RESEARCH AND CONSERVATION PLANNING FOR THE METU FACULTY OF ARCHITECTURE BUILDING COMPLEX BY ALTUĞ-BEHRUZ ÇİNİCİ, ANKARA, TURKEY

ODTÜ METU

Getty Foundation

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THE KIM-METU PROJECT FINAL REPORT:

Conservation Planning for the METU Faculty of Architecture Building Complex

This report presents the research and planning activities that have been conducted for the last three years, as part of the Conservation Planning of the METU Faculty of Architecture building complex. The necessity for an urgent conservation planning procedure became evident and an interdisciplinary graduate studio was established in 2013 to start a research program for the documentation of the material and cultural properties of the building.[1] "Conservation by Documentation" was the motto of the research group and the goal was the establishment of a comprehensive, operational archive within the faculty building. This project gained the invaluable support of the Getty Foundation "Keeping It Modern" grant in 2017.

The grant proposal was accepted on June 6th. The interdisciplinary research activities have been initiated in mid-summer and were formally started after the withdrawal was approved by METU in October 2017. The grant supported the initiation of the conservation management plan to guide long-term maintenance and conservation policies developed for the METU Faculty of Architecture building complex. That required the thorough investigation of its physical condition and the analysis of materials, as well as the documentation of its social and cultural significance. This has been a continuous, interpretative praxis, which will be effective even after the completion of the conservation planning process. The methodology developed for the Faculty of Architecture building complex will form a model for similar undertakings in the other buildings at METU. As the faculty building is located in a campus, and as such, part of a larger uniform entity, the ultimate goal is the acceptance and expansion of conservation activities to the whole campus institutionally.

[1] Ayşen Savaş and Agnes van der Meij, eds., *Diamonds in Sahara: METU Lodgings Documented* (Ankara: METU Press, 2018). See also; Güven Arif Sargın and Ayşen Savaş, "A University Is a Society: An Environmental History of the METU Campus," *The Journal of Architecture* vol.18, no.1 (February 2013): 79–106, Ayşen Savaş, *METU Documented, Exhibition Catalogue* (Ankara: METU Press, 1999).

The building was originally designed as a school of architecture and still accommodates the same function. Particularly for that reason, it has been well preserved over the last 60 years; yet there are challenges. Some of the problems this building faces apply to almost all the early 20th century Modern Architecture buildings, and some of them are very unique to this case. The daily population of the Faculty of Architecture is around 2000 people, including the students, staff and the service support; and the number of students is increasing annually. Ankara has a very hard climate with very drastic temperature changes both daily and annually. New building codes, comfort demands, and IC technologies introduce additional infrastructural requirements. As a result, the building runs the risk of losing its authenticity due to poor workmanship and the lack of skilled maintenance. The roots of the wild trees growing in the courtyards, random irrigations and the humidity generated by the interior and exterior decorative pools also form a rather unconventional list of threats for the building. This list can be expanded to include the recent campus sustainability projects that have been initiated by the different departments of the university.[2]

More important than all these, the ideological shifts and the rapid growth of the city with its new highways, underground transportation systems and additional urban functions are threatening the integrity of the campus and this building complex. Moreover, the 20th century architecture is not of particular interest in Turkish authorities, where the definition of historical heritage is quite narrowly set within a time limit up to the late 19th century. Today the building is at considerable risk for more specific reasons by which the premises of Modernity and thus Modern Architecture have now been openly challenged in tune with Turkey's highly volatile cultural climate. Within this context, the necessity for a daring conservation planning method became evident and in parallel to research activities the research team took the initiative of a wide dissemination project under the title "International Awareness."

As part of the conservation planning activities and acting in collaboration with local NGOs such as SALT Institute in Istanbul, Chamber of Architects in Ankara, and the Goethe Institute in Turkey, the team organized symposia, exhibitions, competitions, alumni events, and oral history workshops. All the publications including books, articles, graduate theses and catalogues were conducted in English in order to be able to reach to an international audience. The website of the projected has been active since October 2018.[3] Besides becoming part of the Getty "Keeping It Modern" project, the building was included in the SOS Brutalism exhibition and its catalogue in 2017. It was also part of the exhibition in the Venice Architecture Biennale - Greek Pavilion in 2018. This project will also be presented in the DO.CO.MO.MO 2019 in Berlin, KIM Morocco Workshop in Casablanca, and in the Research Week in TUDelft.

[2] Photovoltaic panels, new building thermal insulation cladding applications, new roof insulation materials are the sample proposals developed by the various research groups in the engineering departments.

[3] METU-Getty KIM Project website: https://kimproject.arch.metu.edu.tr/en

This preservation strategy is addressing the functional, practical, physical, technical, as well as the social, environmental and the political factors that shaped and later transformed the original design ideas and construction methods. This research will provide owners of the building, managers, and stakeholders, with better guidance on how to initiate their assessments in a way that will enable them to go beyond raising awareness, to undertaking assessments that will lead to the implementation of practical, *in-situ* adaptation actions and decisions.[4]

The very nature of this research required an efficient information sharing system. The interdisciplinary research group that formed the conservation planning team included architects, engineers, social scientist, conservation specialists, IT experts, chemists, archivists, administrative staff and the graduate students. The collection and management of the comprehensive and incremental information gathered during the research process required an effective medium that would provide an environment for the storage and retrieval of the collected data. Moreover, the documentation and preservation of the historical and existing assets in conservation planning are not autonomous, single activities, but rather conditional, continuous processes. They are interpretative incessant operations, where social, cultural and material as well as semantic, geometric and topological data are collected and managed.[5] A comprehensive and expressive 3D environment has been developed for interactive data visualization that can make relevant knowledge accessible and provide insights into a rather sparse and complex data set.

In this project, one of the main research activities was the development of a Heritage Building Information Modeling (HBIM) model. Conservation planning of heritage buildings involves the gathering, structuring, representation and archival of vast amounts of data about the building. The management and accessibility of this information can be possible by the digitization of building data by the help of diverse IC techniques. While computer-aided design (CAD) tools are widely used for geometry modeling, they cannot support the information-rich work-flows of heritage planning processes. Building Information Modeling (BIM) stands as a recent technology that can effectively support conservation planning as well as other Architecture, Engineering, Construction and Facilities Management (AEC/FM) activities. The main premise of BIM is one single model that is encoded in a standard, inter-operable and neutral file format that maintains the whole building data. These data can be related to the 3D geometry, building components, object properties, activities throughout the time dimension etc. The value of BIM is that it provides efficient access to comprehensible and integrated building information and involves innovative technologies. Recently, the scope of BIM has been expanded to support heritage information, namely Heritage Building Information Modeling (HBIM). HBIM aims to

[4]Mohsen Mostafavi and David Leatherbarrow, *On Weathering: The Life of Buildings in Time* (Cambridge, MA: MIT Press, 1993).

[5]Yusuf Arayici, John Counsell, Lamine Mahdjoubi, Gehan Ahmed Nagy, Soheir Hawas, and Khaled Dweidar. *Heritage Building Information Modelling* (Florence: Taylor and Francis, 2017).

leverage the existing capabilities of BIM and further harness it by the domain-specific heritage information gathered through a diverse set of sources such as existing building documentation, on-site surveys, etc.

In this project, Autodesk Revit was used in the development of the HBIM model. The model is intended to act as a representative medium that contains the 3D building form, and the semantic and audio-visual information that can augment and support conservation planning activities during the course of the project and conservation implementation activities in the long run. The key functions that the model fulfils include :

- the visualization of the building, its systems or parts in all scales and levels of detail. This includes not only paper-based or digital visualizations, but also virtual reality environments that offer an immersive experience,

- capturing information from a variety of phases, from initial design concepts to the current building state to future maintenance or conservation implementation processes. These include a wide range of data sources including text-based data, images, diagrams, tables, web links,

- managing conservation planning activities during the course of the project.

The HBIM model can be considered as a virtual replica of the building that evolves in time. This is due to the level of detail that is demanded by the model users. During this project, the pilot area was modeled with a high level of detail and information. The research continues to expand not only to the whole building complex, but also other buildings in the campus.

The introduction of Heritage Building Information Modelling (HBIM) as an effective and practical visualization medium helped the team to make the complex data more accessible, comprehensible and usable. As such, personal histories, historical narrations, memoirs, legal documents, building codes, users' demands, architect's dreams, and many similar and seemingly unrelated data had been overlapped with more quantitative information.

Semantic data is a critical complement to geometric data in HBIM. It accounts for the non-geometric information about the building, its site, components and processes, is gathered through surveying or existing building documentation. This includes not only technical data but also information regarding the cultural, social and historical significance of a heritage building. Despite the increase in the amount and various types of data in HBIM, the uniqueness of each heritage building and its architectural and heritage values challenge the standardization of the model.

The existing building data in the standard BIM schema, as well as the extended schema that contains the new data types, provides critical support to heritage professionals during assessment processes. Therefore, the expressive visualization of these data types is one of the primary concerns of HBIM development. For the faculty building, these new data types and the existing ones are made complimentary to the 3D visualizations of the building. As such, distinctive visual markers are inserted into the 3D view of the building where the data was collected or associated. This could be a room, an architectural element or any part of an element. These markers contain the newly added sets of HBIM data, which, upon clicking, display the information to the users. For instance, during structural assessment, the data regarding an existing crack, such as the images of the crack, its depth and hazard condition, can be viewed by the users. Clicking on a staff office door, helps the retrieval of historical data related to the previous users of that particular space, restorations that the door had been subject to, material properties, manufacturing techniques of that door and the industrial resources of its doorknobs, hinges, and locks. One of the major advantages of this medium is its sustainability. This interactive medium allows further additions, corrections, and subtractions. The simultaneous visualization of the geometry and the semantic data is useful both for assessment activities and also for sharing the architectural heritage values with a wider audience.

The Faculty of Architecture building complex is an outcome of the creative intellect of post-war architectural engineering and became the laboratory of new materials, mechanical equipment and construction techniques in Turkey. Starting from the use of waffle slab system to the production of fan coil units, it marked a number of “firsts” in the country. Making the scientific data visually available is one aspect and providing its integrity with the social and cultural documentation is another. Personal histories, historical narrations, memoirs, legal documents, photographs, films, building codes, the gradual growth and integration of the landscape elements, users’ demands, architect’s dreams, and many similar and seemingly unrelated data need to be overlapped with the more quantitative information. METU HBIM was developed to convey this information effectively and provide insights into a rather sparse and complex data set. Proper visualization provided a different approach to show potential connections and relationships, which are not as obvious in non-visualized qualitative and quantitative data. This comprehensive 3D environment provided an interactive and comparative data visualization that has the capacity to provide relevant knowledge in the most efficient manner possible. The HBIM model can be considered as a virtual replica of the building that evolves in time. Besides being an operational and management tool for heritage buildings it is also has the potential to become a new representation tool for architectural education.

1.1 The Team

This Conservation Planning Report is the product of collaborative work that reflects the research focus and priorities of architects, engineers, stakeholders, specialists and conservation planners. Thus, the conservation team was composed of an interdisciplinary research group that is currently working as researchers and instructors at the METU campus. The Research Lab (90A) of the core group was also located within the Faculty of Architecture building complex. The framework of the policies that is formed to provide a proactive approach to historic conservation of the faculty building had been supported with the expanded groups. The members of these groups were either directly related to or affiliated with the university. The core group was composed of mainly architects yet most of them were specialized in multiple fields such as museology, building performance, 3D modelling and software development. All the research topics of graduate students participated in the team were particularly focusing on the different aspects of the conservation planning of the faculty building.

The number of the participants expanded with the integration of existing elective graduate courses into the project events. Arch524 “Different Modes of Representation”, a course particularly focusing on representation theories was conducted to focus on the visualization of the faculty archives. Moreover, the number of the stakeholders (interest groups) was extended with the collaboration of alumni events, symposia, exhibitions, student competitions, orientation programs, publications and multimedia broadcasting.

Figure 1: The first meeting with the METU Directory of Maintenance staff and the directorate, Jan 11,2018.
Figure 2: Crack measurement with students.

Core Group

The Architectural Team

Prof. Dr. Ayşen Savaş, Architect, Museolog, Project Manager

After being trained as an architect in the METU Department of Architecture and Bartlett School of Architecture, she received her PhD from the History, Theory, and Criticism Program at MIT. For the last 20 years she has been converting historical buildings into museums and curating national and international exhibitions. Currently, she is teaching courses on representation and architectural design at METU. Her publications include exhibition catalogues, books and articles particularly on the transformation of space by means of architectural interventions and the preservation of Modern Architecture. She is the founder of a non-profit organization: Exhibition Design Workshop that established and designed museums such as Sabancı Museum, Erimtan Archeology Museum (EMYA finalist 2017), MKEK Technology Museum and METU Science and Technology Museum. Her achievements include a number of national and international awards and fellowships, including the Getty Keeping It Modern Grant, AIA Architectural Award, AAUW Research Prize, Schlossman Prize in historical research, Sir John Soane Museum, CCA and Bologna University fellowships. The museological theme she had developed for the Turkish Pavilion at the World EXPO in Shanghai won The Silver Medal in 2010.

Sezin Sarıca, Architect, RA

Sarıca graduated from the METU Faculty of Architecture with a bachelor's degree in architecture. She is currently a graduate student and working as a teaching assistant in the same institute. Her research interests include large scale exhibitions and biennales and focused on "relief spaces".

Bengisu Derebaşı, Architect, RA

Having completed undergraduate studies in Architecture Department of METU, Derebaşı continues her research activities in the graduate architecture program in the same institute. Her research interests include archives, libraries and spatial representation of knowledge, formation of the physical archive, data structuring, conceptual reference model ontology.

Fatma Serra İnan, Architect, RA

After receiving her bachelor's degree in Architecture from METU, İnan is completing her graduate studies in the same institute. İnan's research activities are directly related with the visual documentation of the METU Faculty of Architecture as she is specialized in the processes of photographic documentation during her master thesis research focusing on "in-between spaces".

Eyüp Özkan, Architect, RA

Özkan received his bachelor's degree in architecture from Istanbul Technical University and currently enrolled in the graduate architecture program in METU. Özkan's research interest includes representation as design media and bibliographical survey of the twentieth-century architectural productions.

Conservation Planning Advisor

Assist. Prof. Dr. Zeynep Aktüre, Architect, Conservator

She received her B.Arch degree from the METU Faculty of Architecture and continued her graduate studies in the Architecture-Restoration Program and completed her PhD studies in Architecture in the same institution. She is currently working as an Assistant Professor in Izmir Institute of Technology (IZTECH). She teaches courses on architectural and urban design, architectural history and theory, architectural conservation in archaeological sites and management of heritage sites. She has participated in ERASMUS teaching exchange programs and coordinated ERASMUS Intensive Programme projects on archaeological landscapes and urban public spaces. She is the active member of the UNESCO National Committee in Turkey.

Material Assessment Team

Assoc. Prof. Dr. Ayşe Tavukçuoğlu, Architect

She received BArch. degree in Architecture in 1989, MSc and PhD degrees in Building Science in 1992 and 2001, respectively, at METU. She did postdoctoral research in CNR-ITC in Padova (Italy) in 2006. She teaches building materials technologies, building construction technologies, construction design practice, diagnosis and treatment of material decay, laboratory experiments in conservation science courses. Her main research interests are use of non-destructive investigation techniques for diagnostic and monitoring purposes, in-situ building inspection, materials conservation, porous building materials; construction techniques and architectural detailing. She worked in several international and many national research projects as researcher and coordinator.

Prof. Dr. Emine N. Caner-Saltık, Conservation Scientist

She is a part of MCL-METU and has been teaching at "Graduate Program in Conservation" and Graduate program in Archaeometry, concerning materials conservation issues of historic structures, supervising masters and doctorate theses and conducting several European and national research projects on diagnostic analyses of historic building stones, non-destructive analyses of historic timber structures, technological analyses of historic mortars, plasters, Seljuk glazed tiles, medieval bricks, development of repair mortars and plasters for historic masonry, development of nano dispersive treatments for the consolidation of limestone and sandstone, corrosion mechanisms of historic iron and others.

Assist. Prof. Dr. Çagla Meral Akgül, Civil Engineer

Dr. Çağla Meral received her Bachelor of Science and Master of Science from the Civil Engineering Department and Computer Engineering Department at Middle East Technical University. She received her PhD at University of California, Berkeley. She pursued her studies at Massachusetts Institute of Technology (Cambridge, MA), Concrete Sustainability Hub as a visiting researcher. She specializes in the analysis of concrete structures, construction materials, sustainable construction and life cycle assessment of materials.

Fatıma Erol, Chemical Engineer, RA

Graduated from Ankara University, Department of Chemical Engineering and worked as a production engineer for four years. She is currently a graduate student in the Department of Archaeometry at METU and working as a project assistant at MCL-METU since 2015.

Structural Assessment

Prof. Dr. Ahmet Türer, Civil Engineer

Dr. Turer graduated from the METU Civil Engineering Department in 1993 and worked in the field as a project engineer and structural designer until 1995. He continued his graduates studies in the University of Cincinnati, Ohio, USA. He has completd his B.S. in 1997 and Ph.D. in 2000 in the same university. Immediately after his graduation, he has returned to METU as an instructor and is continuing his career at the Civil Engineering Department. Dr. Turer's research areas are mainly in structural health monitoring of civil infrastructure, earthquake evaluation of existing structures, historic structures, computer analytical simulations, forensic studies in structural damage, bridges, recently timber and glass structures.

Assist. Prof. Dr. Bekir Özer Ay

Bekir Özer Ay graduated from Department of Civil Engineering, Middle East Technical University, in 2003. He completed his M.S. research study on "Fragility based assessment of low-rise and mid-rise reinforced concrete frame buildings in Turkey" in 2006. He received his Ph.D. in 2012. His Ph.D. dissertation won the "METU - Thesis of the Academic Year of 2012-2013" award given by Mustafa N. Parlar Education and Research Foundation. His main research subjects are assessing earthquake damage and loss, characteristics of Turkish residential buildings, tall building structural systems and seismic interactions between structural and non-structural members. Currently, he is currently working as an Assistant Professor at METU, Department of Architecture.

Environmental Assessment Team

Assoc. Prof. Dr. Ipek Gürsel Dino, Architect, Project Coordinator

Dr. Gürsel-Dino completed her M.Arch degree at Middle East Technical University, Department of Architecture. She pursued her studies further in computational design at Carnegie Mellon University in USA (M.Arch) and Technische Universiteit Delft in the Netherlands (PhD in Architecture). She has led and participated in research projects in both USA and Europe on the development of computational tools and methods for building performance assessment, sustainable building design, parametric design systems, building information modeling, building energy efficiency, virtual-reality design tools and building retrofit. Dr. Gürsel-Dino is currently working as a faculty member at METU Department of Architecture, where she also acts as the coordinator to the Graduate Program in Architecture.

Şahin Akın, Architect, Architect, RA

Akın completed his bachelor's degree in architecture in Izmir University of Economics with full scholarship. He is currently a master student in graduate architecture program at METU. His research interests include HBIM, performative architecture and digital immersive environments.

Expanded Group

Rectorate
Prof. Dr. Mustafa Verşan Kök, the Rector, Petroleum Engineer
Prof. Dr. Meliha Benli Altunışık, Vice Rector, Political Scientist
Assoc. Prof. Dr. Bahar Gedikli, Advisors to the Rector, Urban Planner
Assoc. Prof. Dr. Eren Kalay, Advisor to the Rector, Metallurgical & Materials Engineer

The Dean's Office
Prof. Dr. Güven Arif Sargın, Dean, Architect
Prof. Dr. Adnan Barlas, Associate Dean, Urban Planner
Prof. Dr. Arzu Gönenç Sorguç, Associate Dean, Mechanical Engineer

The Dean's Office Staff
Haluk Ağırmatlıoğlu, Faculty Secretary General
Kemal Gülcen, Photogrammetry Lab Technician
Erdem Yalçın, Faculty Executive Manager
Kayhan Bakan, Administrative Staff
Rüstem Taşman, Department Secretary
Ozan Bilge, Computer Support Office
Cafer Kurt, Computer Support Office
İrfan Özcan Karataş, Photography Lab

METU General Directorate of Construction Works
Prof. Dr. Oğuzhan Hasançebi, Director, Civil Engineer
Göksal Cülcüloğlu, Deputy Director, Urban Planner
Serhat Güngör, Mechanical Engineer
Haluk Gören, Electrical Technician
Barış Yağlı, Architect

Main Research Labs
MCL | Materials Conservation Laboratory
MCL is an independent academic research center and focuses on the development of scientific conservation studies and conservation practices. Prof.Dr. Emine Nevin Saltık, Assoc. Prof. Dr. Ayşe Tavukçuoğlu, RA. Fatıma Erol are the researchers who involved in the project.

Research Labs
METU Civil Engineering Department Structural Mechanics Laboratory
METU Civil Engineering Department Materials Laboratory
METU Faculty of Architecture Photogrammetry Laboratory
METU Central Laboratory
General Directory of Mineral Research and Exploration (MTA) Laboratory
METU Press Office

Support Group

Conservation of Cultural Heritage Program
Özgün Özçakır, Research Assistant, PhD, METU
Filiz Diri, Specialist, PhD Candidate

Architectural History Program
Assoc.Prof.Dr. Lale Özgenel
Assist.Prof.Dr Pelin Yoncacı Arslan, METU

Landscape and the Immediate Environment of METU
Funda Baş Bütüner, PhD, METU
Assist.Prof.Dr Pelin Yoncacı Arslan, METU

Information Technology
Assoc. Prof. Dr. Özlem Sert, Hacettepe University
Yavuz Eren, JeoIT Director
Çağlar Fırat Özgenel, Research Assistant, PhD, Administrative Staff, METU
Damla Tekin, DT Architecture, Co-director
Ahmet Kılınç, DT Architecture, Co-director

Yapı Destek - Structural Health Monitoring

The organizational mission of the company is to be a leading worldwide engineering company about seismic condition assessment of civil engineering structures, risk analysis, structural health monitoring and sensor development and to carry out R&D as well as application projects about these areas in order to be supportive for state institutions and organizations, private sector and government educational institutions. For this purpose, their founders and employees work on specialized areas with their experience and knowledge rooted from METU - Civil Engineering Department, University of Cincinnati, Drexel University, numerous national and international projects, making use of latest technology.

www.yapidestek.com.tr/en/

Çilingiroğlu Engineering

Çilingiroğlu Engineering was founded in 1954 by Kevork Çilingiroğlu. Since its foundation, the firm has been a pioneer in the technology and engineering field in the country. Educational campuses and large scale projects constitute the majority of their projects. Besides the planning of the mechanical projects, the firm provides advisory and inspection services. The development of the infrastructural system of the METU campus and the Faculty of Architecture building during the establishment of the university was conducted by Çilingiroğlu Engineering.

http://www.cilingiroglu.com.tr/english.htm

Mehmet Okutan (Okutan Engineering)

Okutan Engineering provides high quality building mechanical systems design services as per international standards. Through their competent and experienced staff, the firm can prepare technical specifications in various format and establish the design concept. Their main specialization fields include mechanical installation systems, ecological structure design and complex electromechanical engineering services in high technology buildings. It has strong experience in project management and consultancy.

www.okutan.net/

Engin Pekyılmaz (MPY Engineering)

MPY Engineering delivers services in the design and production of construction drawings and tender documents, on-site supervision, and design consultancy in Turkey and overseas. They strictly follow and utilize latest developments in computer-aided design and drafting technologies. Their field of expertise involves MV Distribution Systems, LV Distribution Systems, Earthing and Lighting Protection Systems, Lighting and Receptacle Systems, Calculation Systems, Security Systems and other systems.

