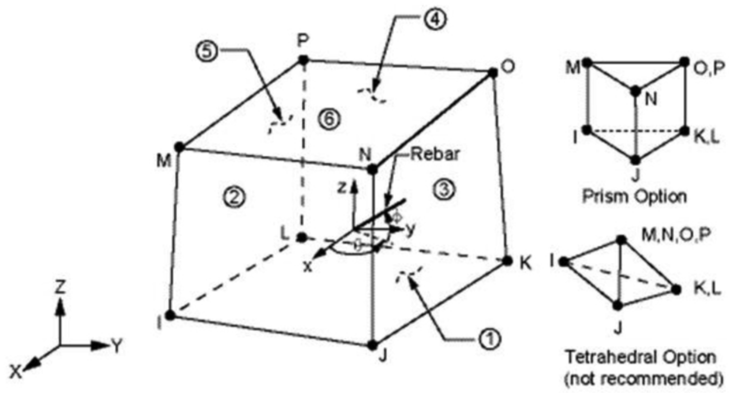

Fig. 4.111. The SOLID65 element characteristics.

The crucial aspect in this issue is non-linear behaviour – concrete is capable of cracking in three orthogonal directions, crushing, plastic deformation and creeping.
Two material models have been adopted in the project – linear and non-linear. Young Modulus and Poisson's ratio were needed for description of the linear material. The non-linear model is described in what follows. The paper [57] is the source of information on the mechanical parameters of concrete. Thus, according to this information, the concrete of the top and bottom rings has been classified as C20/25, which means that its Young Modulus is 30 GPa and the characteristic compressive strength is 20 MPa. The concrete in ribs has been classified as C16/20 – with a Young Modulus of 29 GPa, and the characteristic compressive strength of 16 MPa. The tensile strength has been determined independently to be 2.9 MPa in the top ring, 2.8 MPa in the ribs and 3.6 MPa in the bottom ring.
The behaviour of concrete depends strongly on stress. Compressive stress results in a ductile zone, where the material weakens after reaching maximum stress – a dropping branch develops until the load-bearing capacity is exhausted. In contrast, tensile stress results in a brittle and sudden failure of the material. A total failure of the material (starting from material cracking) depends on a number of factors, and especially on the boundary conditions. What is more, the 'stress – strain' curve of the static balance remains a straight line until the moment of cracking. Another important issue is related to the behaviour of the material in the triaxial state. The triaxial compression results in increasing compressive strength, uniaxial or biaxial compression results in increasing strength for tension in orthogonal planes.
The behaviour of the concrete described above requires an appropriate constitutive model, which developed by putting together two non-linear, isotropic material models. The first one is based on the Willam -Warnke criterion, [58]. The failure criterion in a multi-axial stress situation can be described as follows:

$$\frac{\Psi}{f_c} - S \geq 0 \tag{23}$$

where:

Ψ – function depending on the value of the principal stress in the main directions (σ_{xp} , σ_{yp} , σ_{zp});

S – surface area of failure (fig. 4.112) which is a function of values and signs of the principal stress and 5 material parameters, implemented by the user (tab. 4.1);

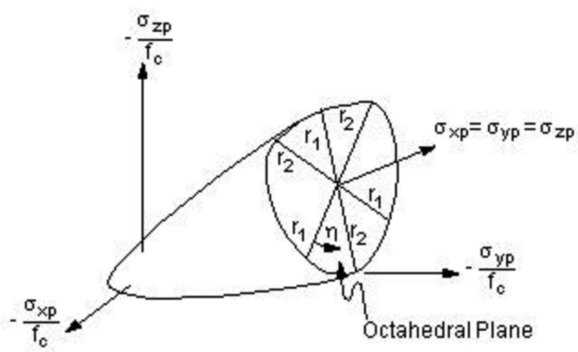

Fig. 4.112. 3D surface of material failure, [7].

In accordance with fig. 4.112, the surface of failure is described by the similarity angle η and meridians r_1 , r_2, and it is built on the basis of 5 strength parameters (tab. 4.1).

Tab. 4.1. Material parameters.

Symbol	Description
f_t	Tensile strength
f_c	Strength in uniaxial compression
f_{cb}	Strength in biaxial compression
σ_h^a	Hydrostatic stress state
f_1	Compressive strength in biaxial compression superimposed on a hydrostatic stress state σ_h^a
f_2	Ultimate compressive strength for a state of uniaxial compression superimposed on a hydrostatic stress state σ_h^a

The description of the materials requires inputing the values of the f_t and f_c parameters. In accordance with the Willam-Warnke theory, the following values are ascribed to the remaining parameters:

$$f_{cb} = 1.2 f_c \tag{24}$$

$$f_1 = 1.45 f_c \tag{25}$$

$$f_1 = 1.725 f_c \tag{26}$$

It must be noted, however, that the above equations are true only for the stress states which satisfy the following condition:

$$|\sigma_h| \le \frac{1}{3} f_c\,, \qquad \left\{\sigma_h = hydrostatic\ stress = \frac{1}{3}(\sigma_{xp} + \sigma_{yp} + \sigma_{zp})\right\} \tag{27}$$

The Willam-Warnke theory describes the behaviour and failure of a material under a full range of stress. This is applied in the numerical programme by means of the Concrete model. The model enables visualisation of cracking and crushing of a wall, with the initiation and propagation of these processes. Unfortunately, the authors of the paper encountered problems in the operation of the model in the compressed zone. As a result of stress concentration, the local compressive stress reaches its limit value at a very low level of loading. In such a situation, the programme eliminates automatically the element from further analysis and the remaining part of the non-linear 'stress – strain' diagram is then not delivered. The analysis is prematurely finished due to exceeded compressive loading in areas of the model, which in laboratory experimental testing and in real life structures remain untouched. Similar problems with the application of this model in the ANSYS software have been noted by a number of researchers, e.g. [59], [60]. As a result of these problems, it was decided that the crushing option should be deactivated, which meant adopting the value of $f_c = -1$. Then, the only condition for material cracking is exceeding the value of f_t by any of the principal stresses. The stiffness matrix $[D^C]$ for the analysed material prior to cracking has the following form:

$$[D^c] = \frac{E}{(1+\nu)(1-2\nu)}\begin{bmatrix} (1-\nu) & \nu & \nu & 0 & 0 & 0 \\ \nu & (1-\nu) & \nu & 0 & 0 & 0 \\ \nu & \nu & (1-\nu) & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{(1-2\nu)}{2} & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{(1-2\nu)}{2} & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{(1-2\nu)}{2} \end{bmatrix} \tag{28}$$

Appearance of cracking at a point of integration is projected through a change in the 'stress – strain' relationship. Points of integration selected in a way ensure that the results of the numerical integration technique applied are as accurate as possible. The change involves introduction of weakening in the plane perpendicular to the surface of cracking. At the same time, the coefficient of the shear transfer β_t is introduced. The coefficient reduces shear strength for those loadings, which will induce shearing (slippage) across the cracking surface. The stiffness matrix $[D_c^{ck}]$ for the material which has cracked in a single direction is as follows:

$$[D_c^{ck}] = \frac{E}{(1+\nu)} \begin{bmatrix} \frac{R^t(1+\nu)}{E} & 0 & 0 & 0 & 0 & 0 \\ 0 & \frac{1}{1-\nu} & \frac{\nu}{1-\nu} & 0 & 0 & 0 \\ 0 & \frac{\nu}{1-\nu} & \frac{1}{1-\nu} & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{\beta_t}{2} & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{1}{2} & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{\beta_t}{2} \end{bmatrix} \tag{29}$$

The top '*ck*' index indicates that the stress – strain relationship corresponds to the coordinate system, parallel to the direction of the principal stress, with the x^{ck} axis perpendicular to the cracking surface. The value R^t indicates the incline (secant modulus of elasticity) defined in fig. 4.113. R^t drops, changing in an adaptive way and gradually declines until it reaches zero at the moment when the solution reaches concurrence – fig. 4.113. The T_C parameter allows to select the required reduction of the stress at the moment of cracking.

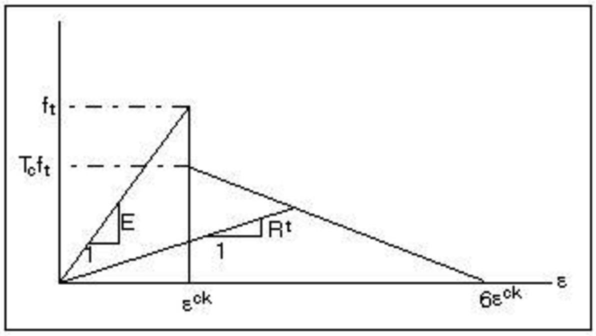

Fig. 4.113. The material behaviour after cracking, [56].

When the value $f_c = -1$ is selected, the programme is not able to generate the complete surface of failure, due to the lack of sufficient data. In such a situation, the failure surface is generated only for negative values of principal stresses. The Multilinear Elastic option has been applied in order to provide the failure criterion with the full range of stress. Such an approach enables selection of the 'stress – strain' path through introducing numerical values for individual points. None of the segments of the curve should represent a value larger than the Young Modulus, but it is possible to select segments with a negative incline. The latter feature is particularly useful, as it allows modelling a dropping branch after the material reaches its maximum compressive stress. The Equations proposed by Kachlakev , [59], for concrete, have been adopted to describe the curve. The ascending branch of the curve was formulated according to the following equations:

$$\sigma_1 = 0.3 f_c \tag{30}$$

$$\varepsilon_1 = \frac{f_1}{E} \tag{31}$$

$$\sigma_i = \frac{E\varepsilon_i}{1+\left(\frac{\varepsilon_i}{\varepsilon_0}\right)^2} \tag{32}$$

$$\varepsilon_0 = \frac{2f_c}{E} \tag{33}$$

Equations (30) and (31) describe the values of stress and strain for the first point of the diagram, respectively. Stress reaches 30 % of the maximum stress value, which means that the elastic behaviour of the material has been adopted up to this level of loading. The subsequent points of the ascending branch are described by means of a parabolic curve (32), where ε_i is any value of strain, which is contained between ε_1, and ε_0. The value ε_0, determined in accordance with (33), represents the strain corresponding to the maximum compressive stress, $\sigma_i = f_c$. After reaching the point (ε_0, f_c) stress relaxation (weakening) occurs to the level of $0.6f_c$. The programme applies Huber's criterion along with the Willam-Warnke theory to the material model structured in this way, and the selected tensile strength f_t corresponds to shearing off stress. The approach described above is analogous to the model proposed by Lofti and Shing, [61].

The lattice-work in the bottom ring and reinforcing steel

The lattice-work was most probably made of steel which corresponds to the steel classified as St3SX (yield point 235 MPa), and reinforcement of St0S steel (195 MPa). The Young Modulus for each of these types of steel is 205 GPa, and the Poisson's ratio is 0.3. There was no need to model the steel as a non-linear material.

All the steel elements were represented with the LINK180 element. It is a 3D element with only axial stiffness. Each of its nodes must have three translational degrees of freedom defined. This element behaves in a way similar to posts in the lattice-work – it carries only tension and compression and has no bending stiffness and no rotational degrees of freedom. During implementation, it is possible to determine if the element is capable of changing its section as a result of loading, which enables determination of actual stress. The surface area of the section of such an element is a required parameter. The shape of the section does not matter as only the axial behaviour of the element is considered. The shape is not specified.

It was mentioned earlier that both, the lattice-work and the steel were not generated when the grid was created using the Ansys Workbench software. This operation was performed in the Classic module, where the elements were spread between the nodes of the concrete matrix grid. This means that the SOLID65 and LINK180 elements share some nodes and in practice, the adherence between steel and concrete has been ensured.

The reinforcement of the top ring, ribs and circumferential beams has not been mapped in an ideal way because of the scale of the problem. The number of bars has been limited, but it is their total surface area which has not changed that is important. For example, the longitudinal reinforcement of the top ring comprises in reality 24 bars, each with a diameter of 30mm. They have been replaced in the analytical model with 8 bars with a total surface area equal to the physical one. Such proceedings are acceptable taking into consideration the scale of the problem and the undisturbed stress state in the approximated elements. The reinforcement of the lantern posts was mapped much more accurately (when it comes to the number of reinforcing bars). These posts were damaged almost immediately after the Hall construction was completed and therefore required more in-depth analysis. The supportive reinforcement of the bottom ring has also been mapped in a very accurate way, as it is situated immediately over the bearings in order to reduce the compressive stress in the concrete, generated in the support zone.

The stirrups have been ignored in the modelling. On the basis of structural drawings, it was deduced that the shape and the way they had been mounted do not translate into desired static behaviour. For this reason, it was decided that they could be safely ignored. It is worth noting that the faulty design of the stirrups is one of only a very few mistakes made by the German structural designers, which is an outstanding achievement when one considers the level of technical knowledge of reinforced concrete structures at the time of Hall construction.

The geometry of the lattice-work joined with rivets has been mapped in accordance with the physical situation. The only change related to modelling as a single section, the posts which in reality comprised 5 parallel bars. Additionally, the belts of the lattice-work have been modelled as being weaker – in order to account for the the rivet openings.

Selected fragments of the reinforcement are presented in the figures below. It is worth noting that the bars in the ribs have been modelled with anchorage zones in the rings.

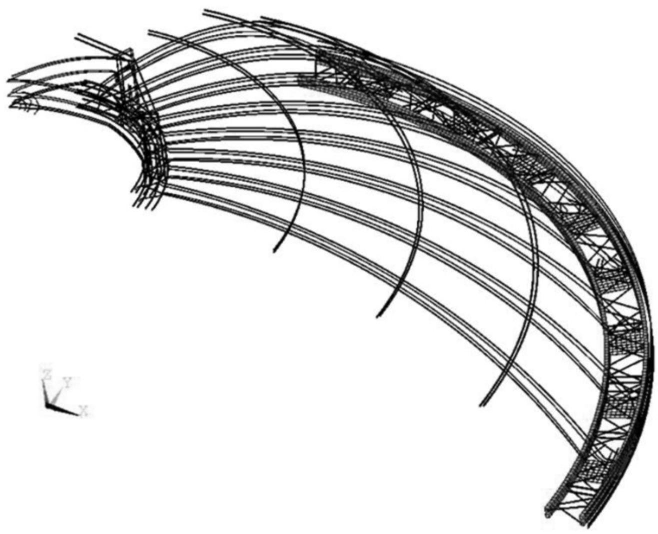

Fig. 4.114. The whole reinforcement in the load-bearing structure.

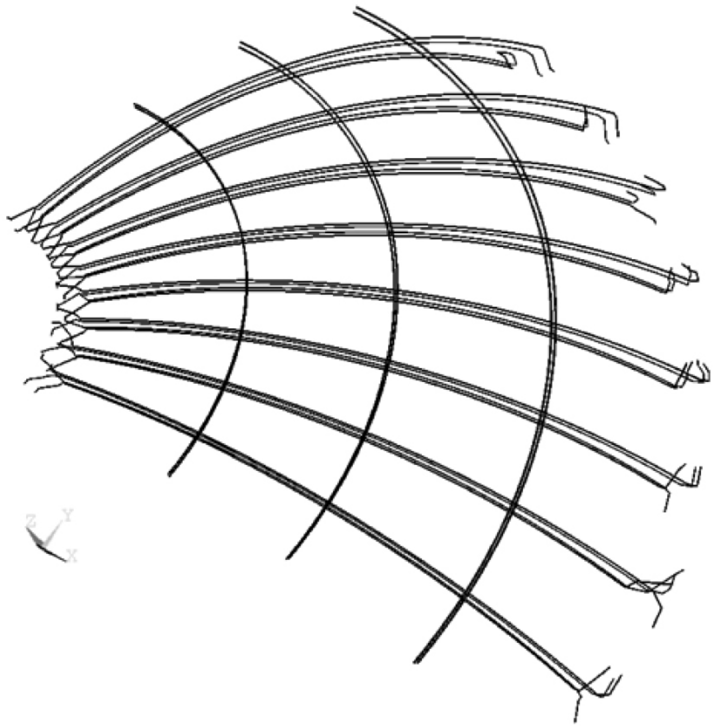

Fig. 4.115. Reinforcement of circumferential beams and ribs including the anchorage zone.

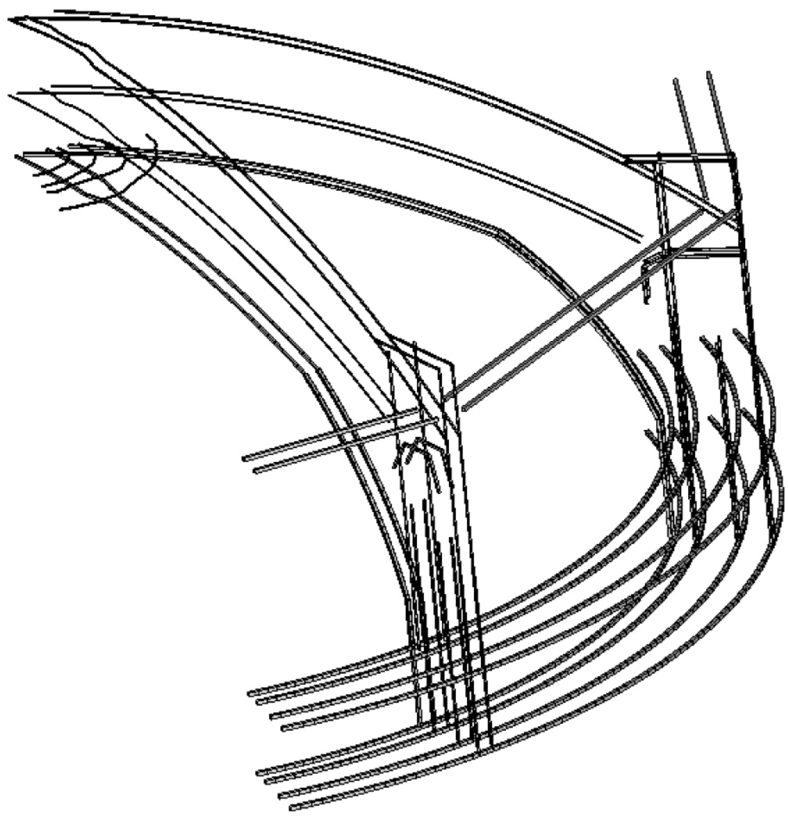

Fig. 4.116. Tie rods between posts, the reinforcement of the posts and the top ring.

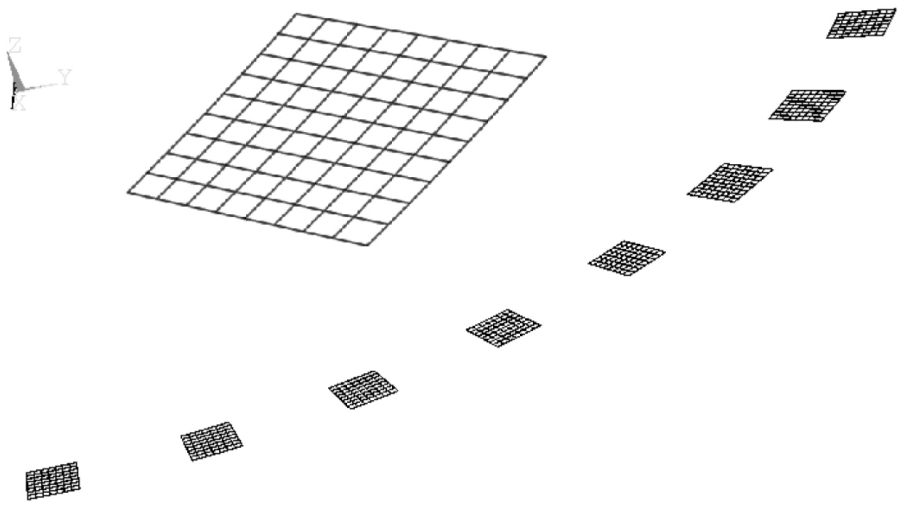

Fig. 4.117. Distribution of supporting reinforcement with a close-up.

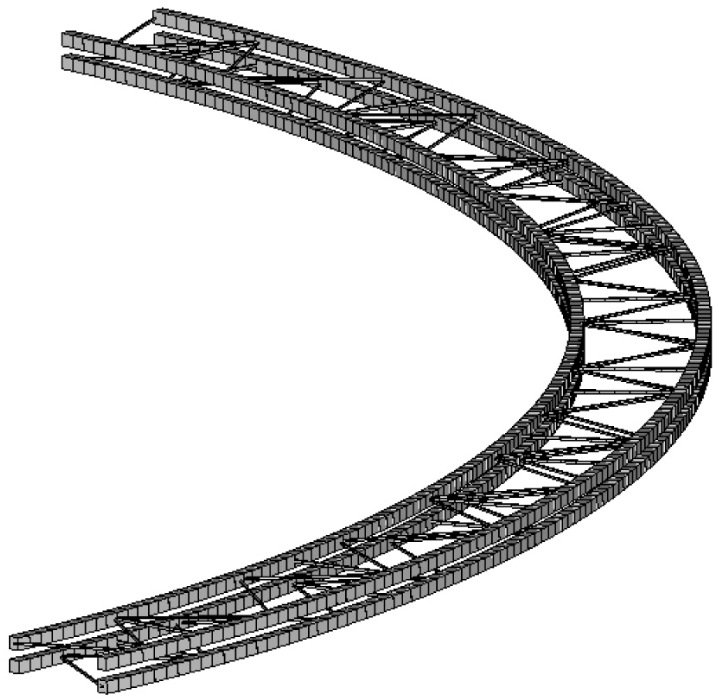

Fig. 4.118. Steel lattice-work in the bottom ring.

Contact elements

As was mentioned earlier, mapping of a coherent grid in the connection zone between ribs and the rings was abandoned in order to reduce the size of the model. Ensuring a stiff connection between these fragments of the structure required the introduction of contact between the surfaces of ribs and the rings.

The phenomenon of contact in numerical methods is a very complex problem, with respect to both the mathematical and physical description, as well as concurrence of the solution. The contact is a non-linear problem – with a non-linearity of the third type, [62].

The augmented Lagrangian method has been used in the work – an iteration 'penalty' method series. The contact stresses (pressure and stresses) are updated during iteration, so that the final penetration does not exceed the maximum permitted value. This method, when compared to the classical 'penalty' method, offers a better concurrence and is less susceptible to the stiffness of contact. A

'bonded' option has been selected in order to project the physical behaviour of the structure. In this option, both the contact and disc surfaces are bonded together in each direction, throughout the whole process of analysis, the value of permitted stress is infinite.
The only defect of this measure is related to local concentrations of stress, which in general do not occur in such models and for this reason are ignored in the analysis of results.
Sixteen contact pairs have been created in this way, two for each rib. Facing surfaces of ribs are the contact surfaces and the surfaces of rings are the discs.

Boundary conditions

The dome is supported on the remaining elements of the structure by 32 bearings. The bottom ring rests upon the bearings, and their location corresponds to the location of the ribs. The bearings are hinged and slide. The hinge allows rotation in the direction of the bending moment in the ribs and the sliding is possible in the radial direction. In order to map this type of support in the numerical model, groups of nodes have been generated on the bottom surface of the ring, which correspond geometrically to the surface of bearings. Next, the so called steering nodes have been created in the centre of gravity of the nodes using the script. The steering node has been then connected to each node in its group using the MPC184 element, formulated as a stiff beam. The term 'stiff' means here, which the algorithm automatically assigns to the beam the Young modulus value, which is higher by several orders of magnitude than the highest value of the modulus used in the model. Next, the degrees of freedom were reduced for the steering node – possibility for vertical translation and for translation in the direction parallel to the radius. In order to achieve the latter condition, the coordinate systems of each of the steering nodes have been rotated in accordance with the cylindrical coordinate system. This resulted in modelling the behaviour of supports in a way that corresponds to the actual bearings – fig. 4.119.
Since the structure has two axes of symmetry, all the nodes located on the coordinate $x = 0$ have been bereft of the translation in the x direction and all the nodes with the coordinate $y = 0$, have been bereft of the translation in the y direction.
A separate boundary condition refers to the tie rods between the posts of the lantern, which have contact with the symmetry planes. In order to model the physical behaviour of the whole structure, conjugate displacement equations in the circumferential and vertical directions have been applied to the relevant nodes of tie rods and posts, following a rotation of nodal coordinate systems - fig. 4.120.

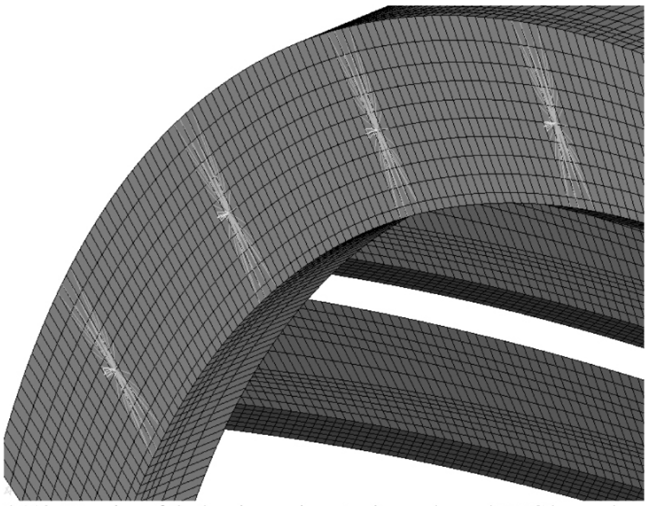

Fig. 4.119. Mapping of the bearings using steering nodes and MPC beam elements.

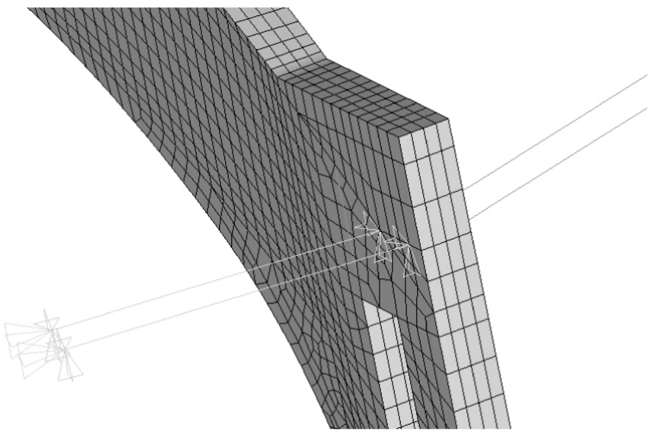

Fig. 4.120. Conjugation of relevant degrees of freedom in order to obtain symmetry.

Loading

In accordance with the description, all loads related to the flat roof and load-bearing walls have been modelled in a separate shell model. Next, the reactions are read out and applied with the opposite sign to the load-bearing structure – at the locations where ribs crosscut the circumferential beams. The forces (vertical, radial and bending moment) were applied with the technique of using steering nodes and MPC184 elements, which has been described above. This technique enabled transferring the moment to the elements with translational degrees of freedom.

Dead load

The weight of the load-bearing structure has been accounted for in the analytical model via gravity. The roof structure has also been accounted for via gravity and the non-structural layers were replaced with a pressure value of 0.0002 MPa – the post-renovation condition. The weight of the vertical walls was determined as an average based on the percentage of surface taken by windows and concrete – a shell 10cm thick has been adopted for the modelling purpose and the concrete weight by volume.

Snow load

The snow load has been determined in accordance with [63].

Location: Wroclaw
Height above sea level: 110 m a.s.l.
Ground snow load zone: 1
The value of the characteristic ground snow load is a function of the snow zone and the height above sea level: $s_k = 0.70\ \frac{kN}{m^2} = 0.0007\ MPa$
The characteristic value of the snow load of the roof:

$$s = s_k * \mu_i * C_e * C_t \tag{34}$$

where:
$C_t = 1.0$ – thermal coefficient, equal to or less than one; conservatively assumed to be equal 1.0
$C_e = 0.8$ – exposition coefficient, the building subjected to wind load – the dome rises considerably above the surrounding buildings and trees
$\mu_i = 0.8$ – roof pitch of no more than 30°
The occurrence of snow drift should be considered as a result of the shape of the flat roof – the presence of several floors. The range of the snow drift l_s can be determined using the following relationship:

$$l_s = 2 * h \tag{35}$$

where:
h - difference in the height of individual floors.

Based on the geometry of the Hall, the range of the snow drift was determined for individual floors. For the floors 3 and 4 the snow drift covered only part of the flat roofs, whereas for the lower floors – 1 and 2 – the snow drift covered the whole surface of the flat roofs. The 'WS' in fig. 4.121 indicates the range of the snow drift cover on the roofs of the Hall.

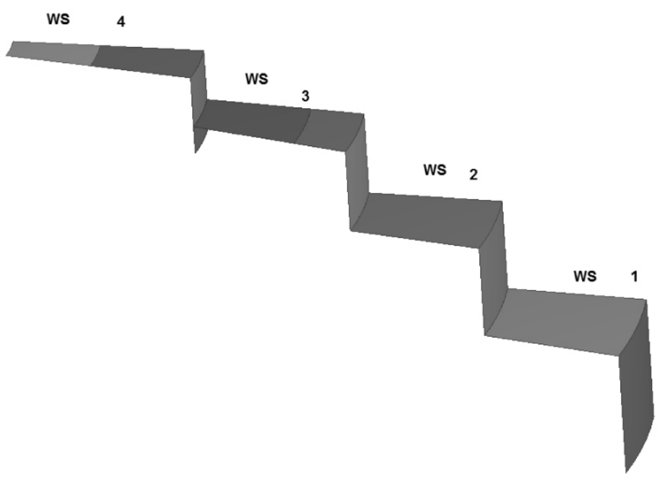

Fig. 4.121. Snow load.

In the case of the geometry selected for modelling, the snow drift factor will always be: $\mu_w = 4.0$.
In accordance with conservative assumptions, a trapezoid distribution of snow drift has been abandoned in favour of a constant distribution. As a result, the following values have been obtained:

The primary characteristic load of the roof:
$s = 0.0007MPa * 0.8 * 0.8 * 1.0 = 0.0004\ MPa$
The snow drift characteristic load of the roof:
$s_w = 0.0007MPa * 4.0 * 0.8 * 1.0 = 0.0022\ MPa$

Wind load

The wind load has been determined in accordance with [63].
Location: Wroclaw
Height above sea level: 110 m a.s.l.
Wind load zone: 1
Based on the above data, the wind load was calculated as follows:
$v_{b,0} = 22\ \frac{m}{s} = 22000\ \frac{mm}{s}$ – the primary value of the basic wind speed
$q_{b,0} = 0.30\ \frac{kN}{m^2} = 0.0003\ MPa$ – average (basic) speed pressure
Terrain category: III
The basic value of the wind speed:

$$v_b = c_{dir} * c_{season} * v_{b,0} \tag{36}$$

where:
$c_{dir} = 1.0$ – direction coefficient
$c_{season} = 1.0$ – season coefficient
hence:
$v_b = 22\ \frac{m}{s} = 22000\ \frac{mm}{s}$

The average wind speed:

$$v_m(z) = c_r(z) * c_o(z) * v_b \tag{37}$$

where:
$c_r(z) = 0.8 * \left(\frac{z}{10}\right)^{0.17} = 1.021$ – for the category III terrain, $z = 42.0m$ – maximum height
$c_o(z) = 1.0$ – terrain configuration coefficient, equal 1.0 ion this case
hence:
$v_m(z) = 1.021 * 1.0 * 22000\frac{mm}{s} = 22462\frac{mm}{s}$
The peak value of the speed pressure:

$$q_p(z) = [1 + 7 * I_v(z)] * \frac{1}{2} * \rho * v_m^2(z) \tag{38}$$

where:
$I_v(z) = \frac{1}{\ln(\frac{z}{z_0})} = 0.202$ – turbulence coefficient, $z_o = 0.3m$ – roughness grade for the category III terrain, ,
$z = 42.0m$ – maximum height
$\rho = 1.25\ \frac{kg}{m^3}$ – air density
hence:
$q_p(z) = [1 + 7 * 0.202] * \frac{1}{2} * 1.25\ \frac{kg}{m^3} * (22462\frac{mm}{s})^2$
$q_p(z) = 0.0008\ MPa$

The structural coefficient for a building with a selected structure and geometry is $c_s c_d = 1$.
Taking into account the specific features of the geometry of the flat roof, it was assumed for the purpose of determination of the external pressure factors, that the vertical parts with windows behave like walls and the horizontal parts were treated as a flat roofs.

Simultaneously, because of the circular shape of the building, changes in wind distribution have to be taken into account in the circumferential direction.

Hence:
$q_w = q_p(z) = 0.0008\ MPa$ – value of pressure on the vertical walls induced by wind on the weather side,
$q_s = -1.2 * q_p(z) = -0.001\ MPa$ – value of pressure on the flat roof (suction).

It has been assumed that the pressure on the weather side includes an aperture angle equal to 45°. This area of vertical walls is subjected to the wind pressure. In other areas vertical walls are subjected to suction of the following value: $q_s = -1.2 * q_p(z) = -0.001\ MPa$.

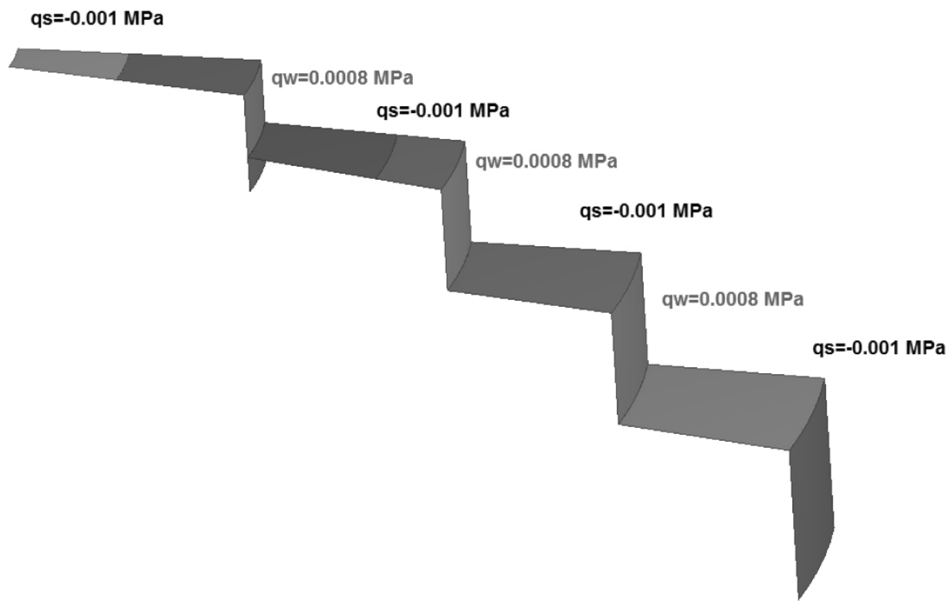

Fig. 4.122. Distribution of wind pressure on the weather side – zone A in fig. 4.124.

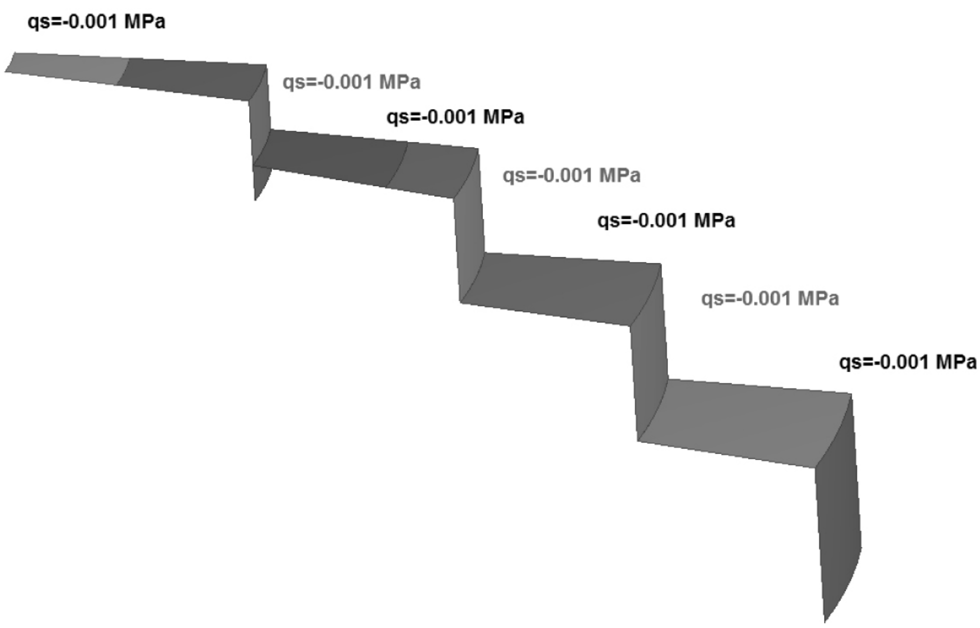

Fig. 4.123. Distribution of pressure out of the weather side – zone B in fig. 4.124.

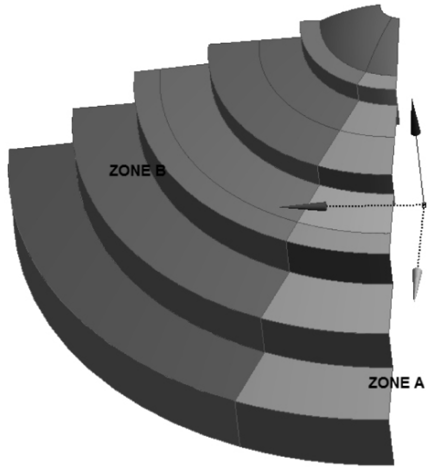

Fig. 4.124. Division into wind zones on the Hall's roof – ¼ of the whole flat roof.

Loading of the surface of the ring

The bottom ring. During the inspection of the building it was that numerous electric installations, cables and a platform are located on the surface of the ring, between the ribs and used only occasionally. It is a load which had not been accounted for in the original design and its impact on the structure needs to be investigated. A load of 200 kg/m^2 was adopted, taken to be distributed evenly across the surface of the ring.

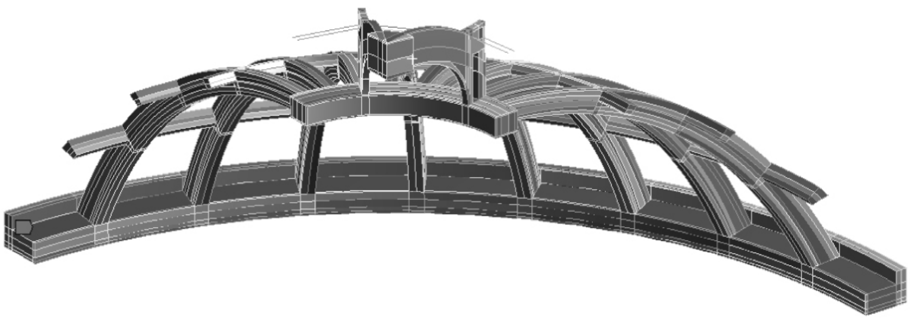

Fig. 4.125. Loading of the ring surface with an unforeseen weight – the area in red.

Ribs. For each rib a total loading of 3 tonnes was adopted: 1 tonne was applied at each location where the rib crosses a circumferential beam.
The top ring. The total operating load of the whole top ring is equal to 40 tonnes. This value in practice is divided between eight points, distributed symmetrically. The same scheme has been adopted for the numerical model, but as only ¼ of the structure was modelled, two loads of 5 tonnes were applied to the bottom surface of the ring.

Prestressing of the bottom ring

In accordance with [55] the prestress was delivered through application of 9 prestressing cables. Each of the cables had an effective surface of steel of 450 mm^2 and was prestressed with a force of 126 kN. In the model seven cables have been mapped due to the grid division with a total surface area equal to the physical one and a total force also equal to the actual situation. The prestressing has been achieved through application of a relevant compressive stress to the distributed mapped LINK180 elements.

4.3.5. Results of the analysis. Conclusions

In analysing the results of the research, it was noted that a comprehensive programme of work was carried out to determine characteristic loads and strength. Moreover, it should be remembered that the notion of the first principal stress has in each case been used to indicate the maximum tensile stress, and the notion of the third principal stress indicates the maximum compressive stress. Both, the concrete and the steel bars have been modelled using nodes without rotational degrees of freedom (and therefore they accurately project the real situation) and they do not have the moment reaction value. Additionally, it is important to note that the reinforcing bars have no lateral stiffness, which means they cannot carry shearing stresses – they can carry only axial stresses.

The flat roof and shielding walls

In accordance with the assumptions made, the shells have not been subjected to detailed stress analysis. Displacements in selected load conditions have been depicted in the pictures below.

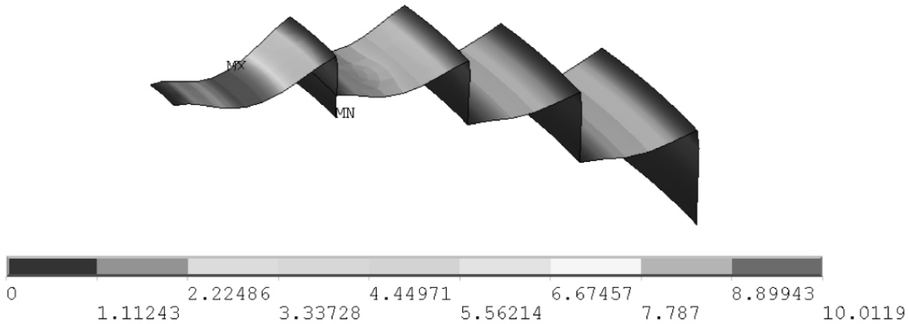

Fig. 4.126. Overall displacement of the flat roof and shielding walls in millimetres under the dead load.

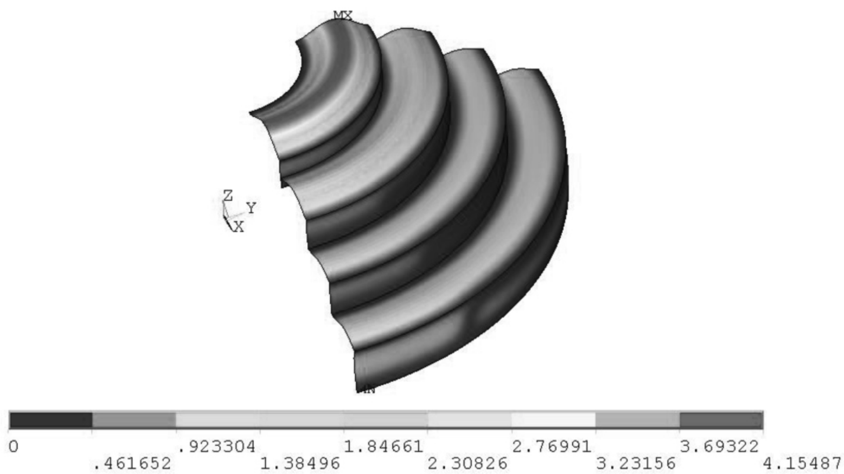

Fig. 4.127. Overall displacement of the flat roof and shielding walls in millimetres under the wind load.

An important conclusion derived from the analysis of the roof of the structure concerns the fact that the direction of reactions transferred to the ribs is not obvious (referring to the horizontal force and bending moment), and all forces transferred from the shell to the load-bearing structure should be determined using a spatial model, e.g. the one proposed in the study.
Additionally, as it has already been suggested, a detailed analysis of a window element is necessary to determine the actual stiffness of shielding walls with windows.

The lantern

The numerical analysis confirmed an earlier observation – the load on the posts of the lantern exceeds their load-bearing capacity. This was demonstrated using a linear analysis – a significant part of the post (concrete matrix) near its base and in the area next to a passageway opening, is subjected to tensile stress which exceeds its tensile strength (2.9 MPa) as a result of only the dead load of the structure – a grey area in fig. 4.128. The destruction of posts affects locally also the top ring.

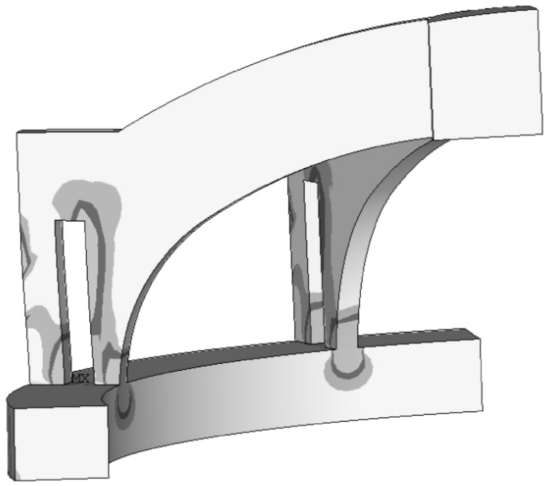

Fig. 4.128. Exceeded tensile stress in the posts – the grey area.

For this reason it was necessary to conduct a non-linear analysis, which would indicate location of cracking in concrete and would assess the real strain of the bars. Fig. 4.129 presents the development of cracking caused by the dead load. The concrete is damaged near the base of the post and partly in the ring itself – area 1. Additionally, the fragment above the door opening has also been damaged, and the degree of destruction is even higher in this location – the analysis demonstrated localised cracking in all three planes – area 2. The damage in area 3 may be a localised effect – a steering node is located there, which transfers reactions from the flat roof to the frame. In the real life structure, there is a flat roof connection here and so this result can also be true. This fragment of the structure should be also subjected to ongoing monitoring. In the case of area 2, the result is caused by insufficient reinforcement in this area. An insufficient reinforcement of concrete in this location was discovered on an archival structural design drawing – fig. 4.130. The area lacks reinforcing elements which could carry loads in the highlighted part of the posts – these are only anchorage zones for individual reinforcing bars. The only reinforcing elements which can carry loads in this zone are the stirrups, which have not been taken into account in the numerical model because of their lack of structural contribution due to faulty installation.

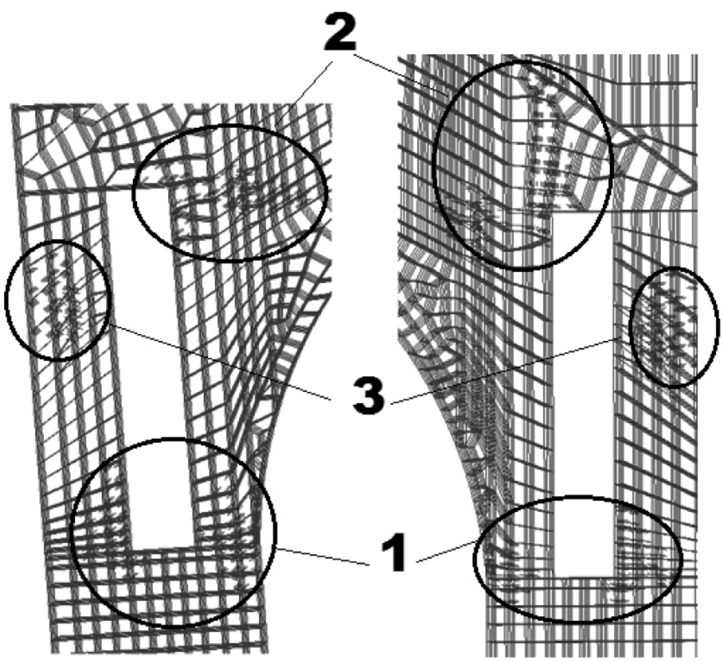

Fig. 4.129. Damages to the concrete as described in the text above.

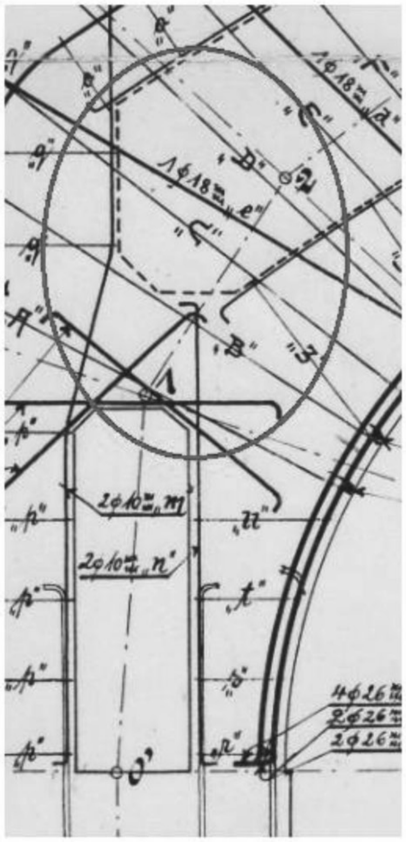

Fig. 4.130. The insufficient reinforcement of the posts at the damage location.

The reinforcement at the base of the posts is also significantly strained. The value of tensile stress in the bars reaches 190 MPa, and is close to the characteristic strength of reinforcing steel, fig. 4.131. This is another area, which requires an ongoing monitoring.

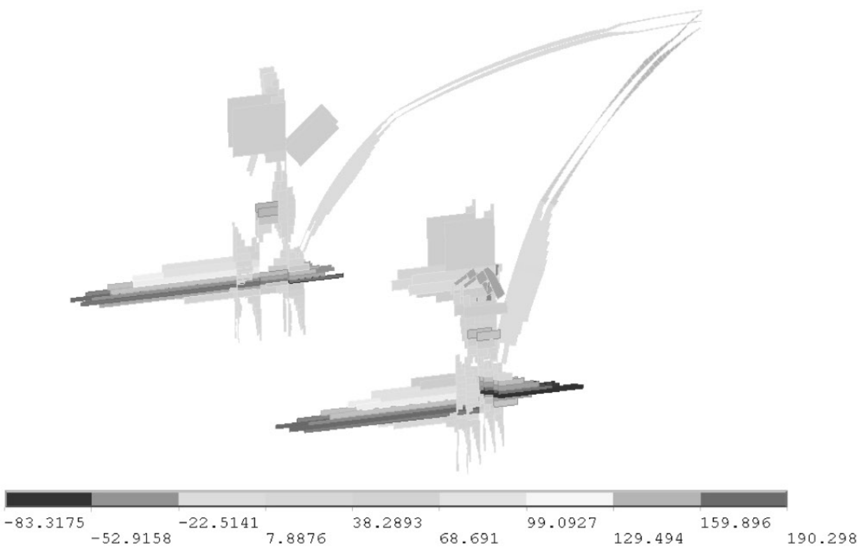

Fig. 4.131. Reinforcing bars of the lantern posts – the most strained fragments.

The analysis conducted indicated that the lantern has no significant impact on the global behaviour of the load-bearing structure. For this reason, further analysis was carried out linearly.
The strain of the tie rods between the posts (dating back to the 1930s) was also investigated and found to be insignificant. Taking into consideration all the loads, the maximum stress was determined as being less than 1 MPa. Thus, the tie rods are redundant and the

structural problems of the lantern are caused by the wrong selection of the concrete section (insufficient) and ineffective reinforcement.

The top ring

The top ring is compressed, in line with the assumptions. Its strain (at the most unfavourable combination of loading) is low. The compressive stress in the concrete is 4 MPa on average (except for the localised impact of the pillars). The maximum strain of the compression bars is 40 MPa, but the strain of the bars in the top row is twice as large as of the bars in the bottom row, which can be a result of the negative impact of the lantern or uneven distribution of compressive forces transferred from the ribs onto the ring - fig. 4.132. The top row of the bars denoted here, group bars located near the top surface of the ring. Similarly, the bottom row of the bars, group of bars situated near the bottom surface of the ring. These are terms, which were introduced at the beginning of this chapter.

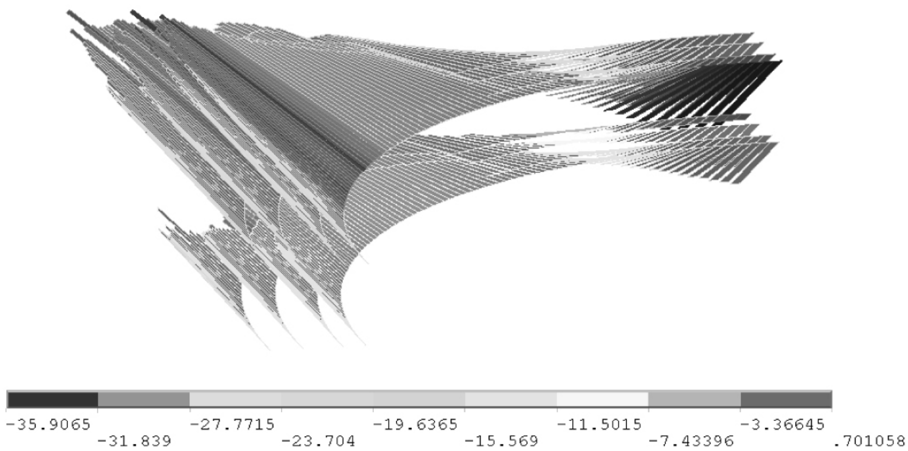

Fig. 4.132. The diagrams of axial forces on the bars in the top ring.

Ribs and circumferential beams

The analysis indicates that the ribs and circumferential beams are not significantly strained. The ribs (at the most unfavourable combination of loading) carry compressive forces, compressive stress in the concrete matrix amounting to 3.2 MPa. Compressive stress in the reinforcing bars (the top row) reaches a maximum of 26 MPa. All the bars located in the ribs are compressed along their whole length. It worth noting that the strain of the bars is twice as large in the anchorage zone, which may be the result of two factors – that the bars carry forces in the rings and that it is a result of connecting ribs and rings with contact elements.

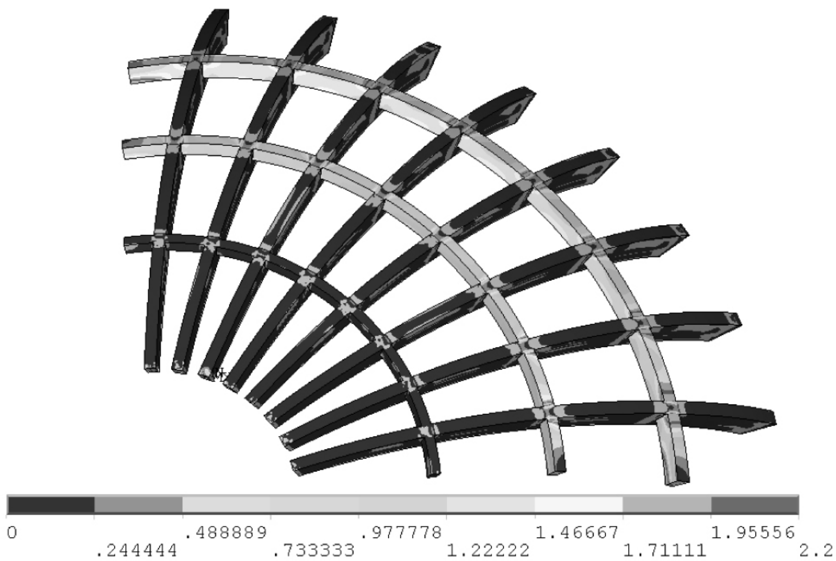

Fig. 4.133. The first principal stresses in the ribs and circumferential beams.

The circumferential beams, depending on their location – the zone of radial displacement in the direction towards the centre of the circle or out of the circle – are compressed or tensioned, respectively. This means that they carry mainly axial forces. This is why a circumferential beam located closest to the top ring is compressed. Two circumferential beams located below carry tensile forces in the circumferential direction and bend locally in the area of the ribs – this phenomenon may be partially a result of the way the loading is applied. The maximum tensile stress in the sections of circumferential beams (concrete matrix) is approximately 1.7 MPa. The strain of the reinforcing bars is 13 MPa. Considering the fact that these are the characteristic values, it is possible that in the actual physical structure, the concrete cracked locally and the reinforcing bars of the circumferential beams are more strained in reality than in the linear analysis which has been presented here.

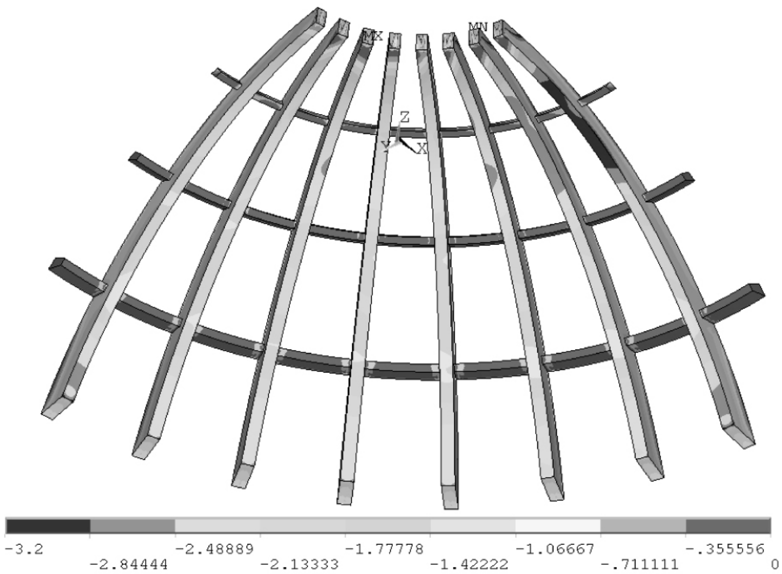

Fig. 4.134. The third principal stresses in the ribs and circumferential beams.

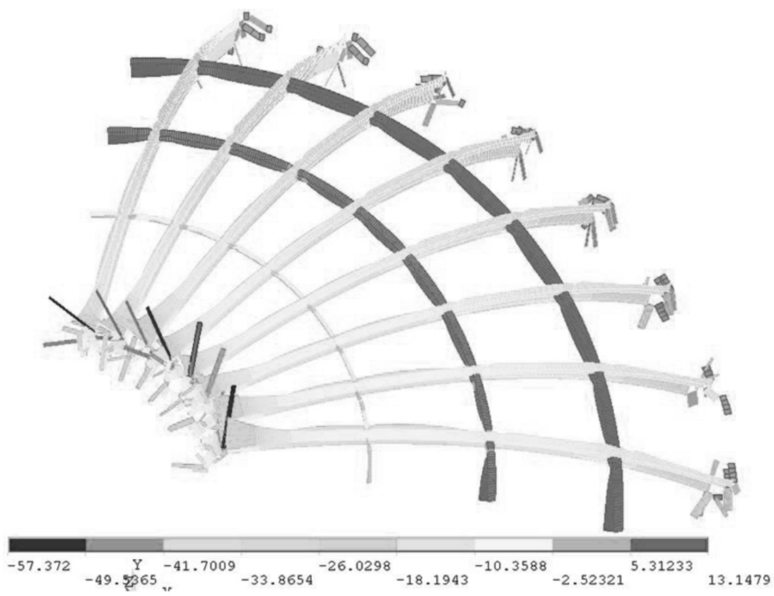

Fig. 4.135. The values of stress in the reinforcing bars of the ribs and circumferential beams.

The bottom ring

The bottom ring and the top ring are the key elements of the structure of the Hall and the failure of any of them may lead to the collapse of the building. Inspection of the Hall discovered localised cracking on the bottom ring, but the nature of theses cracks has not been investigated so far – it is not clear whether they occurred during concrete curing as a result of contraction or result from carrying structural loads. The analysis aimed to determine the causes of cracking of the bottom ring.

Using solid type elements for modelling concrete and mapping of the physical geometry of the lattice-work in the bottom ring enables determination of the stress distribution in these elements with high probability. Fig. 4.136 depicts maximum tensile stress in concrete for the most unfavourable combination of loading.

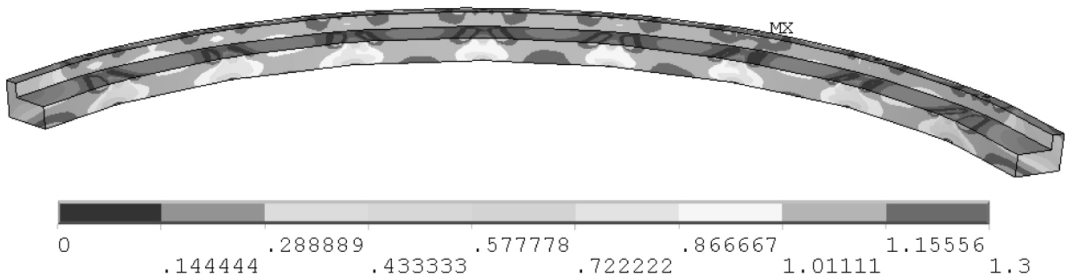

Fig. 4.136. The maximum tensile stress in the bottom ring.

The maximum principal stresses, except the localised changes caused by support and application of forces, are tensile stresses in concrete with values no higher than 1.3 MPa. Considering the fact that the tensile strength of the concrete of the bottom ring obtained in experimental tests amounts to 3.6 MPa, it is clear that the element's load-bearing capacity is sufficient. The strain of the latticework is also small – for the belts it is 3.8 MPa, for cross-bracing: 3.0 MPa, and for the posts: - 1.8 MPa.

Next, an analysis was carried out to take into account the calculation value of the dead load of the structure (factor 1.35) and the weight suspended from the ribs during events in the Hall, which were increased from 3 to 12 tonnes, and for the top ring - from from 40 to 80 tonnes. These loads increased the value of maximum tensile stress up to only 1.7 MPa. This means that an increase in vertical forces does not impact the strain of the bottom ring. Most probably, this results from the way loading is transferred from the ribs to the ring – almost perpendicular to the surface of the ring. For this reason, the horizontal component of the vertical loading is relatively small. The creators of the Hall based their work on the behaviour of compressive curved elements – including arches (the ribs of the Hall) – which involves transferring the reaction to the support in the direction parallel to the radius of the arch. This proposition is confirmed by the fact that the top ring, to which the ribs are attached in its plane and transfer forces along its radius, increases its strain twofold under the impact of the exceptional loading described above.
The conclusion is that the concrete cracked during the process of curing or as a result of application of horizontal forces to the structure, as only these could bring about tensile stress large enough to cause the cracking. They could have occurred, for example, as a consequence of incorrect removal of formwork from the structure.
In addition, the strain of the lattice-work was determined based on the assumption that it has to carry the total value of tensile forces in the ring (with concrete completely cracked). This situation was analysed using the model in the following way – the concrete of the bottom ring was assigned minimum stiffness, with the Young Modulus equal to 300 MPa, whereas the Young Modulus for the lattice-work was 205,000 MPa. In such a situation, for practical purposes, the whole loading is carried by the lattice-work. The results of this analysis are presented in fig. 4.137 to 4.139. The strain in the belts reaches 27 MPa, in posts the range is from 20 MPa to 44 MPa, and in the cross-bracing from 50 MPa to 61 MPa. Taking into account a safety margin of 2 and a characteristic load-bearing capacity of steel of 235 MPa, there is still a safe margin in the load-bearing capacity of the lattice-work.

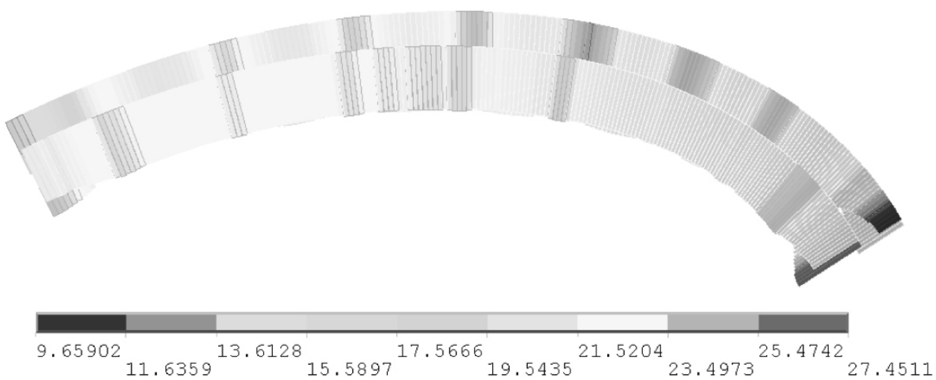

Fig. 4.137. Stresses in the belts of the lattice-work.

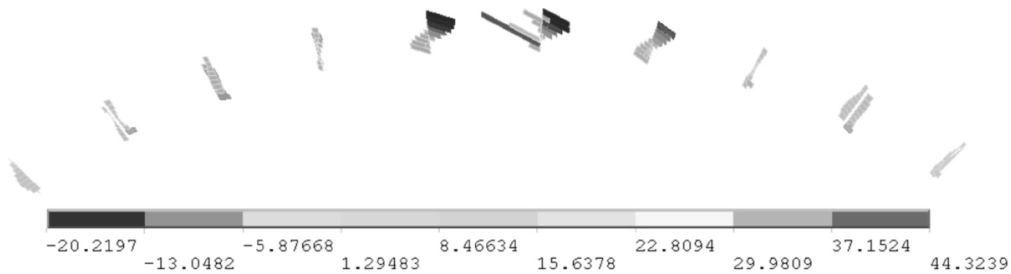

Fig. 4.138. Stresses in the posts of the lattice-work.

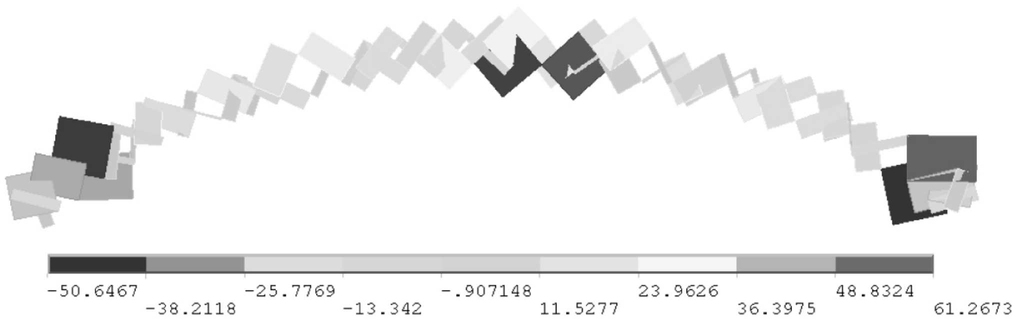

Fig. 4.139. Stresses in the cross-bracing of the lattice-work.

When very large vertical forces are transferred from the ribs to the bottom ring and to the bearings located below the ribs, the reinforcement of concrete in the contact pressure zone becomes critically important. This is confirmed by the results for stress of the support reinforcement, which range from - 180 MPa to 67 MPa (fig. 4.140). The conclusion is that the reinforcement was selected for the static scheme adopted in an informed and appropriate way.

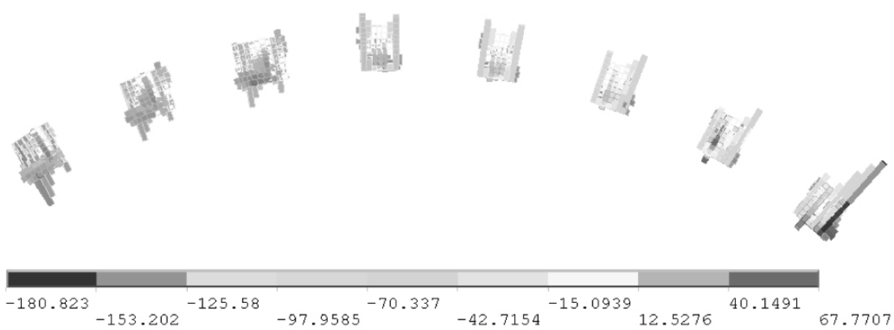

Fig. 4.140. The strain of the support reinforcement.

The prestressing result

The influence of prestressing on the structure of the bottom tension ring was assessed in relation to the displacement of the structure in the radial direction. Fig. 4.141 presents the radial displacement of the structure under the dead load before prestressing (left) and after prestressing (right).

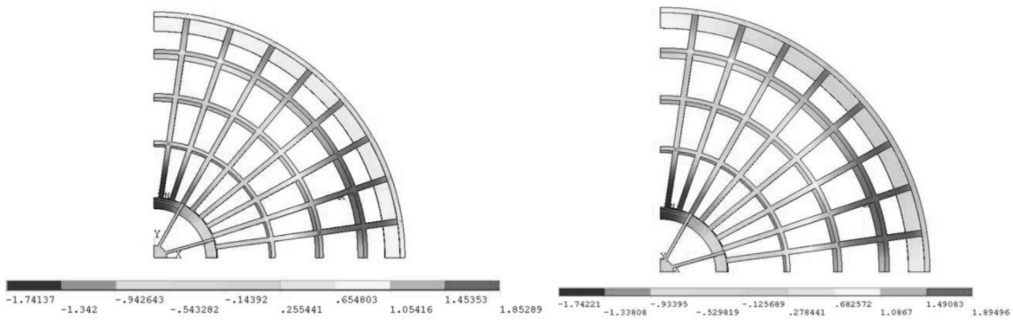

Fig. 4.141. Radial displacement of the ring caused by the dead load before and after prestressing.

It would appear that the prestressing had no significant impact on the structure displacement in the radial direction. This is because the force compressing the cables has a relatively low value.

4.3.6. Final conclusions

- The load-bearing structure of the dome in the Centennial Hall is very stiff vertically, when loaded with its dead load, snow load and additional load during events held in the Hall. It displaces vertically by only 12 mm, whereas the radial displacement is smaller by an order of magnitude. The bottom ring is displaced outwards, whereas the top ring is displaced inwards – which results in tension of the bottom ring and compression of the top one. The zero axis of radial displacement is situated in the mid height of the ribs.
- The strengthening tie rods between the posts of the lantern which were introduced in the 1930s are redundant from the point of view of the strain on the posts. For practical purposes, the posts are not strained at all where they are placed nor in the plain in which they are located. This is confirmed by very low stress values of the tie rods (1 MPa).
- The lantern posts are highly strained, with the strain exceeding their load-bearing capacity. The linear analysis indicated that the tensile strength of concrete (2.9 MPa – in line with what was determined for this fragment of the structure in experimental testing) has been exceeded. The reference here is to fragments of the posts near their base and to cracking above the passageway. The excessive tensile stresses in concrete of the posts joining the top ring result most probably from ineffectively selected cross-sections of the posts – the compressive stress of the ribs on the top ring was not considered at all or was taken addressed in an inadequate way.
- The linear analysis indicated not only the range of cracking in the concrete, but also that the reinforcing steel is strained nearly to the value of its characteristic load-bearing capacity - 190 MPa.
- The damage to the lantern posts is insignificant when considered from the point of view of the static behaviour of the whole structure – the structure of the lantern is not critical to the statics of the whole building – for example, in the dome of the Pantheon in Rome, an opening (oculus) is to be found instead of the lantern. The lantern itself is not in danger provided no additional loading is applied to it. Its static scheme was originally comprised of four frames with all nodes stiff – thus forming an overly stiff structure. When the concrete in the near-base zone was damaged, it would appear that hinges were formed and the degree of stiffness changed. As a result of this change, internal forces were redistributed within the frames and the lantern to attain a new balance.
- The top compression ring is strained only to a small degree – compressive stress in the concrete is 4 MPa, and in the steel: 40 MPa. Concrete under the lantern posts may be slightly cracked in places, but this has no impact on the structural behaviour of the element as a whole
- The ribs carry only compressive forces. Their strain is small – compressive stress in concrete and steel are equal to 3.2 MPa and 26 MPa respectively. Their load-bearing capacity is much higher than the effective loading of the structure.
- The analysis indicates that cracking on the bottom ring must have occurred as a result of concrete contraction during curing or as a result of radial forces which may have been applied inadvertantly to the ring. In the current situation, the maximum tensile stress of in the structure amounts to 1.3 MPa, which is much below the tensile strength of concrete in this element (3.6 MPa).
- Increasing the vertical loading has no significant influence on increasing tensile stress in the concrete of the ring, which is a result of an appropriate shape and form of the ribs.
- The lattice-work in the ring is capable of carrying loads by itself with an acceptable margin of safety. In this situation, the strain of the belts reach 27 MPa, compression posts –20 MPa, tension posts 44 MPa, compression cross-bracing - 50 MPa and tension cross-bracing - 61 MPa. The lattice-work still assures safety margin in its load-bearing capacity, if a safety factor of 2 is adopted and the characteristic load-bearing capacity of steel is equal to 235 MPa.
- The reinforcement of the bottom ring is an important element in relation to the curve adopted for the ribs. The reinforcement works under pressure in places where the ribs transfer loading via the ring to the bearings. As one of only a few elements of the dome of the Centennial Hall, the support reinforcement has not been oversized and the stress in these reinforcing bars ranges from 180 MPa to 67 MPa.
- The prestressing carried out during the last renovation intervention has no practical impact on the deformation of the load-bearing structure of the dome.

4.4. The design concept for comprehensive monitoring of the Hall (as an UNESCO World Heritage Site)

Visual inspection is the most obvious and the simplest method for assessing the condition of a structure. It is one way of assessing the structural condition of a building, which is also straight forward. Significant structural damage is visible to the naked eye, but at the same time the method has its limitions because it is not possible to detect all hidden damage. A visual inspection of a building seeks to assess the level of damage sustained to the value of the building as a heritage site – traces of vandalism or destructive impact of elements. A visual inspection should conclude with a report that includes a description of the changes identified, photographic documentation and initial documentation concerning measurement estimates. Measuring physical values such as: displacements, settlement and cracking requires the use of relevant equipment and enables oversight of the condition of the structure and its security. Comprehensive monitoring provides for an assessment of the structural effectiveness of conservation and renovation work undertaken, which is something of special importance in the case of heritage buildings. Introduction of a monitoring system in existing heritage buildings enables ongoing assessment of structural changes in parameters measured and transposing them into estimates of strain of individual elements. Ongoing registration of measurement results allows monitoring of the static behaviour of the structure over time in response to changes in loading. Such monitoring also enables prediction of the overall and general durability of the building. This is especially important in the case of heritage buildings, such as the Centennial Hall.
Measurement of deformations provides the basis for monitoring of the building structure. The monitoring system has to meet a number of significant requirements:

a) Necessary conditions:
- accuracy,
- repeatability,
- stability of measurements over time.

b) Additional conditions – additional measurements:
- Sensor temperature measurement,
- Structure temperature measurement,
- Measurement of wind force and direction,
- External temperature measurement,
- Precipitation and sun exposure measurement,
- Assessment of the aggressiveness of atmospheric conditions.

For the Centennial Hall, the proposal is to divide the monitoring system into two parts: static monitoring and dynamic monitoring.

4.4.1. Static monitoring

Static monitoring includes assessment of the size of vertical and horizontal displacements, rotation of structural elements, deformation in selected areas, changes in areas of thermal impact, crack aperture and building settlement.
Static monitoring is based on direct readings from monitoring devices or automatic readings where information is collected by electronic equipment. The frequency of readings, set up of measurement sites and selection of equipment can be fixed or changed depending on the conditions and the character of the behaviour of the structure. The following devices can be used in monitoring:

- Inclinometers – to determine the angle of vertical tilt of structural elements.
- Extensometers – to measure changes in the length and linear displacements of elements.
- Benchmarks – to determine the difference in height between measurement points.
- Tensometers – to measure deformations of, e.g. steel elements of bearings or reinforcing bars.
- Mini prisms – which reflect laser beams of tacheometers, the so called Total Stations, which measure vertical and horizontal displacements.
- Feeler gauges/ crackmeters – to determine the width of cracks or joints between two adjacent surfaces.
- Piezometers – for measuring the height of the groundwater table in the aquiferous layers in the surroundings of the building.
- Settlement gauges – to measure settlement of the building.

Taking into consideration the abundance of available devices and the range of their functions, as well as the specific characteristics of the Hall, the most effective measurement systems are those, which can monitor potential displacements and settlement of the Centennial Hall structure.

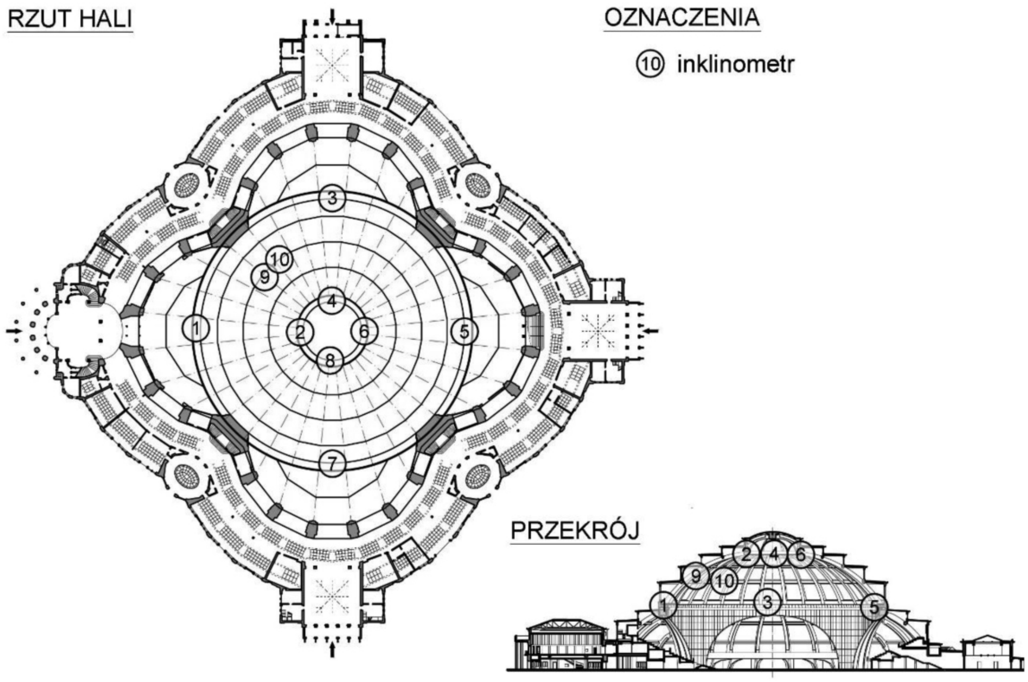

Fig. 4.142. An example of an arrangement of inclinometers.

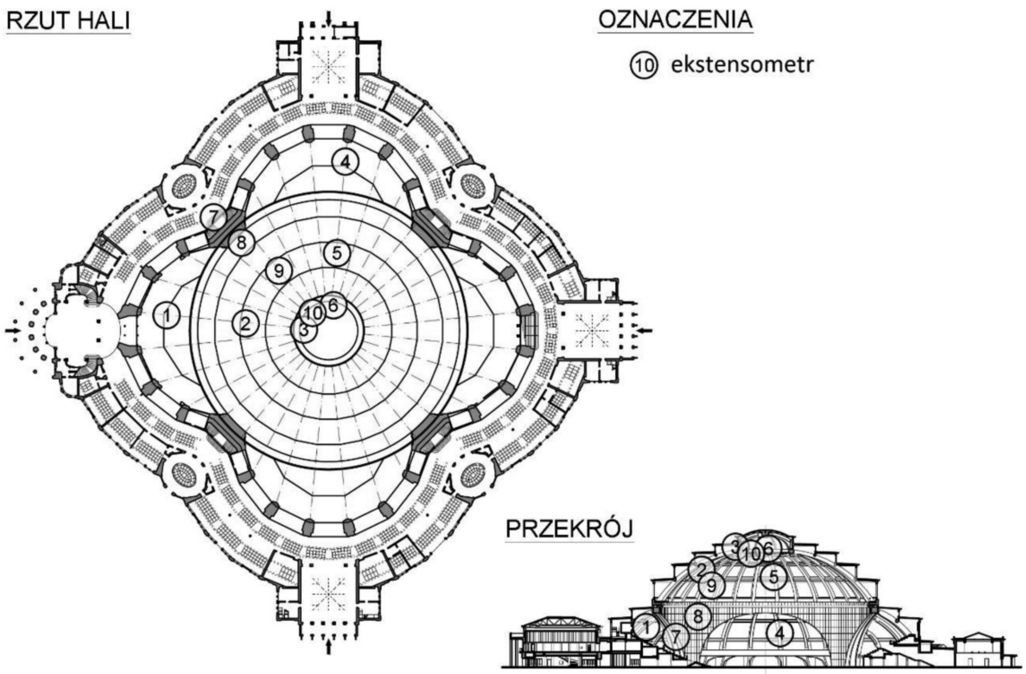

Fig. 4.143. An example of an arrangement of extensometers.

4.4.1.1. Displacement monitoring

Displacement monitoring of critical structural elements of the Hall, should include: the bottom tension ring, the top compression ring with the lantern, the dome's ribs and pillars. Effective monitoring in this regard requires an electronic Total Station tacheometer. This device combines the functions of a laser or electrooptic rangefinder and that of an electronic theodolite, which enables measuring and simultaneously registering angles and distances, and processing obtained data into coordinates of points under observation. This type of equipment is used for investigation of displacements and deformations of existing buildings, during building construction or in building surveys.

In order to ensure comprehensive measurement of displacements in the Centennial Hall, it would be necessary to install at least three tacheometers in the building interiors and at least one tacheometer outside the building. Such an arrangement of tacheometers would monitor displacement of approximately 100 - 120 measurement points, both inside and outside the Hall.

An application of a 3D laser combined with the 4D INSPECTOR software is an interesting solution, which can be used in the Centennial Hall. It is a system (a scanner plus software) for remote control and automatic 4D scanning (3D + time). To date, the data obtained from subsequent scans had to be compared using special software, e.g. Geomagic, which contains a set of tools for rapid transformation of 3D data from laser scanning into 3D digital models, which can be used for analysis and documentation. This software represents one of the fastest programmes available for converting scanning data into parametric CAD models. The surfaces of individual scan images can be transformed into grids of triangles during a comparative analysis, which can then be used for comparison with older scan images.

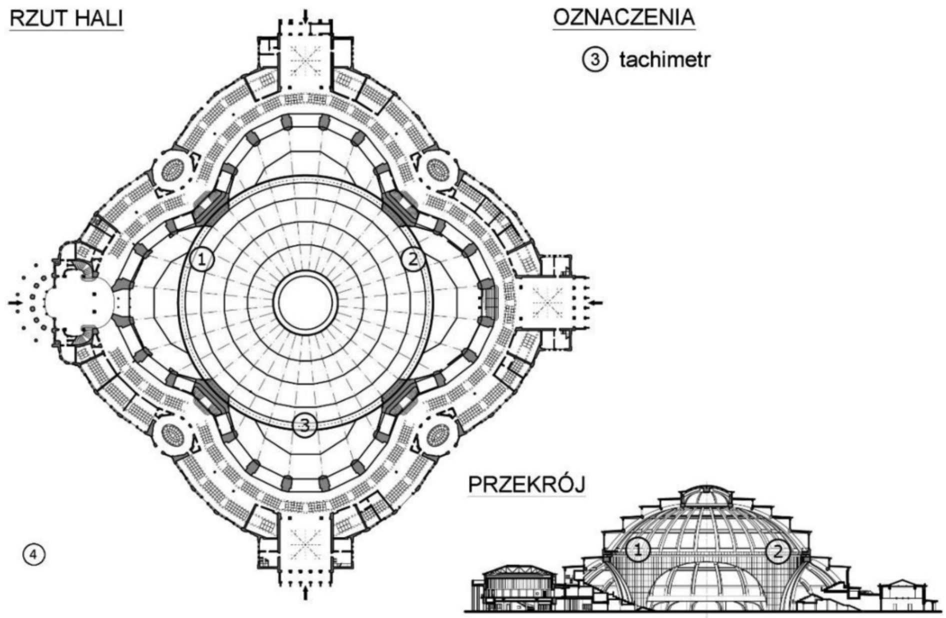

Fig. 4.144. An example of an arrangement of tacheometers.

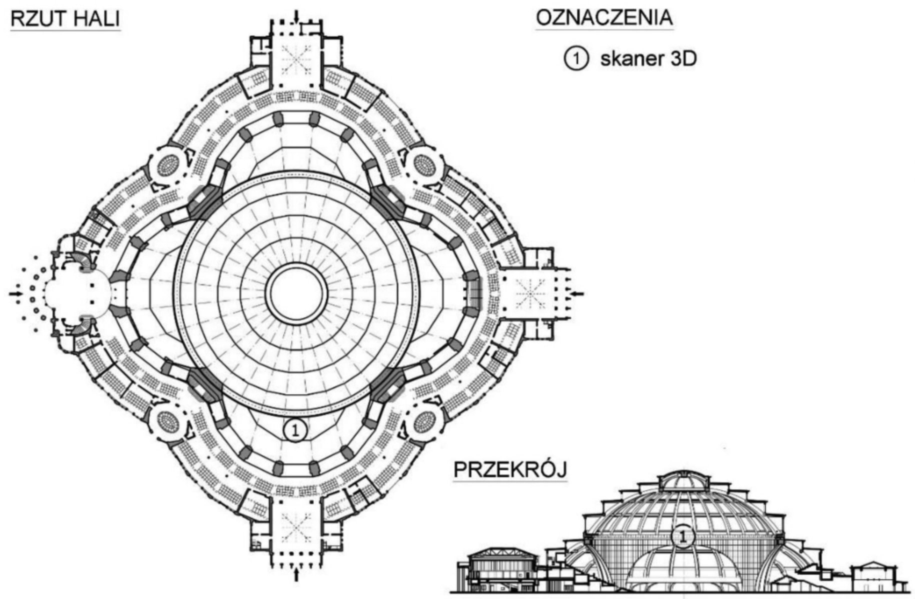

Fig. 4.145. An example of 3D scanning device location..

4.4.1.2. Building settlement monitoring

Building settlement monitoring requires, aside from measurement of displacement of individual points, knowledge concerning the geological structure of the soil upon which the building is constructed (type, depth, layout and inclination of strata), the condition of soil including its stiffness. All this information is necessary for putting into place a correct arrangement of measurement points – benchmarks. However, in addition to detailed soil analysis, it is necessary to investigate also other factors, which can impact the speed and degree of settlement, e.g. soil pre-consolidation.
Settlement monitoring can be carried out using traditional levelling instruments, tacheometers or 3D scanning.
It is also possible to use a DSM system for settlement monitoring. Such a system operates in an automatic and onging way for monitoring structures and registering various settling movements of a building. The system comprises a number of liquid settlement gauges connected to each other. The liquid fills tubes which are connected to a reference tank, located securely not far from the monitored area. The liquid level measurement monitors the difference in height between the gauges and the reference tank.

4.4.1.3. Monitoring of changes in temperature and moisture

In the case of a building with serious ventilation problems such as the Centennial Hall, it is appropriate to install numerous temperature and moisture sensors and to arrange them evenly. The data obtained from these sensors can be used in future for designing an effective system for climate control inside the Hall. Numerous window surfaces and frequent changes in the number of people inside the building pose a particular challenge for the ventilation.

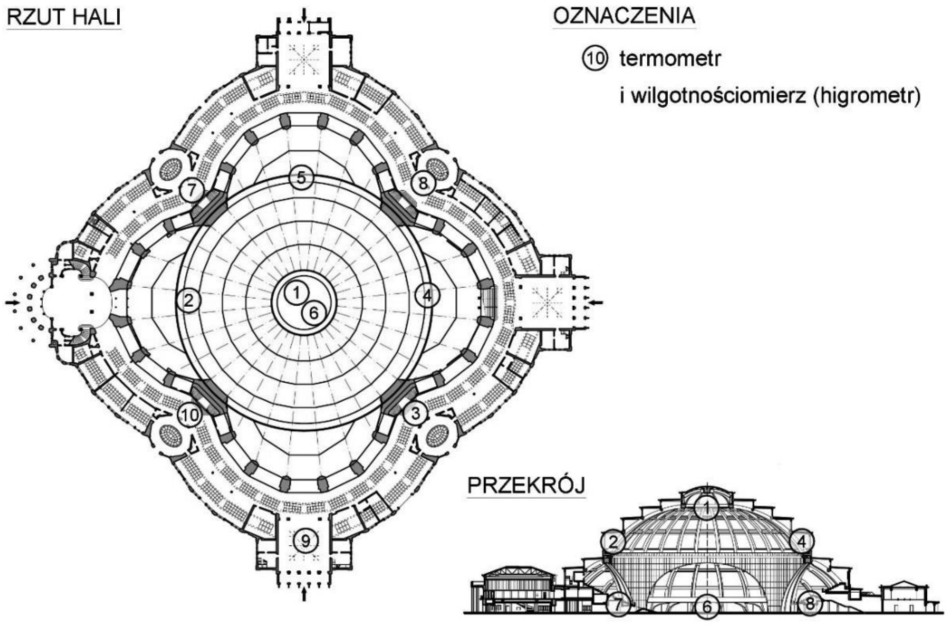

Fig. 4.146. An example of an arrangement of thermometers and hygrometers.

4.4.2. Dynamic monitoring

Dynamic monitoring, which is based on a vibration monitoring system, can perform three functions:

1) Monitoring of the strain of the structure, resulting from dynamic loading of the building,
2) Monitoring of the vibrations reaching the structure (which are generated outside or inside the building) and are capable of exciting the building.
3) Monitoring of potential changes to dynamic (modal) properties of the building; a significant number of changes to these properties could indicate degradation of the structure.

Since the dynamic parameters of the Centennial Hall have not been determined, the correct selection of sites for vibration measurement and the choice of transducers should be preceded by a dynamic numerical analysis of the building (e.g. a dynamic FEM analysis) as well as measurement validation and verification. The suggestions presented below have not been preceded by any such analysis and represent only preliminary proposals.

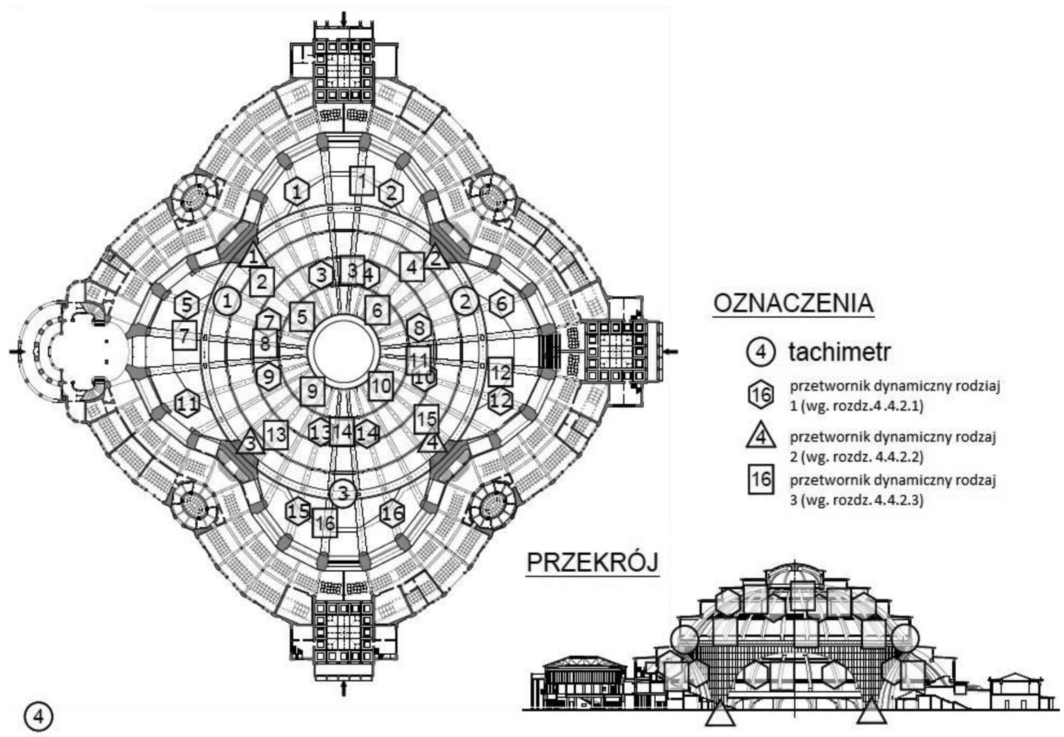

Fig. 4.147. An example of an arrangement of dynamic transducers 1, 2 and 3.

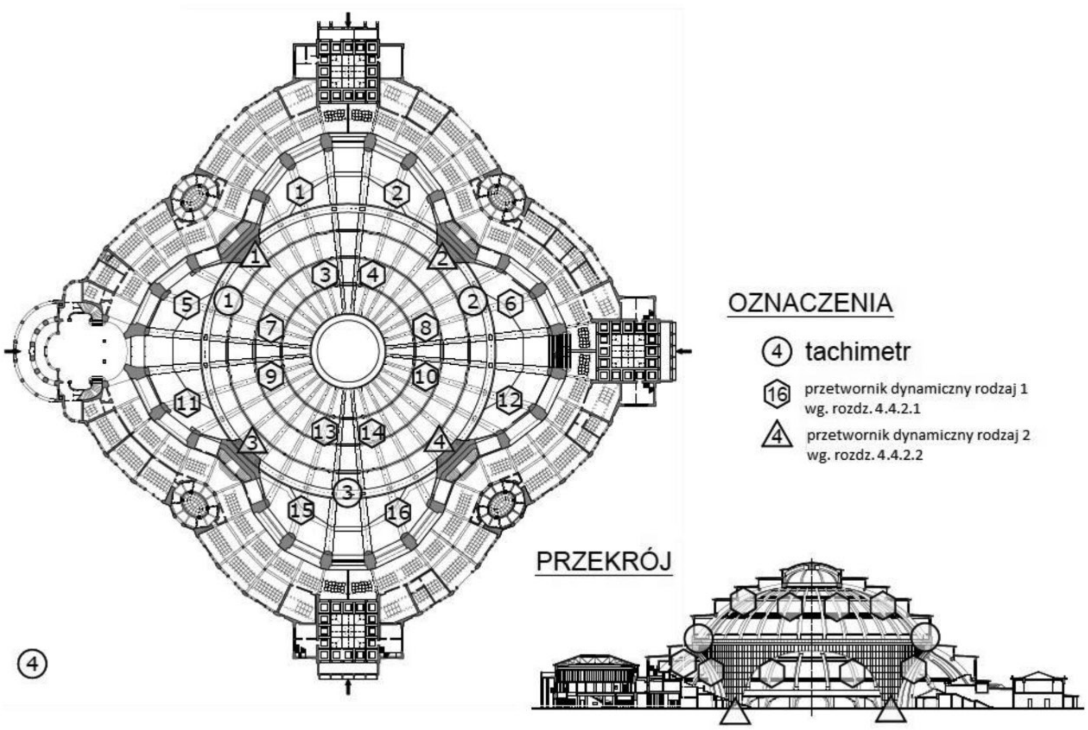

Fig. 4.148. An example of an arrangement of dynamic transducers 1 and 2.

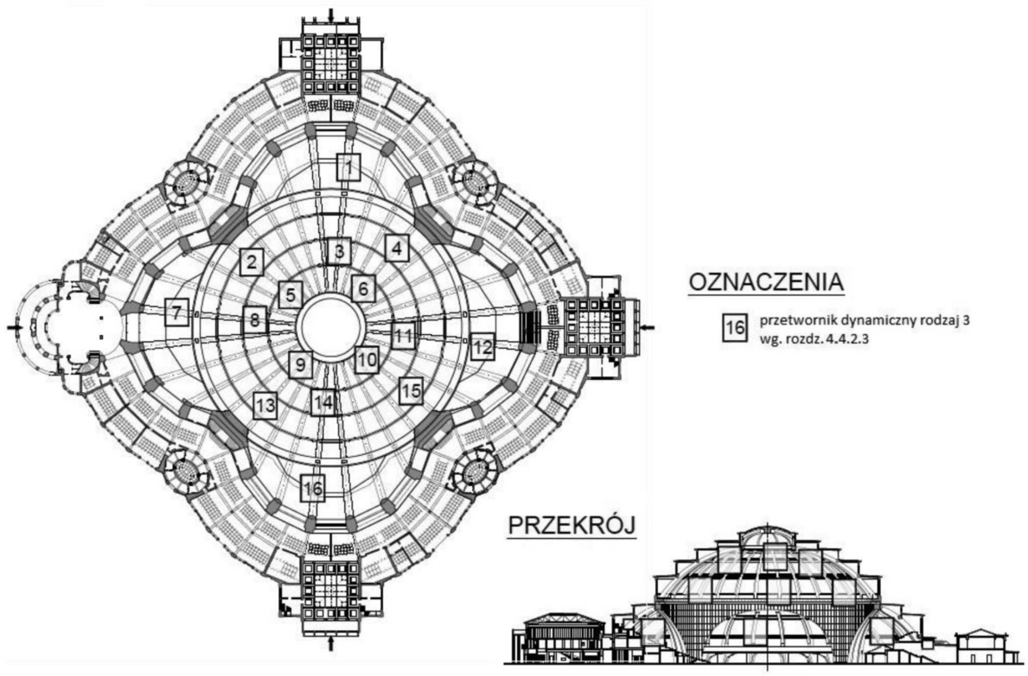

Fig. 4.149. An example of an arrangement of the dynamic transducer 3.

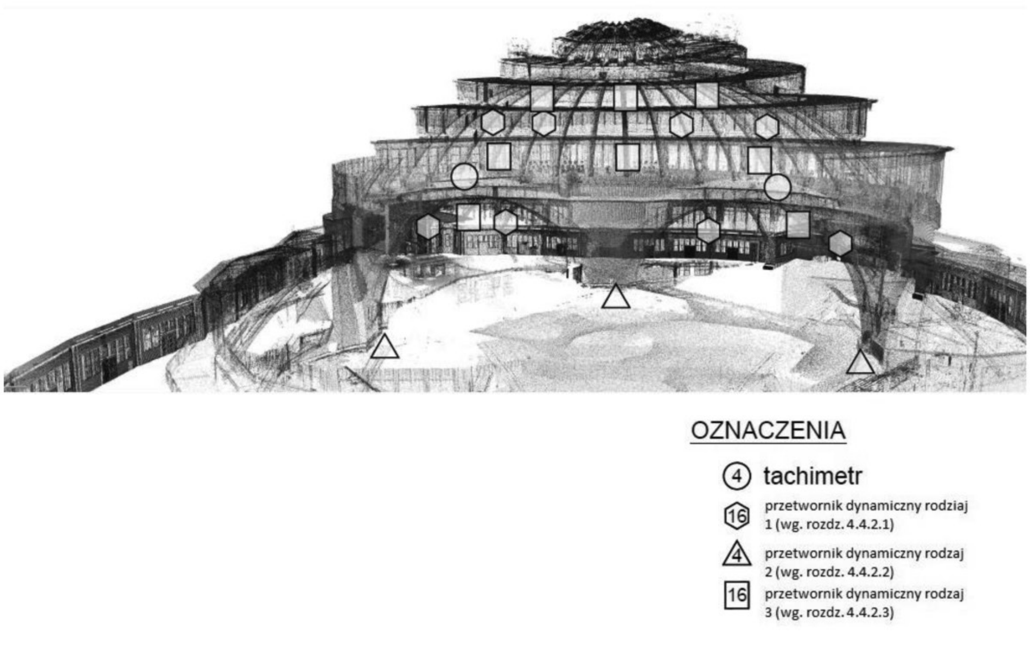

Fig. 4.150. An example of an arrangement of dynamic transducers 1, 2, 3.

4.4.2.1. Monitoring of the building's strain caused by dynamic loading.

The areas of increased strain of the structure should be determined on the basis of on the analysis of static behaviour of the building. Location of the transducers can be based on a joint analysis of static loads and predicted dynamic loads (impact of wind gusts, impacts caused by passing trams, synchronic human traffic during the mass events held in the Hall). The suggested locations include:

– The cylinder (pendentive) (in the middle of its height – approximately at +10.5 m),
– The ribs of the dome (in the middle of their height – approximately +30.0 m),
– For an extended option also other heights on the ribs of the dome.

An arrangement of 4 transducers is proposed as a minimum option, whereas an arrangement of 16 transducers is proposed as the the maximum option. Considering the type of the building (its massive structure), the use of high-sensitivity transducers – accelerometers with a sensitivity of 10 V/g (1 V/ms^{-2}) is recommended.

4.4.2.2. Monitoring of the level of vibrations reaching the structure (which are generated outside or inside the building) and are capable of initiating vibrations

Monitoring of the vibrations which reach the structure should be carried out by measuring the vibration levels of building foundations (at the level of approximately -3.0 m). For the minimum option it is suggested that one transducer is used, whereas for the maximum option, 4 transducers should be used. Considering the type of the building (its massive structure), the use high-sensitivity transducers – accelerometers with a sensitivity of 10 V/g (1 V/ms^{-2}) is recommended.

4.4.2.3. Monitoring of potential changes to dynamic (modal) properties of the building; a significant number of changes to these properties could indicate degradation of the structure

Selection of measurement sites for the purposes of modal analysis should be preceded by a numerical modal analysis (to determine natural modal distribution) in order to prevent measurements at the nodes of the natural mode shapes (where the vibration amplitudes are small or equal to zero). Based on the results of the numerical modal analysis it is possible to determine the number of transducers needed and their locations. The minimum number of transducers (e.g. accelerometers) has been estimated as 16. As it is necessary to install a large number of transducers, it is worth considering separating out measurements for the modal analysis from the monitoring system. The advantage of such a solution involves lowering the one-off investment expense and creating the option of increasing the number of measurement locations. On the other hand, the disadvantages of this solution is the need to to bear separately the costs of data analysis (possibly employing an external company) and to install and disassemble the transducers each time an analysis is conducted. This last disadvantage can be eliminated if non-contact transducers are used (e.g. Laser Doppler Vibrometer – LDV). The laser must be located on stable ground (vibrations of the ground need to be a few orders of magnitude smaller than the measured vibrations of the investigated structure).

4.4.3. Conclusions

The data obtained from material testing and monitoring enables a number of static, dynamic and strength analyses to be conducted with the purpose of assessing the current structural condition of the Centennial Hall. These analyses can also be used to determine the likely causes of damage identified and to indicate the direction for conservation and research activities and further functioning of the building.

The main objective is diagnosis and monitoring using an interactive analysis and presentation of the results of research work.

4.5. Measurement equipment

4.5.1. Displacement measurement equipment

A displacement is a change - both translation or rotation - of the location of the points in the structure. A deformation is a displacement of the points of the structure resulting from a change of its shape, e.g. deflection or buckling. Control measurements are taken once – in order to obtain information on the current condition of the structure, or periodically – in order to indicate the change in the value and direction of displacements or deformations over time. Structural displacements can result in the appearance of cracks and fissures, which – if excessive - may lead to a failure or destruction of the building. Depending on the size of the deformation, the following information should be included in describing the condition of the structure:

– Diagnosis of cracks,
– Verticality of walls and pillars,
– The size of stress in the sections, where stress can concentrate (corners, connections, window posts , etc.),
– The current strength of structural materials,
– The conditions of building use.

There are numerous methods for assessing the impact of structure displacement. One of them involves the following definitions:

– A fissure – a discontinuity of an element, usually not very long and with aperture of less than 0.5 mm,
– A crack – a fissure with aperture of more than 0.5 mm,
– A fracture – a crack with a significant aperture (sometimes running even through the whole width of the section).

Cracking is just like any other structural process undergoing assessment and should be properly documented. The description of the process should contain: location and course of cracks on the surface of the elements, geometrical description, i.e. the width of aperture and depth of cracking, changes to the direction of their course and the description of variations in the process of appearing of new cracks and expanding of the existing ones.

One of the methods for investigating displacement involves monitoring of gypsum or glass seals perpendicular to existing cracks. The method is regarded by many as outdated and unreliable as testing plates are often mounted on a thick layer of gypsum, which is not resistant to weather and can degrade faster than the plate itself. What is more, in case of cracks located high above ground level, it is difficult to check the condition of the testing plate. For this reason, this indicative method is now being replaced with the application of testing plates with a scale (example presented in the picture). An indicator scale allows the increasing value of the displacement to be checked right up until the testing plate is broken.

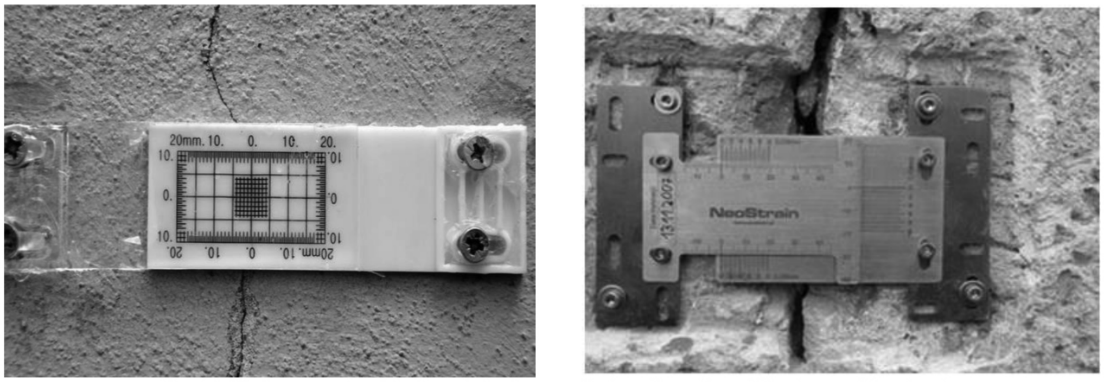

Fig. 4.151. An example of testing plates for monitoring of cracks and fractures of the structure.

Another method for measuring displacement involves application of geodetic devices, which register length, angles and height. They are universal due to the great variety of tesed building structures. The following geodetic devices are among those used most frequently:

– Electromagnetic and laser rangefinders – which use the measurement of time in which the emitted signal covers the distance between the device and the end point of the section, where it gets reflected back to the rangefinder with a reflector. Currently, laser and electrooptic rangefinders with a high accuracy ($2 \div 7\ mm/km$) and a short time $(3 \div 5\ s)$ of measurement are used. The light emitted by the rangefinder most frequently comes from a luminescent magnifier and is an infrared wave. Fig. 4.152 presents an example of a laser rangefinder. It is characterised by a range between 40 and 100 metres (depending on the model) and accuracy of up to $\pm 2\ mm$, continuity of measurement and memory of registered measurements.

Fig. 4.152. A laser rangefinder.

Fig. 4.153. An electronic theodolite.

– Electronic theodolites – are instruments used for automatic measuring of angles. They are mobile devices, characterised by high precision and a capacity for automatic calculation. Measurement data read out from coding circles are transferred directly to a computer which performs the calculations. Devices of this type can be used to check on the accuracy of levelling and impact on measured vertical and horizontal angles. Fig. 4.153 presents an example of an electronic theodolite. This device is weather-resistant, shock-resistant and characterised by an angle accuracy of 2" and is easy to use.
– Electronic tacheometers (Total Station) – which combine the functions of electrooptic or laser rangefinders and electronic theodolites, enabling simultaneous measurement and registration of angle values and distance, and transforming these data into coordinates of observed points. Devices of this type are used to investigate deformation of existing buildings, during building construction or in building surveys. There are industrial tacheometers, photo-tacheometers and tacheometers

integrated with a given operational system, e.g. Windows. Fig. 4.154 presents a tacheometer integrated with the Windows operational system – the device made by the TPI company. The device can be blocked if it gets stolen and is equipped with a system for monitoring of the device integrity. Measurement range is up to 300 m. It is waterproof and easy to use thanks to a clear LCD screen and is linked to a widely used operating system.

Fig. 4.154. An electronic tacheometer

Fig. 4.155. A combi-station device.

– Combi-station devices – which are a combination of an electronic tacheometer and a GPS receiver. The key element of this type of measurement is a data control unit which combines tacheometric and satellite measurements, using the same measurement language, data exchange format and an adequate calculation algorithm. Fig. 4.155 presents a GPS signal receiver. The device is characterised by a frequency of up to 100 Hz, multiple applications and easy and comfortable use.
– Digital and laser levelling instruments – are used for measuring differences in height with the method of geometric levelling with full automatisation of measurement process. The measurement is taken by means of the analysis of the field of vision of the levelling rod with a bar code. The picture is processed into a digital form projected onto the screen of a display unit and registered, or it is overlaid on the measured object or the levelling rod (in case of laser levelling instruments) with a photodetector. Apart from the readings from the levelling rod, the device enables measurement of distance with marginal error. Fig. 4.156 presents a laser levelling instrument. It has a red laser beam, which is visible to a human eye and enables measurements both inside and outside a building. The device is capable of measurements in two planes and with a tilt, and in two directions, in a way that maintains at the same time a high accuracy of $\pm 1\ mm/10\ m$. The range of the device is up to $300\ m$. Measurements can be taken by a single person. The rotational speed of the head can be set individually.

Fig. 4.156. Multi-task laser with levelling function.

The measurement of displacements and deformations of buildings is carried out most commonly by means of devices based on induction transducers. They enable measurement of relative changes in distance, height and angles with high precision and ongoing registration of measurement results. Devices of this type are used for short-lasting phenomena when measurements have to be taken at short time intervals in a large number of measurement locations, especially in hard-to-reach places. Induction transducers are used in such devices as strain gauges, electronic devices for monitoring deflection, hydrostatic levelling instruments or electronic levels for inclination measurement.
The methods used for investigating displacement include relative methods (when the measuring devices, e.g. strain gauges, transducers, pendula etc. are located directly on the object being measured, which results in a very precise measurement) and absolute methods (when the measuring devices are located externally to the object being measured and the measurement is carried out according to the points of reference). The following investigation methods can be used:

- A trigonometric method – involves selection of reference points installed on the object being measured, based on the readings of horizontal angles and distances between points of the reference grid. The measurement is taken from control stations located at a distance of no more than 250m from the reference grid. This method uses electronic tacheometers.
- A constant line method – involves determination of values perpendicular to the vertical plane of displacement which crosses the selected straight line. The line is uniquely determined by four base points, located outside the mobile area, using the theodolite axis or a laser beam. The implementation of the line is achieved through extension e.g. a steel wire through all the points. In each of the points, sensors are located in the form of plates. The vertical displacement of the points is registered in an ongoing way and transferred to the measurement station. This method is most frequently used for measuring displacement of elongated objects, such as e.g. bridges or dams.
- The geometric, trigonometric and hydrostatic levelling method – enables a precise determination of displacements. The geometric levelling method allows for investigating vertical displacements using automatic devices or levels. The measurements are taken on the basis of a constant base of points. In the case the points are located in hard-to-reach places, the trigonometric levelling method can be used. The difference in height is measured via changes of distance and vertical angle. The hydrostatic levelling method involves controlling differences in height using connected vessels with a simultaneous electronic system for reading out the results, which enables very precise measurements and a full picture of the process over time.

4.5.2. 3D scanning devices

3D scanning devices are excellent tools for detailed survey and monitoring of a building, (fig. 4.157). Scanners generate clouds of points, which can generate a very detailed, three-dimensional image of the object. A survey conducted using 3D scanning devices can be used also for further activities, e.g. designing, analysis, monitoring etc.

Fig. 4.157. A 3D scanner.

The process of spatial scanning involves placing a scanning device, comprising a stand, a battery and a head, in a selected location and arranging referential spheres. It is possible to connect the device to a computer in order to track the progress of measuring process. Scanning devices which do not require the use of referential spheres are already accessible on the market. The clouds of points are merged by a software, which analyses the similarities between the clouds of points or through a manual calibration of local coordinate systems. It is also possible to support scanning with GPS devices coupled with the scanner for putting the scans together.
The optimum parameters of scanning images have to be selected prior to the scanning process, depending on the purpose of scanning and planned distance between individual scanning stations. The image definition depends on the rotation of the mirror and the distance to the measured point. The measurement of objects located closer to the scanner is more accurate than of surfaces located further away.
It is possible to measure the distance between the points in the cloud and to determine the planes, immediately after scanning. Subsequent scanning images are saved in separate files, with sizes ranging from 80 MB to 1.5 GB depending on the parameters adopted.

4.5.3. Dynamic sensors

Considering the type of the building (its large weight and high stiffness), and the fact that it is characterised by rather low level vibrations, it is necessary to use high-sensitivity transducers. Accelerometers (piezoelectric or piezoresistive) with sensitivity of 10 V/g (1V/ms^{-2}) appear to be the best choice. They are readily accessible, e.g. the 8340 type transducer made by Bruel & Kjaer (fig. 4.158), the 393B31, 393B12 and 393B05 type transducers made by PCB (fig. 4.159); the KB12VD type transducer made by MMF (fig. 4.160). Given the character of the building, introduction of a cable-connected monitoring system is recommended.

Fig. 4.158. The Bruel&Kjaer 8340 transducer.

Fig. 4.159. The PCB 393B31 transducer.

Fig. 4.160. The MMF KB12VD transducer.

4.5.4. Drones

Drones are unmanned aerial vehicles, (fig. 4.161) and appear to be an interesting solution for supporting detailed monitoring of building structure. Long-range drones dedicated to visual, thermovisual and multispectral monitoring are capable of obtaining high quality photographic and video materials in a fully automatic way. These materials can facilitate visual inspections of buildings, especially in relation to hard-to-reach places in buildings, including heritage objects.

Fig. 4.161. An inspection drone.

Fig. 4.162. A rotary-wing drone.

Rotary-wing drones (fig. 4.162) seem to be especially useful for such purposes. They are primarily used for military tasks but can also be equipped for civil purposes. They usually contain a platform with four electric engines, which enables operation in all conditions. They do not require any support devices for take-off and landing – the platform takes-off vertically form the ground and can land on any flat surface. The application of modular observation heads (daylight and thermal ones) enables the system to carry observations during daylight and in more difficult conditions (night-time, fog). Rotary-wing drones of this type are also equipped with proximity detectors, which enable safe operation in a relatively densely built-up areas.

The drones of this type are more and more often equipped with an automatic pilot unit which enables them to fly autonomously based on a predetermined route and task schedule prepared by the operator of the base unit. It is also possible to steer the drone manually using the ground base unit, based on the video images and detectors located on the flying platform.

4.5.5. Monitoring systems

The variety of measurement equipment can be confusing. It is not easy to selecting an optimal arrangement of devices, software or the right moment for intervention in case any alarming behaviour of the structure is detected. For this reason, expert teams prepare the arrangement of measurement devices, which can be used to determine:

- Distance between the characteristic points, e.g. using rangefinders, tacheometers, theodolites or spatial scanners;
- The position of the measuring device, e.g. using the GPS system;
- Width and direction of crack apertures, e.g. using inclinometers or micrometers;
- Registration of the parameters of the environment, i.e. temperature, snowfall, rainfall, wind, relative moisture, air speed, light intensity, carbon dioxide level, e.g. using detectors of air composition and speed;
- Identification of vibration parameters, e.g. using vibrometers;
- Settlement, e.g. using levelling instruments or satellites;
- Photographs, videos, e.g. using cameras or drones.

The knowledge of statics and dynamics enables the placing of measuring and registering equipment in problematic locations. IT and mathematics experts work to create ever more user friendly software. Their work results in more functional and reliable monitoring systems, which can be adapted to the investigated object and the purpose of the research as defined by the building operator. The variety of functions performed by the objects which are to be monitored determines the selection of a proper solution to be introduced.

The purpose of monitoring usually involves informing users of the building to manage it in such a way prevent negative impact on its structural condition of the object. Each monitoring system comprises a number of dedicated measuring devices, data transmitters which send information to a registering unit as well as ways for presentation of obtained results. The process of results interpretation can be automated and then, if the adopted limit values are exceeded, the emergency procedure is activated. The cost of installing a monitoring system involves:

- Purchase of precision equipment;
- Purchase and installation of relay network between the measuring device and the registering unit or hiring qualified employees for collecting measurements;
- Cost of maintaining the relay software and the software for presentation of the results generated;
- Maintenance of the installation and equipment.

Purchase of precision equipment is the highest cost. The equipment usually cannot be used in other situations and must be permanently installed to age along with the monitored structure. Therefore, when considering different options, it is worth taking into account:

- The anticipated period of time of monitoring;
- The frequency of conducted measurements;
- Possibility for modification of elements of the system in order to fit in with any potential changes in the use of the object.

5. Preliminary observations from monitoring of the geometry of the bottom and top rings of the dome.

The bottom tension ring is an element, which is critical to the structure of the Centennial Hall. The measuring system involved geometric monitoring based on a single TST device – an automatic laser tacheometer (fig. 5.1) – which was installed in the building for three months (May to July 2015). Devices of this type are used in tacheometry, which involve 'mass' measurements of a location of points. There are optical and electronic tacheometers. In the electronic type, the reading of vertical and horizontal directions is carried out automatically and the distance is measured by an electrooptic rangefinder included in the device. A prism, (fig. 5.2), is necessary for measuring distance with a traditional tacheometer. The prism reflects a wave sent by a phase rangefinder installed inside the device. The reflected wave returns to the rangefinder and the distance is calculated based on the difference in phases.

Currently available tacheometers are high precision devices which guarantee high accuracy and repeatability of measurements. Most devices are waterproof and dustproof, which guarantees the continuity of operation even in very difficult conditions.

Fig. 5.1. A tacheometer.

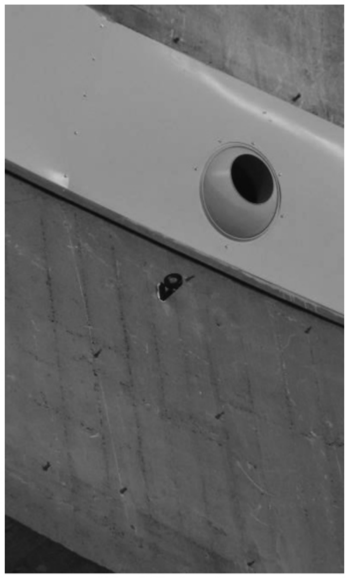

Fig. 5.2. A prism.

Six prisms were mounted on the bottom tension ring of the Centennial Hall and 2 prisms were mounted on the top compression ring (fig. 5.3, 5.4). An additional 2 control prisms were mounted. The location of tacheometer is marked with the letter V in fig 5.3.

Data from the measuring system in the Local Station for Data Acquisition (LSDA) was transmitted to the Data Collecting Centre (DCC). The data gathered by LSDA and then in DCC was used to evaluate the structural behaviour of the structure, potential strain changes etc. The results registered during monitoring can be used as a basis for decisions related to design recommendations regarding structural strengthening and conservation condition of the structure. The fact that the system is automatic and controlled by an external programme significantly increases safety and comfort of operation, as it allows monitoring of the structural behaviour of the building without requiring operators of the measuring equipment to visit unsecured areas.

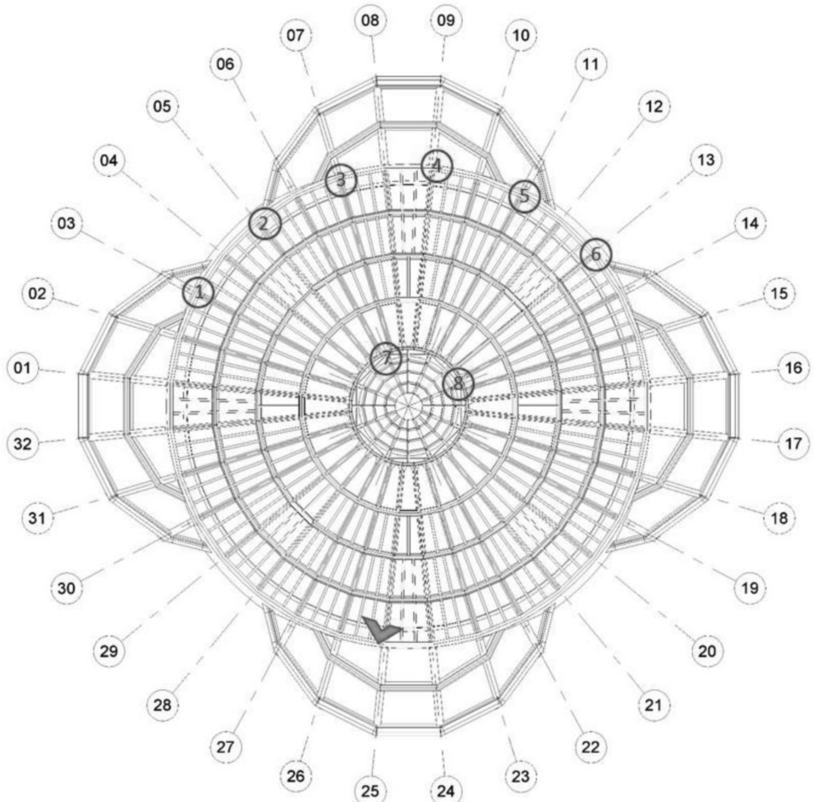

Fig. 5.3. The arrangement of the tacheometer and prisms – the floor plan of the structure of the Centennial Hall.

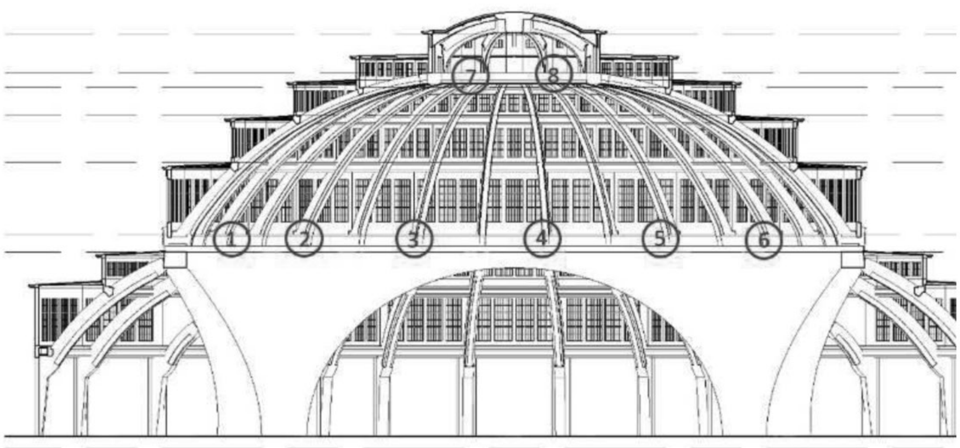

Fig. 5.4. The arrangement of prisms – vertical section of the structure of the Centennial Hall.

Specific limit values (mainly the maximum ones) can be set for the physical values actually being measured. Exceeding those limit values indicates a threat to the structural security of the structure. An emergency procedure is started if the limit is exceeded for any of the values – the computer automatically sends instructions to operators of the system.

5.1. Measurement results

The MSP Rapid PC automatic deformation monitoring system (fig. 5.5) was used for measurement data collection.
When the measuring cycle is finished, the operator of the monitoring system can observe displacements of the individual points being monitored as absolute values and compare them to data obtained in earlier measuring cycles. In order to

facilitate data analysis, the results can be presented as diagrams or they can be directly exported to other programmes for data editing and presentation, e.g. Excel.

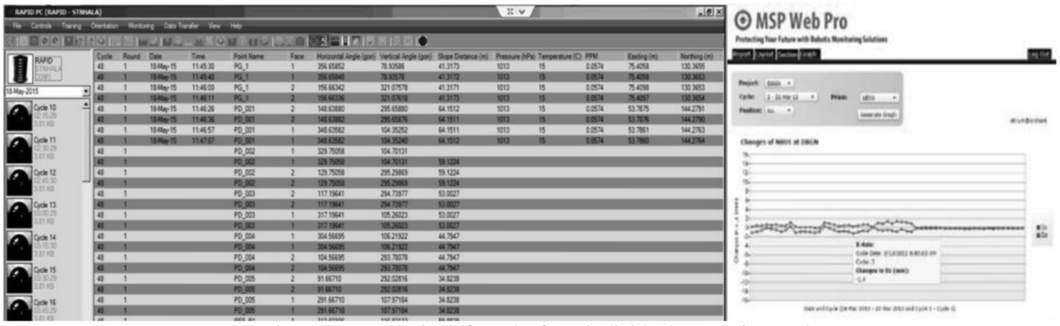

Fig. 5.5. Presentation of results from individual measuring cycles.

Examples of results obtained for selected measurement points on May 22, 2015 are presented below, in Tables 5.1 – 5.3 and in fig. 5.6 – 5.11. These results are also presented in [65].

Tab. 5.1. The measurements of displacements in the X direction.

Date	Cycle (time of measurement)	Measurement point						
		STN1	PG1	PD001	PD002	PD003	PD004	PD005
22.05.2015	00:00:30	0.8	0.0	-0.1	-0.2	-0.2	-0.1	0.0
	00:15:29	0.8	0.0	-0.1	-0.2	-0.2	-0.1	0.0
	00:30:30	0.8	0.0	-0.1	-0.2	-0.2	-0.1	0.0
	00:45:30	0.8	0.0	-0.1	-0.2	-0.2	-0.1	0.0
	01:00:30	0.8	0.0	-0.1	-0.2	-0.2	-0.1	0.0
	01:15:29	0.8	0.0	-0.1	-0.2	-0.2	-0.1	0.0
	01:30:29	0.8	0.0	-0.1	-0.2	-0.2	-0.1	0.0
	01:45:30	0.8	0.0	-0.1	-0.2	-0.2	-0.1	0.0
	02:00:30	0.7	0.0	-0.1	-0.2	-0.2	-0.1	0.0
	02:15:29	0.7	0.0	-0.1	-0.2	-0.2	-0.1	-0.1
	02:30:29	0.7	0.0	-0.1	-0.1	-0.2	-0.1	0.0
	02:45:29	0.7	0.0	-0.1	-0.1	-0.2	-0.1	0.0
	03:00:29	0.7	0.0	-0.1	-0.1	-0.2	-0.1	0.0
	03:15:29	0.7	0.0	-0.1	-0.1	-0.2	-0.1	0.0
	03:30:28	0.7	0.0	-0.1	-0.1	-0.2	-0.1	0.0
	03:45:30	0.7	0.0	-0.1	-0.1	-0.2	-0.1	0.0
	04:00:30	0.7	0.0	-0.1	-0.1	-0.2	-0.1	0.0
	04:15:29	0.7	0.0	-0.1	-0.1	-0.2	-0.1	0.0
	04:30:29	0.7	0.0	-0.1	-0.1	-0.2	-0.1	0.0
	04:45:29	0.7	0.0	-0.1	-0.1	-0.2	-0.1	0.0
	05:00:29	0.7	0.0	-0.1	-0.1	-0.2	-0.1	0.0
	05:15:29	0.7	0.0	-0.1	-0.1	-0.2	-0.1	0.0
	05:30:30	0.7	0.0	-0.1	-0.1	-0.2	-0.1	0.0
	05:45:29	0.7	0.0	-0.1	-0.1	-0.2	-0.1	0.0
	06:00:30	0.7	0.0	-0.1	-0.1	-0.2	-0.1	0.0
	06:15:30	0.7	0.0	-0.1	-0.1	-0.2	-0.1	0.0
	06:30:29	0.7	0.0	-0.1	-0.1	-0.2	-0.1	0.0
	06:45:29	0.7	0.0	-0.1	-0.1	-0.2	-0.1	0.0
	07:00:31	0.7	0.0	-0.1	-0.1	-0.2	-0.1	0.0
	07:15:30	0.7	0.0	-0.1	-0.1	-0.2	-0.1	0.0
	07:30:29	0.7	0.0	-0.1	-0.1	-0.2	-0.1	0.0
	07:45:29	0.7	-0.1	-0.1	-0.1	-0.2	-0.1	0.0
	08:00:30	0.7	-0.1	-0.1	-0.1	-0.2	-0.1	0.0
	08:30:29	0.7	-0.1	-0.1	-0.1	-0.2	-0.1	0.0
	08:45:29	0.7	-0.1	-0.1	-0.1	-0.2	-0.1	0.0
	09:00:29	0.7	-0.1	-0.1	-0.1	-0.2	-0.1	0.0

	09:15:29	0.7	-0.1	-0.1	-0.1	-0.1	-0.1	0.0
	09:30:30	0.7	-0.1	-0.1	-0.1	-0.1	-0.1	0.0
	09:45:30	0.7	-0.1	-0.1	-0.1	-0.1	-0.1	0.0
	10:00:29	0.7	-0.1	-0.1	-0.1	-0.1	-0.1	0.0
	10:15:30	0.7	-0.1	-0.1	-0.1	-0.1	-0.1	0.0
	10:30:30	0.7	-0.2	-0.1	-0.1	-0.1	-0.1	0.0
	10:45:29	0.7	-0.2	-0.1	-0.1	-0.1	-0.1	0.0
	11:00:29	0.7	-0.2	-0.1	-0.1	-0.1	-0.1	0.0
	11:15:29	0.7	-0.2	-0.1	-0.1	-0.1	-0.1	0.0
	11:30:30	0.7	-0.1	-0.1	-0.1	-0.1	-0.1	0.0
	11:45:30	0.7	-0.1	-0.1	-0.1	-0.1	-0.1	0.0
	12:00:29	0.7	-0.1	-0.1	-0.1	-0.1	-0.1	0.0
	12:15:27	0.7	-0.1	-0.1	-0.1	-0.1	-0.1	0.0
	12:30:30	0.7	-0.1	-0.1	-0.1	-0.1	-0.1	0.0
	12:45:29	0.8	-0.1	-0.1	-0.1	-0.1	-0.1	0.0
	13:00:28	0.8	-0.1	-0.1	-0.1	-0.1	-0.1	0.0
	13:15:29	0.8	-0.1	-0.2	-0.1	-0.1	-0.1	0.0
	13:30:28	0.8	-0.1	-0.2	-0.1	-0.1	-0.1	0.0
	13:45:30	0.8	0.0	-0.2	-0.1	-0.1	-0.1	0.0
	14:00:29	0.8	0.0	-0.2	-0.2	-0.1	-0.1	0.0
	14:15:29	0.8	0.0	-0.2	-0.2	-0.1	-0.1	0.0
	14:30:29	0.8	0.0	-0.2	-0.2	-0.1	-0.1	0.0
	14:45:29	0.9	0.0	-0.2	-0.2	-0.1	-0.1	0.0
	15:00:29	0.9	0.0	-0.2	-0.2	-0.1	-0.1	0.0
	15:15:28	0.9	0.0	-0.2	-0.2	-0.1	-0.1	0.0
	15:30:28	0.9	0.1	-0.3	-0.2	-0.2	-0.1	0.0
	15:45:29	0.9	0.1	-0.3	-0.2	-0.2	-0.1	0.0
	16:00:28	0.9	0.1	-0.3	-0.2	-0.2	-0.2	0.0

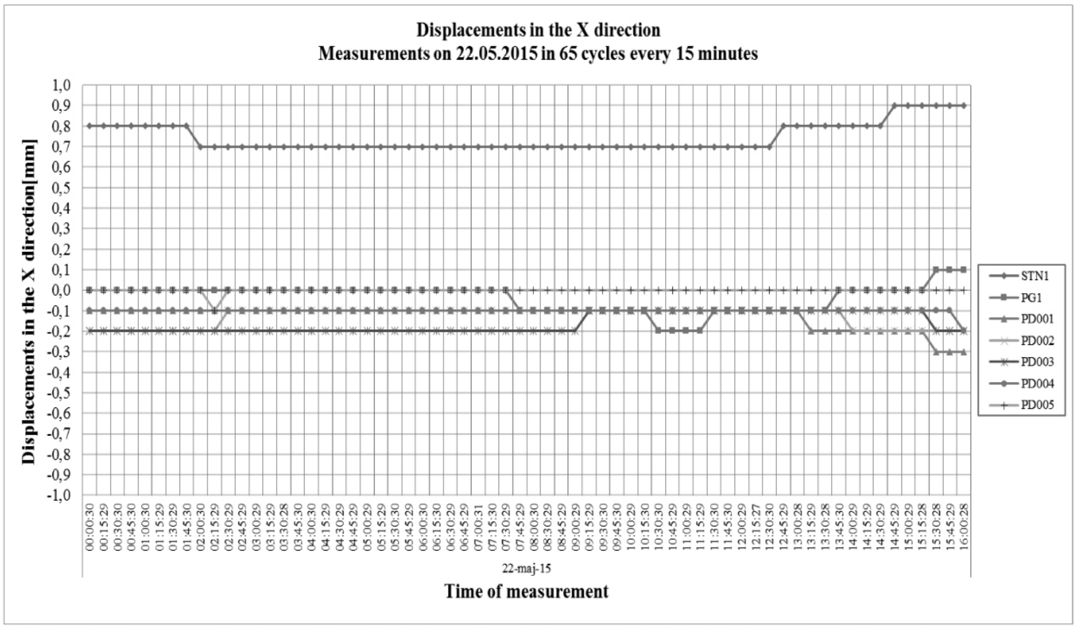

Fig. 5.6. Diagram showing the relationship between the displacement in the X direction and the time of measurement in selected measurement points.

Tab. 5.2. The measurements of displacements in the Y direction.

Date	Cycle (time of measurement)	Measurement point						
		STN1	PG1	PD001	PD002	PD003	PD004	PD005

22.05.2015	00:00:30	-0.4	0.5	0.5	0.2	0.1	-0.2	-0.3
	00:15:29	-0.4	0.5	0.5	0.2	0.1	-0.2	-0.3
	00:30:30	-0.4	0.5	0.5	0.2	0.1	-0.2	-0.3
	00:45:30	-0.4	0.4	0.5	0.2	0.1	-0.2	-0.3
	01:00:30	-0.4	0.4	0.5	0.2	0.1	-0.2	-0.3
	01:15:29	-0.4	0.4	0.5	0.2	0.1	-0.2	-0.3
	01:30:29	-0.4	0.4	0.5	0.2	0.1	-0.2	-0.3
	01:45:30	-0.4	0.4	0.5	0.2	0.1	-0.2	-0.3
	02:00:30	-0.4	0.4	0.5	0.2	0.1	-0.2	-0.3
	02:15:29	-0.4	0.4	0.5	0.2	0.1	-0.2	-0.3
	02:30:29	-0.4	0.4	0.5	0.2	0.1	-0.2	-0.3
	02:45:29	-0.4	0.4	0.5	0.2	0.1	-0.2	-0.3
	03:00:29	-0.4	0.4	0.5	0.2	0.0	-0.2	-0.3
	03:15:29	-0.4	0.4	0.5	0.2	0.0	-0.2	-0.3
	03:30:28	-0.3	0.4	0.5	0.2	0.0	-0.2	-0.3
	03:45:30	-0.3	0.4	0.5	0.2	0.0	-0.2	-0.3
	04:00:30	-0.3	0.4	0.5	0.2	0.0	-0.2	-0.3
	04:15:29	-0.3	0.4	0.5	0.2	0.0	-0.2	-0.3
	04:30:29	-0.3	0.4	0.5	0.2	0.0	-0.2	-0.3
	04:45:29	-0.3	0.4	0.5	0.2	0.0	-0.2	-0.3
	05:00:29	-0.3	0.4	0.5	0.2	0.0	-0.2	-0.3
	05:15:29	-0.3	0.4	0.5	0.2	0.0	-0.2	-0.3
	05:30:30	-0.3	0.4	0.5	0.2	0.0	-0.2	-0.3
	05:45:29	-0.3	0.4	0.5	0.2	0.0	-0.2	-0.3
	06:00:30	-0.3	0.4	0.5	0.2	0.0	-0.2	-0.3
	06:15:30	-0.3	0.4	0.5	0.2	0.0	-0.2	-0.3
	06:30:29	-0.3	0.4	0.5	0.2	0.0	-0.2	-0.3
	06:45:29	-0.3	0.4	0.5	0.2	0.0	-0.2	-0.3
	07:00:31	-0.3	0.4	0.5	0.2	0.0	-0.2	-0.3
	07:15:30	-0.3	0.4	0.5	0.2	0.0	-0.2	-0.3
	07:30:29	-0.3	0.4	0.5	0.2	0.0	-0.2	-0.3
	07:45:29	-0.3	0.4	0.5	0.2	0.0	-0.2	-0.3
	08:00:30	-0.3	0.4	0.5	0.2	0.1	-0.2	-0.3
	08:30:29	-0.4	0.4	0.5	0.2	0.1	-0.2	-0.3
	08:45:29	-0.4	0.4	0.5	0.2	0.1	-0.3	-0.3
	09:00:29	-0.4	0.4	0.5	0.2	0.1	-0.3	-0.3
	09:15:29	-0.4	0.5	0.5	0.2	0.1	-0.3	-0.4
	09:30:30	-0.4	0.5	0.5	0.2	0.1	-0.3	-0.4
	09:45:30	-0.4	0.5	0.5	0.2	0.1	-0.3	-0.4
	10:00:29	-0.4	0.5	0.5	0.2	0.1	-0.3	-0.4
	10:15:30	-0.4	0.5	0.5	0.2	0.1	-0.3	-0.3
	10:30:30	-0.4	0.5	0.5	0.2	0.1	-0.3	-0.4
	10:45:29	-0.4	0.6	0.5	0.2	0.1	-0.3	-0.4
	11:00:29	-0.4	0.6	0.5	0.2	0.1	-0.3	-0.3
	11:15:29	-0.4	0.6	0.5	0.2	0.1	-0.3	-0.3
	11:30:30	-0.4	0.6	0.5	0.2	0.1	-0.3	-0.3
	11:45:30	-0.5	0.6	0.5	0.2	0.1	-0.3	-0.3
	12:00:29	-0.5	0.6	0.5	0.2	0.1	-0.3	-0.3
	12:15:27	-0.5	0.6	0.5	0.2	0.1	-0.3	-0.3
	12:30:30	-0.5	0.6	0.5	0.2	0.1	-0.3	-0.3
	12:45:29	-0.5	0.7	0.5	0.2	0.1	-0.3	-0.3
	13:00:28	-0.5	0.7	0.5	0.2	0.1	-0.3	-0.3
	13:15:29	-0.5	0.7	0.5	0.2	0.1	-0.3	-0.3
	13:30:28	-0.5	0.7	0.5	0.2	0.1	-0.3	-0.3
	13:45:30	-0.5	0.7	0.5	0.2	0.1	-0.3	-0.3
	14:00:29	-0.5	0.7	0.5	0.2	0.1	-0.3	-0.3
	14:15:29	-0.5	0.7	0.5	0.2	0.1	-0.3	-0.3
	14:30:29	-0.6	0.7	0.5	0.2	0.1	-0.3	-0.3
	14:45:29	-0.6	0.7	0.5	0.2	0.1	-0.3	-0.3
	15:00:29	-0.6	0.7	0.5	0.2	0.1	-0.3	-0.3

	15:15:28	-0.6	0.7	0.5	0.2	0.1	-0.3	-0.3
	15:30:28	-0.6	0.7	0.5	0.2	0.1	-0.3	-0.3
	15:45:29	-0.6	0.7	0.5	0.2	0.1	-0.3	-0.3
	16:00:28	-0.6	0.7	0.5	0.2	0.1	-0.3	-0.3

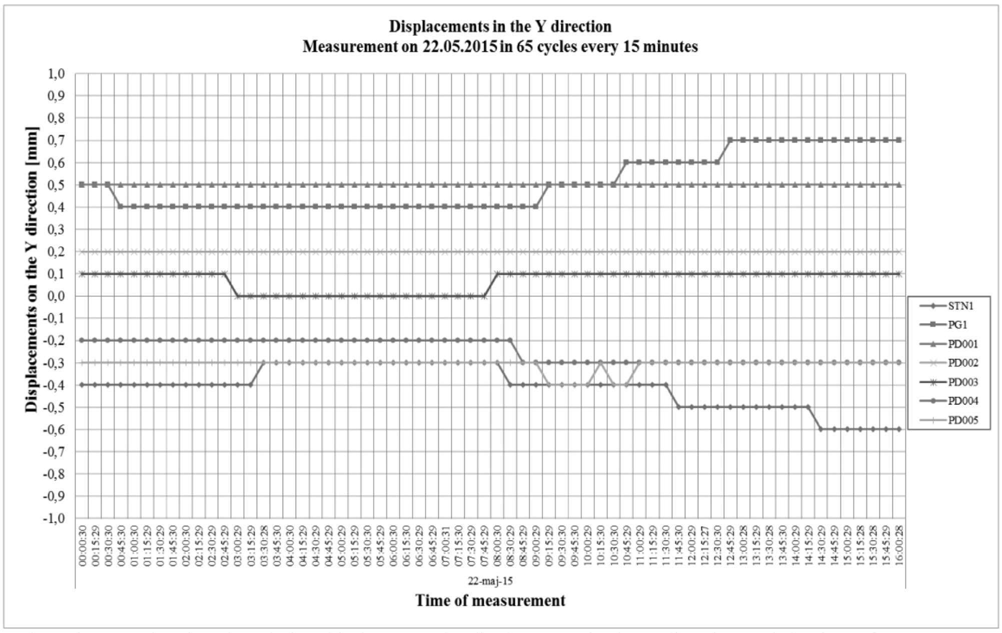

Fig. 5.7. Diagram showing the relationship between the displacement in the Y direction and the time of measurement in selected measurement points.

Tab. 5.3. Measurement of displacements in the Z direction.

Date	Cycle (time of measurement)	Measurement point						
		STN1	PG1	PD001	PD002	PD003	PD004	PD005
22.05.2015	00:00:30	0.3	0.5	0.0	-0.3	-0.1	0.1	-0.1
	00:15:29	0.3	0.5	0.0	-0.3	-0.1	0.1	-0.1
	00:30:30	0.3	0.5	0.0	-0.3	-0.1	0.1	-0.1
	00:45:30	0.3	0.5	0.0	-0.3	-0.1	0.1	-0.1
	01:00:30	0.3	0.5	0.0	-0.3	-0.1	0.1	-0.1
	01:15:29	0.3	0.5	0.0	-0.3	-0.1	0.1	-0.1
	01:30:29	0.3	0.5	0.0	-0.3	-0.1	0.1	-0.1
	01:45:30	0.3	0.5	0.0	-0.3	-0.1	0.1	-0.1
	02:00:30	0.3	0.5	0.0	-0.3	-0.1	0.1	-0.1
	02:15:29	0.3	0.5	0.0	-0.3	-0.1	0.1	-0.1
	02:30:29	0.3	0.5	0.0	-0.3	-0.1	0.1	-0.1
	02:45:29	0.3	0.5	0.0	-0.3	-0.1	0.1	-0.1
	03:00:29	0.3	0.5	0.0	-0.3	-0.1	0.1	-0.1
	03:15:29	0.3	0.5	0.0	-0.3	-0.1	0.1	-0.1
	03:30:28	0.3	0.6	0.0	-0.3	-0.1	0.1	-0.1
	03:45:30	0.3	0.6	0.0	-0.3	-0.1	0.1	-0.1
	04:00:30	0.3	0.6	0.0	-0.3	-0.2	0.1	-0.1
	04:15:29	0.3	0.6	0.0	-0.3	-0.2	0.1	-0.1
	04:30:29	0.3	0.6	0.0	-0.3	-0.2	0.1	-0.1
	04:45:29	0.3	0.6	0.0	-0.3	-0.2	0.1	-0.1
	05:00:29	0.3	0.6	0.0	-0.3	-0.2	0.1	-0.1
	05:15:29	0.3	0.6	0.0	-0.3	-0.2	0.1	-0.1
	05:30:30	0.3	0.6	0.0	-0.3	-0.2	0.1	-0.1
	05:45:29	0.3	0.6	0.0	-0.3	-0.2	0.1	-0.1

	06:00:30	0.3	0.6	0.0	-0.3	-0.2	0.1	-0.1
	06:15:30	0.3	0.6	0.0	-0.3	-0.2	0.1	-0.1
	06:30:29	0.3	0.6	0.0	-0.3	-0.2	0.1	-0.1
	06:45:29	0.3	0.6	0.0	-0.3	-0.2	0.1	-0.1
	07:00:31	0.3	0.5	0.0	-0.3	-0.2	0.1	-0.1
	07:15:30	0.3	0.5	0.0	-0.3	-0.2	0.1	-0.1
	07:30:29	0.3	0.5	0.0	-0.3	-0.2	0.1	-0.1
	07:45:29	0.3	0.5	0.0	-0.3	-0.2	0.1	-0.1
	08:00:30	0.3	0.5	0.0	-0.3	-0.2	0.1	-0.1
	08:30:29	0.3	0.4	0.0	-0.3	-0.2	0.1	-0.1
	08:45:29	0.3	0.4	0.0	-0.3	-0.2	0.1	-0.1
	09:00:29	0.3	0.4	0.0	-0.2	-0.2	0.1	-0.1
	09:15:29	0.3	0.3	0.0	-0.2	-0.2	0.1	-0.1
	09:30:30	0.3	0.3	0.0	-0.2	-0.2	0.1	-0.1
	09:45:30	0.3	0.3	0.0	-0.2	-0.2	0.1	-0.1
	10:00:29	0.3	0.2	0.0	-0.2	-0.2	0.1	-0.1
	10:15:30	0.3	0.2	0.1	-0.2	-0.2	0.1	-0.1
	10:30:30	0.3	0.2	0.1	-0.2	-0.2	0.1	-0.1
	10:45:29	0.3	0.1	0.1	-0.2	-0.2	0.1	-0.1
	11:00:29	0.4	0.1	0.1	-0.2	-0.2	0.1	-0.1
	11:15:29	0.4	0.1	0.1	-0.2	-0.2	0.1	-0.1
	11:30:30	0.4	0.0	0.1	-0.2	-0.2	0.1	0.0
	11:45:30	0.4	0.0	0.1	-0.2	-0.2	0.2	0.0
	12:00:29	0.4	-0.1	0.1	-0.2	-0.2	0.2	0.0
	12:15:27	0.4	-0.1	0.1	-0.2	-0.1	0.2	0.0
	12:30:30	0.4	-0.1	0.1	-0.2	-0.1	0.2	0.0
	12:45:29	0.4	-0.2	0.1	-0.2	-0.1	0.2	0.0
	13:00:28	0.4	-0.2	0.2	-0.2	-0.1	0.2	0.0
	13:15:29	0.4	-0.2	0.2	-0.2	-0.1	0.2	0.0
	13:30:28	0.4	-0.3	0.2	-0.2	-0.1	0.2	0.0
	13:45:30	0.4	-0.3	0.2	-0.2	-0.1	0.2	0.0
	14:00:29	0.5	-0.3	0.2	-0.2	-0.1	0.2	0.0
	14:15:29	0.5	-0.4	0.2	-0.2	-0.1	0.2	0.0
	14:30:29	0.5	-0.4	0.2	-0.2	-0.1	0.2	0.0
	14:45:29	0.5	-0.4	0.2	-0.2	-0.1	0.2	0.0
	15:00:29	0.5	-0.4	0.2	-0.2	-0.1	0.2	0.0
	15:15:28	0.5	-0.5	0.2	-0.2	-0.1	0.2	0.0
	15:30:28	0.5	-0.5	0.2	-0.2	-0.1	0.2	0.0
	15:45:29	0.5	-0.5	0.2	-0.2	-0.1	0.2	0.0
	16:00:28	0.5	-0.5	0.2	-0.2	-0.1	0.2	0.1

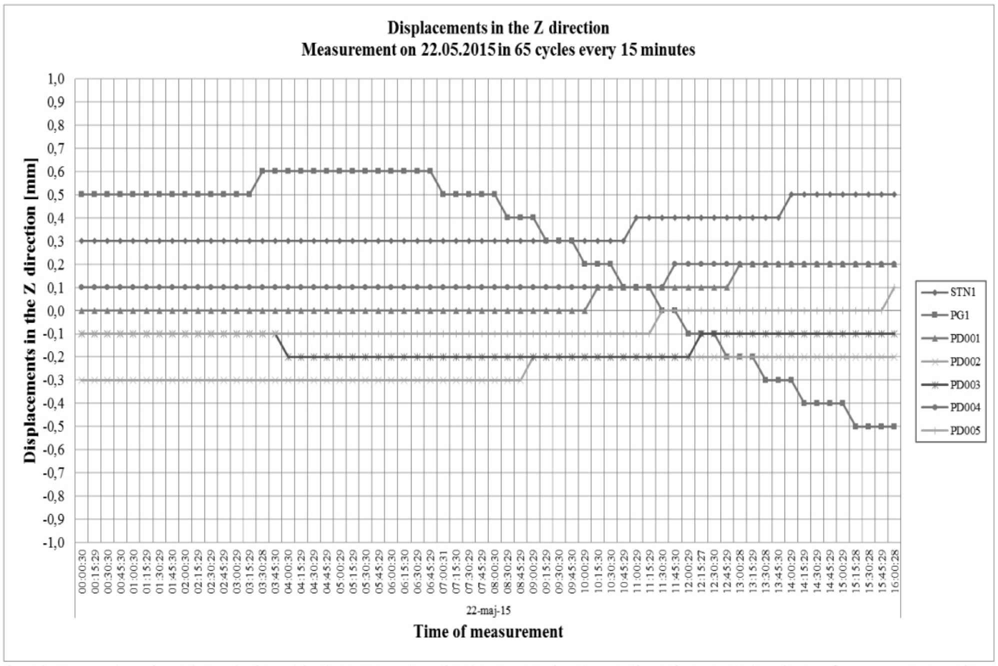

Fig. 5.8. Diagram showing the relationship between the displacement in the Z direction and the time of measurement in various measurement points.

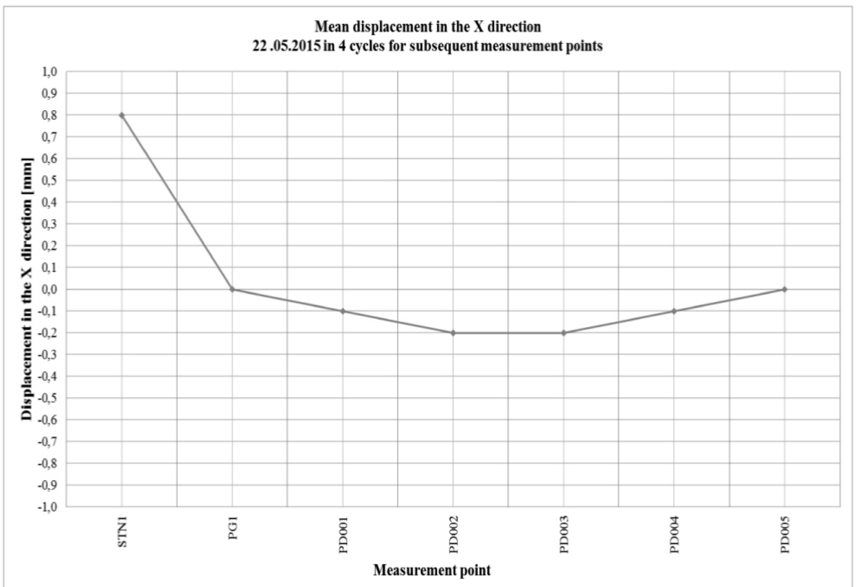

Fig. 5.9. Diagram showing the relationship between the mean displacement in the X direction and the location of a measurement point.

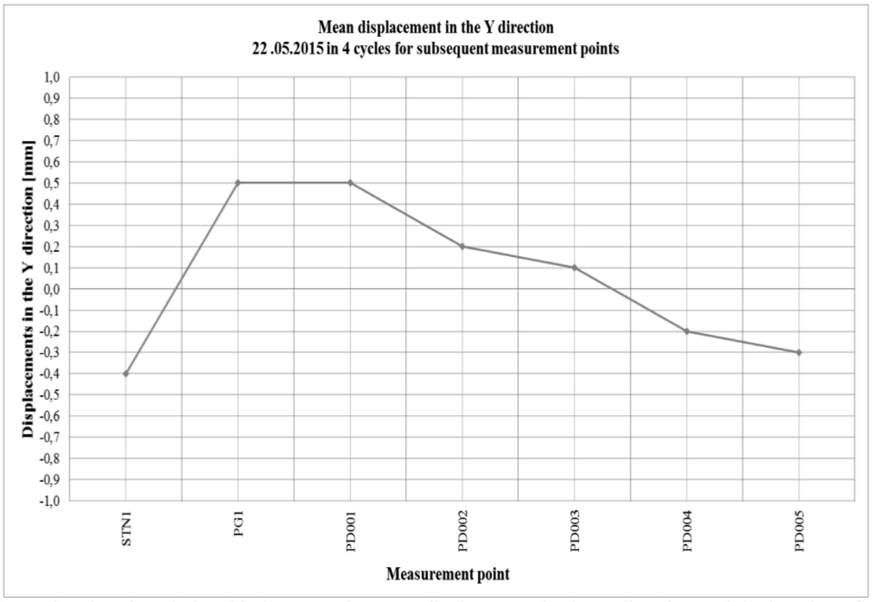

Fig. 5.10. Diagram showing the relationship between the mean displacement in the Y direction and the location of a measurement point.

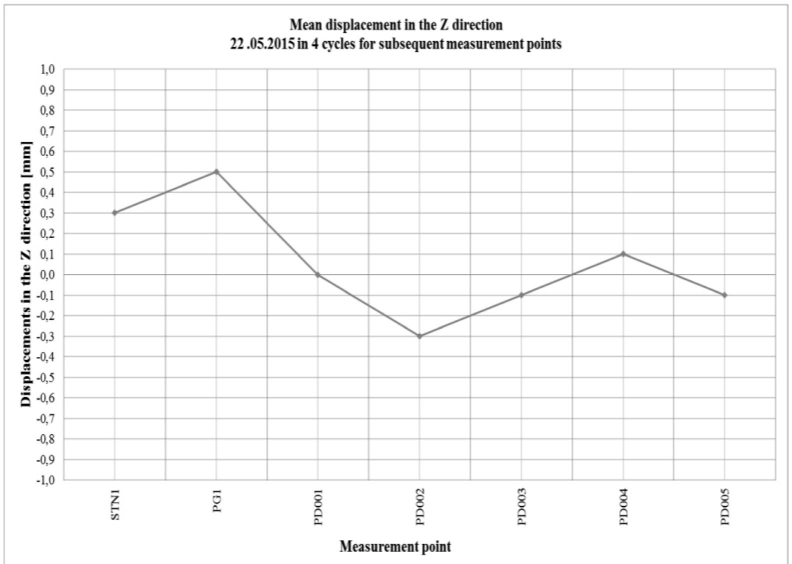

Fig. 5.11. Diagram showing the relationship between the mean displacement in the Z direction and the location of a measurement point.

5.2. Conclusions

The results of measurements presented above are only a fraction of data obtained during the three months of investigation of the Centennial Hall. The highest daily differences between values obtained in subsequent measurements of a given day did not exceed 1.3mm. This proves the static stability of the structure. Structural solutions employed for the Hall prevent deformation of the structural elements of the Hall, and as a result ensure the security of the building. What is more, similar values of displacement in all three directions have been noticed. In case of the Centennial Hall all these values are negligibly small.

The presented method of optical monitoring of the geometry of the Centennial Hall in Wroclaw will enable to develop in future a detailed analysis of the behaviour of the Hall's structure and a comprehensive monitoring of its condition.

The preliminary analysis which was carried out resulted in the formation of the following conclusions:

1) Tacheometric measurements and 3D scanning allow documenting of the actual condition of heritage buildings in a way which is very accurate, less time-consuming, allows description of the whole surface and not just measurements of selected points as is the case of other geodetic methods;
2) Cyclic tacheometric measurements of displacement for numerous points, carried put over time, and laser scanning of the building can be regarded as an approximate, non-invasive method for monitoring of the geometry of the structure, including monitoring of cracking and damage caused by various factors;
3) Tacheometric measurements and laser scanning provide precise and reliable geometric data;
4) Ongoing measurement of reference points conducted in the real time (using a tacheometer, a group of tacheometers or a 3D scanner) provide instant information on potential changes to the geometry of the structure.

An ongoing monitoring of a structure is an effective way for describing its condition and behaviour. Periodical registration of cracking, deformations and more and more popular cyclic monitoring of the structure’s geometry using a 3D scanner can complete the picture of the structure being monitored. These activities can be carried out using remote control, can be repeated a number of times and are mobile. Together with a cyclic safe observation of hard-to-reach sections of heritage structures using drones, they provide a proper basis for the assessment of the condition of heritage buildings.