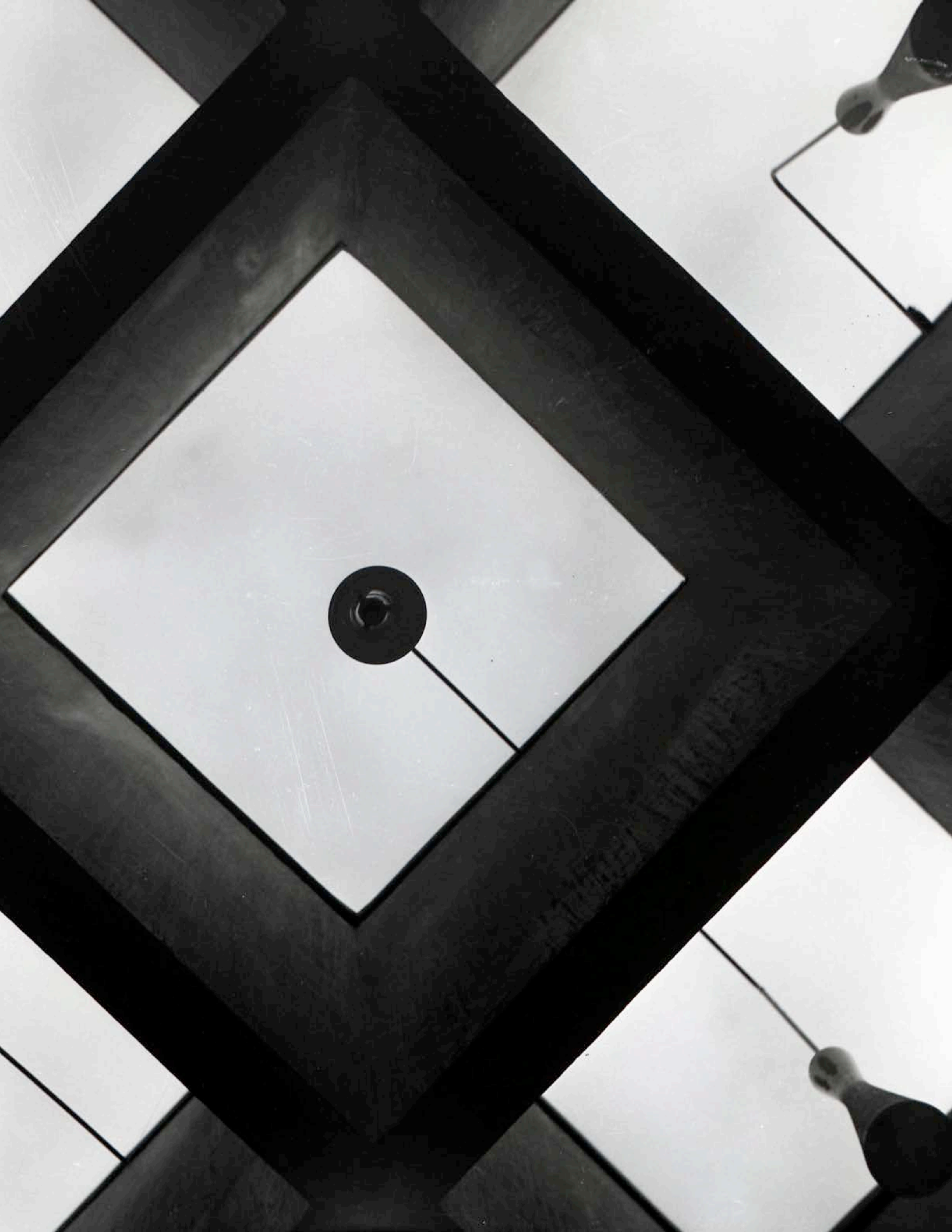
www.mpy.com.tr

Arcasoy Engineering-Laser scanning

Arcasoy Consulting has founded to serve Mining, Engineering and Consultancy Companies related to Earth Sciences, Environment and Geological applications. They have served the natural resource based industries and have consequently developed considerable expertise in Remote Sensing and related GIS technologies. Arcasoy Consulting was founded in 2004 and now has more than 23 years of experience and has been providing services in geology, structural geology, mineral exploration, satellite image enhancement/interpretation, GIS applications, algorithm generations and integration of Remote Sensing and GIS Data.

www.arcasoy.com/en.aspx

Figure 3: The team and the stakeholders (next page)



1.2 The Building

Figure 4: Skylight-Industrial Design Studio, R33, 1961-80, SALT Research, Altuğ-Behruz Çinici Archive.

Name of building: METU Department of Architecture.
Architects: Altuğ Çinici and Behruz Çinici
Design Dates: 1958-1962
Construction Dates: 17/04/1962 to 30/09/1963
Location: Ankara, Turkey
Total Surface Area: 12.675 m2
Height and other dimension: 11.30 m in height (max), 150m in length (max), 130m in width(max).
Engineering Partners: Structural works are conducted by Yusuf Berdan and Necati Noyan; Mechanical works are conducted by Kevork Çilingiroğlu, Adnan Ünlütürk and Kamuran Soyuak; electrical works are conducted by Naci Sarısözen.
History of ownership: Used as the Rectorate between 1963 and 1966 and the Faculty of Architecture starting from 1966.
Evidence of historic listing information: Not listed, 1995 Aga Khan Award METU reforestation program, forest is listed as a "Forest Preservation Area in 2000".
Current and future use of the building, including public access policies: The building is located in the METU Campus, which has a daily population of 40,000 people. Although it is a gated campus that is 10 km away from the city center, it has open access to students, scholars, researchers, users of the library, cultural facilities, METU College and Techno-park. The building is currently used by the Faculty of Architecture, composed of three departments: Architecture, City and Regional Planning, and Industrial Design.

It is not an overstatement to say that METU Faculty of Architecture Building is the best product of Modern Architecture in Turkey. With its architectural elements and built-in furniture, it is the material and symbolic manifestation of the Modernist approach. Not only the architectural qualities but also the curricula of the Faculty of Architecture were motivated by a modified Bauhaus program reflected in the studio-based education system and the functional layout of the building including material workshops, open plan space distribution, transparent courtyards, exposed concrete curtain walls, large glass surfaces, *brise-soleil* façades and flat roofs. Designed by the architect couple Behruz and Altuğ Çinici, for the first years the building complex accommodated the administration offices including the rectorate and the central library. The Faculty of Architecture presents one of the most important success stories of Modernism in Turkey. The architecture, landscaping and the social life in the building, and the urban design of the campus are the representatives of not only Modern Architecture but also the context shaped by cultural, political and economic involvements.

Rather than a single structure, the METU Faculty of Architecture building has to be interpreted as a building complex which is composed of three main structurally, functionally and administratively differentiated units: the museum (originally designed as a library), the auditorium, and the main education building. The directory of museum is part of the administrative structure of the Urban Archaeology Program in the Faculty of Architecture, yet functions under the capacity of the rectorate. The auditorium is managed by the Directory of Cultural Affairs in the university; and its main users are the members of the related Student Clubs. The educational building accommodates three Departments: Architecture, City and Regional Planning and Industrial Design. The museum and the auditorium are single-standing, cubical masses that are connected to the educational unit with a covered arcade. The fragmentation of masses continues in the main education building to be arranged around a cross shaped circulation axis. The architectural program of the building is distributed into physically identified volumes that are expressed with integrated cubic masses from the outside. The scale and the distribution of spaces within its general layout and its location on the sloped ground, make it difficult to conceive the main building as a single unit.

Figure 5: Library-Museum structural system.

The structural systems of these three units in the building complex are very unique, experimental and radically different from each other. The museum is a single standing concrete block that is elevated by six double columns on a recessed ground floor. Two double columns that are located inside support both the upper floor and the one way joist roof slab. Between the double columns, the ribs run both ways to form an unusual beam that is composed of a partial waffle system. The auditorium sits on the ground with exposed concrete shear walls. The solid mass effect is enhanced with the thick concrete parapet placed on this single standing cubical block. The ceiling is supported by nine radial concrete beams running with a symmetric order of 12.50 to 18.50 meters span and meeting on a 120 cm deep reinforced concrete deep arc beam resting on a 40cm. thick shear wall. This beam helps the proper load transfer from the radial beams to the shear wall particularly designed for shear forces. The main educational unit, on the other hand, is composed of three different structural systems. Reinforced concrete waffle slabs are supported by shear walls in large span areas such as studios. Hollow filler flooring is preferred in the ceilings of the circulation halls. Concrete shear walls and concrete flat plates are used in relatively smaller spaces, such as offices and service areas where concrete blocks and brick are installed as infill materials to divide these spaces.

Figure 6: Interior view from the Amphitheatre, showing the structural system of concrete beams.

Despite the above-mentioned variances in the structural system and the architectural elements, the use of exposed materials, the treatment of spatial qualities and the consistency in meticulous detailing, help the conception of the Faculty of Architecture building complex as a coherent whole. Particularly the use of exposed materials such as concrete, wood and brick in the walls and slabs, and the application of natural stone and marble on the floor finishing, are the main unifying elements of these otherwise fragmented units. Flat roof surfaces that are perforated with skylights, the exposed concrete surfaces that are ornamented with the texture of the wooden mould, large glazed surfaces, the concrete water spouts projecting from the parapets and the idea of “open plan” that is supported by an uninterrupted circulation pattern and physical and phenomenal transparencies, enhance the perception of the building as an architectural totality. Instructors, particularly teaching construction techniques and history of the Modern Architecture, have been using the building as a teaching laboratory for the last 50 years. From the first fan coils used in Turkey to the first application of the CIAM principles in urban scale, the Faculty of Architecture building and the other major structures in the METU campus, such as the gymnasium, cafeteria, and the main auditorium, are considered to be the earliest and the most innovative examples of the Modern Architecture not only in Turkey but also in all the region.

1.2.1 Historical Background

"benim beton çocuklarım"[6] (my concrete children)

B. Çinici

The METU Faculty of Architecture building was designed as a school of architecture from the very beginning. Besides its users and architectural milieu, the architects themselves indicated their pride in this building complex in different occasions. In one of the interviews, Behruz Çinici genuinely said that he had always considered this building as his third child.

"The METU Project was part of Turkey's second-wave of modernization efforts in the mid-1950s, and gained its spatial momentum through the American vision of university campuses that flourished in the late 18th century. Ankara was regarded as the tabula rasa of the Turkish Revolution, while the same can be said of METU in respect to modern pedagogy, being envisioned as "ground zero" not only for a new model of higher education and research, but also as a model environment of a university campus in post- war Turkey. While METU was established as a center for the cultivation of ideas that would eventually help the country face up to the challenges posed by modern society on urbanism, its graduates were thought to be the decision-makers and the leaders of the "new society". These predictions came true, and today the alumni of the university are known to have been behind the urbanization and industrialization of Turkey."[7]

[6] Uğur Tanyeli, ed. *Improvisation Mimarlıkta Doğaçlama Ve Behruz Çinici* (Bağcılar, İstanbul: Boyut Kitapları, 1999.)

[7] Ayşen Savaş, "The METU Campus: A Utopia, A Social Project, A Success Story", *Brownbook*, no.67.

Figure 7: *View towards entrance to the faculty of architecture*. Jürgen Joedicke, Bauen+Wohnen vol.19, no. 7 (1965), 275-280.

Both the design of the new campus and the preparation of the academic program of the Department of Architecture were illustrative of the simultaneously developing policies. METU, among the other Turkish universities established with similar goals at the time, including the Ege (Aegean) and Karadeniz (Black Sea) Universities in 1950, and Atatürk University in 1958, was exceptional in many ways. On the 5th of September 1951, a legal agreement was signed between the United Nations and the 28-year-old Turkish Government, authorizing Charles Abrams to conduct research on housing and city planning in Turkey.[9] Abrams was at the time affiliated with the newly established City Planning Department at the University of Pennsylvania, while also teaching at M.I.T. and working as a consultant to the United Nations. Following his research in Turkey in 1953, he wrote a report suggesting the establishment of a Graduate School for Architecture and City Planning in Ankara. A year later, Abrams and Vecdi Diker, then the director of the progressive Highway Department of Turkey, signed an agreement to initiate the establishment of an institute of high academic and environmental standards, "not unlike the best of the American and British Technical Universities".[10] With this agreement, METU became the first such government-owned establishment in the Middle East, assigning the Board of Trustees with full power in its direction and operation, similar to those enjoyed by several state-owned educational institutions in the United States. As defined in the agreement, the university was to be a place "where some of the best architects and city planners of the Western World could be brought together in Ankara to teach selected young people of the Middle East to the same high level as can be found in Western Europe and North America".[11]

The same institution would become "the bulwark of significant fundamental and applied research to strengthen the industrial and agricultural economy in Turkey".[12] After gaining the approval of the government, the Minister of Education put the project into application. G. Holmes Perkins, the head of the Department of Architecture at the University of Pennsylvania, was invited to supervise the structural organization of the school, its program and its academic mission, later assisted by two other members of the Department of Architecture, Léon Loschetter and Wilhelm von Molke, who would travel to Turkey to prepare the plans of the campus and to oversee its establishment and academic development. In this project, Perkins

[9] The contract signed between the Foreign Operations Administration (FAO) and the Trustees of the University of Pennsylvania, METU Archives, 24th of September, 1954.

[10] As cited in Güven Arif Sargın and Ayşen Savaş, "A University Is a Society: An Environmental History of the METU Campus," *The Journal of Architecture* vol.18, no.1 (February 2013): 79–106.

[11] *Ibid*.

[12] *Ibid*.

Figure 8: Main entrance arcade, METU Faculty of Architecture, exterior,SALT Research, Altuğ-Behruz Çinici Archives, 1961-80.

invited two experts from the Fine Arts Department of the University of Pennsylvania, Thomas B. A. Godfrey and Marvin Sevely, to teach and administer the school. Godfrey, a young and talented architect who would later assist Perkins in the Dean's Office and would chair the Fine Arts Department, then became the Founding Dean at the newly established Graduate School. A year later, on the 26th of January 1957, a law was passed that transformed the Graduate School of Architecture and City Planning into a technical university.

At first, it was not easy for the founders of METU to develop a comprehensive environmental program for the campus. Neither the location nor the scale was known, and the curriculum of the university was still under development. Even the local decision-makers were yet to be appointed. It was no coincidence that the first faculty to be established was Architecture and City Planning, and that the first decision-makers were architects specialized in housing and urban planning. Between 1955 and 1960, Dean G. Holmes Perkins and Thomas B. A. Godfrey presented a series of reports and projects to the Board of Trustees related to the campus plan of the university. The report, dated December 1959, summarized all of the initial principles developed for the design of the campus.[13] Even after leaving Turkey, Perkins remained as the main advisor of the campus development plan, which reflected his perception of "high modern architecture and urban planning strategies."

Competition and Construction:
The Board of Trustees launched a competition in November 1958. A number of initial projects were prepared, and two architectural competitions were organized to source a design for the university campus during the late 1950s. Although the first attempts, including the first international competition, would never come to fruition, the initial design ideas and the core of the architectural program of the campus plan were decided during these early establishment years. A second competition was held in 1961. Of the 21 entries, Altuğ and Behruz Çinici's design was given the first prize. The competition was concluded on the 21st of August 1961, and on the 15th of October the Çinici couple signed a contract that included the Faculty of Architecture as the first complex of the campus.

Modernism:
The Faculty of Architecture complex was of extreme significance, as it was regarded as the genesis of the METU Project for several reasons. "The school, the first to be established at METU in October 1956, is considered with all the elements of design and technique which aim to contribute to the improvement of our man-made environment, and seeks to provide its graduates with the ability to understand and integrate these technical factors with the natural surroundings and human needs, that they may serve society better through the improvement of living conditions".[14] Since the construction of its first unit, the faculty building had obtained all the necessary architectural tools to be identified as a landmark of Modernism in Turkey.

Faculty Building:
Since 1975, the building and its annexes- the museum, auditorium, and the garden- have been subject to a series of physical interventions and the courtyards started to lose their original qualities. As stated in the introduction, the 20th century architecture is not of particular interest toTurkish governance, where the definition of historical heritage is quite narrowly defined within a time limit of the late 19th century. Besides ideological disputes and economic fluctuations, the major threat for the building and for the whole campus/forest site is the rapid development of the urban infrastructure in Ankara. The campus site has been fragmented with through traffic roads, particularly during the last four years.

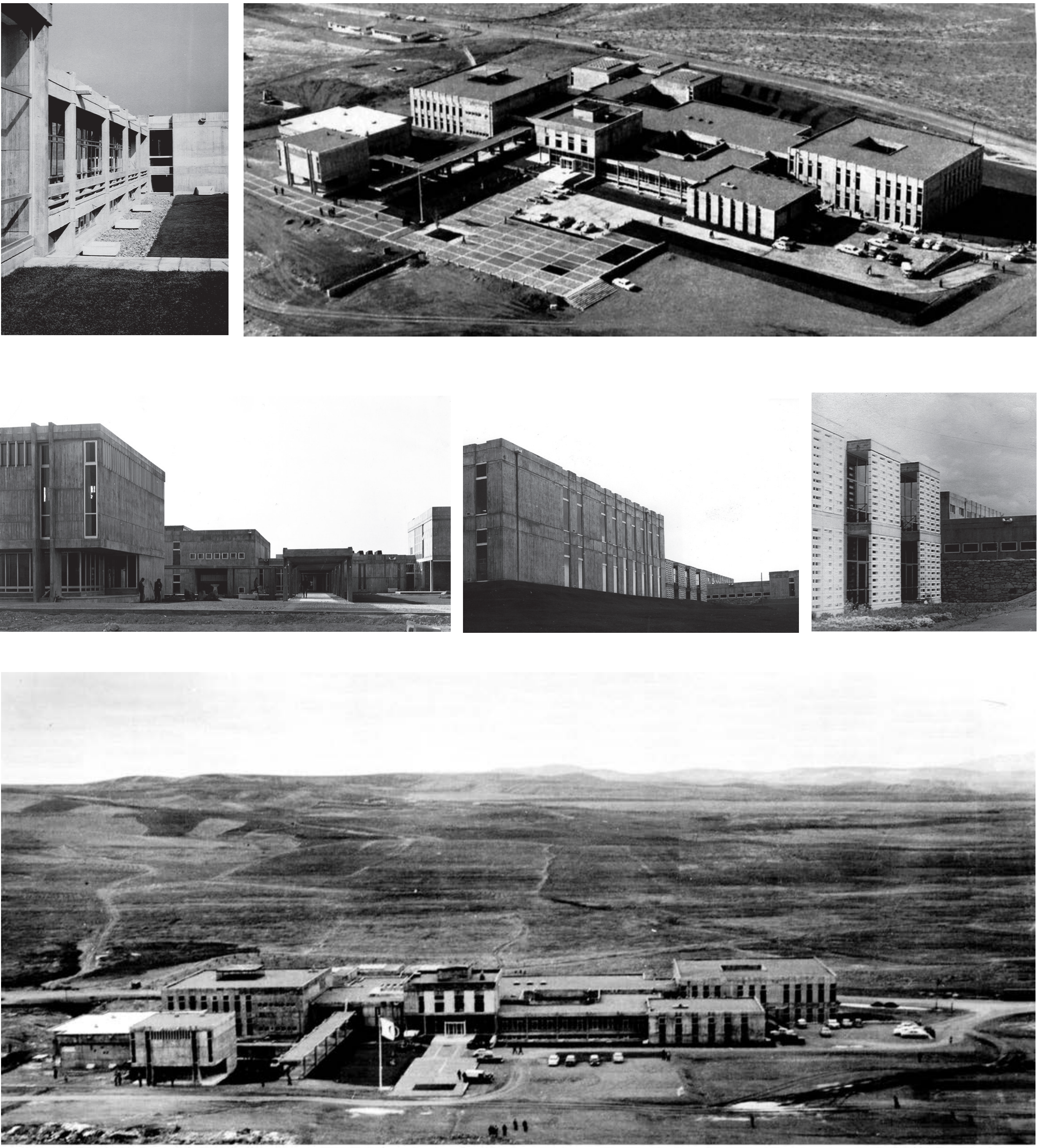
[13] Report to the Board of Trustees on the Campus Plan for METU, December, 1959, approved by the Trustees in January, 1960, METU Archive.

[14] *METU's Prospectus*, School of Architecture (Ankara: METU Press, 1960), p.5.

Figure 9:	Black and white photographs of the faculty building, 1960s.

1.2.2 Visual Background

Figure 10: Black and white photographs of the faculty building, 1960s.