6. Proposed system for monitoring structural safety an behaviour of the Centennial Hall in Wroclaw

The proposed system for monitoring structural safety is an opportunity for integrating knowledge management concerning the property, networking, visualising and archiving displacements and deformation of the building structure, automating diagnosis from the perspective of threats and allowing early warning of building users that structural loading limits of the structural loading of the Hall have been exceeded.
A detailed schematic, which includes specification of the types of tests and measures carried out and the type and number of measurement points, is presented in figure 6.1.
The specific steps involved can be itemised as follows:

1. The first action essential for implementing the proposed system for monitoring structural safety and behaviour involves preparing a spatial scan of the building from both the inside and outside and recording the measurement data obtained.
2. The next step is to process the data obtained from 3D scanning and to take samples of construction materials for strength testing. Such tests can be destructive or non-destructive
3. The next step is to create a BIM model, based on a block model, and then to input parameters and simplifications to the static schema and to carry out an analysis using the Finite Elements Method (MES).
4. For the purposes of static and strength calculations, different scenarios of possible loading of the building during use have to be adopted in addition to data concerning building materials. It is necessary also to include different variants of building failure loading. In this step, it is possible to determine the boundary limits for deformations and stresses for the model.
5. The next step, given that the critical structural points are known, the places can be idenified where the largest unwanted deformations can take place during loading arising from building use and causing building failure, it is possible to plan the number and type of sensors and monitoring devices that is neeed. In the case of the Centennial Hall, it is proposed that these are as follows:
   - anemometers,
   - thermometers,
   - hygrometers,
   - snow guages,
   - tacheometers, i.e. Total Station with point, disc and mini-prism, 3D scanner,
   - inclinometers,
   - extensometers,
   - strain gauges,
   - dynamics sensor (vibration acceloremeter),
   - feeler gauges/ crackmeters,
   - piezometer,
   - inspection drone.
6. The next step involved the continuous registration of data from the monitoring system installed. At the same time, photographs are registered during drone overflights along the same route. Differences in the 3D scans are detected. In the event that boundary values are exceeded, an automatic alarm is initiated. When the alarm signal is not initiated, further measurements are carried out. When the boundary values are exceeded, it is necessary to carry out an additional inspection and additional scans of the building structure.
7. The next step involves creating a BIM model once again, based on creating a block model, and then to input parameters and simplifications to the static schema and to carry out an analysis using the Finite Elements Method (MES).
8. Decisions on possible interventions in the building structure and installation of additional sensor devices.

Only a systemic approach to monitoring structural safety and behaviour of the Hall, supported by an expert team will assure appropriate data analysis, a continuous measurement process and will enable further automation in the future.

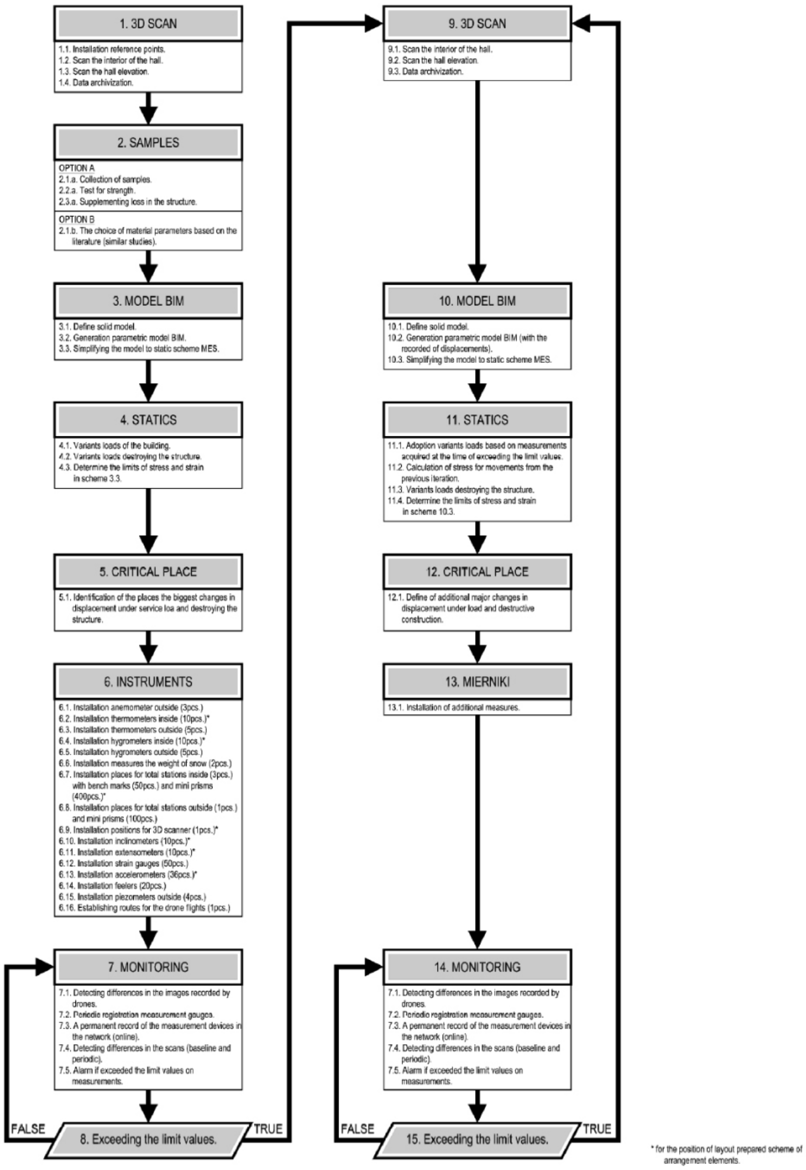

Fig. 6.1. Schematic of the system for monitoring the structural safety and condition of the Centennial Hall in Wroclaw (* detailed schematics showing the location of the sensors described have been prepared for these items).

7. Conclusions

The following conclusions have been formulated on the basis of tests and analysis [85], [86], [87], [88], [89] carried out in 2015 and on the basis of earlier research results:

Concrete in the ribs of the dome:

– The concrete is composed of a granite aggregate with addition of natural aggregate. But the concrete composition varies with respect to individual ribs of the dome. In most cases, the concrete composition is dominated by granite aggregate with a small addition of natural aggregate. But in `some ribs, the content of the two types of aggregate is similar and in the case of rib number Ł17 natural aggregate dominates the concrete composition. Overall, the aggregate composition of concrete in the ribs tested is well-grained.
– The characteristic strength value of the tested concrete can be taken to be no greater than 25.4 MPa and the strength class is estimated as C20/25.
– Based on the results of 'pull-out' tests, the characteristic strength value of the tested concrete can be taken to be no greater than 23.9 MPa and the strength class is estimated as C16/20.
– Concrete complies with strength requirements, which are the basis for any potential surface repair work.
– The mean tensile strength of the tested concrete measured for structural sections of the ribs of the dome using the Brazilian test is approximately 2.0 MPa. This is a considerably lower value than the value of the tensile stren gth of the tested concrete determined with the 'pull-off' method for the carbonated near-surface layer of concrete (4.31 MPa).
– Concrete absorbability values range from 4.08% to 5.45% with the coefficient of variation for this parameter equal to 11.2%, which indicates a high homogeneity of this parameter of the tested concrete. The absorbability value of 5.0% was exceeded only in the case of three ribs (Ł20, Ł23 and Ł28). The mean absorbability value of the tested concrete is approximately 4.6 %, which is below the acceptable limit value (5.0 %).
– The tests which were carried out confirm that the thickness of the near-surface layer of concrete which has been carbonated varies for individual ribs. This ranges from approximately 22 mm to approximately 42 mm.

Concrete in the supporting pillars (pendentives):

– The characteristic strength value of the tested concrete can be assumed to be no greater than 24.5 MPa and its strength class is estimated as C20/25.
– The mean tensile strength of the tested concrete measured for structural sections of the pillars using the Brazilian test is approximately 2.65 MPa.
– Concrete absorbability values range from 3.47% to 5.51% with the variation coefficient for this parameter equal to 12.4%, which indicates a high homogeneity of this parameter of the tested concrete. The absorbability value of 5.0% which constitutes an acceptable limit value was exceeded only in two cases. The mean absorbability value of the tested concrete is approximately 4.3%, which is below the acceptable limit value (5.0%).
– The tests which were carried out confirm the significance of the thickness of the near-surface layer of concrete which has been carbonated. It ranges from approximately 25 mm to approximately 70 mm.

A general assessment of the condition of the concrete indicated that the hardened cement paste of the tested concrete adhering well to the crushed granite aggregate. Its structure was found to be dense, thick and characterised by low absorbability. Low permeability of the cement paste obstructs carbonation and diffusion of chlorides, and thus constitutes a protective barrier for the steel reinforcement. The micro-hardness of the tested concrete was found to be 1.8 GPa and its modulus of elasticity E = 33 GPa. When compared to the classic Mohs' scale or the extended Ridgwey's scale, the micro-hardness of the tested concrete was determined to be 4. The modulus of elasticity determined for the concrete of the circumferential supporting ring investigated complies with requirements corresponding to the C30/37 strength class.
Based on the tests which were conducted, it was determined that the physical properties of the concrete change with the distance from the external surface of the element. The longer the distance from the external surface of the element, the higher the density by volume of the concrete and the lower the porosity and absorbability. This is a result of carbonation of the concrete. The composition and amount of aggregate varies for individual concrete specimens. The closer to the external surface, the lower the content of aggregate in concrete and the higher the content of cement. The ratio of aggregate content to the content of cement for the tested concrete specimens, extracted from the bottom tension ring was determined as 9:1 and 8:1, and should be regarded as relatively low.
The analysis of grain composition of the aggregate indicated that the curve derived from the results for sieve testing, places the aggregate in the 'well-grained' category of aggregates with a fraction below 31.5mm. Quartz aggregate along with crushed granite aggregate was found in the aggregate composition. The content of crushed granite aggregate increases for higher fractions of aggregate. It also increased closer to the external surface of the tested concrete. The presence of fine wood chip inclusions was discovered in aggregate with a fraction below 8 mm.
A lower amount of CaO in the oxide composition of the cement and presence of fine black inclusions indicates that blast-furnace cement may have been used for construction purposes. Introduction of slag into the concrete mix resulted in a dense microstructure of the concrete. The high concentration of C-S-H phase is a product of slag hydration and reaction of calcium hydroxide with silicate anions originating from slag hydration. The amount of calcium hydroxide decreases, resulting in the presence of a C-S-H phase as a dense gel. This leads to lower capillary porosity of the hardened cement paste, which in turn obstructs the diffusion of aggressive agents to the cement matrix. The amount of portlandite and calcium aluminates, which are not resistant to corrosion, is lower in the cement paste. These changes to the microstructure of cement paste based on

blast-furnace cement mean that such cements are characterized by a number of more favourable properties than Portland cements without additives.
Analysis of the microstructure allowed for porosity assessment of the material, as well as the structure and dimensions of pores. Porosity was determined with a micro-CT device for the tested samples, and found to be approximately 10%. The pores in the material are fine-sized, with a sphericity of 0.6-0.7. The majority are micropores smaller than 300μm. Such porosity of the tested concrete accounts for its low absorbability (less than 5%) and permeability, and high mechanical properties (compressive strength and tensile strength), as well as good frost resistance.

Reinforcing steel:
A visual inspection of exposure sections of the elements did not reveal any significant corrosion risk for the reinforcing steel elements, despite the fact that some small corrosion pitting was observed on the surface on the main bars. However the character of this pitting suggests that it was present most probably before the bars were built into the structure of the ribs.

Structural steel:
The strength parameters of the cast-steel used to manufacture the bearings of the bottom ring are inferior to those of the modern cast-steel. This finding refers primarily to the minimum tensile strength value, which is much lower than 400 MPa, even with the most favourable estimations.
The chemical analysis of the samples extracted from lower bearing frames confirmed that the frames were cast at the beginning of the twentieth century using the low-carbon cast-steel. However, the chemical composition of this cast-steel differs considerably from the chemical composition of modern low-carbon cast-steel.
The non-destructive Brinell hardness tests carried out on the unknown type of cast-steel, which had been used to cast the bearing located under the bottom ring of the Centennial Hall's dome, enabled determination of the design strength of the cast-steel in question. This strength value is needed to enable appropriate monitoring of the structural behaviour of the Centennial Hall. Results of experimental testing, which were carried out, were used to develop generalised formulae for describing the relationhip between Brinell hardness of the historical steel and its yield strength and immediate tensile strength. Respective formulae refer to low-carbon steel. The tested cast-steel is also low-carbon, which was confirmed by a chemical analysis of the extracted samples.
Taking all the above into consideration, the design strength f_y of the cast-steel used to manufacture the bearings, can be assumed with a margin of safety to be as follows:

- for analysis in accordance with the standard [27] – f_y = 185 MPa,
- for analysis in accordance with the standard [29] – $f_d = f_y / \gamma_m$ = 185/1.15 = 160 MPa.

Wood in the window frames:
The visual inspection carried out in 2015 indicated that the paint coating on many windows (especially weatherboards and sills) as well as jamb edges was damaged as a result of opening of the windows and the weatherboards banging on the concrete structure. The mechanical damage observed in the woodwork of the windows resulted from people stepping on the window sills. It is recommended that stepping on the window sills be prevented and windows not be left open in ways that allow the weatherboards to bang on the concrete structure in windy conditions (the windows have not been equipped with wind stops). Many windows have damaged surfaces. Continuous monitoring of the paint coating of window woodwork is recommended, as any damage may facilitate water penetration into the interior sections of the wooden elements. The seals in many windows have been installed in an inappropriate and careless way and require careful reinstallation. Numerous fixtures and fittings of turn buttons with handles and knobs have been destroyed and are in need of repair. In some windows, sashes have been distorted, which prevents the window from being closed properly. Regulation of hinges is recommended in windows which are opened frequently.
In addition to visual inspection, analysis of the condition of the material of selected windows was tested using the resistance drilling method (resistographic method) and the stress wave method. No biological degradation was discovered inside sections of window woodwork elements in places where tests were carried out.
The stress wave method was used to test the condition of only 6 elements (stiles in window sashes) due to the quasi-destructive character of the test. The results obtained should be regarded as indicative due to the low number of measurements carried out. The low value of the coefficient of variation for the dynamic modulus of elasticity confirms the homogeneous structure of the tested elements and their similar parameters. The mean value of the dynamic modulus of elasticity E_d = 16.9 GPa, should be regarded as an estimation, because no wood density measurements were carried out as this would have required extracting samples of wood from the window woodwork. Nevertheless, the value obtained is close to the values of the static modulus of elasticity for the ironwood (*Casuarina* wood) cited in the literature.
The BIM and FEM models were developed on the basis of the material analysis data and the geometry data collected for the structure.
The following conclusions can be drawn from the work on the development of the BIM models:

- the way different models reflect differences arising depends on the way calculations are made in relation to the situation actually observed;
- it is possible to develop a model which projects the spatial scanning measurements obtained during a specific time period;
- it is possible to identify deviation of the geometry from the cloud of points obtained;
- a cloud of points can be used again in the future for a repeat analysis, which would enable changes that had taken place to be observed,
- a BIM model can be developed based on Revit software to make use of the cloud of points,

– applications for the Revit software which enable processing of clouds of points are available. They allow, inter alia, automatic development of working plains on the basis of selected points and importing clouds of points to family templates. Some of these can be used with 3D scan processing software as a means for facilitating import of clouds of points to the Revit software;
– an additional application using the C# or VB.Net languages is necessary for measuring the distance between the cloud of points and the BIM model;
– changes to the *.dwg files enable monitoring of changes in the structure over time and updating of the BIM model;
– a benchmark needs to be established to allow measurement of the changes in the geometry of the structure, using repeat 3D scans as a means for monitoring changes in the geometry of the structure;
– it is necessary to set reference points for future measurements and to carry out continuous or periodic monitoring of these points, e.g. using a tacheometer.

The FEM calculations indicated that:
– the load-bearing structure is stiff in the vertical direction and when carrying dead load, snow and loading arising from events organised in the Hall. The deflection of the structure is only 12 mm. Radial displacements are smaller by an order of magnitude; the bottom ring is displaced outwards and the top ring is displaced inwards. The axis of the zero radial displacement is situated in the middle of the height of the ribs;
– strengthening tie rods between lantern posts were added in the 1930s. These are practically redundant given the considerable strain, to which the posts are subjected;
– the lantern posts are extremely strained, practically beyond their capacity. This refers in particular to the parts near their base and above the opening which forms a passageway. The reinforcement near the base is also dangerously strained as the diameter is too small, just as the concrete section is too small. Cracks over the passageway may be the result of a lack of appropriate reinforcement in this section. The strain of the lantern has no immediate impact on the static behaviour of the load-bearing structure of the dome as a whole;
– the compression top ring is strained in to a small extent; small cracks in concrete can appear only locally, below the posts of the lantern; this however, has no impact on straining of concrete and refinforcement of the element as a whole;
– the ribs carry compressive loading – they are strained only to a small extent (the compressive stress in concrete and in reinforcing steel was found to be 3.2 MPa and 26 MPa respectively). The load-bearing capacity is much higher than the actual loading of the structure;
– the analysis indicated that the cracks which appeared on the bottom ring are most probably the result of concrete contraction during the process of curing or were caused by radial loading. Increased vertical loading has had no significant impact on increasing the tensile stress in the concrete of the ring. It appears that the lattice-work in the ring is able to carry the loads itself with a satisfactory safety margin;
– it appears that the prestressing, which was put into place during the most recent renovation of the Hall has had no significant impact on the level of stress in the elements of the load-bearing structure of the Dome.

The results of the static strength analysis enabled assessment of the condition of the structure of the Centennial Hall. Aside significantly strained sections of the lantern structure of the dome, other structural elements did not reveal any signs of extreme strain and did not exceed the load-bearing capacity. Taking into consideration the age of the building, its scale, importance to World Heritage and the condition of the materials used to construct it, regular and comprehensive analysis of the building's structural condition should be continued into the future and linked to the ongoing monitoring of the safety and the condition of the Hall. The results can be used in the future to diagnose possible reasons for damage when these appear, and to determine the direction of further conservation work and the ways in which the Hall should be used.
The visual method for monitoring the geometry of an existing historical building – the Centennial Hall in Wroclaw – as presented in this paper will serve in the future as a basis for detailed analysis of the structural behaviour of the Hall over time and also for comprehensive ongoing monitoring.
The preliminary analysis completed leads to the following conclusions:
– tacheometric measurements and 3D scanning enable documentation of the actual condition of heritage buildings in a way that is highly accurate, but not so time-consuming. This allows for a description of the whole surface area, not just measurements of individual points as is the case with other geodetic methods;
– cyclical tacheometric measurements of many points and laser scanning of the structure can be treated as an indicative, non-invasive method of monitoring of the geometry of the structure, which takes into account monitoring of cracking and other damage caused by a variety of factors;
– tacheometric measurements and laser scanning provide accurate and trustworthy geometric data;
– regular measurements at reference points carried out in real time (by means of a tacheometer, a set of tacheometers or 3D scanner) provide immediate information relating to possible changes in the geometry of the structure;

Ongoing monitoring of a structure is an effective method for describing its condition. Periodic registration of cracks, fissures, deformations and displacements along with increasingly popular cyclical monitoring of geometry using a 3D scanner, will provide a more complete picture of the monitored structure.
The Centennial Hall in Wroclaw is a heritage building of considerable significance and an UNESCO World Heritage site. The safety and the condition of the structure should be monitored on a continuous basis. Monitoring of the changes to the building's geometry and the condition of the elements critical to the building structure in relation also to the surrounding conditions is consistent with the recommendations of the Convention [84] and constitutes part of the process of protecting and developing the UNESCO World Heritage site. Continuous monitoring of the structural safety and conservation condition

of the site should cover not just the main building, but also other structures situated within the boundaries of the UNESCO listed site and its buffer zone.

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6.2.

Ryszard Wójtowicz

Conservation Diagnosis and Color Study of the Centennial Hall in Wrocław

Wrocław 2015

Conservation Diagnosis and Color Study of the Centennial Hall in Wrocław

Synthetic description and historical issues

The Centennial Hall was built in 1912 by the main contractor Dyckerhoff & Widmann. The building shell was officially handed down to the city authorities in December of that year. In May 1913 the Centennial Exhibition was opened.

The Centennial Hall was to fulfill the function of exhibition and assembly space, and in its history was very intensively exploited. During the Centennial Exhibition the Centennial Hall was visited by more than a hundred thousand people. It served as a large provisions warehouse during World War I. With the initiative of the Municipality of Wroclaw a joint-stock company Breslauer Messe A.G. was founded which since 1918 regularly organized industrial trade fairs on the Exhibition Grounds and in the Centennial Hall. In the 1930's sporting events and circus presentations were also held in the Centennial Hall.

Regardless of the extension of the Exhibition Grounds, work under the leadership of architect Richard Konwiarz began on the reconstruction and renovation of Centennial Hall in the 1935–1937. New auditorium seats were built. Parts of the entrances were covered with ocher color travertine as decoration. Suspended ceilings (steel and gypsum construction) with round-shaped lamps were installed in the main entrance hall and foyer.

At the same time an exterior staircase was built on the southern side of the axis of the main entrance hall and Imperial Hall.

The Exhibition Grounds survived World War II in fairly good condition, only some of the buildings were destroyed. The Centennial Hall roof and window glazing were destroyed. In 1948, after a partial refurbishment, a large exhibition of the Regained Territories was organized. The Centennial Hall housed a cinema for many years, events such as sports, concerts and parades were also organized. Repairs or replacements were required in the entire technical infrastructure of the Centennial Hall: foyers, roofs, window and door joinery, and electrical equipment. At various stages of the post-war overhauls, sashes and some of the door woodwork were replaced, the structure of the foyers' skylights and their glazing were renovated.

In connection with the forthcoming Eucharistic Congress in 1994–1995, modernization works mainly related to the reconstruction of the auditorium seats and lowering of the floor level were started. The project was developed by the architectural office of Leszek Konarzewski. In 2009 outer concrete walls (façade) and window joinery was renovated. The project was also developed by the architectural office of Leszek Konarzewski. In 2011 renovations to the main hall's interior and a reconstruction of the auditorium seats was carried out. The project was developed by consortium Chapman Taylor and Wrotech.

In his study *Max Berg's Centennial Hall and Exhibition Grounds in Wrocław* – Jerzy Ilkosz, PhD, provides a description of the interior including the Imperial Hall as follows: *[...] The foyer space has been divided by means of straight concrete pillars: the inner zone functioned as a passageway while the outer zone accommodated the polygonal rooms, each laid out on a dodecagon circumscribed about an ellipse, situated symmetrically between the large side entrance halls and the main entrance to the Centennial Hall.*

Above the hall of the main entrance the first floor accommodates an oval reception room – referred to as the "Imperial Hall". The room is covered with a glass roof and the ceiling is separated from the wall with a facet whose only decoration is an Ionic cymatium (egg-and-dart frieze). The foyer is illuminated through the glass roof overhead and side windows. Access to Centennial Hall's domed main hall is provided through the main entrance hall and the three side entrance halls which lead to the foyer and from there directly through to further multiple doors. Additional entrances have been pierced directly through the external wall between the side entrance halls and the polygonal rooms. The main entrance in the western wall is connected by wide stairs with the square that functions as the courtyard of the Exhibition Grounds [...].

On the basis of the plans from the Building Archive of the City of Wrocław (Max Berg's notes Fig. Ref. 21775), the Imperial Hall was to have 3 m high marble wall cladding, bearing the name – the Marble Hall (Marmorsaal) although the name Stateroom (Empfangsaal) was used interchangeably.

Some information relevant to conservation studies conducted in the Imperial Hall is available in the National Archives in Wrocław (Municipality files, Ref. 17049).

17/02/1913 – The Centennial Hall Construction Board meeting

pos. 5 – The company of Gebrüder Bauer is to construct 5 balcony doors according to the project of the Construction Directorate with the estimated price of 1800 Marks.

pos. 7 – A decision has been made to outsource the formwork for this part of the ceiling, which would not be glazed, to the master carpenter Hossenfelder for 835 Marks.

The statement mentioned the cost of making the Centennial Hall ceiling on a Rabitz for the net price of 1800 Marks.

17/03/1913 – The Centennial Hall Construction Board meeting

pos. 5 – A decision to cover the restroom walls next to the Centennial Hall with tiles, cost 400 Marks. The company Latzel und Pachura was to do the insulation work (blue-green tiles).

pos. 14 – The stucco ceiling in the room next to the Imperial Hall would be outsourced to the company Kunze und Brinke, based on their offer of 11/3/1913 for the amount of 290 Marks, [the facet and the ceiling in a side room on the south].

6/6/1913 – The Centennial Hall Construction Board meeting

pos. 7 – A decision to commission the painter Leistikow to make sketches of utility rooms as well as wall and carpet padding for 300 Marks.

pos. 10 – Skylight glazing was commissioned to the company David Bley for the amount of 1350 Marks.

26/06/1913 – The Centennial Hall Construction Board meeting

pos. 7 – Rabitz ceiling, net cost 1800 Marks, installation by Gebrüder Bauer (represented by E. Mann).

17/01/1919 – The Centennial Hall Construction Board meeting
pos. 4 – Corrections were commissioned to Gebrüder Bauer.
History, urban and spatial layout, design and construction works of Max Berg were carefully analyzed and presented in publications. The following were used for the purposes of this study:

J. Ilkosz, *Hala Stulecia we Wrocławiu – dzieło Maxa Berga*, "Rocznik Historii Sztuki", 1999, vol. XXIV, pp. 131–215.
J. Ilkosz, *Projekty Hansa Poelziga na Wystawę Stulecia we Wrocławiu w 1913 roku*, [in:] *Hans Poelzig we Wrocławiu. Architektura i sztuka*, Wrocław 2000, pp. 367–426.
J. Ilkosz, *Hala Stulecia i Tereny Wystawowe we Wrocławiu – dzieło Maxa Berga,* Wrocław 2005.
L. Konarzewski, *Projekt i realizacja przebudowy wnętrza Hali Ludowej we Wrocławiu w latach 1995–1997*, [in:] *Architektura Wrocławia,* vol. 4: *Gmach,* ed. Jerzy Rozpędowski, Wrocław 1998, pp. 495–517.

Recommendations for the user and contractors

Information in the chapter on *State of preservation* about destructive processes taking place at the Centennial Hall should be considered by the contractors of restoration and repair works. In order to get the proper aesthetic and technical effect, it is recommended to remove the secondary layers, while maintaining the original coating (the first layer color).

Attention should be paid to the information presented in the following chapters:

1.5. Color of exterior walls: ***in the first study of Centennial Hall's painting, the coatings were applied in a differentiated way, relatively thin or semi-transparent.***
2.5. Color description of the interiors and utility rooms at the Imperial Hall: ***in the initial study of painting of the Imperial Hall, the coating was applied smoothly and relatively thin.***

Therefore, modern technology should be adapted to painting techniques used decades ago. The correct end result depends not only on the selection of the appropriate color, but also the appropriate painting techniques, as well as, the preparation of the surface.

The set of colors from the stencils presented in the chapters mentioned above only roughly corresponds to the original color tone, it is an approximation. Finally, in the process of retouching, color tests should be performed, which should be verified by a commission.

The contractor is liable under warranty for removal of defects resulting from incorrectly performed tasks. This also applies to the Contractor's awareness about the historic character of the building, the quality of initial and secondary layers, as well as destructive processes and building exploitation.

1. Diagnosis and color study of the exterior walls of Centennial Hall in Wrocław

1.1. About this facility

– *aspect:* Centennial Hall exterior walls
– *author:* Architect Max Berg, Contractor – Dyckerhoff & Widmann
– *time frame:* masterplan 1910–1911, construction works 1912, ceremonial opening May 1913, extension in 1930's
– *materials and technology:* poured concrete (reinforced) and layers of painted surface
– *dimensions and functions:* specified in project by Autorska Pracownia Projektowa Leszek Konarzewski, 2008

1.2. The diagnosis

The work methodology presented by the author of this study was developed on the basis of previously carried out works of a similar range. In order to determine the scope of the task, consultations were made with Leszek Konarzewski, PhD Architect (designer of the façade renovation), Jerzy Ilkosz, PhD, Director of the Museum of Architecture in Wrocław, and representatives of the People's Hall (Hala Ludowa) Enterprise. Following a preliminary analysis of the state of preservation and technical construction of the building it was established that in the course of activities related to the development of conservation diagnosis for exterior walls of Centennial Hall the following activities would be carried out:

1. Preparation of preliminary photographic documentation.
2. Analysis of the surface to take samples for laboratory tests.
3. Analysis of the state of preservation and deterioration causes of studied fragments (the influence of destructive factors on initial colors).
4. Collection of samples for laboratory tests.
5. Specialized tests in two independent laboratories in Toruń.
6. Examination of collected materials and laboratory test results.
7. Definition of exterior walls coloration in reference to current color templates.

1.3. Map and description of sampling locations

Ten samples were collected for laboratory testing from selected areas. The areas are shown on the cross-section view and plan of the Centennial Hall prepared by Leszek Konarzewski. The technical construction and general state of preservation of the building fragments anticipated for renovation were determined. The origin of samples and other parts characterizing the structure and colors of the exterior walls were recorded on photographs.

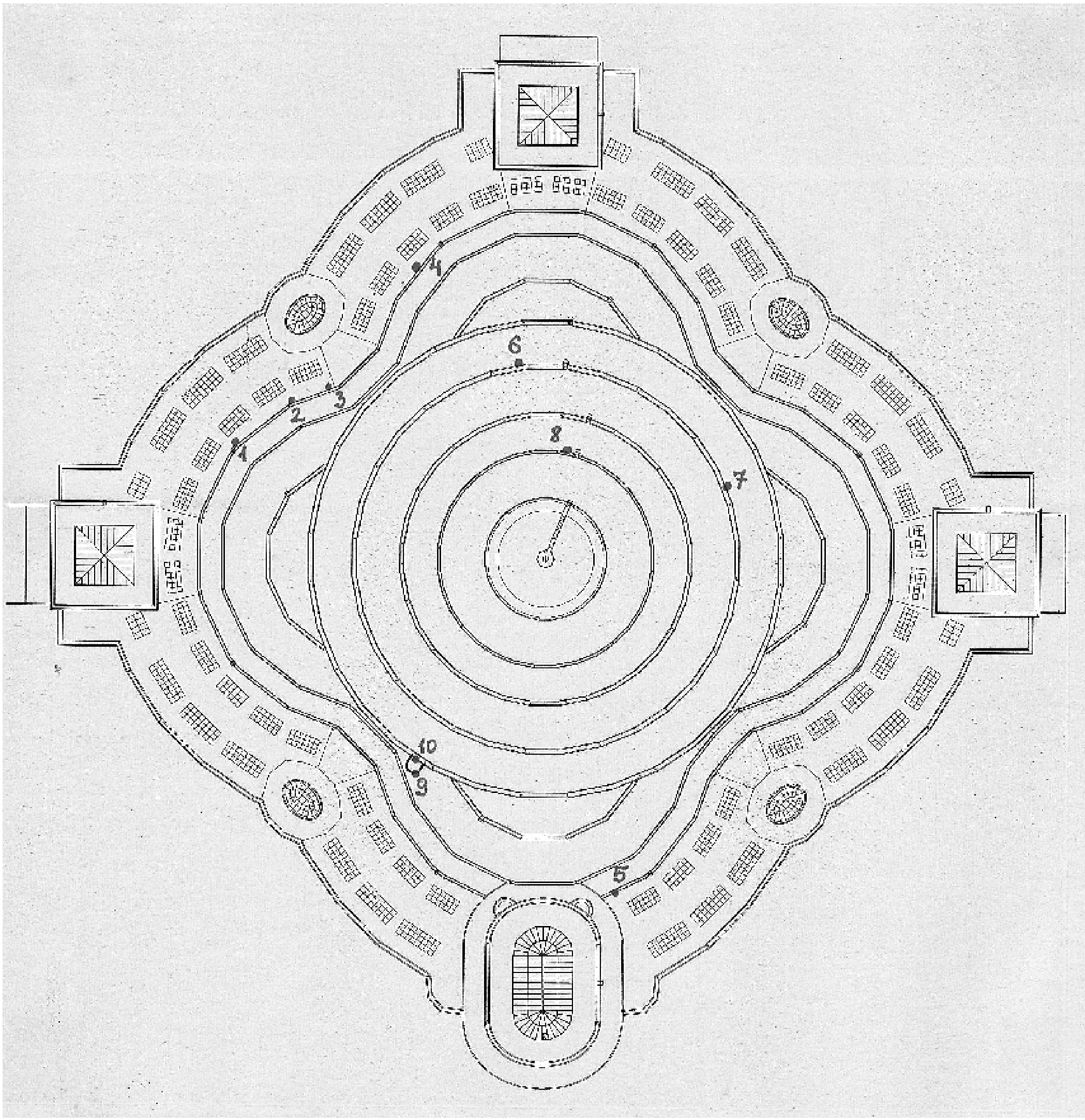
Laboratory tests were conducted in two independent laboratories in Torun:
1. Technical Laboratory in Toruń, *Elżbieta Orłowska – Technical Research Specialist;* Samples 1–10
2. Conservation Laboratory at Nicolaus Copernicus University in Toruń, *Zuzanna Rozłucka – research and photography, Robert Rogal – consultation, Waldemar Grzesik – digital documentation;* samples 4, 6, 7, 9, 10.

Figures 1. Tests – exterior walls
The quality of the individual chronological layers and colors were determined. It was predetermined with the conservation and restoration specialist, that colors will be identified by comparing with the NCS index.

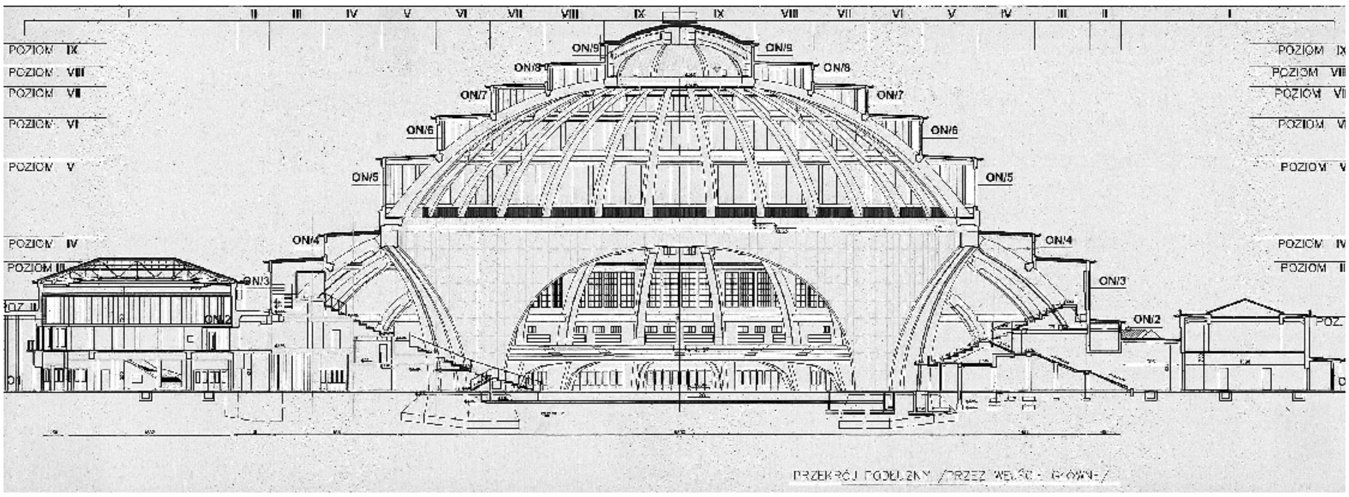
Due to the meager possibility of rendering color variation only on the basis of color templates, to complement the information, colors of exposed layers were also compared with the Keim template (Keim – historisch).
The final result of the evaluation of colors is presented in chapter 2.7. *The juxtaposition of colors (based on templates).*
Autorska Pracownia Projektowa Leszek Konarzewski's views and cross-sections of the Centennial Hall were used to create a map of sampling locations.

Description of sampling locations:
Sample 1.
Level II
Pillar between the drain-pipes 17 and 18, 30 cm above the windowsill
Sample 2.
Level II
Pillar at the drain-pipe 18
Sample 3.
Level II
Pillar on the right side of the drain-pipe 19
Sample 4.
Level II
Semi-circular wall
Sample 5.
Level II
Wall under the window, to the right of the drainpipe
Sample 6.
Level VI
Pillar between windows
Sample 7.
Level VI
Pillar between windows
Sample 8.
Level VIII
Pillar between windows
Sample 9.
Level IV
Outer wall of external staircase
Sample 10.
Level V
Inner wall of external staircase

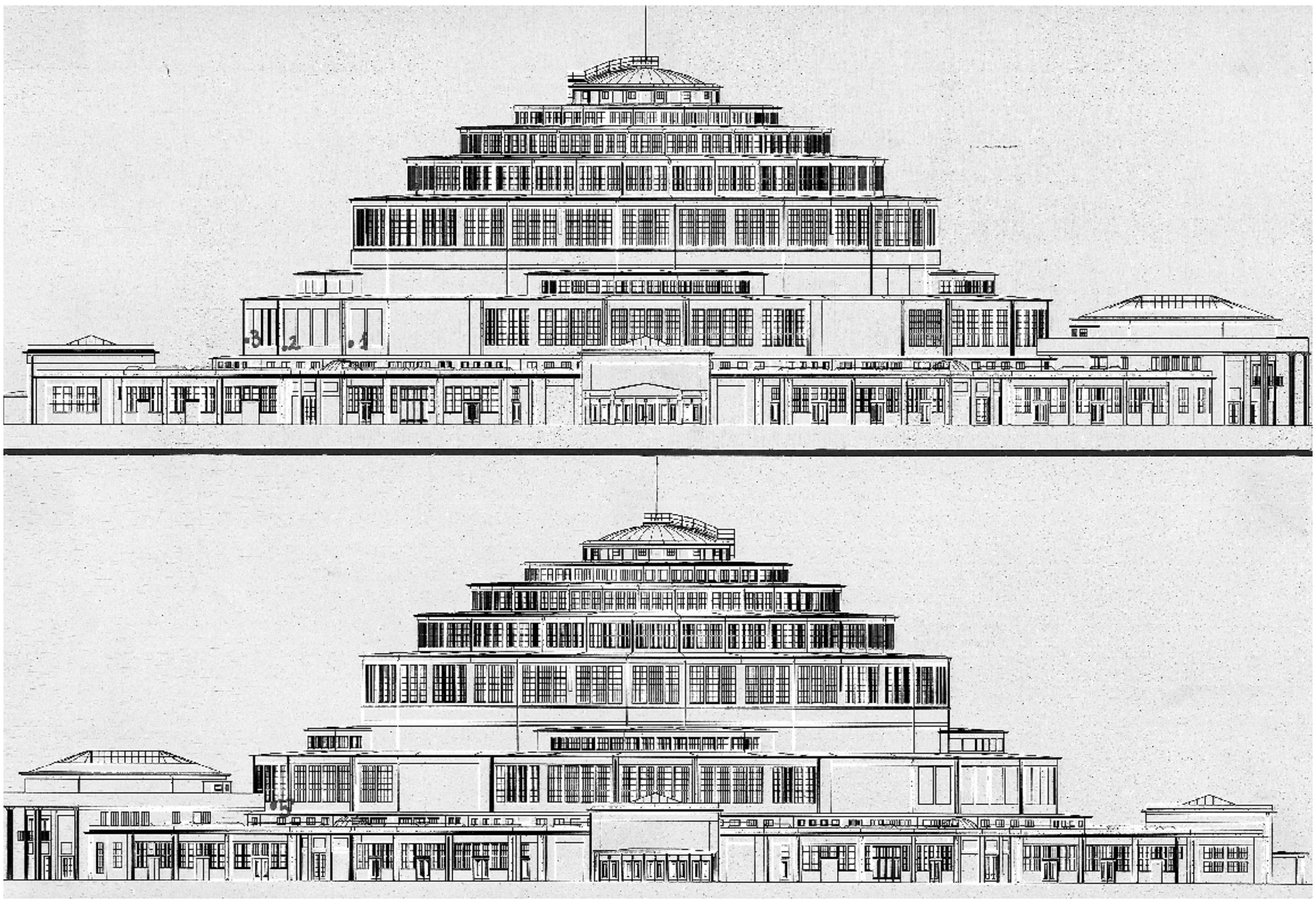
Il. 1.1. Map of sampling locations, Spring 2009. Plan of the Centennial Hall. Autorska Pracownia Projektowa Leszek Konarzewski
Il. 1.2. Longitudinal section of Centennial Hall with levels marked. Autorska Pracownia Projektowa – Konarzewski
Il. 1.3. Map of sampling locations, Spring 2009. External walls of Centennial Hall. Autorska Pracownia Projektowa Leszek Konarzewski



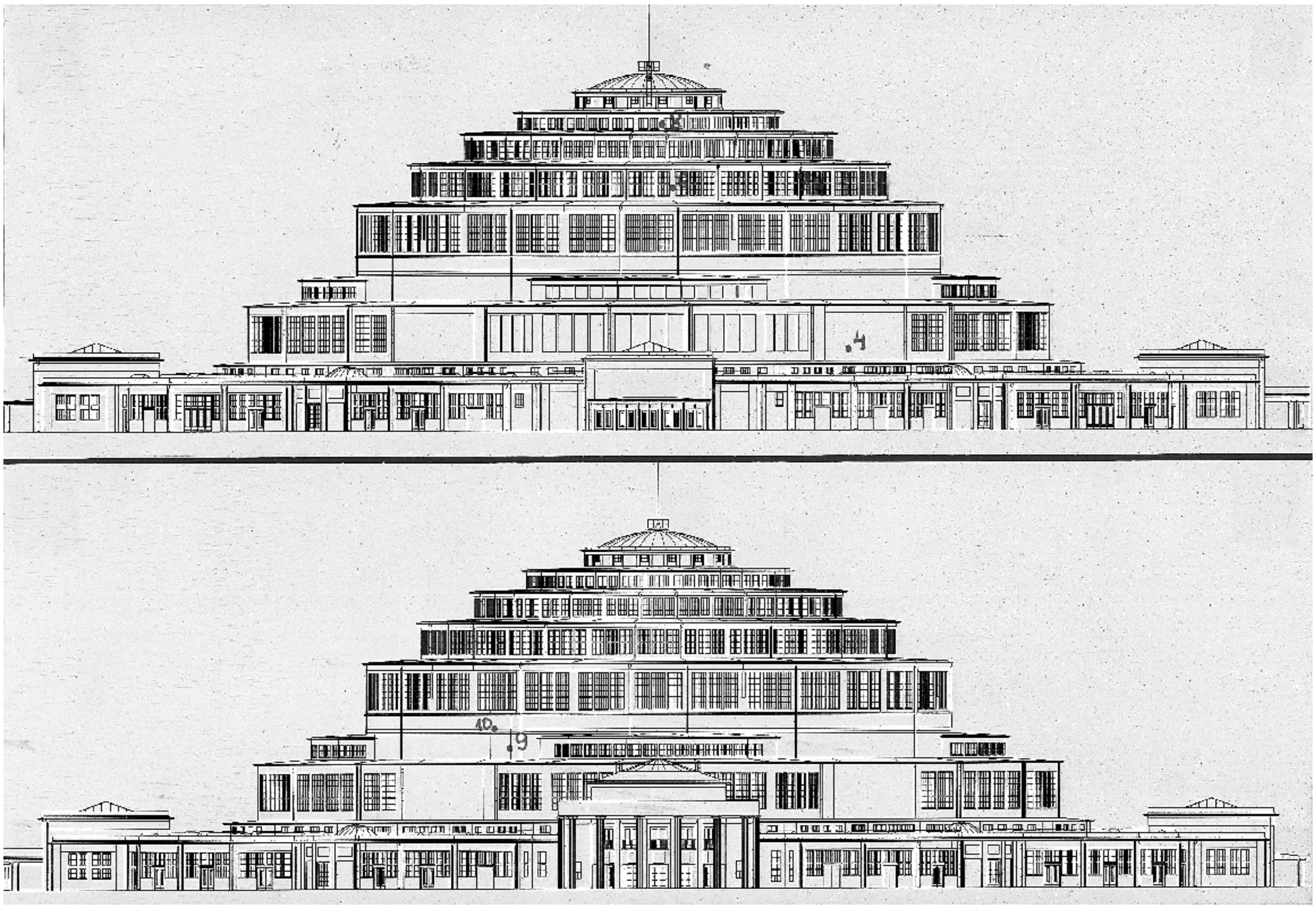
Il. 1.1.


POZIOM IX
POZIOM VIII
POZIOM VII
POZIOM VI
POZIOM V
POZIOM IV
POZIOM III
ON/9
ON/8
ON/7
ON/6
ON/5
ON/4
ON/3
ON/2
PRZEKRÓJ PODŁUŻNY /PRZEZ

Il. 1.2.



Il. 1.3.



Il. 1.4.

Il. 1.4. Map of sampling locations, Spring 2009. External walls of Centennial Hall. Autorska Pracownia Projektowa Leszek Konarzewski

1.4. Laboratory tests

1.4.1. Technical Laboratory in Toruń, *Elżbieta Orłowska – Technical Research Specialist*

TEST RESULTS OF THE MONOCHROME FACADE OF CENTENNIAL HALL IN WROCŁAW
Ten samples of mortar layers of various tints of ochre on its surface were taken for tests.

1. Microscopic observations

Sample 1 is a piece of very hard mortar with a smooth surface on which residues of brittle ocher layer are present between quartz grains.
In **sample 2** a thin layer of ocher lies on hard cement mortar, covered by a thick hard layer of lighter tint, strongly bound to the substrate, difficult to repair.
Sample 3 includes thin slices of cement mortar similar to **sample 2** mortar: a crisp layer of ocher covered by a thick hard lighter layer.

The situation is different with **sample 4**: the tile grout is tightly covered with a thick, shiny, light yellow layer of slippery surface. It is impossible to completely repair the layer; it is difficult to assess whether the earlier layer is preserved.
Sample 5 is similar to samples 2 and 3. It contains two layers of painting on cement mortar.
Sample 6 is similar to sample 1. It consists of one brittle ocher layer amongst the grains of sand.
Sample 7 comprises of thin gray flakes of cement powder covered with an ocher layer.
In S**ample 8** a coarse cement mortar with light tint of ocher layer surrounds large grains of quartz.
Sample 9 is composed of two pieces of mortar, one of which has a brittle, ocher layer (as sample 1) and the other is covered, hard, darker and tightly bonded to the substratum.
Sample 10 is a light yellow tile grout with no traces of paint layer.

2. Examination of pigments and binders
– in 2 M NaOH solution the paint layer samples 1, 6, 7 and 8 and bottom layer samples 2, 3, 5 and 9 slightly soften. Top layers in samples 2, 3, 4, 5 and 9 do not change
– organic binder is not present in any of the layers
– after calcination of layer in samples 6, 7 and 8 and bottom layers of samples 2, 3, 5 and 9 become reddish in color, top layers of samples 2, 3, 4, 5 and 9 become pink
– in 2 M HCl layers on mortar in samples 1, 2, 3, 5, 6 and 8 partly dissolve, white clusters remain. In samples 2, 3, 4, 5 and 9 paint layers become vitreous in hot HCl
– in KSCN and $K_4[Fe(CN)_6]$ acid solution, all samples, result in intensive color reactions characteristic in Fe^{3+} iron
– the pH value of aqueous suspension of paint layers was tested on all samples. Previous pH measurements of distilled water had an acidic value of pH 4.4, which certainly lowed the pH value of the tested solutions. None of the samples were highly alkaline. The maximum was observed in samples 3, 4, 5 and 9, which may suggest silicate binder (according to W. Ślesiński).

Conclusions:
The earliest layer of ocher paint lies directly on the surface of the mortar. Apart from the ocher color, it contains an addition of an unidentified white.

Organic binders or carbonates were not detected in any of the samples. The layers are brittle, it is possible that the original binder disintegrated under the influence of atmospheric factors.

Light yellow overcoating layers are present on the surface in samples 2, 3, 4, 5 and 9. They are thick, sometimes shiny, well-bonded to the substrate. The binder is probably silicate, and ocher was used as a pigment.
Paint layers were not found in sample 10.

1.4.2. Conservation Laboratory at Nicolaus Copernicus University in Toruń

Zuzanna Rozłucka, PhD – tests and photography
Robert Rogal, PhD – consultations
Waldemar Grzesik – photographic documentation

RESULTS OF OPTICAL DIAGNOSIS OF THE FAÇADE OF CENTENNIAL HALL IN WROCŁAW

Five samples of paint layers and substratum were taken for testing. Initial microscopic observation and physical and chemical tests were done.
Then, to determine the detailed stratigraphy of samples, cross-sections were measured for comparative analysis using standard VIS and UV fluorescent microscopy.
The study was conducted on a Nikon Eclipse E600 microscope with an external halogen illumination (for VIS observation) and a Nikon Super HB 1010 mercury lamp and standard UV2A filter (for UV observation).
The results document microscopic photographs of surface samples and their cross-sections, taken in VIS light and UV rays and a description of the structure and composition of paint layers and their chronology.

Sample 4. (1)
The surface of sample 4. (Il. 1.5) is yellow ocher, hard, glassy and dirty. In addition to the ocher and colorless, red particles are also present. Iron pigments have been identified.

Stratigraphy of Sample 4. (1) (Il. 1.6, 1.7, 1.8)
The **cement/limestone mortar** is probably double layered; the aggregate has a larger grain at the bottom (Il. 1.6).
The **light ocher paint layer** contains particles of red pigment form the upper lining (Il. 1.8); the layer probably has a lime binder.
The **ocher paint layer** is difficult to assess, whether it is done in silicate technology or only consolidated with soluble glass.

Sample 6. (2)
Sample 6. The sample surface is very hard, which makes it stand out from the rest. The surface of sample 6 (Il. 1.9) is light ocher, glassy, compact. Iron pigments have been identified.

Stratigraphy of Sample 6. (2) (Il. 1.10, Il. 1.11)
In the **limestone cement mortar** larger grains of aggregate can be seen at the bottom, it appears to contain less lime binder than Sample 4.
A lime binder has been identified in the **light ocher layer of paint** – the thickest of the samples.

Sample 7. (3)
The surface of Sample 7. (Il. 1.12) is fairly homogeneous, light ocher. Variation in the construction of this sample has been observed, therefore, two cross-sections were performed and their stratigraphy was determined. Iron pigments have been identified.

Stratigraphy of Sample 7. (Il. 1.13, Il. 1.14, Il. 1.15)
Contents of ocher paint layer penetrated into the **limestone cement mortar**, probably as a result of secondary activities – like cleaning (?), although penetration of the mortar with darker top paint layer cannot be excluded.
The **ocher paint layer,** is probably inside a lime binder.
The **ocher paint layer, darker orange-like,** completely covered with a transparent film, which is more visible under UV light. It is difficult to clearly define its nature – whether it is salting out or silicate binder?

Stratigraphy of Sample 7' (Il. 1.16, Il. 1.17, Il. 1.18)

Sample 7' has a completely different structure than the others:
Lime mortar with fine clearly fractionated filler, whose surface has been saturated with a solution of water glass, clearly visible under UV light.
Light-ocher paint layer probably with silicate binder.

Sample 9. (4) (Il. 1.19)
The surface of Sample 9 is ocher in color, red and white particles are also present.

Stratigraphy of Sample 9. (Il. 1.20, Il. 1.21, Il. 1.22, Il. 1.23)
Limestone cement mortar of varied size of aggregates.
Ocher color paint layer of lime binder and iron pigments, the surface layer is worn out, salt efflorescence – Phot. 19 – in UV light.

Sample 10. (5) (Il. 1.24)
Sample 10 surface is diverse and has an ocher and gray color here and there, for this reason two cross-sections were made:

Stratigraphy of Sample 10. (Il. 1.25, Il. 1.26, Il. 1.27)
Only **Limestone cement mortar** with fragments of ocher paint layer.
Gray transparent layer – probably a dirty layer of soluble glass.

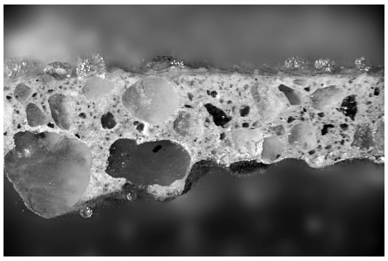
Stratigraphy of Sample 10' (Il. 1.28, Il. 1.29)
Limestone cement mortar
Ocher paint layer iron pigments and silicate binder identified, brown – gray transparent surface as above, that is clearer in UV light, it is probably a layer of soluble glass or salt efflorescence.

Il. 1.5–1.29. External walls of Centennial Hall. Laboratory tests of samples of paint layers with the substrate

1.5. Color of Exterior Walls

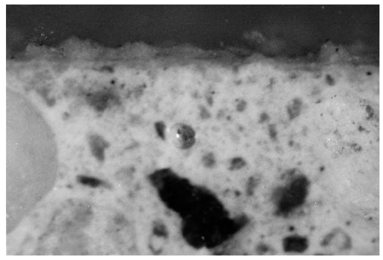
1.5.1. Factors influencing the general color tone of the Centennial Hall architectural form
Factors influencing color tone of the external block are as follows:
1. Local color of paint layer
The Centennial Hall's surface is exposed to severe weather conditions, so the natural ocher color paint used has undergone diverse changes. Rinsing, salting-out, repainting, "scorch" of natural ocher to sun-burnt ocher, and mechanical damage is one of the reasons of color change of the surface of external walls.
2. Types of aggregates
A variety of fillers were used for cast concrete layers, which affected the texture and basic color tones. The current study revealed the presence of aggregates of basalt, granite, stones of different granulation, gravel and sand. Color, density and grain size of fillers, visible in many places on the surface has a significant bearing on the perception of color of the whole building.

Il. 1.5.

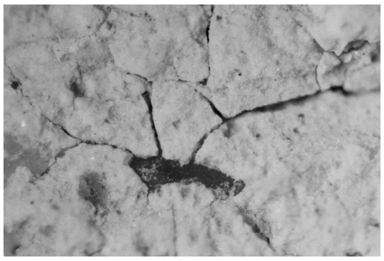


Il. 1.6.

Il. 1.7.



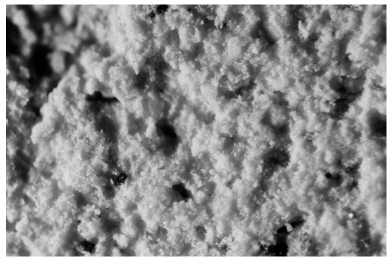
Il. 1.8.



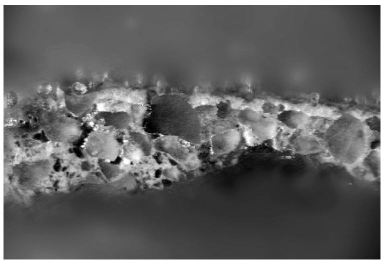
Il. 1.9.

Il. 1.10.

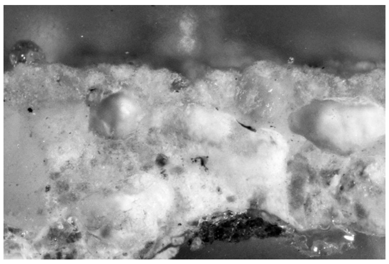
Il. 1.11.



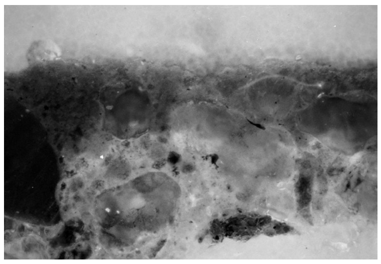
Il. 1.12.



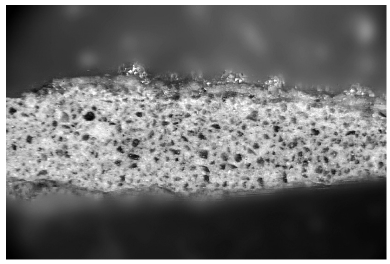
Il. 1.13.



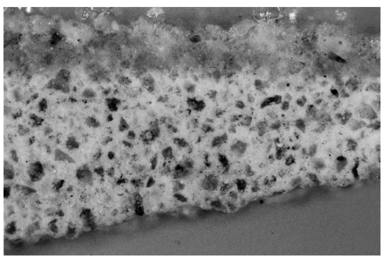
Il. 1.14.



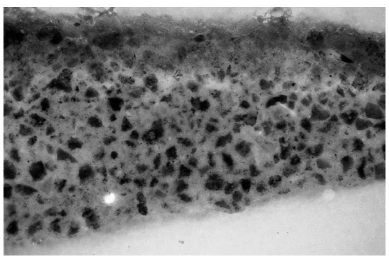
Il. 1.15.



Il. 1.16.

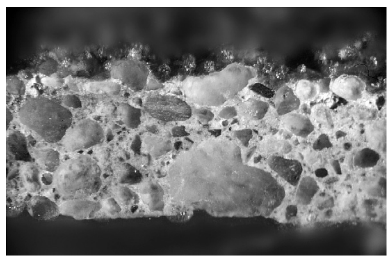


Il. 1.17.

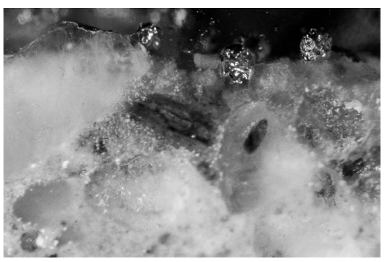


Il. 1.18.

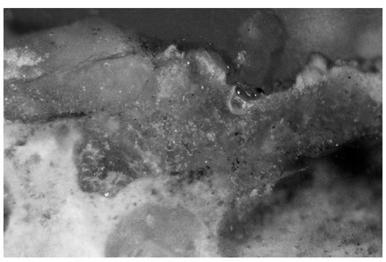
Il. 1.19.



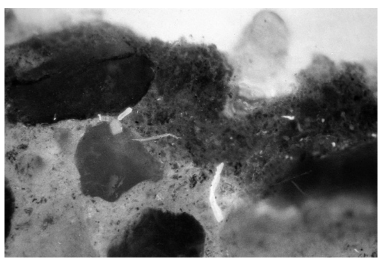
Il. 1.20.



Il. 1.21.

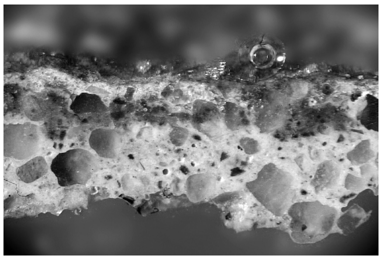


Il. 1.22.

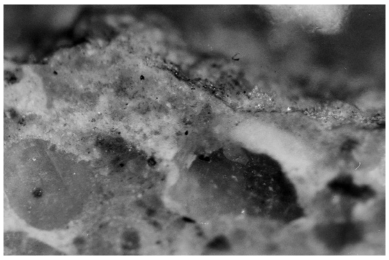


Il. 1.23.

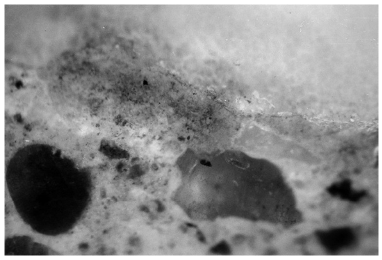
Il. 1.24.



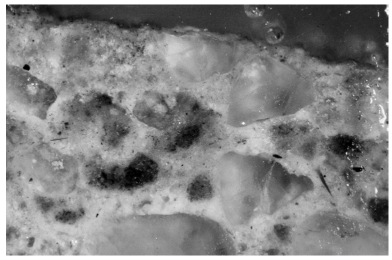
Il. 1.25.



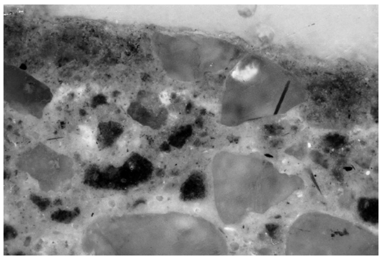
Il. 1.26.



Il. 1.27.



Il. 1.28.



Il. 1.29.

Il. 1.30.

3. Surface texture

The formwork system highlighting the distribution of individual sides of façade gives them a distinct rhythm. The characteristic surface texture, very often with a visible imprint of the formwork boards supplements the range of factors that determine the local color.

4. Others – marginally (imprints, inscriptions)

Imprints of the constructor's logo and other historic signs (e.g. inscriptions), that are the "sign of life" of the building.

Il. 1.30. Dykerhoff & Widmann company trademark, imprinted from the formwork planks. Photo 2009

1.5.2. Color description of the exterior walls of Centennial Hall

Concrete exterior walls and color

The exterior walls were painted directly on the concrete surface with ocher paint or locally on the lime mortar with ocher color. Currently, the surface has many damages and fill-ins, it is also very dirty, which in turn leads to a distortion of perception of the original coloring of the Centennial Hall.

Exterior windows and doors; woodwork and accessories

Mostly window frames of a distinctive color tint of warm red, have been preserved from the original window woodworks. Window shutters were to obtain a tint of red wood structure by placing an undercoat layer of white, and then applying semi-translucent layers of colored paint (red-brown tint). The metallic exterior door handles have been painted with oil paint of warm ocher color as the undercoat. The surface of the metal was originally secured with a dark oil-resin coating. The wooden exterior doors and bulletin boards have the same tint of warm red as the original window woodwork.

Il. 1.31.

In conclusion it should be emphasized that the final color effect of the façade of the Centennial Hall is influenced by many factors, not only the local color. Paint layer color interacts with visible grains, fillers and texture divisions of the facade as well as imprints from formworks.

Il. 1.31–1.32. External concrete walls and their color before renovation work in 2009. The actual color dependent on weather conditions

Il. 1.33–1.35. External concrete walls and their color before renovation work in 2009. The actual color, state of preservation of different parts of the façade

Il. 1.36–1.38. External concrete walls and their color before renovation work in 2009. State of preservation of different parts of the façade

Il. 1.39–1.42. External concrete walls before renovation work in 2009. Fillers: basalt, granite and quartz; addition of wood also visible.

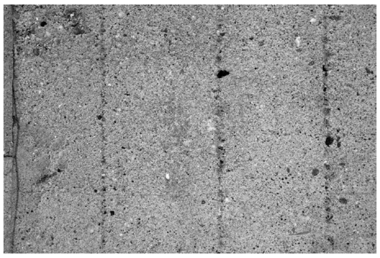
Il. 1.43–1.46. External concrete walls before renovation work in 2009. Fillers: basalt, stones of varying granularity, gravel, sand

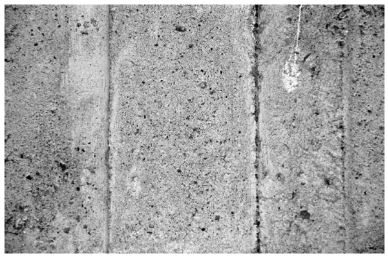
Il. 1.47–1.50. External concrete walls before renovation work in 2009. Fillers: basalt, stones of varying granularity, gravel, sand

Il. 1.51–1.54. External concrete walls before renovation work in 2009. Formwork pattern – separated part of façade

Il. 1.55–1.57. External concrete walls before renovation work in 2009. Surface texture. Surface pattern – formwork and formwork joining and filler texture

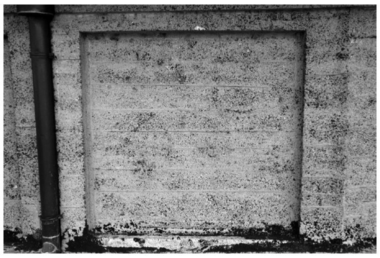

Il. 1.32.


Il. 1.33.

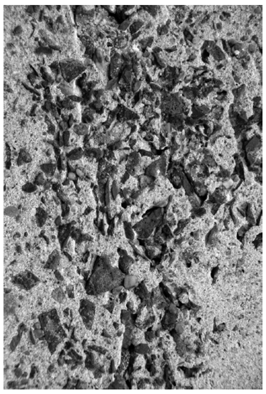

Il. 1.34.


Il. 1.35.


Il. 1.36.


Il. 1.37.

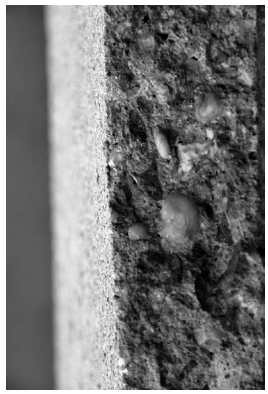

Il. 1.38.


Il. 1.39.


Il. 1.40.


Il. 1.41.


Il. 1.42.

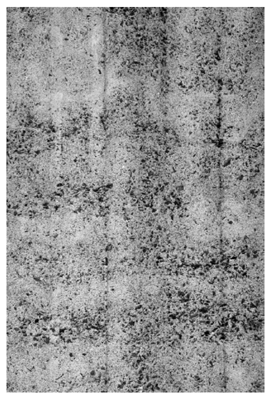

Il. 1.43.


Il. 1.44.


Il. 1.45.


Il. 1.46.


Il. 1.47.

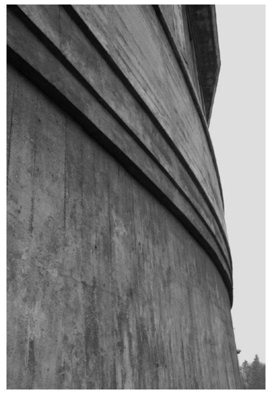

Il. 1.48.


Il. 1.49.

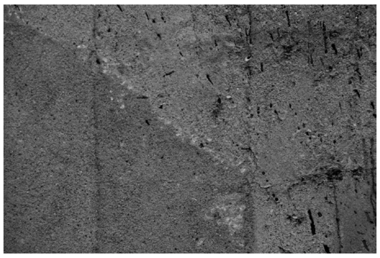

Il. 1.50.


Il. 1.51.


Il. 1.52.

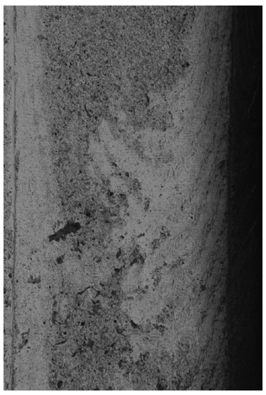

Il. 1.53.


Il. 1.54.

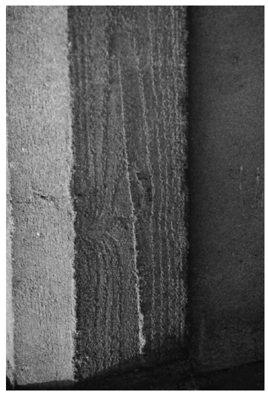

Il. 1.55.


Il. 1.56.


Il. 1.57.


Il. 1.58.


Il. 1.59.


Il. 1.60.


Il. 1.61.


Il. 1.62.


Il. 1.63.


Il. 1.64.

Il. 1.58–1.61. External concrete walls and their color before renovation work in 2009. Surface texture – imprinted from the formwork planks
Il. 1.62–1.64. External concrete walls and their color before renovation work in 2009. Imprint of the Dykerhoff & Widmann company trademark, historical inscriptions on wall surfaces
Il. 1.65–1.68. Windows and woodworks before renovation work in 2009. The preserved remains of the original color of windows in comparison with door and window colors painted during the renovation work in 2004
Il. 1.69–1.72. Windows and woodworks before renovation work in 2009. Façade window hinges
Il. 1.73–1.75. Windows and woodworks before renovation work in 2009. Façade window handles
Il. 1.76–1.78. Façade damages and secondary repairs in 2009. Corrosion of reinforcement and concrete loosening
Il. 1.79–1.81. Façade damages and secondary repairs in 2009. Corrosion of reinforcement and concrete loosening
Il. 1.82–1.84. Façade damages and secondary repairs in 2009. Corrosion of reinforcement and concrete loosening
Il. 1.85–1.87. Façade damages and secondary repairs. Corrosion of reinforcement, loosening of mortar and layers of paint, biological damages
Il. 1.88–1.90. Façade damages and secondary repairs. Concrete structure damages (bullet holes) and abrasions of paint layer.
Il. 1.91–1.93. Façade damages and secondary repairs. Corrosion of reinforcement, cracks and improper fillings

1.6. The juxtaposition of colors

In consultation with the architect Leszek Konarzewski, it was established that the preliminary juxtaposition of colors will be determined by referencing the exposed original color with the palette of colors contained within the NCS (Natural Color System®) template. The layers were also compared with the KEIM template (KEIM – historisch) for a wider reference.
The set of selected colors presented below roughly correspond to the color tone of the original, but just approximately. It should also be emphasized that the painting layers have not been preserved in perfect condition. Being under the influence of changing weather conditions for decades the layers have undergone physio-chemical changes resulting in local changes of color. In almost every sample the original color looks a bit different. Finally, in the process of painting, color tests should be performed, which should be verified by a commission. The correct end result is affected not only by the selection of the appropriate color, but also the appropriate painting technique, as well as preparation of the surface for final touches.
Coatings were applied relatively thin or semi-transparent in the original paint study of the Centennial Hall. Modern painting techniques should therefore be adapted to that of decades ago.

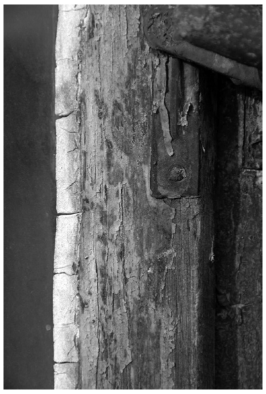
WARNING:
The following is a selection of colors from templates that correspond to the local colors of the facade. It is impossible to determine a single color that corresponds to the preserved fragments. Therefore, the final choice of color should be preceded by tests on the wall, aiming to apply the correct color tint, density and painting technique.

1. Exterior concrete walls and color

NCS	**S 0520 – Y20R**
KEIM – historisch	**35 H 54 (Farbreihe 35 Goldocker)**


Il. 1.65.


Il. 1.66.


Il. 1.67.

Il. 1.68.


Il. 1.69.


Il. 1.70.


Il. 1.71.


Il. 1.72.


Il. 1.73.

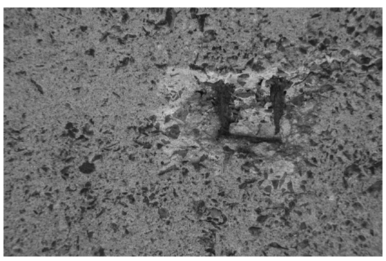

Il. 1.74.


Il. 1.75.


Il. 1.76.


Il. 1.77.


Il. 1.78.

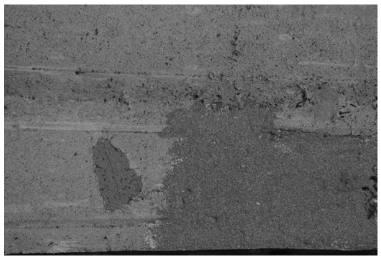

Il. 1.79.


Il. 1.80.


Il. 1.81.


Il. 1.82.


Il. 1.83.


Il. 1.84.

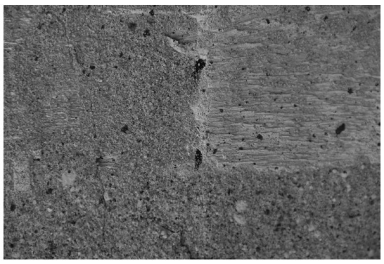

Il. 1.85.


Il. 1.86.


Il. 1.87.


Il. 1.88.


Il. 1.89.


Il. 1.90.


Il. 1.91.


Il. 1.92.


Il. 1.93.

also:

NCS	**S 0510 – Y30R**
NCS	**S 0530 – Y10R**
NCS	**S 1020 – Y20R**
NCS	**S 1010 – Y20R**
NCS	**S 1020 – Y30R**
NCS	**S 2020 – Y30R**
KEIM – historisch	**35 H 52 (Farbreihe 35 Goldocker)**
KEIM – historisch	**35 H 56 (Farbreihe 35 Goldocker)**
KEIM – historisch	**37 H 52 (Farbreihe 37 Ocker grünlich)**
KEIM – historisch	**37 H 54 (Farbreihe 37 Ocker grünlich)**

2. Exterior window woodworks and accessories

exterior woodworks

NCS	**4050 – Y80R**

also:

NCS	**S 4030 – Y60R**
NCS	**S 5040 – Y70R**
NCS	**S 6030 – Y60R**

handles, hinges

NCS	**S 1010 – Y10R**

It is possible to use the initial color, a dark protective layer.

1.7. Damages and secondary repairs of the exterior walls of Centennial Hall

As already mentioned, proper perception of color of the exteriors of the Centennial Hall are influenced by a number of factors, and the fundamental include:

1. Dirty surface.
2. Mechanical physio-chemical damages to the structure and surface facade.
3. Repainting.
4. Multiple reparations of cracks and small damages of the structure.
5. Biological damages.
6. The destruction of the structure and color of window frames and their accessories.
7. Glazing replacements.

The diversity of emerging defects is shown in the photographs. All secondary fixes are basically different from the original development of both color, texture and technique, which in the majority of cases were unstable, and poorly preserved.

The building examinations conducted in 2009, became the basis of renovation and restoration of Centennial Hall's façade conducted in the same year.

The results obtained fulfilled all the assumptions and expectations which were confirmed by inspection in June 2016.

Il. 1.94–1.95. Centennial Hall - general view; fragment – main entrance hall and Imperial Hall. Condition before 2009 and after 2016 renovation and restoration works

Il. 1.96–1.97. Centennial Hall – fragment of south façade, before renovation and restoration works in March 2009 and following renovation and restoration in June 2016.

2. Diagnosis and color study of interior design elements of the Centennial Hall in Wrocław

2.1. About this facility

- *aspect of study:* architectural elements of Centennial Hall: foyer and rooms of the ground floor, main entrance hall and skylight structures.

- *author:* architect Max Berg, Dyckerhoff & Widmann Construction Company

Il. 1.94.

- *date of origin:* project 1910–1911, construction works 1912, ceremonial opening May 1913, extension in 1930's.
- *materials and technology:* poured concrete (reinforced), cement-lime mortar overlays, stuccos and plaster borders, paint, wood and metal elements, stair claddings, doors and window woodworks, metal skylight structure elements and oil coatings.
- *dimensions and functions:* defined in the technical design of a fragment of Centennial Hall in this study

2.2. The diagnosis

The assumed work methodology of the identification of conservation needs and determination of initial colors of the foyer, ground floor rooms and the entrance halls of the Centennial Hall in Wroclaw, was developed on the basis of similar studies carried out previously. In order to determine the scope of tasks consultations were held with Wrocław City Conservation Officer (MKZ Wrocław), renovation and restoration designer, Jerzy Ilkosz, PhD, Director of the Museum of Architecture and representatives of the Centennial Hall.
Following a preliminary analysis of the state of preservation and the technical construction of the object, it has been established that in the course of activities related to the development of identification of conservation needs of the historical elements on the ground floor at Centennial Hall work would be carried out as follows:

1. Preparation of a preliminary photographic documentation.
2. Measurements of selected batches for research.

Il. 1.95.

Inventory data and dimensions of the Centennial Hall are shown on the view and cross-section of the Centennial Hall of Autorska Pracownia Projektowa Konarzewscy s.c.

3. Analysis of the state of preservation and deterioration causes of studied fragments (the influence of destructive factors on initial colors).

4. Outcrop stratigraphy of selected parts of the walls, ceilings, stairs, railings.

5. Analysis of collected material and stratigraphic test results.

6. Definition of initial color study in relation to present color templates.

A series of 150 measurements were taken by inserting stratigraphic probes and sensors into selected areas. The technical construction and general state of preservation of the building's fragments anticipated for repairs was determined. The exposed parts were photographed and systematized by types of architectural elements:

1. Walls and pillars – foyer, main entrance hall and ground floor rooms

2. Ceilings – foyer, main entrance hall and ground floor rooms

3. Wooden stairs and their lining, wooden and metal stairs railings and baseboards along the stairs

4. Door woodworks and accessories

5. External and internal construction of skylights – foyer and ground floor rooms

6. Exterior concrete walls and colors

Il. 1.96.

Il. 1.97.

7. Exterior window and door woodworks and accessories

The quality of individual chronological layers and their colors were determined after consultation with the renovation and restoration designer, it was determined that the type of color would be identified by comparison with the universal NCS template. In order to complement the information, due to a small variety of colors in color the templates, reference was also made to the KEIM template (KEIM – historisch).
The end summary assessment of colors is shown in the chapter on *The juxtaposition of initial colors.*

2.3. Technique and technology

2.3.1. Stratigraphy

Tab. 1. Walls and pillars of the main entrance hall and ground floor rooms (*collective statement*):

Technical layer	Color	Chronological layer	Characteristics of layers
0.	light yellow	X – 2011	colored layer of rough texture
1.	dark beige	IX	colored layer
2.	pink-ocher	VIII	colored layer
3.	white	VIII	undercoat layer
4.	gray-ocher	VII	colored layer
5.	gray-white	VI	colored layer
6.	light blue-gray	V	colored layer
7.	light gray	IV	colored layer
8.	white	IV	undercoat layer
9.	yellow-orange	III	colored layer
10.	white	III	undercoat layer
11.	golden-ocher	I-II	colored plaster finish, sanded or colored layer
12.	gray	I-II	cement-lime mortar
13.	dark-gray	I	structural elements with reinforcement

There is also a layer of green as the first paint layer in the foyer.

In the side entrance hall and vestibule opposite the entrance to the old pipe organ (the Centennial Hall is deprived of stone cladding at the bottom), a red layer as the second coating also exists.