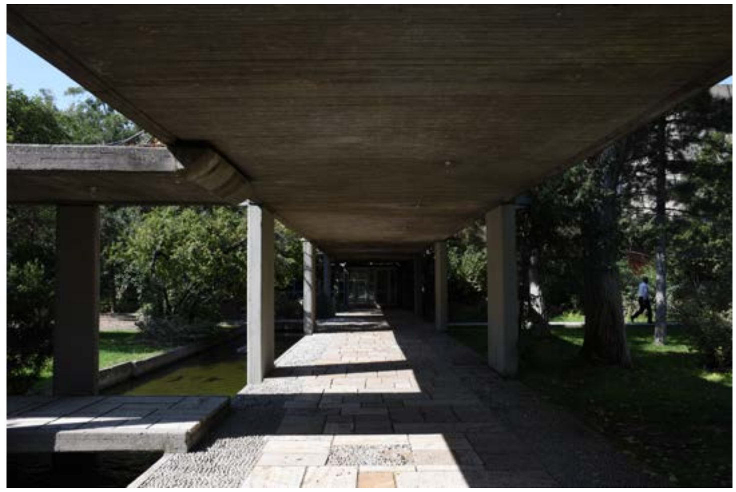


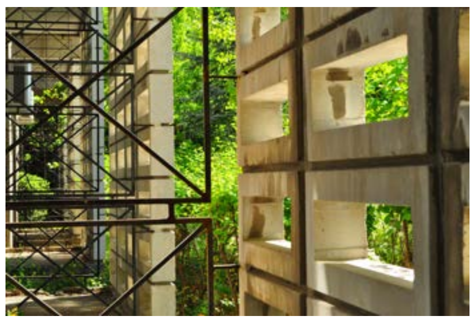


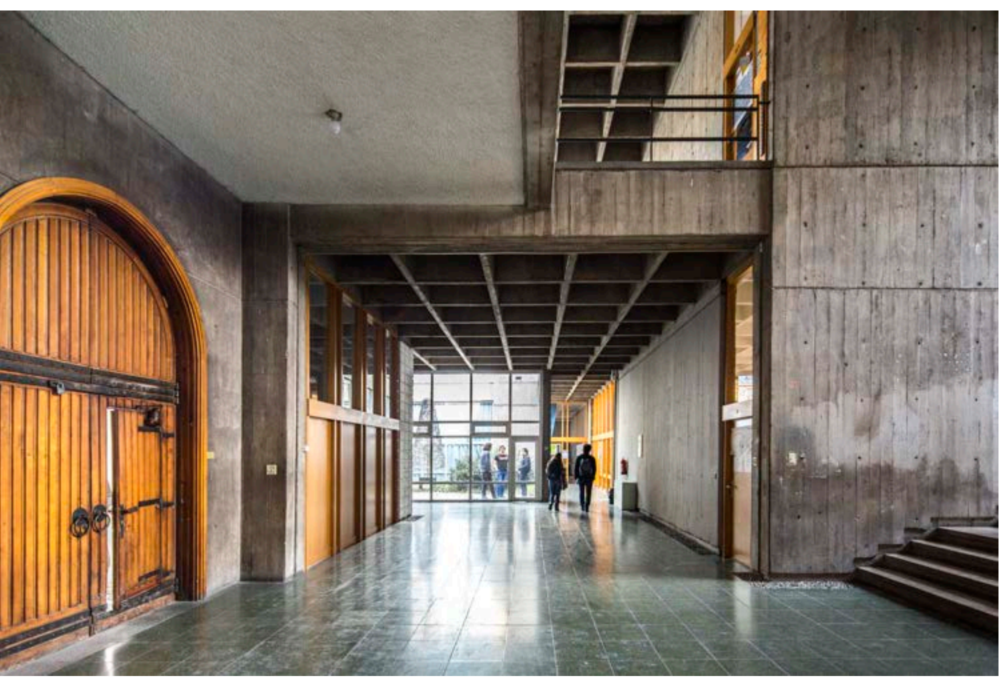










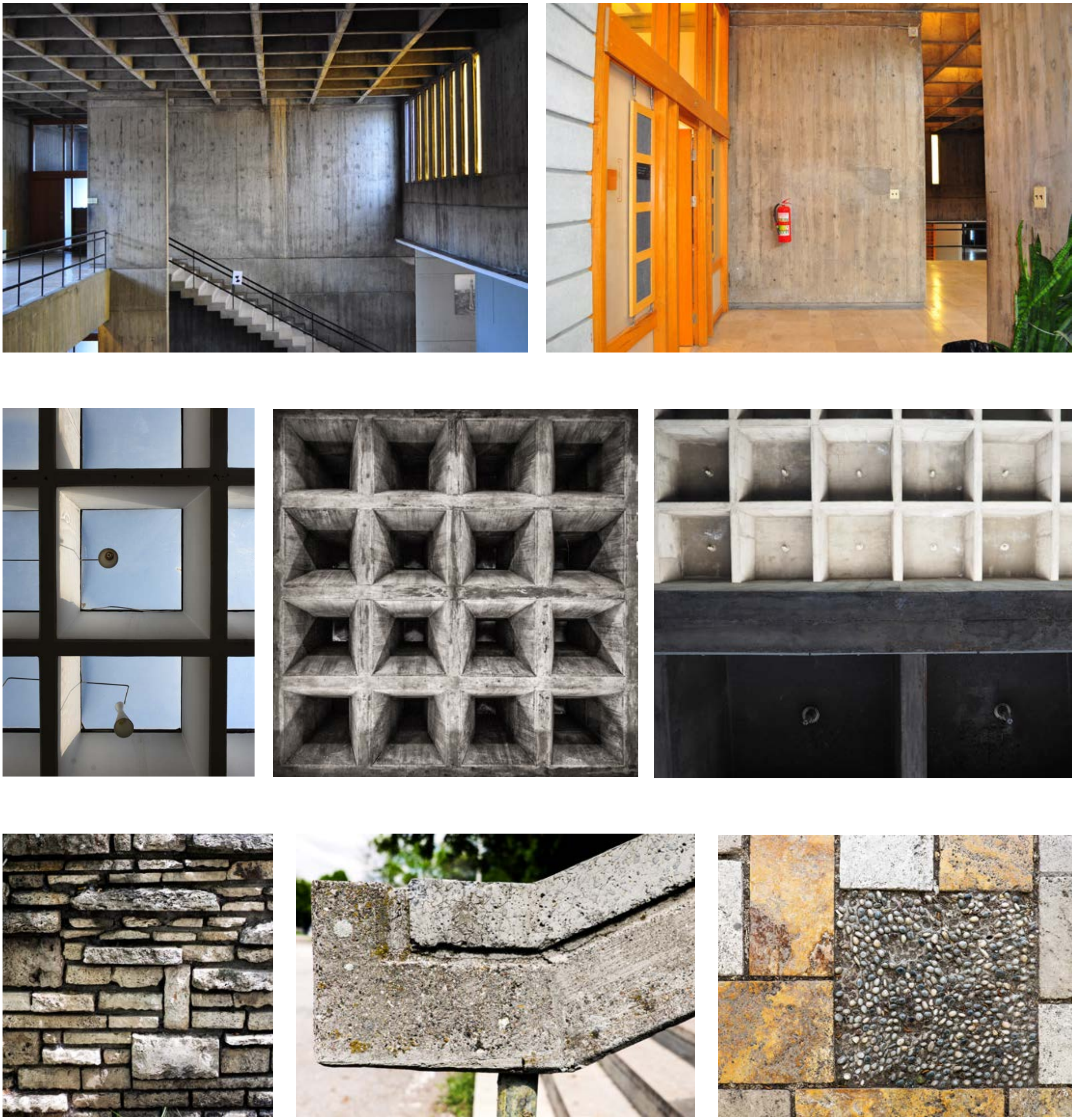



Figure 11: Faculty of architecture building, 2017. Photo credits: Duygu Tüntaş, Ali Rad Yousefnia, F. Serra İnan.

2. METU FACULTY OF ARCHITECTURE CONSERVATION FRAMEWORK

2.1. Focus of Research
2.2. Medium of Research - HBIM

The framework of this research was defined by the help of the previous studies made on the conservation of Modern Heritage. The Getty Conservation Institution's publications and particularly the bibliography published in 2011 were used as the major sources of information during the management of the different stages of this research process. Moreover, it would not be wrong to call specific publications as the "check list" of this report, such as the Salk Institute for Biological Studies Conservation Project, 2017; Sydney Opera House - a Conservation Management Plan (4th edition), 2017; Kommagene Management Plan, 2017; Listed Building Management Guidelines: Golden Lane, 2013; Conservation Plan Guidance, Heritage Lottery Fund, 2012; A Conservation Plan: Louis I. Kahn and The Yale Center for British Art, 2011; Conservation Management Plan for the National Theatre, 2008; Assessing Heritage Significance, NSW Heritage Manual, 2001; Code on Ethics of Co-existence in Conserving Significant Places (adopted by Australia ICOMOS), 1998. These publications provided information not only about the content of the research conducted but also the methodology applied. The thematic workshops organized during the Conserving Modern Architecture Initiative (CMAI) - Conservation Management Planning Workshop that took place in London, in July 2018 and the specific documents particularly related to "the assessment of the significance" and "understanding the place" helped the research group to work together and revise the methodology proposed.

Like any other masterpiece of Modern Architecture, METU Faculty of Architecture Building is unique in its political and social context. From the very beginning, the determination of the larger political context limited the scope of the method applied in this project. Before the conventional phases of the conservation planning, the immediate safety of the building was a priority during the *coup d'etat* which took place in the summer of 2016. Within this desperate context, the research team set their goals as: "conservation by documentation" and "conservation by creating international awareness" in 2017. The stability of the recent political environment following the Summer of 2018 however, motivated the research team to follow also the above mentioned conventional processes of conservation planning. The reality that the building could never be nominated to any international conservations list, on the other hand, remains valid.

The planning and research activities related to the conservation plan of the Faculty of Architecture building comprise three conventional phases that have been simultaneously executed: understanding the place, assessment of significance, developing policies. Understanding the place is fulfilled under four work packages: eliciting cultural and spatial values, identification of the structural assessment procedures, material assessment procedures and environmental performance assessment.

Therefore, rather than challenging the conventional conservation planning methods, a pilot study has been conducted in parallel to the standard conservation planning activities. These activities included the photographic documentation and the verbal description of the interior and exterior spaces, 3D laser scanning, oral history studies with the staff and alumni, and non-destructive structural and material testing procedures. Other activities that are not typically part of conventional methods - and therefore specific to this project - are the development and strategic use of a Heritage Building Information Model (HBIM) of the faculty building, environmental assessment by energy performance and occupant comfort analysis through energy simulation and field measurements, events with stakeholders, national and international exhibitions, symposia and dissemination activities. All the related steps of conservation management plan have been conducted in parallel to the ongoing daily maintenance activities.

During this complex data collection and decision-making procedures, HBIM proved to be a useful tool. As a novel approach, it was adopted to gather, generate and analyze the building data throughout the conservation planning process. With the aid of HBIM, the linear flow of the planning stages has been reinterpreted with inevitable overlaps and transdisciplinary processes.

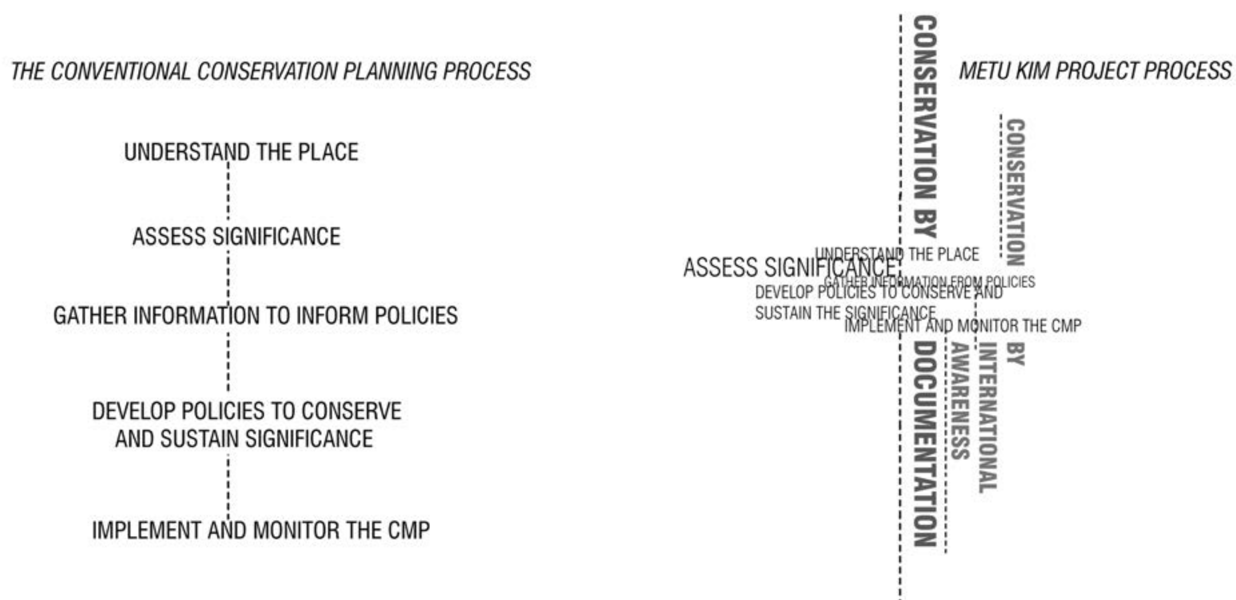
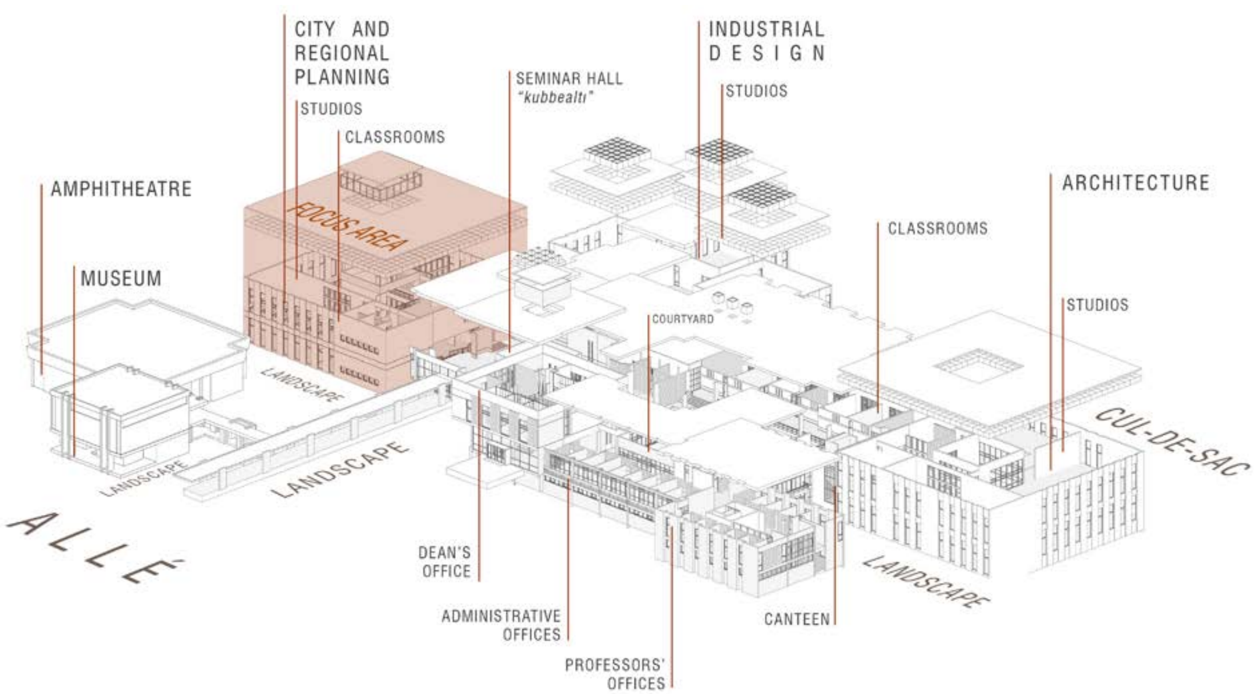


Figure 1: Conventional conservation planning processes *vs*. METU KIM Project process.



CITY AND REGIONAL PLANNING
STUDIOS
CLASSROOMS
SEMINAR HALL "kubbealtı"
INDUSTRIAL DESIGN
STUDIOS
AMPHITHEATRE
FOCUS AREA
MUSEUM
ARCHITECTURE
CLASSROOMS
STUDIOS
COURTYARD
LANDSCAPE
LANDSCAPE
LANDSCAPE
CUL-DE-SAC
ALLÉ
DEAN'S OFFICE
ADMINISTRATIVE OFFICES
PROFESSORS' OFFICES
CANTEEN
LANDSCAPE

2.1 Focus of the Research (the F Block)

The research started with the claim that the conservation planning, preservation activities and all the methodologies developed related to these processes would ultimately be applied to the rest of the METU Campus buildings, which were designed by the same architect couple and constructed during the same time period. As all the buildings in the campus present similar architectural values, structural principles and material choices, the Faculty of Architecture was considered as a model.

In a similar manner, the Faculty of Architecture building complex itself, was composed of separate units. Besides the major three parts - the museum (originally designed as a library), amphitheater, and the main education unit - the division continues to accommodate the different functions in the building complex. Thus each part can be interpreted as a perfect representative of the whole. Knowing the limitations of time and budget within the scope of this project, the team decided to focus on a selected area from the very beginning of the research. The focus area is the F block; and there are material and symbolic reasons in its selection (figure 2).

Moreover, most of the members of the research team are the Faculty of Architecture staff and the research studio of the core group is located in the F block. Thus, *in-situ* analysis became a daily life practice for the research group. Although started with the selection and study of a pilot area, the team applied a six-month period of "visual inspection" inquiry, casing the faculty building as a whole, and analyzed the physical condition of the entire structure. During this period, the "significance hierarchy" was verified and specific locations of the of tests, such as the locations of the foundation inspection dig, crack measurements, sample materials, loading test, thermal heat lost were marked.

Figure 2: METU Faculty of Architecture building, axonometric view, focus area (F Block) highlighted.

Part of a Whole

As stated before, there are specific reasons for the selection of a pilot area to focus on. The most important reason is the goal to make a very thorough analysis in a limited time and budget. Another reason is related with the physical characteristics of the architecture of the building. The METU Faculty of Architecture building complex is composed of quasi-autonomous units connected with very strong circulation and landscape elements. Each function expresses itself with a well-defined cubic unit. The same spatial complexity and formal fragmentation expands to include all the building units of the entire campus (figure 3, See also the conceptual model in the Part 6.1 Exhibitions: TUDelft Exhibition). Therefore, the conservation planning methodology developed for the faculty building can inevitably spread to cover the whole campus also with the aid of landscape elements, urban furniture, and art works.

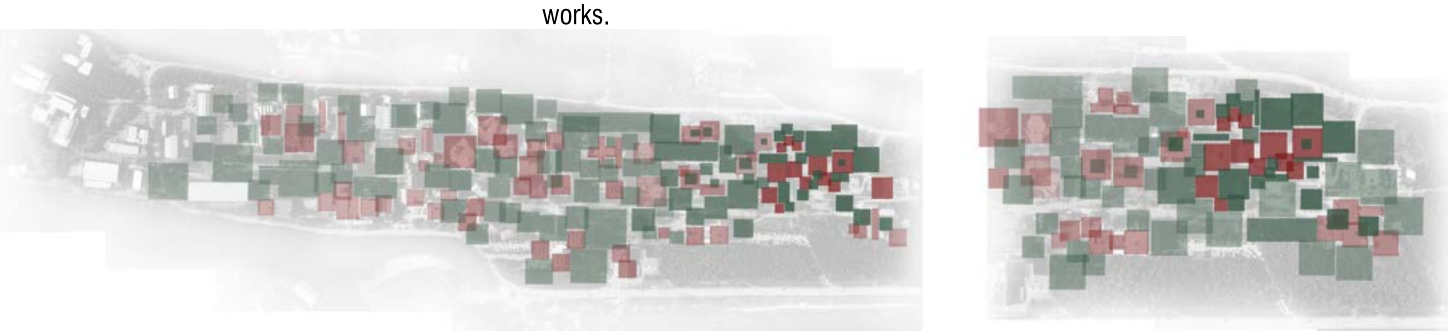
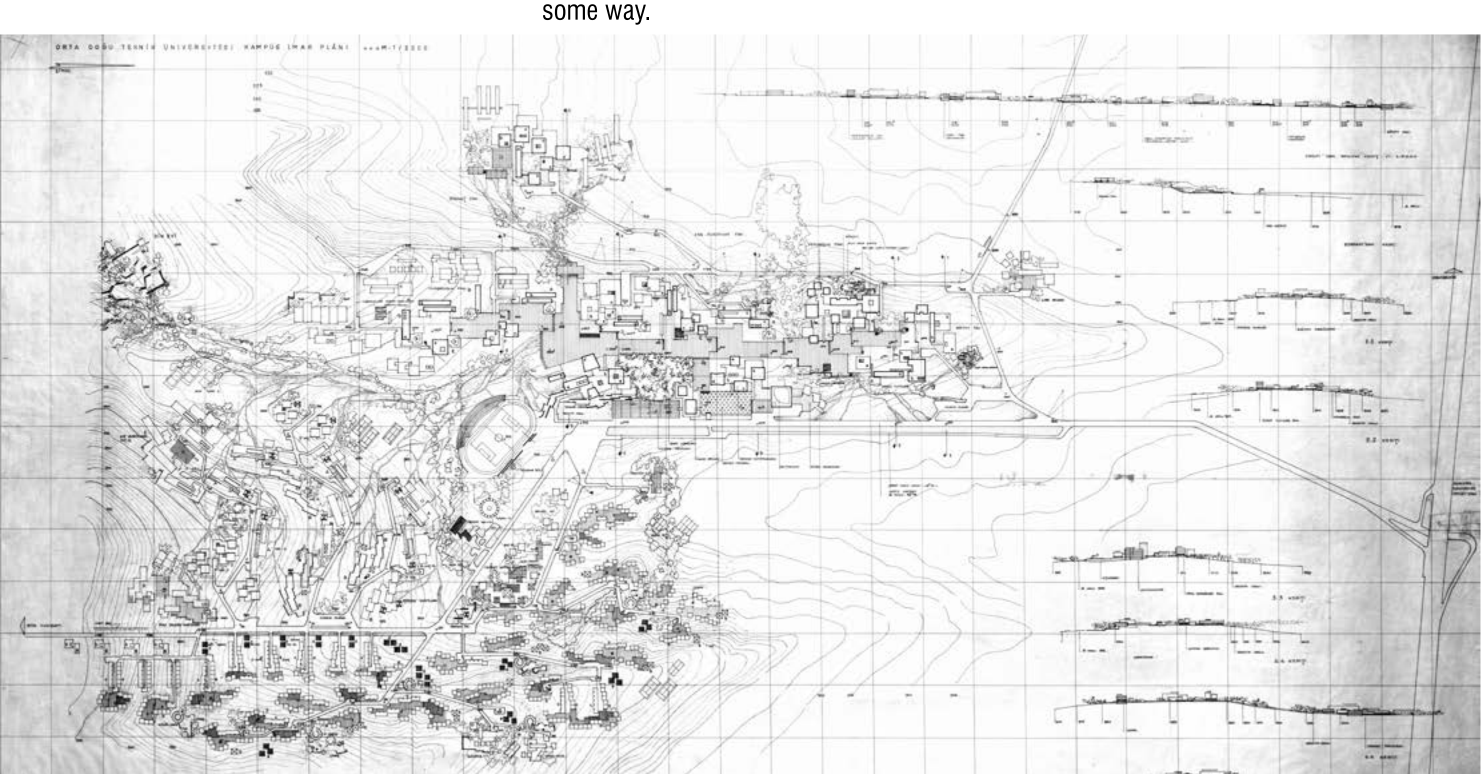


Figure 3: The campus grid, the same patterns reoccurs at every scale.

The campus is laid out on a perfect rectilinear grid-iron plan. This abstract grid divides the land into relatively equal parts, where the landscape and building elements form a homogeneous modular structure. The original campus is formed out of 130 cubic elements grouped into 15 buildings excluding housing units. Particularly today, they form almost a monolithic geometric structure, each part of which has the same formal and physical character as the whole and located on a shared landscape. Same pattern and material qualities recur at progressively smaller scales (figure 4). Each unit is made of parts architecturally similar to the whole in some way.

Figure 4: METU Campus plan grid.



The overall layout makes it very difficult to comprehend the physical borders of the Faculty of Architecture building complex, which is composed of design studios, classrooms, staff offices, workshops, café, print house, archives, computer laboratory, reading room, meeting rooms, exhibition room, multi-purpose area, educational and research labs (photogrammetry, digital, photography, etc.) services, technical room, as well as courtyards, arcades, pools, a museum and an amphitheater. The courtyards, circulation pattern and the specific functions such as the design studios, Dean's office and staff rooms can be identified as separate masses. Expansion joints make this division structurally possible.

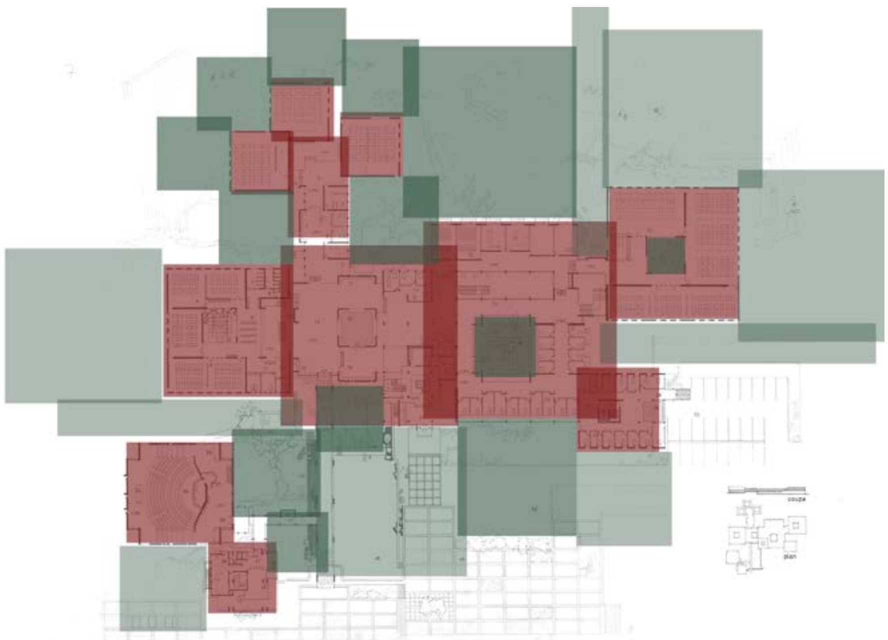


Figure 5: The Faculty of Architecture plan, layout and landscape pattern.

Figure 6: The Faculty of Architecture close-up of plan layout.

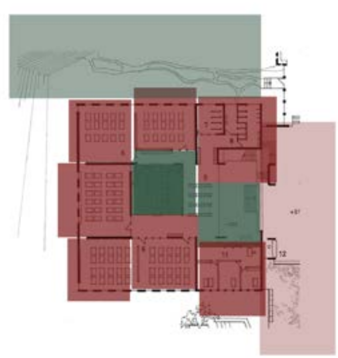


Figure 7: F Block plan layout, in Published Drawings.