Tab. 2. Ceilings – foyer, main entrance hall and ground floor rooms (*collective statement*):

Technical layer	Color	Chronological layer	Characteristics of layers
0.	white	VI – 2011	colored layer
1.	white	V	colored layer
2.	white-ocher	IV	colored layer
3.	light-gray	III	colored layer
4.	gray	III	plaster mash layer
5.	white-gray-ocher	I-II	colored layer
6.	white-ocher-gray	I-II	sanded plaster finish
7.	gray	I	cement-lime mortar
8.	dark-gray	I	structural elements with reinforcement

Tab. 3. Baseboards along the stairs (*collective statement*):

Technical layer	Color	Chronological layer	Characteristics of layers
0.	dark blue-gray	V – 2011	colored layer
1.	dark-red	IV	colored layer
2.	brown-gray	III	colored layer
3.	red-brown	II	colored layer
4.	dark blue-gray	I	colored layer
5.	ocher-brown tint	I	Oak wooden slat

Tab. 4. Door woodworks, wooden stair railings (*collective statement*):

Technical layer	Color	Chronological layer	Characteristics of layers
0.	dark-red-brown	V – 2011	colored layer
1.	dark-red or dark-brown	IV	colored layer
2.	light-gray		colored layer
3.	green		colored layer
4.	ocher	III	colored layer
5.	white	II	undercoat layer
6.	dark-red-brown	I	semi-translucent colored layer
7.	light-ocher tint	I	Pine wood

2.4. Technical structure and list of materials used

2.4.1. Wall and pillars – foyer, main entrance hall and ground floor rooms

Reinforced concrete structure, partially cement-lime-sand overlays, 3–4 mm thick plaster stuccos, dyed golden--ocher and sanded, surface securely bonded. Metal reinforcements inserted into the wall edges. Corners of the inner walls of the foyer near the stairs (canal casing) made of wood planks and metal nets (cross motif), light paint primer, final color adapted to the color of the main walls. Walls devoid of gypsum layers, undercoated with white paint, finishing layer of golden ocher tone. The first layer of the bottom part of the walls painted up to the 15 –16 mark from the current floor level (line made with copy pencil); this layer was green.

2.4.2. Ceilings – foyer, main entrance hall and ground floor rooms

Reinforced concrete structure, painted off-white (warm in tone), in the foyer the original coffered ceiling is ocher in color.

Suspended ceilings, thickness of approx. 5 cm, made of rebar truss – steel, structure filled with cement-lime-sand overlay, hooks on rods of ø 5 mm, embedded in the original concrete ceiling tied with elements of reinforced plate approx. 50 cm in rows, external overlay stucco 3–4 mm thick. The surface of the ceiling is painted an off-white warm tone; the space between the ceiling and skylight is painted golden ocher like the walls.

Round lamps of frosted glass on one side, 5 mm thick, approx. 44 cm ø are mounted on the ceiling; a cup-shaped internal reflecting screen, white enamel metal sheet, positioned on two supports; an external frame of brass-coated profiled copper-sheet is attached to the ceiling with 3–5 bolts.

2.4.3. Wooden stairs and claddings, wood and metal stair railings and baseboards of the staircase.

The stairs are of reinforced concrete, with wooden treads and rounded edges. The riser cladding is approx. 3 mm thick and has a clear-coat of paint. The tread surface is covered with a lining of green linoleum (approx. 3 mm thick) on a jute base bonded to the substrate; the protruding edge of the tread – is profiled like a "nose", and has an approx. 7–10 mm thicker strip of gray linoleum attached.

Wood railings with profiled baseboards, painted a semi-translucent dark red color, similar to the wooden wall railing. Metal railings on the stairs leading to the old pipe organ and the main hall (different constructions), painted dark blue-gray. Both railings in the main hall are made of copper, the brass handrails are oval in shape.

Staircase baseboards are made of oak, fitted individually to the shape of the stairs, and painted a dark blue-gray color as the first color layer.

2.4.4. Door woodworks and accessories

Wooden doors in the foyer are of simple profiled form, painted dark red, with hinges and handles painted black.

Wooden doors in the foyer are painted similarly, with metal (aluminum), shiny-chrome door handles.

2.4.5. External and internal construction of skylights – foyer and ground floor rooms

The supporting structure of skylights is made of I-beams and flat bars fitted into the ceiling; the interior steel profiles are painted red, and protected with red corrosion resistant coating; interior borders are painted with a warm white oil paint; besides the corrosion resistant coating, the exterior borders as the first layer have a dark – warm gray oil coating.

It appears that the original skylight windows were made of crystal reinforced glass (reinforcing mesh approx.

5 mm thick), with a slightly uneven surface (the glass is preserved in some of the triangular side walls). The outer side walls with opening ventilation windows are regulated by a metal semi-circular handle, which is spherical at the end.

2.4.6. Exterior concrete walls and colors

The walls are made of reinforced concrete with a very diverse filler (gravel of different granularity, sand). The poured concrete has left imprints of the formwork boards (intentional). The entire surface is golden-ocher in color. It should be assumed, that the original color of the walls has somewhat changed due to physical and chemical changes occurring in the yellow iron pigments, caused by the action of light and heat (scorching).

2.4.7. Exterior window and door woodworks and accessories

The original woodwork made of exotic eucalyptus wood (*Eucaliptus marginata*) and German *Jarrahholz* was imported from Australia, and is red-orange in color. The original elements of window woodworks have been preserved – window frames, window and door sashes. The wood has a transparent coating. Post-war window sashes were first painted with a white undercoat so that it resembled wood, and then with a translucent layer of warm red.

Cast iron door handles and ferrules were painted in the first layer with golden-ocher oil paint.

2.5. State of preservation:

A state of conservation analysis of different parts of the object of study has been conducted in the course of the current diagnosis.

Many architectural elements of the intensively utilized Centennial Hall are currently in poor condition.

The basic destructive factors include:

- **initial material defects and local diverse material preparation techniques**
- **natural factors: sunlight, rainwater, frost**
- **the natural aging process of materials initially used, e.g. sedimentation of dust and dirt, dimensional changes, cracking**
- **changes in spatial arrangement (reorganization), change in room function, replacement of original elements and the introduction of modern elements (adverse aesthetic and technical changes, e.g. windows, partition walls, and radiators)**
- **physical and chemical damages: humidity caused by sealing of the walls and ceilings due to repeated painting, delamination and cracking, incrustations**
- **mechanical damages: wallops, abrasion, breaking off, repetitive load (on stairs), loss of individual components (e.g. door handles), removal of layers during new exhibition preparations**
- **aesthetical changes: overlapping of new paint coating without removing previous layers, inadequate surface treatment, adverse changes in color (non-compliant with the original) and the use of different recycled materials (e.g. skylight glazing)**

Besides intensive use of the building (to be expected), serious damages occurred during World War II.

All elements of architecture and interior design have been repeatedly repaired and repainted. The first major transformation took place in the 1930's, when suspended ceilings, stone claddings, and stuccos was introduced. This work done by Richard Konwiarz, former cooperator of Max Berg, was not favorable for the appearance of the interiors. It can be considered as a historical effect on the cycle of changes taking place in interior design.

In the years to follow, the entire surface of the walls, pillars, foyer and foyer ceilings, halls, including window and door woodworks were repainted several times (without removing the previous layers). Such a sealing of surfaces leads to prolonged humidity of the first layer, and a significant increase in the thickness of layers resulting in the loosening of the whole structure of paint layers from the base. Besides the obvious change in colors, these coatings, of considerable thickness also caused the deformation of the original forms.
One of the basic conservation indications for renovation work is the need to remove the layers of paint and ensure proper preparation of the structure and surface treatment prior to the final painting. Tight sealing coatings are not to be used.
In the course of the excavations, after the removal of the secondary layer, the uncovered original layer looked relatively well preserved.
Multiple repairs, an increase in the number of visible secondary elements (doors, walls, joinery, lamps, heaters, etc.), and also advertisement and information signs cause aesthetic chaos, impeding correct perception of the original values of the historic building. A matter of concern is the perception of the interiors due to the condition and appearance of the floor in the foyer, which requires a comprehensive and targeted study. Losses in small pieces of woodwork, the unsuitable appearance of secondary surface layers and color stains complement the list of adverse occurrences in the historic interior.
A separate and serious concern is the condition of the exterior reinforced concrete wall structure, a problem that requires an individual study.

2.6. Color description of architectural elements

2.6.1. Wall and pillars – foyer, main entrance hall and ground floor rooms

Stratigraphic cross-sections are shown in Table 1. The first layer of the concrete base and stuccos is golden-ocher in color, with a relatively intense hue. In the case of concrete substrates, fragments of walls are made of boards, the first base layer is white. During subsequent repairs, the walls were painted to a different height and in different colors ranging from green to black, ending in gray. It is interesting that in the second chronological layer, the walls of the foyer are painted green. The original golden-ocher color also appears in the excavations on profiled stucco strips on the outside walls of the foyer and upper parts of Centennial Hall's walls (the color of the walls matched the tint of the stone cladding). In the excavations on the walls of the foyer (leading to the old pipe organ) the second layer revealed the presence of a cold tone of red iron. Secondary layers of specific and substantial thickness were found in the main hall, additional tones of brown and red divided into zones appear in the secondary layers.

2.6.2. Ceilings – foyer, main entrance hall and ground floor rooms

The stratigraphic cross-section of layers is shown in Table 2. The first layer of color on the exposed concrete foyer ceilings (the exterior space) was a tone of off-white. The view of foyer concrete ceilings in confined. Suspended ceiling spaces revealed that their surfaces were also painted white. In contrast, the concrete, hidden coffered ceiling in the main hall is ocher in color, which complies with the color of the exterior walls. All suspended and coffered ceilings in other halls and rooms were painted off-white (warm tint). This color is consistent with a tint of the metallic skylight borders and small windows in the foyer. Certainly, the white paint in the foyer's ceilings comes from before the installation of the suspended ceiling, as auxiliary assembly lines for embedding hooks connecting the concrete ceiling with the reinforcement of the ceiling were found there.

It should also be emphasized, that the plaster base made in the early twentieth century on the walls and coffered ceilings in the three side entrance halls is of excellent quality. Curved ceilings above the staircases on the sides of the main lobby also feature plaster ceilings connected to the wall with bed-moldings.

2.6.3. Wooden stairs and claddings, wood and metal stair railings and baseboards of the staircase.

The stratigraphic cross-section of layers is shown in Table 3 and 4. Wooden stair treads are lined with a lively green hue linoleum (repainted twice with oil paints), in protruding parts, gray cladding slats of increased thickness are fitted into the triple phased (cross milling) treads. Veneered risers are of thick pine in a natural shade of wood, with a clear coat finish. Metal railings and baseboards in the first preserved colored layer are dark blue-gray. Wooden staircase railings and handrails have been repeatedly repainted, originally coated with a semi-transparent layer of dark red (the hue matches the color of door woodworks). The secondary layers of white, gray, green, change the original color. The metal stair railing in the main lobby also has a first coat of dark blue-gray. Copper plated (originally brass-plated) handrails are now mechanically damaged and heavily worn out.

2.6.4. Door woodworks and accessories

The stratigraphic cross-section of layers is shown in Table 4. The initially carefully prepared wooden surface has been painted with a semi-transparent layer dark red in tone. Secondary structures of the layers are similar to that described for wooden stair railings. A large number of doors were subjected to paint layer removal by using coarse sandpaper on a random orbit sander. The wood was then painted a brown tone with a semi-transparent coating. The initial light metal handles were painted with a thin glossy metal coating (chrome plated).

2.6.5. External and internal construction of skylights – foyer and ground floor rooms

The first layer of borders of the internal skylight was painted off-white (warm tint). The internal and external metal structures were protected with corrosion-resistant paint of a warm gray color as in the first layer. Then repeatedly repainted (black, red, gray, light-gray, green emerald, warm green).

2.6.6. Exterior concrete walls and colors

The external walls were painted ocher directly on the concrete surface.

2.6.7. Exterior window and door woodworks and accessories

Mostly window frames with a distinctive shade of warm red have remained from the initial window woodworks. The red wooden structure of the window shutters was obtained by putting a white primer, and then applying semi-transparent layers of colored paint (red-brown hue). The metal exterior door handles were painted warm ocher with oil paint. The wooden exterior doors and bulletin boards have a warm red tint, the same color as the initial window woodworks.

2.7. The juxtaposition of initial colors

After consultation with architect Leszek Konarzewski, it was determined that the initial juxtaposition of colors would be identified by comparison of the uncovered initial colors with the universal NCS template (Natural Color System®). In order to complement the information, reference was also made to the KEIM template (KEIM – historisch).

The set of colors selected from the color chart presented below relatively corresponds to the original color tone (this is an approximation). It should be noted, however, that the revealed initial layers, in relatively small excavations, have not been preserved in perfect condition. For several years, physical and chemical factors caused local color changes, while these initial layers were located under the secondary layers. The initial color looks a bit different from the unveiled color in almost every case. In the process of painting, color tests should be performed and verified by a commission. The correct end result will not only be affected by the selection of the appropriate color, but also the appropriate use of painting techniques, and in no lesser degree, the preparation of the surface for finishing.

In the initial paint study of the Centennial Hall, the applied coatings were relatively thin or semi-transparent. Therefore, modern painting techniques should be adapted to those utilized decades ago.

1. Wall and pillars – foyer, main entrance hall and ground floor rooms

NCS **S 0520 – Y10R**

KEIM – historisch **37 H 54 (Farbreihe 37 Ocker grünlich)**

2. Ceilings – foyer, main entrance hall and ground floor rooms

NCS **S 0502 – Y**

KEIM – historisch **37 H 58 (Farbreihe 37 Ocker grünlich)**

3. Wooden stairs and lining, wooden and metal stairs railings and baseboards in the staircase.

green linoleum

NCS **S 5020 – G10Y**

gray linoleum

NCS **S 3502 – Y**

wooden railing

NCS **S 6030 – Y90R**

blue metal railing and baseboards in staircase

NCS **S 5030 – B10G**

4. Door woodworks and accessories

door woodworks

NCS **S 6030 – Y90R** *(as in wood railing)*

handles and hinges

NCS **S 8502 – Y**

5. External and internal construction of skylights – foyer and ground floor rooms

internal skylight

NCS **S 0502 – Y** *(as ceilings of foyer, main entrance hall and ground floor rooms)*

external skylight I protective layer

NCS **S 3060 – Y70R**

external skylight I colored layer

NCS **S 3502 – Y** *(as gray linoleum)*

6. Exterior concrete walls and colors

NCS **S 0520 – Y20R**

KEIM – historisch **35 H 54 (Farbreihe 35 Goldocker)**

7. Exterior window and door woodworks and accessories

external woodworks

NCS **S 4050 – Y80R**

handles and hinges

NCS **S 1010 – Y10R**

Il. 2.1. Walls and pillars – foyer and ground floor rooms. Concrete wall samples Undercoat layer – white, first paint layer – golden ocher

Il. 2.2. Walls and pillars – foyer and ground floor rooms. June 2015

Il. 2.3. Walls and pillars – foyer, main entrance hall and ground floor rooms . Internal walls of the foyer and back entrance. Corner made of planks of wood and metal wire, samples 2005

Il. 2.4. Walls and pillars – foyer, main entrance hall and ground floor rooms. Internal walls of the foyer and back entrance. Corner 2005

Il. 2.5. Walls and pillars – foyer, main entrance hall and ground floor rooms. Internal walls of the foyer and back entrance. Corner 2015

Il. 2.6. Walls and pillars – foyer, main entrance hall and ground floor rooms. Walls of the foyer. Walls with multiple repainted lower part, 2005

Il. 2.7. Walls and pillars – foyer, main entrance hall and ground floor rooms. Inner walls of the foyer and wooden stairs with cladding, wooden and metal railings, staircase baseboards. Side stairs; the state of preservation before renovation and restoration works, 2005

Il. 2.8. Walls and pillars – foyer, main entrance hall and ground floor rooms. Inner walls of the foyer and wooden stairs with cladding, wooden and metal railings, staircase baseboards. Side stairs; the state of preservation after completion of renovation and restoration work, 2015

Il. 2.9. Walls and pillars – foyer, main entrance hall and ground floor rooms. The corner near the main entrance hall. Stratigraphy showing color variation between the ceiling and the profiled wall of the skylight, 2005

Il. 2.10 Walls and pillars – foyer, main entrance hall and ground floor rooms. Foyer walls after completion of renovation and restoration works, 2015

Il. 2.11. Ceilings – foyer, main entrance hall and ground floor rooms. Concrete ceiling of the foyer; the interior space of suspended ceiling, 2005

Il. 2.12. Ceilings – foyer, main entrance hall and ground floor rooms. Concrete ceiling of the foyer; surface and hooks of suspended ceiling, 2005

Il. 2.13. Ceilings – foyer, main entrance hall and ground floor rooms. Faceted ceiling in main entrance hall after completion of renovation and restoration works, 2015

Il. 2.14. Ceilings – foyer, main entrance hall and ground floor rooms. Coffered ceiling of the side entrance hall. Surface treatment; the first layer of color on the ceiling – off-white, 2005

Il. 2.15. Ceilings – foyer, main entrance hall and ground floor rooms. Coffered ceiling of the side entrance hall after completion of renovation and restoration works, 2015

Il. 2.16. External and internal construction of skylights – foyer and ground floor rooms. Internal skylight in foyer, 2005

Il. 2.17. External and internal construction of skylights – foyer and ground floor rooms. Internal skylight in foyer, after completion of renovation and restoration works, 2015

Il. 2.18. Wooden stairs and claddings, wooden and metal stairs railings and staircase baseboards. Stairs from the east side entrance hall, 2005

Il. 2.19. Wooden stairs and claddings, wooden and metal stairs railings and staircase baseboards. Stairs from the east side entrance hall, after completion of renovation and restoration works, 2015
Il. 2.20. Wooden stairs and claddings, wooden and metal stairs railings and staircase baseboards. Stairs from the east side entrance hall, 2005. Metal railing, treads cladding, staircase baseboards.
Il. 2.21. Wooden stairs and claddings, wooden and metal stairs railings and baseboards in the staircase Stairs from the east side entrance hall, 2005. Metal railing, treads cladding, staircase baseboards
Il. 2.22. Wooden stairs and claddings, wooden and metal stairs railings and baseboards in the staircase. Stairs from the east side entrance hall, 2005 r. Wooden handrails, wooden side-staircase railing; stratigraphy layers; the first layer of color – red
Il. 2.23. Wooden stairs and claddings, wooden and metal stairs railings and baseboards in the staircase. Stairs from the east side entrance hall after completion of renovation and restoration works, 2015
Il. 2.24. Wooden stairs and claddings, wooden and metal stairs railings and baseboards in the staircase. Main entrance hall staircase, 2005
Il. 2.25. Wooden stairs and claddings, wooden and metal stairs railings and baseboards in the staircase. Main entrance hall staircase after completion of renovation and restoration works, 2015
Il. 2.26. Door woodworks and accessories, Side door, 2005
Il. 2.27. Door woodworks and accessories, Side door, 2015
Il. 2.28. Door woodworks and accessories, 2005. Side door, door in the main entrance hall, window frames. Stratigraphy of paint layers
Il. 2.29. Door woodworks and accessories, 2005. Side door. Stratigraphy of paint layers
Il. 2.30. Door woodworks and accessories, 2005. Foyer door to main hall, 2015
Il. 2.31. Exterior door and window woodworks and accessories, 2005. Wooden external door and information board. Original color visible in the sample – red-brown
Il. 2.32. Exterior door and window woodworks and accessories. Wooden external door, 2005
Il. 2.33. Exterior door and window woodworks and accessories. Wooden external door of foyer after completion of renovation and restoration works, 2015
Il. 2.34. Exterior door and window woodworks and accessories. Wooden external door of utility room, after completion of renovation and restoration works, 2015
Il. 2.35. Exterior door and window woodworks and accessories. Information board after completion of renovation and restoration works, 2015
Il. 2.36. Door woodworks and accessories. Side entrance hall; door between hall and vestibule. Door wings and metal handle (chrome plated), 2005
Il. 2.37. Door woodworks and accessories. Side entrance hall; door between hall and vestibule after completion of renovation and restoration works, 2015
Il. 2.38 Exterior door, window woodworks and accessories, 2005. Window wings and frames. The color of original wood structure visible in the sample
Il. 2.39. Exterior door, window woodworks and accessories, 2005. Window handles. Original color – ocher– visible in sample
Il. 2.40. Interior and exterior door, window woodworks and accessories. Windows and skylights of foyer, after completion of renovation and restoration works, 2015
Il. 2.41. Walls and ceiling of foyer. Stains and salting out; abrasions and mechanically damaged layers; loosening of overlaid layers of paint, 2005
Il. 2.42. Walls and ceiling of foyer after completion of renovation and restoration works, 2015
Il. 2.43 North side entrance hall after completion of renovation and restoration works, 2015

Il. 2.44. North side entrance hall after completion of renovation and restoration works, 2015

Il. 2.45. North side entrance hall, skylight after completion of renovation and restoration works, 2015

3. Diagnosis and excavation analysis of the Imperial Hall and utility rooms

3.1. About this facility

– *aspect of study:* Imperial Hall and utility rooms of Centennial Hall in Wrocław

– *author:* architect Max Berg, Dyckerhoff & Widmann Construction Company and subcontractors responsible for plasters, stuccos, suspended ceilings, skylights, glazing, and window joinery.

– *date of origin:* project 1910–1911, construction works 1912, ceremonial opening May 1913, extension in 1930's.

– *materials and technique:* poured concrete (reinforced), cement-lime mortar overlays, stuccos and plaster profiles and ornaments, paints, wood and metal elements, doors, skylight metal structures.

– *dimensions and functions:* defined in the technical design of a fragment of the Centennial Hall in this study

3.2. The diagnosis

The assumed work methodology of the identification of conservation needs was developed on the basis of similar previous studies carried out on the foyer and external walls. In order to determine the scope of tasks, consultations were held with the Director of the Museum of Architecture and current representatives of the Centennial Hall.

Following a preliminary analysis of the state of preservation and the technical construction of the object of study, it has been established that in the course of activities related to the development of identification of conservation needs for historical elements at the Imperial Hall and in the utility rooms of the Centennial Hall work would be carried out as follows:

1. Preparation of a preliminary photographic documentation.

2. Analysis of the state of preservation and deterioration causes of studied fragments (the influence of destructive factors on initial colors).

3. Outcrop stratigraphy of selected parts of the walls and ceilings of the Imperial Hall and utility rooms.

4. Analysis of collected material and stratigraphic test results.

5. Definition of initial color study in relation to present color templates.

A series of 85 measurements was taken by inserting stratigraphic probes and sensors into selected areas. The technical construction and general state of preservation of the building's fragments anticipated for repairs were determined. The exposed parts were photographed and systematized by types of architectural elements:

The quality of the individual chronological layers and their colors were determined. On the basis of earlier studies of the Centennial Hall, colors have been determined by comparison with the NCS template.

It should be noted, that exposed portions of wall and ceiling surfaces prompted the uncovering of the initial layers, which enabled a fuller assessment of color and reconstruction of the original conservation methods (stippling, conservative reconstruction).

3.3. Technique and Technology

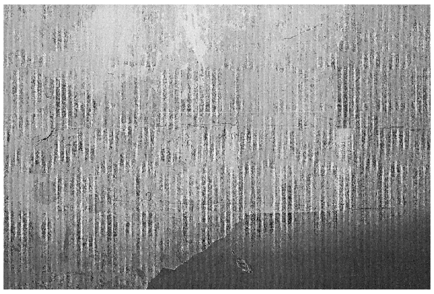
3.3.1. Stratigraphy

Tab. 1. Imperial Hall walls and pillars (*collective statement*):

Technical layer	Color	Chronological layer	Characteristics of layers
0.	white	VIII – 2011	colored layer
1.	light beige	VII	colored layer
2.	dark yellow	VI	colored layer
3.	white	V	undercoat layer
4.	yellow lemon	IV	colored layer
5.	deep vivid red	III	colored layer
6.	white	III	undercoat layer
7.	black	I-II	colored layer
8.	pink-purple (dark and light)	I-II	colored layer
9.	transparent brown	I-II	insulation layer
10.	white	I-II	gypsum mortar
11.	white	I	whitewash
12.	gray	I	cement-lime mortar
13.	gray	I	cement-lime mortar
14.	dark gray	I	structural elements with reinforcement

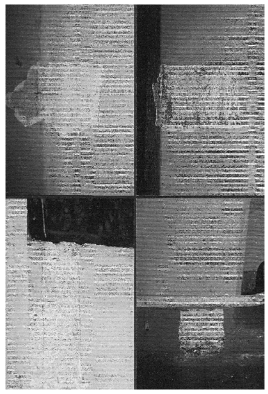
Tab. 2. Imperial Hall ceiling coves and ceilings (*collective statement*):

Technical layer	Color	Chronological layer	Characteristics of layers
0.	white	VIII – 2011	colored layer
1.	light beige	VII	colored layer
2.	yellow lemon	IV	colored layer
3.	white	III	undercoat layer
4.	black	I-II	colored layer
5.	transparent brown	I-II	insulation layer
6.	white	I-II	gypsum mortar, profile and decorative molds
7.	white	I	whitewash
8.	gray	I	cement-lime mortar
9.	gray	I	cement-lime mortar
10.	dark gray	I	structural elements with reinforcement

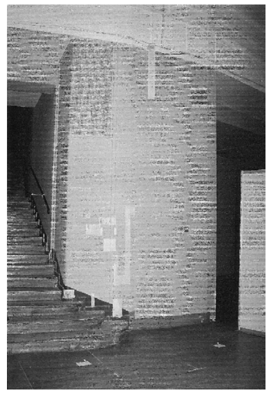


Il. 2.1.

Il. 2.2.



Il. 2.3.



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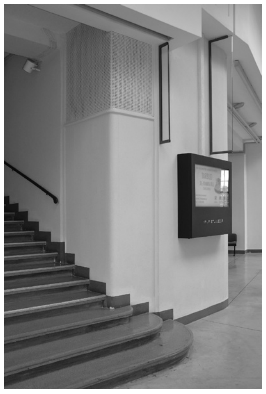

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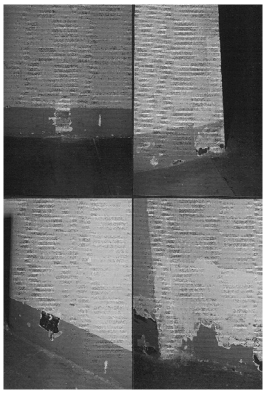

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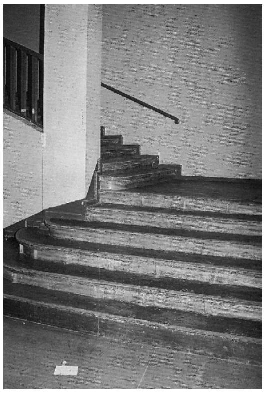

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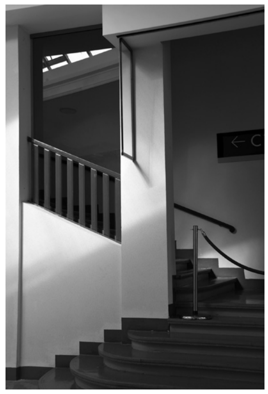

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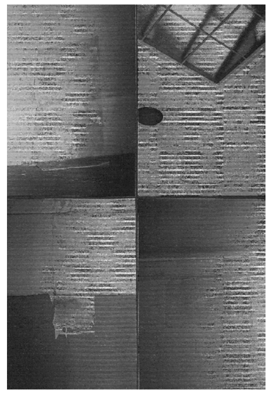

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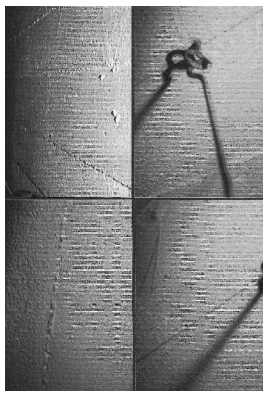

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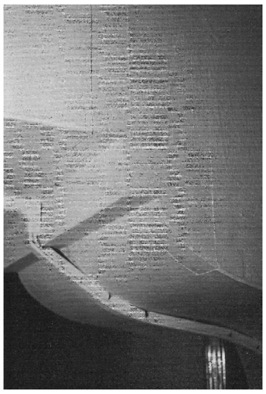

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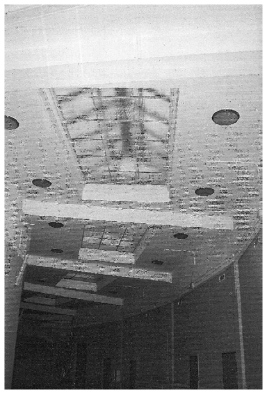

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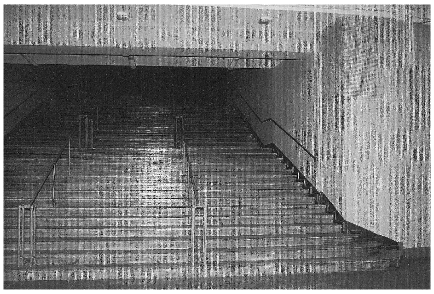

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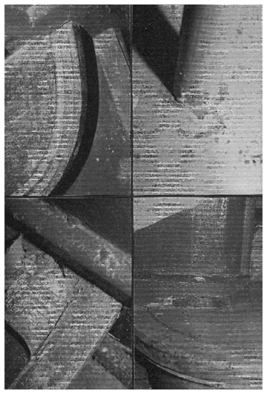

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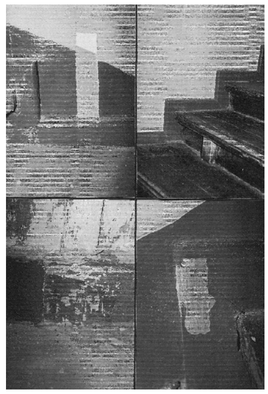

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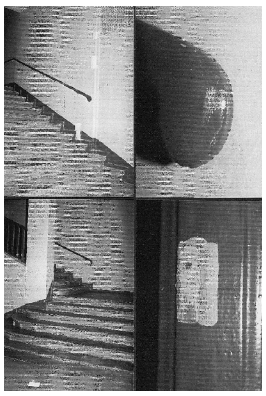

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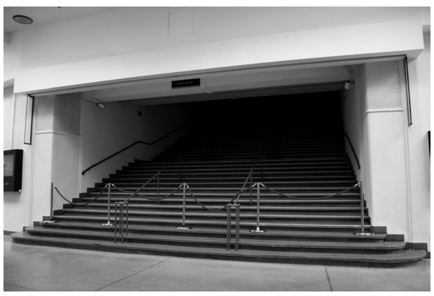

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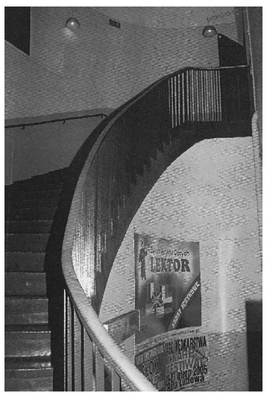

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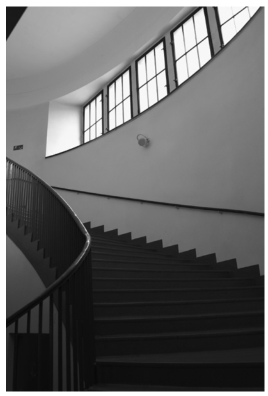


Il. 2.25.

Tab. 3. Door woodworks (*collective statement*):

Technical layer	Color	Chronological layer	Characteristics of layers
0.	brown	V – 2011	colored layer
1.	dark red or brown red	IV	colored layer
2.	light gray		colored layer
3.	green		colored layer
4.	ocher	III	colored layer
5.	white	II	undercoat layer
6.	dark red-brown	I	semi-transparent colored layer
7.	light shade of ocher	I	pine wood

3.4. Technical structure and list of materials

3.4.1. Imperial Hall walls and pillars

Reinforced concrete structure; cement-lime-sand overlays with a carefully developed (obliterated) surface and corners; a thin layer of lime whitewash; sanded plaster stuccos 1–10 mm; surface probably securely bond; two initial layers: pinkish-purple and black oil-based paint applied on a smooth, even layer; up to 6 repainted layers on the entire surface (these layers form a certain texture thicker and different from the initial).

Two layers, the first approximately 2 mm thick, the second 8–10 mm have been applied on the cement-lime-sand mortar concrete base; fine-grain and carefully selected sand has been used as filler.

Dimensions:

Wall circumference approximately 62 m; area approximately 425 m^2

3.4.2. Imperial Hall ceiling coves and ceiling

Reinforced concrete construction; cement-lime-sand overlays with a carefully developed (obliterated) surface and corners plotted on a Rabitz grid; a thin layer of lime whitewash; stuccos and gypsum profiles (including the main ornamental motif – Ionic cymatium) 1–10 mm thick, polished, surface probably securely bond; two initial layers: pinkish-purple and black oil-based paint applied on a smooth, even layer; up to 4 paint layers on the entire surface (these layers form a certain texture thicker and different from the initial). Cement-lime-sand mortar layers applied, the first thicker one approximately 15 mm (varied filler – brown-ocher sand with gravel grains), the second thinner approximately 3–8 mm (filler carefully selected, lighter shade of fine grain sand).

Dimensions:

Walls circumference approx. 62 m; area:

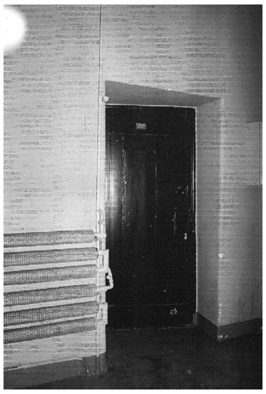
– dome base and ceiling: approx. 295 m^2

– oval-shaped motif (approx. 500 elements): approx. 18 m^2

The total area of walls and ceiling: approx. 738 m^2

3.4.3. Imperial Hall skylight

The supporting structure of skylights is made of Double-T and flat bars fitted into the ceiling; internal steel profiles protect against corrosion. Interior borders are painted with black oil paint.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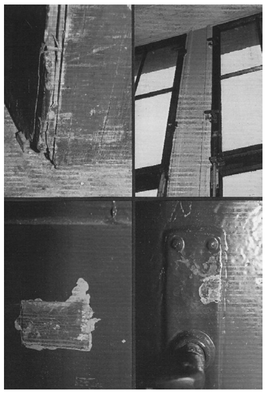
Il. 2.27.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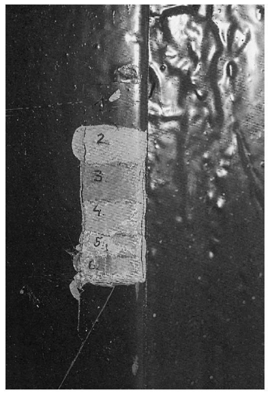
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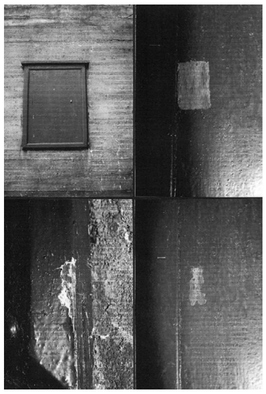
Il. 2.30.

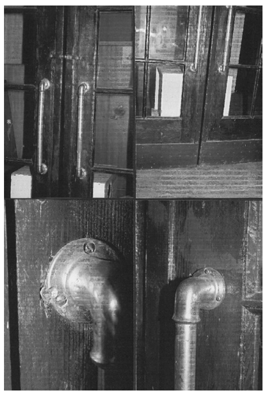

Il. 2.31.


Il. 2.32.

Il. 2.33.

Il. 2.34.


Il. 2.35.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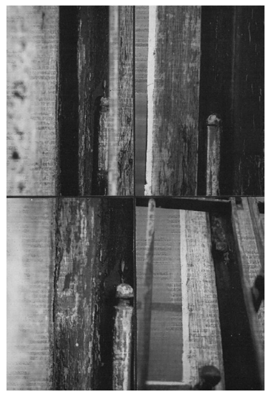
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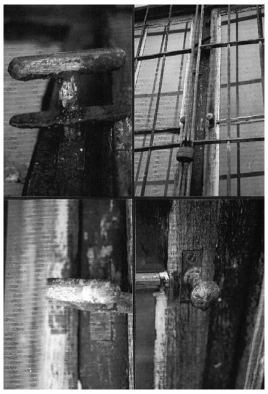

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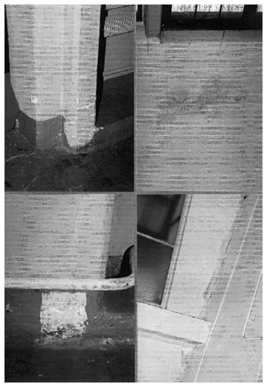
Il. 2.40.



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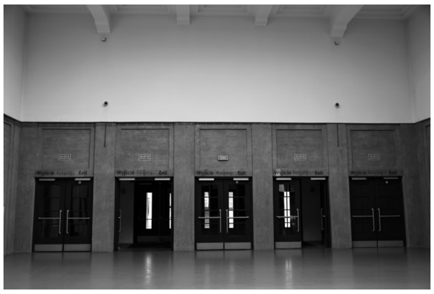
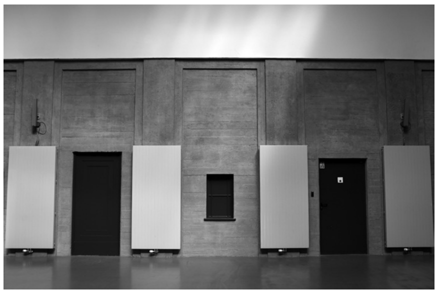
Il. 2.42.



Il. 2.43.



Il. 2.44.

Il. 2.45.

It appears that the original skylight glazing was made of clear reinforced glass (dense mesh reinforcement approx. 5 mm), with a slightly uneven surface (the glass is retained in some of the triangular side walls of the Centennial Hall). Currently, the glazing is made of matt polycarbonate sheets.

3.4.4. Imperial Hall utility rooms

Reinforced concrete and brick construction; cement-lime-sand overlays with a carefully developed (obliterated) surface and corners; a thin layer of lime whitewash; the first two layers are light-ocher and light blue-green, light milky blue-green glass tiles partly on the northern walls of the main room; up to 4–5 secondary paint layers on the entire surface: ceiling coves and cornices in the room on the south side covered with gypsum mortar 5–10 mm thick and sanded, surface probably securely bond; two initial layers: pinkish-purple and black oil-based paint applied on a smooth, even layer; up to 4 paint layers on the entire surface (these layers form a certain texture thicker and different from the initial).

Cement-lime-sand mortar layers applied, the first thicker one approx. 15 mm (varied filler – brown-ocher sand with gravel grains), the second thinner approx. 3–8 mm (filler carefully selected, lighter shade of fine grain sand).

3.4.5. Door woodworks

The original wooden door of the northern wing of the Imperial Hall is in good condition (sash covered with a slab of plywood), and also the doorframes of 3 entrances from inside the Centennial Hall (East side), straight-profiled form elements (as those in the foyer), painted dark red and hung on hinges painted black like the door handles. Other wooden doors are modern and should be replaced with new ones, that match the type and color of the original.

3.4.6. Storage room and foyer

Reinforced concrete structure; partly with cement-lime-sand overlays with a carefully developed (obliterated) surface and corners; a thin layer of lime whitewash; sanded plaster stuccos 1–10 mm; surface probably securely bonded; initial layer: light-ocher wall, white and white-yellow ceilings (colors correspond to the color of the foyer); 4–6 paint layers on the entire surface (these layers form a certain texture thicker and different from the initial).

3.4.7. Stairs with railings

The stairs are of reinforced concrete, with wooden treads and rounded edges. The riser cladding is approx. 3 mm thick with a clear-coat of paint. The tread surface is covered with a lining of green linoleum (approx. 3 mm thick) on jute base bonded to the substrate; the protruding edge of the tread – profiled to look like a "nose" has an approx. 7-10 mm thicker strip of gray linoleum attached.

Both railings in the main hall are made of copper, brass-plated oval handrails, partly replaced by modern handrails made of tubular steel (partially preserved) railing tabs, partly supplemented with new ones different from the original.

Staircase baseboards are made of oak, fitted individually to the shape of the stairs and painted with a dark blue-gray color as the first layer.

3.5. The color description of Imperial Hall's interior and utility rooms

- **Imperial Hall walls and pillars**

The stratigraphic cross-section of layers is shown in Table 1. The tambour walls and pillars, together with a simple cornice between these elements, consist of two initial colored paint layers: pink-purple (varying saturation) and black laid in a smooth, even coat – oil paint. It was discovered, that a layer of pink-purple paint is on the entire surface while the black layer was painted to varying heights. A black framing motif on the pink-purple surface appears on the pillars near the balcony door.

The layout of secondary layers – there are up to 6 layers of paint on the whole surface as shown in illustrations 3.5–3.22.

– light pink – tambour walls:	**NCS**	**S 1030 – R10B**
– dark pink – pillars:	**NCS**	**S 4030 – R20B**
– black:	**NCS**	**S 8000 – N**

- **Imperial Hall ceiling coves and ceiling**

The stratigraphic cross-section of layers is shown in Table 2. Part of the Centennial Hall starting from the decorative strip of oval-shaped and pearl motifs and ending in the skylight joint has one original color layer – smooth and even coat of black oil paint. The whole strip of oval-shaped and pearl motifs is also black in color.

The layout of secondary layers – there are up to 4 layers of paint on the whole surface. The original is shown in illustrations 3.23.– 3.28.

– black:	**NCS S 8000 – N**

- **Imperial Hall skylight**

The first layer of internal skylight borders is black, similar to that of the tambour walls and ceiling. The metal structure has a protective anti-corrosive coating on the inside and outside. The following is a layer of black that has been repainted several times and now has a light off-white color – that matches the ceiling coves and walls.

– black:	**NCS S 8000 – N**

- **Imperial Hall utility rooms**

The first two layers are light white-ocher and light blue-green, light milky blue-green glass tiles partly on the northern walls of the main room; up to 4–5 secondary paint layers on the entire surface; ceiling coves and cornices are covered with gypsum mortar on the south side of the Centennial Hall. Two initial layers: pinkish-purple and black oil-based paint applied on a smooth, even layer; there are up to 4 paint layers on the entire surface.

Northern wing

– light blue-green – walls:	**NCS S 1010-B50G**
– light white-ocher – walls and ceilings:	**NCS S 0502 – Y**

Southern wing

– light pink – walls:	**NCS S 1030 – R10B**
– black:	**NCS S 8000 – N**

- **Door woodworks**

The stratigraphic cross-section of layers is shown in Table 3. The initially carefully developed wood surface has been painted dark red with semi-translucent paint. The structure of secondary layers is similar to that described for wood stair railings. A large number of doors were subjected to paint layer removal by using coarse sandpaper on a random orbit sander. The wood was then painted with a brown tone of a semi-transparent coating.

– dark red-brown – doors and jambs	**NCS S 6030 – Y90R**
–black – handles, hinges	**NCS S 8502 – Y**

- **Current storage rooms and foyer**

The initial paint layer: light – walls, white-ocher – ceilings (combination of colors corresponds to the color of the foyer); 4–6 paint layers on the entire surface.

– light –ocher – walls:	**NCS S 0520 – Y10R**
– light white-ocher – ceilings:	**NCS S 0502 – Y**

- **Stairs with railings**

Wooden stair treads are lined with lively green hued linoleum (repainted twice with oil paints), in the protruding parts, gray cladding slats of increased thickness are fitted into triple phased (cross milling) treads. Veneered risers are of thick pine in a natural shade of wood, with a clear coat finish. The first preserved layer of metal railings and baseboards is dark blue-gray in color. The secondary layers of white, gray, green change the original color layout. The metal stair railing in the foyer also has a first coat of dark blue-gray. Copper plated handrails, which were formerly brass-plated, are now mechanically damaged, heavily worn out and require cleaning, minor repairs, and surface protection.

– *green linoleum:* **NCS S 5020 – G10Y**
– *gray linoleum:* **NCS S 3502 – Y**
– *blue metal railing and stair wall border:* **NCS S 5030 – B10G**

The above symbols are taken from matching the colors with the Sigma Color System C21.1 (NCS – Natural Color System).
A set of selected colors is only an approximation of the color tone of the original (which is highly varied in each layer of color). It should be noted, that the uncovered initial layers, in relatively small spots, have not been preserved in perfect condition. While these initial layers were located under the secondary layers for several years, physical and chemical factors caused local color changes. The original color looks a bit different in almost every collected sample. Before direct finishing touches, color tests should be performed and verified by a commission. The correct end result will be affected not only by the selection of the appropriate color, but also the appropriate use of painting techniques, and in no lesser degree the preparation of the surface for finishing.
In the initial study of Centennial Hall's painting, the applied coatings were relatively smooth and thin. Therefore, modern painting techniques should be adapted to those utilized decades ago.

3.6. State of preservation

An analysis of the state of conservation of the different parts of the object of study have been conducted in the course of the current diagnosis.
Many fragments of walls, ceilings and decorative elements of the Imperial Hall and utility rooms of the intensively utilized Centennial Hall are currently in poor condition.

The basic destructive factors include:
– initial material defects and local diverse material preparation techniques
– natural factors: sunlight, rainwater, frost
– natural aging process of initially used materials e.g. sedimentation of dust and dirt, dimensional changes, cracking
– changes in spatial arrangement (reorganization), changes in room function, replacement of original elements and the introduction of modern elements (adverse aesthetic and technical changes, e.g. casings, partition walls, radiators, new doors)
– physical and chemical damages: humidity caused by repeated painting, delamination, cracking, incrustation
– mechanical damages: wallops, abrasion, breaking off, repetitive load (on the stairs), loss of individual components (e.g. door handles), removal of paint layers during new exhibition preparations
– aesthetical changes: overlapping new paint coating without removing previous layers, inadequate surface treatment, adverse changes in color (non-compliance with the original) and the use of different recycled materials (e.g. skylight glazing)

Besides the intensive use of the building (as could be expected), serious damage occurred during World War II. In the years to follow, the entire surface of the walls, halls, pillars, foyer ceilings and the foyer including window and door woodworks were repainted over a dozen times (without removing the previous layers). Such a sealing of surfaces leads to prolonged humidity of the first layer, and a significant increase in the thickness of layers resulting in the loosening of the whole structure of paint layers from the base. Besides the obvious change in colors, these coatings, of considerable thickness also caused the deformation of the original forms.
One of the basic conservation indications for renovation work is the need to remove the layers of paint and the proper preparation of the structure and surface treatment prior to the final painting. Tight sealing coatings are not to be used.
In the course of the excavations, after the removal of the secondary layer, the uncovered original layer looked relatively well preserved.
Multiple repairs, an increase in the number of visible secondary elements (doors, walls, joinery, lamps, heaters, etc.), cause aesthetic chaos, impeding correct perception of the original values of the historic building. Loss of small pieces of woodwork, the unsuitable appearance of secondary surface layers and color stains complete the list of adverse occurrences in the historic interior.
A separate and serious concern is the condition of fragments of gypsum profiles, especially some parts of the ceiling – a problem that requires an individual study.

3.7. Conservation assumptions

The historic interior of the Imperial Hall and its utility rooms should be subjected to comprehensive conservation, which takes into account the correlation of all of its elements.
The primary objective of conservation and restoration works should be first to stop the advancing processes of destruction of the original structural elements of the Imperial Hall. So far, during the ongoing renovation work no attempts have been made to uncover the original coating layers. In light of the current knowledge and improved methods of conservation it seems possible to accomplish.
Subsequently, proper maintenance should be performed (a complete process), then a retouching of paint layers and an adaptation to the original. It is necessary to remove the negative effects of destructive migration of water through wall and ceiling leaks, as well as the elimination of discoloration, repairs of multi-level plaster, stucco and profile stratification. It seems necessary to be very careful in preparations and workmanship (both texture and color) of new mortar (in damaged spots).
The possibility of local renovation of initial surfaces should be considered; after consolidating initial paint layers, mortar should be supplemented to match the original texture, colors should be merged using the lava technique.

GENERAL RECOMMENDED PROGRAM OF CONSERVATION WORK

1. Photographic documentation, and description of the state; before, during and after conservation (full and complete post-completion documentation).
2. Disinfection of infected fragments of walls and ceilings.
3. Securing of mobile fragments.
4. Removal of secondary paint layers.
Wash with hot water and stream; after checking, optionally apply compresses with 10% neutral ammonium carbonate in a 3% methylcellulose solution, remove the paint layers with warm water. Use acetone locally on swelled secondary layers.

This procedure can be considered to be completely safe after the time of complete decomposition of ammonium carbonate (approx. 80 days)

5. Mechanical cleaning of remnants of secondary layers with a scalpel.

6. Mechanical removal of secondary improperly laid plaster and sand-lime mortar.

7. Repairs of multi-level plaster stratification.

Injections of an acrylic dispersion and partial addition of filler, optionally Malta (Brescia) or Ledan (filling sacs). The use of mechanical link reinforcement is assumed.

8. Supplementation of mortar damages and surface preparation so as to match the original texture.

To supplement the layers of mortar, apply a lime-cement-sand mortar and gypsum composition similar to the original. The material should be prepared of a multi-year, slaked lime and mining sand, which had previously been rinsed and sifted for suitable granulation. The mortar should be applied in layers, after initial binding, work with a felt hand float to match the original texture. After a carbonization of fillings, it is possible to apply an aggregate made of acrylic binder Primal AC-33, chalk and dry pigments. The aggregate will enable the matching of the texture of the fillings with the original and improve retouches.

9. Alternatively, the structural consolidation of the paint layer.

Apply with brush or spray 2–3% (concentration, method and means, will ultimately be determined after performing tests on the surface) Paraloid B-67 solution in white spirit or B-72 in xylene by brushing or spraying.

10. Painting, retouching the damages (lava technique)

The use of high-quality conservation paint combined with acrylic resins.

The final method of conservation will be developed after extensive restoration of the entire structure.

Il. 3.1. Centennial Hall with Imperial Hall, view from the west, April 2010

Il. 3.2. Centennial Hall with Imperial Hall, view from the south, April 2010

Il. 3.3. Interior of Imperial Hall, view from the west, April 2010

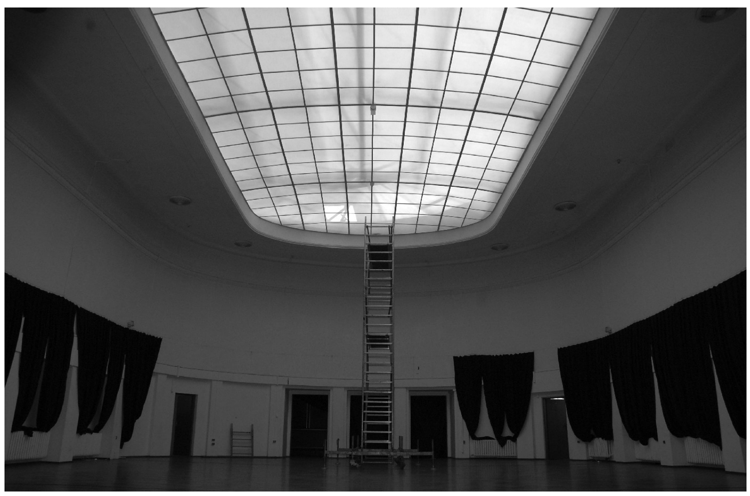
Il. 3.4.–3.14. Interior of Imperial Hall, walls and pillars – stratigraphy April 2010

Il. 3.15.–3.28. Interior of Imperial Hall, facet of Ionic cymatium and skylight – stratigraphy April 2010

Il. 3.29. Interior of Imperial Hall, lower part of the wall covered by curtains, 2015

Il. 3.1.

Il. 3.2.



Il. 3.3.

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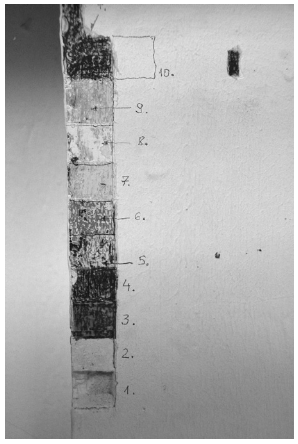

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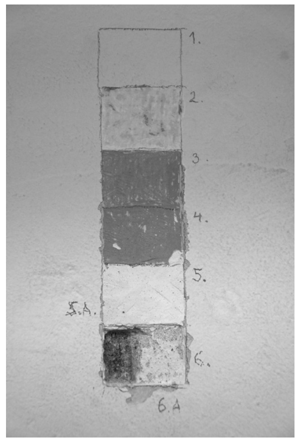

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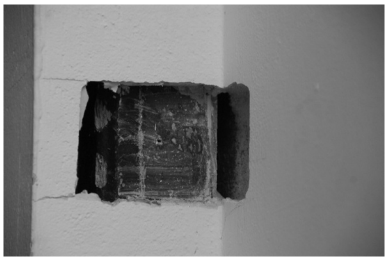

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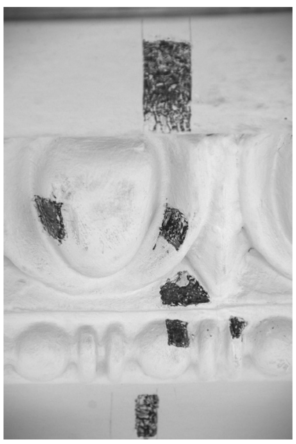
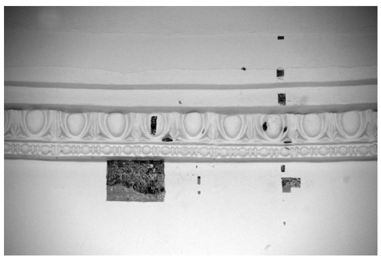


Il. 3.19.

Il. 3.20.



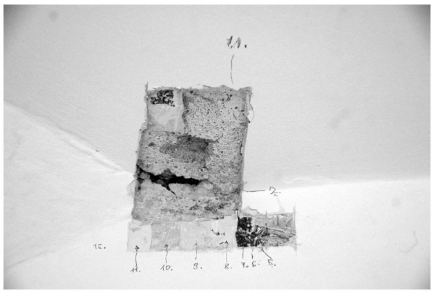
Il. 3.21.

Il. 3.22.

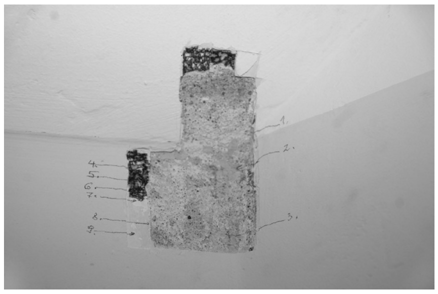
Il. 3.23.

Il. 3.24.

Il. 3.25.



Il. 3.26.



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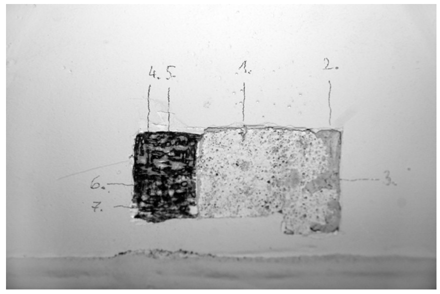


Il. 3.28.

Il. 3.29.

6.3.

Anna Ornatek

Environmental Studies of the Centennial Hall.

Analysis of greenery surrounding the Centennial Hall

Wrocław 2015

Study title:	**CONSERVATION MANAGEMENT PLAN (CMP)** **Environmental Studies of the Centennial Hall** **Analysis of greenery surrounding the Centennial Hall**
Property:	**CENTENNIAL HALL COMPLEX**
Address of property:	**1, Wystawowa Street, WROCŁAW**
Field:	Vegetation
Stadium:	Tree inventory and vegetation conservation guidelines
Mandator:	Museum of Architecture in Wroclaw (Muzeum Architektury we Wrocławiu, ul. Bernardyńska 5, 50-156 Wrocław)

LANSCAPE ARCHITECTURE		Signature:
author:	Anna Ornatek, landscape architect Permission PZOS no. 8/96	
cooperation:	Monika Ziemiańska, PhD landscape architect Grzegorz Grajewski, PhD	

DISCLAIMER: This study is in accordance with the contract and complete in terms of the objective which it is to serve

CENTENNIAL HALL IN WROCŁAWIU
CONSERVATION MANAGEMENT PLAN (CMP)

Environmental Studies of the Centennial Hall

Analysis of greenery surrounding the Centennial Hall

CONTENTS

I GENERAL INFORMATION

I. 1. Initial information

Property: area surrounding the Centennial Hall

Address: Wystawowa Street, Wrocław

Subject to legal protection and guardianship of monuments, register of monuments:

- Centennial Hall (Peoples Hall) – no. A/5291/198 dated 24.04.1962.
- Centennial Hall Complex (Peoples Hall) – no. A/5259/343/Wm dated15.04.1977.

Recognized as a Historic Monument

- Regulation by the President of the Republic of Poland of April 13, 2005, Journal of Laws of the Republic of Poland (Dz. U.) no. 64, par. 570.

The UNESCO World Cultural and Natural Heritage list

- Decision adopted on July 16, 2006.

Owner: State Treasury, Lower Silesia Voivodeship

Management: Wrocławskie Przedsiębiorstwo „Hala Ludowa” sp. z o.o. (WP The People’s Hall Ltd.)

2. Initial data

Basic map for consultative purposes in 1:1000 scale, by Geodesy, Cartography and Cadaster Office of Wrocław (Zakład Geodezji, Kartografii i Katastru Miejskiego we Wrocławiu), 2013.

Works and measurements carried out in the area in May, 2015.

Archival materials: Wrocław City Construction Archives (Archiwum Państwowe we Wrocławiu).

3. Aim and scope of the study

The aim of the study was to assess the state of preservation and development of conservation guidelines for the restoration of the historic layout and composition of greenery around the Centennial Hall (immediate surroundings of the building and the courtyard in front of the western facade).

The area covered by the study includes the following Streets: Wystawowa – Z. Olszewskiego – underground parking garage, M. Kopernika and the Pergola.

Area: 5 hectares of land (6 hectares with the Centennial Hall building).

II. DETAILED DESCRIPTION OF DENDROLOGICAL INVENTORY

1. Description of inventoried trees

A detailed dendrological inventory was done in May 2015.

More than 520 plants were inventoried - trees and shrubs of 29 botanical species, including some so-called acclimatized species of foreign origin.

This study is a detailed documentary of vegetation around the Centennial Hall - species, plant parameters, forms and states of preservation.

The dendrological inventory has enabled analysis, based on archival materials on the composition of plants, and determined the scope of work involving the care and maintenance of trees.

The aim of the study is to develop conservation guidelines for the restoration of the historic layout and composition of greenery around the Centennial Hall.

Documentation contents:

1. Alphabetical list of botanical Latin names and English inventoried plant species, which states: Latin name of the species by adopted botanical nomenclature; the short form of the author's name, English common name, the number of specimen of a given species occurring within the studied area. The list of acclimated species is distinguished in italics.
2. List of inventoried plants containing:

- plant inventory number, same as the number on the graphic board,
- English common names,
- approximate plant height in meters,
- approximate crown span in meters,
- circuit or trunk diameter in cm measured at a height of 130 cm, so called DBH (diameter at breast height) or area in m²,
- comments on the sanitary condition etc.,
- maintenance guidelines for existing trees, i.e. tree care,

3. Graphic design in 1: 500 scale,

- inventoried plants, tree crown view or range of groups of shrubs are marked by numbers consistent with the numbers on the list of inventoried plants, on the basic map for consultative purposes in 1:1000 scale, by Geodesy, Cartography and Cadaster Office of Wrocław (Zakład Geodezji, Kartografii i Katastru Miejskiego we Wrocławiu), 2013,
- coniferous and deciduous plants are graphically differentiated on the drawing, newly planted Linden rows are highlighted, deficiencies in Linden rows are also indicated,
- individual rows are marked in Roman numerals from I to XXVI.

2. Alphabetical list of inventoried botanical names of plants.

Key - Spiraea- acclimatized plants

	Latin botanical name	Common English name	quantity/area in m²
	Ailanthus altiisima Swingle	Tree of Heaven	1
	Acer platanoides L.	Maple	1
	Acer platanoides “Globosum “	Globe Norway Maple	1
	Buxus sempervirens L.	Boxwood	area ~150m²
	Caragana arborescens “Pendula”	Weeping Peashrub	6
	Carpinus betulus L.	Hornbeam	4 130m²
	Cornus alba L.	White Dogwood	100m²
	Euonymus fortunei ‘Emerald Gaiety’	Euonymus fortunei ‘Emerald Gaiety’	20m²
	Euonymus fortunei 'Emerald'n Gold'	Euonymus fortunei 'Emerald'n Gold'	5m²
	Fraxinus excelsior L.	Ash	23
	Fraxinus excelsior L. pendula	Weeping Ash	4
	Juglans nigra L.	Black Walnut	18
	Juniperus chinensis L.	Chinese Juniper	1
	Juniperus chinensis Pfitzeriana	Pfitzer Chinese Juniper	9
	Juniperus horizontalis Moench.	Creeping Juniper	8
	Lonicera tatarica L.	Tartarian honeysuckle	4
	Parthenocissus quinquifolia Planch.	Virginia creeper	35 places
	Parthenocissus tricuspidata Planch.	Japanese creeper	2 places
	Picea abies Karst.	Norway Spruce	1
	Picea pungens Eng.	Blue Spruce	1
	Quercus rubra L.	Red oak	1
	Robinia pseudoaccacia L.	Black locust	6
	Sorbaria sorbifolia A.Br.	False spirea	3
	Spiraea arguta Zab.	Spiraea arguta	1
	Taxus baccata L.	European Yew	3
	Tamarix pentandra Pall.	Saltcedar	1
	Tilia cordata Mill.	Littleleaf Linden	75
	Tilia euchlora k. Koch	Crimean Linden	335
	Tilia tomentosa Moench.	Silver Linden	2

3. List of inventoried plants

KEY

robinia – acclimatized species

●- hazardous plants - sanitary felling,

▲ – plants for conservation

* - new plantings

Number according to the number on the figure	English common name	Height in meters	Crown span in meters	circum-ference or Ø diameter in cm /area in m^2	comments on sanitary condition, etc.	maintenance guidelines for existing trees, i.e. tree care
	Boxwood	0.4	0.6	area ~150 m^2	Trimmed hedge	
	Virginia creeper	12			On nine columns	
	Japanese creeper	12			On two columns	
	Virginia creeper + Japanese creeper	12			On one column	Remove creeper from electrical cable
	Maple	20	10	188	~1.7m, 2-creepers, mistletoe and dry branches on the crown, part of the roots on the ground	Self-sown, grew as a result of negligence, maintenance
ROW I						
Asymmetric crown from the outside, crowns raised to a height of 4 to 5m, plant spacing ~ 3x3m, distance between rows ~ 6m						
	Crimean Linden	7.0	2.5	84		
	Crimean Linden	7.0	3	92		
	Crimean Linden	7.0	3	94		
	Crimean Linden	7.0	2.5	79		
	Crimean Linden	7.0	2.5	87		
	Crimean Linden	7.0	3	86		
	Crimean Linden	7.0	3	89		
	Crimean Linden	7.0	2.5	87		
	Crimean Linden	7.0	4	110		
1. *	Littleleaf Linden	6.0	3	28	New plantings, unshaped tree crowns	Replace with Crimean Linden seedlings, formed in the nursery with >35 cm circumference trunks
1. *	Littleleaf Linden	6.0	3	28		
1. *	Littleleaf Linden	6.0	2.5	26		
	Crimean Linden	7.0	5	107		
	Crimean Linden	7.0	5	107		
1. *	Littleleaf Linden	4.0	2	17	New planting, unshaped tree crown	Replace with Crimean Linden seedlings, formed in the nursery with >35 cm circumference trunks
	Crimean Linden	7.0	2.5	81	10^0 deflection of trunk	
	Crimean Linden	6.0	2	49		
	Crimean Linden	7.0	3	96	Fissure on trunk up to h~1,7m, callus	
	Crimean Linden	7.0	4	106		
	Crimean Linden	7.0	3	84		
	Crimean Linden	7.0	3	96		
	Crimean Linden	7.0	4.5	92		
ROW II						
crowns raised to a height of 3 to 5m plant spacing ~3x3m,						
	Crimean Linden	7.0	4	95		

Number according to the number on the figure	English common name	Height in meters	Crown span in meters	circum-ference or Ø diameter in cm /area in m^2	comments on sanitary condition, etc.	maintenance guidelines for existing trees, i.e. tree care
	Crimean Linden	7.0	4.5	93	Asymmetric tree crown	
	Crimean Linden	7.0	4	97	Asymmetric tree crown	
	Crimean Linden	7.0	4	79		
	Crimean Linden	7.0	5	106		
	Crimean Linden	7.0	5	102		
	Crimean Linden	7.0	4	86		
	Crimean Linden	7.0	4.5	94	Partly callus fissure on trunk from h~1.7m to the end of the bough	
	Crimean Linden	7.0	4	91		
	Crimean Linden	7.0	5	108	Fissure on trunk - h~1.5 to 4.5 m	
1. *	Littleleaf Linden	2.5	1.5	17	New planting, unshaped tree crown	Replace with Crimean Linden seedlings, formed in the nursery with >35 cm circumference trunks
	Crimean Linden	6	3.5	58	Asymmetric tree crown, shrouded by poplar growing at IASE parking lot	
1. *	Littleleaf Linden	3.5	1.5	17	New planting, unshaped tree crown	Replace with Crimean Linden seedlings, formed in the nursery with >35 cm circumference trunks
	Crimean Linden	7.0	5	88	Shrouded by Poplar growing at IASE parking lot	
	Crimean Linden	7.0	4.5	93		
ROW ALONG Z. WRÓBLEWSKIEGO STREET – GROWING IN PLACE OF THE FORMER HORNBEAM HEDGE						
	Ash	7	3	50	Grows 1m from the wall, loss of bark on the trunk	self-sown
	Hornbeam	8	4	93	Dry top, fine deadwood in the crown, resin	Leftovers of former Hornbeam hedge
	Ash	10	6	122	Deadwood in the crown	
	Spiraea arguta	1.7	2.5	area 4.7 m^2		
ROW III						
Asymmetric crown from the outside, crowns raised to a height of 4 to 5m, plant spacing ~ 3x3m, distance between rows ~ 6m						
	Crimean Linden	7.0	4.5	96		
	Crimean Linden	7.0	4	93		
	Crimean Linden	7.0	4	85		
	Crimean Linden	7.0	4	90		
1. ▲	*Crimean Linden*	7.0	4	94	From h 1.5m - fissure filled with brick rubble and cement mortar	After expertise - possibly remove the filling, clean the inside of the trunk
1. ▲	*Crimean Linden*	7.0	4	97	From h 1.7m to 5m - fissure filled with brick rubble and cement mortar	After expertise - possibly remove the filling, clean the inside of the trunk
1. ▲	*Crimean Linden*	7.0	4	100	From h 0.15m to 4m - fissure filled with brick rubble and cement mortar	After expertise - possibly remove the filling, clean the inside of the trunk
	Crimean Linden	7.0	5	128		

Number according to the number on the figure	English common name	Height in meters	Crown span in meters	circum-ference or Ø diameter in cm /area in m^2	comments on sanitary condition, etc.	maintenance guidelines for existing trees, i.e. tree care
1. *	Littleleaf Linden	7.0	2	18	New plantings, unshaped tree crown	Replace with Crimean Linden seedlings, formed in the nursery with >35 cm circumference trunks
	Crimean Linden	7.0	4.5	112		
1. *	*Crimean Linden*	7.0	4.5	107	From h 1.7m to 4m - fissure filled with brick rubble and cement mortar	After expertise - possibly remove the filling, clean the inside of the trunk
	Crimean Linden	7.0	4.5	107	From h 1.5m to 4m - fissure filled with brick rubble and cement mortar	After expertise - possibly remove the filling, clean the inside of the trunk
	Crimean Linden	7.0	4	61		
	Crimean Linden	7.0	5	96		
	Crimean Linden	7.0	4.5	95		
	Crimean Linden	7.0	5	97	Thickening at the trunk's base - traces of grafting	
	Crimean Linden	7.0	6	116	Callus fissure on trunk from h 2-4m	
1. *	*Crimean Linden*	7.0	5	115	Fissure on trunk to h~3.5 m, w 10cm, filled with brick rubble and cement mortar	After expertise - possibly remove the filling, clean the inside of the trunk
	Crimean Linden	7.0	4,5	102		
	Crimean Linden	7.0	4	111		
	Crimean Linden	7.0	4	81		
	Crimean Linden	7.0	4,5	110	Fissure on trunk to h ~3.5 m, w 10cm, filled with brick rubble and cement mortar	After expertise - possibly remove the filling, clean the inside of the trunk
1. *	Littleleaf Linden	4	1,2	17	New plantings, unshaped tree crown	Replace with Crimean Linden seedlings, formed in the nursery with >35 cm circumference trunks
	Crimean Linden	7	5	71		
	Creeping Juniper - *4 pcs*	0.4	1,5	Area ~$5m^2$	Grows on heating chamber h 40cm	
			ROW IV			
Asymmetric crown from the outside, crowns raised to a height of 4 to 5m, plant spacing ~ 3x3m, distance between rows ~ 6m						
	Tree of Heaven	22	16	112+327	2 -trunk from 1.2 m, fine deadwood in the crown, self-sown, about 40 years old	
	Crimean Linden	7.0	3	94		
	Crimean Linden	7.0	4	80		
	Crimean Linden	7.0	4	85		
	Crimean Linden	7.0	4.5	86		
	Crimean Linden	7.0	4	85		
	Crimean Linden	7.0	4	84		
	Crimean Linden	7.0	4	90		
	Crimean Linden	7.0	4	84		
	Crimean Linden	7.0	4.5	83		
	Crimean Linden	7.0	4.4	96		

Number according to the number on the figure	English common name	Height in meters	Crown span in meters	circum-ference or Ø diameter in cm /area in m^2	comments on sanitary condition, etc.	maintenance guidelines for existing trees, i.e. tree care
82 A	*Crimean Linden*	7.0	5	83		
	Crimean Linden	7.0	5	115		
	Crimean Linden	7.0	5	115	Callus cavity on trunk to h 0.1 -0.5m, w 10cm	
	Crimean Linden	7.0	4	84		
	Crimean Linden	7.0	4	86		
	Crimean Linden	7.0	4	87		
	Crimean Linden	7.0	4	90		
	Crimean Linden	7.0	4	84	Callus cavity on trunk h~1m, area 15x8cm	
	Crimean Linden	7.0	4	94		
	Crimean Linden	7.0	4	85		
	Crimean Linden	7.0	4	93		
	Crimean Linden	7.0	4	93		
	Crimean Linden	7.0	4	87		
	Crimean Linden	7.0	4	102		
	Crimean Linden	7.0	4	63	Leaning trunk	
ROW V						
Diameter at breast height is approximate, trunks covered with boards due to the renovation of the Four Dome Pavilion, Asymmetric crown from the outside, crowns raised to a height of 4 to 5m, plant spacing ~ 3x3m, distance between rows ~ 6m						
97-108	*Crimean Linden*	7.0	4-4.5	Ø28-32		
109-121	*Crimean Linden*	7.0	4	Ø28-32		
ROW VI						
Diameter at breast height is approximate, trunks covered with boards due to the renovation of the Four Dome Pavilion, Asymmetric crown from the outside, crowns raised to a height of 4 to 5m, plant spacing ~ 3x3m, distance between rows ~ 6m						
122*	Littleleaf Linden	3.5	1.5	17	New plantings, unshaped	Replace with Crimean Linden seedlings, formed in the nursery with >35 cm circumference trunks
123-137	*Crimean Linden*	7	4	Ø28-35		
ROW VII						
Asymmetric crown from the outside, crowns raised to a height of 4 to 5m, plant spacing ~ 3x3m, distance between rows ~ 6m						
	Crimean Linden	7.0	4	92		
	Crimean Linden	7.0	4	96		
	Crimean Linden	7.0	3	63		
	Crimean Linden	7.0	4	91		
	Crimean Linden	7.0	4	79		
	Crimean Linden	7.0	3	83		
	Crimean Linden	7.0	3	87		
	Crimean Linden	7.0	3	72		
	Crimean Linden	7.0	3	77		
	Crimean Linden	7.0	3	69		
	Crimean Linden	7.0	3	75		

Number according to the number on the figure	English common name	Height in meters	Crown span in meters	circum-ference or Ø diameter in cm /area in m²	comments on sanitary condition, etc.	maintenance guidelines for existing trees, i.e. tree care
	Crimean Linden	7.0	3	96		
	Crimean Linden	7.0	3	88		
138 O	Felled Littleleaf Lin-den, sample taken for study of tree age			Ø28+ Ø 24		Grub up the tree, supplement hedge with Crimean Linden seedlings, formed in the nursery with >35 cm circumference trunks
	Crimean Linden	7.0	3	84		
	Crimean Linden	7.0	3	77		
	Crimean Linden	7.0	3	76		
	Crimean Linden	7.0	3	97		
	Crimean Linden	7.0	3	91		
ROW VIII						
Asymmetric crown from the outside, crowns raised to a height of 4 to 5m, plant spacing ~ 3x3m, distance between rows ~ 6m						
	Crimean Linden	7.0	3	117		
	Crimean Linden	7.0	4.5	113	Thickening on the trunk	
	Crimean Linden	7.0	4	74		
	Crimean Linden	7.0	5	90		
	Crimean Linden	7.0	4.5	76		
	Crimean Linden	7.0	3	68		
138 ▲	*Crimean Linden*	7.0	3	75	Cavity filled with concrete	After expertise - possibly clean the cavity and remove concrete
	Crimean Linden	7.0	3	54		
	Crimean Linden	7.0	4	91		
	Crimean Linden	7.0	4	86		
	Crimean Linden	7.0	4	88		
	Crimean Linden	7.0	4	68		
	Crimean Linden	7.0	3.5	79		
	Crimean Linden	7.0	3	86		
	Crimean Linden	7.0	3.5	89		
	Crimean Linden	7.0	3	92		
	Crimean Linden	7.0	3	91		
ROW IX						
Asymmetric crown from the outside, crowns raised to a height of 4 to 5m, plant spacing ~ 3x3m, distance between rows ~ 6m						
	Crimean Linden	7.0	4	92		
	Crimean Linden	7.0	4	96	Callus cavity on bark to h ~1.5m, w 11cm	
	Crimean Linden	7.0	4	92		
	Crimean Linden	7.0	4	73		
	Crimean Linden	7.0	4	79		
	Crimean Linden	7.0	4	85		
	Crimean Linden	7.0	4	93		
	Crimean Linden	7.0	3	77		
	Crimean Linden	7.0	3	65		

Number according to the number on the figure	English common name	Height in meters	Crown span in meters	circum-ference or Ø diameter in cm /area in m^2	comments on sanitary condition, etc.	maintenance guidelines for existing trees, i.e. tree care
	Crimean Linden	7.0	4	97		
	Crimean Linden	7.0	3.5	80		
	Crimean Linden	7.0	4	87		
	Crimean Linden	7.0	4	88		
	Crimean Linden	7.0	4	89		
	Crimean Linden	7.0	4	83		
	Crimean Linden	7.0	4	86		
	Crimean Linden	7.0	4	117		
ROW X						
Asymmetric crown from the outside, crowns raised to a height of 4 to 5m, plant spacing ~ 3x3m, distance between rows ~ 6m						
	Crimean Linden	7.0	4	72		
138 *	Littleleaf Linden	3.5	1.5	21	New plantings, unshaped	Grub the tree, supplement hedge with Crimean Linden seedlings, formed in the nursery with >35 cm circumference trunks
	Crimean Linden	7.0	2.5	71	Deep cavity on trunk h 0.8 -1.5m, w 10cm	
	Crimean Linden	7.0	3.5	77		
	Crimean Linden	7.0	3.5	76		
	Crimean Linden	7.0	3	78		
	Crimean Linden	7.0	3	73		
	Crimean Linden	7.0	3	68		
	Crimean Linden	7.0	3.5	78		
	Crimean Linden	7.0	3	69		
	Crimean Linden	7.0	3	86		
	Crimean Linden	7.0	3	62		
	Crimean Linden	7.0	3	79		
	Crimean Linden	7.0	3	82		
	Crimean Linden	7.0	4	76		
	Crimean Linden	7.0	4	79	Open fissure on trunk from h~4m	
	Crimean Linden	7.0	3	88		
	Crimean Linden	7.0	3	96		
ROW XI						
Asymmetric crown from the outside, crowns raised to a height of 4 to 5m, plant spacing ~ 3x3m, distance between rows ~ 6m						
	Crimean Linden	7.0	4.5	78		
138 *	Littleleaf Linden	10	2	36	New plantings, square shaped	Appropriate row supplementation
	Crimean Linden	7.0	3	101	Fissure from h 1 to 2m, cleaned, impregnated	
	Crimean Linden	7.0	3	83		
	Crimean Linden	7.0	3	70		
	Crimean Linden	7.0	4	84		