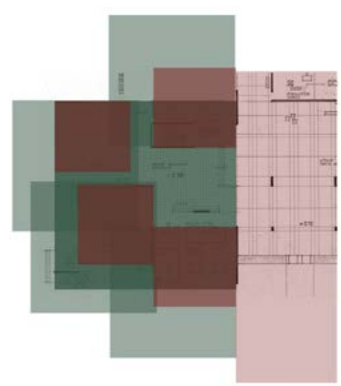


Figure 8: F Block plan layout, in Competition Drawings.

The selected area, the F block, is the most appropriate subset of the whole building since it has architecturally, structurally and spatially important aspects, which can be studied in accordance with the rest of the building. First of all, this part can be considered as representative of the whole building. The manageable scale of the sample space allows detailed surveying, analysis and testing activities. The area can be studied separately as it is clearly divided by architectural massing, space organization and expansion joints. It includes sample representative functions of the building namely; design studios, classrooms, staff offices, service spaces.

The selected part also includes typical architectural features, structural systems, and material qualities that characterize the whole building such as the flat roof, waffle system, skylights, stairs, exposed concrete façades, concrete block in-fills, large glass surfaces, level differences, balustrades, light features, surface treatments, separation walls, load bearing and infill elements, different slab types, structural and spanning systems.

Moreover, the F block possesses several typical structural problems such as shear cracks, bending cracks, settlement, water drainage problems, which will be addressed as part of the conservation planning report. The exterior façades of the selected area are facing three different directions (South, East and West), which allow the observation and analysis of thermal performance of rooms and spaces of different orientations. Besides all these, the focus area is aesthetically and spatially one of the most appealing parts of the faculty building. It includes built-in furniture, artworks and symbolic platforms. Thus, the pilot area, which is also separated with an expansion joint, is selected as a representative subset of the whole building. While focusing on this selected block, the research on the historical, architectural, structural, material and environmental aspects have been expanded to include the whole building whenever it is found necessary.

The Architecture of the F Block:

The pilot area has been subject to a series of physical and functional changes over time. As there are no official records of these changes, the best medium to follow the traces of the major alterations in the architects' design ideas through the four sets of architectural drawings prepared for different purposes during the execution of the project. Subsequently, these drawings can be listed as the "Competition Drawings" (1961), "Conceptual Drawings" (1961-62), "Application Drawings" (1962), and the "Publication Drawings" (1964-69). In addition to these four sets, "Survey Drawings" (2018) are prepared during this project in order to be able to show the alterations after the construction until today.

The original competition entry drawings, dated 1961, indicates that the architects designed the F Block as a two-storey, self-sufficient unit, which would accommodate the city planning and "*arazi mimarlığı* (land architecture)" programs (figure 9).

The functional list in the Competition Drawings of Çinici Architects includes two workshops (100 m2 and 120 m2), administrative offices, and services. The architects repeat the same plan arrangement and functional layout in the upper floor. Here the only change can be observed in the workshops, which are transformed into classrooms (figure 10).

As it also applies to the rest of the building, the circulation spaces cover over 50% of the total surface area in the F block. The Published Drawings which are considered to be an as-built drawing set[1] represent a similar ratio, where the circulation area becomes more central and the studio and the classroom units become relatively smaller to include five studios connected with an internal circulation layout. The dimensions of the service spaces increase and the offices remain in the north-east corner to form a more compact sub-unit. The upper floor reflects the lower floor plan that is punched with two galleries. Here, the east and west studios remain as undivided single spaces (figure 11).

[1] For details please see section "3.1. 1.2.3.4.Published Drawings"

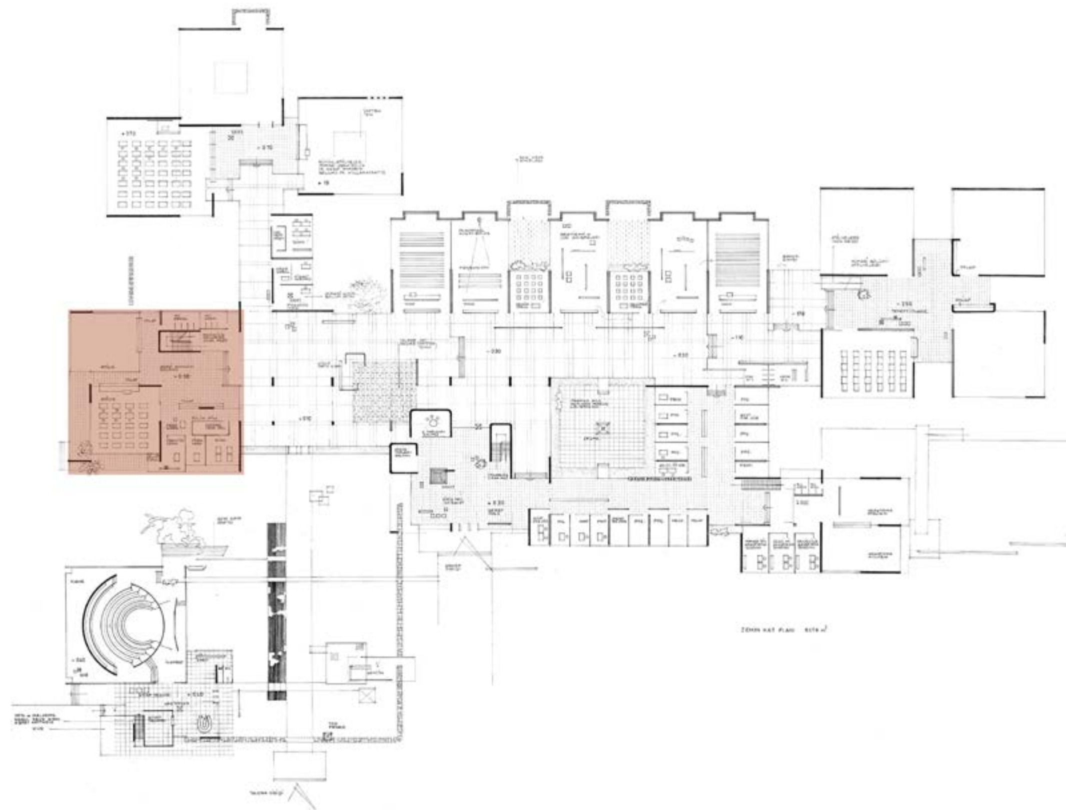


Figure 9: Altuğ, Behruz Çinici, Competition Entry, Ground Floor Plan, 1961.

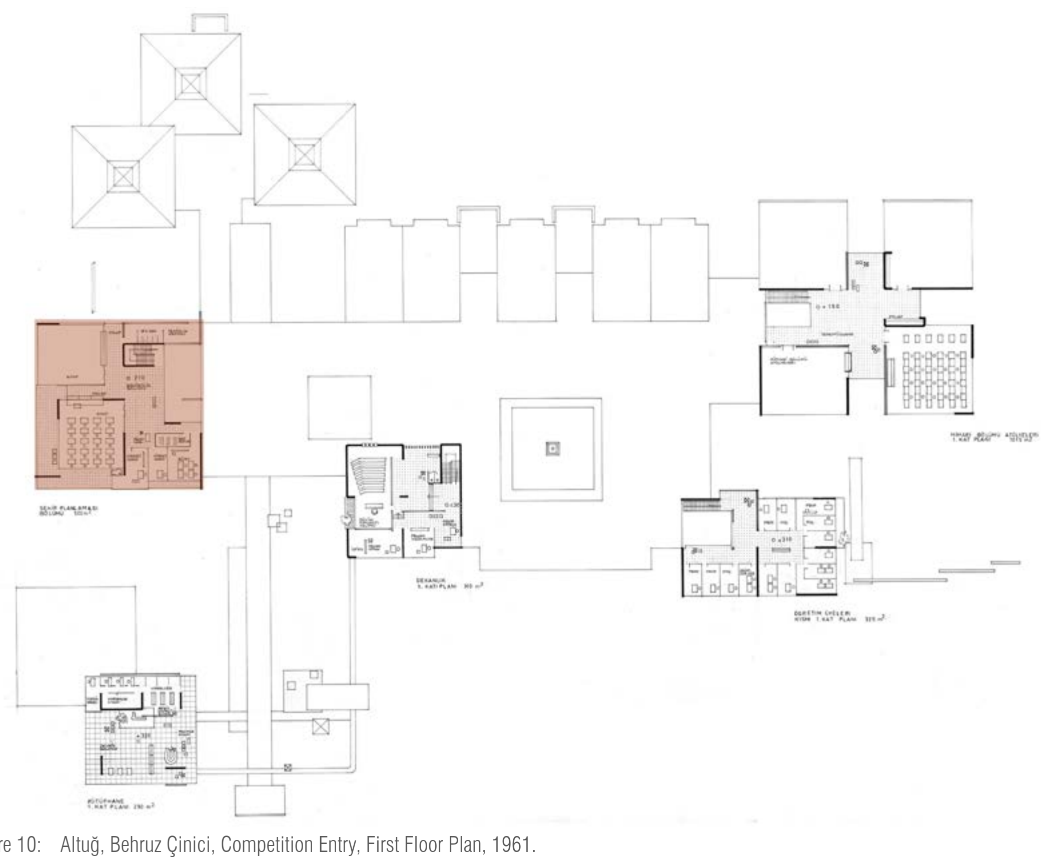


Figure 10: Altuğ, Behruz Çinici, Competition Entry, First Floor Plan, 1961.

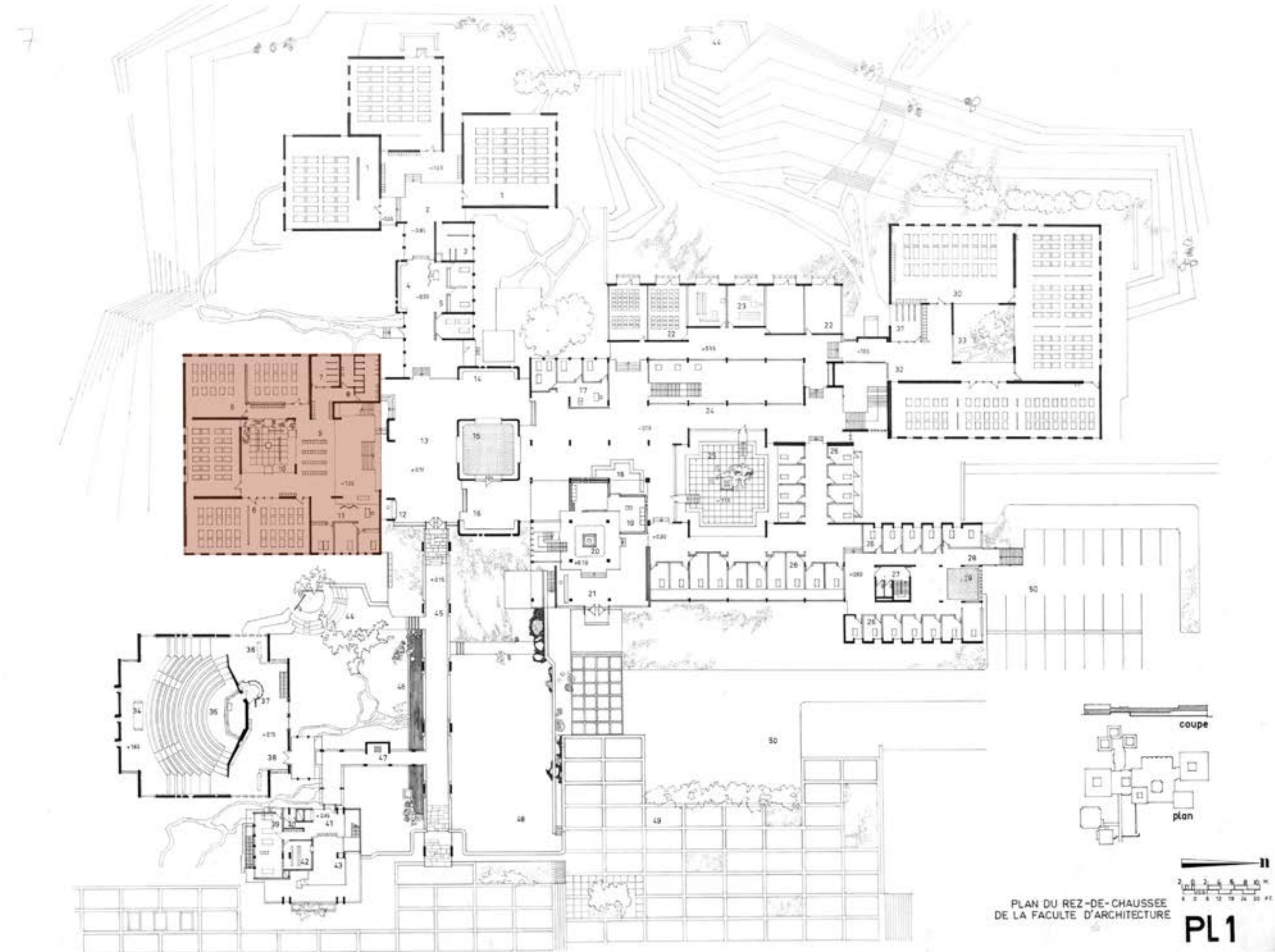


Figure 11: Altuğ, Behruz Çinici, Publication Drawings, 1969

The major architectural element that changes the whole character of this area is the skylight, which does not exist in the original Competition Drawings and is added later to the application project. The skylight is a square with 8x8m dimensions and 1.5m height and suggested to be covered by copper plates from the outside and inside.

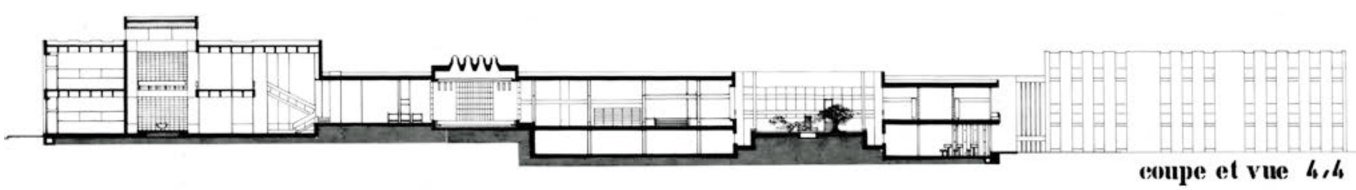


Figure 12: Altuğ, Behruz Çinici, Publication Drawings, Section, 1962

Underneath, the skylight defines a platform, which is 40cm raised from a sunken square area covered by gravel stone. There are three onyx cladded, 110x110cm concrete steps, bridging over and connecting the platform to the ground level. The raised platform is originally thought to be cladded by a 12x12 onyx checkerboard pattern composed of 144 onyx marbles. Around the raised platform, the outer square surface is thought to be finished by a gravel and mosaic surface / wash-concrete (figure 14).

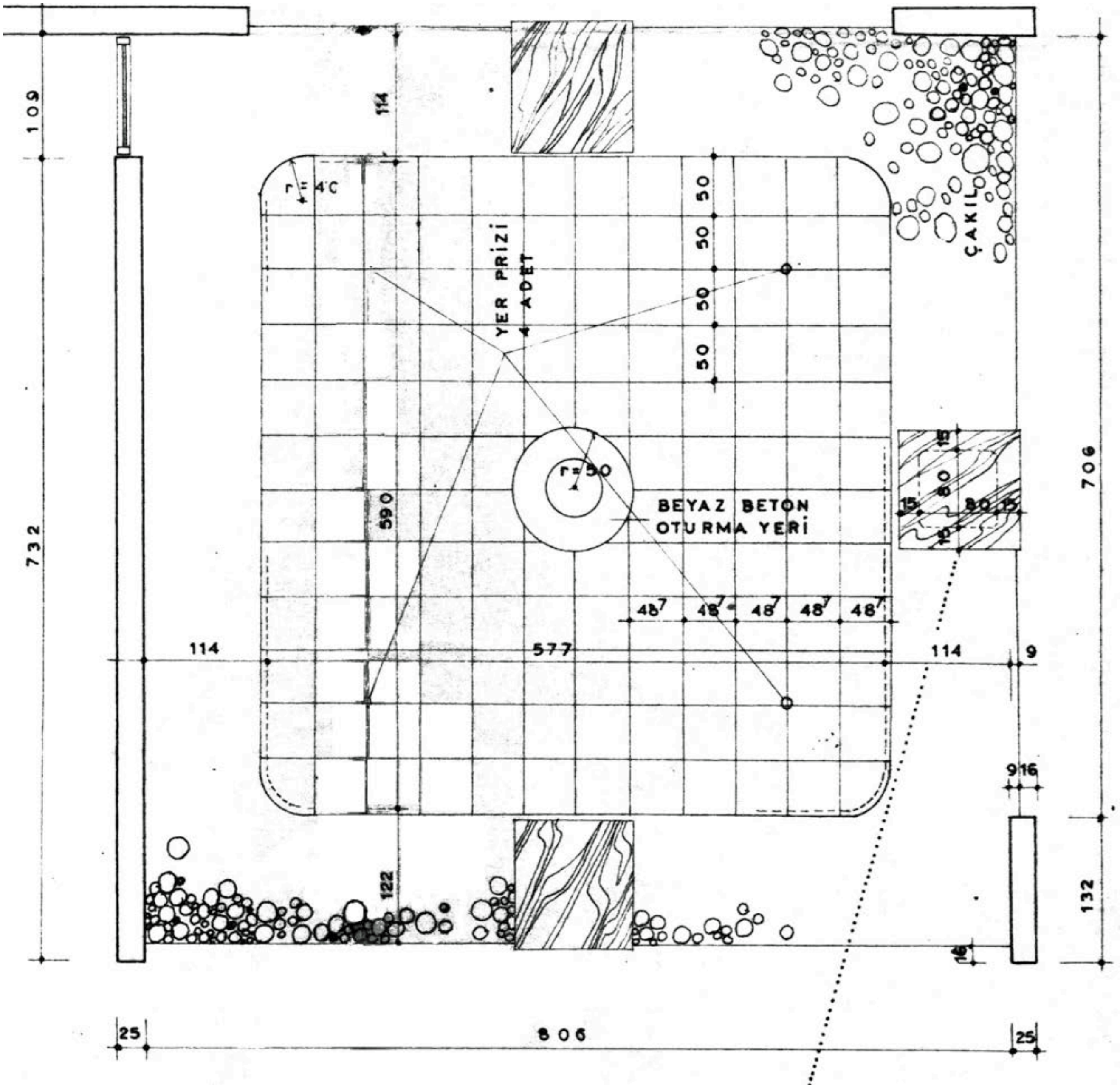


Figure 13: Altuğ, Behruz Çinici, Plan, Architectural Decoration Drawings, 1962

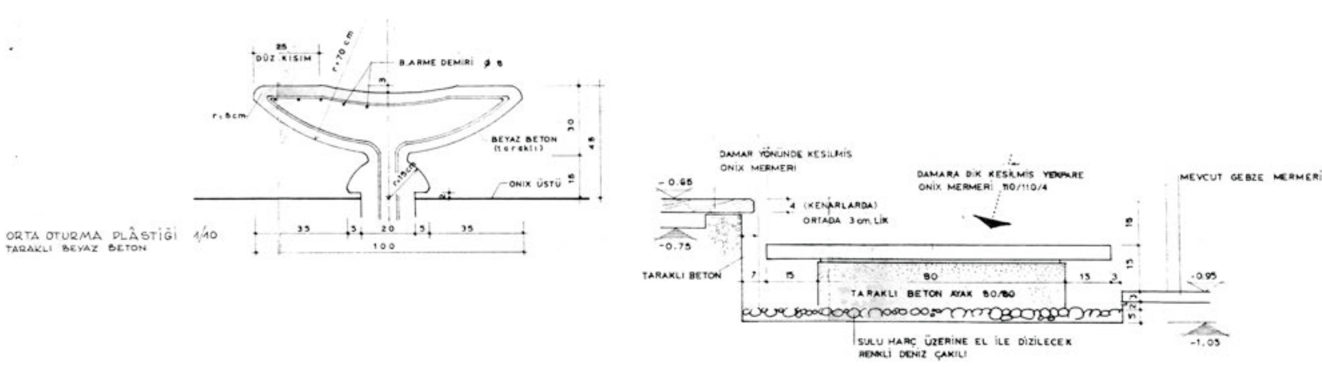


Figure 14: Altuğ, Behruz Çinici, Sections, Architectural Decoration Drawings, 1962

Figure 15: *Göbektaşı* platform close-up, material details.

[2] The art object, *Göbektaşı* was originally designed as a seating unit. The sign placed on it by the students reads as “please do not sit” to protect this fragile architectural element.

Indicated with the number “10”, this space was originally designed as an enclosure. It was defined by structural elements and demountable lockers for the students and represented as almost a courtyard. This claim is also supported by the fact that in detail drawings, it is depicted in the same drawing board next to the other two courtyard drawings in the building.

In the Application Drawings, at the center of the platform, there is an object illustrated to be made out of reinforced concrete. In its detail drawings, architects named it as “the central seating plastic”. They used the term “plastic” to refer to its aesthetic and material aspects. In the actual application, the raised platform is cladded by travertine with a unique pattern and the central object (R 50) is located on an 80x80cm gravel stone square surface.

Although this object had an assigned function, it had been conceived as an art work and later became one of the most valued symbolic objects in the faculty. It also gained a nickname over the years: “*Göbektaşı*” (figure 15).[2]

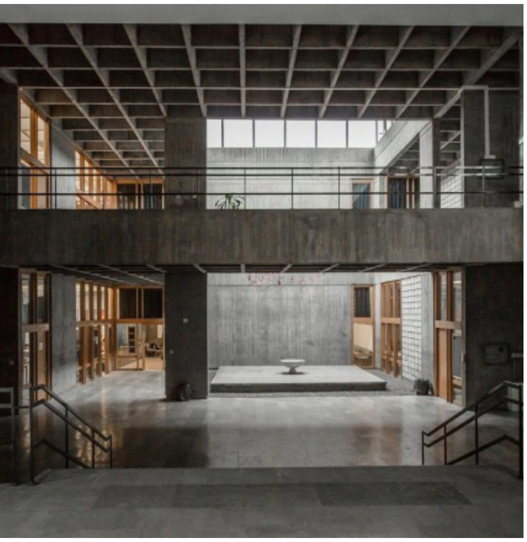
Today, the whole space surrounding it is called “*Göbektaşı*”, meaning the tummy stone in Turkish, which is also the name given to the heated marble slab located in the traditional Turkish baths. The term “*göbek*” is also in use to refer to the central arrangements in vernacular architecture. The circular form of the object supports this analogy. The *Göbektaşı* area in the F block is also very unique with its light quality, which has never been indicated in the drawings.

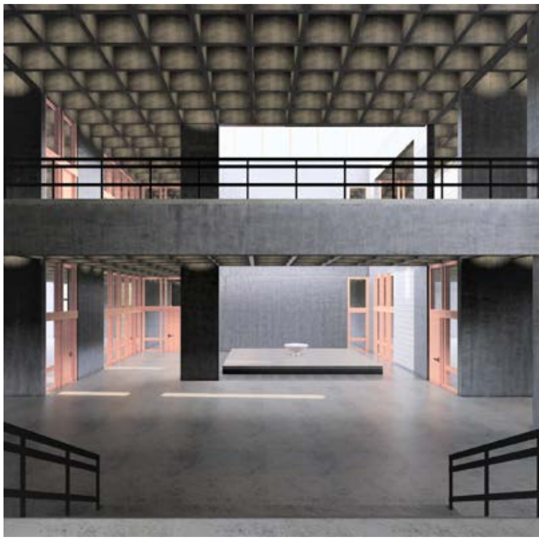
Designed to be an “exhibition space” and a “meeting point” in the Application Drawings, this area has become one of the sacred spaces for the users of the campus. Besides exhibitions and juries, it accommodates events such as dance performances, concerts, award ceremonies and yoga sessions. As stated before, the two-storey high volume under this skylight became one of the most symbolic spaces of the Faculty building over the years.