Number according to the number on the figure	English common name	Height in meters	Crown span in meters	circum-ference or Ø diameter in cm /area in m^2	comments on sanitary condition, etc.	maintenance guidelines for existing trees, i.e. tree care
	Crimean Linden	7.0	3.5	86		
	Crimean Linden	7.0	4	102	Fissure to 1m, cleaned, impregnated	
	Crimean Linden	7.0	3.5	72		
	Crimean Linden	7.0	3	78		
	Crimean Linden	7.0	3.5	87		
	Crimean Linden	7.0	3.5	82	Callus cavity on trunk from h 0.9 to 1.3m	
138 ▲	*Crimean Linden*	7.0	2,5	74	Cavity on trunk h 1m, w 20cm, filled with concrete	After expertise – possibly remove filling, clean trunk interior
	Crimean Linden	7.0	4	100		
	Crimean Linden	7.0	4	81		
	Crimean Linden	7.0	4	87		
138 *	Littleleaf Linden	3.0	1.5	17	New plantings, unshaped	Replace hedge with Crimean Linden seedlings, formed in the nursery with >35 cm circumference trunks
	Crimean Linden	7.0	3.5	119	Dry top and branches, withering	Perform an expertise and possibly cut and replace with Crimean Linden seedlings, formed in the nursery with >35 cm circumference trunks
ROW XII						
Asymmetric crown from the outside, crowns raised to a height of 4 to 5m, plant spacing ~ 3x3m, distance between rows ~ 6m						
138 *	Littleleaf Linden	4.0	1,5	29	New plantings, unshaped	Replace with Crimean Linden seedlings, formed in the nursery with >35 cm circumference trunks
138 *	Littleleaf Linden	4.0	2	28	New plantings, unshaped	Replace with Crimean Linden seedlings, formed in the nursery with >35 cm circumference trunks
	Crimean Linden	7.0	6	86		
	Crimean Linden	7.0	6	102		
	Crimean Linden	70	6	122		
	Crimean Linden	7.0	5	88		
138 *	Littleleaf Linden	3.5	2	17	New plantings, unshaped	Replace with Crimean Linden seedlings, formed in the nursery with >35 cm circumference trunks
	Crimean Linden	7.0	4.5	79		
	Crimean Linden	7.0	5	80		
	Crimean Linden	7.0	5	87		
	Crimean Linden	7.0	4	78		
	Crimean Linden	7.0	4	80		
	Crimean Linden	7.0	5	83		
	Crimean Linden	7.0	2.5	62	10^0 deflection of trunk	
	Crimean Linden	7.0	6	90		
	Crimean Linden	7.0	5	96		

Number according to the number on the figure	English common name	Height in meters	Crown span in meters	circum-ference or Ø diameter in cm /area in m²	comments on sanitary condition, etc.	maintenance guidelines for existing trees, i.e. tree care
	Crimean Linden	7.0	4.5	84		
	Crimean Linden	7.0	4	107		
ROW XIII						
Asymmetric crown from the outside, crowns raised to a height of 4 to 5m, plant spacing ~ 3x3m, distance between rows ~ 6m						
	Crimean Linden	7.0	5	121	Chafing of the bark	
	Crimean Linden	7.0	4.5	77		
	Crimean Linden	7.0	4.5	118		
	Crimean Linden	7.0	5	83		
	Crimean Linden	7.0	5	89		
	Crimean Linden	7.0	5	75		
	Crimean Linden	7.0	6	112		
	Crimean Linden	7.0	4	100		
	Crimean Linden	7.0	5	103		
	Crimean Linden	7.0	6	132		
138 *	Littleleaf Linden	3.5	1.2	15	New plantings, unshaped	Replace with Crimean Linden seedlings, formed in the nursery with >35 cm circumference trunks
	Crimean Linden	7.0	6	150		
	Crimean Linden	7.0	4	89		
	Crimean Linden	7.0	4	90		
	Crimean Linden	7.0	5	114		
ROW XIV						
Asymmetric crown from the outside, crowns raised to a height of 4 to 5m, plant spacing ~ 3x3m, distance between rows ~ 6m						
	Crimean Linden	7.0	4	96		
	Crimean Linden	7.0	4	103		
138 *	Littleleaf Linden	3.5	1.5	15	New plantings, unshaped	Replace with Crimean Linden seedlings, formed in the nursery with >35 cm circumference trunks
	Crimean Linden	7.0	5	93		
	Crimean Linden	7.0	6	104		
	Crimean Linden	7.0	5	85		
	Crimean Linden	7.0	4	83		
266A	*Crimean Linden*	7.0	4	77		
	Crimean Linden	7.0	5	110		
	Crimean Linden	7.0	6	130	Fissure to h 1.7m, w 30cm, cleaned, impregnated	
	Concrete flower bed with Creeping Juniper				In the place of the felled Linden	Replace with Crimean Linden seedlings, formed in the nursery with >35 cm circumference trunks
	Crimean Linden	8.0	8	120		
	Crimean Linden	8.0	6	129		
	Crimean Linden	7.5	5	130		

Number according to the number on the figure	English common name	Height in meters	Crown span in meters	circum-ference or Ø diameter in cm /area in m^2	comments on sanitary condition, etc.	maintenance guidelines for existing trees, i.e. tree care
ROW XV Plant spacing ~2.9x2.9 m,						
	Littleleaf Linden - 19 pcs	4-4.5	1-2	20-22	New plantings	Begin shaping trees into cubes until they attain parameters of the existing historic tree rows around the Centennial Hall
ROW XVI						
-irregular plant spacing, tree crowns unshaped						
	Crimean Linden	14	7	102		
	Crimean Linden	14	7	103		
	Crimean Linden	12	7	86		
	Crimean Linden	14	7	102		
	Crimean Linden	14	7	97		
	Littleleaf Linden	10	6	56	Leaning trunk, chafing on the bark	
ROW XVII Plant spacing ~2,8x2,8m						
	Littleleaf Linden - 14 pcs	4-4.5	1-1.5	20-22	New plantings	Begin shaping trees into cubes until they attain parameters of the existing historic tree rows around the Centennial Hall
ROW XVIII Plant spacing ~2.8x2.8m						
	Littleleaf Linden - 13 pcs	4-4.5	1-1.5	20-22	New plantings	Begin shaping trees into cubes until they attain parameters of the existing historic tree rows around the Centennial Hall
ROW XIX						
Asymmetric crown from the outside, crowns raised to a height of 4 m, plant spacing ~ 3x3m, distance between rows ~ 6m						
	Crimean Linden	7.0	4.5	120		
	Crimean Linden	7.0	4.5	93		
	Crimean Linden	7.0	5	93		
138 *	Littleleaf Linden	3.5	1.5	15	New plantings, unshaped	
	Crimean Linden	7.0	4.5	123		
	Crimean Linden	7.0	4.5	98		
138 ▲	*Crimean Linden*	7.0	5	75	At h1,6m, 10cm diameter hole with brick rubble and cement mortar filling	Perform an expertise – clean, remove filling
	Crimean Linden	7.0	5	112		
	Crimean Linden	8.0	5	142		
138 *	Littleleaf Linden	2.0	1.5	15	New plantings, unshaped, broken top	Replace with Crimean Linden seedlings, formed in the nursery with >35 cm circumference trunks

Number according to the number on the figure	English common name	Height in meters	Crown span in meters	circum-ference or Ø diameter in cm /area in m^2	comments on sanitary condition, etc.	maintenance guidelines for existing trees, i.e. tree care
138 *	Littleleaf Linden	3.5	1.3	15	New plantings, broken top, unshaped	Replace with Crimean Linden seedlings, formed in the nursery with >35 cm circumference trunks
	Crimean Linden	7.0	5	82		
	Crimean Linden	7.0	5	110	Chafing on the bark of trunk	
138 ▲	*Crimean Linden*	7.0	4	112	Cracked trunk at h~4m in branching point, at h~2m fissure on trunk 30x15 cm, with brick rubble and cement mortar filling	Perform an expertise – clean, remove filling
	Littleleaf Linden	7.0	4	59		
	Crimean Linden	7.0	6	130		
			ROW XX			
Asymmetric crown from the outside, crowns raised to a height of 4 m, plant spacing ~ 3x3m, distance between rows ~ 6m						
	Crimean Linden	7.0	4.5	138		
	Crimean Linden	7.0	4.5	99		
	Crimean Linden	7.0	5	100		
	Crimean Linden	7.0	4	76		
	Crimean Linden	7.0	5	102		
	Crimean Linden	7.0	4	74		
	Crimean Linden	7.0	5	125		
	Crimean Linden	7.0	5	107		
138 *	Littleleaf Linden	4	2.5	18	New plantings, unshaped	Replace with Crimean Linden seedlings, formed in the nursery with >35 cm circumference trunks
	Crimean Linden	7.0	5	100		
	Crimean Linden	7.0	5	100		
	Crimean Linden	7.0	5	102		
138 *	Littleleaf Linden	4	1.5	27	New plantings, truncated top, unshaped	Replace with Crimean Linden seedlings, formed in the nursery with >35 cm circumference trunks
138 *	Littleleaf Linden	3	1.3	15	New plantings, truncated top, unshaped	Replace with Crimean Linden seedlings, formed in the nursery with >35 cm circumference trunks
	Crimean Linden	7.0	4.5	144		
			AREA BETWEEN THE BUILDING AND PEDESTRIAN BRIDGE			
			Part of Linden row, unshaped			
	Crimean Linden	12.0	8	116		
	Crimean Linden	12.0	7	96		
	Cherry fruit tree	2.5	2	45		
	Cherry fruit tree	2.5	2	38		
	Cherry fruit tree	2.0	2	40		
138 ▲	Tartarian honey-suckle	3-4	2-4	-	Shaped row, plant spacing ~2m	Perform rejuvenation pruning

Number according to the number on the figure	English common name	Height in meters	Crown span in meters	circum-ference or Ø diameter in cm /area in m²	comments on sanitary condition, etc.	maintenance guidelines for existing trees, i.e. tree care
			ROW XXI			
Asymmetric crown from the outside, crowns raised to a height of 4 m, plant spacing ~ 3x3m, distance between rows ~ 6m						
	Crimean Linden	7.0	4	120		
	Crimean Linden	7.0	5	100		
	Crimean Linden	7.0	4.5	84		
	Crimean Linden	7.0	4	83		
	Crimean Linden	7.0	5	109		
	Crimean Linden	7.0	4	133		
	Crimean Linden	7.0	4.5	100		
	Crimean Linden	7.0	3.5	69		
	Crimean Linden	7.0	5	120		
	Crimean Linden	7.0	5	106		
	Crimean Linden	7.0	4	75		
	Red oak	8.0	3	87		
	Crimean Linden	7.0	4.5	88		
	Crimean Linden	7.0	5	96		
	Crimean Linden	7.0	4	87		
	Crimean Linden	7.0	5	128	Leaning trunk	
	Crimean Linden	7.0	4.5	80		
			ROW XXII			
Asymmetric crown from the outside, crowns raised to a height of 4 m, plant spacing ~ 3x3m, distance between rows ~ 6m						
	Crimean Linden	7.0	5	135		
	Crimean Linden	7.0	4.5	103		
138 A	*Crimean Linden*	7.0	4	88		
338	*Silver Linden*	7.0	3	53		
	Silver Linden	7.0	3.5	93		
	Crimean Linden	7.0	4	94	Fissure on trunk from h 0.14 to 1.2m	
138 ▲	*Crimean Linden*	7.0	4	89	Fissure on trunk approx. 1m,filled with brick rubble and cement mortar	Perform an expertise – afterwards possibly clean cavity, remove filling
138 ▲	*Crimean Linden*	7.0	4	90	Fissure on trunk approx. 1.2m, filled with brick rubble and cement mortar	Perform an expertise – afterwards possibly clean cavity, remove filling
	Crimean Linden	7.0	4	108		
	Crimean Linden	7.0	3	65	10^0 deflection of trunk	
	Crimean Linden	7.0	4	113		
	Crimean Linden	7.0	4	111		
	Crimean Linden	7.0	4	80		
	Littleleaf Linden	7.0	3	55		
	Littleleaf Linden	7.0	3	64		
	Crimean Linden	7.0	3.5	93		
			ROW XXIII			
Asymmetric crown from the outside, crowns raised to a height of 4 m, plant spacing ~ 3x3m, distance between rows ~ 6m						

Number according to the number on the figure	English common name	Height in meters	Crown span in meters	circum-ference or Ø diameter in cm /area in m^2	comments on sanitary condition, etc.	maintenance guidelines for existing trees, i.e. tree care
	Crimean Linden	7.0	3.5	99		
	Crimean Linden	7.0	4	101		
	Crimean Linden	7.0	4	89	Bark damage	
	Crimean Linden	7.0	4	94		
	Crimean Linden	7.0	4	90		
	Crimean Linden	7.0	4	75		
	Crimean Linden	7.0	4	78		
	Crimean Linden	7.0	4	75		
	Crimean Linden	7.0	4	80		
	Crimean Linden	7.0	4	86		
	Crimean Linden	7.0	4	87		
	Crimean Linden	7.0	4	76		
	Crimean Linden	7.0	4	82		
	Crimean Linden	7.0	3.5	81		
	Crimean Linden	7.0	3	61		
	Crimean Linden	7.0	4	102		
	Crimean Linden	7.0	4	89		
ROW XXIV						
Asymmetric crown from the outside, crowns raised to a height of 4 m, plant spacing ~ 3x3m, distance between rows ~ 6m						
	Crimean Linden	7.0	4	102		
	Crimean Linden	7.0	4	86		
	Crimean Linden	7.0	3.5	96		
	Crimean Linden	7.0	3.5	80		
	Crimean Linden	7.0	3	75	Bark damage	
	Crimean Linden	7.0	4	92		
	Crimean Linden	7.0	3.5	84		
	Littleleaf Linden	6.0	2	55		
	Crimean Linden	7.0	3.5	88		
	Crimean Linden	7.0	3.5	89		
	Crimean Linden	7.0	3.5	81		
	Crimean Linden	7.0	3.5	94		
	Crimean Linden	7.0	4	100		
	Littleleaf Linden	7.0	4.5	50		
	Crimean Linden	7.0	4	91		
	Crimean Linden	7.0	4	98		
	Crimean Linden	7.0	4.5	100		
ROW XXV						
Asymmetric crown from the outside, crowns raised to a height of 4 m, plant spacing ~ 3x3m, distance between rows ~ 6m						
	Littleleaf Linden	7.0	4	80		
	Crimean Linden	7.0	4	90		
	Crimean Linden	7.0	4	95		
	Crimean Linden	7.0	3.5	66		

Number according to the number on the figure	English common name	Height in meters	Crown span in meters	circum-ference or Ø diameter in cm /area in m^2	comments on sanitary condition, etc.	maintenance guidelines for existing trees, i.e. tree care
	Crimean Linden	7.0	4.5	95		
	Crimean Linden	7.0	4	86		
138 ▲	*Crimean Linden*	7.0	4	94	30x5 cm hole at h 1.2m and at trunk base 10x5cm fissure filled with concrete	Perform an expertise – afterwards possibly clean cavity, remove filling
138 ▲	*Crimean Linden*	7.0	4	100	12x5 cm hole at h 1.2m and at trunk base 12x5cm fissure filled with concrete	Perform an expertise – afterwards possibly clean cavity, remove filling
	Littleleaf Linden	7.0	3	42		
	Crimean Linden	7.0	3.5	94		
	Crimean Linden	7.0	4	85		
	Crimean Linden	7.0	4	89		
	Crimean Linden	7.0	3.5	89		
	Crimean Linden	7.0	2.5	65		
	Crimean Linden	7.0	4	92		
	Crimean Linden	7.0	3.5	86		
	Crimean Linden	7.0	4	108		
ROW XXVI						
Asymmetric crown from the outside, crowns raised to a height of 4 m, plant spacing ~ 3x3m, distance between rows ~ 6m						
	Crimean Linden	7.0	4	113		
	Crimean Linden	7.0	4.5	98		
	Crimean Linden	7.0	3	84		
	Crimean Linden	7.0	4	90		
	Crimean Linden	7.0	4	87		
	Crimean Linden	7.0	4	87		
	Crimean Linden	7.0	3.5	56		
	Crimean Linden	7.0	4.5	94		
	Crimean Linden	7.0	4	55		
	Crimean Linden	7.0	4	97		
138 ▲	*Crimean Linden*	7.0	4	80	Cavity filled with concrete from h 0.8 to 1.5m	Perform an expertise – afterwards possibly clean cavity, remove filling
	Crimean Linden	7.0	4	80		
138 ▲	*Crimean Linden*	7.0	4	82	15x5 cm cavity filled with concrete at h 0.7m	Perform an expertise – afterwards possibly clean cavity, remove filling
	Crimean Linden	7.0	4	92		
	Littleleaf Linden	7.0	3	57		
	Crimean Linden	7.0	3.5	85		
	Crimean Linden	7.0	3.5	84		
	Crimean Linden	7.0	4	97		
	Crimean Linden	7.0	4	99		
CLOSE SURROUNDINGS OF CENTENNIAL HALL BUILDING - PERIPHERAL WALLS						
	White Dogwood	1		Area ~50m^2	shaped	
	White Dogwood	1		Area ~50m^2	shaped	

Number according to the number on the figure	English common name	Height in meters	Crown span in meters	circum-ference or Ø diameter in cm /area in m^2	comments on sanitary condition, etc.	maintenance guidelines for existing trees, i.e. tree care
	Virginia creeper				On the facades of the building	
	Euonymus fortunei 'Emerald'n Gold'			Area ~20m^2		Supplement plantings
	Euonymus fortunei 'Emerald Gaiety'			Area ~5m^2		
GREEN BELT ALONG Z. WRÓBLEWSKIEGO STREET						
	Hornbeam	2.3	2	110m^2	Trimmed hedge	
	Weeping Peashrub	1.5	1.5	23	Grafted on the trunk	
	Pfitzer Chinese Juni-per	2		Area ~25m^2		
	Pfitzer Chinese Juni-per	1.5		Area ~9m^2		
	Weeping Peashrub	1.1	1.2	22		
	Weeping Peashrub	1.3	1.2	26		
	Pfitzer Chinese Juni-per mottled	3	2		Both grow together	
	Pfitzer Chinese Juni-per	1.2		Area ~9m^2		
	European Yew	3.5	5	Area ~1.6m^2		
	Weeping Peashrub	2	2	46	Cracked trunk, root sprouts	
138 ●	Ash	6	2	84	Greatly reduced crown	Felling for compositional reasons
138 ●	Ash	7	4	79	Greatly reduced crown	Felling for compositional reasons
	Blue Spruce	12	6	174	Deadwood in the crown, resin	
138 ●	Norway Spruce	7	4	81	No bark on 1/4 of the trunk up to h~2.8m, deadwood in the crown	Felling for sanitary purposes
	Weeping Peashrub	1.2	1.0	23		
	Weeping Ash	4	3.5	46	Little deadwood in the crown	
	Pfitzer Chinese Juni-per	1.0	3.5	Area ~9m^2		
	Pfitzer Chinese Juni-per	1.0	3.5	Area ~9m^2		
	Pfitzer Chinese Juni-per	1.0	3.5	Area ~9m^2		
	Weeping Peashrub	1.7	1.7	42	Cracked trunk,	
	European Yew	3.5	5	Area ~19m^2		
	Hornbeam	2.0	0.7	Area ~37m^2	Trimmed hedge	
	Pfitzer Chinese Juni-per	1.4	2.5	Area ~5m^2		
	Creeping Juniper	1	5	Area ~20m^2		
	Pfitzer Chinese Juni-per	2.5	6	Area ~28m^2		
	Pfitzer Chinese Juni-per	1.5	5	Area ~20m^2		
	Creeping Juniper	0.6	4	Area ~12,5m^2		

Number according to the number on the figure	English common name	Height in meters	Crown span in meters	circum-ference or Ø diameter in cm /area in m^2	comments on sanitary condition, etc.	maintenance guidelines for existing trees, i.e. tree care
	Tamarix parviflora	5	6	Area ~28m^2		
	Creeping Juniper	0.6	4	area~12,5 m^2		
	savin Juniper	2	4	Area ~12.5m^2		
	Creeping Juniper	0.6	4	Area ~12.5m^2		
	Creeping Juniper	1.5	5	Area ~20m^2		
	False spirea - 4 pcs	2-4	1.5-3.0			
138 ▲	Globe Norway Maple	14	12	185	unshaped, some deadwood	Perform formative pruning
	Hornbeam -3 pcs	2	2	30+32+15	Partly Trimmed hedge	
	Creeping Juniper - 4 pcs	0.8	5	Area ~25m^2		
	Weeping Ash	4	4	48		
	Weeping Ash	4	4	49		
138 ▲	*Black locust*	18	10	147+127	2-trunk from h~1m, cavities in branching points, reduced crown, 5 mistletoes, deadwood	Cleanse crown from deadwood and mistletoe
	Black Walnut	10	5	85		
	Black Walnut	8	4	80		
	Ash	16	10	136	Some deadwood in the crown	Cleanse crown from deadwood
GREENBELT ALONG Z. WRÓBLEWSKIEGO STREET NEAR TRAM TRACK						
	Ash	18	10	Ø55		
	Ash	16	10	Ø45		
	Ash	16	8	Ø40		
	Ash	16	7	Ø35		
	Black Walnut	14	9	Ø35		
	Ash	14	7	Ø32		
	Black Walnut	18	14	264	4-trunk from h~4m, reduced crown, mistletoe	
138 ▲	*Black Walnut*	18	10	190	3-trunk from h~3.5m, reduced crown, deadwood	Cleanse crown from deadwood
	Ash	10	5	Ø15		
	Ash	14	8	Ø45		
	Ash	10	6	Ø15		
	Ash	8	4	Ø20		
	Black Walnut	16	8	Ø45		
	Black Walnut	16	8	Ø50		
	Black Walnut	16	8	Ø50		
	Ash	7	4	Ø15		
	Black Walnut	7	4	Ø20		
	Black Walnut	16	10	Ø60		
	Black locust	18	12	Ø75		
	Black Walnut	8	8	Ø40		
	Black locust	8	5	Ø15		

Number according to the number on the figure	English common name	Height in meters	Crown span in meters	circum-ference or Ø diameter in cm /area in m^2	comments on sanitary condition, etc.	maintenance guidelines for existing trees, i.e. tree care
	Black Walnut	8	4	Ø23		
	Black locust	14	7	Ø35		
	Black Walnut	14	8	Ø38		
	Black Walnut	14	8	117		
	Black Walnut	14	8	116	Reduced crown with deadwood	Cleanse crown from deadwood
	Black Walnut	10	7	86	Truncated top	
	Ash	8	5	53		
	English oak	10	10	9	From the side of the road truncated bough, outflow of resin in the cut	
	Ash	6	3	58	Truncated top	
	Ash	6	5	81	Deadwood in crown	Cleanse crown from deadwood
138 •	Ash	4	1	21	Withering, broken bough	Fell
	Ash	6	4	59	Truncated top	
	Ash	6	4	50		
	Black Walnut	8	6	84		
	Black Walnut	10	7	79		
	Ash	7	4	87		
	Ash	10	7	110	Reduced crown	

4. Description of the state of preservation and the state of health of the existing trees.

The greenery directly surrounding the Centennial Hall was planted in about 1920 as part of the Exhibition Grounds decorations.

The natural habitat of the examined area is characteristic of the Big Island. These include varying levels of groundwater, resulting from the geological structure of the soil - geologically impermeable layers.

The Exhibition Grounds were not and are not a park because of their function. Characterized by the predominance of paved roads over green lawns, which have a significant impact on plant growth conditions. The form of greenery, intensively trimmed Linden rows, being the main element of the composition, affect the condition of the trees.

The sanitary condition of trees surrounding Centennial Hall can be described as good. Out of more than six hundred inventoried pieces, only 4 trees are eligible for felling due to bad sanitary condition, and about 16 pieces require care and maintenance.

Square-shaped Linden rows were regularly supplemented with new plantings. For this reason, the age of each Linden is different and difficult to determine. Their state of preservation is also varied. The best preserved rows according to their dendrological inventory numbers are: IV, V, VIII, X, XXI, XXIII, XXIV, where Crimean Linden has almost identical parameters. This testifies to the same period of planting, there is no loss of trees in rows and saplings.

Rows of Lindens grow in high density, each planted 3m apart. The area of land around the trunks is limited by impermeable, bituminous pavement. Both factors caused deterioration of their living conditions. Differences in the development of trees due to growth conditions are visible - Lindens growing on the ends of the rows have a larger trunk circumference - variations of up to 20cm, and their crowns are more developed.

Slower growth is the result of difficult conditions - smaller increase in trunk circumference and trunk damage as a result of poorly cut boughs. The side effects are extensive trunk damages in 20 Lindens.

Over the years, these trees were subjected to different types of maintenance.

Fissures were filled with rubble brick and cement-lime mortar in 10 trees, and 6 with concrete. Expert opinion is needed to state whether to remove or leave the fillings, so as not to cause more damage.

Four Linden tree trunks have been cleaned to the wood and impregnated, in adherence to tree surgery regulations in force in the 1990's.

Years of crown molding have caused distortion and improper bough cutting contributed to bough injuries and forming of deadwood in the crowns.

Rows were improperly trimmed - cutting was performed on an uneven height, crowns not trimmed in a trapezoid.

Rows were supplemented with 25 new unformed saplings, species and form incompatible with the historical composition of tree rows.

A few old pieces (inventory no. 474 and 475) on the Avenue of Black Walnuts planted along the tramway track on Z. Wróblewskiego Street has been preserved. This Avenue is now replenished with Ash trees.

Trees along the tramway track have a reduced crown due to the collision with power grids.

Probably in the 1940's, the composition of greenery around the Centennial Hall from Z. Wróblewskiego Street was replenished with a Hornbeam hedge and composition of Conifers.

In the 1980's, the Hornbeam hedge was reconstructed and replenished with a composition of Dwarf Conifers and Weeping Caragan and Ash.

In 2013, after the construction of the underground parking garage, freestanding, unshaped rows of Littleleaf Linden were planted from the side of the Hall.

5. Analysis of tree age based on collected samples.

Monika Ziemiańska, Ph.D., from the Institute of Landscape Architecture, Wrocław University of Environmental and Life Sciences conducted a study to determine the age of a tree in the alley near Centennial Hall in Wrocław.

The study involved only one tree that was felled about 10 years ago. The remaining trees have not been examined since it would require invasive methods and their age can be determined by archival research.

It turned out, that the felled tree was a Littleleaf Linden (Tilia cordata L.), which was probably planted in 1948 to replace one damaged during the war or one which had withered. Tree nursery material was used from 1936 - 1945 (1947). This supplementation of existing plantings can be connected with the organization of the Recovered Territories Exhibition in Wroclaw in 1948.

What is relevant for this study is the expert opinion confirming that habitat conditions in Centennial Hall's surroundings limit the development of trees. An additional factor is the regular crown molding, resulting from the adopted landscape design.

The full text of the opinion is attached.

6. Photographic documentation of existing tree count. (June, 2015).

6.1. TREE ROW VIEWS

1.1. View of the colonnade - main entrance to the Exhibition Grounds - wine-ivy columns no. 2, 3, 4 and hedges of Boxwood no. 1

1.2. View of Linden row no. 1

1.3. View of a road between rows no. II and III

1.4. View of Linden row no. III

1.5. View of Linden row no. IV

1.6. View of Linden row no. VI

1.7. View of Linden row no. VII

1.8. View of a road between rows no. VII and VIII

1.9. View of a road next to the parking lot between rows no. XI and XII

1.10. View from Centennial Hall of a lawn turned into a parking lot – and row no. XII

1.11. View of a street light in row XII

1.12. View of a street light in row no. XIII and row no. XIV

1.13. Row near the garden – Linden no. 274–279

1.14. View of rows no. XXII and XIX

1.15. View from the parking lot of a road between rows no. XXI and XXII

6.2. VIEW OF TREES AND SHRUBS

2.1. No. 5 Norway Maple

2.2. No. 72 Tree of Heaven

2.3. No. 13 Linden – trunk fissure filled with brick rubble and mortar

2.4. No. 15 Linden – callus traces of removed root offshoots on the trunk

2.5. View of new plantings of Linden no. 15, 16, 17 in row I

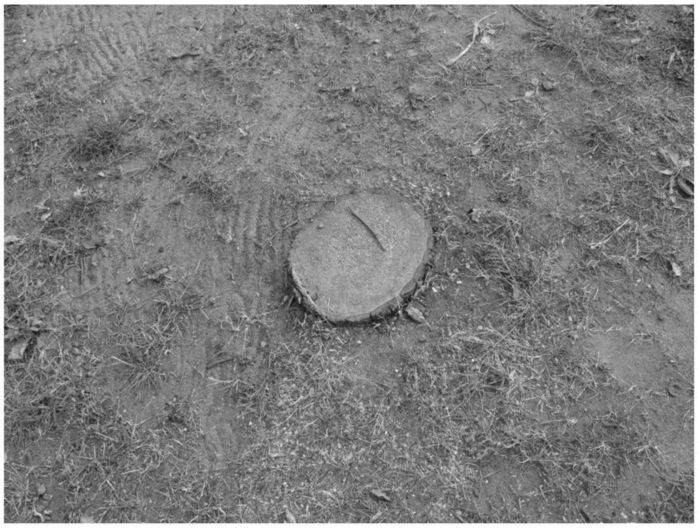
2.6. No. 44 European Hornbeam – hedge residue

2.7a. No. 62 Linden – traces of grafting on the trunk

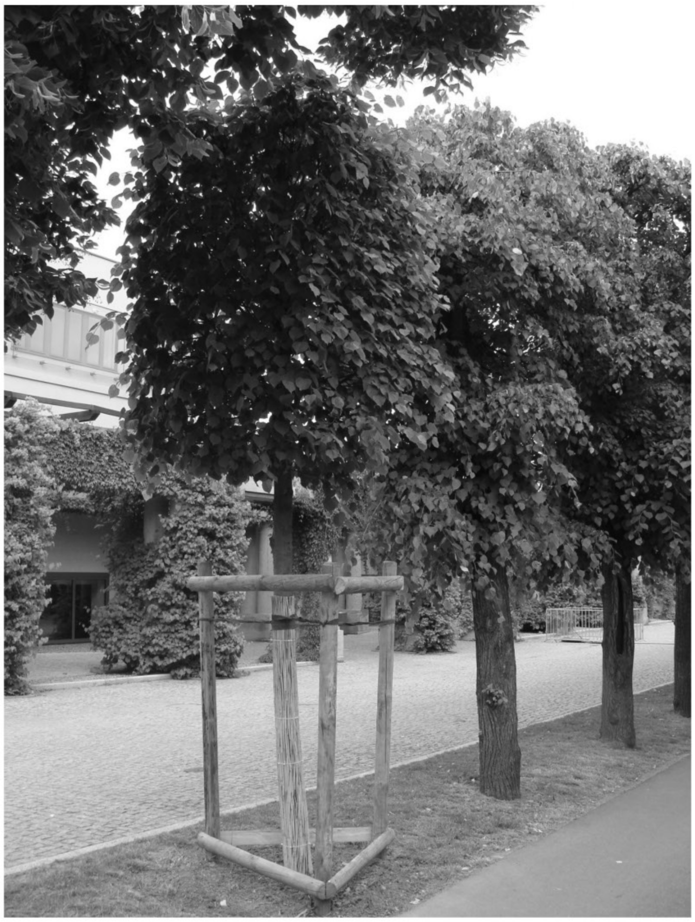
2.7b. No. 53 Linden – partly callus fissure on trunk

2.8. No. 64 Linden – fissure on the trunk filled with brick rubble and mortar

2.9. No. 68 Linden – cavity filled with brick rubble and mortar



2.10. No. 151 felled tree trunk from which the sample was taken for age analysis



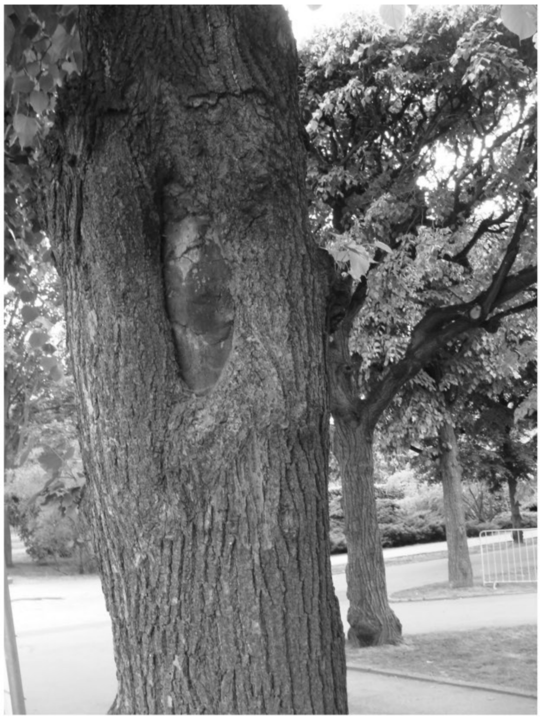
2.11. No. 210 Linden – new planting in row, propagated in the nursery

2.12. No. 211 Linden – trunk cavity cleaned and impregnated

2.13. No. 216 Linden – trunk cavity cleaned and impregnated

2.14. No. 221 Linden – trunk cavity filled with concrete

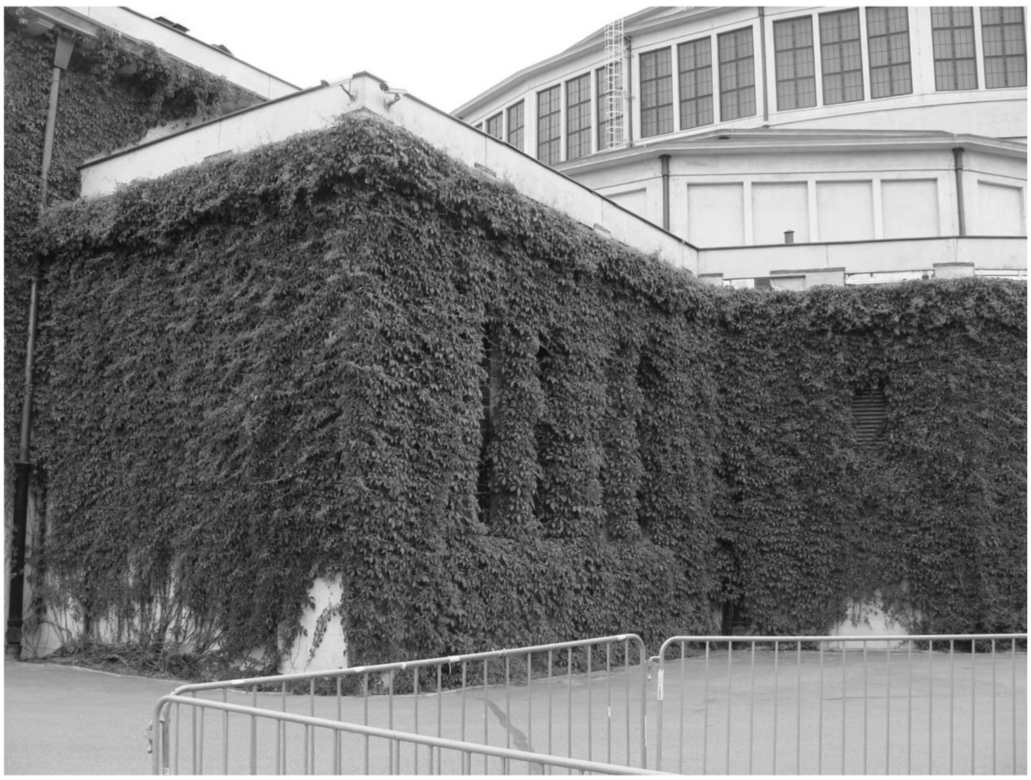
2.15. No. 268 Linden – callus trunk cavity and no. 269 – flowerbed in place of felled Linden tree



2.16. No. 269 trunk cavity filled with concrete

2.17. No. 340 Linden – cavity filled with brick rubble and mortar

2.18. Linden no. 341 – cavity filled with brick rubble and mortar



2.19. North East façade of the Centennial Hall overgrown with Virginia creeper no. 423

2.20. View from the Hall of Hornbeam hedge no. 447, Junipers no. 448 to 452 and Saltcedar no. 453

2.21. No. 458 False Spirea

2.22. Ash no. 437 and no. 436

2.23. Weeping Ash nos. 462 and 463

2.24. Black Walnut nos. 475 and 474

III. COMPOSITIONAL AND HISTORICAL ANALYSIS OF GREENERY SURROUNDING CENTENNIAL HALL

Hans Poelzig (Ilkosz 2005, p. 93) is recognized as the author of the 1913 urban and architectural concept of the Exhibition Grounds. On the basis of archival records, it can be concluded that in the case of the direct surroundings of Centennial Hall, the final decision on its arrangement was made by Max Berg after 1918, who respected his colleague's vision.

The Exhibition Grounds landscape composition is subordinated to the Centennial Hall, located at the intersection of two perpendicular axes, in which the longer (NW - SW) starts with the apex of the parabola colonnade, and goes to the south by Z. Wróblewskiego Street, where the second part of the exhibition was located. The shorter axis starts from the east with the Garden Exhibition Pavilion and ends in the west with the main entrance to the Exhibition Grounds.

The height of greenery surrounding the Centennial Hall was to emphasize the transparency of structure and monumentality of the main building of the Exhibition Grounds. Geometric, regularly planted rows of trees were to frame triangular corners of the quadrangle sides of approx.160, whose diagonals pass through the center of the Centennial Hall, crossing at an angle of 45 degrees with the principal axes. This arrangement is shown in the August 1912 design of the Centennial Exhibition by students of the Royal School of Arts and Crafts in Wroclaw (Ilkosz 2005, Fig. 123). Hans Leistikow used this vision to prepare a colored perspective drawing showing the Centennial Hall surrounded by rows of trees with molded crowns (Ilkosz 2005, Fig. 150) and became the basis for the bird's eye view of the Exhibition Grounds included in the official guide for the Centennial Exhibition. In 1913, the tree rows were not planted, but only for the duration of the exhibition – the edges of triangular quarters of the quadrangle were emphasized by orange trees in buckets in the middle of which temporary, classic pavilions were installed, and the rectangular courtyard in front of the main entrance to the Centennial Hall was decorated with two rows of buckets with trimmed Laurels (Ilkosz 2005 Ill. 128, 196).

The condition of greenery surrounding Centennial Hall is shown in the Files of the City of Wrocław plan, ref.no. 35389 par. 80 and 81 signed on November 7, 1914 by Hugo Richter, Director of Wrocław City Horticulture (a position he held from 1891 to 1921). Only the lawns are preserved and the courtyard in front of the main entrance to the Centennial Hall is decorated with hedges. The fact that it is a genuine illustration of the contemporary state of greenery can be seen in the scrupulous marking of tree thickets (Chestnut) to be replanted on both sides of the Main Terrace Restaurant. Equal care was taken to map other landscaping elements: stairs and street lamp location.

After the end of World War, I, Max Berg returned to the idea of filling the surroundings of Centennial Hall with trees. For this reason, he sent a questionnaire to several German cities, asking what species and plant arrangement they would recommend. The intention was to emphasize the promenading character of this part of Wrocław's exhibition assumptions. Tree crowns were to be formed, which was a conscious reference to, regular, geometrical, classicist parks, and especially the promenade assumptions. The respondents unanimously recommended the Linden tree, planted at intervals of 3 m to 4 m, 6 to 8 meters.

Preserved plans from the State Archives in Wroclaw, Files of the City of Wrocław enabled the reconstruction of the process of selecting the final layout, which in four triangular quadrants of the quadrangle separated by paths led out axially from the outline of the Centennial Hall, and were in line with the original concept of Hans Poelzig.

The oldest known plan, Files of the City of Wrocław, ref. 35384 par. 285 was signed on November 3, 1918 by Hugo Richter. A part of Hans Poelzig's project was implemented: the planting pattern of parallel Avenues in the courtyard before the main entrance to Centennial Hall, with rhododendrons on the outside. However, triangular quarters of Centennial Hall's surroundings were to be planted with trees in rows of two, that were on a quarter circle layout. It also indicated that Linden trees were to be planted.

Another plan from the Files of the City of Wrocław ref. 35385 par. 4 was signed in February 1919 by Max Berg. Double rows were to be planted in the courtyard in front of the main entrance to the Centennial Hall, with a gap in the middle at the entrance to the Four Dome Pavilion. While two rows of benches separated by shrubs were to be set up parallel to tree rows in the courtyard. Each of the triangular quadrants of a quadrangle around the Centennial Hall was to be divided symmetrically into two isosceles triangles with the placement of rows of trees (probably Lindens) on each side, the external sides of the quadrangle were to have double rows. It was anticipated that space for sculpture exhibitions would be provided in the isosceles triangles, from one to four in each field. Essential for further consideration is that bordering rows were to be spaced 6 meters apart.

It seems that this project was not carried out, but was used to develop the final version featuring shaped Linden plantings around the Centennial Hall and the courtyard in front of the main entrance to the Centennial Hall, which was completed between 1919 and 1922, and supplementations probably done in 1923, or 1924.

Evidence of this is the Centennial Hall landscape assumption project (Jahrhunderthalle an der Gartenanlage) from the Files of the City of Wrocław ref. no. 35358 paragraph 14 signed in February 1919 by a municipal construction councilor (no handwritten signature of Max Berg, who at the time held the position). The phase of completion on the eastern side of the Hall i.e. soil exchange and tree planting was drifted on the project in 1922. The project had been stamped and signed on August 14, 1922 by Paul Dannenberg – Hugo Richter's successor, director of Wrocław Urban Gardening since 1921. The files accompanying the plan show that greenery works around the Centennial Hall in the years 1923-1924 were financed from funds reserved to reduce unemployment. The quadrangle around the Centennial Hall was divided into triangular quarters, which were symmetrically divided into two isosceles triangles by a path. Double rows were planted on the external sides of the triangles. The triangular sides facing the Centennial Hall were to be planted, probably with hedges. Equilateral triangles filled the lawns with pedestals for sculptures. In terms of planting and layout of paths, this project corresponds to the present state. The project's landscape layout of shaped Lindens can be seen in many photographs from the 1920's, 1930's and 1940's.

The site plan of the Exhibition Grounds dated March 1922 from the Files of the City of Wrocław ref. no. 35361 par. 93 shows that planting was carried out in 1919 according to the project approved by Max Berg in February 1919 - Files of the City of Wrocław ref. no. 35358 par. 14. It reveals that the courtyard in front of the main entrance to the Centennial Hall and two triangular quadrants, southwest and northwest had been already planted, but there were no planted trees on the triangular quadrants from the east.

Further proof is the terrain analysis - tree row distance and pavement measurement. A comparison of the condition in 1919 to the current situation. Measurements showed that the spacing of Lindens in all rows is ~ 3m and ~ 6m between the rows in the Avenue, the width of paths in the alleys is ~ 4m. These dimensions match the dimensions of the 1919 project.

It was not possible to unquestionably determine whether the hedges near the Centennial Hall and flowerbeds near the Four Dome Pavilion were planted according to the assumptions of the 1919 project. The site plan of the Exhibition Grounds from 1931, the sectional plan of 1934 and photographs from before 1945 do not suggest that hedges were planted.

Determining the age of the trees planted around the Centennial Hall is exceptionally difficult due to unusual environmental conditions: pavements close to root balls, high density - plant spacing every 3m, systematic crown reduction (shaping of Lindens into squares) and lack of information about the age of used nursery plants. All this makes it impossible to clearly determine the age of the plants.

Visible differences in the development of trees caused by growth conditions – Linden trees growing at the ends of tree rows have a larger trunk circumference – differences up to 20cm, and more developed crowns. The result of the difficult conditions is slower tree growth – little increase in trunk circumference. Additionally, trees in rows were regularly replenished, making it, even more, difficult to determine their age.

The study of the only available sample did not bring the expected results. On the other hand, it turned out that it is an interesting example – when planted as a successor tree, despite the difficult habitat conditions at the time of felling, the tree's trunk diameter was similar to its twenty years' older neighbors.

Perhaps in the 1940's Hornbeam rows were planted along the eastern facade of the Four Dome Pavilion (presently non-existent) and the Black Walnut along the tramway track at Z. Wroblewskiego Street. Apparent development of greenery in front of the Centennial Hall from the south - from Z. Wroblewskiego Street can be seen on photographs from 1942–1944. At that time, a hedge of Conifers grew there. They were probably Spruces, numbered 248 and 349 in the 2015 inventory. The tree alley along the tram tracks is probably the Black Walnut, also identified in the inventory.

Photographs taken just after 1945 confirm the existence of the Hornbeam hedge, Spruce and Black Walnuts and small lawns near the Centennial Hall and creepers on the façade.

During the field research, it was found that the composition of Linden rows was supplemented several times, Crimean Lindens were planted instead of Littleleaf Lindens. Losses were perhaps first supplemented in 1948, during preparations of the Recovered Territories Exhibition. This procedure is being continued.

Archives:

State Archives in Wroclaw, Files of the City of Wrocław, ref. no. 35384 par. 285; 35385 par. 4; ref. no. 35358 par. 14; 35361 par. 93; ref. no. 35389 par. 80 and par. 81;

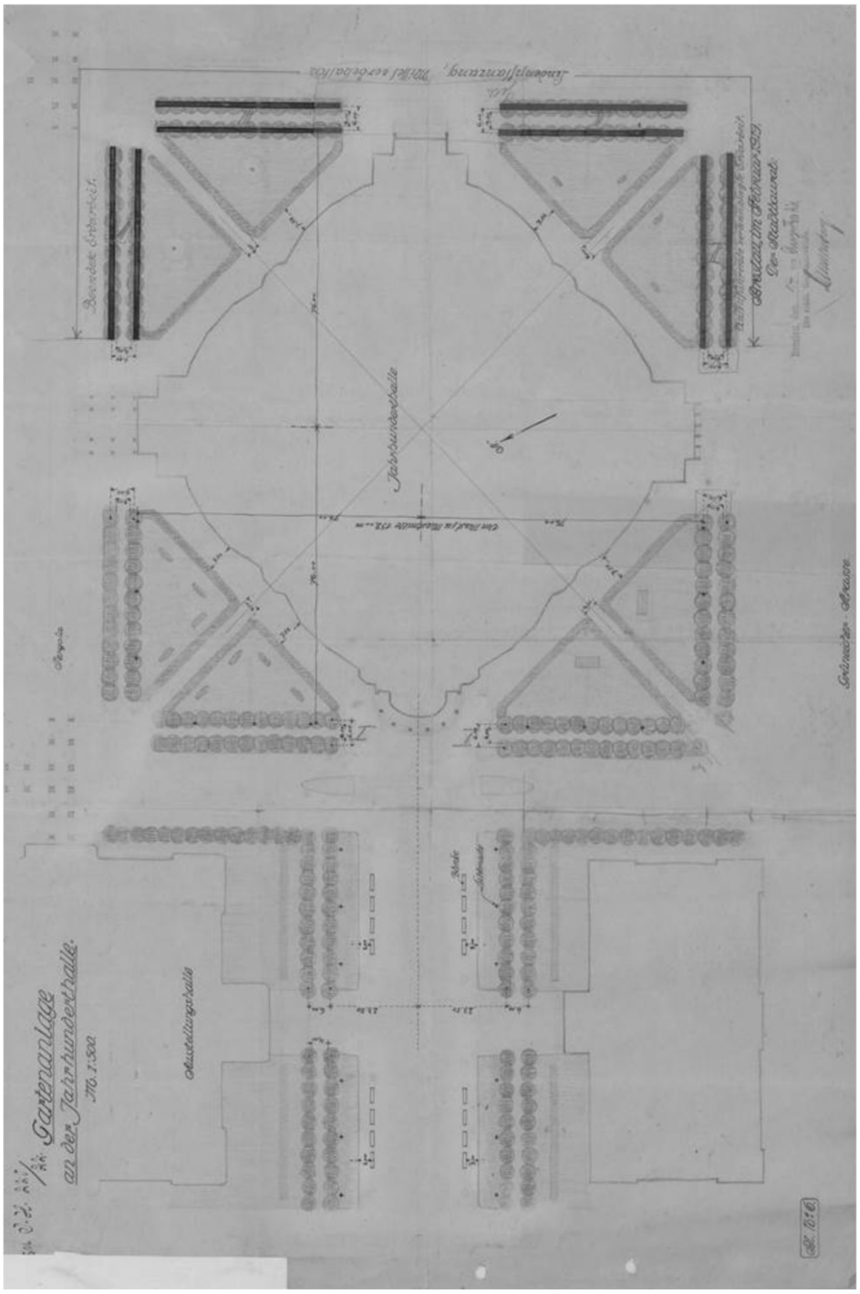
Literature:

Natura i miasto. Publiczna zieleń miejska we Wrocławiu od schyłku XVIII do początku XX wieku, by Bińkowska I., Wrocław 2006.

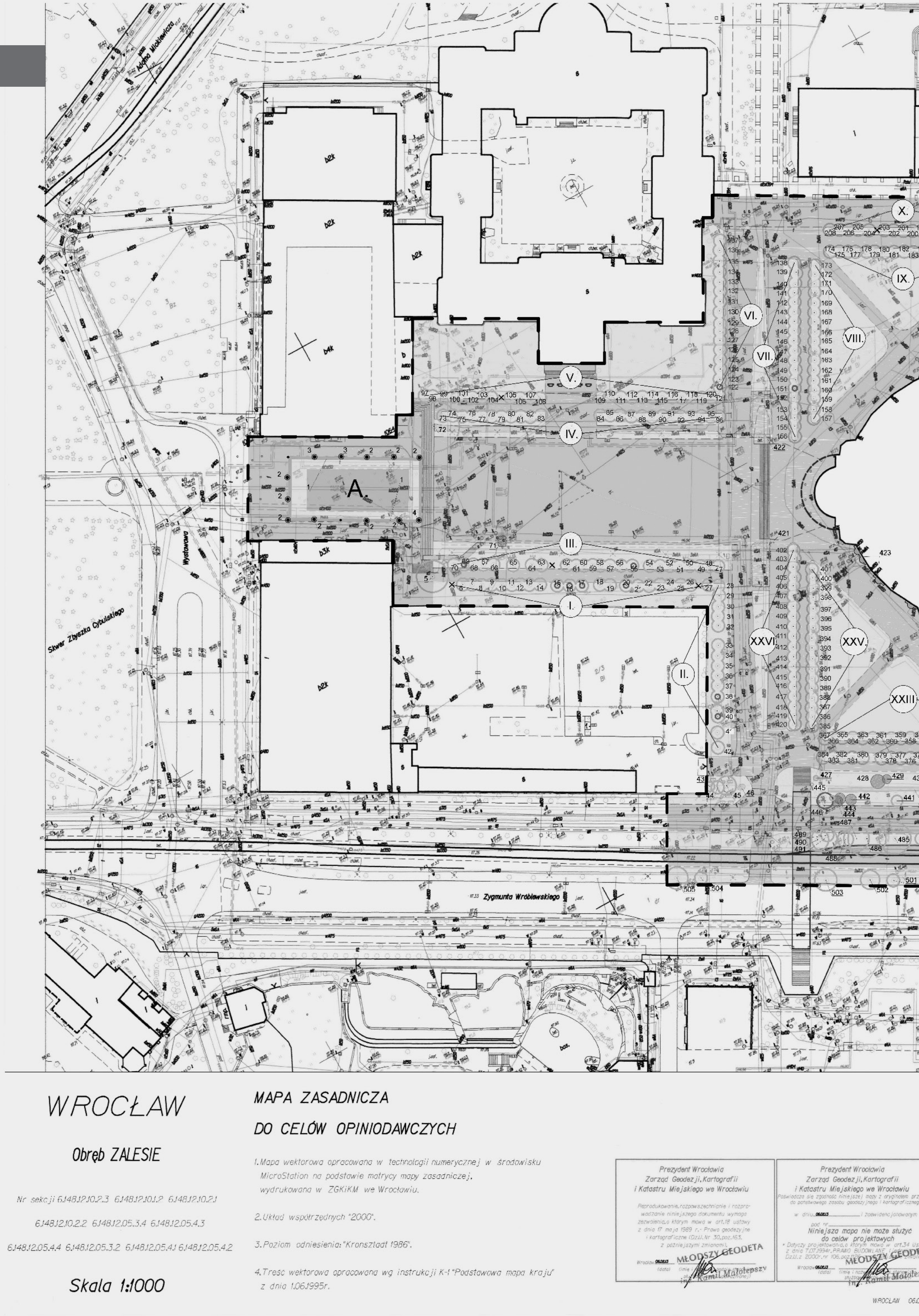
Hala Stulecia i Tereny Wystawowe we Wrocławiu – dzieło Maksa Berga, by Ilkosz J., Wrocław 2005.

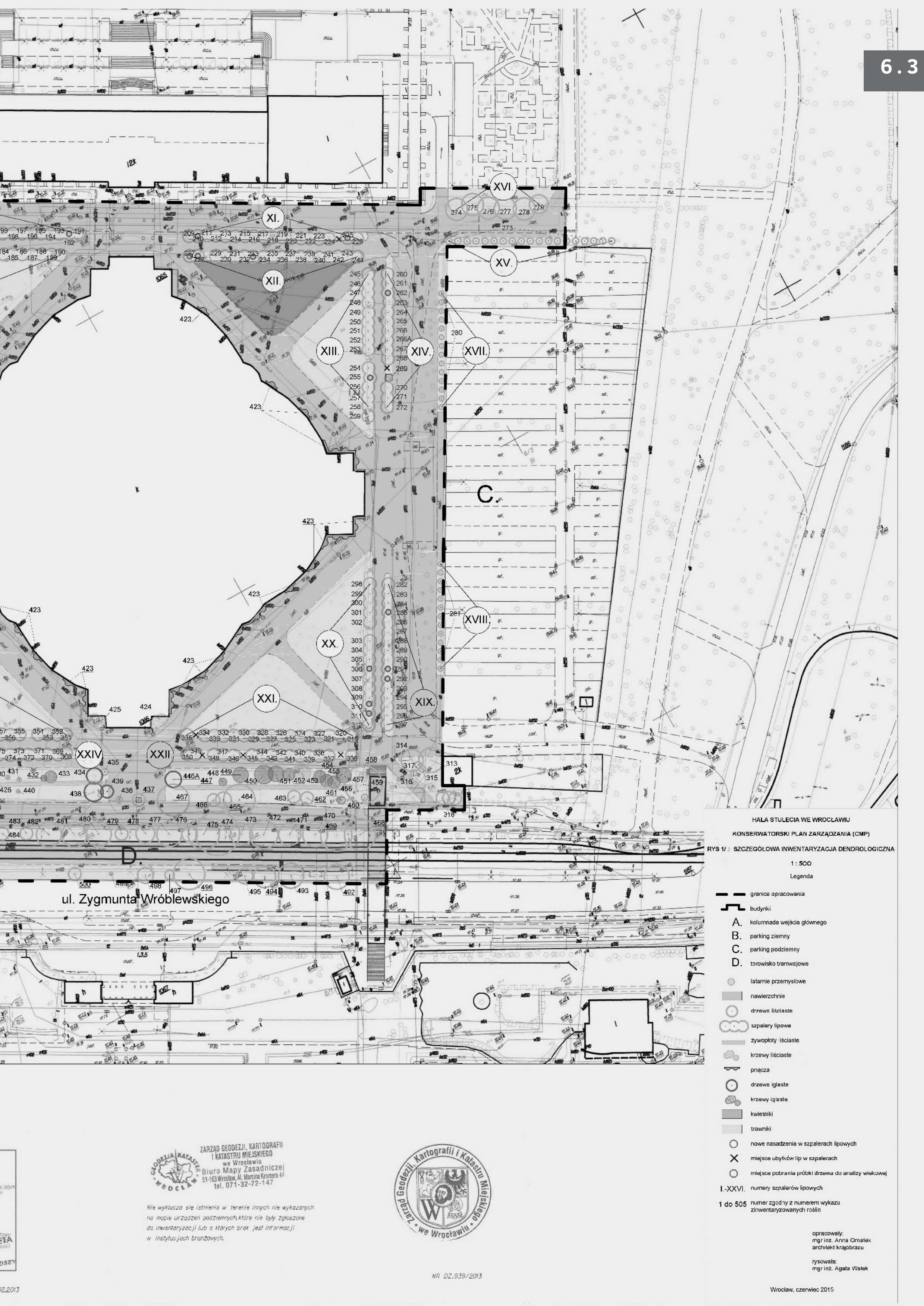
Leksykon architektury Wrocławia, by Eysymontt R., Ilkosz J., Tomaszewicz A., Urbanik J., Wrocław 2011.

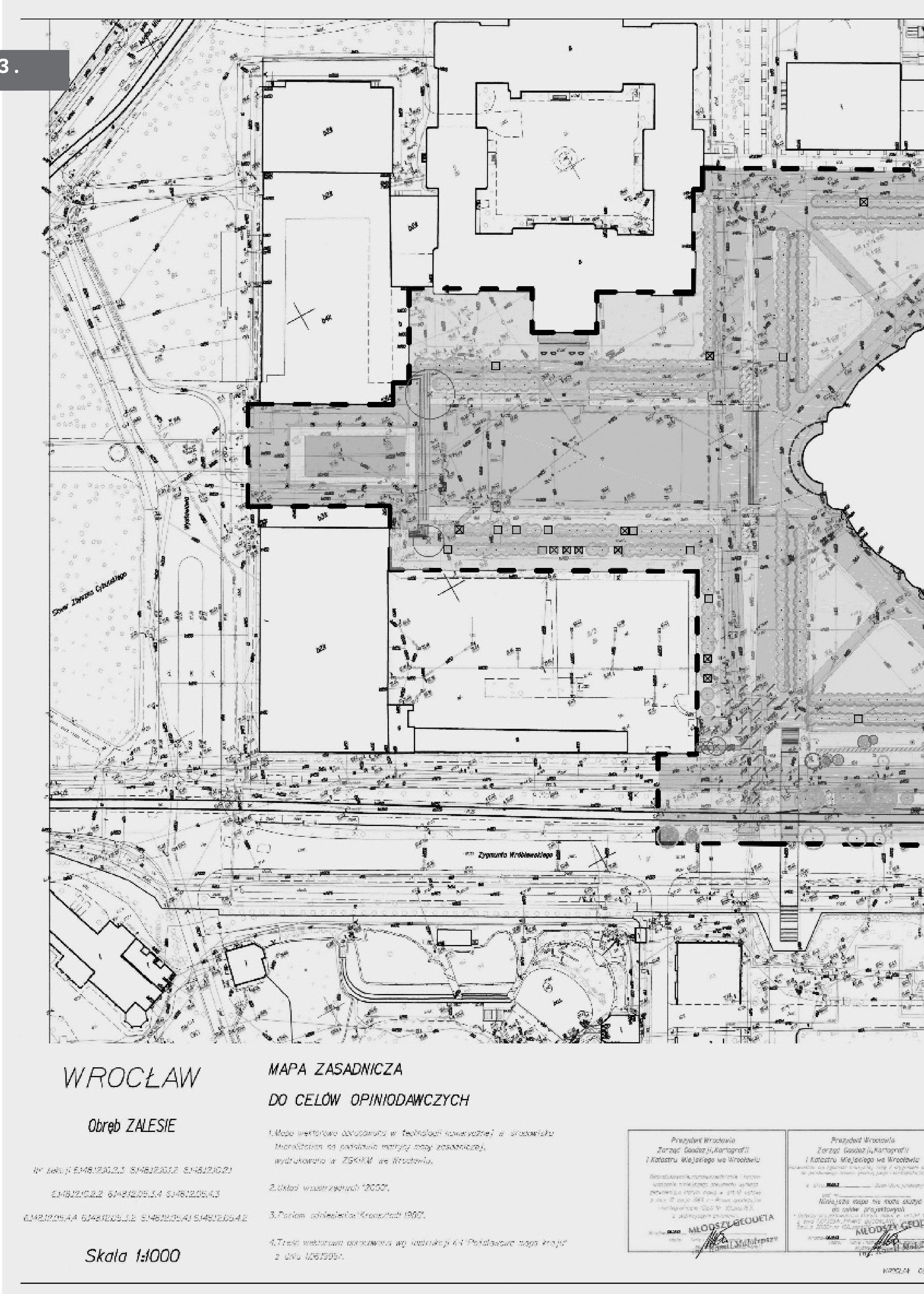
Leksykon zieleni Wrocław, by I. Bińkowska, E. Szopińska, Wrocław 2013.

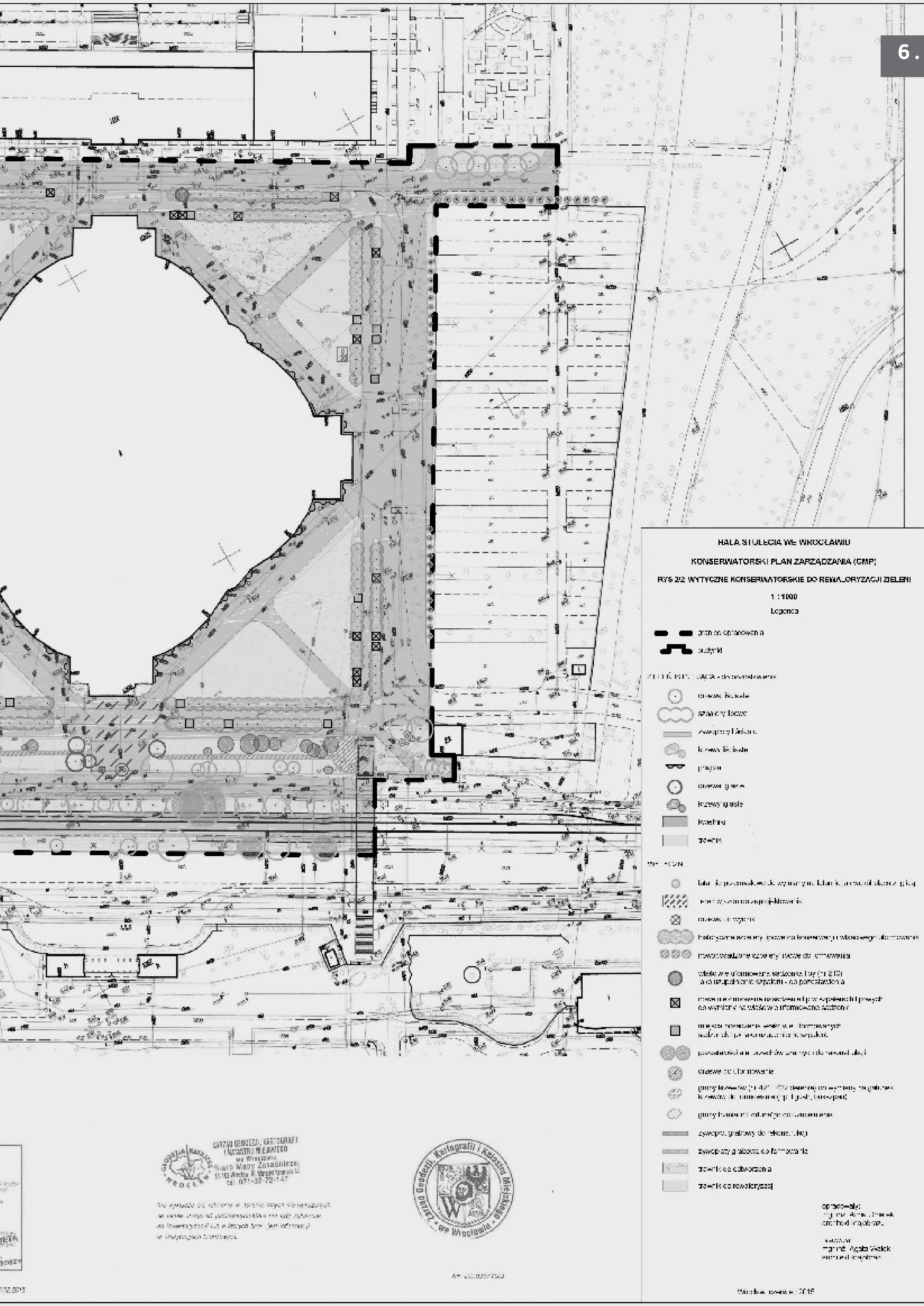


The landscape project for Centennial Hall surroundings, 1919, supplemented plantings marked red, 1922, scale 1: 500. *Gartenanlage an der Jahrhuderthalle M 1: 500.* The caption under the drawing *Breslau, im Februar 1919*. Stamp of *Der Stadtbaurat. Breslau, den 14-ten August 1922. Die Städt. Gartendirekton* signature *Dannenberg.* The State Archives in Wrocław, Files of the City of Wrocław, ref. no. 35 358, par. 14


Adama Mickiewicza
Skwer Zbyszka Cybulskiego
Wystawowa
Zygmunta Wróblewskiego
A.
I.
II.
III.
IV.
V.
VI.
VII.
VIII.
IX.
X.
XXIII
XXV.
XXVI.
WROCŁAW
Obręb ZALESIE
Nr sekcji 6.148.12.10.2.3 6.148.12.10.1.2 6.148.12.10.2.1
6.148.12.10.2.2 6.148.12.05.3.4 6.148.12.05.4.3
6.148.12.05.4.4 6.148.12.05.3.2 6.148.12.05.4.1 6.148.12.05.4.2
Skala 1:1000
MAPA ZASADNICZA
DO CELÓW OPINIODAWCZYCH
1.Mapa wektorowa opracowana w technologii numerycznej w środowisku MicroStation na podstawie matrycy mapy zasadniczej, wydrukowana w ZGKiKM we Wrocławiu.
2.Układ współrzędnych "2000".
3.Poziom odniesienia:"Kronsztadt 1986".
4.Treść wektorowa opracowana wg instrukcji K-1 "Podstawowa mapa kraju" z dnia 1.06.1995r.
Prezydent Wrocławia
Zarząd Geodezji, Kartografii
i Katastru Miejskiego we Wrocławiu
Reprodukowanie, rozpowszechnianie i rozprowadzanie niniejszego dokumentu wymaga zezwolenia, o którym mowa w art.18 ustawy z dnia 17 maja 1989 r.- Prawo geodezyjne i kartograficzne (Dz.U. Nr 30, poz.163. z późniejszymi zmianami).
Wrocław 06.02.13
(data)
MŁODSZY GEODETA
inż. Kamil Małołepszy
Prezydent Wrocławia
Zarząd Geodezji, Kartografii
i Katastru Miejskiego we Wrocławiu
Poświadcza się zgodność niniejszej mapy z oryginałem prz
do państwowego zasobu geodezyjnego i kartograficzneg
w dniu 06.02.13 i zaewidencjonowanym
pod nr
Niniejsza mapa nie może służyć
do celów projektowych
Wrocław 06.02.13
(data)
MŁODSZY GEOD
inż. Kamil Małołe
WROCŁAW


XI.
XII.
XIII.
XIV.
XV.
XVI.
XVII.
XVIII.
XIX.
XX.
XXI.
XXII.
XXIV.
C.
D.
ul. Zygmunta Wróblewskiego
HALA STULECIA WE WROCŁAWIU
KONSERWATORSKI PLAN ZARZĄDZANIA (CMP)
RYS 1/2 SZCZEGÓŁOWA INWENTARYZACJA DENDROLOGICZNA
1 : 500
Legenda
granice opracowania
budynki
A. kolumnada wejścia głównego
B. parking ziemny
C. parking podziemny
D. torowisko tramwajowe
latarnie przemysłowe
nawierzchnie
drzewa liściaste
szpalery lipowe
żywopłoty liściaste
krzewy liściaste
pnącza
drzewa iglaste
krzewy iglaste
kwietniki
trawniki
nowe nasadzenia w szpalerach lipowych
miejsce ubytków lip w szpalerach
miejsce pobrania próbki drzewa do analizy wiekowej
I.-XXVI. numery szpalerów lipowych
1 do 505 numer zgodny z numerem wykazu zinwentaryzowanych roślin
opracowały:
mgr inż. Anna Ornatek
architekt krajobrazu
rysowała:
mgr inż. Agata Wałek
Wrocław, czerwiec 2015
ZARZĄD GEODEZJI, KARTOGRAFII I KATASTRU MIEJSKIEGO we Wrocławiu
Biuro Mapy Zasadniczej
51-163 Wrocław, Al. Marcina Kromera 44
tel. 071-32-72-147
Nie wyklucza się istnienia w terenie innych nie wykazanych na mapie urządzeń podziemnych, które nie były zgłoszone do inwentaryzacji lub o których brak jest informacji w instytucjach branżowych.
Zarząd Geodezji, Kartografii i Katastru Miejskiego we Wrocławiu
NR DZ.939/2013


Zygmunta Wróblewskiego
WROCŁAW
Obręb ZALESIE
Skala 1:1000
MAPA ZASADNICZA
DO CELÓW OPINIODAWCZYCH
MŁODSZY GEODETA


HALA STULECIA WE WROCŁAWIU
KONSERWATORSKI PLAN ZARZĄDZANIA (CMP)
RYS 2/2 WYTYCZNE KONSERWATORSKIE DO REWALORYZACJI ZIELENI
1 : 1000
Legenda

IV. CONCLUSIONS

1. It should be noted that the historical spatial layout and composition of the vegetation surrounding the Centennial Hall has been maintained to a large extent.
2. The 1925 exhibition building located at the site of the current parking lot at the IASE building and the main entrance colonnade to the Exhibition Grounds disappeared from the Exhibition Grounds complex as a result of the war. Post-war renovations involving the setting of the steel spire on the east-west axis in 1948, the replacement of gravel pavement to stone and bitumen, and the installation of new street lights did not affect the uniformity of this part of the landscaping assumption.
3. The existing vegetation requires more care and expert supervision over the activities performed during maintenance and reconstruction.
4. Some pavements and landscaping elements require rearrangement and overhauls.

V. GUIDELINES FOR CONSERVATION

1. A detailed project of the reconstruction of Linden tree rows and other elements of greenery around Centennial Hall must be developed, assuming the following:

- arboristic expert opinion of sealed trees and poor sanitary condition as indicated in the inventory,
- exchange newly planted Littleleaf seedlings for nursery grown square-shaped Crimean Lindens, with a trunk circumference of > 35cm,
- gap-filling with new Linden seedlings as mentioned above,
- development of a detailed manual of pruning and shaping historical and newly planted tree rows along with the underground parking garage,
- cultivation and fertilization recommendations based on research and analysis of soil,
- consider implementation of lawn irrigation system,
- exchange groups of White Dogwood for group of shaped shrubs,
- complete reconstruction of Hornbeam hedge and level up the height over the whole length,
- regeneration of tree rows along the tram track
- consider the possibility of reconstructing flower beds according to 1922 design.

2. Prepare a project of replacing existing street lamps with ones in a historical setting like those replaced in Spire Square.
3. Repairs of all damaged surfaces and stairs
4. Eliminate the gravel parking lot near the Hall and install a lawn in its place.
5. Develop a design of the entrance to the Hall and the IASE building's parking lot and the courtyard in front of the entrance to the Hall from Z. Wróblewskiego Street.
6. Design a coherent system of information and advertising in the Hall's surroundings.
7. Tidy up random growing plants along the wall of the IASE building's parking lot from Z. Wróblewskiego Street.
8. Prohibit the parking of buses in alleys between rows of Lindens located near the underground car park.

Written by:
Anna Ornatek, landscape architect
Permission PZOS no. 8/96

Wrocław, June 2015

UNIWERSYTET PRZYRODNICZY WE WROCŁAWIU
WYDZIAŁ INŻYNIERII KSZTAŁTOWANIA ŚRODOWISKA I GEODEZJI
INSTYTUT ARCHITEKTURY KRAJOBRAZU

Wrocław, 02.07.2015

Institute of Landscape Architecture
Wrocław University of Environmental and Life Sciences
Pl. Grunwaldzki 24a,
50 – 363 Wrocław

Title: **Dendrological expertise – littleleaf linden (*Tilia cordata* L.) growing in the alley near Centennial Hall in Wrocław till 2005.**

Investor: Wrocławskie Przedsiębiorstwo Hala Ludowa Sp. z o.o.
ul. Wystawowa 1
51-618 Wrocław
NIP 896-000-10-95

Research basis: External commission

Stadium: expertise

Field: vegetation

Author: Monika Ziemiańska, Ph.d, Eng. signature:

Date of documentation: 02.07.2015

WROCŁAW 2015

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NIP: 896-000-53-54

UNIWERSYTET PRZYRODNICZY WE WROCŁAWIU
WYDZIAŁ INŻYNIERII KSZTAŁTOWANIA ŚRODOWISKA I GEODEZJI
INSTYTUT ARCHITEKTURY KRAJOBRAZU

1. RESEARCH BASIS

The research basis:
- sample collected on 01/06/2015,
- area map,
- subject literature:

* *Zarys struktury i fizjologii drzew leśnych*, 2012. J. Kopcewicz, A. Szmidt-Jaworska, K. Kannenberg,
* *Dendrochronologia*, A. Zaleski, M. Krąpiec 2009,
* *Tree rings and climate,* A., C. Fritts 2010,
* *Fundamentals of tree ring research*, J. H. Speer 2012,
* *An introducing to tree ring dating,* M. A. Stokes, T. L. Smiley 1996.

2. AIM AND SCOPE OF RESEARCH

The aim of this study is to determine the tree age – littleleaf linden (*Tilia cordata* L.) growing in Centennial Hall in Wrocław surroundings till 2005.

Area range: plot no. 6/4 (Wróblewskiego Street) Zalesie Surveying District

Time range: 1.06.2015 – 1.07.2015

Substantive scope: to estimate tree age from wood sample – ring taken from the base of the linden trunk.

SUBJECT AND METHOD OF RESEARCH

The sample taken on 01.06.2015 from the littleleaf linden tree growing near Centennial Hall in Wroclaw was the object of study. The sample was collected from the height of approx. 5-10 cm above the ground using an STIHL chainsaw. The thickness of the log is approx. 6cm. The following equipment was used to measure the annual growth: electronic LINTAB6 measuring system, and Leica microscope with TSAPWin software, which is part of our unit's equipment. The measurement accuracy is 0.01 mm.

It should be noted that linden wood is characterized by irregular vascular tissue arrangement (barely legible without specialized equipment). Additionally, it is a species that develops wedging rings, disappearing around the circumference of the trunk so called, false rings. With the help of LINTABU 6, the aforementioned false rings were eliminated. (the whole cross-section of the trunk)

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WYDZIAŁ INŻYNIERII KSZTAŁTOWANIA ŚRODOWISKA I GEODEZJI
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INITIAL DATA

Tabel 1. Littleleaf linden dating (*Tilia cordata* L.)

	year	Annual growth in [mm]	comments / interpretation of biological growth rates
1.	1936	3,48	10-12 years (presently) presumably the tree was nursery grown
2.	1937	3,22	
3.	1938	3,29	
4.	1939	2,44	
5.	1940	3,57	
6.	1941	0,13	
7.	1942	0,77	
8.	1943	4,49	
9.	1944	2,02	
10.	1945	3,14	
11.	1946	3,51	
12.	1947	3,45	
13.	1948	3,72	Approximate year of planting (1948) +/- 3 years
14.	**1949**	**5,21**	**(1949) maximum annual increase**
15.	1950	3,99	
16.	1951	2,49	
17.	1952	2,49	
18.	1953	2,78	
19.	1954	2,21	
20.	1955	0,35	
21.	1956	3,13	
22.	1957	4,69	
23.	1958	2,44	
24.	1959	1,61	
25.	1960	1,24	
26.	1961	0,21	
27.	1962	1,53	
28.	1963	2,01	
29.	1964	0,98	

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30.	**1965**	**1,99**	Scientific publications (interpretation of chronology) say that the juvenile phase, characterized by higher annual growth (which is confirmed by this measure), lasts up to approx. 30 years in the case of littleleaf linden species. After this time, the tree naturally reduces its annual growth. However, the size of increment during the juvenile, mature and senile phase is influenced by various factors.
31.	1966	2,63	
32.	1967	2,27	
33.	1968	1,72	
34.	1969	1,03	
35.	1970	1,29	
36.	1971	1,99	
37.	1972	2,14	
38.	1973	1,45	
39.	1974	1,51	
40.	1975	1,46	
41.	1976	1,37	
42.	1977	1,88	
43.	1978	0,84	
44.	1979	0,76	
45.	1980	0,85	
46.	1981	0,95	
47.	**1982**	**0,12**	**(1982) minimum annual increase**
48.	1983	1,12	
49.	1984	0,81	
50.	1985	0,76	
51.	1986	0,58	
52.	1987	0,70	
53.	1988	0,46	
54.	1989	0,49	
55.	1990	0,56	
56.	1991	0,61	
57.	1992	0,50	
58.	1993	0,54	
59.	1994	0,56	
60.	1995	0,53	
61.	1996	0,55	
62.	1997	0,62	
63.	1998	0,55	
64.	1999	0,63	
65.	2000	0,52	

66.	2001	0,66	
67.	2002	0,54	
68.	2003	0,56	
69.	2004	0,38	
70.	**2005**	**Approximate year (2005) of cutting down the tree (no increase in growth)**	

3. RESULTS AND CONCLUSIONS

The littleleaf linden (Tilia cordata L.) growing in the alley near the Centennial Hall in Wroclaw was approx. 70 years old at the time of cutting.

This tree grew in a characteristic manner for its species.

Detailed interpretation of measurements:
1936 - 1945(47) – growth in nursery (10-12 years)
1936 - 1965 (67) - juvenile period of growth (increased annual growth)- (30 - 32 years)
1966(68) - 2004 – mature and senile growth phase (reduced annual growth) - (39 - 37 years)
1949 - the year in which the linden developed maximum annual increase of 5.21 [mm] in the early stages of juvenile tree growth
1982 - the year in which the linden developed minimum annual increase of 0.12 [mm] in the stage of mature tree growth
2005 - the year in which request for permission to cut down the tree was submitted to Wrocław City Conservator.

The annual growth of trees is affected by various factors:
- air temperature,
- precipitation,
- length of snow cover,
- habitat conditions prevailing at the place of growth (light, soil conditions, i.e. soil nutrients, soil structure, environmental pollution)
- tree care treatment e.g. cutting of the tree crown – i.e. limiting (decreasing) the surface of the process of photosynthesis and transpiration.