Today, in general, the physical and functional aspects of the pilot area remain almost unchanged. All the changes made are provisional and reversible. It is possible to plan its conservation without harming the original ideas of the architects. The information covering the restitution phase has been represented in a hierarchy compatible with the hierarchy of significance in the following sections of this report.

Figure 16: Social events and extra-curricular activities in the focus area.

Figure 17: Architects, Altuğ and Behruz Çinici at Göbektaşı during the openning of a Arch524 exhibition - entitled as "Representing Itself" particularly focusing on the details of the building.





2.2 Medium of Research - HBIM

As stated before, the interdisciplinary research group of the conservation planning team includes historians, architects, engineers, social scientist, conservation specialists, IT experts, chemists, archivists, administrative staff and the graduate students. The collection and management of the comprehensive and incremental information gathered during the research process required an effective medium that would provide an environment for the storage and retrieval of the collected data. Besides archival information, such as photographs, drawings, models and written documents, information related to the structure, mechanical system, electrical and electronic infrastructure of the building, material and environment performance analyses have been collected in different media.

The information-intense nature of this research requires an efficient information sharing system. Simple representational media for the storage of data, such as tables, databases, 3D architectural models and personal computer filing systems remain insufficient for the level of complexity of heritage buildings and conservation planning practices. Therefore, a comprehensive 3D environment is essential for an interactive and comparative data visualization that has the capacity to provide relevant knowledge in the most efficient manner possible.

BIM for heritage buildings: a general perspective

Heritage building conservation planning is an information-intense process that involves the gathering, representation, visualization and sharing of vast amounts of data about a building. According to the Recording, Documentation, & Information Management (RecorDIM) guiding principles of the Getty Conservation Institute, heritage documentation includes

[1] Robin Letellier. *Recording, Documentation and Information Management for the Conservation of Heritage Places. Guiding Principles.* (Los Angeles, CA: Getty Conservation Institute, 2007).

[2] Yusuf Arayici, John Counsell, Lamine Mahdjoubi, Gehan Ahmed Nagy, Khaled Dweidar, and Soheir Hawas, eds. *Heritage Building Information Modelling.* (Taylor & Francis, 2017).

[3] Tim Taylor, John Counsell. "What are the goals of HBIM?" In *Heritage Building Information Modelling* (London: Routledge,2017),15-31.

[4] Tristan Randall. "Construction Engineering Requirements for Integrating Laser Scanning Technology and Building Information Modeling." *Journal of Construction Engineering and Management* vol.137, no. 10 (2011), 797-805.

metric, quantitative, and qualitative information about the building assets, their values and significance, their management, their condition, their maintenance and repairs, and the threats and risks to their safekeeping.[1] The precise and effective means for the management and accessibility of this data can be possible by means of digitization using diverse Information and communication technologies (ICT). While computer aided architectural design (CAAD) tools are widely used for geometric modeling, they cannot extensively support the information-rich workflows of heritage planning processes. Building Information Modeling (BIM) stands as a recent technology that can effectively support conservation planning as well as other Architecture, Engineering and Construction and Facilities Management (AEC/FM) activities. The main premise of BIM is one single model that is encoded in a standard, interoperable file format that maintains the whole building data. This data can be related to a wide range of sources including 3D object geometry, building components, object properties, activities throughout the time dimension, building actors etc. The value of BIM is realized as it provides direct access to building information and it allows the near-seamless integration of innovative technologies.

Following the increased need for information management for heritage buildings, the scope of BIM has been expanded to support heritage information, namely Heritage Building Information Modeling (HBIM). HBIM aims to leverage the existing capabilities of BIM and further harness it by the domain-specific heritage information gathered through a diverse set of sources such as existing building documentation, on-site surveys, performance assessment etc. The object-oriented structure of BIM allows a diverse set of heritage building objects with properties that both exist as part of the model and that can be added as needed. In contrast with BIM, HBIM additionally aims to capture the as-is condition of heritage buildings while making room for imprecision and incompleteness due to missing information or degradation. The data types include, but are not limited to geometry, data tables, audio, still or moving images, web pages, and other types embedded in various software tools.

It is generally argued that HBIM primarily aims to realize the value and significance of cultural heritage assets and to support long-term conservation activities for all stakeholders.[2] A wide range of technologies (including information capturing and structuring, performance analysis, visualization) need to converge on HBIM. Central to such technologies is the capture of building geometry, which is primarily handled with 3D data acquisition methods such as photogrammetry and 3D laser scanning. The latter is being increasingly used to document heritage buildings due to its increased accuracy, dataset quality and data visualization capabilities, albeit with significantly higher costs. The resulting 3D model is significant especially for the archival of buildings under the threat of being demolished, for the remote/ virtual access of heritage buildings that are otherwise inaccessible, and for buildings that require the application of visual analytical methods on buildings in three dimensions.[3] Despite the advantages of laser scanning in as-building modeling, the conversion of 3D point clouds into BIM, known as Scan-to-BIM, is still a labor-intensive and error-prone process.[4] Scan-to-BIM workflows involve the "fitting" of parametric BIM objects (i.e. windows, columns) onto the point cloud, which requires design drawings and site surveys.[5] Depending on the reliability of these information BIM creation from point clouds is still a challenging, semi-manual process. The development of automated methods and tools is still an active research area, which needs to resolve many problems regarding object identification, labeling, clutter and occlusion.[6]

Semantic data is a critical complement to geometric data in HBIM. It accounts for the non-geometric information about the building, its site, components and processes, is gathered through surveying or existing building documentation. This includes not only technical data but also information regarding the significance values (i.e. the cultural, social and historical significance) of a heritage building. Despite the increase in the amount and various types of data in HBIM, the uniqueness of each heritage building and its architectural and heritage values challenge the standardization of the model. Therefore, there is a tradeoff between the level of detail and generality of models that support heritage building planning.

[5] Burcin Becerik-Gerber, Hamid Hajian. "Scan to BIM: Factors Affecting Operational and Computational Errors and Productivity Loss." In *Proceedings of the 27th International Symposium on Automation and Robotics in Construction (ISARC)* (2010), 265-272.

[6] Xuehan Xiong, Antonio Adan, Burcu Akinci, and Daniel Huber. "Automatic Creation of Semantically Rich 3D Building Models from Laser Scanner Data." *Automation in Construction,* vol.31, (2013), 325-337.

[7] Pieter Pauwels, Ruben Verstraeten, Ronald De Meyer, and Jan Van Campenhout. "Architectural Information Modelling in Construction History." In *3rd International Congress on Construction History*, vol. 3, (Brandenburg University of Technology Institut für Bau-und Kunstgeschichte, 2009), 1139-1146.

[8] Khee Po Lam, Nyuk Hien Wong, Ardeshir Mahdavi, K. K. Chan, Zhijian Kang, and Shashank Gupta. "SEMPER-II: an Internet-Based Multi-Domain Building Performance Simulation Environment for Early Design Support," *Automation in Construction vol* 13, no. 5 (2004), 651-663.

[9] Rebekka Volk, Julian Stengel, Frank Schultmann. Building Information Models (BIM) for Existing Buildings – Literature Review and Future Needs in " *Automation in Construction.* vol. 38. (2014),109-127.

Other advantages of BIM are the auxiliary functionalities such as energy performance analysis or environmental performance analysis. Tools that operationalize simulation-based analyses can be made accessible through semantics-based interoperability standards (i.e. the Industry Foundation Classes, gbXML) that allow access to a BIM model through (semi)automated methods and procedures.[7] As such, concurrent performance evaluation in distributed environments through both synchronous and asynchronous communication modes can be facilitated.[8] Other potential benefits of BIM for existing building include planned or *ad-hoc* maintenance planning, assessment and monitoring, energy and space management, emergency management and retrofit planning.[9]

Barriers against the use of HBIM in heritage building planning

Currently, comprehensive, well-documented prototypes of HBIM are still scarce. Agreement on a shared, standard schema for heritage buildings is challenging, due to the fragmentation of the heritage-related information sources and the technical and cultural difficulties in integrating considerable volumes of interdisciplinary information into one single BIM schema using a wide range of different technologies.[10] For existing buildings specifically, missing, outdated or incorrect building information that results from the lack of continuous as-is building documentation is common.[11]

The need for customization

In new or unconventional application areas, wherein no a priori agreement on the domain exist, there are other difficulties including the volatility of the domain knowledge that continuously changes and expands, the unpredictability of transactions between process actors, and the incompleteness of models, especially in new or unconventional application areas wherein no a priori agreement on the domain exist.[12] Heritage buildings constitute such a new domain of expertise that has no consensus or shared standards on the domain ontology. Therefore, there is a need to seamlessly manage the fluid conventions of different disciplines, cultures and periods in the development of building information models.[13] As such, the a priori and top-down BIM approaches, which “offer a complete and uniform description of the project data, mainly independent of any project specifics”[14] run the risk of failing to capture the complexity and specificity of heritage building information. In contrast, this research supports that the diversity of heritage buildings needs to be maintained, rather than absorbed in standard domain models. Therefore, there is a need to integrate bottom-up a posteriori approaches that allow evolving custom representations while adhering to universal, top-down representational standards. As such, standardized building representations can be augmented with a local, strategic, and pragmatist character.[15]

Level of Detail (LOD) and Level of Information (LOI)

BIM LOD is an important concept that determines which BIM object will be defined in what detail. According to the American Instiitute of Architects (AIA), the LOD defines “the minimum dimensional, spatial, quantitative, qualitative, and other data included in a Model Element”.[16] BIM LOI (Level of Information) is the amount of information content of a BIM object, including various types of semantic information such as materials, dimensions, cost etc. Heritage building information model LOI is a critical concept for heritage building conservation planning processes, as large amounts of information gathered, processed, documented and/or discarded during the process by various disciplines. This information is typically fragmented, interdisciplinary and distributed across actors, software tools and planning contexts. HBIM, when used for conservation planning activities, needs to be specified in a high LOI to be able to capture the variety of information types.

[10] Khee Po Lam, Nyuk Hien Wong, Ardeshir Mahdavi, K. K. Chan, Zhijian Kang, and Shashank Gupta. “SEMPER-II: an Internet-Based Multi-Domain Building Performance Simulation Environment for Early Design Support.” *Automation in Construction vol* 13, no. 5 (2004), 651-663.

[11]Rebekka Volk, Julian Stengel, Frank Schultmann. “Building Information Models (BIM) for Existing Buildings – Literature Review and Future Needs,” in *Automation in Construction.* vol. 38. (2014),109-127.

[12] Matej Fischinger, Tomo Cerovsek, and Ziga Turk. “EASY: A Hypermedia Learning tool,” *Electronic Journal of Information Technology in Construction 3* (1998), 1-12.
[13]Khee Po Lam, Nyuk Hien Wong, Ardeshir Mahdavi, K. K. Chan, Zhijian Kang, and Shashank Gupta. “SEMPER-II: an Internet-Based Multi-Domain Building Performance Simulation Environment for Early Design Support,” *Automation in Construction vol* 13, no. 5 (2004), 651-663.

[14] Rudi Stouffs. “Constructing Design Representations Using a Sortal Approach.” *Advanced Engineering Informatics* vol. 22, no. 1 (2008), 71-89.

[15] Khee Po Lam, Nyuk Hien Wong, Ardeshir Mahdavi, K. K. Chan, Zhijian Kang, and Shashank Gupta. “SEMPER-II: an Internet-Based Multi-Domain Building Performance Simulation Environment for Early Design Support,” *Automation in Construction vol* 13, no. 5 (2004), 651-663.

[16] American Institute of Architects, “Building Information Modelling and Digital Data Exhibit” in *Guide, Instructions, Commentary to the 2013 AIA Digital Practice Documents*, (2013), 11.

With respect to the abovementioned needs for information documentation, a Heritage Building Information Model was developed. The HBIM development process was carried out in parallel with the other planning activities, including the elicitation of cultural and spatial values, structural assessment, and material assessment and environmental performance assessment. The data that was generated during these diverse set of activities were first identified, categorized and integrated into the model by the development team. The purpose of the model is for (a) documentation of the building, including the three-dimensional geometry, architectural significance, and the results of the assessment activities (b) data sharing between the work packages during the project, and (c) data interoperability with the 3rd party analysis tools, such as structural analysis tools (WP2) and energy performance simulation tools (WP3). The HBIM also has the potential to be used as a long-term digital medium that supports future activities regarding operations and maintenance, major renovation or analysis.

The HBIM for the Faculty building was developed using Autodesk Revit Architecture 2018, a 3D building modeling software tool used for building information modeling in Architectural, Engineering and Construction/ Facility Management practices. Autodesk Revit® was preferred due to its widespread adoption in architecture and object-oriented structure. Revit Architecture consists of three-dimensional parametric objects to define architectural elements, and create building models and documents with these elements. Revit maintains the parametric attributes of each element defined in the model, both geometrical and non-geometrical. Moreover, all building elements that take place in the model are created using families. Autodesk Revit 2018 defines a family as “a group of elements with a common set of properties, called parameters, and a related graphical representation”. A comprehensive set of families are maintained by Autodesk for different elements such as walls, roofs, and floors. These predefined families are independent of the building model, and are loaded into the model as needed. Families belong to a predefined classification system, in which they are grouped and sorted in content libraries. A family element, for instance a wall type, may have different variations that are represented by the family types. The type properties maintain the specific information for all instances of the family type in the building model. Therefore, any change applied on the type properties has an effect on all instances of the type. A robust, consistent but customizable building model can be developed and shared across project participants.

During HBIM development, a number of families were customized for the building. The standardization in architectural elements and the resulting identical repetition of these elements further justified the use of standard families custom-made for the Faculty building. An example of this standardized use of types is the windows. During HBIM development, certain window types are identified, parametrically modeled and instantiated in the building models in a repeating manner. In the table below, five different window families that are modeled for the Faculty building can be found. Yet, there are several objects –either artwork or furniture- that are unique in the building such as the *Göbektaşı* or the chandelier at the Dean’s Office. Although these elements were fully modeled as families, they were used only once.

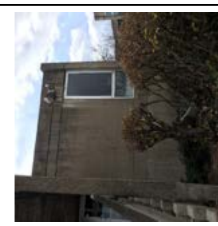
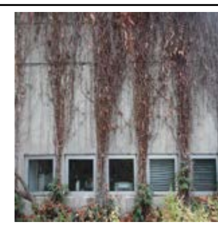
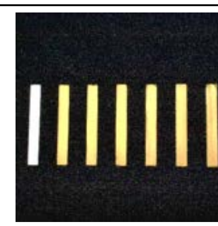
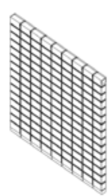
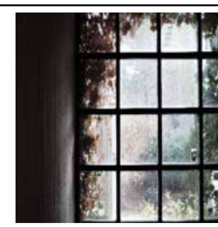
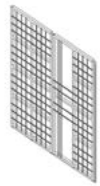
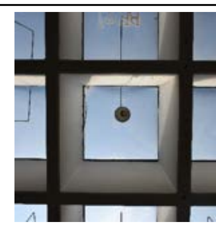
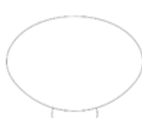
Category	Family	Type	Image	Properties	Description	Photo
Window	getty_studios_ window	getty_gobektasi window		Level: -0.95 Sill Height: 0.00 Opening Aperture: Bottom Frame Material:getty_aluminum Glass Material: getty_glass Height: 390 cm Width: 112 cm Split Line Height: 270 cm Frame Thickness: 5 cm Glass thickness: 1.36 cm Function: Exterior Arch. Significance: Moderate	Vertical window with single opening, bottom-hung (design studios)	
Window	getty_studios_ window	getty_north facade		Level: +1.04 Sill Height: 0.00 Opening Aperture: Side Frame Material:getty_aluminum Glass Material: getty_glass Height: 306 cm Width: 100 cm Split Line Height: 90 cm Frame Thickness: 5 cm Glass thickness: 1.36 cm Function: Exterior Arch. Significance: Moderate	Vertical window with single opening, side-hung (north facing offices)	
Window	getty_square window	getty_gobektasi office		Level: -0.95 Sill Height: 80.00 Opening Aperture: Bottom Frame Material:getty_aluminum Glass Material: getty_glass Height: 95 cm Width: 95 cm Frame Thickness: 5 cm Glass thickness: 1.36 cm Function: Exterior Arch. Significance: Moderate	Square shaped window, operable opening, bottom-hung (offices)	
Window	getty_triple window	getty_dean		Level: +4.71 Sill Height: 0.00 Opening Aperture: Bottom Frame Material:getty_aluminum Glass Material: getty_glass Height: 350 cm Width: 190 cm 1st Split Line Height: 210 cm 2nd Split Line Height: 260 cm Frame Thickness: 8 cm Glass thickness: 1.36 cm Function: Exterior Arch. Significance: Moderate	Triple window with single opening, bottom-hung (Dean's Office)	

Figure 1: Table of selected Revit families

Window	getty_sloped window with 4division	getty_4 division		Level: +0.25 Sill Height: 10.00 Opening Aperture: None Frame Material:getty_iron Glass Material: getty_glassstained Height: 347 cm Width: 39 cm Division Line: 31.50 cm Frame Thickness: 4 cm Glass thickness: 1.36 cm Function: Exterior Arch. Significance: High	Non-operable slim window, with stained glass, four black iron dividers and exterior angled opening cut	
Window	getty_clere-story	getty_clerestory gobektasi		Level: +5.00 Sill Height: 68.40 Opening Aperture: None Frame Material:getty_iron Glass Material: getty_glassyellow Height: 200 cm Width: 40 cm Frame Thickness: 4 cm Glass thickness: 1.36 cm Function: Exterior Arch. Significance: High	Non-operable slim clerestory window with colored glass, black iron frame and exterior an-gled opening cut	

Wall	System Family: Curtain Wall	getty_concrete block 20 cm		Base Constraint: -3.45 Top Constraint: Unconnected Unconnected Height: 335 cm Structural: No Vertical Grid: 8 Horizontal Grid: 14 Length: 379 cm Area: 12.697 m2 Function: Interior Vertical Spacing: 43 cm Horizontal Spacing: 22 cm Arch. Significance: Moderate	Partition wall con-sists of concrete cement blocks and concrete toe kick	
Wall	System Family: Curtain Wall	getty_metu id square		Base Constraint: -0.75 Top Constraint: Unconnected Unconnected Height: 267.00 Structural: No Vertical Grid: 4 Horizontal Grid: 6 Length: 228 cm Area: 6.089 m2 Function: Exterior Vertical Spacing: 45.25 cm Horizontal Spacing: 37.80 cm Arch. Significance: Moderate	Equally divided rectangular curtain wall with black iron mullions	

Wall	System Family: Curtain Wall	getty_kubbealti		Base Constraint: +0.25 Top Constraint: Unconnected Unconnected Height: 370.00 Structural: No Vertical Grid: 14 Horizontal Grid: 17 Length: 400 cm Area: 15.190 m2 Function: Interior Vertical Spacing: 20.50 cm Horizontal Spacing: 20.50 cm Arch. Significance: High	Square wooden partition wall with equally distributed vertical and horizontal wooden rods	

Ceiling	Skylight	getty_kubbealti skylight		Level: +5.35 Elevation: 0.00 Host: Floor: getty_roof-48cm Material: getty_concrete Arch. Significance: Exceptional	Waffle Slab with modular structural elements that also act as skylights, located in "Kubbealtı"	
Structural Framing	Skylight	getty_waffle skylight		Level: +10.95 Offset: 22.00 Volume: 0.65 m3 Rebar Cover: Yes Default Elevation: 121.00 Host: Floor: getty_roof-11cm Material: getty_whitepaint Glazing Material: getty_glass Arch. Significance: Moderate	Waffle Slab with modular structural elements that also act as skylights, located in ID studios	
Door	getty_dean exterior door	getty_dean exteriordoor		Width: 372.50 Height: 232.00 Glazing Material: getty_glass Frame Material: getty_aluminum Function: Exterior Hori. Divider Height: 95 cm Side Opening Width: 70 cm Hardware Height: 130 cm Door Pane Width: 95 cm Arch. Significance: Moderate	Entrance door for Dean's Office, glass, aluminum framed door with two wings	
Furniture	Gobektasi	getty_Gobektasi		Level: -0.65 Elevation: 0.00 Host: Floor: getty_floor60 Material: getty_gobektasi Arch. Significance Exceptional	Concrete, circular table alike sculpture that is one of the symbols of the faculty building	

a. The existing drawings: a number of existing drawings of the Faculty building that were drawn at different times were identified. The most reliable sources were developed by the Photogrammetry Lab of the Faculty, by METU official Architect Barış Yağlı who created a revised version of the same drawings, and the Program of Conservation of Cultural Heritage of METU. Due to the different methods of surveying, the level of precision of these drawings was not sufficient to be able to draw a detailed and accurate model. Nevertheless, these drawings acted as the primary resources as a three-dimensional model before the Faculty building's HBIM model was fully developed.

b. Low-precision 3D laser scanning: The faculty building was documented using a hand-held 3D laser scanner, called ZEB-REVO. ZEB-REVO scanner is advantageous to steady cameras due to its ease of use, flexibility and speed of scan. The scanner has -/+ 0.1% accuracy with an indoor range of 30m and it has a 43.200 points/sec data acquisition range with 905 nanometers –nm laser wavelength. That makes the laser invisible to human eye with a Class 1 Eye Safety precaution. The scanner has 100Hz of line speed that gives a very good homogeneous data collection while in operation. The scanning process was complete in four sessions, as detailed in Figure 4. During scanning, a number of reference objects called as "Ground Control Points" were placed as reference points to merge the scan data of the four different sessions. The result of the laser scanning process is a point cloud with x, y, and z coordinates of all the physical objects in the physical environment. This includes all the architectural elements, but also the furniture, people and other objects. The four separate point cloud sessions are co-registered to each other by using the Cloud Compare (CC) software (Figure 4). CC detects the reference points automatically and aligns each point cloud according to the reference point cloud data. The resulting point cloud consisted of approximately 140.000.000 points.

c. High-precision 3D laser scanning: A second phase of laser scanning was carried out specifically for the selected foucs area of the Faculty building, the Museum and the amphitheater. A stationary, high-precision laser scanning device, Faro Focus Laser Scanner 120, was used. Faro is a high-speed scanning device used for detailed measurement of detailed and complex environments and geometries. Faro covers a 360° x 300° field of view. The following scan settings for scan quality and speed were selected. Scanning was carried out both internally and externally resulting in a dense point cloud. The 3D point cloud models were generated as a result of a total number of 150 sessions in 6 days (30 sessions and 2 days for the Museum; 40 sessions and 1,5 days for the amphitheater; 75 sessions and 2 days for the selected focus area of the education building). The resulting partial scans were registered using the Faro Scene software tool to align the data of separate sessions (point clouds) into a single point cloud for each building.