The age of the tree analyzed is partly confirmed by the information contained in the publication by J. Kocewicz, A. Smidt-Jaworski and K. Kannenberg entitled „Zarys struktury i fizjologii drzew leśnych" z 2012 r. (str. 384-385) ["The outline of the structure and physiology of forest trees", 2012. (pp. 384-385)] - quote "*The light has a strong influence on the habitat. In the same species, the shape, thickness, and length of the trunk depend largely on lighting. The differences between the typical shape of the trees growing in close formation and in open space are caused by varying light intensity in these conditions.* ***Lone standing trees have at their disposal both overhead and side light. So they develop a broad, large, and lowly embedded crown. Their growth is slower at the top and the lower part of the trunk is significantly thicker than the upper.*** *Trees growing in close formation are much less illuminated, they have their peaks pointing upward toward the light, they become long and slender and their crowns are set high and relatively small. Low-lying branches in close formation die due to inadequate access to light, have poor assimilation, are undernourished, create narrower rings of annual growth, and finally slowly die, wither and fall off. In general, it can be stated that with increasing close formation, and side shading, the length and the size of the crowns decrease, the thickness of trees decrease, the trunks become fuller and with lesser branches."*

In addition, it must be acknowledged that trees during juvenile stage grow faster than when they are mature or senile, which is this research confirms.

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WYDZIAŁ INŻYNIERII KSZTAŁTOWANIA ŚRODOWISKA I GEODEZJI
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5. PHOTOGRAPHIC DOCUMENTATION

	
Photo. 1. Sample location.	Photo. 2. Prior to collecting the sample

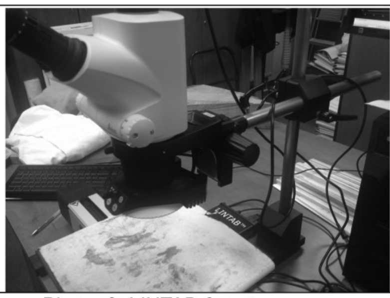
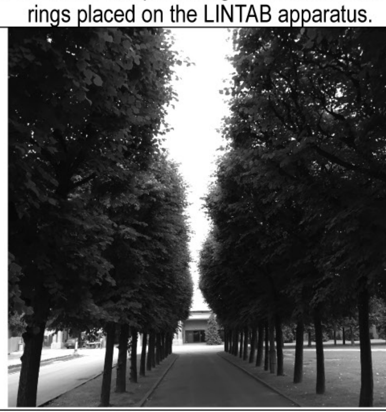



Photo. 3. LINTAB 6 test apparatus.	Photo. 4. Linden sample during measurement of annual rings placed on the LINTAB apparatus.
	
Photo. 5. Traces of intense molding visible in the crowns.	Photo. 6. Compositional pattern in which the linden grew.

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Wrocław, 2.07.2015

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7.

Archival materials

7. Archival materials

Archival materials concerning the Centennial Hall are stored in different institutions: libraries, archives and museums in Wrocław, Erkner near Berlin, Berlin and Munich. These documents entail the construction of the facility, cartographic materials, Implementation designs and detailed drawings, construction bidding materials, Centennial Hall's descriptions, press materials (newspaper clippings), and iconographic materials, including pictures.

The most important materials and main Implementation designs from the construction period are located in the archives at the Museum of Architecture in Wrocław – Building Archive of the City of Wrocław (Muzeum Architektury we Wrocławiu – Archiwum Budowlane Miasta Wrocławia), and the Leibniz Institute for Research on Society and Space in Erkner near Berlin (Leibniz-Institut für Raumbezogene Sozialforschung – IRS, formerly Leibniz-Institut für Regionalentwicklung und Strukturplanung), the National Archives in Wrocław (Archiwum Państwowe we Wrocławiu), the archives of the Deutsches Museum in Munich (Deutsches Museum von Meisterwerken der Naturwissenschaft und Technik München) and the National Museum in Wrocław (Muzeum Narodowe we Wrocławiu) and University Library in Wrocław (Biblioteka Uniwersytecka we Wrocławiu) – Graphics Collection Department and Silesiaca and Lusatica Collection Department (formerly Department of Silesia and Lausitz regions).

Museum of Architecture in Wrocław – Building Archive of the City of Wrocław (Muzeum Architektury we Wrocławiu – Archiwum Budowlane Miasta Wrocławia)

The archive includes projects from the period of construction of the Exhibition Grounds and the Centennial Hall – the years of 1910–1913, as well as Implementation designs and architectural drawings of later reconstructions and small makeshift buildings prepared during the use of the Exhibition Grounds for exhibitions, meetings, sports and artistic events. These Implementation designs come from the years of 1914–1940. The materials are sometimes accompanied by static calculations and structural short descriptions.

Plans and drawings from the Building Archive of the City of Wrocław come from the former Construction Inspector of the City of Wrocław (Baupolizei) and the Implementation design studio of Building Deputation of Wrocław, the Construction Counselor's Office, then Max Berg (Baudeputation, Büro Stadtbaurat Berg). The most important point of this study includes drawings of the Centennial Hall approved for implementation by the Mayor of Wrocław, Wrocław Municipality and the Construction Inspector.

All the resources concering Centennial Hall have been digitized and are being gradually introduced to the website http:, , ma.wroc.pl, archiwum-budowlane-zbiory.html. All architectural documentation of the Centennial Hall is on the lists.

National Archives in Wrocław (Archiwum Państwowe we Wrocławiu – APWr)
Materials related to the Centennial Hall are located in the files of “Akta miasta Wrocławia” (AmW), mainly in two sections: Section 21 – Construction and Section 59 – “Die Jahrhunderthalle”.

Section 21 – Construction
This section includes 59 files (envelopes), mainly containing documents concerning the issues of construction and facility equipment of the Exhibition Grounds and Centennial Exhibition in 1913, organizational matters of the exhibitions, including press releases (clippings), writings of architects and artists, city officials and city and regional authorities. The files also contain materials related to tender competitions for construction work, processes and the work of two construction committees – Centennial Exhibition and Centennial Hall. The most important are files concerning only the Centennial Hall, but also the files on both the pavilions and the make-shift buildings for the Centennial Exhibition, the Pergola and the Four Dome Pavilion adjacent to the Centennial Hall – due to conservation and protection issues from the perspective of this study. Individual Implementation designs and drawings, including construction drawing are also included in the descriptive materials. Analysis of folder titles reveal that records are incomplete, for example, “Festhale” numbered according to volumes, should include documents from volume 1 to at least volume 27. There are deficiencies of: “Band” 1–3, 19–21 and 26. Likewise, other units of the section are missing.

Section 59 – “Die Jahrhunderthalle”
The section contains 75 files dated 1913 to 1935, concerning use of the Centennial Hall, Exhibition Grounds, as well as the Breslauer Messe A.G. company. These materials also include drawings, newspaper clippings, occasionally iconographic materials related to the aforementioned issues, reparation documents, prepared exhibitions, details pertaining to the maintenance of the Exhibition Grounds and facilities located there. Materials relating to repairs of the Centennial Hall after 1936 are missing.

Leibniz Institute for Research on Society and Space in Erkner near Berlin (Leibniz-Institut für Raumbezogene Sozialforschung – IRS, formerly Leibniz-Institut für Regionalentwicklung und Strukturplanung)
The institute holds Implementation designs, architectural drawings and photographs of Max Berg from the whole period of his creative activity – dated 1891–1928 – in Szczecin, Wrocław and Berlin, including the period of his studies. These materials contain very important documents – one of the first conceptual Implementation designs of the Centennial Hall and the various incomplete possibilities for the future Centennial Hall. This collection is in the scientific IRS catalogue (Die Wissenschaftlichen sammlungen des IRS), in section “C” of the legacies and personal details resources (Nachlaß und persönliche Bestand). In addition to Centennial Hall Implementation design drawings, very important from the CMP point of view, include also completed and uncompleted expansion and reconstruction plans of the Exhibition Grounds signed by Max Berg and dated 1919–1925, as well as photographs from the period of construction and opening of the Centennial Exhibition. The institute has digitalized 198 records and presents them on the website: http://www.digipeer.de/index.php?sf=0&al=%22Nachlass+Max+Berg%22. The legacy of Max Berg is probably a collection of his achievements previously stored at the Akademie für Stadtbau in Berlin, which is the institution Max Berg was chairman of in the 1930’s. These materials were probably transported from Wrocław after 1925 following his resignation from the post of Construction Counselor.

National Museum in Wrocław (Muzeum Narodowe we Wrocławiu)
In the Documents Department of the National Museum in Wrocław there is a small but very valuable collection of glass slides from 1911, containing Implementation designs and concepts of the Centennial Hall, which Max Berg used during the presentation of his project to the Town Councilors and residents of Wrocław. These projects – combined with the archives of the Leibniz-Institut für Regionalentwicklung und Strukturplanung in Erkner near Berlin and the Building Archive of the City of Wrocław – enable a full restoration of the main phases of the Implementation design of Max Berg’s main work. In addition to these slides the museum holds photographs on the staging of Gerhart Hauptmann by Max Reinhardt’s at the Centennial Hall in 1913 and the iconography associated with the Exhibition of the Recovered Territories in 1948.

Deutsches Museum in Munich (Deutsches Museum von Meisterwerken der Naturwissenschaft und Technik München)
The Deutsches Museum in Munich archives hold the legacy of Max Berg, containing the architect's manuscripts, including his published and unpublished texts, papers, correspondence and biographical materials. The entire collection was developed and described in catalog number NL 050. This collection was donated to the archive in the 1970's by Max Berg's family. The collection includes the architect's Implementation designs from his whole creative period and high quality photographs. From the point of view of this publication the most valuable photographs concerning Centennial Hall from the construction period and 1913–1938, as well as unfinished reconstruction Implementation designs of the Exhibition Grounds from 1919–1924.

University Library in Wrocław (Biblioteka Uniwersytecka we Wrocławiu)
The Silesiaca and Lusatica Collection of the University Library in Wrocław holds printed sources – newspaper clippings, occasional prints, postcards from the period of construction of Centennial Hall and the opening and duration of the Centennial Exhibition, commemorative stamps, access cards and posters. All these materials originated from the former Stadtbibliothek. The library also collected regional magazines from 1910–1930, in which materials on the Centennial Hall were found, both written and iconographic ("Schlesische Zeitung", "Breslauer Zeitung", "Schlesien", "Ostdeutsche Bauzeitung", "Schlesische Heimatblätter", "Schlesische Monatshefte" and others).
The Graphic Collection Department stores original photographs from the period of construction of the Centennial Hall.

7.1. The National Archives in Wrocław (Archiwum Państwowe we Wrocławiu)

Szczytnicki Park and Horserace track
Szczytnicki Park and the surrounding plots with tagged buildings, plot numbers and names of owners [Situations-Plan von einem Theile der Feldmark von Alt-Scheitnig]. Linear scale in feet. 1863.03.23. Multi-colored drawing, silky tracing paper. National Archives in Wrocław (further referred to as: APWr), Akta miasta Wrocławia (further referred to as: AmW), call no. 25574 (III, 15146), chart 16.
Breslauer Festwoche exhibition outline organized at the Horserace track was used to determine ponds where gondolas could sail [Gelände für die Breslauer Festwoche – in the upper left corner. Zum Gondeln bestimmte Teichfläche – bottom right corner.]. Scale 1:1500. 1911.08.03. Richter. Ozalid, multi-colored drawing, APWr, AmW, call no. 25588 (III, 15160), chart 168.

Exhibition Grounds – general
Exhibition Grounds construction site. Advert placement on fences, samples [Bauzaun der Ausstellungshalle Reklame-Beschriftung.]. Scale 1:20. 1912.03. Berg. Ozalid, APWr, AmW, call no. 27449 (III, 17021), chart 164.
Centennial Hall and Exhibition Grounds bird's eye view, perspective drawing. Ausstelung zur Jahrhundertfeier der Freiheitskriege Breslau 1913 [Vogelschau des Geländes. *Prospekt Die Jahrhundertfeier der Freicheitskriege Breslau 1913.*]. 1913. Print. APWr, AmW, call no. 27452 (III, 17024), chart 279v.

Centennial Hall
Centennial Hall. Topographic map of the old Horserace track construction site [Lage und Höhenplan von der alten Rennbahn am Grüneicher Weg.]. Scale 1:100, 1:200. 1911.04.11. Schnabel. Ozalid, multi-colored drawing. APWr, AmW, call no. 27458 (III, 17030), chart 3.
Centennial Hall. Construction site range [Ausstellungshalle Lageplan.]. Scale 1:1500. 1911.09.06. Ozalid, multi-colored drawing. APWr, AmW, call no. 27456 (III, 17028), chart 55.
Centennial Hall. Plan, 1911, zoom on both sides of the entrances from the east, south and north bearing a red

color, 191.[Ausstellungshalle Breslau Grundriss Erdgeschoss.]. Scale 1:100. 1911.11. Ozalid, multi-colored drawing, APWr, AmW, call no. 27451 (III, 17023), chart 154.
Centennial Hall. Sketch of the outline of the stadium from the north. 1911 (?). Paper, multi-colored drawing. APWr, AmW, call no. 27476 (III, 17048), chart 4.
Centennial Hall. Outline of the Centennial Hall with the sports grounds marked in the north [Spiel und Sportplatz. Skizze 1.]. Scale 1:1500. 1912 (?). Ozalid. APWr, AmW, call no. 27476 (III, 17048), chart 246.
Centennial Hall. South side entrance hall, explication of façade [Ausstellungshalle Breslau Nebenaingangshalle. Vorderansicht u. Gürtelbauten.]. Scale 1:50. 1912.02.08. Berg, Konwiarz. Ozalid. APWr, AmW, call no. 27466 (III, 17038), chart 13.
Centennial Hall. The ceiling of the transformer room near the north side entrance [Ausstellungshalle Scheitnig. Decke im Transformatorenraum am Nordeingang.]. Scale 1:20. 1912.12.13. Lolat-Eisenbeton-Breslau. Ozalid, multi-colored drawing. APWr, AmW, call no. 27457 (III, 17029), chart 238.
Centennial Hall. The ceiling of the transformer room near the north side entrance [Schalt– und Transformatorenstation im Ostausgang der Festhalle. Ostausgang crossed-out and corrected to Nordausgang.]. Scale 1:20. 1912.09.12. Ozalid, multi-colored drawing. APWr, AmW, call no. 27457 (III, 17029), chart 239.
Centennial Hall. Transformer room plan [Transformatoren Raum am Ostausgang der Festhalle. Maßstab 1:10. Ostausgang crossed-out.]. 1912.09.12. Tracing paper, ink. APWr, AmW, call no. 27457 (III, 17029), chart 239a.
Centennial Hall. The ceiling of the transformer room near the north side entrance [Ausstellungshalle Scheitnig. Decke im Transformatorenraum am Nordeingang.]. Scale 1:20. 1912.12.23. Ozalid, multi-colored drawing. APWr, AmW, call no. 27457 (III, 17029), chart 240.
Centennial Hall. Arrangement of expansion joints in the ring closing the pillars [Austellungshalle, Breslau. Ausbildung der Dilatationen auf den Abschlussbögen.]. Scale 1:100. 1912.02.03. Dyckerhoff & Widmann. Tracing paper, multi-colored drawing. APWr, AmW, call no. 27454 (III, 17026), chart 36.
Centennial Hall. Sketch of reinforcement of the dome's lower tension ring. Scale n, a. 1912.03.12. Dyckerhoff & Widmann. Multi-colored drawing. APWr, AmW, call no. 27455 (III, 17027), chart 234.
Centennial Hall. Vertical cross-sections of the dome and apse cornices [Ausstellungshalle Breslau. Kuppel und Absidengesimse. Maßstab 1:10. Kuppel: 1. Ring. 2. Ring. 3. Ring. 4. Ring. Apside: Unt. Ring. Ob. Ring.]. Scale 1:10. 1912.03.07. Berg, Konwiarz. Ozalid. APWr, AmW, call no. 27461 (III, 17033), chart 150.
Centennial Hall. Plan and sections of the dome and apse corners [Ausstellungshalle Breslau. Eckenausbildungs der Absiden und Kuppelringe. Maßstab 1:10. Kuppel: 1. Ring. 2. Ring. 3. Ring. 4. Ring. 5. Ring. Apside: 1. Ring. 2. Ring.]. Scale 1:10. 1912.03.07. Berg, Konwiarz. Ozalid. APWr, AmW, call no. 27461 (III, 17033), chart 151.
Centennial Hall. Vertical cross-section of the cornice above the side entrance. Scale 1:1. 1912.03. Konwiarz. Paper, pencil. APWr, AmW, call no. 27461 (III, 17033), chart 154.
Centennial Hall. Vertical cross-section of cornice [Skizze für Gürtelbaugesims.]. Scale 1:1. 1912.02. Konwiarz. Paper, pencil. APWr, AmW, 27461 (III, 17033), chart 156.
Centennial Hall. Drawing (photographic reproduction of the drawing). Fragment of drawing of the western façade and main entrance. Black ink outline of reliefs on the cornice, inscription on both sides [Fest– und Ausstellungsshalle Breslau Haupteingangshalle Ansicht von Vorn.]. Scale 1:25. 1912. Berg. Photograph, ink. APWr, AmW, call no. 27455 (III, 17027), chart 91.
Centennial Hall. Sketch of the load bearing structure of the attic with bas-relief above the main entrance. Lack of scale. 1912.07.18. Berg. Multi-colored drawing. APWr, AmW, call no. 27455 (III, 17027), chart 281.
Centennial Hall. Plan of the polygonal room skylight [Oberlicht d. Polygonsaal. Skizze II. Nr. 117a.]. Scale 1:25. 1912.05.13. Berg, Konwiarz. Ozalid. APWr, AmW, call no. 27452 (III, 17024), chart 216.
Centennial Hall. Two cross-sections of the polygonal room skylight [Ausstellungshalle Breslau Oberlicht Polygonsaal, Schematische Darstellung. Schnitt A-B, Schnitt C-D. Nr. 117b.]. Scale 1:25. 1912.05. Konwiarz. Ozalid. APWr, AmW, call no. 27452 (III, 17024), chart 217.
Centennial Hall. Plan of four levels [Festhalle Breslau Gesamt-Grundriß. Erdgeschoss. Fundamente. Decken und Oberlichter. Obergeschoss. Apsiden– Kuppelaufbauten und Laterne. Obergeschoss. Apsiden– Kuppelnrippen und Verteifungsbänder. Obergeschoss.]. Scale 1:200. 1912.09. Berg, Trauer, Trentin. Ozalid. APWr, AmW, call no. 27464 (III, 17036), chart 80.

Centennial Hall. Male restroom adjacent to the main entrance, adjustment [Männerkloset am Haupteingang.]. Scale 1:25. 1912.11.04. Ozalid, multi-colored drawing. APWr, AmW, call no. 27453 (III, 17025), chart 48.
Centennial Hall. Diagrammatic plan of the skylight structure of Imperial Hall [2. Festhalle Breslau. Oberlicht des Empfangssaals. Nr. 235.]. Scale 1:25. 1913.01. Berg. Ozalid, multi-colored drawing. APWr, AmW, call no. 27453 (III, 17025), chart 167.
Centennial Hall. Technical drawing – detail of the apse window installation, cross-section [Austellungshalle Breslau. Fenster Detail des Logenabsatzes in den Absiden.]. Scale 1:10. 1913.04. Ozalid, multi-colored drawing. APWr, AmW, call no. 27453 (III, 17025), chart 83.
Centennial Hall. Plan, marked partition walls of the soloist room in the organ apse, and two variants of their appearance [Solistenräume der Orgelapside.]. Scale 1:100. 1913.02.19. Berg, Konwiarz, Kuhnot. Ozalid, multi-colored drawing. APWr, AmW, call no. 27454 (III, 17026), chart 58.
Centennial Hall. Sketch of reinforcement of the dome's lower tension ring. Lack of scale. 1912.03.12, 1912.04.04. Dyckerhoff & Widmann, Trauer. Multi-colored drawing. APWr, AmW, call no. 27455 (III, 17027), chart 232.
Centennial Hall. Diagram of skylights glass installation. Scale 1:1. 1913.03.08. Paper, ink. APWr, AmW, call no. 27456 (III, 17028), chart 132.
Centennial Hall. Imperial Hall – sketch marking the outline of pilaster strips on the pillars [Jahrhunderthalle – Breslau. Vertikale Leistenteilung im Empfangssaal.]. Scale 1:25. 1913.05.06. Berg, Konwiarz. Paper, pencil. APWr, AmW, call no. 27456 (III, 17028), chart 271.
Centennial Hall. Plan of dome's ribs showing the lighting points [Festhalle Breslau. Kuppelplan für die Beleuchtungsanlage.]. Scale 1:200. 1913.01.11. Konwiarz. Ozalid, pencil. APWr, AmW, call no. 27457 (III, 17029), chart 45.
Centennial Hall. Floral decoration arrangement of the stage at the opening of the Exhibition – Plan [Jahrhundert Halle Dekorat. Bei Eröffnung. D. Ausstellung am 20. Mai. 13.]. Scale 1:100. 1913.05.03. Berg. Paper, multi-colored drawing. APWr, AmW, call no. 27460 (III, 17032), chart 161.
Centennial Hall. Floral decoration arrangement of the stage at the opening of the Exhibition – cross-sectio [Dekorat. zur Eröffnung am 20. Mai. 13. Jahrhundert Halle Breslau. Ansicht.]. Scale 1:50. 1913.05.03. Berg. Paper, multi-colored drawing. APWr, AmW, call no. 27460 (III, 17032), chart 162.
Centennial Hall. Plan, September 1912, floodlight layout in stands. 1913.04.10. Ozalid, multi-colored drawing. APWr, AmW, call no. 27462 (III, 17034), chart 155.
Centennial Hall. Marked points for wood lining in the organ apse [Jahrhunderthalle Breslau. Holzverkleidung der Orgelapside.]. Scale 1:50. 1913.08.16. Konwiarz. Ozalid. APWr, AmW, call no. 7462 (III, 17034), chart 204.
Centennial Hall. Cross-section and plan of a music stand for the conductor [Jahrhunderthalle. Pult für den Dirigenten.]. Scale 1:10. 1913.06. Ozalid. APWr, AmW, call no. 27459 (III, 17031), chart 96.
Centennial Hall. Floor layout of the main entrance [Festhalle Breslau. Fussboden der Haupteingangshalle.]. Scale 1:25. 1913.01.13. Berg, Konwiarz. Ozalid. APWr, AmW, call no. 27465 (III, 17037), chart 135.
Centennial Hall. Construction project of Rabitz walls in rooms adjacent to the Imperial Hall [Rabitzwände des Empfagszimmers.]. Scale 1:15. 1913.02.06. Konwiarz. Paper, pencil. APWr, AmW, call no. 27466 (III, 17038), chart 107.
Centennial Hall. Amphitheater cross-section [Schnitt durch das Amphitheater. 1913.]. Berg. Tracing paper, pencil. APWr, AmW, call no. 27467 (III, 17039), chart 170.
Centennial Hall. Cross-sections of ceiling support concrete beam bypass and dilatation filling. Lolat-Eisenbeton-Breslau. 1916.05.23. Ozalid, multi-colored drawing. APWr, AmW, call no. 27523 (III, 17095), chart 48.
Centennial Hall. Plan, 1912, red lines show the existing ceiling expansion joints and wall bypasses existing in 1917. HUTA Hoch– und Tiefbau-Aktiengesellschaft Breslau. 1917.09.26. Ozalid, multi-colored drawing. APWr, AmW, call no. 27523 (III, 17095), chart 66.
Centennial Hall. Technical details of crack reinforcement [Jahrhunderthalle Breslau. Einzelheit über die Ausbildung der Dehnungsfugen in den Ringbauten.]. Scale 1:10. 1917.09.26. Ozalid, multi-colored drawing. APWr, AmW, call no. 27523 (III, 17095), chart 67.
Centennial Hall. Ground level plan of fire alarm installations. 1918 (?). Ozalid, multi-colored drawing. APWr, AmW, call no. 27481 (III, 17053), chart 66f.
Centennial Hall. Seat arrangement in the stands of the Centennial Hall, for a total of 6342 people [Jahrhunder-

thalle Breslau Bestuhlung.]. Scale 1:200. 1919.08.02. Berg. Tracing paper, pencil. APWr, AmW, call no. 27521 (III, 17093), chart 181.
Centennial Hall. Implementation design of poster board arrangement on the Hall's façade, signed by Berg, Bl. nr 29. Scale 1:50. 1919. Berg. Ozalid. APWr, AmW, call no. 35362, chart 99.
Centennial Hall. Poster board Implementation design, signed by Berg, Bl. nr 159, sketched construction details. Scale 1:10. 1919. Berg. Ozalid. APWr, AmW, call no. 35362, chart 100.
Centennial Hall. Poster board Implementation design, Berg, Bl. nr 159, sketched construction details. Scale 1:10. 1919. Berg. Ozalid. APWr, AmW, call no. 35362, chart 101.
Centennial Hall. Reconstruction for the purpose of creating office space on the right of the south side entrance [Zeichnung zur Einrichtung von Büroräumen im Südeingang rechts, der Jahrhunderthalle, Bauamt H.N. den 18. November 19.]. Schmiter Magistrats– Baurat. Scale 1:50. 1919.11.18. Ozalid, multi-colored drawing. APWr, AmW, call no. 35364, chart 23.
Centennial Hall. Reconstruction for the purpose of creating office space on the right of the south side entrance [Zeichnung zur Einrichtung von Büroräumen im Südeingang rechts, der Jahrhunderthalle, Bauamt H.N. den 18. November 19.]. Schmiter Magistrats– Baurat.Scale 1:50. 1919.11.18. Ozalid, multi-colored drawing. APWr, AmW, call no. 35364, chart 24.
Centennial Hall. Implementation design of a double window cash desk and posterboard near the main entrance to the Hall, signed by M. Berg, scale 1:25. 1919.11. Berg. Ozalid, multi-colored drawing. APWr, AmW, call no. 35364, chart 62.
Centennial Hall. Implementation design of a double window cash desk and poster board near the main entrance to Hall, Implementation design of KASSE superscription, signed by M. Berg, scale 1:10. 1919.11. Berg. Ozalid, multi-colored drawing. APWr, AmW, call no. 35364, chart 64.
Centennial Hall. Construction of a track and stands for a weekly cycling race. Scale 1:200. 1920.12. Ozalid. APWr, AmW, call no. 27522 (III, 17094), chart 283.
Centennial Hall. Construction of a track and stands for a weekly cycling race. Scale 1:200. 1920.12.14. Ozalid. APWr, AmW, call no. 27522 (III, 17094), chart 284.
Centennial Hall. Construction Implementation design for an intermediate ceiling on the east side of the south side entrance. C.H. Jerschke Company. Scale 1:50. 1920.10.02. Ozalid. APWr, AmW, call no. 27522 (III, 17094), chart 311.
Centennial Hall. Construction Implementation design for intermediate ceiling on the east side of the south side entrance. C.H. Jerschke Company. Scale 1:50. 1920.10.02. Ozalid. APWr, AmW, call no. 27522 (III, 17094), chart 316.
Centennial Hall. Plan of foyer near the east side entrance, high power electrical terminals [Skizze über die vorzunehmenden Bauarbeiter für Umänderung der Schaltanlage – Jahrhunderthalle.]. Scale 1:200. 1921.04.15. Tracing paper, pencil, crayon. APWr, AmW, call no. 35365, chart 105.
Centennial Hall. Implementation designation of spots for exhibition stands. Scale 1:600. 1917. Print, multi-colored drawing. APWr, AmW, call no. 35475, chart 345.
Centennial Hall. Approval for the stands arrangement with number of seats on the ground floor and balconies. 1912.12.24. Ozalid, multi-colored drawing. APWr, AmW, call no. 35344, chart 100.

Centennial Hall – Organs

Centennial Hall. Cross-section of the Organ stands [Festhalle Breslau Orgelbtribüne Schnitt durch die Mitte der Orgel.]. Scale 1:50. 1912.11. Berg, Konwiarz. Ozalid, multi-colored drawing. APWr, AmW, call no. 27456 (III, 17028), chart 228.
Centennial Hall. Horizontal plan of the organ apse, outline of the walls of the bellows motor room is marked in red [Festhalle Breslau Orgeltribüne Erdgeschoss.]. Scale 1:50. 1912.12. Berg, Konwiarz. Ozalid, multi-colored drawing. APWr, AmW, call no. 27456 (III, 17028), chart 230.
Centennial Hall. Main Organs, partial organ view and plan [Stamp of W. Sauer Orgelbauanstalt Inhaber – bottom right, signed by Paul Walcker, Frankfurt d. 7. Jan. 1913.]. Scale 1:15. 1913.01.07. Walcker. Tracing paper, pencil. APWr, AmW, call no. 27563 (III, 17135), chart 164.

Centennial Hall. Remote Organs (Fernorgel), organ view and cross-section [Fernwerk auf dem Kuppelring, der Hauptorgel gegenüber. Stamp of W. Sauer Orgelbauanstalt Inhaber – bottom right, signed by Paul Walcker, Frankfurt a.O. d. 7. Jan. 1913.]. Scale 1:50. 1913.01.07. Walcker. Ozalid, multi-colored drawing. APWr, AmW, call no. 27563 (III, 17135), chart 170.
Centennial Hall. Remote Organs (Fernorgel), organ view and cross-section, location of the bellows motor [Fernwerk auf dem Kuppelring, der Hauptorgel gegenüber.]. Scale 1:50. 1913.01.07. Walcker. Ozalid, multi-colored drawing. APWr, AmW, call no. 27563 (III, 17135), chart 171.
Centennial Hall. Main Organs, horizontal plan of the Main Organs [Orgelraum Festhalle Breslau. Blatt No. 203 – in the upper right; stamp of W. Sauer Orgelbauanstalt Inhaber – bottom right, signed by Paul Walcker, Frankfurt a.O. d. 7. Jan. 1913.]. Scale 1:50. 1913.01.07. Walcker. Ozalid, multi-colored drawing. APWr, AmW, call no. 27563 (III, 17135), chart 172.
Centennial Hall. Main Organs, vertical section of the organ apse with table [Breslau Festhalle Orgelraum. Blatt Nr. 204. Stamp of W. Sauer Orgelbauanstalt Inhaber – bottom right, signed by Paul Walcker, Frankfurt a.O. d. 7. Jan. 1913.]. Scale 1:50. 1913.01.07. Walcker. Ozalid, multi-colored drawing. APWr, AmW, call no. 27563 (III, 17135), chart 173.
Centennial Hall. Remote Organs (Fernorgel), cross-section of the remote organs (Fernorgel) [Stamp of W. Sauer Orgelbauanstalt Inhaber – bottom right, signed by Paul Walcker.]. Ozalid, multi-colored drawing. APWr, AmW, call no. 27563 (III, 17135), chart 187.
Centennial Hall. Remote Organs (Fernorgel), plan and sections [Fernwerk auf dem Kuppelring, der Hauptorgel gegenüber. Maßstab 1:50. Blatt Nr. 206. Stamp of W. Sauer Orgelbauanstalt Inhaber – bottom right, signed by Paul Walcker, Frankfurt a.O. d. 7. Jan. 1913.]. 1913.01.07. Walcker. Ozalid, multi-colored drawing. APWr, AmW, call no. 27563 (III, 17135), chart 188.
Centennial Hall. Remote Organs (Fernorgel), details of wind beam and bellows [Blatt 119, Maßstab 1:50. Stamp of W. Sauer Orgelbauanstalt Inhaber – bottom right, Paul Walcker.]. 1913.01.29. Walcker. Ozalid, multi-colored drawing. APWr, AmW, call no. 27563 (III, 17135), chart 189.
Centennial Hall. Balcony for Remote Organs (Fernorgel), cross-section and plan [Jahhundert-Halle, Breslau. Orgelfernwerk auf dem Kuppelring der Hauptorgel gegenüber.]. Scale 1:25. 1913.04.16. APWr, AmW, call no. 27461 (III, 17033), chart 261.

Centennial Hall – Rows of Linden
Centennial Hall. Rows of Linden. Planting Implementation design. Scale 1:1000. 1914.11.07. Richter. Ozalid, multi-colored drawing. APWr, AmW, call no. 35389, chart 80.
Centennial Hall. Rows of Linden. Planting Implementation design. Scale 1:1000. 1914.11.07. Richter. Ozalid, multi-colored drawing. APWr, AmW, call no. 35389, chart 81.
Centennial Hall. Rows of Linden. Linden trees planting Implementation design (incomplete version), by Richter, scale 1:5000. 1918.11.03. Richter. Ozalid, multi-colored drawing. APWr, AmW, call no. 35384, chart 285.
Centennial Hall. Rows of Linden. Linden trees planting Implementation design (incomplete version), by Berg. Scale 1:5000. 1919. Berg. Ozalid, multi-colored drawing. APWr, AmW, call no. 35385, chart 4.
Centennial Hall. Rows of Linden [Gartenanlage an der Jahrhunderthalle.]. Plantings Implementation design on Breslau Plan, in February 1919, signed on August 14, 1922 by Richter's Gardens Director. Scale 1:500. 1922.08.14. Richter. Ozalid, multi-colored drawing. APWr, AmW, call no. 35358, chart 14.

The Four Dome Pavilion – Historical Exhibition Pavilion.
Four Dome Pavilion. Construction outline of screening walls, cross-section [Ausmauerung der Umfassungswände.]. Scale 1:10. 1912.09. Ozalid, multi-colored drawing. APWr, AmW, call no. 27478 (III, 17050), chart 61.
Four Dome Pavilion. Sewage and drainage channels [Regenwasserableitung vom Ausstellungsgebäude usw., wie sie nach den Forderungen von K.W. ausfallen würde.]. Scale 1:1000. 1912.12.14. Ozalid, multi-colored drawing. APWr, AmW, call no. 27478 (III, 17050), chart 164.
Four Dome Pavilion. Female restroom plan [Abortanlage für Dame nam Eingangssaal.]. Scale 1:50. 1912.10.08. Ozalid. APWr, AmW, call no. 27478 (III, 17050), chart 270.

Four Dome Pavilion. North-Western part of the Pavilion [Grundriss zur statischen Berechnung für die Eisenbetonkonstruktionen zum Neubau des historischen Ausstellungs– Gebäudes zu Breslau.]. Scale 1:100. 1912.09.12. Ozalid. APWr, AmW, call no. 27478 (III, 17050), chart 274.

Four Dome Pavilion. North-Western part of the Pavilion [Grundriss zur statischen Berechnung für die Eisenbetonkonstruktionen zum Neubau des historischen Ausstellungs– Gebäudes zu Breslau.]. Scale 1:100. 1912.09.12. Ozalid. APWr, AmW, call no. 27478 (III, 17050), chart 274b.

Four Dome Pavilion. Northern part of the Pavilion [Grundriss des Gebäudes für die historische Ausstellung zu Breslau.]. Scale 1:100. 1912.07. Ozalid. APWr, AmW, call no. 27478 (III, 17050), chart 275.

Four Dome Pavilion. Southern part of the Pavilion [Grundriss des Gebäudes für die historische Ausstellung zu Breslau.]. Scale 1:100. 1912.07. Ozalid. APWr, AmW, call no. 27478 (III, 17050), chart 276.

Four Dome Pavilion. Plan [Grundriss des Gebäudes für die historische Ausstellung zu Breslau.]. Scale 1:194. 1912. Ozalid. APWr, AmW, call no. 27478 (III, 17050), chart 277.

Four Dome Pavilion. Outline of the pavilion with marked levels [Höhenplan der Strasse an der Nord– u. Westseite des Ausstellungsgebäudes.]. Scale 1:200. 1912.12.14. Poelzig. Tracing paper, pencil. APWr, AmW, call no. 27479 (III, 17051), chart 11.

Four Dome Pavilion. Description of rooms, marked locations of fire hydrants [Grundriß des ständigen Ausstellungsgebäudes der Stadt Breslau. Mit Einteilung der historischen Ausstellung zur Jahrhundertfeier der Freiheitskriege.]. Scale 1:200. 1912. Ozalid. APWr, AmW, call no. 27479 (III, 17051), chart 20.

Four Dome Pavilion. Heating system [Ausstellungs-Gebäude Breslau.]. Scale 1:200. 1912. Ozalid. APWr, AmW, call no. 27479 (III, 17051), chart 70f.

Four Dome Pavilion. Heating system [Grundriß des ständigen Ausstellungsgebäudes der Stadt Breslau. Mit Einteilung der historischen Ausstellung zur Jahrhundertfeier der Freiheitskriege.]. Scale 1:200. 1912. Ozalid. APWr, AmW, call no. 27479 (III, 17051), chart 112.

Four Dome Pavilion. Roof and attic cross-section – illustration of roofing paper installation [Details der Dacheindeckung.]. Scale 1:10. 1912.10.16. Ozalid, multi-colored drawing. APWr, AmW, call no. 27479 (III, 17051), chart 243.

Four Dome Pavilion. Restrooms [Abortanlagen.]. Scale 1:50. 1912.12.03. Ozalid, multi-colored drawing. APWr, AmW, call no. 27480 (III, 17052), chart 297.

Four Dome Pavilion. Plan of cross-sections of individual foundation footings at the level of foundations [Ausstellungshalle Breslau. Abrechnungszeichnung. Fundamente.]. Scale: varied. 1913. Ozalid. APWr, AmW, call no. 27479 (III, 17051), chart 271.

Four Dome Pavilion. Fountain – cross-section. Marked elements to be made of reinforced concrete, pencil sketches of Poelzig on the drawing. Scale 1:10. 1913. Poelzig. Ozalid, pencil. APWr, AmW, call no. 27480 (III, 17052), chart 4.

Four Dome Pavilion. Electric powers system [Grundriß des ständigen Ausstellungsgebäudes der Stadt Breslau. Mit Einteilung der historischen Ausstellung zur Jahrhundertfeier der Freiheitskriege.]. Scale 1:200. 1913. Ozalid, ink. APWr, AmW, call no. 27480 (III, 17052), chart 285.

Four Dome Pavilion. Fire alarm ladders diagram [Neubau Ausstellungshalle Ausschreibung Feuerleitern.]. Scale 1:20. 1913.01. Tracing paper, pencil. APWr, AmW, call no. 27478 (III, 17050), chart 114.

Four Dome Pavilion. Restroom layout details [Detailzeichnung für die Abortanlagen.]. Scale 1:50. 1913.06. Ozalid, multi-colored drawing. APWr, AmW, call no. 27480 (III, 17052), chart 295.

Four Dome Pavilion. Restroom layout details [Detailzeichnung für die Abortanlagen.]. Scale 1:50. 1913.06. Ozalid, multi-colored drawing. APWr, AmW, call no. 27480 (III, 17052), chart 296.

Four Dome Pavilion. Restroom layout details [Detailzeichnung für die Abortanlagen.]. Scale 1:50. 1913.06. Ozalid, multi-colored drawing. APWr, AmW, call no. 27480 (III, 17052), chart 316.

Four Dome Pavilion. Restroom [Vorgesehen Abortanlagen, 2 Stück.]. Scale 1:50. 1913.12. Ozalid, multi-colored drawing. APWr, AmW, call no. 27480 (III, 17052), chart 317.

Four Dome Pavilion. Columns and corner (north-west), which should be reinforced. Scale 1:200. 1913.12.15. Ozalid, multi-colored drawing. APWr, AmW, call no. 27480 (III, 17052), chart 323.

Four Dome Pavilion. Plan. Scale 1:100. 1913. Ozalid, multi-colored drawing. APWr, AmW, call no. 27480 (III, 17052), chart 341.

Four Dome Pavilion. Cross-section through the north wing. Scale 1:100. 1913. Ozalid, multi-colored drawing. APWr, AmW, call no. 27480 (III, 17052), chart 347.
Four Dome Pavilion. Cross-section through the dome of the east wing. Scale 1:100. 1913. Ozalid, multi-colored drawing. APWr, AmW, call no. 27480 (III, 17052), chart 348.
Four Dome Pavilion. Cross-section through the dome of the side wing. Scale 1:100. 1913. Ozalid, multi-colored drawing. APWr, AmW, call no. 27480 (III, 17052), chart 349.
Four Dome Pavilion. Cross-section through the side wings. Scale 1:100. 1913. Ozalid, multi-colored drawing. APWr, AmW, call no. 27480 (III, 17052), chart 350.
Four Dome Pavilion. Cross-section through the dome of the north wing. Scale 1:100. 1913. Ozalid, multi-colored drawing. APWr, AmW, call no. 27480 (III, 17052), chart 351.
Four Dome Pavilion. Façade of the north wing as seen from the courtyard. Scale 1:100. 1913. Ozalid, multi-colored drawing. APWr, AmW, call no. 27480 (III, 17052), chart 352.
Four Dome Pavilion. Historical and artistic exhibition pavilion showing interior lighting. Scale 1:200. 1913. Ozalid, multi-colored drawing. APWr, AmW, call no. 27579 (III, 17151), chart 250.
Four Dome Pavilion. Historical and artistic exhibition pavilion showing interior lighting. Scale 1:100. 1912, 1913. Ozalid, multi-colored drawing. APWr, AmW, call no. 27579 (III, 17151), chart 251.
Four Dome Pavilion. Electric power system. Scale 1:200. 1914.07.08. Ozalid, multi-colored drawing. APWr, AmW, call no. 35386, chart 111–112.
Four Dome Pavilion. Implementation designation of places that require repair. Scale 1:200. 1913, 1917. Ozalid, multi-colored drawing. APWr, AmW, call no. 27481 (III, 17053), chart 51f.
Four Dome Pavilion. Exhibition spots. Scale 1:500. 1917. Print, multi-colored drawing. APWr, AmW, call no. 35475, chart 346.
Four Dome Pavilion. Electric sockets, scale 1:500. 1922 (?). Print, multi-colored drawing. APWr, AmW, call no. 35365, chart 64.

Terrace Restaurant
Terrace Restaurant. Plans and cross-sections. Scale 1:100. 1912. Ozalid. APWr, AmW, call no. 27453 (III, 17025), chart 63–65.
Terrace Restaurant. Façade of the Terrace Restaurant in the background of Centennial Hall, Terrace Restaurant plan, cross-section of the Hall and Terrace Restaurant to the edge of the Pond [Festhallerestaurant.]. Scale 1:500. 1912.06.05. Berg. Ozalid. APWr, AmW, call no. 27476 (III, 17048), chart 130.
Terrace Restaurant. Arrangement of restaurant tables and beer gardens [Festhallenrestaurant Erdgeschoss. Blatt 2.]. Scale 1:200. 1912.08.01. Berg. Ozalid. APWr, AmW, call no. 27516 (III, 17088), chart 101.
Terrace Restaurant. Plans and sections [Terrassen-Restaurant. Maßstab 1:200.]. 1912.11.06. Ozalid. APWr, AmW, call no. 27579 (III, 17151), chart 236.
Terrace Restaurant. Implementation design of kitchen appliances with equipment from Gebrüder Roeder, Darmstadt. Scale 1:50. 1913.04.04. Ozalid. APWr, AmW, call no. 27516 (III, 17088), chart 14.
Terrace Restaurant. Cellar and location of Centennial Hall's central heating system. Scale 1:100. 1913. Ozalid, multi-colored drawing. APWr, AmW, call no. 27453 (III, 17025), chart 66.
Terrace Restaurant. Implementation design for a dual arm candelabra. Scale 1:10. 1913.04.13. Berg. Ozalid, pencil. APWr, AmW, call no. 27516 (III, 17088), chart 85.
Terrace Restaurant. Implementation design for candelabra [Kandelaber am Restaurant Verstärkung des Ausladenfusses. Mat. G.]. Scale 1:10. 1913.07.17. Berg. Tracing paper, pencil, tempera paint. APWr, AmW, call no. 27516 (III, 17088), chart 86.
Terrace Restaurant. Roofing of the terrace opening [Terassenueberdachung auf dem Ausstellungsgelände der Stadtbauamtsaustellung in Breslau. Gebr. Casse Frankfurt a. M.]. 1913.05.08. Ozalid. APWr, AmW, call no. 27516 (III, 17088), chart 172.
Terrace Restaurant. Beer garden tent [Bierzelt auf dem Ausstellungsgelände der Stadtbauamtsaustellung in Breslau. Gebr. Casse Frankfurt a. M.]. 1913.05.13. Ozalid, multi-colored drawing. APWr, AmW, call no. 27516 (III, 17088), chart 173.

Terrace Restaurant. Stepped base of the tambour lantern and flower box layout. Festhallerestaurant. Blumenkästen auf der Kuppel.]. Scale 1:50. 1913.03. Ozalid. APWr, AmW, call no. 27516 (III, 17088), chart 220.
Terrace Restaurant. Kitchen installation in the western wing of the restaurant [Westliche Ausgabe Festhallen Restaurant.]. 1913.01.04. Tracing paper, pencil. APWr, AmW, call no. 27516 (III, 17088), chart 221.
Terrace Restaurant. Implementation design for an oval wooden pavilion for the orchestra [Zeichnung zur Herstellung von zwei runden Musikorchestern für die Stadt Breslau Ausstellung 1913.]. 1913.03.03. Ozalid. APWr, AmW, call no. 27516 (III, 17088), chart 281.
Terrace Restaurant. Construction sketch of the vestibule on the axis from the south and north. 1915.09.28. Ozalid, multi-colored drawing. APWr, AmW, call no. 27517 (III, 17089), chart 76.
Terrace Restaurant. Construction sketch of wooden partitions on a side staircase. 1915. Ozalid. APWr, AmW, call no. 27517 (III, 17089), chart 76f.
Terrace Restaurant. Construction sketch of the vestibule on the axis from the south and north. 1915. Ozalid. APWr, AmW, call no. 27517 (III, 17089), chart 79.

The Pergola and pond

Pergola. The cross section of the pond [Ausstellung. Dichtung des Wasserbecken. Two drawings on a board. Gesamtfläche des Wasserbeckens Maßstab, 1:500. Detail der Beckenkante, Maßstab 1:20.]. 1912.08.09. Ozalid. APWr, AmW, call no. 27453 (III, 17025), chart 250a.
Pergola. Pond with fountain nozzle arrangement, horizontal plan [Skizze für die Springbrunnen im Wasserbecken. Maßstab 1:400.]. 1912.08.19. Berg. Ozalid. APWr, AmW, call no. 27453 (III, 17025), chart 250.
Pergola. Sketch of fountains on the pond [Skizze für die Springbrunnen im Wasserbecken.]. Scale 1:200. 1912.12.12. Berg. Ozalid. APWr, AmW, call no. 27453 (III, 17025), chart 249.
Pergola. Pond, wall buttress at the restaurant [Wasserbecken auf dem Ausstellungsgelände. Böschungsmauer vor dem Restaurant.]. Scale 1:20. 1912.09.03. Ozalid. APWr, AmW, call no. 27476 (III, 17048), chart 125.
Pergola. Pond, horizontal plan. Scale 1:400. 1912.05.04. Poelzig. Ozalid. APWr, AmW, call no. 27476 (III, 17048), chart 126.
Pergola. Pond, cross-section. Scale 1:200. 1912.05.21. Richter. Ozalid. APWr, AmW, call no. 27476 (III, 17048), chart 127.
Pergola. Pond and stairs. Scale 1:1000. 1912.06.15. Poelzig. Ozalid. APWr, AmW, call no. 27476 (III, 17048), chart 128.
Pergola. Cross-section through the Pergola and the pond marking the position of shrubs [Gartenbauausstellnug Breslau 1913. Schnitt durch die Böschungen von der Pergola bis zum Wasserbecken.]. Scale 1:100. 1912.06.10. Berg. Ozalid. APWr, AmW, call no. 27476 (III, 17048), chart 129.
Pergola. Cross-section through the Pergola and pond with shrubs marked and adjustments in red made on 08.06.1912 [Gartenbauausstellnug Breslau 1913. Schnitt durch die Böschungen von der Pergola bis zum Wasserbecken.]. Scale 1:100. 1912.06.08. Ozalid, multi-colored drawing. APWr, AmW, call no. 27476 (III, 17048), chart 131.
Pergola. Centennial Hall, Terrace Restaurant and pond, cross-section. Scale 1:200. 1912. Ozalid. APWr, AmW, call no. 27476 (III, 17048), chart 132.
Pergola. Pond, water draining valves, cross-section. Scale 1:500, 1:20. 1912. Ozalid. APWr, AmW, call no. 27476 (III, 17048), chart 180.
Pergola. Pergola and pond, horizontal plan [Wasserbecken mit Pergola.]. Scale 1:1000. 1913. Ozalid, multi-colored drawing. APWr, AmW, call no. 27459 (III, 17031), chart 45.
Pergola and pond. Cross-section [Wasserbecken mit Pergola. Profil.]. Scale 1:100. 1913. Ozalid, multi-colored drawing. APWr, AmW, call no. 27459 (III, 17031), chart 47.
Pergola. Pergola, plan and cross-section of concrete stairs [Austellungsgelände in Scheitnig. Anordnung der Fundamente für die Treppen 6–15. Breslau, im März 1913, stamp of Beton– und Cementwarenfabrik Guido Simon, G.m.b.H. Zum Br. R. 26.3.13.]. 1913.03.26. Ozalid. APWr, AmW, call no. 27575 (III, 17147), chart 189.
Pergola. Cross-section of the stairs [Ausstellung in Scheitnig Treppenstufen. Maßstab 1:5. Breslau, im Februar 1913, stamp of Beton– und Cementwarenfabrik Guido Simon, G.m.b.H.]. 1913.02. Tracing paper, pencil. APWr, AmW, call no. 27575 (III, 17147), chart 190.

Pergola. Cross-section of the stairs [Treppenstufen für das Ausstellungsgelände in Scheitnig. Maßstab 1:4. Breslau, den 21.2.1913, stamp of Lolat-Eisenbeton-Breslau.]. 1913.03.21. Ozalid. APWr, AmW, call no. 27575 (III, 17147), chart 191.
Pergola. Cross-section of the stairs, mixed hollow brick construction [Ausstellung in Scheitnig Treppenstufen. Maßstab 1:5. Breslau im Februar 1913, stamp of: Beton– und Cementwarenfabrik Guido Simon, G.m.b.H.]. 1913.02. Tracing paper, pencil. APWr, AmW, call no. 27575 (III, 17147), chart 194.
Pergola. Column pillars pedestals and stairs with marked gradelines [Festhalle Pergola rechte Hälfte, Maßstab 1:100.]. 1913. Tracing paper, pencil. APWr, AmW, call no. 27575 (III, 17147), chart 164.
Pergola. Implementation design for gable roof over the flower boxes of the horizontal beams of the Pergola [Jahrhundert – Ausstellung Schutzdach für die Blumenkästen der Pergola. Breslau im August 1913. Stamp of: Gustaw Hossenfelder Zimmermeister Breslau.]. 1913.08. Tracing paper, pencil, drawing in monochrome. APWr, AmW, call no. 27576 (III, 17148), chart 225.
Pergola. Cross-section of neighboring columns of the Pergola and installation system diagram of the electrical box base [Skizze über die Unterbringung der Schalttafel in dem Säulensockel der Pergola. Maßstab 1:100.]. 1912. Tracing, pencil. APWr, AmW, call no. 27580 (III, 17152), chart 10.
Pergola. Pergola pond with marked gradelines and cross-sections of buttresses [Maßstab 1:400. Breslau, Mai 1912, Poelzig.]. 1912.05.04. Poelzig. Ozalid. APWr, AmW, call no. 27580 (III, 17152), chart 18.
Pergola. Pergola pond with marked gradelines and cross-sections of buttresses [Maßstab 1:400. Breslau, Mai 1912, Poelzig.]. 1912.05.04. Poelzig. Ozalid. APWr, AmW, call no. 27580 (III, 17152), chart 19.
Pergola. Entablatures of the Pergola near the crossing through the colonnade leading to the entrance of the Historical and Artistic exhibition pavilion [Lösung B. Festhalle – Scheitnig. Pergola. Maßstab 1:100. Bauamt H.O. II der 25. Oktober 1912.]. 1912.12.25. Paper, multi-colored drawing. APWr, AmW, call no. 27580 (III, 17152), chart 53.
Pergola. Entablatures of the Pergola near the crossing through the colonnade leading to the entrance of the Historical and Artistic exhibition pavilion [Lösung A. Festhalle – Scheitnig. Pergola. Maßstab 1:100. Bauamt H.O. II der 25 Oktober 1912.]. 1912.12.25. Paper, multi-colored drawing. APWr, AmW, call no. 27580 (III, 17152), chart 54.
Pergola. Transverse beam section showing reinforcements. Pergola (Scheitnig) [Detail des Betonbalken über dem Blumentrog. Maßstab 1:10. Breslau, den 30 Sept. 1912. Stamp of: Beton– u. Eisenbetonbau Pfeffer Pringsheim & Co.]. 1912.09.30. Ozalid, multi-colored drawing. APWr, AmW, call no. 27580 (III, 17152), chart 55.
Pergola. Implementation design for concrete transverse beams for the Pergola [Pergola (Scheitnig). Detail des Betonbalken über dem Blumentrog. Maßstab 1:10. Breslau, den 30 Sept. 1912.]. 1912.09.30. Ozalid. APWr, AmW, call no. 27580 (III, 17152), chart 162.
Pergola. Detail of the wooden entablature joints of the Pergola [Pergola (Scheitnig). Maßstab 1:5.]. 1912 (?). Paper, pencil. APWr, AmW, call no. 27580 (III, 17152), chart 88.
Pergola. Catwalk between Centennial Hall and the Terrace Restaurant [Festhalle Breslau. Anschluss des Nordeinganges an Restaurant und Pergola. Maßstab 1:50. Nr. 176 – bottom left. Konwiarz 2.11.12. – bottom right, Breslau 2. Nov. 1912. Der Stadtbaurat, signed by Berg.]. Roof span sketch adjustment in the Ozalid print, the original roof was to cover all three naves, following adjustments only the middle was covered. 1912.11.02. Berg, Konwiarz. Ozalid, multi-colored drawing. APWr, AmW, call no. 27580 (III, 17152), chart 103.
Pergola. Catwalk between Centennial Hall and the Terrace Restaurant. No signature and date. 1913. Paper, pencil, crayon. APWr, AmW, call no. 27580 (III, 17152), chart 98.
Pergola. Catwalk between Centennial Hall and the Terrace Restaurant. Perspective drawing, diagram of roof structure [Pergola Scheitnig Maßstab 1:20. 1913. Ozalid, multi-colored drawing. APWr, AmW, call no. 27580 (III, 17152), chart 104.
Pergola. Suggestions on how to reinforce entablature boxes and dilatation. 1914 (?). Paper, pencil. APWr, AmW, call no. 27580 (III, 17152), chart 142.
Pergola. Repair of retaining wall of Pergola stairs to the north of the Terrace Restaurant. 1916 (?). Ozalid, multi-colored drawing. APWr, AmW, call no. 27485 (III, 17057), chart 175.
Pergola. Implementation design for metal railings between bays of the Pergola [Ausstellungsgelände Scheitnig – Drahtzaun in der Pergola, Maßstab 1:25. Signed by Berg, Konwiarz, drawing Nr. 122.]. 1921.11. Berg, Konwiarz. Ozalid, multi-colored drawing. APWr, AmW, call no. 35361 chart 90.

Pergola. Implementation design for metal fence with concrete posts south of the Hall and ticket office [Umwährung des Ausstelungsgeländes, Maßstab 1:15. Signed by Berg, Konwiarz. 1922. Berg, Konwiarz. Ozalid, multi-colored drawing. APWr, AmW, call no. 35361, chart 91.

Pavilion of the Association of Silesian Artists (Künstlerbund Schlesien)

Pavilion of the Association of Silesian Artists. Sewer connections [Ausstellungsgelände Verwaltungsgebäude Lageplan 1:100. Bauamt H.O. II, 22 Oktober 1912.]. 1912.10.22. Ozalid, multi-colored drawing. APWr, AmW, call no. 27612 (III, 17184), chart 32.

Pavilion of the Association of Silesian Artists. Plan of a building with office locations for the fire brigade, doctor, nurses and military police [Nachtragszeichnung zum Grundriss des Verwaltungsgebäudes Maßstab 1.100. Breslau Nov. 1912.Signed by Poelzig.]. 1912.11. Poelzig. Ozalid, multi-colored drawing. APWr, AmW, call no. 27575 (III, 17147), chart 88.

Pavilion of the Association of Silesian Artists. Plan [Kunstausstellungs– und Verwaltungsgebäude auf dem Festplatz in Scheitnig. Maßstab 1:1000. Bottom right: Breslau, Deutsch-Lissa im November 1912. Für die Ausführung. Stamp of Städt. Bauamt HO 2, Breslau, den 7 Dezember 1912.]. 1912.12.07. Ozalid, multi-colored drawing. APWr, AmW, call no. 27573 (III, 17145), chart 41.

Pavilion of the Association of Silesian Artists. Cross-section of the admistrative building of the Exhibition Grounds indicating the sewage system. Scale 1:100. 1913.01.07. Ozalid, multi-colored drawing. APWr, AmW, call no. 27573 (III, 17145), chart 27.

Pavilion of the Association of Silesian Artists. Façade [Kunstausstellungs– und Verwaltungsgebäude. Ansicht von der Grüneicher Chaussee. Bottom right, Breslau, Okt. 1912, stamps of: Städt. Bauamt HO 2, Breslau, den 7. Dezember 1912, Eduard Freytag, building inspector's approval, 10-ten Januar 1913.]. 1913.01.10. Ozalid, multi-colored drawing. APWr, AmW, call no. 27573 (III, 17145), chart 42.

Pavilion of the Association of Silesian Artists. Façade [Kunstausstellungs– und Verwaltungsgebäude. Vorder Ansicht. Maßstab 1:100.]. Perspective view of the building above the façade [Bottom right Breslau, Okt. 1912, stamps of: Städt. Bauamt HO 2, Breslau, den 7. Dezember 1912, Eduard Freytag, building inspector's approval, 10-ten Januar 1913.]. 1913.01.10. Ozalid, multi-colored drawing. APWr, AmW, call no. 27573 (III, 17145), chart 43.

Pavilion of the Association of Silesian Artists. Side façade [Kunstausstellungs– und Verwaltungsgebäude. Seitenansicht. Maßstab 1:100. Bottom right, Breslau, Okt. 1912, stamps of: Städt. Bauamt HO 2, Breslau, den 7. Dezember 1912, Eduard Freytag, building inspector's approval 10-ten Januar 1913.]. 1913.01.10. Ozalid, multi-colored drawing. APWr, AmW, call no. 27573 (III, 17145), chart 44.

Pavilion of the Association of Silesian Artists. Site location [Austellung 1913. Lageplan des Westlischen Festhallen Vorplatzes. Maßstab 1:1000. On the right: stamps of Städt. Bauamt HO 2, Breslau, den 7. Dezember 1912, Eduard Freytag, building inspector's approval, 10-ten Januar 1913.]. 1913.01.10. Ozalid, multi-colored drawing. APWr, AmW, call no. 27573 (III, 17145), chart 45.

Pavilion of the Association of Silesian Artists. Façade of the inner courtyard [Kunstausstellungs– und Verwaltungsgebäude. Ansicht vom Innenhof. Maßstab 1:100. Bottom right, Breslau Okt. 1912, signed by Poelzig. Stamps of: Städt. Bauamt HO 2, Breslau, den 7. Dezember 1912, building inspector's approval January 10 1913.]. 1913.01.10. Poelzig. Ozalid, multi-colored drawing. APWr, AmW, call no. 27573 (III, 17145), chart 46.

Pavilion of the Association of Silesian Artists. Postal agency in the administrative building [Postanlage im Verwaltungsgebäude. Maßstab 1:50. Bottom right, Breslau 28. Jan. 13, Poelzig. Below initials and date, 30.1.1913.]. 1913.01.30. Poelzig. Ozalid, multi-colored drawing. APWr, AmW, call no. 27573 (III, 17145), chart 71.

Pavilion of the Association of Silesian Artists. Water supply system construction [Be– und Entwässerungsanlage zum (Kunstausstellungs– und) Verwaltungsgebäude auf dem Festplatz in Scheitnig. Maßstab 1:1000. Breslau – Deutsch Lissa im Dezember 1912. Investor: Städt. Bauamt HO 2. Constructor: Eduard Freytag. Approval 13.1.1913, 15.1.1913.]. 1913.01.15. Ozalid, multi-colored drawing. APWr, AmW, call no. 27573 (III, 17145), chart 26.

Pavilion of the Garden Exhibition and the Rheingold restaurant

Pavilion of the Garden Exhibition. Rheingold restaurant, pland and cross-section, location of the meat storage room [Restaurant Rheingold.]. Scale 1:50. 1913. Tracing paper, pencil. APWr, AmW, call no. 27512 (III, 17084), chart 170.

Pavilion of the Garden Exhibition. Rheingold restaurant plan and cross-section, location of meat storage room [Restaurant Rheingold.]. Scale 1:50. 1913. Tracing paper, pencil. APWr, AmW, call no. 27512 (III, 17084), chart 171.
Pavilion of the Garden Exhibition. Rheingold restaurant, plan and cross-section, location of meat storage room. [Restaurant Rheingold.]. Scale 1:50. 1913. Ozalid. APWr, AmW, call no. 27512 (III, 17084), chart 178.
Pavilion of the Garden Exhibition. Rheingold restaurant, plan and cross-section, location of meat storage room. [Restaurant Rheingold.]. Scale 1:50. 1913. Ozalid. APWr, AmW, call no. 27512 (III, 17084), chart 179.
Pavilion of the Garden Exhibition. Rheingold restaurant plan and cross-section, location of meat storage room. [Restaurant Rheingold.]. Scale 1:50. 1913. Ozalid. APWr, AmW, call no. 27512 (III, 17084), chart 180.
Pavilion of the Garden Implementation Design Exhibition. Plan. Scale 1:100. 1913. Ozalid. APWr, AmW, call no. 27512 (III, 17084), chart 204.
Pavilion of the Garden Exhibition. Façades [Zeichnung zur Errichtung eines Weinrestaurant, Gartenbauaustellungshalle u. Schuppen auf dem Festplatz der Jahrhundertfeier in Breslau.]. Scale 1:100. 1913.01.28. Poelzig. Ozalid. APWr, AmW, call no. 27512 (III, 17084), chart 205.
Pavilion of the Garden Exhibition. Façades [Zeichnung zur Errichtung eines Weinrestaurant, Gartenbauaustellungshalle u. Schuppen auf dem Festplatz der Jahrhundertfeier in Breslau.]. Scale 1:100. 1913.01.28. Poelzig. Ozalid. APWr, AmW, call no. 27512 (III, 17084), chart 206.
Pavilion of the Garden Exhibition. Roof construction schematic drawing. Scale 1:100. 1913. Ozalid. APWr, AmW, call no. 27512 (III, 17084), chart 207.
Pavilion of the Garden Exhibition. Building frame structure schematic drawing. Scale 1:100. 1913. Ozalid. APWr, AmW, call no. 27512 (III, 17084), chart 208.
Pavilion of the Garden Exhibition. Building frame structure schematic drawing. Scale 1:100. 1913. Ozalid. APWr, AmW, call no. 27512 (III, 17084), chart 209.
Pavilion of the Garden Exhibition. Building frame structure schematic drawing. Various scales. 1913. Ozalid. APWr, AmW, call no. 27512 (III, 17084), chart 210.
Pavilion of the Garden Exhibition. Building frame structure schematic drawing. Various scales. 1913. Ozalid. APWr, AmW, call no. 27512 (III, 17084), chart 211.
Pavilion of the Garden Exhibition. Building frame structure schematic drawing. Various scales. 1913. Ozalid. APWr, AmW, call no. 27512 (III, 17084), chart 213.
Pavilion of the Garden Exhibition. Plan, modules division. Scale 1:100. 1913.01.28. Poelzig. Ozalid. APWr, AmW, call no. 27512 (III, 17084), chart 214.
Pavilion of the Garden Exhibition. Arrangement of seats in the congress hall. Scale 1:100. 1913. Ozalid. APWr, AmW, call no. 27512 (III, 17084), chart 215.
Pavilion of the Garden Exhibition. Plan, walls shifting, adjustment date 10.2.1913. [Gartenbau-Ausstelung.]. Scale 1:200. 1913.02.10. Poelzig. Ozalid, multi-colored drawing. APWr, AmW, call no. 27512 (III, 17084), chart n, a.
Pavilion of the Garden Exhibition. Plan, restroom sinks in red [Verkehrshalle, Ausstellung, Waschbeckenanlagen.]. Scale 1:200. 1913.05.25. Ozalid, multi-colored drawing. APWr, AmW, call no. 27512 (III, 17084), chart 154.

Open-air Theater

Open-air Theater. Plan and section [Freilichttheater für Jahrhundertfeier in J. 1913.]. Scale ca. 1:100. 1912.07.13. Schreiber. Ozalid. APWr, AmW, call no. 27147 (III, 16719), chart 191.
Open-air Theater. Implementation design for wooden dressing room building close to the theater [Freilichttheater Jahrhundertfeier 1913 Garderobenhaus. Breslau, den 31 März 1913, Stadtbauinspektor.]. 1913.03.31. Ozalid, multi-colored drawing. APWr, AmW, call no. 27579 (III, 17151), chart 103.
Open-air Theater. Implementation design for wooden restroom building to the west of the open-air theater [Jahrhundertfeier 1913. Herstellung eines Abortgebäude auf dem Ausstellungsgelande in Scheitnig (mit Grubensystem). Breslau, d. 14 April 1913.]. 1913.04.14. Ozalid. APWr, AmW, call no. 27570 (III, 17142), chart 254.
Open-air Theater. Implementation design for a wider bridge at the open-air theater [Ausstelungsgelände. Brücke am Naturtheater– Verbreitung. Blat I. Maßstab 1:50. Breslau, den 14 Juni 1913. Centralbaustelle für die Jahrhundertfeier. Signed by Schneider Stadtbauinspektor.]. 1913.06.14. Ozalid. APWr, AmW, call no. 27570 (III, 17142), chart 37.

Open-air Theater. Implementation design for theater supervisor's barracks [Ausstelungsgelände. Nathurtheater– Bretterhäuschen für den Oberleiter. Blat I. Maßstab:150. Breslau, den 14 Juni 1913. Centralbaustelle für die Jahrhundertfeier. Signed by Schneider Stadtbauinspektor.].1913.06.14. Ozalid. APWr, AmW, call no. 27570 (III, 17142), chart 38.
Open-air Theater. Implementation design for additional wooden stands and orchestra platform [Jahrhudertfeier 1913 – Freilichttheater. Schnitt und Einzelzeichnungen. Maßstab 1:100, Maßstab:20. Zentralbaustelle der Jahrhundertfeier V. Stadtbauinspektor. Blat II.]. 1913.12.31. Ozalid, multi-colored drawing. APWr, AmW, call no. 27579 (III, 17151), chart 66.
Open-air Theater. Implementation design for additional wooden stands and orchestra platform [Jahrhudertfeier 1913 – Freilichttheater. Grundriss. Maßstab 1:100. Zentralbaustelle der Jahrhundertfeier V. Stadtbauinspektor. Blat I.]. 1913.12.31. Ozalid, multi-colored drawing. APWr, AmW, call no. 27579 (III, 17151), chart 67.
Open-air Theater. Reconstruction of the wooden platform ramp at the open-air Theater [Naturtheater. Änderungen an der Bühne. Maßstab 1:10. Breslau, Mai 1914.]. 1914.05. Tracing paper, pencil. APWr, AmW, call no. 27578 (III, 17150), chart 81.

Japanese Garden
Japanese Garden. Entrance Implementation design [Eingang am Japanischen Garten. Maßstab 1:50, Breslau, d. 4. April 1913, Städt. Bauamt H02, Breslau, den 10. April 1913.]. 1913.04.04. Ozalid, multi-colored drawing. APWr, AmW, call no. 27572 (III, 17144), chart 119.
Japanese Garden. Construction Implementation design for wood covered bridge over the Eichborn pond, Japanese garden area [Zeichnung zum Erweiterungsbau der Eichbornbrücke im Ausstellungsgelände der Jahrhundertfeier in Breslau-Scheitnig. Breslau – Dt. Lissa, den 5. Juni 1913. Stamp of Gartenbauausstellung Breslau 1913.]. 1913.06.05. Ozalid. APWr, AmW, call no. 27571 (III, 17143), chart 172.
Japanese Garden. Assembly sketch of pump engine in the existing, machine room of the timbre skeleton building [Skizze für das Motorhäuschen des Pumpenmotores im japanischen Garten im Scheitniger Park.]. Scale 1:20. 1916.10. Ozalid, multi-colored drawing. APWr, AmW, call no. 27485 (III, 17057), chart 3.

Temporary pedestrian overpasses over the current Z. Wróblewskiego Street
Exhibition Grounds. Pedestrian viaduct over the current Z. Wróblewskiego Street. Unfinished Implementation design of reinforced concrete overpass at Grüneicher Weg, plans, sections [Überbrückung des Grüneicherwegs. Brücke in Eisenbeton. Aufgänge Säulen in Schleuderbeton oder Stampfbeton. Füllmaern: Priess'sche Wände, verjucht. Maßstab 1:200. Breslau 11. Juni 1912. Der Stadtbaurat signed by Berg. Annotation on the back: zu HO.II.i.142, 12 and a postscript: Ungültig 17.10.12.]. 1912.10.02. Berg. Ozalid. APWr, AmW, call no. 27571 (III, 17143), chart 138.
Exhibition Grounds. Viaducts over the current Z. Wróblewskiego Street. Implementation design for two provisional pedestrian bridges [Zeichnung zum Bau zweier provisorischer Brücken über dem Grüneicher Weg, auf dem Ausstellungsplatz der J.F. 1913 in Scheitnig. Enthält: Grundriss, Ansichten u. Schnitte. Maßstab 1:100. Breslau den Februar 1913. Der Bauherr: Städt. Bauamt HO 2. Der Bauleiter: Hugo Baum.]. 1913.02. Ozalid. APWr, AmW, call no. 27571 (III, 17143), chart 85.
Exhibition Grounds. Viaducts over the current Z. Wróblewskiego Street. Site plan of amusement park with viaduct locations [Plan des Vergnügungsparkes zur Jahrhundertfeier der Freiheitskriege Breslau 1913. Maßstab 1:1000. Lageplan zum Bau zweier provs. Brücken über dem Grüneicher Weg auf dem Ausstellungsplatz der J.F. 1913 in Scheitnig. Breslau, den Februar 1913.]. 1913.02. Ozalid, multi-colored drawing. APWr, AmW, call no. 27571 (III, 17143), chart 99.
Exhibition Grounds. Viaducts over the current Z. Wróblewskiego Street. Construction layout for wooden viaduct. 1913.04.12. Ozalid. APWr, AmW, call no. 27571 (III, 17143), chart 84.

Exhibition Grounds close to the Centennial Hall – main entrance, temporary pavilions, lightings and roads
Exhibition Grounds [Lageplan des Ausstellungsgeländes zur Jahrhundertfeier der Freiheitskriege Breslau 1913.]. 1913. Print, multi-colored drawing. APWr, AmW, call no. 27512 (III, 17084), chart 17.

Exhibition Grounds. Main entrance. Section through the stairs of the main entrance to the Exhibition Grounds. Attachment to offer dated 21.2.1913. [Teilzeichnung der Treppe am Haupteingang zur Jahrhundertaustellung. Maßstab 1:100. In lower right: stamp of C.H. Jerschke, G.m.b.H. Eisenbeton u. Betonbau.]. Scale 1:100. 1913.02.21. Tracing paper, pencil. APWr, AmW, call no. 27575 (III, 17147), chart 174.
Exhibition Grounds. Main entrance. Implementation design for the main entrance [Haupteingang zur Ausstellung in Scheitnig. Maßstab 1:50. Bottom right: Breslau 27.3.13.]. Scale 1:50. 1913.03.27. Ozalid. APWr, AmW, call no. 27572 (III, 17144), chart 274.
Exhibition Grounds. Main entrance. The structural Implementation design of the roof of the main entrance [Detailzeichnung zur Binderkonstruktion des Haupteinganges. Maßstab 1:20. Eduard Freytag.]. Scale 1:20. 1913.04.13. Ozalid. APWr, AmW, call no. 27572 (III, 17144), chart 276.
Exhibition Grounds. Implementation design for wooden octagonal pavilion to the south-west of the Centennial Hall [Ausstellung zur Jahrhundertfeier in Breslau 1913. Herstellung eines Ausstellungs– Pavillons auf dem Ausstellungsgelände in Scheitnig. Breslau, den 29. März 1913. Der Bauherr Städt. Bauamt HO 2 Breslau den 3 April 1913. Der Bauausführende Zimmermeister Breslau, Monhauptstraße Nr. 20, signed by Gustav Hossenfelder.]. 1913.03.29. Ozalid, multi-colored drawing. APWr, AmW, call no. 27571 (III, 17143), chart 222.
Exhibition Grounds. Implementation design for a water supply system to the Belvedere with terraces in the Renaissance garden [Gartenbau– Ausstellung 1913. Terrasse in dem Renaissance-Garten (mit Weinrestaurant). Maßstab 1:100. Bottom right: Zentralbaustelle der Jahrhundertfeier A., below: stamp of Architect Th. Effenberger.]. Scale 1:100. 1912. Effenberger. Ozalid, multi-colored drawing. APWr, AmW, call no. 27577 (III, 17149), chart 58.
Exhibition Grounds. Implementation design for the entrance to the rose garden [Gartenbau Ausstellung Eingang zum Rosarium. Maßstab 1:50. Bottom right: Breslau, am März 1913, Stadtbauinspektor Jaide.]. SDcale 1:50. 1913.05. Ozalid, multi-colored drawing. APWr, AmW, call no. 27572 (III, 17144), chart 101.
Exhibition Grounds. Perspective view of the entrance to the rose garden. Signed by Jaide. 1913.05. Ozalid, multi-colored drawing. APWr, AmW, call no. 27572 (III, 17144), chart 102.
Exhibition Grounds. Relocation of the garden exhibition fence [Ausstellungsgelände Scheitnig Zaumversetzung Antrag vom III.12.]. Scale 1:1500. 1912.03.12. Ozalid. APWr, AmW, call no. 27467 (III, 17039), chart 230.
Exhibition Grounds. Arrangement of additional lamps around the Centennial Hall. 1913 (?). Tracing paper, pencil, crayon. APWr, AmW, call no. 27485 (III, 17057), chart 254.
Exhibition Grounds. Implementation design for lamps with fluted shaft. Scale 1:10, 1:1. 1913.02.13. Poelzig. Tracing paper, pencil. APWr, AmW, call no. 27485 (III, 17057), chart 268.
Exhibition Grounds. Site plan of lighting masts and flagpole arrangement [Plan für die Aufstellung der Beleuchtungsmaste. Maßstab 1:500. Abgeändert Kandelaberstellung vom 15.IV.1913. Bottom left: No. 277, illegible signature 25.3.13, signature of Konwiarz 35.3.13. Bottom right: Breslau, im März 1913 Der Stadtbaurat.]. Scale 1:500. 1913. Berg, Konwiarz. Ozalid. APWr, AmW, call no. 27569 (III, 17141), chart 51.
Exhibition Grounds. Implementation design for lantern mast, scale 1:10, sections of stairs on the shaft, scale 1:1 [Bottom right: Kandelaber des Ausstellungsgeländes, Breslau, dem 18.3.13. Implementation design by: Hans Poelzig.]. 1913.08.03. Poelzig. Ozalid. APWr, AmW, call no. 27569 (III, 17141), chart 52.
Exhibition Grounds. Site plan, measurements of roads, lawns and graveled areas [Skizze für die Vermessung der Kiesschüttung, der Straßse und der Bodensteine. Maßstab 1:1000. Stamp of: O. Kleinert. Tiefbaugeschäft Breslau. Postscript: Ungültig v. 28.10.13 Fleischer.]. Scale 1:1000. 1913. Ozalid. APWr, AmW, call no. 27569 (III, 17141), chart 135.
Exhibition Grounds. Construction site, worker's locker room [Unterkunftsrüme für Bauhofarbeiter. Maßstab 1:50. Breslau 24.4.13 Stadtbauinspektor.]. Scale 1:50. 1913.04.13. Ozalid. APWr, AmW, call no. 27569 (III, 17141), chart 210.
Exhibition Grounds. Construction Implementation design of wooden restroom, to the west of the open-air Theater [Jahrhundertfeier 1913. Herstellung eines Abortgebäudes auf dem Ausstellungsgelande in Scheitnig (mit Grubensystem). Breslau, d. 14 April 1913.]. 1913.04.14. Ozalid. APWr, AmW, call no. 27571 (III, 17143), chart 196.
Exhibition Grounds. Location of restroom, to the east of the garden exhibition pavilion [Lageplan der Abortanlagen auf dem Ausstellungsgelande in Scheitnig. Maßstab 1:1000. Paul Rögge & Co. Breslau.]. Scale 1:1000. 1913.04. Ozalid, multi-colored drawing. APWr, AmW, call no. 27571 (III, 17143), chart 200.

Exhibition Grounds. Location of restroom close to A. Mickiewicza Street [Lageplan der Abortanlagen auf dem Ausstellungsgelande in Scheitnig. Maßstab 1:1000. Paul Rögge & Co. Breslau.]. Scale 1: 1000. 1913.04. Ozalid, multi-colored drawing. APWr, AmW, call no. 27571 (III, 17143), chart 201.
Exhibition Grounds. Implementation design for 4 restrooms [4 Abortanlagen auf dem Ausstellungsgelände in Scheitnig. Paul Rögge & Co. Breslau.]. 1913.04. Ozalid. APWr, AmW, call no. 27571 (III, 17143), chart 202.
Exhibition Grounds. Implementation design for restroom [Jahrhundertfeier 1913. Herstellung von 5 Abortanlagen auf dem Ausstellungsgelände in Scheitnig. Breslau den 21. März 1913. Maßstab 1:50. Signed by Gustav Hossenfelder.]. Scale 1:50. 1913.03.21. Ozalid. APWr, AmW, call no. 27571 (III, 17143), chart 203.
Exhibition Grounds. Implementation design for wooden restroom. 1913.04.11. Tracing paper, pencil. APWr, AmW, call no. 27572 (III, 17144), chart 25.
Exhibition Grounds. Plan of fencing [Plan des Ausstellungsgeländes zur Jahrhundertfeier der Freiheitskriege Breslau 1913. Umzäunung. Maßstab 1:100. Breslau am 25 Mai 1912 (building plan), Breslau 20.9.1912 (fencing), 24.4.1913 (building inspector's approval).]. Scale 1:100. 1913.04.24. Ozalid, multi-colored drawing. APWr, AmW, call no. 27573 (III, 17145), chart 8.
Exhibition Grounds. Implementation design for fencing [Jahrhundertfeier 1913. Zaun Grüneicher Weg: Eisenbeton Dielenfüllung. Zaun Tiergatenstraße.]. 1913.09.11. Ozalid. APWr, AmW, call no. 27573 (III, 17145), chart 10.
Exhibition Grounds. Plan of Exhibition Grounds with fencing adjustments, approved on 25.3.1913 by building inspector [Plan des Ausstellungsgeländes zur Jahrhundertfeier der Freiheitskriege Breslau 1913. Umzäunung. Maßstab 1:100. Breslau am 25 Mai 1912 (building plan date), Breslau 25.2.1913 (date of marking the fence), 25.3.1913 (date of building inspector's approval).]. Scale 1:100. 1913.03.25. Ozalid, multi-colored drawing. APWr, AmW, call no. 27573 (III, 17145), chart 13.
Exhibition Grounds. Single-storied building of the kitchen at the restaurant on the edge of the rose garden at Lindenberg [Zeichnung zur Herstellung einer Aufwaschküche für das Wirtschaftsgebäude der Restauration auf dem Lindenberg. Zur Jahrhundertfeier 1913. Breslau, den 15. Juni 1913.]. 1913.06.15. Tracing paper, ink. APWr, AmW, call no. 27573 (III, 17145), chart 154.
Exhibition Grounds. Auxilliary building and tent for the Lindenberg restaurant [Zeichnung zur Herstellung eines Wirtschaftsgebäudes nebst Zelter für die ◊Restauration auf dem Lindenberg". Zur Jahrhundertfeier 1913 in Breslau. Breslau, d. 6. Mai 1913.]. 1913.05.06. Ozalid, multi-colored drawing. APWr, AmW, call no. 27573 (III, 17145), chart 155.
Exhibition Grounds. Plan of road fragments marked for reinforcement [Plan des Ausstellungsgeländes zur Jahrhundertfeier der Freiheitskriege Breslau 1913. 1913.04 was used.]. Print, multi-colored drawing. APWr, AmW, call no. 27575 (III, 17147), chart 56.
Exhibition Grounds. Sections and construction layout of the Garden Exhibition frame shed [Gartenbauaustellung-Schuppen.] Scale 1:100. 1913. Ozalid, multi-colored drawing. APWr, AmW, call no. 27575 (III, 17147), chart 68.
Exhibition Grounds. Sections and construction layout of the Garden Exhibition frame shed [Gartenbauaustellung-Schuppen.]. Scale 1:100. 1913. Ozalid, multi-colored drawing. APWr, AmW, call no. 27575 (III, 17147), chart 69.
Exhibition Grounds. Extension of the general and rainwater drainage system along present Z. Wróblewskiego Street. Scale 1:1000. 1912.02. Ozalid, multi-colored drawing. APWr, AmW, call no. 27577 (III, 17149), chart 135.
Exhibition Grounds. Sketch, section of plantings on both sides of Grüneicher Weg. 1912. Paper, multi-colored drawing. APWr, AmW, call no. 27577 (III, 17149), chart 233.
Exhibition Grounds. Sketch showing different types of road surfaces on Grüneicher Weg [Abrechnung Skizze Grüneicher Weg vom Zoologischen Garten bis Finkenweg.]. Scale 1:250. 1913.06. Ozalid, multi-colored drawing, distemper, APWr, AmW, call no. 27577 (III, 17149), chart 237.
Exhibition Grounds. Locations requiring pavement parking for horse-drawn carriages and entry to the Exhibition Grounds [Befestigung des Droschkenhalteplatzes u. d. Zufuhrstrs. am Ausstellungsgelände.]. Scale 1:250. 1913.06. Ozalid, multi-colored drawing, tempera. APWr, AmW, call no. 27577 (III, 17149), chart 238.
Exhibition Grounds. Passage ways over Grüneicher Weg from the Exhibition Grounds, north to south. Scale 1:250. 1913.06. Ozalid, multi-colored drawing, tempera. APWr, AmW, call no. 27577 (III, 17149), chart 239.

Exhibition Grounds. Sketch of passage routes in from of the main entrance to the Exhibition Grounds [Ausstellung Breslau 1913. Maßstab 1:1000. In lower right: Breslau im Sept. 12. Der Stadtbaurat. Gez. Unreadable signature. Note in pencil in the middle of the upper margin: Für Herrn Prof. Poelzig.]. Scale 1:1000. 1912.09. Tracing paper, multi-colored drawing. APWr, AmW, call no. 27577 (III, 17149), chart 240.
Exhibition Grounds. Horse and carriage stop in front of the main entrance [Ausstellung 1913. Haupteingang. Wagenhalteplatz, Zufahrtstraße.]. Scale 1:500. 1913.01.03. Ozalid, multi-colored drawing. APWr, AmW, call no. 27577 (III, 17149), chart 241.
Exhibition Grounds. Plantings close to Grüneicher Weg, section, adjustments and comments Max Berg. No date. Paper, multi-colored drawing. APWr, AmW, call no. 27578 (III, 17150), chart 116.
Exhibition Grounds. Site plan of provisional lighting of arc lamps at current Diana Square and Z. Wróblewskiego Street during the exhibition [Provizorische Beleuchtung des Grüneicher Weges, sowie der Tiergartenstraße zwischen Paßbrücke u. Parkstraße mit 49 Bogenlampen während der Ausstellungszeit.]. 1913.03.31. Ozalid, multi-colored drawing. APWr, AmW, call no. 27579 (III, 17151), chart 240.
Exhibition Grounds. Site plan, at current Diana's Square with a layout of roads and parking spaces in front of the main entrance to the Exhibition Grounds [Ausstellung 1913. Haupteingang, Wagenhalleplatz, Zufahrtstraße.] Scale 1:500. 1912. Ozalid, multi-colored drawing. APWr, AmW, call no. 27579 (III, 17151), chart 251a.
Exhibition Grounds. Expansion plan of the Zoo and the area of the Oder, to the east, without entering the Exhibition Grounds, signed and designed by the municipal gardener, Richter. 06.01.1913. Ozalid, multi-colored drawing. APWr, AmW, call no. 35358, chart 15.
Exhibition Grounds. Centennial Hall layout and calculation of surrounding road surfaces, site plan [Ausstelungsgelaende. Abrechnungszeichnung der Wegebefestigung. Vertrag vom 28 Dez. 1912, Vertrag vom 29 März 1913.]. Scale 1:500. 1912, 1913. Ozalid, multi-colored drawing. APWr, AmW, call no. 35388, chart 31.
Exhibition Grounds. Lawn, site plan. Scale 1:10 000. 1914. Richter. Ozalid, multi-colored drawing. APWr, AmW, call no. 35389, chart 23.
Exhibition Grounds. Coverage area of Maschinenmarkt exhibition (1914), site plan. Scale 1:500. 1914.05. Ozalid, multi-colored drawing. APWr, AmW, call no. 35390, chart 93.
Exhibition Grounds. Main entrance and lawn, site plan. Scale 1:10 000. 1914.06.22. Print, multi-colored drawing. APWr, AmW, call no. 35388, chart 24.
Exhibition Grounds. Coverage area of Maschinenmarkt exhibition (1914), site plan. Scale 1:1000. 1914.07.03. Ozalid, multi-colored drawing. APWr, AmW, call no. 35390, chart 113.
Exhibition Grounds. Coverage area of Das Kind exhibition, site plan. Plan from 1913 was used. Scale 1:1000. 1915. Print, multi-colored drawing. APWr, AmW, call no. 35391, chart 57.
Exhibition Grounds. Boundaries of the Spring Fair (1920), site plan. Scale 1:1000. 1920. Print, multi-colored drawing. APWr, AmW, call no. 35375, chart 124.
Exhibition Grounds. Fencing around the Centennial Hall. Scale 1:1000. 1922.03. Ozalid, multi-colored drawing. APWr, AmW, call no. 35361, chart 93.
Exhibition Grounds. Roads and paths, rainwater drainage route along with their lengths, site plan. Scale 1:1 000. 1922.02.24. Ozalid, multi-colored drawing. APWr, AmW, call no. 35367, chart 10.
Exhibition Grounds. South-west annexation of the Zoo, Implementation design. Scale 1:2000. 1922.03.04. Print, multi-colored drawing. APWr, AmW, call no. 35373, chart 386.
Exhibition Grounds. Plan and layout of commercial stands in the Hall, in the shape of a letter Ca. 1922.07. Ozalid, multi-colored drawing. APWr, AmW, call no. 35373, chart 279.
Exhibition Grounds. Implementation design for the development of the space under the eastern pedestrian viaduct for the purposes of a ticket office and transformer station [Maßstab 1:50, signed by Breslau, Dez. 25. Bauamt Stadterweiterung Konwiarz.]. Scale 1:50. 1925.12. Ozalid, multi-colored drawing. APWr, AmW, call no. 35360, chart 80.
Exhibition Grounds. Exhibition Grounds, preparation for the agricultural equipment exhibition, plan. Scale 1:5000. 1925. Print, multi-colored drawing. APWr, AmW, call no. 35374, chart 125.
Exhibition Grounds. Implementation design for the model garden with various types of wooden gazebos and plantings proposals. 1926.03.31. Ozalid. APWr, AmW, call no. 35374, chart 128–133.

Exhibition Grounds. Implementation design assumptions for the Arboretum [Arboretum der Firma Reinhold Behnsch Brockau.]. Scale 1:200. 1926.09.06. Ozalid. APWr, AmW, call no. 35362, chart 201.
Exhibition Grounds. The range of the southern part of the Exhibition Grounds. Scale 1:200. 1932.08.03. Print, multi-colored drawing. APWr, AmW, call no. 35358, chart 34.
Exhibition Grounds. Construction Implementation design for the tram siding from Z. Wróblewskiego Street to the Hall from the south-east, variants A and B. Scale 1:50. 1932.08.02. Ozalid, multi-colored drawing. APWr, AmW, call no. 35360, chart 70.

Amusement park – layout and exhibition buildings
Amusement park. Implementation design for Cafe Grundmann winery tent [Weinzelt – Festwiese 1911. [sic!].]. 1912.05.20. Ozalid, multi-colored drawing. APWr, AmW, call no. 27611 (III, 17183), chart 167.
Amusement park. Roads plan and pavement of the main road [Plan des Vergnügungsparkes zur Jahrhundertfeier der Freiheitskriege Breslau 1913. Maßstab 1:1000. Breslau, den 31. Juli 1912.]. Scale 1:1000. 1912.07.31. Ozalid, multi-colored drawing. APWr, AmW, call no. 27611 (III, 17183), chart 74.
Amusement park. Implementation design for amusement park administration building [Centralbaustelle für die Jahrhundertfeier 1913. Verwaltungsgebäude für den Vergnügungspark. Maßstab 1:100. Breslau, den 20 August 1912.]. Scale 1:100. 1912.08.20. Ozalid, multi-colored drawing. APWr, AmW, call no. 27575 (III, 17147), chart 292.
Amusement park. Implementation design for amusement park administration building [Centralbaustelle für die Jahrhundertfeier 1913. Verwaltungsgebäude für den Vergnügungspark. M. 1:100. Breslau, den 20 August 1912.]. Scale 1:100. 1912.08.20. Ozalid, multi-colored drawing. APWr, AmW, call no. 27575 (III, 17147), chart 304.
Amusement park. Small sales pavilions designed by Alfred Köhler, Bau– und Zimmereigeschäft [Inhaber: Gebr. Stark. Jahrhundertfeier 1913 – Verkaufshäuschen – Vergnügungspark.]. Scale 1:50. 1912.08.20. Ozalid. APWr, AmW, call no. 27611 (III, 17183), chart 40.
Amusement park. Two drawings, Implementation design of Bier-Ritze restaurant for George Lange [Restaurant Bier-Fitze Breslau. Stamp of: Bureau für Architektur und Bauausführungen Walther Grossmanna Baumeister Dersden.]. 1912. Ozalid. APWr, AmW, call no. 27611 (III, 17183), chart 103–104.
Amusement park. Plan of medium-voltage cables route [Plan des Vergnügunsparkes zur Jahrhundertfeier der Freiheitskriege Breslau 1913.]. Scale 1:1000. 1912.10.15. Ozalid, multi-colored drawing. APWr, AmW, call no. 27457 (III, 17029), chart 242.
Amusement park. Pavilion of Hartwig Kantorowicz company from Poznań, Implementation design [Pavillon Kantorowicz Posen. Jahrhundertfeier in Breslau 1913.]. Scale 1:100. 1912.11. Ozalid. APWr, AmW, call no. 27611 (III, 17183), chart 21.
Amusement park. Location of temporary sports stadium with wooden stands, 1912, 1908 base maps were used. Scale 1:1000. 1912. Tracing paper, multi-colored drawing. APWr, AmW, call no. 27576 (III, 17148), chart 272.
Amusement park. Sports stadium with a race track and the stands at the amusement park [Spiel– und Sportplatz.]. Scale 1:1000. 1913. Ozalid, multi-colored drawing. APWr, AmW, call no. 27459 (III, 17031), chart 44.
Amusement park. Sports stadium, section of race track [Spiel– und Sportplatz. Profil.]. Scale 1:100. 1913. Ozalid, multi-colored drawing. APWr, AmW, call no. 27459 (III, 17031), chart 46.
Amusement park. Location of stands at the stadium. Scale 1:1000. 1913.4.17. Ozalid. APWr, AmW, call no. 27570 (III, 17142), chart 11.
Amusement park. Layout of restrooms at the amusement park [Lageplan der Abortanlagen auf dem Ausstellungsgelande in Scheitnig. Paul Rögge & Co. Breslau.]. Scale 1:1000. 1913.04. Ozalid, multi-colored drawing. APWr, AmW, call no. 27571 (III, 17143), chart 199.
Amusement park. Construction Implementation design of two wooden stands in the sports grounds of the amusement park [Grüneiche Städt. Terrain hinter der Radennbahn. Herstellung zweier überdeckter Tribünen für sportliche Veranstaltungen. Breslau, d. 4. April 1913. Der Bauherr Städt. Bauamt HO 2, Breslau, den 7. April 1913, Der Bauausführende Zimmermeister Monhauptstrasse 20. Signed by Gustav Hossenfleder.]. 1913.04.04. Ozalid, multi-colored drawing. APWr, AmW, call no. 27571 (III, 17143), chart 284.
Amusement park. Two restrooms and a urinal in the amusement park, construction Implementation design

[Grüneiche Städt. Terrain hinter der Radennbahn. Herstellung zweier Abortanlagen nebst eines einzeln zu errichtenden Pissoirstandes auf dem Sprotplatze Grüneiche während der Dauer der Jahrhundertsfeier 1913. Breslau 5. Mai 1913. Der Bauherr. Signed by: Der Bauausführende and Gustav Hossenfelder.]. 1913.05.05. Ozalid, multi-colored drawing. APWr, AmW, call no. 27571 (III, 17143), chart 285.
Amusement park. Dance tent location [Jahrhundertfeier 1913 – Vergnügungspark Lageplan des Tanzzeltes.]. 1913. Tracing paper, multi-colored drawing. APWr, AmW, call no. 27576 (III, 17148), chart 189.
Amusement park. Location of the Dance tent ["Tanzhalle" Jahrhundertfeier 1913. Lageplan mit Eintragung der Bäume und der Pergola. Blatt 34. Breslau, den 27 Januar 1913. Der Architekt, stamp: Helbig Architekt.]. 1913.01.27. Tracing paper, multi-colored drawing. APWr, AmW, call no. 27576 (III, 17148), chart 199.
Amusement park. Section of the stands of the temporary sports stadium. Scale 1:100. 1913.04.04. Tracing paper, multi-colored drawing. APWr, AmW, call no. 27576 (III, 17148), chart 281.
Amusement park. Implementation design of amusement park water slide [Wasserrutschbahn im Vergnügungspark der Jahrhundertaustellung Breslau 1913. Implementation design by Fritz Engert, Zimmerei und Baugeschäft dla Kredit– u. Spar-Bank.]. 1913.05.21. Ozalid, multi-colored drawing. APWr, AmW, call no. 27577 (III, 17149), chart 24.
Amusement park. Music pavilion for amusement park [Musikpavillion Vergnügunspark. 13 März 1913.].Scale 1:100. 1913.03.13. Ozalid, multi-colored drawing. APWr, AmW, call no. 27579 (III, 17151), chart 295.
Amusement park. Music pavilion for amusement park [Musikpavillion mit Restaurant für Vergnügunspark 1913.]. Scale 1:100. 1913.03.13. Ozalid, multi-colored drawing. APWr, AmW, call no. 27579 (III, 17151), chart 296.
Amusement park. Implementation design for garden labyrinth [Gartenbau – Ausstellung Breslau 1913 Irrgarten.]. Scale 1:200. 1913. Ozalid. APWr, AmW, call no. 27611 (III, 17183), chart 231.
Amusement park. Implementation design for three-level Belvedere garden labyrinth [Zeichnung zu einer Beobachtungswarte für den Irrgarten im Vergnügungspark der Jahrhundertfeier in Breslau. Maßstab 1:50. Breslau– Dt. Lissa, den 30. April 1913, Der Ausführende: Eduard Freytag.]. Scale 1:50. 1913.04.30. Ozalid. APWr, AmW, call no. 27611 (III, 17183), chart 48.
Amusement park. Implementation design for Belvedere illumination near the labyrinth. 1913. Drawing. APWr, AmW, call no. 27611 (III, 17183), chart 88.
Amusement park. Implementation design for buffet in the labyrinth garden [Likör Pavillon in Irrgarten. Maßstab 1:50 Breslau, den 6.VI.13.]. Scale 1:50. 1913.06.06. Ozalid, multi-colored drawing. APWr, AmW, call no. 27611 (III, 17183), chart 232.
Amusement park. Implementation design no. 2 for a market hall by the Municipal Building Construction Office [Verkaufshalle 2 – Vergnügungspark – Jahrhundertfeier 1913. Maßstab 1:100. Breslau, den 1. April 1913.]. Scale 1:100. 1913.04.01. Ozalid, multi-colored drawing. APWr, AmW, call no. 27611 (III, 17183), chart 115.
Amusement park. Site plan with the location of market hall no. 2 [Situationsplan zum Bau der Verkaufshalle 2 Vergnügungspark – Jahrhundertfeier 1913. Breslau, den 1. April 1913.]. 1913.04.01. Ozalid, multi-colored drawing. APWr, AmW, call no. 27611 (III, 17183), chart 116.
Amusement park. Pastry and Coffee Shop building, Implementation design [Jahrhundertfeier 1913. Zeichnung zur Aufstellung einer Conditorei und Kaffee in dem Vergnügungspark Scheitnig.]. Scale 1:100. 1913. Ozalid, multi-colored drawing. APWr, AmW, call no. 27611 (III, 17183), chart 142.
Amusement park. Pastry and Coffee Shop building, location [Plan des Vergnügunsparkes zur Jahrhundertfeier der Freiheitskriege Breslau 1913. Lageplan zur Aufstellung einer Conditorei und Kaffee.]. Scale 1:1000. 1913. Ozalid, multi-colored drawing. APWr, AmW, call no. 27611 (III, 17183), chart 143.
Amusement park. Pastry and Coffee Shop, building Implementation design, plan with hand-written amendments [Jahrhundertfeier 1913 – Vergnügungspark. Konditorei u. Caffee.]. Scale 1:100. 1913. Ozalid, multi-colored drawing. APWr, AmW, call no. 27611 (III, 17183), chart 149.
Amusement park. Pastry and Coffee Shop building, lighting Implementation design [Beleuchtungs Anlage Cafe Grundmann.]. 1913.03.31. Ozalid, multi-colored drawing. APWr, AmW, call no. 27611 (III, 17183), chart 153.
Amusement park. Lighting layout in the Pastry and Coffee Shop building [Lampenverteilungsplan für das Grand Kaffe im Vergnügungspark der Jahrhundertfeier 1913.]. 1913.04.01. Ozalid, multi-colored drawing. APWr, AmW, call no. 27611 (III, 17183), chart 154.

Amusement park. Implementation design for the ticket office near the labyrinth [Zeichnung zum Bau eines Kassenhäuschens im Vergnügungspark der Jahrhundertfeier 1913. Maßstab 1:50, Breslau März 1913.]. Scale 1:50. 1913.03. Ozalid, multi-colored drawing. APWr, AmW, call no. 27611 (III, 17183), chart 186.
Amusement park. Implementation design for a beer-house [Bierlokal im Vergnügungspark der Jahrhundertfeier. Breslau, d. 9. Mai 1913.]. 1913.05.09. Ozalid, multi-colored drawing. APWr, AmW, call no. 27611 (III, 17183), chart 189.
Amusement park. Implementation design for "Gulaschhütte" restaurant [Bierlokal zur "Gulaschhütte" im Vergnügungspark der Jahrhundertausstellung 1913. Breslau den Juli 1913.]. 1913.07. Ozalid, multi-colored drawing. APWr, AmW, call no. 27611 (III, 17183), chart 193.
Amusement park. Sewage system [Plan des Ausstellungsgeländes zur Jahrhundertfeier der Freiheitskriege Breslau 1913.]. Scale 1:1000. 1912.09.09. Ozalid, multi-colored drawing. APWr, AmW, call no. 27612 (III, 17184), chart 19.
Amusement park. Implementation design for amusement park administration building, sewage system installation chart [Centralbaustelle für die Jahrhundertfeier 1913. Verwaltungsgebäude für den Vergnügungspark. Maßstab 1:100. Breslau, den 20 August 1912. Der Stadtbauinspektor Schneider.]. 1912.08.20. Ozalid, multi-colored drawing. APWr, AmW, call no. 27612 (III, 17184), chart 34.
Amusement park. Implementation design for corner building in the amusement park, sewage system installation chart [Jahrhundertfeier 1913. Eckbau im Vergnügungspark.]. Scale 1:100. 1913.03.11. Ozalid, multi-colored drawing. APWr, AmW, call no. 27612 (III, 17184), chart 36.
Amusement park. Site plan of buildings at the main entrance to the amusement park, water supply and Pastry and Coffee shop building sewage system [Kaffee u. Konditorei, Be- u. Entwässerung. Lageplan 1:1000.]. Scale 1:1000. 1913.02.15. Ozalid, multi-colored drawing. APWr, AmW, call no. 27612 (III, 17184), chart 38.
Amusement park. Implementation design for Pastry and Coffee Shop showing the waterworks and sewage system plan [Ausstellung zur Jahrhundertfeier in Breslau 1913. Herstellung einer Conditorei und Kaffee auf dem Ausstellungsgelände in Scheitnig. Breslau, den Februar 1913.]. 1913.02. Ozalid, multi-colored drawing. APWr, AmW, call no. 27612 (III, 17184), chart 39.
Former amusement park. Sketch of the location of the sports grounds, landscaping and list of species to be planted with the Implementation design for the southern area of the Exhibition Grounds. Scale 1:1000. 1920. Tracing paper, pencil. APWr, AmW, call no. 35362, chart 187.

7.2. The Museum of Architecture in Wrocław – Building Archive of the City of Wrocław (Muzeum Architektury we Wrocławiu – Archiwum Budowlane Miasta Wrocławia)

Centennial Exhibition – Centennial Hall
Architectural drawing. 1911.06.22. Paper, Ozalid, 65,5 x 64,5 cm, call no. MAt-VI-21376.
Site plan (August 1911), made on the geodetic measurement drawing (1911.04.24). Implementation design approved for implementation by Wrocław Municipality. 1911.08. Berg. Ozalid, paper, ink, taped with canvas, 66 x 100 cm, call no. MAt-VI-21501.
Ground floor plan, Implementation design for stands and platform. Implementation design approved for implementation by Wrocław Municipality. 1911.08. Berg, Trauer. Print, paper, 166 x 156 cm, call no. MAt-VI-9391.
Gallery level plan. Implementation design for stands arrangement. Implementation design approved for implementation by Wrocław Municipality. 1911.08, Berg, Trauer. Print, paper with pencil inscriptions, 81 x 167 cm, call no. MAt-VI-9392.
Ground floor plan (dome rib plan). Implementation design approved for implementation by Wrocław Municipality. 1911.08. Berg, Trauer. Print, paper, 99 x 162 cm, call no. MAt-VI-9393.
Section A-B on side entrance axis (north-south). Implementation design approved by Wrocław Municipality. 1911.08. Berg, Trauer. Print, paper, 66 x 183 cm, call no. MAt-VI-9395.

Section C-D on side entrance axis (east-west). Implementation design approved by Wrocław Municipality. 1911.08. Berg, Trauer. Print, paper, 66 x 189 cm, call no. MAt-VI-9394.
Western façade, main entrance. Implementation design approved by Wrocław Municipality. 1911.08. Berg, Trauer. Print, paper, 65.5 x 186 cm, call no. MAt-VI-9396.
Crane Implementation design construction of the Hall. Ropeway. Technical drawing. 1911.08.31. Schreiber, Trauer. Paper, ozalid, 67 x 158 cm, call no. MAt-VI-21380.
Drawing of construction calculations. Calculations for main pillars foundations. 1911.08. Berg, Trauer, Schreiber. Print, paper, 84 x 95 cm, call no. MAt-VI-21526.
Construction drawing of support pillars. 1911.09. Schreiber, Trauer. Paper, Ozalid, 66,5 x 49,5 cm., call no. MAt-VI-21386.
Construction drawing of foundations of the great pillars and arch buttresses. 1911.09. Paper, Ozalid, 32,5 x 51 cm, call no. MAt-VI-21374.
Construction drawing of arch buttresses, 1911.09. Schreiber, Trauer. Paper, Ozalid, 66,5 x 51 cm, call no. MAt-VI-21383.
Construction drawings of the great pillars foundations. 1911.09. Paper, Ozalid, 32,5 x 50,5 cm, call no. MAt-VI-21381.
Construction drawing for great pillars. 1911.09. Paper, ink, 37 x 58,5 cm, call no. MAt-VI-21481.
Construction drawing of the great pillars and foundations. 1911.09.23. Schreiber, Trauer. Paper, Ozalid, 70 x 57 cm, call no. MAt-VI-21385.
Construction drawing of the great pillars and foundations. 1911.09.23. Schreiber, Trauer. Paper, Ozalid, 71 x 57,5 cm, call no. MAt-VI-21384.
Implementation design. Plan of half of the Hall in 4 units: foundation, supports and pillars, dome ribs, balconies and lanterns. 1911.09.30. Berg, Trauer, Schreiber. Print, paper, 75 x 117 cm, call no. MAt-VI-21521.
Partial cross-section with view of the interior. 1911.09.30. Berg, Trauer, Schreiber. Print, paper, 64 x 86 cm, call no. MAt-VI-21522.
Implementation design of part of the side entrance, foundations, plan. 1911.10. Berg, Schreiber, Trauer. Ozalid, paper, 129 x 92 cm, call no. MAt-VI-21494.
Implementation design. Foundations of the foyer – sections, plans, details. 1911.10.18. Berg, Schreiber, Trauer. Ozalid, paper, 62 x 54 cm, call no. MAt-VI-21491.
Crane Implementation design and scaffolding. Plans, sections. 1911.10.27. Schreiber, Gehler. Paper, Ozalid, 84 x 119 cm, call no. MAt-VI-21760.
Implementation design. Basement ceiling in the northern part of the Hall, plan. 1911.11. Berg, Meyer, Schreiber, Trauer. Ozalid, paper, 80 x 105 cm, call no. MAt-VI-21498.
Ground floor plan. Amphitheater and stage layout, imperial stands, foyer divisions for exhibition space and wardrobes. Evacuation plan. Number of seats and arrangement in different parts of the Hall. 1911.11. Berg, Trauer. Print, paper-addition of colored ink, 159 x 161 cm, call no. MAt-VI-21511.
Implementation design. Construction drawing. 1911.11. Schreiber, Trauer. Paper, Ozalid, crayon, 33 x 42 cm, call no. MAt-VI-21490.
Implementation design. Construction drawing. 1911.11. Meyer. Paper, Ozalid, crayon, 33 x 42 cm, call no. MAt-VI-21489.
Implementation design. Construction drawing. 1911.11. Meyer. Paper, Ozalid, 33 x 20,5 cm, call no. MAt-VI-21488.
Implementation design. Construction drawing. 1911.11. Meyer, Trauer. Paper, Ozalid, 33 x 42 cm, call no. MAt-VI-21487.
Implementation design. Construction drawing of pillars. 1911.11. Meyer, Trauer. Paper, Ozalid, crayon, 33 x 20,5 cm, call no. MAt-VI-21486.
Implementation design. Construction drawing of ceiling. 1911.11. Meyer, Trauer. Paper, Ozalid, crayon, 33 x 42 cm, call no. MAt-VI-21485.
Ground floor ceiling Implementation design. Construction drawing. 1911.11. Meyer, Trauer. Paper, Ozalid, crayon, 33 x 42 cm, call no. MAt-VI-21484.

Upper level ceiling Implementation design. Construction drawing. 1911.11. Meyer, Trauer. Paper, Ozalid, crayon, 33 x 42 cm, call no. MAt-VI-21483.
Implementation design for scaffolding and boarding for the large arcs. Plans, sections. 1911.11.01. Schreiber, Trauer, Gehler. Paper, Ozalid, 91 x 120,5 cm, call no. MAt-VI-21761.
Implementation design for scaffolding and boarding for the large arcs. Sections, views. 1911.11.04. Schreiber, Trauer, Gehler. Paper, Ozalid, 64,5 x 103 cm, call no. MAt-VI-21762.
Implementation design for scaffolding and boarding for the large arcs. Details of truss nodes. 1911.11.08, Schreiber, Trauer, Gehler. Paper, Ozalid, 65 x 99 cm, call no. MAt-VI-21763.
Makeshift canteen for construction workers. Site plan, ground floor plan, section, side façade drawing. Restrooms arrangement. 1911.11.08. Nitsch Arnold. Paper, canvas, Ozalid, water colors, 43,5 x 68,5 cm, call no. MAt-VI-21427.
Implementation design of cranes and scaffolding. Tower for lift cables. Plan, section, general view. 1911.11.11. Schreiber, Trauer, Gehler. Paper, Ozalid, 138 x 94 cm, call no. MAt-VI-21764.
Implementation design for scaffolding and boarding for the large arcs. Details of truss nodes. 1911.11.18. Schreiber, Trauer, Gehler. Paper, Ozalid, 54,5 x 73,5 cm, call no. MAt-VI-21765.
Structural studies of the dome arcs tensions. 1911.11.21. Berg, Trauer, Schreiber. Paper, print, 101 x 54 cm, call no. MAt-VI-21531.
Construction drawing. Study of dome arcs tensions, bendings and movements. 1911.11.21. Berg, Trauer, Schreiber. Paper, print, 91 x 111 cm, call no. MAt-VI-21540.
Singer's platform (apse "c") Implementation design. Sections. 1911.12.20. Schreiber, Trauer, Gehler. Paper, Ozalid, ink, 75 x 115,5 cm, call no. MAt-VI-21389.
Implementation design for balcony. Plan, cross-section, view of the bracket construction drawing. 1911.12. Schreiber, Trauer, Gehler. Paper, canvas, Ozalid, 68,5 x 105 cm, call no. MAt-VI-21388.
Implementation design for scaffolding and boarding. Plan. 1911.12.08. Schreiber, Trauer, Gehler. Paper, Ozalid, 40 x 60 cm, call no. MAt-VI-21766.
Implementation design for scaffolding and boarding, for the dome. Section and details. 1911.12.19. Schreiber, Trauer, Gehler. Paper, Ozalid, 65 x 61,5 cm, call no. MAt-VI-21771.
Construction drawing relating to statistics (weight relationships of the dome's arcs to the peripheral wall). 1911.12.20. Berg, Trauer, Schreiber. Paper, Ozalid, 75 x 67 cm, call no. MAt-VI-21533.
Implementation design for the Imperial stands (apse "a"). Sections: a-b, c-d. 1911.12.20. Schreiber, Trauer, Gehler. Paper, Ozalid, ink, 46 x 67,5 cm, call no. MAt-VI-21407.
Implementation design for Singer's stands (apse "c"). Sections: a-b, c-d, e-f, g-h, i-k. 1911.12.20. Schreiber, Trauer, Gehler. Paper, Ozalid, ink, 66 x 97 cm, call no. MAt-VI-21391.
Implementation design for Singer's stands (apse "c"). Sections. 1911.12.20. Schreiber, Trauer, Gehler. Paper, Ozalid, ink, 75 x 115 cm, call no. MAt-VI-21390.
Plan, foundations, northern part basement. 1912.01.05. Berg, Meyer, Trauer. Paper, Ozalid, 43 x 42 cm, call no. MAt-VI-21495.
Tension (stress) of the main arch of the dome. Construction drawing (section O). 1912.01.09. Berg, Trauer, Schreiber. Paper, print, 68 x 74 cm, call no. MAt-VI-21532.
Construction drawing. Tension (stress) of the main arch of the dome (load calculations). Section no. 1. 1912.01.09. Berg, Trauer, Schreiber. Paper, print, 69 x 59 cm, call no. MAt-VI-21539.
Implementation design for scaffolding and boarding of the resistance arch. Section and details. 1912.01.09. Schreiber, Trauer, Gehler. Paper, Ozalid, 65 x 54,5 cm, call no. MAt-VI-21767.
Implementation design for scaffolding and boarding of the resistance arch. Section and details. 1912.01.11. Schreiber, Trauer, Gehler. Paper, Ozalid, 64,5 x 49,5 cm, call no. MAt-VI-21768.
Tension (stress) of the main arch of the dome. Construction drawing (load calculations). Sections no. 4–5. 1912.01.13. Berg, Trauer, Schreiber. Paper, print, 64 x 83 cm, call no. MAt-VI-21535.
Construction drawing of main arch of the dome (structural calculations of the point of bending and twisting as a result of perpendicular forces). 1912.01.13. Berg, Trauer, Schreiber. Paper, print, 68 x 86 cm, call no. MAt-VI-21536.

Construction drawing. Tension (stress) of the main arch of the dome (load calculations). Sections no. 6–7. 1912.01.13. Berg, Trauer, Schreiber. Paper, print, 60 x 87 cm, call no. MAt-VI-21537.
Construction drawing. Tension (stress) of the main arch of the dome (load calculations). Sections no. 2–3. 1912.01.13. Berg, Trauer, Schreiber. Paper, print, 64 x 83 cm, call no. MAt-VI-21538.
Implementation design for scaffolding and boarding of the resistance arch. Details, section and view. 1912.01.13. Schreiber, Trauer, Gehler. Paper, Ozalid, 33 x 60 cm, call no. MAt-VI-21769.
Implementation design for scaffolding and boarding of the dome ribs. Plans. 1912.01.19. Schreiber, Trauer, Gehler. Paper, Ozalid, 55 x 63,5 cm, call no. MAt-VI-21770.
Drawing of the reinforcement structure of 4 main pillars and arch endings (ribs) of the dome. 1912.01.22. Berg, Trauer, Schreiber. Paper, print, 75 x 100 cm, call no. MAt-VI-21534.
Construction drawing of the balconies. 1912.01.26. Paper, Ozalid, 64,5 x 43,5 cm, call no. MAt-VI-21392.
Drawing of static calculations of the main rib arch. 1912.01.31, Berg, Trauer, Schreiber, Paper, print, 68 x 87 cm, call no. MAt-VI-21523.
Drawing of static calculations of the main rib arch. 1912.01.31. Berg, Trauer, Schreiber, Paper, print, 68 x 87 cm, call no. MAt-VI-21524.
Polygonal room, plan, construction diagram, 1912.02.01, Berg, Moshamer, Schreiber, Trauer. Paper, Ozalid, tinted watercolor, 55 x 105 cm, call no. MAt-VI-21499.
Construction drawing of elements of the gallery. 1912.02.01. Paper, Ozalid, 95,5 x 65 cm, call no. MAt-VI-21394.
Implementation design. Section of dome ribs. 1912.02.08. Berg, Trauer, Schreiber. Paper, print, 70 x 120 cm, call no. MAt-VI-21525.
Implementation design for the Imperial stands (apse “a”). Sections. 1912.02.15. Schreiber, Trauer, Gehler. Paper, Ozalid, ink, 91 x 128 cm, call no. MAt-VI-21406.
Side entrance – section. 1912.02.16. Berg, Schreiber, Trauer. Paper, Ozalid, 32 x 119 cm, call no. MAt-VI-21504.
Implementation design. Construction drawing of apse resistance arch. 1912.02.17. Schreiber, Trauer. Paper, Ozalid, ink, 109 x 97,5 cm, call no. MAt-VI-21408.
Implementation design. Construction drawing of resistance arch joints. Sections. 1912.03.04. Schreiber, Gehler. Paper, Ozalid, ink, 67 x 51 cm, call no. MAt-VI-21409.
Implementation design, fragment, side entrance – plan. 1912.03.06. Berg, Schreiber, Trauer. Paper, Ozalid, green ink, 123 x 90 cm, call no. MAt-VI-21510.
Implementation design. Study of buttress bindings under the dome. 1912.04.02. Berg, Trauer, Schreiber. Paper, print, 63 x 94 cm, call no. MAt-VI-21527.
Closing of the arch of the dome in plan and section. Symbols (calculations) section of the arch and equalization plane. 1912.04.19. Berg, Trauer, Schreiber. Paper, print, 141 x 85 cm, call no. MAt-VI-21530.
Implementation design. Construction drawing. Main entrance – upper level. Plan. 1912.04.24. Schreiber, Trauer. Paper, Ozalid, crayon, 74,5 x 74,5 cm, call no. Mat-VI-21410.
Implementation design. Construction drawing of windscreen frame. 1912.04.30. Schreiber, Trauer. Paper, Ozalid, ink, 86,5 x 63 cm, call no. MAt-VI-21411.
Implementation design. Main entrance to the Hall. Ground floor and mezzanine of the side rooms and vestibule. Plan. 1912.05.01. Berg, Schreiber, Trauer. Paper, Ozalid, 86.5 x 134 cm, call no. MAt-VI-21773.
Plan of basement. 1912.05.13. Berg, Konwiarz, Schreiber. Paper, print, 101 x 85 cm, call no. MAt-VI-21429.
Implementation design. Foundations of the main entrance, plan. 1912.05.14. Berg, Schreiber, Trauer. Paper, Ozalid, red crayon drawing, 90 x 139 cm, call no. MAt-VI-21503.
Implementation design. Construction drawing of resistance arches, sections. 1912.05.20. Gehler, Trauer, Schreiber. Paper, Ozalid, 84 x 83 cm, call no. MAt-VI-21412.
Construction drawing of dome rib rings. 1912.05.24. Behrendt Fritz, Trauer. Paper, Ozalid, 65,5 x 113 cm, call no. MAt-VI-21413.
Implementation design of the apse. Section a-b, c-d, construction detail. 1912.05.24. Trauer, Klein, Schulz. Paper, Ozalid, 94 x 75 cm, call no. MAt-VI-21414.

Implementation design. Construction drawing of dome ribs. 1912.06.03. Schreiber, Trauer. Paper, Ozalid, 97,5 x 74,5 cm, call no. MAt-VI-21424.
Implementation design of reception hall, floor plan. 1912.06.13. Berg, Schreiber, Trauer. Paper, Ozalid, 80 x 134 cm, call no. MAt-VI-21774.
Implementation design of dome rib. Construction drawing, sections. 1912.06.28. Trauer, Jaide. Paper, Ozalid, 77,5 x 117 cm, call no. MAt-VI-21415.
Implementation design. Construction drawing of reinforced concrete ceiling of the basement in the northern part of the Hall. 1912.06.29. Berg, Trauer, Schreiber. Paper, Print, water colors, 57 x 71 cm, call no. MAt-VI-21541.
Implementation design. Main entrance and reception hall. Section. 1912.07.02. Berg, Schreiber, Trauer. Paper, Ozalid, 69.5 x 125 cm, call no. MAt-VI-21775.
Implementation design. Main entrance and reception hall. Longitudinal section. 1912.07.08. Berg, Schreiber, Trauer, Konwiarz. Paper, Ozalid, 62 x 153 cm, call no. MAt-VI-21776.
Implementation design. Construction drawing of dome elements. 1912.07.30. Paper, Ozalid, 48,5 x 73,5 cm, call no. MAt-VI-21378 call no. MAt-VI-21378.
Implementation design for concrete structure gallery in the apses. 1912.08.13. Fechtel, Schreiber, Trauer. Paper, Ozalid, water colors, 77,5 x 81 cm, call no. MAt-VI-21416.
Projections in different sectional planes (ground floor and top floors). Overall plan. 1912.09. Berg, Trauer. Paper, print, 92 x 83 cm, call no. MAt-VI-21512.
Implementation design. Construction drawing with details. 1912.09. Schreiber (Bauamt), Trauer (Städt. Brückenbauamt). Paper, Ozalid, 95,5 x 100 cm, call no. MAt-VI-21420.
Implementation design. Construction drawing of dome elements. 1912.09. Schreiber, Trauer (Städt. Brückenbauamt). Paper, Ozalid, 33 x 42 cm, call no. MAt-VI-21418.
Implementation design for lantern rib. 1912.09.14. Trauer, Jaide. Paper, Ozalid, 64 x 61 cm, call no. MAt-VI-21421.
Plumbing installations Implementation design. Ground floor plan dated May 6, 1912. 1912.10.04. Schreiber (Bauamt), Dünnebier Johannes, Berg. Paper, canvas, print, ink, 92 x 80,5 cm, call no. MAt-VI-21805.
Plumbing installations Implementation design. Plan dated May 22, 1912. 1912.10.04. Schreiber, Dünnebier Johannes. Paper, canvas, print, ink, 93 x 80,5 cm, call no. MAt-VI-21804.
Implementation design. Construction drawing of wall supports in the basement. 1912.11.15. Beer A., Schreiber. Paper, canvas, Ozalid, 46,5 x 35 cm, call no. MAt-VI-21422.
Implementation design. Main entrance and reception hall. Steel roof structure. 1912.11.18. Schreiber, Trauer. Paper, Ozalid, 59 x 94 cm, call no. MAt-VI-21777.
Implementation design. Main entrance and reception hall. Steel roof structure. 1912.11.24. Trauer, Schreiber. Paper, Ozalid, 49 x 112 cm, call no. MAt-VI-21778.
Implementation design. Main entrance and reception hall. Steel roof structure. 1912.11.24. Trauer, Schreiber. Paper, Ozalid, 90 x 130,5 cm, call no. MAt-VI-21779.
Implementation design. Heating channel closing details. 1912.12. Schreiber. Paper, Ozalid, 55,5 x 41,5 cm, call no. MAt-VI-21780.
Implementation design. Reinforced concrete sewage coverings in the main entrance. 1912.12.14. Schreiber, Trauer. Paper, Ozalid, 45 x 52 cm, call no. MAt-VI-21781.
Plumbing installations Implementation design. Plan. Ca. 1912. Paper, Ozalid, 40 x 39 cm, call no. MAt-VI-21456.
Organ stands. Foundation and acoustics (plan and cross-section). 1913.01. Berg, Trauer, Schreiber. Paper, print, 85 x 119 cm, call no. MAt-VI-21528.
Transformer room at the east entrance in the south. 1913.02.25. Schreiber, Trauer. Paper, Ozalid, 57 x 85 cm, call no. MAt-VI-21782.
Dome skylight. Section and plan. 1913.03.05. Konwiarz. Paper, print, 129,5 x 87 cm, call no. MAt-VI-21783.
Implementation design for *Festspiel* Gerhart Hauptmann amphitheater. Plan and section. 1913.03.14. Berg, Trauer. Paper, drawing in black and red, 100 x 104 cm, call no. MAt-VI-21516.

Completion of the Implementation design for *Festspiel* Gerhart Hauptmann amphitheater. Sections (A-B, C-D). 1913.03.14. Berg, Trauer. Ozalid, brown, red, and green ink, 66 x 105 cm, call no. MAt-VI-21520.
Plan and section of the stage for the opening of the Centennial exhibition in May 1913. 1913.04. Berg, Trauer. Ozalid, crayon on paper, 58 x 102 cm, call no. MAt-VI-21513.
Plan and section of the stage for the opening of the Centennial exhibition in May 1913. 1913.04. Berg, Trauer. Paper, Ozalid, 60 x 108 cm, call no. MAt-VI-21519.
Hall. Section of the main axis with selected dimensions of the main elements of buildings. 1913.04. Berg, Trauer. Paper, print, 40 x 92 cm, call no. MAt-VI-2724.
Main entrance. Construction drawing. 1913.04.17. Paper, Ozalid, 85 x 135 cm, call no. MAt-VI-21784.
Plan. Stands seat arrangement in the amphitheatre before the opening in May 1913. 1913.05.17. Berg, Trauer. Paper, print, 83 x 164 cm, call no. MAt-VI-21514.
Ground floor plan and layout of the stands and the stage (base), extension of wooden dressing rooms for the artists in the north entrance, plan and cross-sections of *Festpiel* Gerhart Hauptmann. 1913.06.25. Berg, Trauer, Schreiber. Paper, print, drawing in red, 82 x 85 cm, call no. MAt-VI-21515.
Building inventory. Section of the main axis, mid-1913, copy 1921. 1913.06. Berg. Paper, Ozalid, 30 x 83 cm, call no. MAt-VI-21787.
Horizontal projection. Ca. 1913. Paper, print, 36 x 32 cm, call no. MAt-VI-21453.
Horizontal projection. Ca. 1913. Paper, print, 36 x 32 cm, call no. MAt-VI-21452.
Horizontal projection. Ca. 1913. Paper, print, 29,5 x 22,5 cm, call no. MAt-VI-21446.
Horizontal projection. Ca. 1913. Paper, print, 29,5 x 22,5 cm, call no. MAt-VI-21445.
Horizontal projection. Ca. 1913. Paper, print, 29,5 x 22,5 cm, call no. MAt-VI-21444.
Diagram of switchboard. Ca. 1913. Paper, Ozalid, ink, 34 x 27,5 cm, call no. MAt-VI-21477.
Diagram of switchboard. Ca. 1913. Paper, Ozalid, ink, 32 x 23 cm, call no. MAt-VI-21476.
Diagram of switchboard. Ca. 1913. Paper, Ozalid, ink, 18 x 23 cm, call no. MAt-VI-21475.
Stands seat arrangement. Horizontal projection. Ca. 1913. Paper, print, 82 x 76 cm, call no. MAt-VI-21433.
Horizontal projection (half). Ca. 1913. Paper, canvas, print, 84,5 x 163 cm, call no. MAt-VI-21795.
Stands seat arrangement Implementation design. Ca. 1913. Schreiber. Paper, Ozalid, ink, 84,7 x 84,4 cm, call no. MAt-VI-21793.
Stands seat arrangement Implementation design. 1919.09. Berg. Paper, Ozalid, ink, 84,9 x 84,8 cm, call no. MAt-VI-21788.
Apse and entrance hall. Implementation design for passage. Plans of parts of the basement and first floor. 1919.09. Paper, Ozalid, 32,5 x 41 cm, call no. MAt-VI-21786.
Western apse and reception hall. Implementation design for passage. Plans of parts of the basement and first floor. 1919.09. Paper, Ozalid, ink, 32 x 42 cm, call no. MAt-VI-21791.
Western apse. Implementation design for room leading to the roof over the Imperial hall. Roof plan. 1919.09.25. Schreiber. Paper, Ozalid, 33 x 42 cm, call no. MAt-VI-21790.
Western apse. Implementation design for room leading to the roof over the Imperial hall. Roof plan. 1919.09.25. Schreiber. Paper, Ozalid, ink, 33 x 41,5 cm, call no. MAt-VI-21789.
Implementation design for seat arrangement, October, 1919. Horizontal projection. 1919.11. Schreiber. Paper, print, water colors, 85 x 85 cm, call no. MAt-VI-21792.
Implementation design for seat arrangement. Ca. 1919. Berg. Paper, print, 85 x 84,6 cm, call no. MAt-VI-21794.
Implementation design for offices close to the south entrance. Horizontal projection, section. 1920.10.02. Schreiber (Magistratsbaurat), Jerschke P. Paper, Ozalid, crayon, 44,5 x 46 cm, call no. MAt-VI-21430.
Implementation design for stands of Six Days race track. Horizontal projection, sections of built-in parts. 1920.11. Hossenfelder Gustav. Paper, Ozalid, water colors, ink, 86 x 99 cm, call no. MAt-VI-21431.
Implementation design for stands of Six Days race track. Horizontal projection, section. 1920.12. Hossenfelder Gustav. Paper, Ozalid, ink, crayon, 65,5 x 60 cm, call no. MAt-VI-21432.
Horizontal projection. Ca. 1920. Paper, Ozalid, 29 x 23 cm, call no. MAt-VI-21449, 2.
Horizontal projection. Ca. 1920. Paper, Ozalid, 29 x 23 cm, call no. MAt-VI-21449, 1.

Horizontal projection. Ca. 1920. Paper, Ozalid, 29 x 23 cm, call no. MAt-VI-21449, 3.
Horizontal projection. Ca. 1920. Paper, print, 29 x 23 cm, call no. MAt-VI-21449.
Implementation design for seat arrangement. Horizontal projection. 1921.09. Konwiarz, Berg. paper, Print, water colors, 84,8 x 86 cm, call no. MAt-VI-21797.
Implementation design for seat arrangement. Horizontal projection. 1921.09. Konwiarz, Berg. paper, Print, water colors, 84,7 x 86 cm, call no. MAt-VI-21796.
Implementation design for stands. Horizontal projection. 1921.09.12. Konwiarz, Berg. Paper, print, water colors, 88 x 87 cm, call no. MAt-VI-21801.
Implementation design for balconies in the western apse for the Gerhart Hauptmann Arts Festival. Horizontal projection (fragment). 1922.07. Berg. Paper, Ozalid, 60,5 x 69,5 cm, call no. MAt-VI-21435.
Implementation design for stage and stands for the Gerhart Hauptmann Arts Festival. Section. 1922.07. Paper, Ozalid, ink, 21 x 85 cm, call no. MAt-VI-21434.
Implementation design arrangement of fair stands. Horizontal projection. 1923.03.28. Schreiber. Paper, print, water colors, 97 x 82 cm, call no. MAt-VI-21436.
Stands plan at the sports arena. Horizontal projection. 1923.12. Paper, Ozalid, ink, water colors, 86 x 99,5 cm, call no. MAt-VI-21437.
Main stands. Plan, cross-section a-b. 1924.06.16. Wolf. Paper, Ozalid, water colors, crayon, 50 x 80,5 cm, call no. MAt-VI-21799.
Sports arena stands plan. Horizontal projection. 1924.07.18. Bremer Georg, Architect, Berlin. Paper, Ozalid, water colors, 83 x 79,5 cm, call no. MAt-VI-21438.
Sports arena stands plan. Horizontal projection. 1924.07.18. Bremer Georg, Architect, Berlin. Paper, Ozalid, water colors, 83 x 83,5 cm, call no. MAt-VI-21439.
Sports arena stands plan. Horizontal projection. 1924.07.18. Bremer Georg, Architect, Berlin. Paper, Ozalid, water colors, 83,5 x 83 cm, call no. MAt-VI-21440.
Implementation design for ring and stands for boxing tournament. Horizontal projection. 1924.09.06. Paper, canvas, Ozalid, 35 x 62 cm, call no. MAt-VI-21798.
Horizontal projection. 1925. Paper, print, 28,5 x 22,5 cm, call no. MAt-VI-21443.
Horizontal projection. 1925. Paper, print, 28,5 x 22,5 cm, call no. MAt-VI-21442.
Hall and extension of a makeshift exhibition pavilion at the east side entrance. Horizontal projection. 1925. Paper, print, 28,5 x 22,5 cm, call no. MAt-VI-21441.
Diagram of a fire alarm system at the Exhibition Grounds with the main control room in the Hall. Site plan. 1926. Kaschner. Tracing paper, print, 42 x 67,5 cm, call no. MAt-VI-21447.
Horizontal projection. 1926.02.15. Paper, Ozalid, crayon, 29 x 23 cm, call no. MAt-VI-21450.
Diagram of fire protection installations switchboard. 1926.03.05. Paper, ink, water colors, 66 x 98,5 cm, call no. MAt-VI-21448.
Krone Circus stands plan. Horizontal projection. 1926.03.30. Paper, Ozalid, water colors, 82,5 x 79,5 cm, call no. MAt-VI-21451.
Implementation design for seat arrangement for Passion performance in 1926. Horizontal projection. 1926.07.30. Hoppe R. Tracing paper, pencil, 74 x 81 cm, call no. MAt-VI-21800.
Landscape Implementation design assumptions for Linden alley around the Centennial Hall. Horizontal projection. 1928.11.12. Stephan. Paper, Ozalid, crayon, 40 x 37,5 cm, call no. MAt-VI-21454.
Implementation design for plumbing installations around the Centennial Hall. Horizontal projection. 1929.01.30. Paper, Ozalid, ink, 34 x 33 cm, call no. MAt-VI-21455.
Implementation design for plumbing installations. Horizontal projection. 1929.02.05. Paper, Ozalid, 33 x 40 cm, call no. MAt-VI-21457.
Stands seat arrangement plan. Horizontal projection. 1930.05. Behrendt Fritz, Konwiarz. Cardboard, Ozalid, 91 x 85 cm, call no. MAt-VI-21459.
Stands seat arrangement plan. Horizontal projection. 1930.05. Behrendt Fritz, Konwiarz. Cardboard, Ozalid, 90 x 85 cm, call no. MAt-VI-21458.
Implementation design for transformer station. Site plan, horizontal projection, sections a-b, c-d. 1930.09.20.

Paper, canvas, Ozalid, water colors, 46,5 x 54 cm, call no. MAt-VI-21460.
Implementation design for arrangement of seats for bike races. Horizontal projection. 1932.03.03. paper, print, 85,5 x 80 cm, call no. MAt-VI-21461.
Implementation design for seat arrangement for the XII. Deutsches Sängerbundesfest 1937. Horizontal projection. 1937. Paper, Ozalid, 85 x 105 cm, call no. MAt-VI-21467.
Implementation design for seat arrangement. Horizontal projection. 1937.10. Konwiarz. Paper, canvas, print, water colors, 85 x 103 cm, call no. MAt-VI-21466.
Implementation design for stands seat arrangement during a boxing tournament. Horizontal projection. 1937. Paper, Ozalid, 30 x 58 cm, call no. MAt-VI-21465.
Stands seat arrangement. Horizontal projection. 1937.02. Paper, Ozalid, water colors, 28 x 34 cm, call no. MAt-VI-21464.
Stands seat arrangement for XII Deutsches Sängerbundesfest. Horizontal projection. 1937. Paper, Ozalid, 86 x 104,5 cm, call no. MAt-VI-21473,.
Section of the main axis, west-east. 1937.01. Konwiarz. Paper, Ozalid, 34,5 x 101 cm, call no. MAt-VI-21462.
Implementation design for artists dressing rooms behind the organs. Horizontal projection. 1937.05.27. Paper, canvas, Ozalid, ink, water colors, 50 x 84 cm, call no. MAt-VI-21471.
Implementation design for space under the main auditorium. Horizontal projection. 1937.05.27. Paper, canvas, Ozalid, ink, water colors, 62 x 55 cm, call no. MAt-VI-21470.
Implementation design for space under the main auditorium. Horizontal projection. 1937.05.27. Paper, canvas, Ozalid, ink, water colors, 62 x 55 cm, call no. MAt-VI-21469.
Site plan. 1937.05.27. Paper, canvas, Ozalid, water colors, 30,5 x 25 cm, call no. MAt-VI-21468.
Implementation design for space under the main auditorium. Horizontal projection. 1937.06. Paper, Ozalid, 61 x 97 cm, call no. MAt-VI-21472.
Stage Implementation design for the XII Congress of the German Association of Singers in July, 1937. 1937.07.06. Paper, Ozalid, 41,5 x 106 cm, call no. MAt-VI-21772.
Implementation design for seat arrangement for the Passion performance. Horizontal projection. 1937.10. Konwiarz. Paper, print, crayon, 82,5 x 100 cm, call no. MAt-VI-21802.
Implementation design for seat arrangement for the Passion performance. Horizontal projection. 1937.10. Konwiarz. Paper, print, crayon, 82,5 x 100 cm, call no. MAt-VI-21803.
Implementation design for seat arrangement during a boxing tournament. Horizontal projection. 1938.10.28. Paper, Ozalid, 36,5 x 64 cm, call no. MAt-VI-21474.
Diagram of a switchboard in the Centennial Hall. 1938.11.06. Paper, print, crayon, ink, 30 x 21 cm, call no. MAt-VI-21478.
Diagram of a switchboard in the Centennial Hall. 1938.11.06. Tracing paper, ink, crayon, 30 x 21 cm, call no. MAt-VI-21853.
Implementation design for restroom. Plan, section. 1938.12.23. Konwiarz, Schwarz. Paper, canvas, ozalid, water colors, ink, 25 x 44,5 cm, call no. MAt-VI-21479.
People's Hall. Ground and first floor horizontal projection. 1957.07.15. Paper, Ozalid, 131,5 x 64,5 cm, call no. MAt-VI-21480.

Centennial exhibition, Historical Exhibition Pavilion
Implementation design approved for implementation, September 11, 1912. Horizontal projection. 1912.07.00. Poelzig, Schreiber. Paper, canvas, Ozalid, water colors, 125 x 96,5 cm, call no. H415.
Implementation design approved for implementation, September 11, 1912. Implementation design for front façade and side façade with avant-corps in the southern wing. 1912.07.00. Poelzig, Schreiber. Paper, canvas, Ozalid, water colors, 33 x 94 cm, call no. H414.
Implementation design approved for implementation, September 11, 1912. Implementation design for side façade in the east and west wings. 1912.07.00. Poelzig, Schreiber. Paper, canvas, Ozalid, 27 x 95,5 cm, call no. H413.
Implementation design approved for implementation, September 11, 1912. Courtyard façade Implementation design in the north wing. 1912.07.00. Poelzig, Schreiber. Paper, canvas, Ozalid, water colors, 30 x 90 cm, call no. H412.

Implementation design approved for implementation, September 11, 1912. Section of the south wing. 1912.07.00. Poelzig, Schreiber. Paper, canvas, Ozalid, water colors, 42 x 97 cm, call no. H411.
Implementation design approved for implementation, September 11, 1912. Implementation design for rear façade of the northern wing. 1912.07.00. Poelzig, Schreiber. Paper, canvas, Ozalid, 29,5 x 117 cm, call no. H410.
Implementation design approved for implementation, September 11, 1912. Dome hall, dedicated to Wrocław and the garden hall in the north wing, section. 1912.07.00. Poelzig, Schreiber. Paper, canvas, Ozalid, water colors, 33 x 64 cm, call no. H409.
Implementation design approved for implementation, September 11, 1912. Courtyard façade Implementation design in the north wing. 1912.07.00. Poelzig, Schreiber. Paper, canvas, Ozalid, water colors, 32 x 93 cm, call no. H408.
Implementation design approved for implementation, September 11, 1912. Longitudinal section through the dome hall in the east and west wings, showing the scale of man inside. 1912.07.00. Poelzig, Schreiber. Paper, canvas, Ozalid, water colors, 32 x 63 cm, call no. H407.
Implementation design approved for implementation, September 11, 1912. Section of the dome hall's main entrance in the southern wing. 1912.07.00. Poelzig, Schreiber. Paper, canvas, Ozalid, water colors, 36 x 62,5 cm, call no. H406.
Implementation design approved for implementation, September 11, 1912. Sections M-N through rooms close to the domed hall in the north wing, section I-J through rooms at the corners of the building, section K-L through the Halls in the west and south wings. 1912.08.00. Schreiber. Paper, canvas, Ozalid, water colors, 57 x 75 cm, call no. H403.
Implementation design approved for implementation, September 11, 1912. Cross-sections of: A-B rooms in southern wing, C-D and E-F through rooms in northern wing, G-H section through northern wing, construction details. 1912.08.00. Schreiber. Paper, canvas, Ozalid, water colors, 78,5 x 93 cm, call no. H401.
Implementation design approved for implementation, September 11, 1912. Structural Implementation design and cross-section of the pillars of the dome. 1912.09.00. Schreiber, Müller, Prof. Paper, canvas, Ozalid, 65 x 100 cm, call no. H402.
Implementation design approved for implementation, September 11, 1912. Construction Implementation design, horizontal projection. 1912.09.20. Schreiber. Paper, canvas, Ozalid, water colors, 126 x 81 cm, call no. H405.
Implementation design approved for implementation, September 11, 1912. Cross-sections of: O-P side rooms in the entrance hall of the southern wing, R-S atrium in the southern wing, T-U garden room in the northern wing. 1912.09.21. Schreiber. Paper, canvas, Ozalid, water colors, 64,5 x 77 cm, call no. H404.
Implementation design for sewer lines installation. Site plan. 1912.11.30. Schreiber (Bauamt). Paper, canvas, Ozalid, ink, 33 x 42 cm, call no. H733.
Ground floor plan and exhibition halls functions. Telephone cable layout. 1912.12.00. Paper, print, 72 x 98 cm, call no. H210.
Implementation design for skylight. construction drawing. 1913.07.00. Schreiber, A. Saal. Paper, canvas, Ozalid, water colors, 39 x 54,5 cm, call no. H584.
Implementation design for skylight, construction drawing. 1913.07.00. Schreiber, A. Saal. Paper, canvas, Ozalid, water colors, 39 x 58,5 cm, call no. H583.
Implementation design for storm drain network. Site plan. 1913.10.15. Schreiber, Dünnenbier Johannes. Paper, canvas, Ozalid, ink, 33 x 61,5 cm, call no. H734.
Building inventory. Horizontal projection. 1913.11.01. Poelzig, Schreiber. Paper, canvas, Ozalid, water colors, 105 x 140 cm, call no. H582.
Building inventory. Horizontal projection. 1913.11.01. Poelzig, Schreiber. Tracing paper, ink, 74 x 71 cm, call no. H581.
Subcontractor building inventory. Cross-section of the south wing A-B of the dome in the main entrance hall. 1913.11.01. Poelzig, Schreiber. Paper, canvas, Ozalid, 56,5 x 75,5 cm, call no. H580.
Building inventory. Longitudinal section C-D of the south wing. 1913.11.01. Poelzig, Schreiber. Paper, canvas, Ozalid, 48,5 x 79 cm, call no. H579.
Building inventory. Cross-section E-F of the domed hall dedicated to Wrocław in the northern wing. 1913.11.01.

Poelzig, Schreiber. Paper, canvas, Ozalid, water colors, 49 x 81,5 cm, call no. H578.
Building inventory. Longitudinal cross-section G-H of the north wing. 1913.11.01. Poelzig, Schreiber. Paper, canvas, Ozalid, water colors, 56,5 x 76 cm, call no. H577.
Building inventory. Longitudinal cross-section J-K, eastern and western wings. 1913.11.01. Poelzig, Schreiber. Paper, canvas, Ozalid, water colors, 50,5 x 98 cm, call no. H576.
Building inventory. Cross-section L-M, eastern and western wings, and courtyard façade in the southern wing. 1913.11.01. Poelzig, Schreiber. Paper, canvas, Ozalid, water colors, 48 x 101 cm, call no. H575.
Building inventory. Cross-section N-O, conference room adjacent to the corners of the southern and northern wings and courtyard façade of the western wing. 1913.11.01. Poelzig, Schreiber. Paper, canvas, Ozalid, water colors, 48 x 100 cm, call no. H574.
Building inventory. Cross-section P-Q, western and eastern wings and courtyard façade of the northern wing. 1913.11.01. Poelzig, Schreiber. Paper, canvas, Ozalid, water colors, 47,5 x 99,5 cm, call no. H573.
Building inventory. Drawing of the front façade in the southern wing. 1913.11.01. Poelzig, Schreiber. Paper, canvas, Ozalid, 48 x 99 cm, call no. H572.
Building inventory. Drawing of back façade in the north wing. 1913.11.01. Poelzig, Schreiber. Paper, canvas, Ozalid, 50 x 100,5 cm, call no. H571.
Building inventory. Drawing of the side façade in the eastern wing. 1913.11.01. Poelzig, Schreiber. Paper, canvas, Ozalid, 50 x 131,5 cm, call no. H570.
Plan. Ca. 1913. Paper, print, 76 x 62 cm, call no. H810.
Implementation design for the removal of partition walls in the exhibition rooms. Plan and section. 1914.07.00. Paper, Ozalid, ink, water colors, 39 x 42 cm, call no. H586.
Implementation design for chimney installations. Horizontal projection. 1914.07.22. Paper, canvas, Ozalid, ink, 83,5 x 57,5 cm, call no. H585.
Implementation design for removal of partition wall and two pillars of reinforced concrete. 1914.09.00. Paper, Ozalid, ink, 33 x 42 cm, call no. H589.
Site plan. Location of roads to the pavilion. 1925.00.00. Tracing paper, pencil, 35.5 x 35.5 cm, call no. H205.
Wrocław Autumn Fair, 1923. Plan. 1929.06.11. Paper, print, 29 x 20 cm, call no. H735.
Implementation design of a dummy cake for the Confectionery Exhibition, 1930. Site plan, cross-section, drawing of front part. 1930.05.20. Kabierschke Albrecht, Architect. Paper, canvas, Ozalid, 31 x 39,5 cm, call no. H588.

The Pergola and artificial pond

Artificial pond close to the Pergola. Site plan. Cross section of the sump drainage system. 1932.02.07. Paper, canvas, Ozalid, water colors, 40 x 46 cm, call no. H736.
Final Implementation design. Site plan. 1912.08.15. Beton– u. Eisenbetonbau, Pfeffer, Pringsheim & Co. Paper, canvas, Ozalid, crayon, 50 x 38,5 cm, call no. H388.
Construction Implementation design. 1912.09.30. Paper, Ozalid, 23 x 57 cm, call no. H387.

Centennial Exhibition, Main Restaurant

Site plan of the former Horserace track with Centennial Hall projection and unbuilt Implementation design of the restaurant and layout of the area adjacent to the Hall. 1912.03.30. Berg, Schreiber. Paper, Ozalid, red ink, 49 x 65 cm, call no. A07.
Final Implementation design. Plan of cellars. 1912.10.12. Schreiber, Oscar Haase. Paper, Ozalid, 42,5 x 118,5 cm, call no. H001.
Final Implementation design. Plan of cellars. 1912.10.12. Schreiber, Oscar Haase. Paper, Ozalid, 43,5 x 116 cm, call no. H002.
Final Implementation design. Section D-D. 1912.10.12. Schreiber. Oscar Haase. Paper, Ozalid, 33 x 37 cm, call no. H003.
Final Implementation design. Section D-D. 1912.10.12. Schreiber, Oscar Haase. Paper, Ozalid, 34 x 95 cm, call no. H004.
First floor plan. 1912.11.12. Schreiber, Oscar Haase. Paper, Ozalid, 42,5 x 113 cm, call no. H005.

First floor plan. 1912.11.12. Schreiber, Oscar Haase. Paper, Ozalid, 42,5 x 114,5 cm, call no. H006.
Second floor plan. 1912.11.12. Schreiber, Oscar Haase. Paper, Ozalid, 42,5 x 112,5 cm, call no. H007.
Second floor plan. 1912.11.12. Schreiber, Oscar Haase. Paper, Ozalid, 42,5 x 112,5 cm, call no. H008.
Layout of table arrangement on the Terrace Restaurant. 1912.11.06. Schreiber, Oscar Haase. Paper, Ozalid, 42,5 x 95,5 cm, call no. H009.
Construction of stairs in the northern part of the restaurant. Site plan. 1914.03.25. Schreiber, Oscar Haase. Paper, Ozalid, 32,5 x 65 cm, call no. H010.
Construction of stairs in the northern part of the restaurant. Partial section and plan. 1914.03.25. Schreiber, Oscar Haase. Paper, Ozalid, 33 x 47 cm, call no. H011.
Drawing for construction of 2 small annexes, in the southern part of the restaurant and the beer storage room. Site plan. 1914.04.14. Schreiber, Oscar Haase. Paper, Ozalid, 32,5 x 63 cm, call no. H012.
Drawing for construction of 2 small annexes, in the southern part of the restaurant and the beer storage room. Partial section and plan. 1914.04.14. Schreiber, Oscar Haase. Paper, Ozalid, 32,5 x 42 cm, call no. H013.
Restaurant extension. Plan of cellar. 1915.06.12. Schreiber. Paper, Ozalid, 60 x 92 cm, call no. H014.
Restaurant extension. Plan of cellar. 1915.06.12. Schreiber. Paper, Ozalid, 60 x 92 cm, call no. H015.
Approved Implementation design. Façade from side of the Centennial Hall, cross-section. 1912.07.01. Berg, Schreiber, Oscar Haase. Paper, print, 33 x 87 cm, call no. H016.
Restaurant extension. Ground floor plan with marked changes to the stairs and entrance to the pond. 1915.06.12. Schreiber. Paper, Ozalid, 59 x 92,5 cm, call no. H017.
Restaurant extension. Ground floor plan with marked changes of stairs and entrance to the pond. 1915.06.12. Schreiber. Paper, Ozalid, 58 x 92,5 cm, call no. H018.
Restaurant extension. Section A-B. 1915.06.12. Schreiber. Paper, Ozalid, 52 x 41,5 cm, call no. H019.
Main restaurant. Restaurant extension. Section A-B. 1915.06.12. Schreiber. Paper, Ozalid, 57 x 42 cm, call no. H020.
Construction drawing for stairs leading from the basement to the ground floor. Ground floor plan. 1915.08.21. Schreiber, Oscar Haase. Paper, Ozalid, 42 x 72 cm, call no. H021.
Construction drawing for stairs leading from the basement to the ground floor. Site plan. 1915.08.21. Schreiber, Oscar Haase. Paper, Ozalid, 32,5 x 64 cm, call no. H022.
Construction drawing for glass walls separating the terrace from the flat tar roof. Sections. 1915.09.25. Schreiber, Oscar Haase. Paper, Ozalid, 33 x 55 cm, call no. H023.
Construction drawing for glass walls separating the terrace from the flat tar roof. Site plan. 1915.09.25. Schreiber, Oscar Haase. Paper, Ozalid, 33 x 63,5 cm, call no. H024.
Construction drawing for glass walls separating the terrace from the flat tar roof. First floor plan. 1915.09.25. Schreiber, Oscar Haase. Paper, Ozalid, 33,5 x 15 cm, call no. H025.
Construction drawing for stairs leading from the basement to the Terrace Restaurant. Plan, sections. 1915.08.21. Oscar Haase, Schreiber. Paper, Ozalid, 33 x 86,5, call no. H026.
Approved Implementation design. Façade from side of the pond. Side façade and cross-section. 1912.08.00. Berg, Schreiber, Richard Haase. Paper, Ozalid, 43,5 x 113,5 cm, call no. H027.
Final Implementation design. Dome and cupola of the Terrace Restaurant. Plan and section. 1912.11.00. Schreiber. Paper, Ozalid, 66,5 x 62,5 cm, call no. H028.
Approved for implementation Exhibition Grounds site plan version for the area of 50 ha dated 25.05.1912. Site plan for the building of the Terrace Restaurant. 1912.05.25. Gustav Haase, Oscar Haase. Paper, print, 90, 5 x 140 cm, call no. H029.
Implementation design. Ground floor, terraces plan and location of music pavilions in front of the terraces from the north. Cross section of the terraces in front of the pond. 1912.08.01. Berg, Schreiber. Paper, print, 69,5 x 112 cm, call no. H031.
Approval for implementation. Façade Implementation design and cross-section from the side of the Centennial Hall. 1912.08.01. Berg, Oscar Haase, Schreiber. Paper, print, 33 x 67,5 cm, call no. H052.
Approval for implementation. View of the façade from the pond, side façade and cross-section. 1912.08.01. Berg, Oscar Haase, Schreiber. Paper, print, 43 x 114 cm, call no. H053.

Greenery layout. Site plan. 1929.00.00. Stephan. Tracing paper, ink, 41,5 x 56 cm, call no. H054.
Site plan. 1933.00.00. Tracing paper, ink, 63 x 47,5 cm, call no. H055.
Site plan. 1933.00.00. Tracing paper, ink, 63 x 47,5 cm, call no. H056.
Garden assumptions in front of the main restaurant. 1929.06.05. Stephan. Paper, Ozalid, crayon, 41,5 x 58,5 cm, call no. H501.
Garden assumptions in front of the main restaurant. 1943.11.03. Stephan. Paper, Ozalid, crayon, ink, 41,5 x 56,5 cm, call no. H500.
Garden assumptions in front of the main restaurant. 1930.0?.00. Paper, Ozalid, 47 x 53,5 cm, call no. H499.
Garden assumptions in front of the main restaurant. 1930.0?.00. Paper, Ozalid, 41,5 x 49 cm, call no. H498.
Garden assumptions in front of the main restaurant. 1930.0?.00. Paper, Ozalid, 41 x 53,5 cm, call no. H497.
Implementation design for an additional room. Site plan, horizontal projection of the second floor, cross-section, drawing of the façade. 1928.05.09. Mager Alexander. Paper, canvas, Ozalid, water colors, ink, 41 x 43 cm, call no. H385.
Implementation design for a garage. Horizontal projection, cross-section, drawing of front and back. 1928.05.09. Mager Alexander. Paper, canvas, Ozalid, water colors, 34 x 42 cm, call no. H383.
Electric motor installation. Site plan, horizontal projection. 1928.01.03. Wurmer. Tracing paper, ink, 34 x 51 cm, call no. H382.
Implementation design for rafter. Section. 1912.11.01. Hossenfelder Gustav. Tracing paper, ink, 33,5 x 21 cm, call no. H381.
Seating and table arrangements. Ground floor plan. 1922.04.00. Sust Max. Paper, print, water colors, 54 x 99,5 cm, call no. H378.
Implementation design for ceiling above the cafe. Horizontal projection. 1917.11.00. Schreiber. Paper, canvas, Ozalid, ink, 26,5 x 33,5 cm, call no. H377.
Implementation design of a celler for beer and cold room in the basement. Site plan, horizontal projection, sections: A-B, C-D, E-F, G-H, I-K. 1916.03.14. Haase Oscar, Ratsmaurermeister. Paper, canvas, Ozalid, ink, water colors, 66 x 89,5 cm, call no. H376.
Implementation design for laundry and dwelling rooms in the western wing. Horizontal projections of I and II floor, cross-section. 1915.09.24. Haase Oscar, Ratsmaurermeister. Paper, canvas, Ozalid, ink, water colors, 33 x 81,5 cm, call no. H375.
Implementation design for laundry and dwelling rooms in the western wing. Site plan. 1915.09.24. Haase Oscar, Ratsmaurermeister. Paper, canvas, Ozalid, ink, water colors, 33 x 64 cm, call no. H374.
Implementation design for the reconstruction and installation of new restrooms and bathing rooms. Site plan, floor plans: basement, ground floor and first floor. In the central and eastern wing, cross-sections of these parts. 1915.09.24. Paper, canvas, Ozalid, ink, water colors, 52 x 81 cm, call no. H373.
Implementation design of plumbing system. Ground floor horizontal projection. 1912.11.00, Rogge Paul, Schreiber. Paper, canvas, Ozalid, ink, water colors, 44 x 113 cm, call no. H372.
Implementation design of plumbing system. Horizontal projection of basement. 1912.11.00. Rogge Paul, Schreiber. Paper, canvas, Ozalid, ink, water colors, 44 x 116 cm, call no. H371.
Implementation design of plumbing system. Sections A-B and C-D. 1912.11.00. Rogge Paul, Schreiber. Paper, canvas, Ozalid, ink, water colors, 33 x 105 cm, call no. H370.
Implementation design for side staircase. Site plan. 1916.08.30. Haase Oscar, Ratsmaurermeister, Schreiber. Paper, canvas, Ozalid, ink, water colors, 32,5 x 64 cm, call no. H369.
Implementation design for side staircase. Horizontal projection, section. 1916.08.30. Haase Oscar, Ratsmaurermeister, Schreiber. Paper, canvas, Ozalid, ink, water colors, 33 x 50 cm, call no. H368.
Electric motor installation. Horizontal projection, section A-B. 1917.02.21. Tracing paper, ink, 42,5 x 46 cm, call no. H367.