Resolution		*Quality*	*Speed (kpt/sec)*	*Noise Compression*	*Net Scan Time (full scan)*	*pt/360°*	*NOHD [m]*	
Mio. Pts (full scan)							*axial*	*radial*
28.4	1/5	4x	122	-	0:04:35	8,192	*10.60*	*3.30*

Figure 2: Table of Laser Scanning specifications

The 3D point cloud data of the focus area of the Faculty building was used as a starting point for HBIM development in Revit Architecture. The library of parametric objects (Revit families) that was developed previously were both validated and articulated during this phase using the 3D point cloud. Finally, the Revit model was built using these parametric objects. In case of discrepancies between the survey results and the point cloud, the model was adjusted accordingly. As a result, a precise, as-is geometry model was built in Revit.

ffice	getty_office door 80 cm		Level: +0.25 Sill Height: Unconnected Height: 383.00	Interior wooden door with non-op-erable single glazed surface on top	

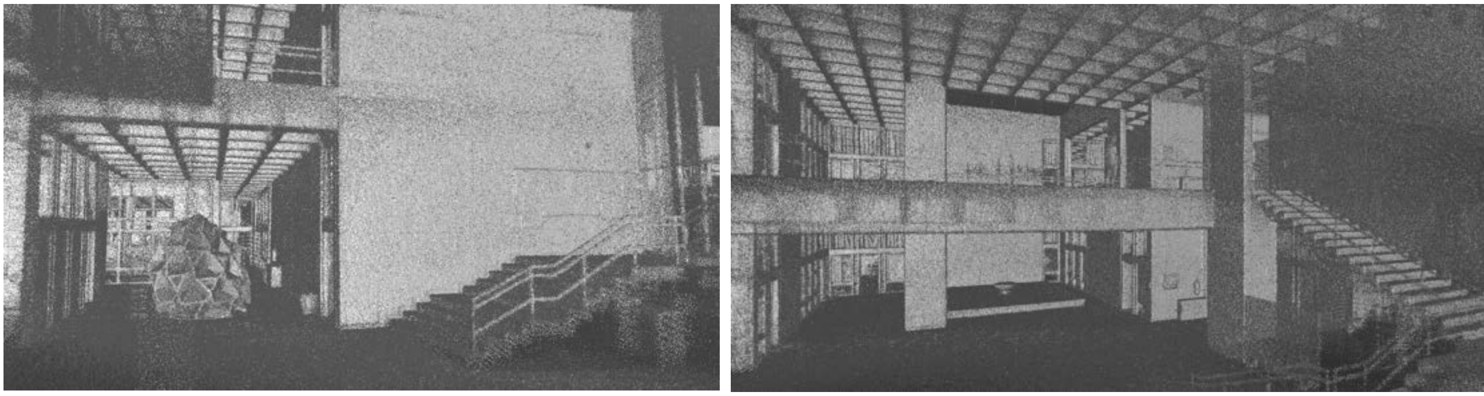


Figure 3: Point cloud modeling of the interior spaces.

d. Surveying: In the final step, the building details that were not previously documented or not captured by the laser scanner were documented by means of on-site surveys. This task was carried out in parallel with the data collection and condition assessment activities, and registered the gathered information in the model as required. The information that was already contained in the Revit model was instantiated directly. However, as will be described in the following section, a great deal of new information types was identified and captured during the project, which were added to the HBIM by extending the Revit API as classes or class properties.

HBIM Data sources

The data sources for the HBIM model were identified during the assessment of the current condition as a parallel process. The HBIM development team registered the various data types that were gathered and generated during assessment processes of all work packages. As mentioned above, custom development of building information models for heritage planning call for bottom-up, a posteriori approaches that can result in custom, one-of-a-kind representations while adhering to universal, top-down representational standards. The object-oriented structure of Revit, namely the use of Revit families as parametric building elements, allows a diverse set of building objects with properties that both exist as part of the model and that can be added as needed. In contrast with BIM, HBIM aims to capture the as-is building while making room for information imprecision and incompleteness due to missing information or degradation. Therefore, the existing Revit objects are extended with new object parameters and new classes (in the object-oriented programming sense) that were not originally part of the Revit API. The data sources are as follows:

Documentary Evidence of Architectural and Social Values

HBIM is interpreted to create a medium to make the semantic data visually accessible. The archival documents are composed of different groups of materials: 1. visual documents: black and white photographs, illustrating the different construction stages of the METU Faculty of Architecture Building, blueprint drawings, films, architectural models; 2. written documents including the construction diaries indicating the details of the application and implementation processes, institutional meeting notes, memorandums, the official correspondence between the UN-TAA, UPenn and the Turkish Ministries' representatives and 3. physical objects including the building materials, finishing details and the furniture. The variety of the medium and the material qualities of the archival material challenged the existing documentation software. HBIM, on the other hand, is developed in this project not only to store but also to retrieve the data related to the above mention list of visual, textual and material documents. This process is carried into an interactive environment where it is possible to 'click' and further click to reach a range of information from social histories to material properties. Clicking on a staff office door, for instance, helps the retrieval of historical data related to the previous users of that particular space, restorations that the door had been subject to, material properties, manufacturing techniques of that door and the industrial resources of its doorknobs, hinges, and locks. One of the major advantages of this medium is its sustainability. This interactive medium allows further additions, corrections, and subtractions.

Structural and Material Assessment

Structural assessment data collection for the faculty building was carried out during several different phases. Visual evaluation of the Building involved expert inspection during building surveys. Different structural parts of the building are investigated by putting special emphasis on each element. To evaluate compressive strength of the concrete and its variations, non-destructive Schmidt hammer testing was carried out on a selected part of the building. Moreover, the reinforcement layout of selected concrete columns and slabs was identified using a ferrometer and was registered on 2D drawings. Finally, eight problematic areas (7 bending and 1 shear cracks) in the concrete waffle slabs were identified, and 8 crack meters (potentiometric LVDTs) and two temperature sensors were installed to track the crack width over a duration of year. The data obtained from these sources were integrated to the HBIM model in different data formats and data types.

The material assessment procedures started with the determination of material conditions through visual inspections. A framework to map the visual decay forms (Material loss, Detachment, Discoloration and deposits, Cracks and deformation) was developed, and the assessed materials were classified under these categories. The location and distribution of these decay forms in the building are needed for diagnostics as well as for long-term monitoring of the decay form. Therefore, HBIM also responsible of managing asset information (building elements) for long-term condition assessment, planning and maintenance scheduling. Moreover, laboratory studies on the concrete samples for characterization were carried out, which include x-ray fluorescence (XRF), X-ray powder diffraction (XRD) and ultrasonic testing. These tests result in different data types including numeric or graphical, and data structures such as singular data or ordered lists.

Environmental Performance Assessment

Environmental performance assessment procedures are motivated by the reduction of resource consumption –and thereby reducing the environmental footprint- and improving the occupant comfort of the building. The current condition of the building was assessed through visual inspections, where information regarding the building geometry, materials, setpoints and schedules (mainly of building use and internal loads) was gathered by observation or from other project sources. The HBIM model was also used for energy modeling and simulation to quantify the energy use (heating + electricity) and occupant comfort (indoor air temperature + adaptive comfort + overheating) using EnergyPlus. A number of performance-improvement scenarios that include various measures were developed, energy modeled and simulated to assess the most effective measures that can be implemented. As such, the potential of BIM as a tool of interoperability that can support data integration between disparate tools was realized. Field measurements were also carried out to monitor the indoor dry bulb temperature and relative humidity of two critical rooms in the faculty building. Similar to the potentiometric LVDTs that continuously measured the crack width in the structural assessment phase, these sensors took measurements every minute and registered them into time-stamped data tables. The resulting data set can provide invaluable insight into occupant comfort in building spaces.

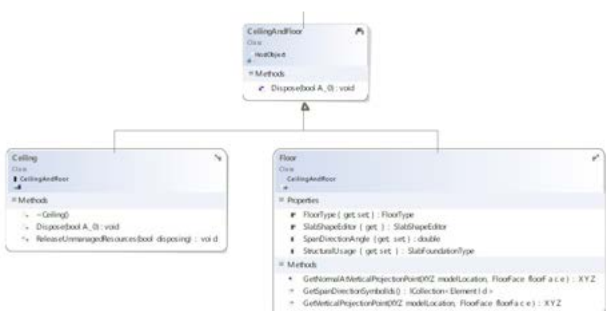
Extending Revit API for HBIM

Modeling for heritage buildings and their conservation planning activities requires that the existing model is extended with the custom data types and classes. This extension is made on the Revit Class model on the following existing classes:

• System Object > Autodesk.Revit.DB Element > Autodesk.Revit.DB HostObject > *Autodesk.Revit.DB Wall*

Represents a wall in Autodesk Revit. This class inherits all properties of its parent objects, and also has wall-specific properties such as flipping wall orientation.

• System Object > Autodesk.Revit.DB Element > Autodesk.Revit.DB HostObject > Autodesk.Revit.DB CeilingAndFloor > *Autodesk.Revit.DB Ceiling*



Represents a ceiling in Autodesk Revit.

• System Object > Autodesk.Revit.DB Element > Autodesk.Revit.DB SpatialElement > *Autodesk.Revit.DB.Architecture Room*

Provides access to the room topology in Autodesk Revit.

First, a property (in text format) titled Architectural Significance is added as a property to the *Autodesk.Revit.DB Element* class. An element, according to Revit API documentation, usually corresponds to a single component of a building or drawing, such as a wall, door, or dimension, but it can also be something more abstract, like a wall type or a view. The Element class is the parent class of the classes that were primarily used in the HBIM developed for this research. Therefore, the Architectural Significance property is inherited by the child classes of the Element class, namely all the physical entities (Wall, Ceiling, Floor etc.) as well as the Rooms. Moreover, the following classes are added to the abovementioned classes:

- **Material Assessment:** This class represents the tests performed on the material samples. Therefore, the class includes information on the sample collection process, sample description and the tests. Material Assessment class is associated with the HostObject class. HostObject is a base class that represents objects that can host other objects, such as walls roofs, and floors. The following properties are part of the Material Assessment class:
    - Sample taken at: The time of sample collection
    - Sample taken by: The name of the person who collected the sample
    - Sample ID: A unique ID for the sample
    - Sample category: A string that describes the category of the sample
    - Sample description: A string that describes the sample
    - Sample history: Originality of the sample
    - Sample photos: Images showing the sample
    - Sample location photos: Images showing the sample location
    - Visual decay forms: To be selected from: Material loss, Detachment, Discoloration and deposits, Cracks and deformation
    - Water absorption: water absorption of the sample material (%)
    - Density: density of the sample material (KG/m3)
    - Ultrasonic pulse velocity: Ultrasonic pulse velocity results table (.xls)
    - XRF: XRF results table (.xls)
    - XRD: XRD results graph (image format or PDF)
    - TGA: TGA results graph (image format or PDF)
    - IR: IR results graph (image format or PDF)
    - SEM: SEM images (image format)

- **Structural Assessment:** This class represents the procedures followed during structural assessment and the data collected or generated during this process. As in the Material Assessemnt class, this class is also associated with the HostObject class. The following properties are part of the Structural Assessment class:
    - LVTD Measurements: LVDT is an acronym for Linear Variable Differential Transformer
    - Bending Moment Regions:
    - Crack Width Change Graph:
    - Cracked Slab Temperature Graph:
    - As Built Rebar Placement Drawing:
    - Strength of Concrete Measurements:
    - Crack:
    - Crack Depth:
    - Crack Condition:

- **Probe measurements:** This class represents data sets that are results of continuous on-site data collection through sensors. Some measurements that were considered in this research were air dry bulb temperature, air relative humidity for environmental assessment and crack width measurements for structural assessment procedures. This class is associated both with the HostObject and Room classes, as these data sets can be collected from both types.
    - Probe Type:
    - Start date:
    - End date:
    - Data Collection Frequency:
    - Result Graph:
    - Result Table:
    - Gadget Photo:

- **Architectural Documentation:** This class represents the documentation of the building in a variety of media, such as drawings, images. The wide range of archival data can also be made part of this class.
    - Phase Name: Indicates the builging phase duing which documentation was made.

For this project, the following phases were found: “Competition Drawings” (1961), “Conceptual Drawings” (1961-62), “Application Drawings” (1962), and the “Publication Drawings” (1964-69).

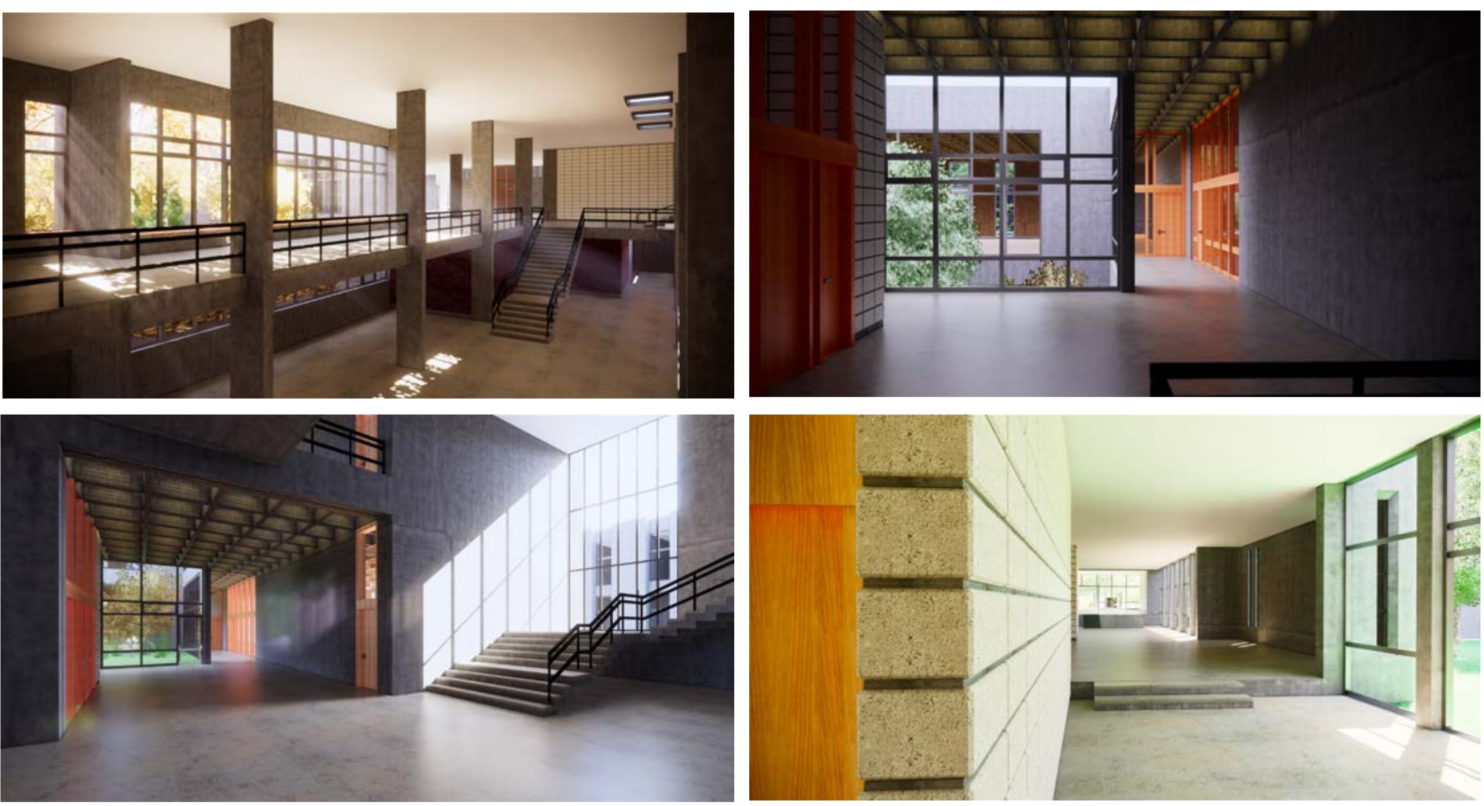
- Detail Drawings: The detail drawings of the building (PDF, image or vector drawing)
- Elevation Drawings: The Elevation drawings of the building (PDF, image or vector drawing)
- Plan Drawings: The plan drawings of the building (PDF, image or vector drawing)
- Section Drawings: The section drawings of the building (PDF, image or vector drawing)
- Building Photos: Photos of the building that were taken during the phase.
- Electrical Engineering Drawings: The electrical engineering drawings of the building (PDF, image or vector drawing)
- Mechanical Engineering Drawings: The mechanical engineering drawings of the building (PDF, image or vector drawing).
- Space Name: The name of the space that the documentation belongs to, if any.
- Structural Drawings: The structural drawings of the building (PDF, image or vector drawing)

• **Environmental Assessment**

- Room Calculated Overheating Degree Hours: Overheating degree hours, as calculated by the energy performance assessment procedures (WP4)
- Room SDA Analysis: Room Spatial Daylight Autonomy value, as calculated by the energy performance assessment procedures (WP4)
- Room Occupancy: The daily / annual occupancy data that represents the estimated total number of occupants in the room
- Room Energy Simulation Graphs: Image files representing the simulation results of energy performance, such as annual energy use, CO2 emissions, thermal balance.

The resulting Class diagram and an instance of the new Classes can be seen below. It must be stressed that the research team followed a bottom-up approach in the development of HBIM for the Faculty building. This means that the proposed extension of the Revit model was carried out based on the collected / generated data types. While the new classes proposed by the research team have the capacity to cover a wide range of heritage conservation planning activities, it still can be developed further to include new classes or properties if and when required by other practices.

Figure 4: Realistic render views from the HBIM of Faculty building.

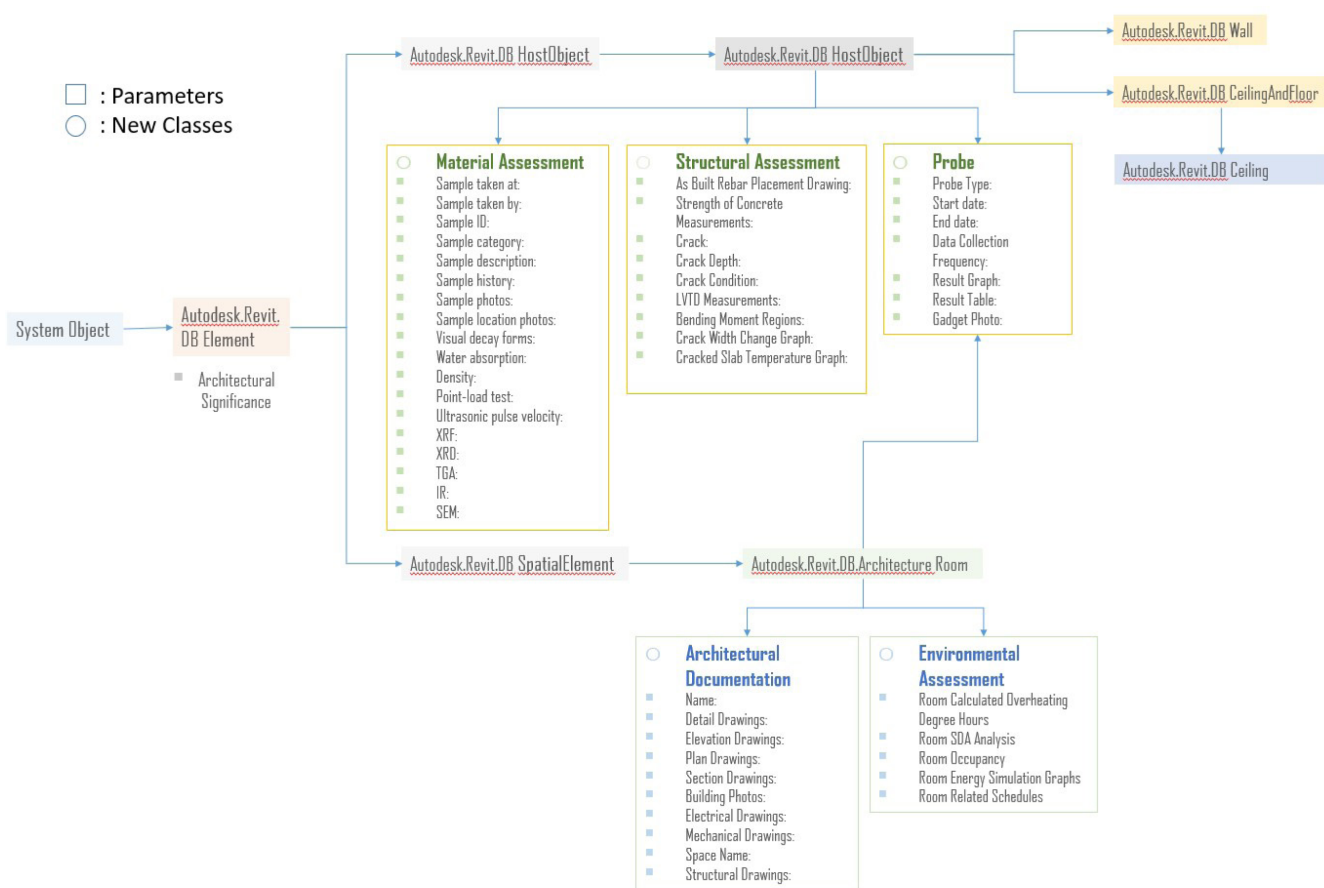


2.2.1. Visualization of HBIM

In the previous sections, the development of the HBIM model for the faculty building as well the proposed extension to Revit with the newly generated assessment data types were explained. The existing building data in the standard BIM schema, as well as the extended schema that contains the new data types, can provide critical support to the heritage professionals during assessment processes. Therefore, the expressive visualization of these data types is one of the primary concerns of HBIM development. For the Faculty building, these new data types and the existing ones are made complimentary to the 3D visualizations of the building. As such, distinctive visual markers (spherical shapes) are inserted into the 3D view of the building where the data was collected or associated with. This could be a room, an architectural element or any part of an element. These markers contain the newly added sets of HBIM data, which, upon clicking, display these data to the users next to the 3D model. For instance, during structural assessment, the data regarding an existing crack, such as the images of the crack, its depth and hazard condition, can be viewed by the users. The simultaneous visualization of the geometry and the semantic data is useful both for assessment activities and also for sharing the architectural heritage values with a wider audience. At the same time, the HBIM environment acts as an interactive medium in which users can view, visualize, edit and share the model and its elements for various purposes.

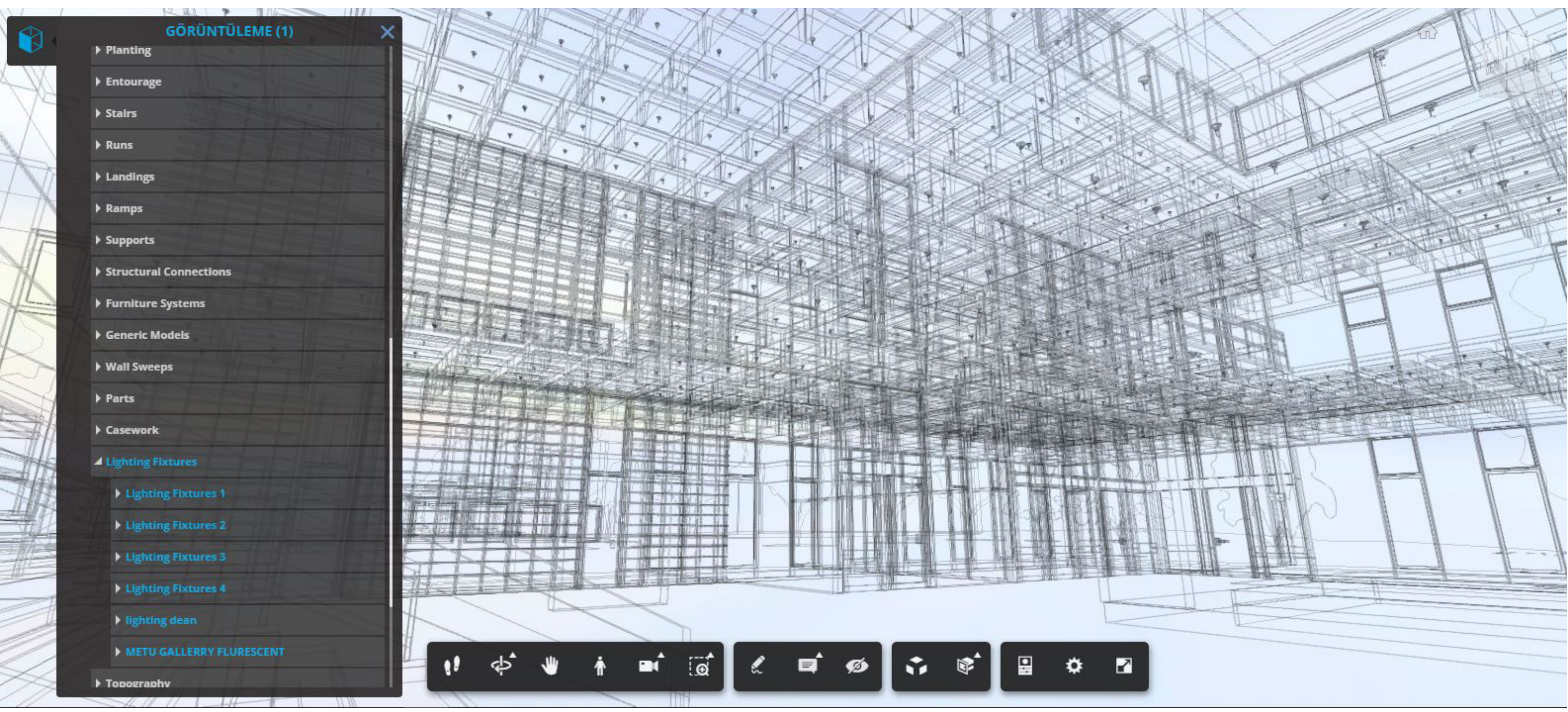
In the final step, the HBIM made available in the virtual reality environment. The graduate studies of one of the team members is particularly focused on a seamless integration between BIM modeling, simulation processes and fully-immersive virtual reality (VR). Both the geometry and the information associated with building elements successfully made available in the VR environment. The model then was visualized using HTC Vive.