Centennial Exhibition's amusement park
Site plan. 1912.07.31. Schreiber. Paper, print, 76,5 x 65,5 cm, call no. H335.
Site plan, front façade view, section, plan. 1912.08.20. Schreiber. Paper, canvas, print, supplemented with wa-

ter colors, 51,5 x 47,5 cm, call no. H336.
Site plan. 1912.10.05. Nitsch, Fritz Engert. Paper, print, ink, 66 x 63 cm, call no. H224.
Site plan. 1912.10.05. Robert Raschke, Zimmermeister. Paper, print, ink, 75 x 65 cm, call no. H215.
Watchtower. Site plan. 1912.10.15. Paper, Ozalid, 75,5 x 65 cm, call no. H346.
Winery. Site plan. 1912.10.15. Schreiber. Paper, print, 75 x 63 cm, call no. H328.
Section. 1912.11.00. Dudler. Paper, Ozalid, 44,5 x 74 cm, call no. H343.
Construction drawing, section. 1912.11.01. Helbig. Tracing paper, ink, 63,5 x 154 cm, call no. H306.
Construction drawing, section. 1912.11.01. Helbig C. Tracing paper, pencil, crayon, 38 x 63 cm, call no. H307.
Site plan. 1912.11.05. Helbig. Paper, canvas, Ozalid, ink, 65,5 x 62,5 cm, call no. H302.
Plan, sections, view of façade. 1912.11.05. Helbig. Paper, canvas, Ozalid, ink, water colors, 65,5 x 104 cm, call no. H303.
Site plan, plans, section, front and back façade view, view of fence. 1912.11.06. Fritz Engert. Paper, canvas, Ozalid, ink, 47,5 x 62 cm, call no. H225.
Horizontal projection. 1912.11.09. Helbig. Paper, canvas, Ozalid, water colors, 50 x 62,5 cm, call no. H305.
Implementation design for side façade. 1912.11.27. Walther Grossmann, Arch., (Dresden), A. Nitsch. Paper, Ozalid, 33,5 x 51,5 cm, call no. H280.
Implementation design for side façade. 1912.11.27. Walther Grossmann, Arch., (Dresden), A. Nitsch. Paper, Ozalid, 33,5 x 51,5 cm, call no. H281.
Implementation design for front façade. 1912.11.27. Walther Grossmann, Arch., (Dresden), A. Nitsch. Paper, Ozalid, 33 x 63 cm, call no. H282.
Drawing of garden façade. 1912.11.27. Walther Grossmann, Arch., (Dresden), Fritz Engert. Paper, Ozalid, 33 x 62,5 cm, call no. H284.
Section of rafter. 1912.11.27. A. Nitsch, Fritz Engert. Paper, canvas, Ozalid, ink, 45 x 63 cm, call no. H285.
Construction details. 1912.11.27. A. Nitsch. Tracing paper, ink, 41,5 x 66,5 cm, call no. H288.
Ground floor plan. 1912.11.27. Fritz Engert, Walther Grossmann – Dresden. Paper, Ozalid, water colors, 39,5 x 62 cm, call no. H289.
Horizontal projection of ground floor. 1912.11.27. Fritz Engert, Walther Grossmann – Dresden. Tracing Paper, Ozalid, 66,5 x 63,5 cm, call no. H291.
Section. 1912.11.27. Fritz Engert, Walther Grossmann – Dresden. Tracing Paper, Ozalid, 33,5 x 54,5 cm, call no. H292.
Implementation design for greenhouse. Plan, sections, façades. 1912.11.27. Cabanis (Charlot). lack of call no.
Plan, sections, front view. 1912.11.28. Schreiber, Gustaw Hossenfelder. Paper, canvas, Ozalid, ink, 41,5 x 74 cm, call no. H245.
Site plan. 1912.12.12. Schreiber. Paper, print, ink, 69,5 x 59 cm, call no. H247.
Plans, sections, views of individual buildings. 1912.12.12. Gebr. Krebs. Paper, Ozalid, 65 x 96,5 cm, call no. H248.
Site plan. 1912.12.12. Paper, print, ink, 66 x 60 cm, call no. H228.
Plan, sections. 1912.12.12. Paper, Ozalid, 71 x 111 cm, call no. H229.
Construction drawing. 1912.12.12. Paper, Ozalid, 45,5 x 130 cm, call no. H231.
Horizontal projection. 1912.12.13. Helbig. Paper, canvas, Ozalid, water colors, 49,5 x 63 cm, call no. H304.
Front and back façade views, sections, plan, detail, site plan. 1912.12.23. Paper, canvas, Ozalid, red ink, 51 x 98 cm, call no. H337.
Section. 1912.12.24. Walther Grossmann. Paper, Ozalid, 25 x 30 cm, call no. H320.
View of façade from the street. 1912.12.24. Walther Grossmann. Paper, Ozalid, crayon, 24,5 x 35 cm, call no. H321.
Plan. 1912.12.24. Walther Grossmann. Tracing Paper, Ozalid, 52 x 34 cm, call no. H322.
Winery. Section, plan. 1912.12.28. Helbig. Paper, canvas, print, water colors, 74 x 83,5 cm, call no. H277.
Horizontal projection. 1912.12.30. Helbig. 93 x 62,5 cm, call no. H273.
Perspective drawing. 1912.12.30. Helbig. Paper, print, 33 x 77,5 cm, call no. H274.
Site plan. 1912.12.30. Helbig. Paper, Ozalid, ink, 33 x 41,5 cm, call no. H275.
Winery. Façade view. 1912.12.30. Helbig. Paper, print, 66 x 62,5 cm, call no. H276.

Construction drawing. Section of rafter. 1912.12.31. A. Nitsch, Fritz Engert. Paper, canvas, Ozalid, 37,5 x 63 cm, call no. H286.
Plan, sections, detail, site plan. 1913.01.00. Eduard Freytag. Paper, Ozalid, 49,5 x 79 cm, call no. H338.
Site plan. 1913.01.02. A. Nitsch, Maurer– u. Zimmermstr., Fritz Engert, Zimmerei– u. Baugesch. Paper, print, ink, 65,5 x 63 cm, call no. H279.
Construction drawing. Layout of rafter beams. 1913.01.02. A. Nitsch, Fritz Engert. Paper, canvas, Ozalid, 57 x 83 cm, call no. H287.
Site plan, plan, section, façade view. 1913.01.13. Alfred Kolbe, Zimmermeister, Schreiber. Paper, canvas, print, ink, 65,5 x 42 cm, call no. H311.
Construction drawing. 1913.01.18. Walther Grossmann. Tracing paper, ink, 38,5 x 48 cm, call no. H323.
Construction details drawing, section. 1913.01.23. Paper, Ozalid, canvas, supplemented with ink, 54,5 x 54 cm, call no. H339.
Construction drawing, section. 1913.01.23. Tracing paper, ink, 64 x 97 cm, call no. H232.
Front, side and back façade view. 1913.02.00. A. Lorenz. Paper, canvas, Ozalid, 49 x 83 cm, call no. H294.
Plan, section, view. 1913.02.00. Hermann Boese. Paper, canvas, Ozalid, water colors, 40,5 x 42 cm, call no. H219.
Implementation design for 2 round stages. Drawing of façade, section and plan. 1913.02.10. Jaide. Paper, Ozalid, 33 x 22,5 cm, call no. H156.
Implementation design for details. 1913.02.14. Fritz Engert, A. Nitsch. Tracing paper, ink, 33,5 x 41,5 cm, call no. H283.
Horizontal projection, façade view, section. 1913.02.15. Schreiber, Fritz Freudenreich. Paper, canvas, print, ink, 43 x 42 cm, call no. H272.
Site plan. 1913.02.15. Schreiber, Gustaw Hossenfelder. Paper, canvas, print, ink, 66 x 74 cm, call no. H244.
Plan, sections. 1913.02.15. Paper, Ozalid, 74 x 62 cm, call no. H230.
Waterslide. Section, plan, façade view. 1913.02.18. Helbig. Paper, canvas, Ozalid, 55,5 x 62,5 cm, call no. H278.
Implementation design. Drawing of façade, section and plan. 1913.02.19. Jaide. Paper, Ozalid, 56,5 x 64,5 cm, call no. H157.
Site plan, plan, front and side façade view. 1913.02.22. Gustaw Hossenfelder. Paper, canvas, Ozalid, 33 x 52 cm, call no. H246.
Plan, section, drawing of façade. 1913.03.00. Fritz Freudenreich, Schreiber. Paper, Ozalid, ink, 32,5 x 41,5 cm, call no. H327.
Site plan, plan, rafter section, front and side façade view. 1913.03.00. Albert Grau [?]. Paper, Ozalid, water colors, 34,5 x 66,5 cm, call no. H250.
Site plan, plan, section, view. 1913.03.00. Hugo Baum. Paper, canvas, Ozalid, ink, 32,5 x 42 cm, call no. H220.
Site plan, plan, section of rafter, front and side façade view. 1913.03.01. Albert Grau [?]. Paper, canvas, Ozalid, water colors, 33,5 x 65 cm, call no. H249.
Plan, section, façade view. 1913.03.03. Hermann Stricker, Schreiber. Tracing paper, ink, 53,5 x 91,5 cm, call no. H300.
Site plan. 1913.03.03. Hermann Stricker, Schreiber. Tracing paper, ink, 33,5 x 21 cm, call no. H301.
Implementation design on canvas, painted screens along the tram track. Sections. 1913.03.07. Paper, Ozalid, ink, 48,5 x 69,5 cm, call no. H233.
Implementation design on canvas, painted screens along the tram track. Plan, sections. 1913.03.07. Paper, Ozalid, ink, 65 x 106 cm, call no. H234.
Site plan, façade view, plan, section. 1913.03.08. Erich Grau. Paper, canvas, Ozalid, ink, 33 x 62,5 cm, call no. H332.
Plan, cross-section A-B. 1913.03.10. A. Lorenz. Paper, canvas, Ozalid, 59 x 41,5 cm, call no. H297.
Site plan, plan, section, view. 1913.03.13. Alfred Kolbe. Paper, canvas, Ozalid, ink, 66 x 42 cm, call no. H252.
Site plan. 1913.03.14. Schreiber, Fritz Freudenreich. Paper, print, ink, 66,5 x 65,5 cm, call no. H271.
Site plan. 1913.03.15. Hermann Stricker. Paper, print, crayon, ink, 33 x 21 cm, call no. H312.
Plan, section, façade view. 1913.03.15. Hermann Stricker. Tracing paper, ink, 33 x 42,5 cm, call no. H313.
Construction drawings, static calculations. 1913.03.15. Schreiber, Michael Kaliski. Paper, ink, 33,5 x 42,5 cm, call no. H213.

Site plan, projection, sections, view. 1913.03.15. Schreiber, Michael Kaliski. Paper, Ozalid, ink, 65 x 82 cm, call no. H214.
Site plan. 1913.03.17. Paper, print, 66 x 63 cm, call no. H324.
Projection, sections, façade views. 1913.03.17. Arthur Potzsch. Paper, Ozalid, 41 x 83 cm, call no. H325.
Construction drawing. Section. 1913.03.17. A. Lorenz. Tracing paper, ink, 33 x 42 cm, call no. H296.
Amusement park plan. Site plan. 1913.03.18. Fritz Freudenreich, Schreiber. Paper, print, ink, 66 x 63 cm, call no. H265.
Projection, section, façade view. 1913.03.18. Fritz Freudenreich. Paper, Ozalid, 33 x 42 cm, call no. H266.
Miniature railway station. Site plan, projection and cross-section, façade views. 1913.03.22. Michael Kaliski. Paper, Ozalid, 55 x 62 cm, call no. H318.
Site plan. 1913.03.22. A. Lorenz. Tracing paper, ink, 33 x 20,5 cm, call no. H295.
Photography Pavilion. Site plan, projection and cross-section, front façade view. 1913.03.27. Michael Kaliski. Paper, print, 53 x 42 cm, call no. H314.
Site plan, section, projection. 1913.03.29. Paper, Ozalid, 65 x 83 cm, call no. H342.
Site plan, projection, section, view. 1913.03.29. Alfred Kolbe. Paper, canvas, Ozalid, ink, 65,5 x 42 cm, call no. H223.
Site plan, projection, section. 1913.03.31. Fritz Valentin. Paper, canvas, Ozalid, 67 x 65 cm, call no. H315.
Front and side façade. 1913.03.31. Fritz Valentin. Paper, canvas, Ozalid, 34,5 x 63,5 cm, call no. H316.
Projection, section, façade view. 1913.04.00. R. Hallmann. Paper, canvas, Ozalid, supplemented with ink, 32,5 x 50 cm, call no. H329.
Plan, section, view. 1913.04.00. Fritz Freudenreich. Paper, canvas, Ozalid, water colors, 35 x 43,5 cm, call no. H241.
Plan, section, view. 1913.04.01. Schreiber, Hermann Stricker. Tracing paper, ink, 33 x 42 cm, call no. H221.
Plan, section, façade view. 1913.04.02. Robert Raschke, Zimmermeister. Paper, canvas, Ozalid, 61 x 96,5 cm, call no. H216.
Implementation design for screening and projection booth. Site plan. 1913.04.09. Fritz Engert. Paper, canvas, Ozalid, 33 x 61 cm, call no. H267.
Drawing of the front and side façade. 1913.04.09. Michael Kaliski. Paper, print, 33 x 109 cm, call no. H263.
Site plan, horizontal projection, cross-sections. 1913.04.09. Michael Kaliski. Paper, print, 58,5 x 88,5 cm, call no. H264.
Site plan. 1913.04.11. Fritz Freudenreich. Paper, print, 33 x 60 cm, call no. H326.
Site plan, projection, sections. 1913.04.16. Paper, print, 64,5 x 92 cm, call no. H333.
Plan, façade view. 1913.04.16. Robert Raschke, Zimmermeister. Paper, canvas, Ozalid, ink, 60,5 x 95 cm, call no. H217.
Site plan. 1913.04.25. Fritz Valentin. Paper, print, 23 x 29,5 cm, call no. H298.
Plan, section, façade view. 1913.04.25. Fritz Valentin. Paper, canvas, Ozalid, 34,5 x 46,5 cm, call no. H299.
Construction detail drawing. 1913.04.28. Dudler. Paper, Ozalid, 43 x 57 cm, call no. H344.
Section, façade view, projections. 1913.04.30. Schreiber. Paper, canvas, Ozalid, ink, 53 x 73 cm, call no. H347.
Implementation design for track arrangement. 1913.05.02. Paper, Ozalid, red ink, 65 x 62 cm, call no. H317.
Horizontal projection, section, façade drawing. 1913.05.04. Arnold Nitsch. Paper, canvas, Ozalid, 32,5 x 41,5 cm, call no. H270.
Site plan, projection, sections, façade drawing. 1913.05.05. Michael Kaliski. Paper, Ozalid, 55,5 x 81,5 cm, call no. H268.
Site plan, projection, view. 1913.05.07. Paper, Ozalid, 32,5 x 41,5 cm, call no. H340.
Site plan, projection, view. 1913.05.07. Paper, Ozalid, 32,5 x 41 cm, call no. H341.
Depot. Site plan, projections, sections. 1913.05.08. 33 x 48,5 cm, call no. H235.
Site plan, projection, sections, view. 1913.05.14. Gustaw Hossenfelder. Tracing paper, ink, 33 x 43,5 cm, call no. H239.
Implementation design for a rotating podium for the orchestra. Projection, sections. 1913.05.16. Richard Hallmann. Paper, canvas, Ozalid, ink, 66,5 x 76 cm, call no. H238.
Site plan. 1913.05.21. Paper, Ozalid, 67,5 x 61,5 cm, call no. H330.
Plan, section, view. 1913.05.21. Paper, canvas, Ozalid, ink, 32,5 x 42 cm, call no. H331.

Site plan. 1913.05.21. Arnold Nitsch. Paper, print, ink, 67,5 x 62 cm, call no. H269.
Site plan. 1913.05.21. Nitsch. Paper, print, 66 x 63 cm, call no. H236.
Plan, section, view. 1913.05.21. Nitsch. Paper, canvas, Ozalid, ink, crayon, 65,5 x 98 cm, call no. H237.
Site plan. 1913.05.21. Nitsch Arnold. Paper, Ozalid, 66 x 62,5 cm, call no. H512.
Section through the kitchens and terraces. Construction drawing. 1913.05.22. Fritz Engert, Walther Grossmann – Dresden. Paper, canvas, Ozalid, 44 x 42 cm, call no. H290.
Site plan. 1913.05.23. Fritz Freudenreich. Paper, print, ink, 75,5 x 65 cm, call no. H240.
Construction drawing. 1913.05.23. Robert Raschke, Zimmermeister. Tracing paper, ink, 38 x 61 cm, call no. H218.
Meat grinding machine installation instructions. Horizontal projection, view, cross-section. 1913.06.09. Tracing paper, ink, 33 x 44 cm, call no. H334.
Ground floor plan and garden kiosk Implementation design. 1913.06.10. Helbig C. Paper. canvas, Ozalid, crayon, 34,5 x 72,5 cm, call no. H308.
Site plan, sections, projection. 1913.06.14. Fritz Valentin. Paper, Ozalid, 33 x 42 cm, call no. H345.
Ground floor plan, section, details. Dancing stage. 1913.06.26. Fritz Engert, Walther Grossmann – Dresden. Paper, canvas, Ozalid, 55 x 83 cm, call no. H293.
Site plan, projection, section, façade view. 1913.07.00. Fritz Valentin, Jaide (Stadtbauinsp.). Paper, Ozalid, water colors, 36,5 x 50 cm, call no. H309.
Site plan, projection, section, façade view. 1913.07.00. Fritz Valentin. Paper, Ozalid, water colors, 33,5 x 51,5 cm, call no. H310.
Implementation design for tent between the two pavilions. Site plan, projection, section. 1913.07.00. Max Pitschmann. Paper, Ozalid, water colors, 32 x 42 cm, call no. H251.
Icehouse Implementation design. Ground floor plan, section A-B. 1913.07.08. Paper, canvas, Ozalid, 65,5 x 63 cm, call no. H562.
Site plan, projection, section, front view. 1913.07.09. Curt Ebneter. Paper, Ozalid, water colors, 30,5 x 43 cm, call no. H242.
Site plan. 1913.07.28. Hermann Stricker. Paper, print, ink, 33 x 21 cm, call no. H226.
Site plan, projection, section, view. 1913.07.29. Michael Kaliski. Paper, Ozalid, ink, 50,5 x 41,5 cm, call no. H243.
Site plan, projection, section, view. 1913.07.29. Hermann Stricker. Tracing paper, ink, 33 x 42 cm, call no. H227.
Inventory. Plan, sections, façades. 1914.03.21. Cabanis (Charlot). lack of call no.

7.3. The National Museum in Wrocław (Muzeum Narodowe we Wrocławiu)

Max Berg, Centennial Hall interior Implementation design, February 1910 (?), reproduction of a diapositive used by Berg for readings conducted at the beginning of 1911, Documents Department, call no. 2490.
Max Berg, Centennial Hall interior Implementation design, ca. 1910 (?), reproduction of a diapositive used by Berg for readings conducted at the beginning of 1911, Documents Department, call no. 2489.
Max Berg, Centennial Hall, Implementation design, cross-sections, December 1910, reproduction of a diapositive used by Berg for readings conducted at the beginning of 1911, Documents Department, call no. 2494.
Max Berg, Centennial Hall, Implementation design, perspective drawing, December 1910, reproduction of a diapositive used by Berg for readings conducted at the beginning of 1911, Documents Department, call no. 2492.
Max Berg, Centennial Hall, Implementation design, plan, February 1911, reproduction of a diapositive used by Berg for readings conducted at the beginning of 1911, Documents Department, call no. 2491.
Max Berg, Centennial Hall, Implementation design, perspective drawing, 1910/1911, reproduction of a diapositive used by Berg for readings conducted at the beginning of 1911, Documents Department, call no. 2493.
Comparison of the Hall's plan with other objects, reproduction of a diapositive used by Berg during his speech delivered on February 24, 1911 for Kunstgewerbeverein members, Documents Department, call no. 2488.
Centennial Hall under construction, concreting of large apse arches supporting the dome, scaffolding and formwork construction under the ribs of the dome, Document Department, call no. 3464.

Centennial Hall under construction, view of foyer and tension arches formwork. Reproduced from a diapositive, Documents Department, call no. 3465.
Centennial Hall under construction, view of foyer and tension arches formwork. Reproduced from a diapositive, Documents Department, call no. 3463.
Centennial Hall under construction, view of foyer, concreting of dome ribs. Reproduced from a diapositive, Documents Department, call no. 3462.
Centennial Hall, main entrance to the Centennial Exhibition, postcard from the period of the exhibition, Documents Department, call no. 518.
Rough draft of the Historical Exhibition Pavilion, 1911–1912, projection, reproduction of a diapositive used by the architect during a reading conducted on February 27 in the Hall of the Silesian Museum of Arts and Crafts and Antiquities in Wrocław, Documents Department.
Historical Exhibition Pavilion Implementation design, facades from the courtyard, September 1912, reproduction of a photograph, Documents Department.
Hall dedicated to the Prussian army, interior Implementation design, September 1912 (?), reproduction of a photograph, Documents Department.
Plan with the Hall's functions during the Historical Exhibition. Reproduction of a diapositive made in 1912, Documents Department.
Historical Exhibition Pavilion (Four Dome Pavilion), view of southern facade, photo from the final period of construction of the pavilion, postcard, Documents Department, call no. 518(15).
Historical Exhibition Pavilion (Pavilion of Four Domes), view of the southern facade and part of the western facade, postcard from the period of the opening of the Centennial Exhibition, Documents Department, call no. 518.
Pergola, pond from the historic gardens, postcard from 1920's, Documents Department, call no. 518.
Fritz Behrendt, Implementation design for entrance gate to the Cemetery Art exhibition, photograph made from a diapositive, Documents Department.
Caricature included in the "Simplicissimus" magazine in connection with a photo of Gerhart Hauptmann's performance during the Centennial Exhibition and the related scandal. Reproduced from a diapositive, Documents Department, call no. 4690.
Stage and costume Implementation designs for the performance of the Commemoration Masque (*Festspiel* of Gerhart Hauptmann) by Ernst Stern. Reproduced from a diapositive, Documents Department, call no. 4682.
Puppets from the performance of Commemoration Masque (Gerhart Hauptmann *Festspiel in deutschen Reimen*) presented at the exhibition dedicated to the works of Hauptmann in 1924 (?), photograph, Documents Department.
View of Four Dome Pavilion and the path along the eastern facade, postcard from ca. 1930, Documents Department, call no. 518/5.

Paintings, graphics and medals up to 1945
Descriptions:
Ikonografia Wrocławia, exhibition catalog, edited by P. Łukasiewicz, Wrocław 2008, Volume I and II. Directory entries are indicated in square brackets.
The New Wrocław (Centennial Hall and Home for the lonely, view), oil on canvas, G. Nerllich, 1931 [vol. II, pos. 395].
The Pergola from the south. Pencil lithography, S. Laboschin, 1926 [vol. I, pos. 599].
Medal for the occasion of the construction of the Centennial Hall in Wrocław, 1913 [vol. II, pos. 447].
National medal for the Horticultural Exhibition in Wrocław, 1913 [vol. II, pos. 448].
Wrocław tram token, 1921 [vol. II, pos. 452].
National Medal of the Silesian Regional Singers Holiday, 1927 [vol. II, pos. 456].

Postcards published before 1945
Descriptions:
Ikonografia Wrocławia – Pocztówki, edited by Z. Bandurska, Wrocław 2008. Directory entries are indicated in square brackets, postcards showing the exhibits of the Historical and Artistic exhibition of 1913 are not enumerated.

Exhibition in 1913

Centennial Hall, view from the west, main entrance gate in the foreground. Drawing, heliograph, 1913, call no. P W/205 [pos. 508].

Centennial Hall, view from the west. Drawing, heliograph, 1913, call no. P W/206 [pos. 509].

Centennial Hall, view from the west. Colored drawing, autotype, 1913, call no. P W/207 [pos. 510].

Centennial Hall, view from the west and entrance surmounted by a tympanum (not in accordance with M. Berg's Implementation design), drummer (1813) and trumpet player on horseback (1913) presented on the rim. Colored drawing, autotype, 1913, call no. P W/270 [pos. 511].

Centennial Hall, main entrance portal, heliograph in color, 1913, call no. P W/208 [pos. 512].

Centennial Hall, Terrace Restaurant and Pergola, view from north-west, heliograph, 1913, call no. P W/222 [pos. 513].

Centennial Hall, view from the north-east, reproduction of watercolor, autotype, 1913, call no. P W /223 [pos. 514].

Historical Exhibition Pavilion – Four Dome Pavilion, view from the south-west, photograph, heliograph, 1913, call no. P W/237 [pos. 515].

Historical Exhibition Pavilion – Four Dome Pavilion, view from the south, reproduction of watercolor, multi-colored autotype, 1913, call no. P W/241 [pos. 516].

Historical Exhibition Pavilion – Four Dome Pavilion, view from south, photograph, heliograph, 1913, call no. P W/242 [pos. 517].

Historical Exhibition Pavilion – Four Dome Pavilion, view to the south-east, photograph, heliograph, 1913, call no. P W/238 [pos. 518].

Historical Exhibition Pavilion – Four Dome Pavilion, view from the north-east, photograph, heliograph, 1913, call no. P W/239 [pos. 519].

Historical Exhibition Pavilion – Four Dome Pavilion, courtyard surrounded by a colonnade (not in accordance with H. Poelzig's Implementation design), water colors, multi-colored autotype, 1913, call no. P W/240 [pos. 520].

Historical Exhibition Pavilion – Four Dome Pavilion, view of Austrian Hall, photography, heliograph, 1913, call no. P W/266 [pos. 521].

Exhibition Grounds. Belvedere in the Renaissance garden, photography, multi-colored autotype, 1913, call no. P W/245 [pos. 526].

Exhibition Grounds. Japanese Garden, view of the pavilion on the water, photography, multi-colored autotype, 1913, call no. P W/267 [pos. 527].

Exhibition Grounds. Japanese Garden, view of the pavilion on the island, pavilion on the water, photography, multi-colored autotype, 1913, call no. P W/303 [pos. 528].

Amusement park, water slide, photograph, heliograph, 1913, call no. P W/268 [pos. 529].

After 1913

Centennial Hall, view from the west, drawing reproduction, multi-colored autotype, before 1923, call no. P W/209 [pos. 531].

Centennial Hall, view from the west, drawing reproduction as above, heliograph, before 1923, call no. P W/210 [pos. 532].

Centennial Hall, view from the west, photography, heliograph in color, before 1923, call no. P W/211 [pos. 533].

Centennial Hall, view from the west, photography, rotogravure, before 1929, call no. P W/212 [pos. 534].

Centennial Hall, view from the west, photography, heliograph in color, ca. 1929, call no. P W/213 [pos. 535].

Centennial Hall, view from the west, photography, heliograph, before 1932, call no. P W/214 [pos. 536].

Centennial Hall, view from the west from the side of the main entrance, photograph, before 1939, call no. P W/215 [pos. 537].

Centennial Hall, view from the west from the side of the main entrance, photography, rotogravure, before 1941, call no. P W/265 [pos. 538].

Centennial Hall, view of the west from the side of the main entrance, photography, rotogravure, before 1942,

call no. P W/217 [pos. 539].
Centennial Hall, view of the west from the side of the main entrance with a fragment of the colonnade, photograph, before 1942, call no. P W/218 [pos. 540].
Centennial Hall, drawing reproduction of the view of the Hall from the north-west, Baroque garden at the Historical Exhibition Pavilion in the foreground, multi-colored autotype, before 1920, call no. P W/225 [pos. 541].
Centennial Hall and Terrace Restaurant, the Pergola in the foreground, multi-colored autotype, 1922, call no. P W/230 [pos. 542].
Centennial Hall and Terrace Restaurant, view from the south, photography, heliograph, ca. 1940, call no. P W/231 [pos. 543].
Centennial Hall, view from the north-west, Historical Exhibition Pavilion on the right, photograph, heliograph, before 1940, call no. P W/234 [pos. 544].
Centennial Hall, view from north-west, photography, rotogravure, ca. 1940, call no. P W/232 [pos. 545].
Centennial Hall, view through the Pergola, flowerbeds Implementation designed by Hugo Richter between the pond and the Pergola, photography, multi-colored autotype, before 1919, call no. P W/224 [pos. 546].
Centennial Hall, view through the Pergola, photography, heliograph, ca. 1919, call no. P W/226 [pos. 547].
Centennial Hall, view through the Pergola, photograph, heliograph, before 1938, call no. P W/227 [pos. 548].
Centennial Hall, view through the Pergola, photograph, multi-colored autotype, ca. 1938, call no. P W/229 [pos. 549].
Centennial Hall, view through the Pergola, Oscar van Houtte reproduction of watercolor, multi-colored autotype, ca. 1930, call no. P W/228 [pos. 550].
Centennial Hall, Ivy-covered Pergola, photograph, black/white print, ca. 1938, call no. P W/220 [pos. 551].
Centennial Hall and Terrace Restaurant, view from the south, photograph, black and white heliograph, before 1936, call no. P W/219 [pos. 552].
Centennial Hall, view from the pond, night shot of the illuminated Terrace Restaurant, photograph, ca. 1930, call no. P W/221 [pos. 553].
Historical Exhibition Pavilions, view from the north-east, photograph, rotogravure, before 1938, call no. P W/243 [pos. 554].
Historical Exhibition Pavilion, view from north-west, photograph, ca. 1940, call no. P W/233 [pos. 555].
Historical Exhibition Pavilion, courtyard with statue of Athena Parthenos, photograph, print, 1938, call no. P W/244 [pos. 556].
Historical Exhibition Pavilion, Baroque sculptures to the north of the pavilion, photograph, heliograph, before 1939, P W/246 [pos. 557].
Centennial Hall and Exhibition Grounds, aerial photograph, 1929, call no. P W/235 [pos. 557].
Centennial Hall and Exhibition Grounds, aerial photograph, 1929, call no. P W/236 [pos. 558].

7.4. University Library in Wrocław (Biblioteka Uniwersytecka we Wrocławiu)

Exhibition Grounds. Competition for land utilization, planning and development of the Zoological Garden. Second prize, I.P. Grossmann from Berlin motto “Centralpark”. Graphic Collection Department, call no. 753.
Exhibition Grounds. Competition for land utilization, planning and development of the Zoological Garden. Purchased Implementation design, by Theo Effenberger, the motto “Oderstraße”. Perspective drawing, view of the pavilion, northern facade in the southern part of the area, Graphic Collection Department, call no. 4043.
Exhibition Grounds. Competition for land utilization, planning and development of the Zoological Garden. Purchased Implementation design, by Theo Effenberger, the motto “Oderterrase”. Perspective drawing, view from Oder river, Graphic Collection Department, call no. 4041.
Exhibition Grounds. Competition for land utilization, planning and development of the Zoological Garden. Third prize in the competition, Implementation design by Franz Seeck from Berlin-Steglitz, A. Gellhorn from Wrocław

and Paul Freye from Berlin, motto “vereint und doch getrent”. Site plan of the garden and the southern part of the area. Graphic Collection Department, call no. 752.
Exhibition Grounds. Competition for land utilization, planning and development of the Zoological Garden. Purchased Implementation design, by Theo Effenberger, the motto “Oderterrase”. Perspective drawing, view of pavilion, facade, Graphic Collection Department, call no. 4044.
Exhibition Grounds. Competition for land utilization, planning and development of the Zoological Garden. Purchased Implementation design, by Theo Effenberger, the motto “Oderterrase”. Perspective drawing, view of the avenue with fragments of pavilions, Graphic Collection Department, call no. 4042.
Exhibition Grounds. Competition for land utilization, planning and development of the Zoological Garden. First prize, Alfred Bose and F. Glum from Cottbus, motto “ZOO”. Site plan of southern area 1:500, Graphic Collection Department, call no. 751.
Exhibition Grounds. Competition for land utilization planning and development of the Zoological Garden. Purchased Implementation design, by Theo Effenberger, motto “Oderterrase”. Drawing, bird’s eye view from Oder river, Graphic Collection Department, call no. 4040.
Exhibition Grounds. Unfinished Implementation design of Max Berg, land layout of the Exhibition Grounds and the Zoological Garden. Fragment of the main entrance to the Exhibition Grounds, another version of the Implementation design. Photograph from drawing by H. Götz. Graphic Collection Department, call no. 4045.
Model presented at Ostdeutsche Ausstellung in Poznań in May 1911. View of the interior. The model was made in the January-May 1911. Photograph by H. Götz. Graphic Collection Department, call no. 764.
Hall Implementation designs and model presented at Ostdeutsche Ausstellung in Poznań in May 1911, Graphic Collection Department, call no. 754.
Hall Implementation designs and model presented at Ostdeutsche Ausstellung in Poznań in May 1911, Graphic Collection Department, call no. 755.
Centennial Hall under construction, concreting of large apse and tension arches, Graphic Collection Department, call no. 556.
Centennial Hall under construction, view from the interior of the construction of wooden scaffolding, beginning of construction work, formwork installation and concreting under the great supporting pillars, Graphic Collection Department, call no. 760.
Centennial Hall under construction, view from the north-west after a partially dismantling of the substructure formwork for the dome and tension arches. Construction of dome ribs formwork, Graphic Collection Department, call no. 759.
The People’s Hall (Hala Stulecia), gouache depicting the Hall by Hans Leistikow, postcard, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Centennial Hall under construction, view from the western side with a portion of concrete covering the foyer and the construction of the dome rib formwork and a mounted prefabricated element of window frames, Graphic Collection Department, call no. 761.
Centennial Hall, postcard with author’s etching, footnotes signed “EKF”, ca. mid-1912, showing the Hall construction progress, call no. Yb 2286a.
Centennial Hall under construction, general view from the north-west, concreting of the dome’s ribs, Graphic Collection Department, call no. 657.
Centennial Hall under construction, general view from the north-west, concreting of the dome’s ribs, Graphic Collection Department, call no. 657.
Centennial Hall under construction, interior, after partial dismantling of the scaffolding, Graphic Collection Department, call no. 763.
Centennial Hall, view from the pond of the Terrace Restaurant and Hall, postcard, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Centennial Hall, view from the north-west during the Centennial Exhibition, postcard, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Centennial Hall, view of the main entrance during the Centennial Exhibition, postcard, Silesiaca and Lusatica Collection, call no. Yb 2286a.

Centennial Hall, celebration of the 125th anniversary of the "liberation war", view of interior, photograph, Graphic Collection Department.
Centennial Hall, interior during the ceremony at the end of 1930's, view of the organ apse,
photography, Graphic Collection Department.
Historical Exhibition Pavilion (Four Dome Pavilion), view from the roof of Centennial Hall to the north-west, photograph from the construction period, early 1913, postcard, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Historical Exhibition Pavilion (Four Dome Pavilion), interior, eastern wing, exhibition halls, presentation of the ruling families from England, Hanover, Brunswick, Hesse and Baden, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Historical Exhibition Pavilion (Four Dome Pavilion), interior, eastern wing, exhibition halls, presentation of artistic crafts and pottery from ca. 1800, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Historical Exhibition Pavilion (Four Dome Pavilion), view of the southern courtyard facade, Empire garden and a fountain topped with the Pallas Athena statue. Photograph by Anton Pichler from the period of the opening of the Centennial Exhibition, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Historical Exhibition Pavilion (Four Dome Pavilion), interior, eastern wing, exhibition halls, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Historical Exhibition Pavilion (Four Dome Pavilion), interior, eastern wing, exhibition halls, Silesiaca and Lusatica Collection, call no. Yb 2286a.
The Terrace Restaurant view from the pavilion hosting the Historical exhibition, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Pergola, pond, view of path between the columns near the historical gardens, postcard, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Pergola, pond, general view from the pavilion hosting the Historical Exhibition, postcard, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Pergola pond, view from the north of the pavilion hosting the Historical Exhibition, postcard, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Pergola, pond, view through the Pergola of the Terrace Restaurant and Centennial Hall, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Pergola, pond, view through the Pergola of the Terrace Restaurant and Centennial Hall, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Cemetery Art Pavilion under construction, interior view, cloister surrounding a courtyard, photograph from early-1913 by Anton Pichler, Graphic Collection Department.
Cemetery Art Pavilion under construction, front view, photograph from early-1913 by Anton Pichler, Graphic Collection Department.
Cemetery Art Pavilion under construction, view from courtyard, photograph from early-1913 by Anton Pichler, Graphic Collection Department.
Cemetery Art Pavilion under construction, interior view, photograph from early-1913 by Anton Pichler, Graphic Collection Department.
Historical Gardens, Renaissance garden, view of garden and Belvedere, postcard, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Main entrance gate, view towards the Centennial Hall, postcard, 1913, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Exhibition Grounds, bird's eye view, gouache – postcard, May 1912, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Bird's eye view of the Exhibition Grounds, Hans Poelzig Implementation design painted by students of the Academy of Arts and Crafts in Wrocław in August 1912. Postcard reproduction, September 1912, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Music Pavilions. View of the western pavilion and corner of the Terrace Restaurant, postcard, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Entry ticket to a festive evening in Wrocław's Town Hall, May 20, 1913 at 8.00 pm in connection with the opening of the Centennial Exhibition, Silesiaca and Lusatica Collection, call no. Yb 2286a.

Entry ticket Implementation design for the Centennial Exhibition, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Program annex and poster of the play Commemoration Masque (*Festspiel* of Gerhart Hauptmann) staged by Max Reinhardt, Friedrich Winckler-Tannenberg, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Title page of the Commemoration Masque (*Festspiel* of Gerhart Hauptmann) program, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Invitation to the opening of the Centennial Exhibition at the Centennial Hall and the Historical Exhibition of Professor Hipp – Director of the Municipal Library, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Commemorative stamps featuring official posters of the Centennial Exhibition Implementation designed by Johann Drobeck, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Centennial Exhibition. Miscellaneous. Invitation to a festive evening in Wrocław's Town Hall on May 20, 1913 at 8.00 pm for professor Hipp – director of the Municipal Library in connection with the opening of the Centennial Exhibition, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Invitation for Professor Hipp – director of the Municipal Library for the ceremonial opening of the Centennial Exhibition in the presence of the Imperial Heir, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Example of an honorary entry ticket to the Centennial Exhibition, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Centennial Exhibition opening, group photo before entering the Hall of Wrocław Personalities with the Imperial Heir, photograph, Graphic Collection Department, call no. 750.
Centennial Exhibition opening, group photography of Wrocław's and the Silesian province's personalities. Max Berg and Hans Poelzig, standing side by side in the last row, on the left near the middle, Graphic Collection Department, call no. 749.
Concert program, choir made up of 2800 students from Wrocław schools, August 31, 1913 Silesiaca and Lusatica Collection, call no. Yb 2286a.
Program of the concert, closing the Centennial Exhibition in Wrocław, October 26, 1913 Silesiaca and Lusatica Collection, call no. Yb 2286a.
Lecture program with slides on the organs at the Centennial Hall, given by Paul Walcker, playing of the organ by organist Otto Burkert, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Commemorative stamp for the Centennial Exhibition, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Baroque garden, view of the Pergola, postcard, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Historical gardens. General view towards the south along the path around the historical gardens. In the foreground, a garden fence from the Carolingian days, postcard, Silesiaca and Lusatica Collection, call no. Yb 2286a.
English Garden – romantic, general view, postcard, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Baugesellschaft Deutschland Garden, general view, postcard, Silesiaca and Lusatica Collection, call no. Yb 2286a.
C. Berndt from Zirlau Garden, general view, postcard, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Japanese Garden, view from the current A. Mickiewicza Street towards the south-east of the pavilion on the water and the arbor bridge on the Eichborn pond, postcard, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Japanese Garden, view from the former tea house towards the south-west, postcard, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Japanese Garden, view from the tea house towards the west, current A. Mickiewicza Street of the pavilion, garden gazebo and island, postcard, Silesiaca and Lusatica Collection, call no. Yb 2286a.
Bird's eye view from the north, photograph, ca. 1927, Graphic Collection Department, call no. 765.
View from the Pergola towards the Terrace Restaurant and Four Dome Pavilion, photograph by Heinrich Klette, ca. 1935, Graphic Collection Department, call no. 2656.
Bird's eye view from the south side, photograph, 1942, Graphic Collection Department.

7.5. The Leibniz Institute for Research on Society and Space in Erkner near Berlin (Leibniz-Institut für Regionalentwicklung und Strukturplanung)

Max Berg in cooperation with Richard Konwiarz, Centennial Hall Implementation design, second version, February 21, 1910, scientific collections, partial legacy of Max Berg.

Max Berg in cooperation with Richard Konwiarz, Centennial Hall Implementation design, second version, cross-section and plan, February 23, 1910, scientific collections, partial legacy of Max Berg.
Max Berg, Centennial Hall Implementation design, perspective drawing, February 28, 1910, scientific collections, partial legacy of Max Berg.
Max Berg, Centennial Hall Implementation design, main entrance facade, November 1910, scientific collections, partial legacy of Max Berg.
Max Berg – Centennial Hall Implementation design, cross-section, December 1910, scientific collections, partial legacy of Max Berg.
Max Berg – Centennial Hall Implementation design, front view, ca. 1910/1911, scientific collections, partial legacy of Max Berg.
Max Berg, Centennial Hall Implementation design, perspective drawing, February-March 1911, scientific collections, partial legacy of Max Berg.
Max Berg, Centennial Hall Implementation design, plan of the main entrance facade with marked changes and a perspective sketch, July 1911, scientific collections, partial legacy of Max Berg.
Max Berg in cooperation with Richard Konwiarz, Centennial Hall Implementation design, main entrance facade with marked changes, July 1911, scientific collections, partial legacy of Max Berg.
Max Berg, Centennial Hall interior Implementation design, July 1911, scientific collections, partial legacy of Max Berg.
Max Berg, Centennial Hall interior Implementation design, July 1911, scientific collections, partial legacy of Max Berg.
Max Berg in cooperation with Richard Konwiarz, Centennial Hall Implementation design, cross-section, July 1911, scientific collections, partial legacy of Max Berg.
Max Berg, Centennial Hall Implementation design, view of facade of the side entrance, July 1911, scientific collections, partial legacy of Max Berg.
Max Berg, Centennial Hall Implementation design, plan and cross-section, 1911, scientific collections, partial legacy of Max Berg.
Hans Leistikow (Hans Hall), Centennial Hall, colored postcard, 1912, scientific collections, partial legacy of Max Berg.
Centennial Hall, beginnings of concreting and formwork set-up under the dome ribs, photography ca. spring time – July 1912, scientific collections, partial legacy of Max Berg.
Centennial Hall, interiors, under construction, photograph from fall of 1912, scientific collections, partial legacy of Max Berg.
Max Berg in cooperation with Albert Kempter, crematorium Implementation design, cross-section, October 1912, scientific collections, partial legacy of Max Berg.
Max Berg in cooperation with Albert Kempter, crematorium Implementation design, ground floor plan, October 1912, scientific collections, partial legacy of Max Berg.
Centennial Hall, masonry work phase, photograph from the turn of 1912/1913, scientific collections, partial legacy of Max Berg.
Centennial Hall, Historical Exhibition pavilion and Künstlerbund Schlesien pavilion, under construction, photograph from early 1913, scientific collections, partial legacy of Max Berg.
Stands during a show at the Centennial Hall in 1913. Photograph, scientific collections, partial legacy of Max Berg.
Final scene of Commemoration Masque (*Festspiel in deutschen Reimen* of Gerhart Hauptmann), photograph, 1913, scientific collections, partial legacy of Max Berg.
Centennial Hall, interiors, under construction, photograph, spring 1913, scientific collections, partial legacy of Max Berg.
Centennial Exhibition opening reception on May 20, 1913, photograph, scientific collections, partial legacy of Max Berg.
Centennial Exhibition, before the entrance to the Hall, photograph from 1913, scientific collections, partial legacy of Max Berg.
Centennial Hall, interior, photograph from 1913, scientific collections, partial legacy of Max Berg.

Max Berg, Implementation design for expansion of the Exhibition Grounds in Wrocław, Terrace Restaurant's interior Implementation design, 1919–1920, scientific collections, partial legacy of Max Berg.
Centennial Hall, interior, dome ribs and lantern, photograph ca. 1920, scientific collections, partial legacy of Max Berg.
Max Berg, Implementation design for the expansion of the Exhibition Grounds in Wrocław, site plan, 1922, scientific collections, partial legacy of Max Berg.
Max Berg, Implementation design for the expansion of the Exhibition Grounds in Wrocław, site plan, 1922, scientific collections, partial legacy of Max Berg.
Max Berg, Implementation design for the expansion of the Exhibition Grounds in Wrocław, exhibition hall Implementation design, view, 1922, scientific collections, partial legacy of Max Berg.
Max Berg, Implementation design for the expansion of the Exhibition Grounds in Wrocław, exhibition hall Implementation design, cross-section, 1922, scientific collections, partial legacy of Max Berg.
Max Berg, Implementation design for the expansion of the Exhibition Grounds in Wrocław, exhibition hall Implementation design, ground floor plan, 1922, scientific collections, partial legacy of Max Berg.
Max Berg, Implementation design for the expansion of the Exhibition Grounds in Wrocław, exhibition hall Implementation design, emporium floor plan, 1922, scientific collections, partial legacy of Max Berg.
Max Berg, Implementation design for the expansion of the Exhibition Grounds in Wrocław, exhibition hall Implementation design, ground floor plan, 1922, scientific collections, partial legacy of Max Berg.
Max Berg, Implementation design for the expansion of the Exhibition Grounds in Wrocław, Exhibition Hall Implementation design, cross-sections, facades, 1922, scientific collections, partial legacy of Max Berg.
Max Berg, Implementation design for the expansion of the Exhibition Grounds in Wrocław, exhibition hall Implementation design, facade from Grüneicher Weg, 1922, scientific collections, partial legacy of Max Berg.
Max Berg, Implementation design for the new Exhibition Hall (Messehalle), site plan, 1924, scientific collections, partial legacy of Max Berg.
Max Berg, Implementation design for the new Exhibition Hall (Messehalle), plan, second version, 1924, scientific collections, partial legacy of Max Berg.
Max Berg, Implementation design for the new Exhibition Hall (Messehalle), view, 1924, scientific collections, partial legacy of Max Berg.
Max Berg, Implementation design for the new Exhibition Hall (Messehalle), plaster model, 1924, scientific collections, partial legacy of Max Berg.
Max Berg, Implementation design for the new Exhibition Hall (Messehalle), plaster model, 1924, scientific collections, partial legacy of Max Berg.
Max Berg, Implementation design for the new Exhibition Hall (Messehalle), plaster model, 1924, scientific collections, partial legacy of Max Berg.
Max Berg, the new Exhibition Hall (Messehalle) and the main entrance (Messehof), photograph ca. 1925, scientific collections, partial legacy of Max Berg.

7.6. The Deutsches Museum in Munich (Deutsches Museum von Meisterwerken der Naturwissenschaft und Technik München)

Max Berg, Gründe und Sinn der Errichtung der Jahrhunderthalle in Breslau, manuscript, 16 p., n/a, call no. NL 050/165.
Max Berg, Gedanken über Künstlerischen Ausbau der Jahrhunderthalle, typescript, n/a, call no. NL 050/050.
Max Berg's letter to Mayor Paul Matting dated September 26, 1913 and Max Berg's letter to Mayor Paul Matting dated September 7, 1913, call no. NL 050/165.
Model of Centennial Hall, photograph, 1911, call no. NL 050/233–259.
Drawing from a sketchbook, Centennial Hall interior decoration, 1911–1912, call no. NL 050/230.

Max Berg, description of the Centennial Hall, manuscript with a colored drawing of interiors and projection, call no. NL050/169.
Two postcards – Centennial Hall, watercolor of external structure by Hans Hal (Leistikow), 1912, call no. NL 050/167.
Centennial Hall under construction, photograph, 1912, call no. NL 050/233–259.
Centennial Hall under construction, photograph, 1912, call no. NL 050/234,4.
Centennial Hall under construction, photograph, 1912, call no. NL 050/005.
Centennial Hall under construction, interior, photograph, 1912, call no. NL 050/234,5.
Centennial Hall during Centennial Exhibition, view from the main entrance, photograph, 1913, call no. NL 050/233––259.
Centennial Hall, exterior, from the main entrance, photograph, 1913, call no. NL 050/233–259.
Centennial Hall, exterior, from the main entrance, photograph, 1913, call no. NL 050/238,5.
Centennial Hall, exterior, from the Pergola, photograph, 1913, call no. NL 050/238,7.
Centennial Hall, exterior, main entrance, photograph, 1913, call no. NL 050/236.
Centennial Hall, exterior, dome space, photograph, 1913, call no. NL 050/233–259.
Centennial Hall, exterior, dome space, photograph, 1913, call no. NL 050/241,11.
Centennial Hall, exterior, dome space, panorama, photograph, 1913, call no. NL 050/240,6.
Centennial Hall, exterior, dome space, panorama, photograph, 1913, call no. NL 050/241,9.
Centennial Hall, exterior, balcony support structures, photograph, 1913, call no. NL 050/241,3.
Centennial Hall, exterior, dome space, photograph, 1913, call no. NL 050/241,14.
Centennial Hall, exterior, foyer, photograph, 1913, call no. NL 050/241,2.
Centennial Hall, exterior, dome ribs, photograph, 1913, call no. NL 050/233–259.
Centennial Hall, exterior, dome ribs, photograph, 1913, call no. NL 050/233–259.
Centennial Hall, exterior, dome space, photograph, 1913, call no. NL 050/233–259.
Centennial Hall, exterior, dome space, photograph, 1913, call no. NL 050/233–259.
Centennial Hall, exterior, dome space, photograph, 1913, call no. NL 050/233–259.
Centennial Hall and Historical Exhibition pavilion, photograph, 1913, call no. NL 050/233–259.
Alfred Vocke, sculpture in front of Centennial Hall main entrance, photograph, 1913, call no. NL 050/238,4.
Charcoal sketches of Centennial Hall by Erich Mendelsohn (?), 1913, b. call no. NL 050/106.
Centennial Hall, interior, view of the eastern organ emporia 1918, call no. NL 050/240,5.
Bird's eye view of the Exhibition Grounds, photograph, 1919, call no. NL 050/238,33.
Max Berg, Article *Gerhart Hauptmanns Festspiel ein Weg zum Volksschauspiel*, ca. 1922, call no. NL 050/017.
Correspondence between Max Berg and Gerhart Hauptmann, call no. NL 050/199.
Centennial Hall, interior, view of the eastern organ emporia, preparation of the stage for a play, photograph, ca. 1922, call no. NL 050/233–259.
Four Implementation designs by Hans Leistikow for the Gerhart Hauptmann play in the Centennial Hall, 1922, photograph, call no. NL 050/245.
Photographs of the main entrance and the Exhibition Hall (Messehof and Messehalle), 1924–1925, under construction, interior, exterior, call no. NL 050/233–259.
Bird's eye view of the Exhibition Grounds, photographs, 1924, call no. NL 050/233– 259.
Two photographs of the main entrance (Messehof) to the Exhibition Grounds, 1925, call no. NL 050/237.
Three postcards – "WUWA" Breslau Werkbund Ausstellung und Werkraum, 1929, call no. NL 050/167.
Centennial Hall from the south, photograph, 1920's, call no. NL 050/233–259.
Centennial Hall main entrance, photograph, 1920's, call no. NL 050/233–259.
Study of proportion, drawing by Max Berg, ca. 1930, call no. NL 050/106.
Max Berg, *Proportionen und künstlerisches Schaffen* (proportion in architecture treaty), typescript, ca. 1930, call no. NL 050/106.
Max Berg's letter to Friedrich Sesselberg dated February 18, 1941, call no. NL 050/214.

7.7. The German Documentation Center for Art History – Bildarchiv Foto Marburg (Deutsches Dokumentationszentrum für Kunstgeschichte – Bildarchiv Foto Marburg)

[annotations: were made only for photographs taken before 1945, reproductions of illustrations were omitted]
Centennial Hall. View from the west. Photograph, 1913. Call no. 1 158 579, mi09352g14.
Centennial Hall. View from the west, south-west. Photograph, 1913. Call no. Fm 94853.
Centennial Hall. View from the west, Centennial Exhibition. Photograph, 1913. Call no. 1 135 377, mi04364f14.
Centennial Hall. View from the west. Photograph after 1925. Call no. Fm 821804.
Centennial Hall. View from the north-west from the Belvedere terrace. Photograph, before 1926. Call no. 1 194 244, mi09352g03.
Centennial Hall and accompanying buildings, aerial photograph. Photograph taken after 1925 and before 1927. Call no. Fm 1157929.
Centennial Hall. View from the west. Photograph, Trinks, ca. 1930. Call no. FD 160 276, mi09352g13.
Centennial Hall. View from the west in front of the main entrance colonnade. Photograph, 1930. Call no. 205 885, mi00326c08.
Centennial Hall. View from the west in front of the main entrance colonnade. Photograph, Möbius, 1938. Call no. FD M 4 042, mi09352g12.
Centennial Hall. View from the north from the Pergola colonnade. Photograph, 1930. Call no. 205 886, mi00326c10.
Centennial Hall. View from the north from the Pergola colonnade. Photograph, Möbius, 1938. Call no. FD 58 161.
Four Dome Pavilion. Courtyard, fountain with the figure of Athens. Photograph, 1913. Call no. 343 674 mi04365a11.
Four Dome Pavilion. Courtyard. Photograph, 1913. Call no. FD 103 191, mi09353a01.
Pergola and pond. View from the south towards north. Photograph, 1913. Call no. Fm 94851.
Pergola. View of the colonnade, interior with original concrete entablature. Photograph, 1913. Call no. Fm 94852.
Pergola. View of the western arm. Photograph, 1913. Call no. Fmz 25104.

7.8. The Herder Institute for Historical Research on East Central Europe – Institute of the Leibniz Association (Herder-Institut für historische Ostmitteleuropaforschung – Institut der Leibniz-Gemeinschaft)

[annotations: were made only for photographs and postcards created before 1945]
Exhibition Grounds. Bird’s eye view (1919–1935)
Exhibition Grounds. Bird’s eye view, 1919, no. 78. Hansa-Luftbild 59875.
Exhibition Grounds. Bird’s eye view, 1924, no. 49. Hansa-Luftbild 59874.
Exhibition Grounds. Bird’s eye view, 1924.09.07, AKI 446. Hansa-Luftbild 60021.
Exhibition Grounds. Bird’s eye view, 1924.09.07, AKI 447. Hansa-Luftbild 60022.
Exhibition Grounds. Bird’s eye view, 1924.09.07, AKI 448. Hansa-Luftbild 60023.
Exhibition Grounds. Bird’s eye view, 1925.02.26, AKI 740. Hansa-Luftbild 60069.
Exhibition Grounds. Bird’s eye view, 1925.02.26, AKI 743. Hansa-Luftbild 60072.
Exhibition Grounds. Bird’s eye view, 1925.02.26, AKI 748. Hansa-Luftbild 60073.
Exhibition Grounds. Bird’s eye view, 1925, AKI 750. Hansa-Luftbild 60074.
Exhibition Grounds. Bird’s eye view, 1925, AKI 781. Hansa-Luftbild 60075.
Exhibition Grounds. Bird’s eye view, 1925, AKI 782. Hansa-Luftbild 60076.
Exhibition Grounds. Bird’s eye view, 1925, AKI 783. Hansa-Luftbild 60077.
Exhibition Grounds. Bird’s eye view, 1925, AKI 785. Hansa-Luftbild 60079.
Exhibition Grounds. Bird’s eye view, 1925, AKI 1514. Hansa-Luftbild 59880.

Exhibition Grounds. Bird's eye view, 1925, AKI 1515. Hansa-Luftbild 59881.
Exhibition Grounds. Bird's eye view, 1925, AKI 1846. Hansa-Luftbild 59882.
Exhibition Grounds. Bird's eye view, 1925, AKI 1847. Hansa-Luftbild 59883.
Exhibition Grounds. Bird's eye view, 1925, AKI 1995. Hansa-Luftbild 59884.
Exhibition Grounds. Bird's eye view, 1925, AKI 1996. Hansa-Luftbild 59885.
Exhibition Grounds. Bird's eye view, 1925.02.26, AKI 737. Hansa-Luftbild 60066.
Exhibition Grounds. Bird's eye view, 1925.02.26, AKI 738. Hansa-Luftbild 60067.
Exhibition Grounds. Bird's eye view, 1925.02.26, AKI 739. Hansa-Luftbild 60068.
Exhibition Grounds. Bird's eye view, 1925.02.26, AKI 741. Hansa-Luftbild 60070.
Exhibition Grounds. Bird's eye view, 1925.02.26, AKI 742. Hansa-Luftbild 60071.
Exhibition Grounds. Bird's eye view, 1925.05.15, AKI 1408. Hansa-Luftbild 60101.
Exhibition Grounds. Bird's eye view, 1927, AKI 4158. Hansa-Luftbild 60080.
Exhibition Grounds. Bird's eye view, 1927, AKI 4159. Hansa-Luftbild 60081.
Exhibition Grounds. Bird's eye view, 1927, AKI 4161. Hansa-Luftbild 60083.
Exhibition Grounds. Bird's eye view, 1927, AKI 4162. Hansa-Luftbild 60084.
Exhibition Grounds. Bird's eye view, 1928.09, AKI 6418. Hansa-Luftbild 59886.
Exhibition Grounds. Bird's eye view, 1928.09, AKI 6419. Hansa-Luftbild 59887.
Exhibition Grounds. Bird's eye view, 1931.05.31 (Stahlhelmtag), AKI 10172. Hansa-Luftbild 59876.
Exhibition Grounds. Bird's eye view, 1931.05.31, AKI 10173. Hansa-Luftbild 59877.
Exhibition Grounds. Bird's eye view, 1931.05.31, AKI 10174. Hansa-Luftbild 59878.
Exhibition Grounds. Bird's eye view, 1932.08.13, AKI 11102. Hansa-Luftbild 59888.
Exhibition Grounds. Bird's eye view, 1932.08.13, AKI 11103. Hansa-Luftbild 59889.
Exhibition Grounds. Bird's eye view, 1933.10.08, AKI 11328. Hansa-Luftbild 59890.
Exhibition Grounds. Bird's eye view, 1933.10.08, AKI 11328 [sic!]. Hansa-Luftbild 61669.
Exhibition Grounds. Bird's eye view, 1934.04.09, no. 11401. Hansa-Luftbild 59891.
Exhibition Grounds. Bird's eye view, 1934.09.09, no. 11402. Hansa-Luftbild 59892.
Exhibition Grounds. Bird's eye view, 1934.09.15, no. 11418. Hansa-Luftbild 60085.
Exhibition Grounds. Bird's eye view, 1934.09.15, no. 11419. Hansa-Luftbild 60086.
Exhibition Grounds. Bird's eye view, 1934.09.15, no. 11420. Hansa-Luftbild 60087.
Exhibition Grounds. Bird's eye view, 1934.09.15, no. 11421. Hansa-Luftbild 60088.
Exhibition Grounds. Bird's eye view, 1934.09.15, no. 11422. Hansa-Luftbild 60089.
Exhibition Grounds. Bird's eye view, 1935.05.06, AKI 11205. Hansa-Luftbild 60348.
Exhibition Grounds. Bird's eye view, before 1920, postcard. Ortsansicht Scheitnig mit Jahrhunderhalle. Breslau. Panorama v. Scheitnig m. Jahrhunderthalle u. Oderpartie / Original-Fliegeraufnahme No. 1. Hettwer 258286.
Exhibition Grounds. Aerial photograph taken before 1920, postcard. Postkarte 105942.
Exhibition Grounds. Aerial photograph taken before 1929. Brodt 130117.
Exhibition Grounds. Bird's eye view, [1929]. Postkarte 105934.
Exhibition Grounds. Bird's eye view, [1929], Goettinger-Bildwerk 176124. [National Museum of Wrocław, call no. P W/235, pos. 558].
Exhibition Grounds. Bird's eye view, [1929]. Postkarte 176118. [National Museum of Wrocław, call no. P W/236, pos. 559]

Centennial Hall

Centennial Hall, view from the west, drawing. Postcard, 1913. Goettinger-Bildwerk 176126.
Centennial Hall, view from the west, colored drawing. Postcard, 1913. Postkarte 106231.
Centennial Hall, view from the west, colored drawing. Postcard, 1913. Postkarte. Goettinger-Bildwerk 190708.
Centennial Hall, view from the west, colored drawing. Postcard, 1913. Postkarte 106235.
Centennial Hall, view from the west, colored drawing. Postcard, 1913. Postkarte 176121.
Centennial Hall, view from the west, drawing. Postcard, 1913. Postkarte 106234. Dublet: 176121.
Centennial Hall, view from the west, colored drawing. Postcard, 1913. Postkarte 106228.

Centennial Hall, view from the west, colored drawing. Postcard, 1913. Goettinger-Bildwerk 190707. Dublet 106228.
Centennial Hall, view from the west, drawing. Postcard, 1913. Postkarte 176128.
Centennial Hall, view from the west, photograph, multi-colored print. Postcard, 1913. Postkarte 190709.
Centennial Hall, view from the west, photography, monochrome print. Postcard, 1913. Postkarte. Goettinger-Bildwerk 146716.
Centennial Hall, view from the west, photograph, monochrome print. Postcard, 1913. Hettwer 258288.
Centennial Hall, view from the west, photograph, monochrome print. Postcard, 1913. Goettinger-Bildwerk 176122.
Centennial Hall, view from the west, photograph, monochrome print. Postcard, 1913. Goettinger-Bildwerk 176131.
Centennial Hall, view from the west, main entrance, photograph, monochrome print. Postcard, 1913. Postkarte 176116.
Centennial Hall, view from the west, fragment of ticket offices of the main entrance in the foreground, photograph, monochrome print. Postcard, 1913. Hettwer 258285.
Centennial Hall, view from the west, photograph, monochrome print. Postcard, after 1920. Goettinger-Bildwerk 176127.
Centennial Hall, view from the west, photograph, monochrome print. Postcard, after 1920. Postkarte 105939.
Centennial Hall, view from the west, photograph, monochrome print. Postcard, after 1935. Goettinger-Bildwerk 176129.
Centennial Hall and main entrance colonnade. Photograph, postcard, after 1925. Postkarte 105941.
Centennial Hall and main entrance colonnade. Photograph, postcard, after 1925. Goettinger-Bildwerk 176148.
Centennial Hall, view from the west, photograph by P. Poklekowski, 1926. BAG_0354.
Centennial Hall, view from the west, photograph by Staatliche Bildstelle Berlin. Before 1933. NBA 129848.
Centennial Hall, interior, photograph by Staatliche Bildstelle Berlin. Before 1933. NBA 56633.
Centennial Hall, interior, fragment of the dome ribs, photograph by Staatliche Bildstelle Berlin. Before 1933. No. 882. NBA 241223.
Centennial Hall, view from the west, photograph. Postcard, after 1938. Goettinger-Bildwerk 176130.
Centennial Hall, view from the west, print developed on the basis of photograph 176130. Postcard, after 1938. Goettinger-Bildwerk 190706.
Centennial Hall and colonnade of the main entrance. Photograph, after 1925. NBA 241218.
Main entrance colonnade to the east the roof of the Centennial Hall, the Four Dome Pavilion to the right. Photograph, 1934. NBA 120306.
Main entrance colonnade, Centennial Hall in the background, view from the west. Photography by Staatliche Bildstelle Berlin. After 1925. NBA 87395.
Main entrance colonnade, view from the west. Photograph by Staatliche Bildstelle Berlin. 1936. Former no. 10928. NBA 241222.
Main entrance colonnade, the main entrance (Messehof) in the background, view from north-west. Photograph by Staatliche Bildstelle Berlin. 1936. Former no. 10928 [sic!]. NBA 115247.
Main entrance colonnade, view from the west. Photograph, postcard, after 1925. Postkarte 105936.
Main entrance colonnade, view from the west. Photograph, postcard, after 1925. Goettinger-Bildwerk 176147.
Centennial Hall, Terrace Restaurant, Four Dome Pavilion, Pergola and pond, view from the north. Photograph, postcard, after 1913. Goettinger-Bildwerk 176125.
Centennial Hall, Terrace Restaurant. Colored photograph, postcard, after 1920. Postkarte. 176119.
Centennial Hall and the Terrace Restaurant. Photograph, postcard, after 1926. Postkarte 69576.
Centennial Hall, Terrace Restaurant and Pergola. Colored photograph, postcard, 1913. Postkarte 106230.
Centennial Hall, Terrace Restaurant and Pergola. Photograph, postcard, 1913. Goettinger-Bildwerk 176134.
Centennial Hall, Terrace Restaurant and Pergola. Photograph, postcard, after 1920. Goettinger-Bildwerk 176132.
Centennial Hall, Terrace Restaurant and Pergola. Colored photograph, postcard, 1913. Hettwer 258278.

Centennial Hall, Terrace Restaurant and Pergola. Photograph, postcard, after 1913. Goettinger-Bildwerk 176146.
Centennial Hall, Terrace Restaurant and Pergola. Colored photograph (variant 176146), postcard, 1913. Postkarte 106229.
Centennial Hall, Terrace Restaurant and Pergola. Colored photograph (variant 176146), postcard, 1913. Postkarte 176114. Dublet: 176114.
Centennial Hall, Terrace Restaurant and Pergola. Photograph, postcard, before 1926. Goettinger-Bildwerk 176138.
Centennial Hall, Terrace Restaurant and Pergola. Photograph, postcard, after 1913. Postkarte 105940.
Centennial Hall, Terrace Restaurant and Pergola. Photograph, postcard, ca. 1930. Postkarte 190710.
Centennial Hall, Terrace Restaurant and Pergola. Photograph, postcard, ca. 1930. Goettinger-Bildwerk 176141.
Centennial Hall, Terrace Restaurant and Pergola. Photograph, postcard, before 1929. Goettinger-Bildwerk 176151.
Centennial Hall, Terrace Restaurant and Pergola. Photograph, postcard, before 1929. Goettinger-Bildwerk 176133. Dublet: 176151.
Centennial Hall, Terrace Restaurant and Pergola. Photograph, postcard, before 1926. Goettinger-Bildwerk 176123.
Centennial Hall, Terrace Restaurant and Pergola. Photograph, postcard, before 1926. NBA 241217.
Centennial Hall, Terrace Restaurant and Pergola. Photograph, postcard, after 1926. Goettinger-Bildwerk 176145.
Centennial Hall, Terrace Restaurant and Pergola. Photograph, postcard, after 1926. Goettinger-Bildwerk 176136.
The Pergola, view of the Centennial Hall. Multi-colored drawing, postcard, before 1926. Postkarte 105938.
The Pergola. Photograph, postcard, 1913. Goettinger-Bildwerk 176253.
The Pergola. Photograph, postcard, before 1929. Goettinger-Bildwerk 176150.
The Pergola. Photograph, postcard, before 1929. Postkarte 105935.
The Pergola. Photograph, postcard, before 1929. Postkarte 176139.
The Pergola. Photograph, postcard, before 1929. Postkarte 106233.
The Pergola. Colored photograph, postcard, before 1929. Goettinger-Bildwerk 176137.
Centennial Hall and Terrace Restaurant. Colored photograph, postcard, 1913. Hettwer 258284.
Centennial Hall and Terrace Restaurant. Colored photograph, postcard, 1913. Postkarte 176112.
Centennial Hall and Terrace Restaurant. Colored photograph, postcard, before 1917. Postkarte 176113.
Centennial Hall and Terrace Restaurant. Colored photograph, postcard, 1913. Hettwer 258279.
Centennial Hall and Terrace Restaurant. Photograph, postcard, before 1924. Goettinger-Bildwerk 176144.
Centennial Hall and Terrace Restaurant. Photograph, postcard, before 1943. Goettinger-Bildwerk 176140.
Centennial Hall and Terrace Restaurant. Photograph, postcard, 1913. Postkarte 176117.
Centennial Hall and Four Dome Pavilion. Photograph, postcard, 1913. Postkarte 176120.
Centennial Hall and Four Dome Pavilion. Colored photograph, postcard, 1913. Hettwer 258282.
Centennial Hall and Pergola. Photograph, postcard, before 1938. Postkarte 105937.
Exhibition Grounds and Szczytnicki Park. Photographs, four-part postcard, before 1938. Goettinger-Bildwerk 176252.
Four Dome Pavilion, inner courtyard. Photograph by Staatliche Bildstelle (?), 1937. NBA 241224.
Exhibition Hall, interior. Photograph, after 1925. NBA 87394.

Church in Szczytnicki Park
Old and new church in Kędzierzyn. Photographs, two-part postcard, after 1913. Postkarte 108408.
Plan of the church in Szczytnicki Park. Cardboard, ink, Scale 1:100, 1934.02, A. Zinkler. NBA 244667.
Church in Szczytnicki Park, view from the west. Photograph, before 1934. NBA 129388.
Church in Szczytnicki Park, view from the east. Photograph, before 1934. NBA 240599.

Church in Szczytnicki Park, view from the south-west. Photograph, 1934. NBA 240601.
Church in Szczytnicki Park, view from the south. Photograph, 1934. NBA 85187.
Church in Szczytnicki Park, view from the west. Photograph, postcard, before 1945. Postkarte 106372.
Church in Szczytnicki Park, view from the east. Photograph, postcard, before 1945. Postkarte 87240.
Exhibition Grounds. Horticultural Exhibition. Garden Implementation design by Paul Hatt. 1913. Photograph, print. Former no. 5931. NBA 241220.
Exhibition Grounds. Horticultural Exhibition. Garden Implementation design by Paula Hatt. 1913. Photograph, print. NBA 241221.
Rock garden at the Werkbund "WUWA" Exhibition (1929.15.6.–15.9.), Photograph, postcard. Goettinger-Bildwerk 176149.

7.9. The Technical University in Berlin – Museum of Architecture (Technische Universität Berlin Architekturmuseum)

The Four Dome Pavilion – Historical and Artistic Exhibition Pavilion
Implementation design drawings
Four Dome Pavilion. Longitudinal cross-section through the southern wing. Schnitt A-B. 1913, Hans Poelzig. Ozalid and pencil, 40,0 x 97,09 cm. TU Berlin, call no. 2687.
Four Dome Pavilion. Longitudinal cross-section through the side wing. Schnitt C-D. 1913, Hans Poelzig. Ozalid and pencil, 37,0 x 71,0 cm. TU Berlin, call no. 2688.
Four Dome Pavilion. Longitudinal cross-section of the northern wing. Schnitt E-F. 1913, Hans Poelzig. Ozalid and pencil, 41,0 x 70,0 cm. TU Berlin, call no. 2689.
Four Dome Pavilion. Cross-section of the northern wing Schnitt G-H. 1913, Hans Poelzig. Ozalid and pencil, 40,0 x 61,5 cm. TU Berlin, call no. 2690.
Four Dome Pavilion. Cross-section of the southern wing. Schnitt J-K. 1913, Hans Poelzig. Ozalid and pencil, 48,0 x 61,0 cm. TU Berlin, call no. 2691.
Four Dome Pavilion. Perspective view. Cardboard, ink, 21 x 68 cm. TU Berlin, call no. 2692.

Photographs
Four Dome Pavilion. View from the south-west under construction. Photograph, 1913. TU Berlin, call no. 2693.
Four Dome Pavilion. View from the south-east after construction. Photograph, 1913. TU Berlin, call no. F 1520.
Four Dome Pavilion. View from the south-east after construction. Photograph, 1913. TU Berlin, call no. F 1521. [second copy: call no. F 1520]
Four Dome Pavilion. View from the south. Photograph, 1913. TU Berlin, call no. F 1522.
Four Dome Pavilion. View from the south, central part. Photograph, 1913. TU Berlin, call no. F 1523.
Four Dome Pavilion. View from the south, central part. Photograph, 1913. TU Berlin, call no. F 1524. [second copy: call no. F 1523]
Four Dome Pavilion. View from the south, central part. Photograph, 1913. TU Berlin, call no. F 1525. [third copy: call no. F 1523]
Four Dome Pavilion. Internal courtyard. Photograph, 1913. TU Berlin, call no. F 1526.
Four Dome Pavilion. Internal courtyard. Photograph, 1913. TU Berlin, call no. F 1527.
Four Dome Pavilion. Internal courtyard. Photograph, 1913. TU Berlin, call no. F 1528. [second copy: call no. F 1527]
Four Dome Pavilion. View from the north-east. Photograph, 1913. TU Berlin, call no. F 1529.
Four Dome Pavilion. View from the north. Photograph, 1913. TU Berlin, call no. F 1530.
Four Dome Pavilion. View from the north. Photograph, 1913. TU Berlin, call no. F 1531. [second copy: call no. F 1530]
Four Dome Pavilion. View from the south-east. Photograph, 1913. TU Berlin, call no. F 1532.
Four Dome Pavilion. View from the west. Photograph, 1913. TU Berlin, call no. F 1533.

Four Dome Pavilion. View from the west. Photograph, 1913. TU Berlin, call no. F 1534. [second copy: call no. F 1533]
Four Dome Pavilion. View from the west. Photograph, 1913. TU Berlin, call no. F 1535. [third copy: call no. F 1533]
Four Dome Pavilion. View from the west. Photograph, 1913. TU Berlin, call no. F 1535. [forth copy: call no. F 1533]
Four Dome Pavilion. View from the north-east. Photograph, 1913. TU Berlin, call no. F 1537.
Four Dome Pavilion. View from the north-east. Photograph, 1913. TU Berlin, call no. F 1538. [second copy: call no. F 1537]
Four Dome Pavilion. View from the south-east, dome of the main entrance. Photograph, 1913. TU Berlin, call no. F 1539.
Four Dome Pavilion. Inner courtyard, view to the north. Photograph, 1913. TU Berlin, call no. F 1540.
Four Dome Pavilion. Inner courtyard, view to the north. Photograph, 1913. TU Berlin, call no. F 1541. [second copy: call no. F 1540]
Four Dome Pavilion. Inner courtyard, view to the north. Photograph, 1913. TU Berlin, call no. F 1542. [third copy: call no. F 1540]
Four Dome Pavilion. Inner courtyard, view to the north. Photograph, 1913. TU Berlin, call no. F 1543. [forth copy: call no. F 1540]
Four Dome Pavilion. View from the south, main entrance colonnade under construction. Photograph, 1913. TU Berlin, call no. F 1544.
Four Dome Pavilion. View from the north-west, entrance to the Garden Hall under construction. Photograph, 1913. TU Berlin, call no. F 1545.
Four Dome Pavilion. View from the south-west, dome of the main entrance. Photograph, 1913. TU Berlin, call no. F 15456.
Four Dome Pavilion. View from the south-west, dome of the main entrance. Photograph, 1913. TU Berlin, call no. F 15457. [second copy: call no. F 1556]
Four Dome Pavilion. View from the south-west, dome of the main entrance. Photograph, 1913. TU Berlin, call no. F 15458. [third copy: call no. F 1556]
Four Dome Pavilion. View from the south-west, dome of the main entrance, under construction. Photograph, 1913. TU Berlin, call no. F 15459.
Four Dome Pavilion. Interior of Wrocław Hall. Photograph, 1913. TU Berlin, call no. F 1556.
Four Dome Pavilion. Interior of Wrocław Hall. Photograph, 1913. TU Berlin, call no. F 1557.
Four Dome Pavilion. Interior of Wrocław Hall. Photograph, 1913. TU Berlin, call no. F 1558. [second copy: call no. F 1557]
Four Dome Pavilion. Interior of Wrocław Hall. Photograph, 1913. TU Berlin, call no. F 1559. [third copy: call no. F 1557]
Four Dome Pavilion. Interior of the Hall with the statue and boards of the fallen, eastern wing. Photograph, 1913. TU Berlin, call no. F 1560.
Four Dome Pavilion. Interior of the Hall with the statue and boards of the fallen, eastern wing. Photograph, 1913. TU Berlin, call no. F 1561.
Four Dome Pavilion. Exhibition space interior. Photograph, 1913. TU Berlin, call no. F 1562.

The Pergola and pond
Pergola. View from the north-western arm. Photograph, 1913. TU Berlin, call no. 1550.
Pergola. View from the north-western arm. Photograph, 1913. TU Berlin, call no. 1551. [second, copy: call no. 1550]
Pergola. View from the north-western arm. Photograph, 1913. TU Berlin, call no. 1552. [third copy: call no. 1550]
Pergola. View from the north-western arm. Photograph, 1913. TU Berlin, call no. 1552. [forth copy: call no. 1550]
Pergola. View from the north-western arm. Photograph, 1913. TU Berlin, call no. 1552. [fifth copy: call no. 1550]
Pergola. View from the north-western arm. Photograph, 1913. TU Berlin, call no. 1555.

Horticultural Exhibition Building and Rheingold Restaurant
View of the Rheingold Restaurant from the north-west. 1913. Photograph, 1913. TU Berlin, call no. 3313.

The southern part of the Exhibition Grounds
Location concept: in the southern areas of the Exhibition Grounds, large and small exhibition halls. Lageplan. After 1913? Hans Poelzig. Ozalid, 38 x 40 cm. TU Berlin, call no. 2684.
Implementation design for a large and small exhibition hall. Erdgeschoss. Projection and cross-section. Marked sections showing the possibility of building inside the cycling race track. Scale 1:500. After 1913? Hans Poelzig. Ozalid, 41,5 x 43,5 cm. TU Berlin, call no. 2685.
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Centennial Hall, view from the west. Photograph, after 1925. Call no. SLUB Dresden 160276.
Centennial Hall, Interior. Photograph by Walter Möbius, before 1938. Call no. SLUB 58162.
Centennial Hall, Interior. Photograph by Walter Möbius, before 1938. Call no. SLUB 58163.
Centennial Hall, Interior. Photograph by Walter Möbius, before 1938. Call no. SLUB 4636.
Centennial Hall, Interior. Photograph by Walter Möbius, before 1938. Call no. SLUB 4637.
Centennial Hall and Terrace Restaurant. Photograph by Walter Möbius, before 1937. Call no. SLUB Dresden 58161.
Centennial Hall and main entrance colonnade. Photograph by Walter Möbius, before 1937. Call no. SLUB Dresden 4042.
Four Dome Pavilion. Courtyard. Photograph, 1913. Call no. SLUB Dresden 103191.

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8.

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The bibliography has been divided into two parts – sources published before 1945 along with texts by the architects and artists involved in the Exhibition Grounds, Centennial Exhibition and “Wohnung und Werkraum” (WuWA) Exhibition (in alphabetical order), and literature printed after 1945 with list of sources in chronological order.

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