The HBIM that was developed during this research was used to represent, store, share and visualize the building related information across the project participants. As such, it was operationalized as an inseparable tool for analysis and planning activities for a research team



that consisted of different disciplines. The HBIM has the potential to be used in the long-term to continuously support various activities. For instance, the archival documents, as they are found in the future, can be added to the corresponding classes. Similarly, the data regarding the future assessment activities can be aggregated in the model, so to allow a continuous analysis of building or material behavior and performance.

Figure 5: Views from the HBIM of the Faculty building, categorization, isolation and query of the selected HBIM elements in web-based Autodesk Myhub360, available at http://kimproject.arch.metu.edu.tr/en.



2.2.2. HBIM - Interactive and Immersive

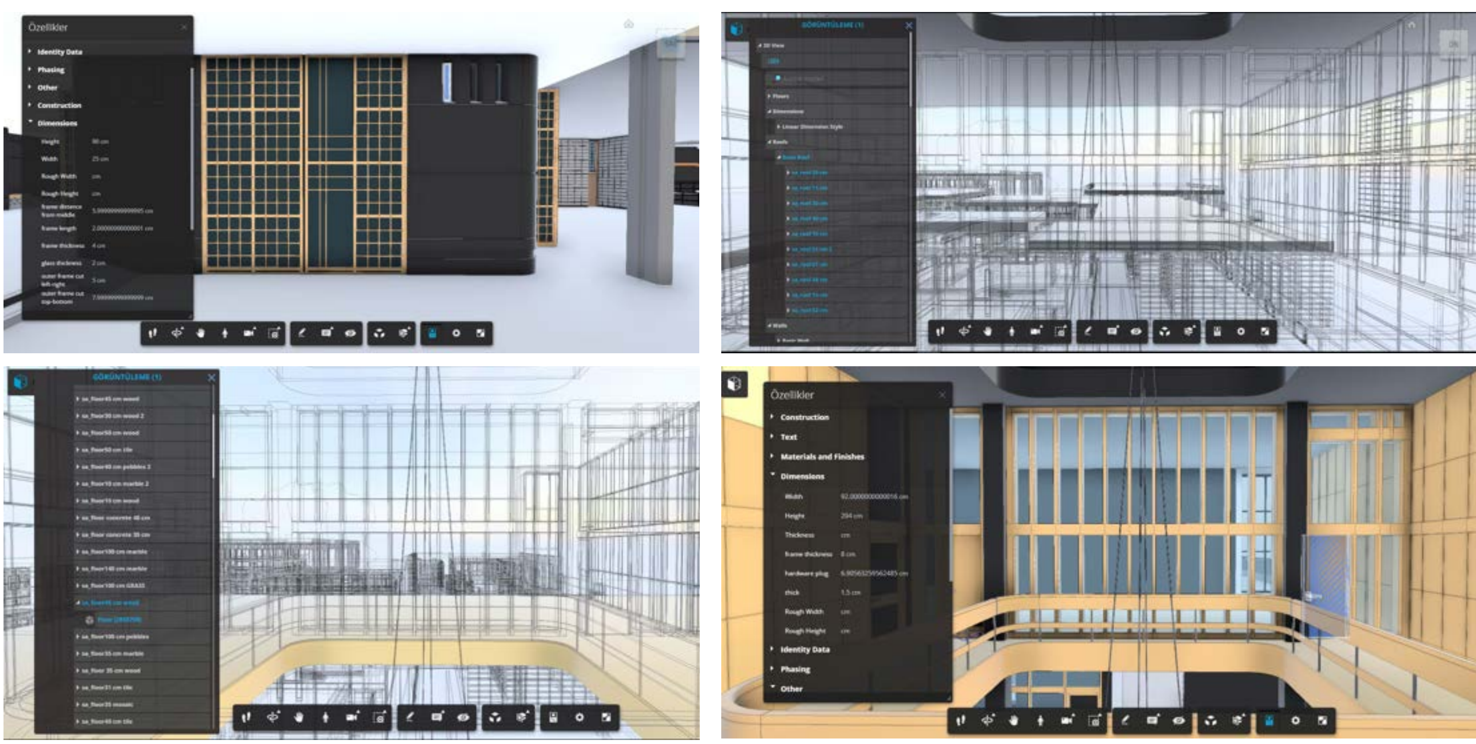
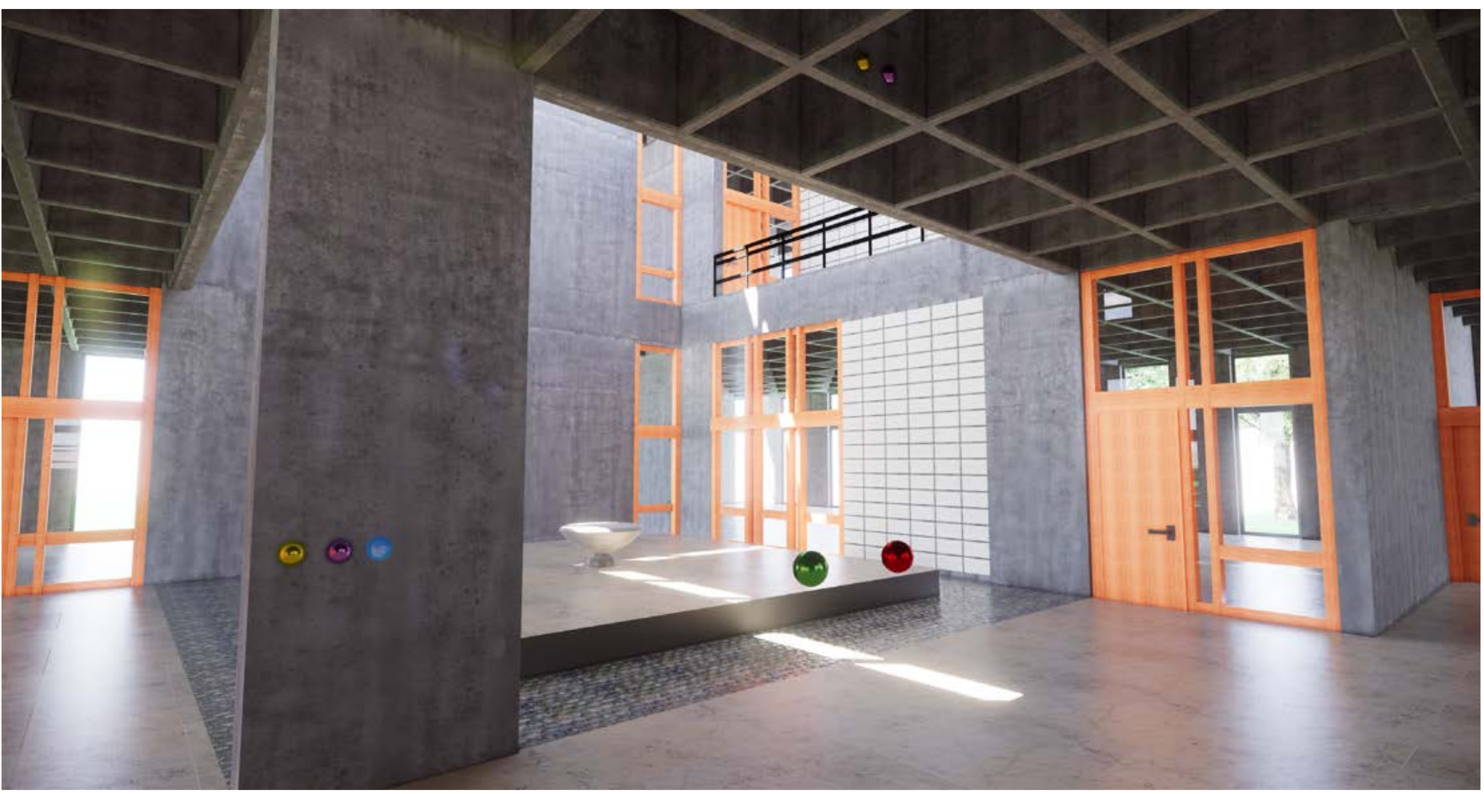


Figure 6: Rendered view of the Smart globes (supported in standalone exe. and web-based standalone available at kimproject.arch.metu.edu.tr/en.).

Figure 7: tandalone app



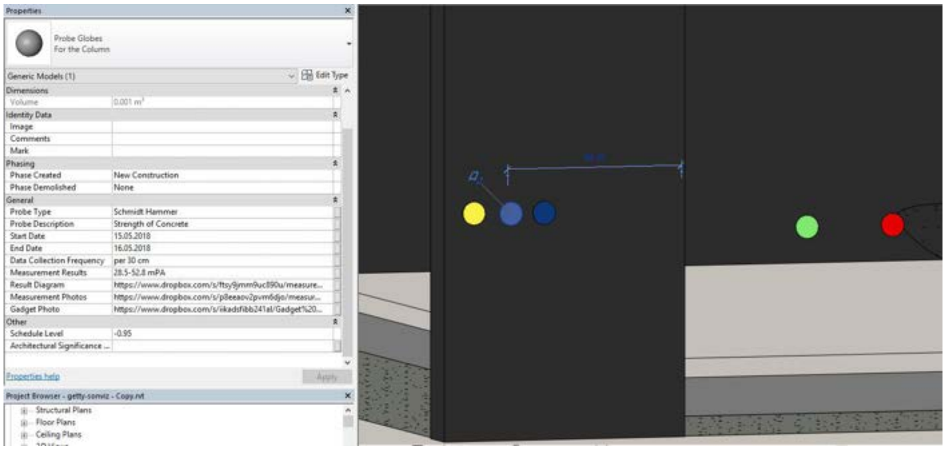


Figure 8: Revit view of the Smart globes (Associated data can be displayed on the properties tab)

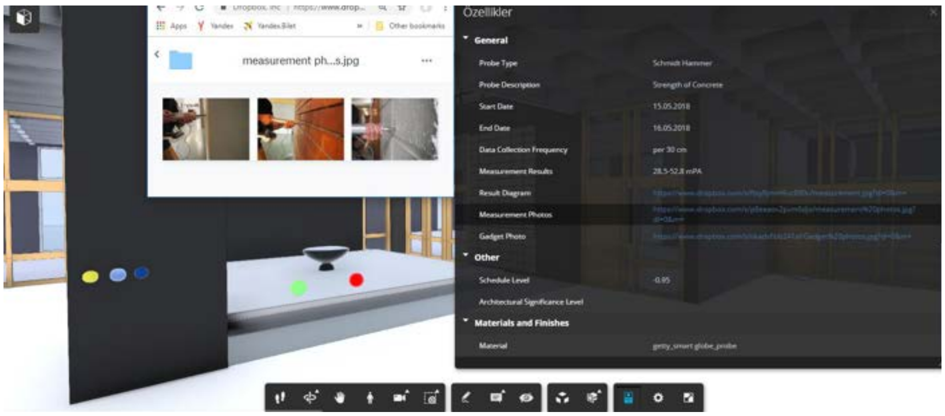


Figure 9: Autodesk Myhub360 view on the web browser of the Smart globes (Associated data can be displayed interactively on the web)

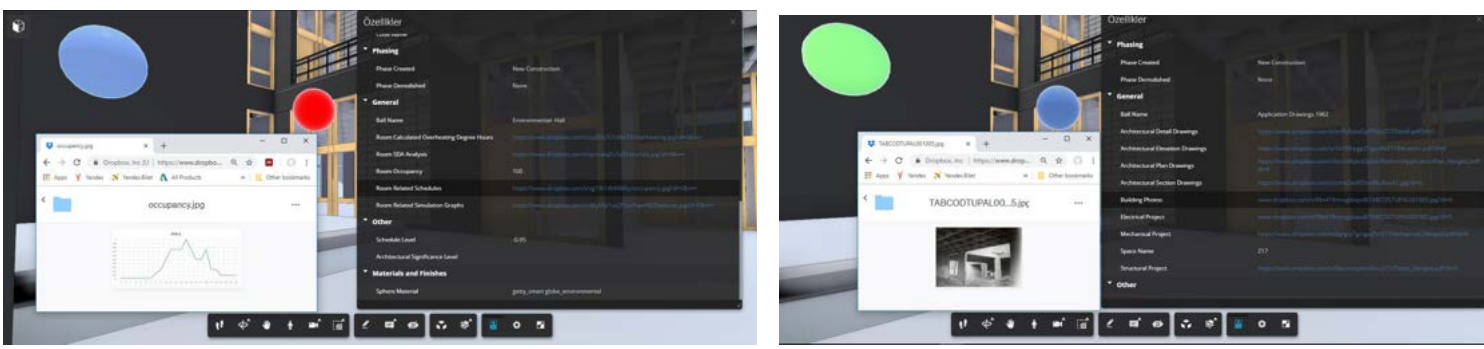


Figure 10: Interactive web-based HBIM model on Autodesk Myhub360, room hosted "Smart Globes" and their associated workpackage data.

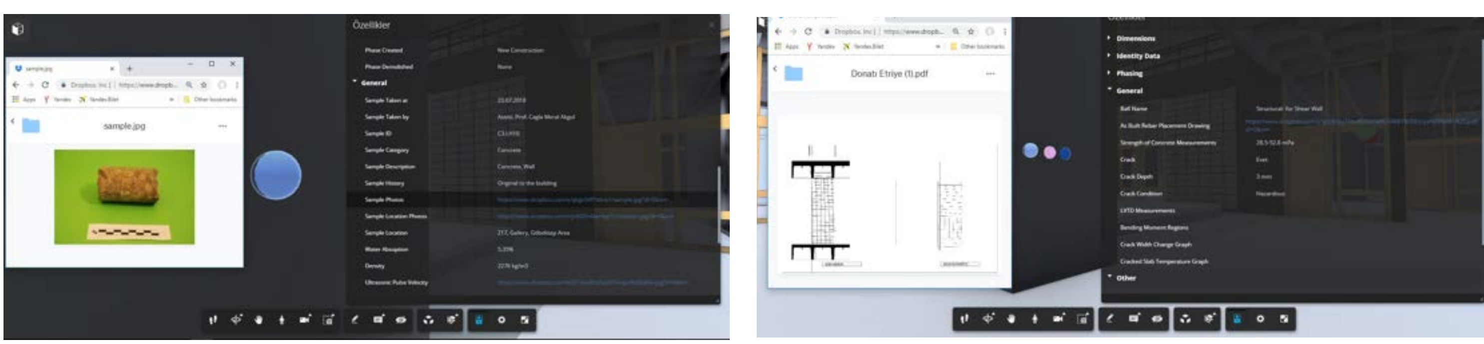


Figure 11: Interactive web-based HBIM model on Autodesk Myhub360, face hosted "Smart Globes" and their associated workpackage data.

Figure 12: Interactive visualization of the faculty building with BIM data on Revit Live, can be accessed at http://kimproject.arch.metu.edu.tr/en.

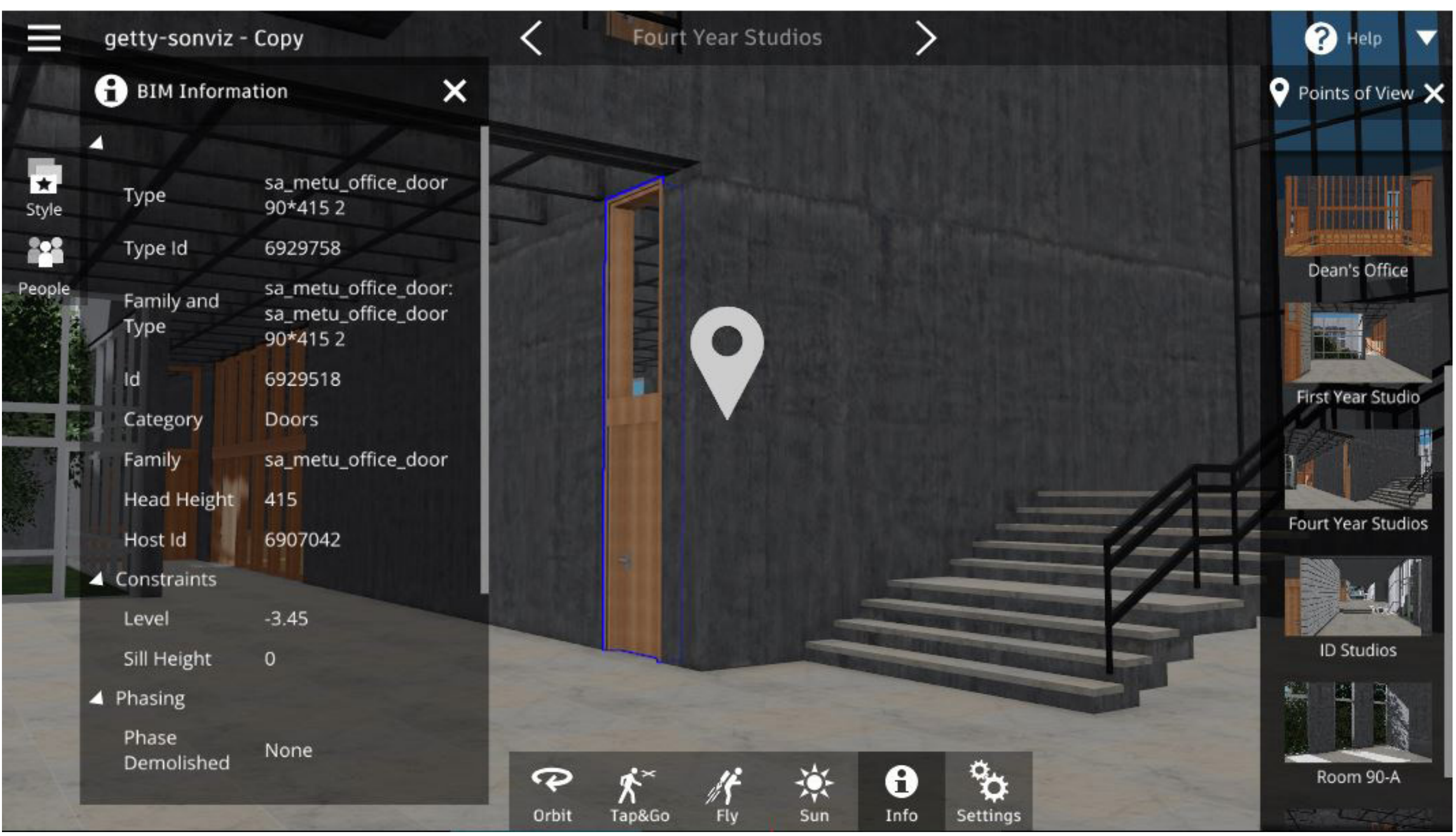


Figure 13: Standalone walkthrough application for immersive visualization of the faculty (VR Ready)

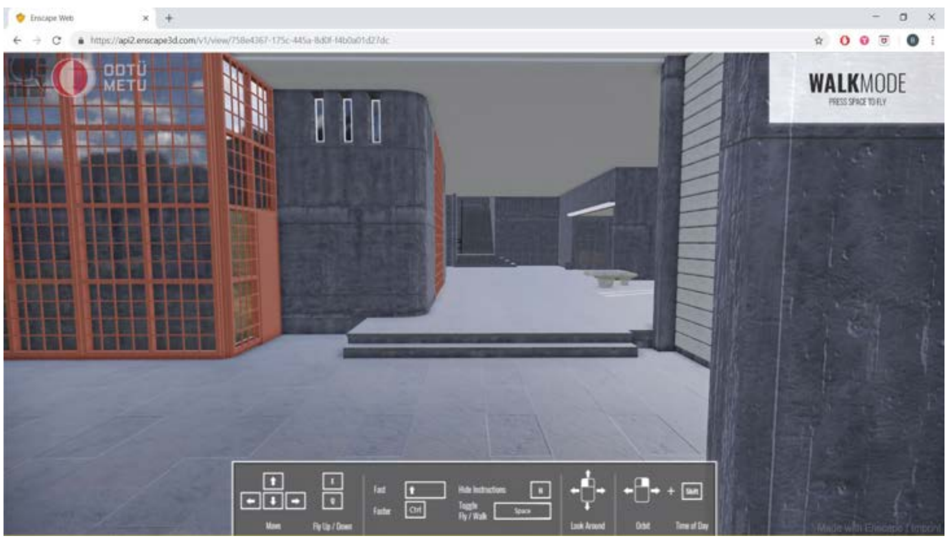


Figure 14: Standalone walkthrough for rendered visualization of the HBIM on web browser (can be accessed at http://kimproject.arch.metu.edu.tr/en.)

Figure 15: Immersive, stereo-panorama rendering example from HBIM, can be accessed via QR codes

3. UNDERSTANDING THE PLACE

3.1. Eliciting Architectural and Social Values
3.2. Structural Documentation and Assessment
3.3. Material Documentation and Assessment
3.4. Environmental Performance Documentation and Assessment
3.5. Infrastructural Notes

A comprehensive understanding of the METU Faculty of Architecture building as a modern heritage, together with its history, development and present state, was essential for achieving appropriate assessments and consequently relevant proposals for the principles, policies and related actions for its conservation. Accordingly, this phase of the research covers the summary of the documentation of the history of the building, its context, and a survey of the current condition of the building, which included data, on the physical, functional, social, environmental, administrative and managerial structures. The processes of data collection and analysis included the values defined by the stakeholders and their future expectations.

This research was conducted under four subtitles: Eliciting Architectural and Social Values, Heritage Building Information Modeling, Structural Documentation and Assessment, Material Documentation and Assessment and Environmental Performance Documentation and Assessment. As all these procedures required expertise, the team was composed of a multi-disciplinary group of researchers working in different departments of METU. Besides their particular fields of study and experience in the conservation of cultural heritage, the members of the team came together to involve the major laboratories and research centers in the University.

3.1. Eliciting Architectural and Social Values

The subtitle "Eliciting Architectural and Social Values" covers a wide range of documentary evidences. The method developed in this report includes two major archival procedures. The first procedure focuses on the existing documents of/on/about the building-"From Document to Building"; the second procedure, on the other hand, involves the production of new material from/about the physical aspects of the building-"From Building to Documents".[1] "Documentary Evidences - From Document to Building", includes the "textual", "visual", and the "artefactual "documents. "The Physical Evidence - From Building to Document" includes the "survey drawings", "point cloud data", and "photographic documentation".

Although the ontology of the report suggests an equal distribution of the resources, the variety in the archival material proves otherwise. More specifically, the larger portion of the "textual" materials in the archive are related to the establishment processes of the whole Campus. The content, therefore, does not necessarily focus on the architectural aspects but indicates related issues. The "visual" materials primarily include photographs and drawings. Photographs documenting the construction phases of the campus form the majority of this archival section. The rest of the photographic collection is related to social events and personal activities. Drawings are the most significant part of the collected material. All the blueprints of the application drawings of the campus buildings are preserved in a general archive located in the Directory of Constructional Works building in the University. The originals of these drawings are made public by the open archive of a private cultural institution in Istanbul,

[1] James S. Kerr, *Conservation plan* (7th ed.) (Sydney: The National Trust of Australia, 2013), 4-8.

Figure 1: Stained glass window of the amphitheatre.

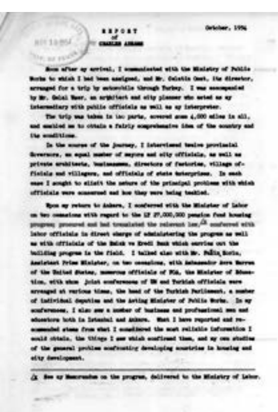
SALT. Besides the architectural models, the artefactual documents are composed of a random collection of the original building features such as the door knobs, electrical sockets, spots, finishing materials, signs, office equipment, etc., as well as Çinici Architects' selected office and drawing materials.

As the Faculty of Architecture was the first building to be constructed, the drawings produced during its construction were used as a "model" during the development of the rest of the buildings in the campus.[2] Besides the blueprints of the architectural drawings, the research team collected different sets of drawings representing the different phases of design, application, as-built (survey) and alterations in time (restitution) and the engineering and infrastructural drawings of the building. In addition to these, the Competition Drawings of the Çinici Architects and the drawing sets that they sent to the international publications were collected during this research. This final set in particular was treated as the main source of information to read the data regarding the intentions of the architects. Hence, this section occupies a larger part of the report.

To prepare the "Building to Document" section, the team worked on a comprehensive procedure of reproduction of the existing drawings. "Survey Drawings" were used as unique representations, reading and analysis and interpretation tools, to understand the significance of the building. As every process of re-drawing is conceived as an epistemological process, the team made a comparative analysis of these "originals" and "reproductions".[3] A 3D scan cloud model that is generated through laser scanning was also studied in comparison to the BIM Model. A series of "photographic documentations" of the building were made under different themes, by different photographers during different times of the day and the year.

[2] Ayşen Savaş and Güven Arif Sargın, "University as a Society: An Environmental History of METU Campus," *The Journal of Architecture* vol.18 no.1 (2013), 79-106.

[3] Robin Evans, "Architectural Projection." in *Architecture and its image: Four Centuries of Architectural Representation* eds. Eve Blau and Edward Kaufman (Montreal: Canadian Center for Architecture, 1989), 19-36.


REPORT
of
CHARLES ABRAMS

October, 1954

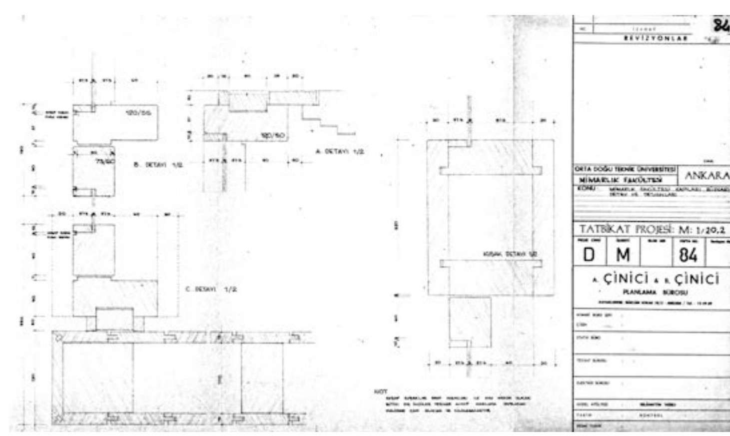
Soon after my arrival, I communicated with the Ministry of Public Works to which I had been assigned, and Mr. [illegible], the director, arranged for a trip by automobile through Turkey. I was accompanied by Mr. [illegible], an architect and city planner who acted as my intermediary with public officials as well as my interpreter.

The trip was taken in two parts, covered some 4,000 miles in all, and enabled me to obtain a fairly comprehensive idea of the country and its conditions.

In the course of the journey, I interviewed twelve provincial Governors, an equal number of mayors and city officials, as well as private architects, businessmen, directors of factories, village officials and villagers, and officials of state enterprises. In each case I sought to elicit the nature of the principal problems with which officials were concerned and how they were being tackled.

Upon my return to Ankara, I conferred with the Minister of Labor on two occasions with regard to the LT 27,000,000 pension fund housing program, procured and had translated the relevant law,[1] conferred with labor officials in direct charge of administering the program as well as with officials of the Emlak ve Kredi Bank which carries out the building program in the field. I talked also with Mr. [illegible], Assistant Prime Minister, on two occasions, with Ambassador Avra Warren of the United States, numerous officials of FOA, the Minister of Education, with whom joint conferences of UN and Turkish officials were arranged at various times, the head of the Turkish Parliament, a number of individual deputies and the Acting Minister of Public Works. In my conferences, I also saw a number of business and professional men and educators both in Istanbul and Ankara. What I have reported and recommended stems from what I considered the most reliable information I could obtain, the things I saw which confirmed them, and my own studies of the general problem confronting developing countries in housing and city development.

[1] See my Memorandum on the program, delivered to the Ministry of Labor.



3.1.1. Documentary Evidence - From Document to Building

Conservation by Documentation:

METU Faculty of Architecture building is now located in a challenging geography that is contested with continuous social, political and economic conflict. The research focusing on its conservation has been conducted with the belief that the only way to overcome mass destructions of cultural heritage is education in general and documentation in particular. The need for new overarching strategies as well as true-to-life action plans is evident; and since 2013, the METU research group has been conducting academic research, executing archival projects, establishing institutions, organizing international exhibitions and training academics, experts, technicians, workers and laymen on the way to help the documentation, preservation, conservation and the display of tangible and intangible heritage. Exceeding mere local borders, the ultimate goal is raising institutional and public awareness through international co-operational programs.[4]

Documentation here is understood as the first step of the said conservation method. Motivated by the desire to uncover the initial design principles, material qualities and social/environmental integrity of the METU Faculty of Architecture, the METU-KIM group brought together the sources of “original” impetus behind design, construction and use. This preservation strategy addresses the functional, practical, physical, technical, as well as the social, environmental and political factors that shaped and later transformed the original design ideas and construction methods. This research will provide owners of the building, managers, and stakeholders, with better guidance on how to initiate their assessments in a way that will enable them to go beyond raising awareness, to undertaking assessments that will lead to the implementation of practical, in-situ adaptation actions and decisions.[5]

[4] Theodore H. M. Prudon, *Preservation of Modern Architecture* (New York, NY: John Wiley & Sons, 2008).

[5] Mohsen Mostafavi and David Leatherbarrow, *On Weathering: The Life of Buildings in Time* (Cambridge, MA: MIT Press, 1993).

Figure 2: Report by Charles Abrams, October 1954, METU Faculty of Architecture Archives.
Figure 3: Faculty of Architecture, interior views, October 1963, METU Faculty of Architecture Archives.
Figure 4: Faculty of Architecture, application drawings, Door details, 1/20, 1/2, 1961-80, SALT Research, Altuğ-Behruz Çinici Archive.

3.1.1.1. Initiation of an Archive

Collection of the archival material focusing on the establishment of the faculty and the formation of its physical environment:

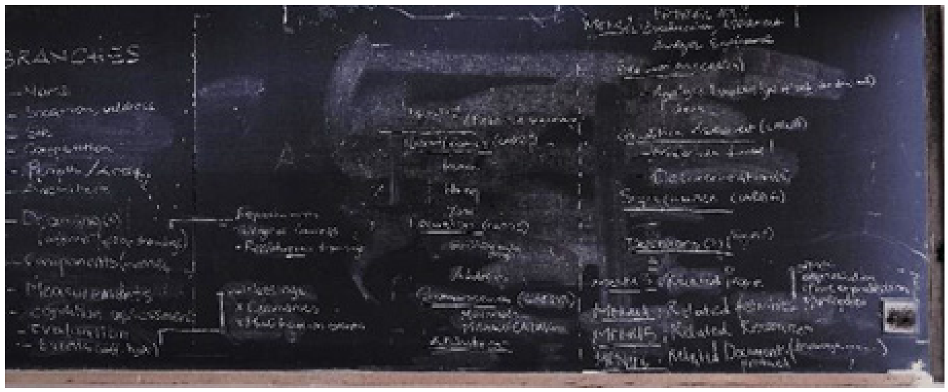


Figure 5: Preliminary study for the ontology mapping of the archive by the core group, May 2018.

The initiation of a less systematical documentation of the archival material started during the preparation processes of an exhibition in 1999.[6] Displaying mostly the black and white photographs of the university in its inauguration years, this exhibition gathered a large number of visual documents found in the Rectorate's archives, the Faculty of Architecture Dean's Office, and the personal archives of the staff and the alumni. A more systematic collection was gathered during the establishment years of the METU Science and Technology Museum between the years 2000 and 2006. The first exhibition of the museum was composed of scientific objects collected from the laboratories of the five major departments of the university. This collection grew very fast, particularly with the donations from the interested individuals. The objects in the museum collection were also representing the main ideas behind the establishment of the University campus. During those six years, the research unveiled a large number of written documents related to the foundation of the institution. Most of them were taken from their original folders in the Rectorate's archives for publication purposes and later kept in boxes in a storage space in the same building. Hand-written notes indicate the fact that the real dislocation of the archives was during the publications of the political history of the university.

Figure 6: METU Textual Documents in physical environment.

During the 50th year events of the establishment of the university, both the architect Behruz Çinici and the founder president of the University campus Kemal Kurdaş were interviewed and the black and white photographs of the campus buildings and inauguration events of early 1960s were documented by the Audio-visual Systems Research and Application Center (GISAM) of the university. The same year, a group initiated an "oral history" project in the Faculty of Architecture of which the outcome was an exhibition and a book.[7] During the preparation of this exhibition, a selected collection of documents was gathered from the graduates of the faculty, which were scanned and returned to their owners. The originals were returned because of the lack of an archival space in the faculty. DOME, the general archives of the Faculty of Architecture were officially established in 2015.

In 2017, with the support of the Getty Conservation Institute and the Dean's Office, a systematic collection and documentation of the Faculty Archive started. The major goal behind the collection of the archival material was to focus on the establishment years of the faculty and the formation of its physical environment. The black and white photographs, illustrating the different construction stages of the METU Faculty Building, constitute the most substantial section of the METU visual archives. The construction diaries indicating the details of the application and implementation processes, blueprint drawings, institutional meeting notes and memorandums are the written documents that help the interpretation of these handmade photograph albums. A wide range of written documents, including the official correspondence between the United Nations Technical Assistance Administration (UN-TAA), University of Pennsylvania, and the Turkish Ministries' representatives constitute the foundations of the archival collection.

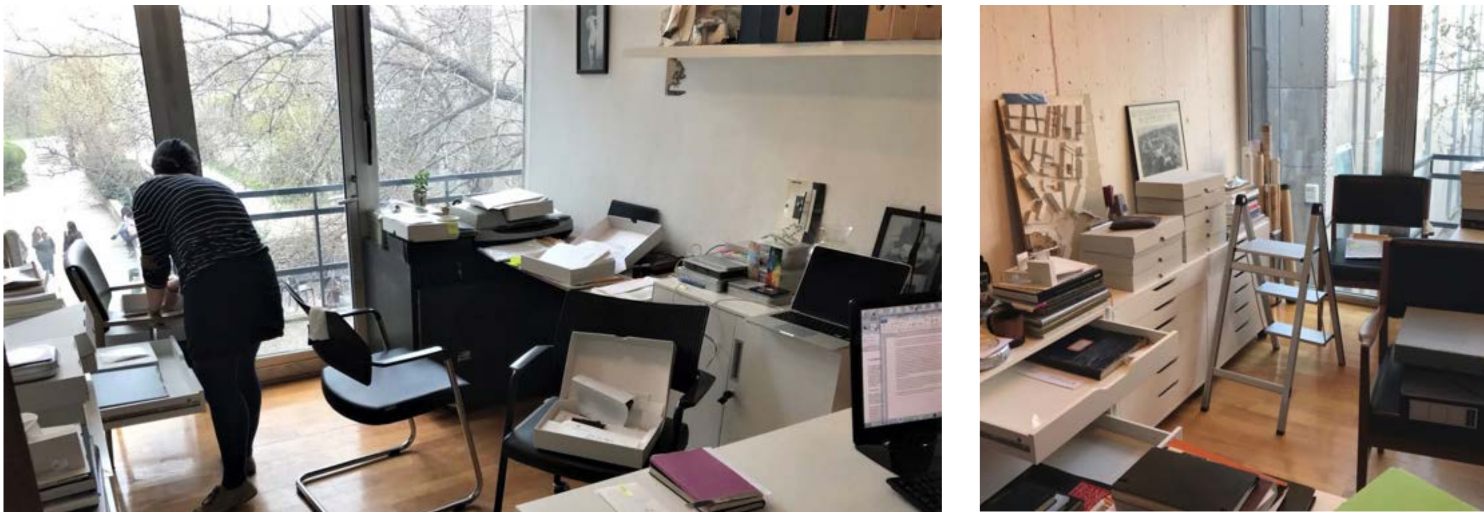


Figure 7: Classification of the physical archive, R57, March 2018.

Moreover, the published archival material section includes historical surveys in book format, such as Arif Payaslıoğlu "Barakadan Kampusa: Türk Yükseköğretiminde Bir Yeniliğin Tarihi" (From Barracks to the Campus: A History of Change in the Turkish Higher Education) (1996); Uğur Ersoy "Bozkırı Yeşertenler: ODTÜ Kuruluş Yılları Anıları" (Those Who Transform the Steppes Into Green: Memories of METU Establishment Years) (2002), Nurettin Çalışkan "ODTÜ Tarihçe" (METU History) (2002); and autobiographical books such as Kemal Kurdaş "ODTÜ Yıllarım: Bir Hizmetin Hikayesi" (My Years at METU: The Story of a Mission) (1998), Üstün Alsaç "Orhan Alsaç: Bir Türk Mimarının Anıları, Yaşamı, Etkinlikleri" (Orhan Alsaç: Memories, Life and Work of a Turkish Architect) (2003); oral histories such as "Anılar: Bir Sözlü Tarih Çalışması" (Memories: An Oral History) (2007); exhibition catalogues such as METU Documented (1999), Memories: An Oral History (2007), Summer Practice: 1967 (2017); published articles such as "A University is a society": an environmental history of the METU 'campus'" by Güven Arif Sargın and Ayşen Savaş in The Journal of Architecture (2016), The METU Campus: A Utopia, A Social Project, A Success Story by Ayşen Savaş in Brownbook Ankara issue (2018), METU Newsletters, bulletins, graduation catalogs, annual reports, board reports, meeting minutes and the curricula development reports.

The parallel development of the curriculum and the architectural program of the faculty can be traced in the fragmented charts, tables and diagrams found in various folders kept in the above-mentioned university archives. In the absence of the originals, architectural models produced with different techniques were added to the archival collections in recent years. Selected drafting equipment and personal memorabilia of the architect of the building, Behruz Çinici, were donated to the archives in 2017 by his son, architect Can Çinici.

[6] Ayşen Savaş, *METU Documented, Exhibition Catalogue* (Ankara: METU Press, 1999).

[7] Sevgi Aktüre, Sevin Osmay and Ayşen Savaş, eds., *Memories. An Oral History. (Anılar. Bir Sözlü Tarih Çalışması.1956'dan 2006'ya ODTÜ Mimarlık Fakültesi-nin 50 Yılı)*, (Ankara: METU Press, 2007).

Motivated by the desire to uncover the initial design principles, material qualities and social/environmental integrity of the METU Faculty of Architecture, the METU-KIM group brought together architectural drawings, photographs, publications, films, student projects, course syllabi, studio assignments, etc., the sources of "original" impetus behind design, construction and use.

Material, structural and environmental analysis processes supported this archive with a number of documents presented in different format and media. The information both gathered during inspections and generated as a result of laboratory tests, sensors and performance simulations was initially registered in their own formats (related software tools, tables). However, as mentioned in the motivation section for the Heritage Building Information Modeling (HBIM) section, the fragmentation and difficulties in accessibility of building information is an obstacle against the effective use of valuable information that should be shared across team members. The HBIM model that was developed as part of this research facilitated the structured representation and sharing of the building data as well as the information generated during the research activities.

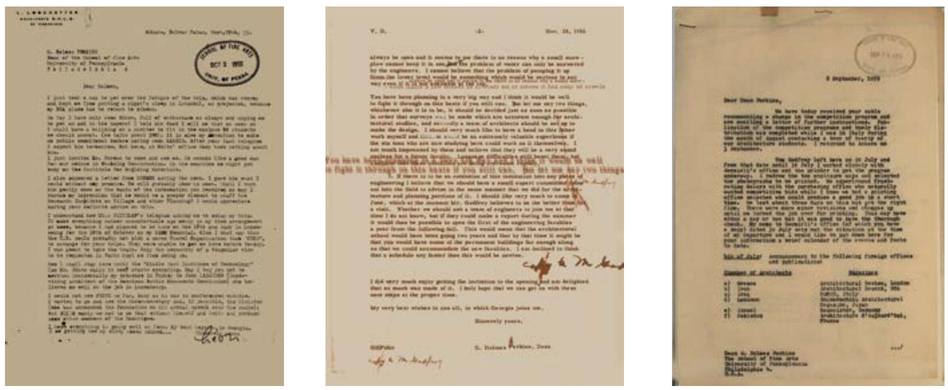


Figure 8: Selected documents from the archive.

The Entry of Archival Information and Its Retrieval

The diversity of the archival material required the development of a spatial archival method. Archival processes necessitate appropriate ontologies and applicable software tools. Thus, a series of meetings were arranged with the experts in the University, with the purpose of obtaining information about the available tools. The compatibility between the material in the archive and the working principles of the software tools were the major topics of these meetings. The goal was to formulate the most convenient environment that would enable the representation and processing of data gathered from the above mentioned visual, textual and spatial resources. After introducing ARCHES and the research project to the participants of these meetings (architects; GIS, IT and conservation experts), the software programs, GIS and ARCHES, were evaluated regarding the certain characteristics and necessities of the METU project.

It was explained that GIS works with three types of visual data: node, line and polygon. It structures the information both by providing a categorization system and linking the textual information to a spatial entity that can correspond to various data types. As a result, it provides geographical and visual analysis of the given spatial entity. Conventionally used in urban-scale data collection projects, GIS is found more appropriate for documentation gathered from multi-layered historical heritage environments. Information gathered from a single building, however, requires a more focused and three-dimensional media. GIS as a mapping environment is found to be compatible with ARCHES developed by the Getty Conservation Institute. ARCHES was developed to "turn open source GIS into a Heritage Inventory and Management System".

ARCHES in general and the Conceptual Reference Modeling in particular are studied due to their capacity in processing spatial information and creating a basis for an interpreted model for the METU Project.

It is concluded that, due to its ontological structure, this system works in a rather deductive method, which contrasts with the inductive process of the formation of a "yet to be built" or a "becoming" archive.

NVivo, a well-known software tool used for qualitative content analysis, was suggested by the Faculty's GIS expert Dr. Yücel Can Severcan, in order to be able to organize, analyze and find insights in unstructured or qualitative data including texts, images, videos, audios, etc. By employing NVivo, it would be possible to classify and store the archival material by designating "Parent" and "Child" nodes. Considering the fact that the content research of the archival materials is still in process, the ease that NVivo proposes in modifying the hierarchical and taxonomic relations among nodes and sub-nodes could be useful. NVivo has the capability of browsing the document, which is scanned into searchable PDF format, as vector-based text. As stated before, the METU project proposes an inductive process, which necessitates the employment of software that works with the same ontological principle. Therefore, employing NVivo for the current stage is found more appropriate.

As the major resources in the archive were texts and images, while various information in different media related to the building, require a geometric model, the final proposition was the generation of a Heritage Building Information Model (HBIM). Although BIM Models are typically used during the design and construction processes of a building, in the METU Project it is adapted as an archival environment. In addition, HBIM gives the opportunity to define spaces, where textual and visual information can be associated with the model. Following this decision, the conclusive method was entering the basic information retrieved from the documents as well as the documents themselves as archival objects, as the extensions of conventional BIM systems.

MS Excel is an effective tool in capturing and structuring raw data in a variety of formats including plain text, numbers, enumerated data or dates. Its advanced capabilities in managing and analyzing large amounts of data, as well as its ease of interoperability with other tools are found advantageous for the purpose of this stage of archiving. Data integration between the excel spreadsheets and other tools that are used in this study, primarily the Revit HBIM model, will be fully or semi-automatically carried out in the following steps.

3.1.1.2. Content of the Archive: Textual and Visual Documents

3.1.1.2.1. Textual Documents: Correspondences and Reports

The expression “textual document” is here understood to encompass various written material related to the architectural and social formation of the METU Faculty of Architecture building. It refers to all published and unpublished texts as well as the supplementary material, which help their interpretation and cultural interaction. Rather than one historiographical position, each document has been treated as a distinct and autonomous source of information.

The major sources of the textual material gathered, organized and consulted during the preparation of this report now constitute one of the major sections in the METU Faculty of Architecture Archives. Reports, correspondences - including letters, memos and telegrams - meeting notes, articles, competition booklets, newspaper clips, books, magazines, bulletins, course outlines and syllabuses, curriculum charts, budget charts and reports, construction reports, receipts, legal documents, agreements, and the drafts of the said documents - have been collected over the last twenty-five years. The first restoration process of this collection was carried out between 2003 and 2008 under the consultancy of the paper preservation experts in the Topkapı Palace in Istanbul. After this procedure, the textual archive was scanned and organized in a chronological order and placed to be protected in acid-free boxes in the archive. Following the transformation of the textual material into the digital environment, the documentation procedures started in parallel to the development of the information retrieval environments in HBIM. This new method of storage, preservation and the information access of the digital data was found extremely efficient and effective by the research team, and was presented in this report as a model for future developments.


Birleşmiş Milletler tarafından
Ankara'da bir Teknik Üniversite kurulacak
Ankara'da bir Teknik Üniversite Kuruluyor
Mimari Akademisinin kuruluş hazırlıkları

Figure 9: Press clippings attached to the letter written by Sait Turan to Holmes G. Perkins June 1, 1955, METU Faculty of Architecture Archives.

Textual documents in the archive include the preliminary reports prepared by the specialist and the members of the institutions invited by the Turkish government during the establishment years of the republic (1922-54). John Dewey, Ernst Egli, SOM (Skidmore, Owings and Merrill LLP) and Charles Abrams were among these names who took charge in the establishment, execution and institutionalization processes of the proposed school in terms of administration and education. There are two “Dewey Reports” that focus on the educational policies of the new republic. The “Egli Report”, and the “types” he proposed for the architectural design of elementary schools were believed to establish the foundations of Modern Architecture in Turkey. The “Abrams Report” took the lead in the establishment of an architecture and town planning institute, later to became the METU Faculty of Architecture. There are also assessment reports in the archive, which were prepared by the responsible experts assigned to the overseas mission to Turkey by the UN. Thomas Godfrey, Leon Loschetter, and Holmes Perkins were among them.

The research group particularly focused on the textual documents that were produced between the years 1954 and 1980s, and a greater importance was given to the period of 1954-1970 in order to be able to apprehend the establishment processes of the Faculty of Architecture, the selection procedure of the site and the architects and the development of the design principles. The correspondence and the meeting notes that were produced by the above-mentioned corporations (i.e, UNTAA, FOA, Government of Turkey), help the clarification of the historical issues related with the construction of not only the building complex but also the curricula and the educational principles.

Referring to Foucault and his epistemological method of “archaeology”, those textual documents are treated as ascertainable historical traces. They are “grouped, made relevant, and placed in relation to one another to form totalities”.[8] The first grouping is chronological and based on the creation date of the documents. Acid-free boxes are arranged annually and each box is dedicated to a specific year. Within this rather chronological arrangement, there are ruptures and overlaps that are caused by the correspondence of one person with different parties. Complementary documents help in reconstructing and reinterpreting the historical processes and tracing the different positions of the individuals and the national and international institutions.

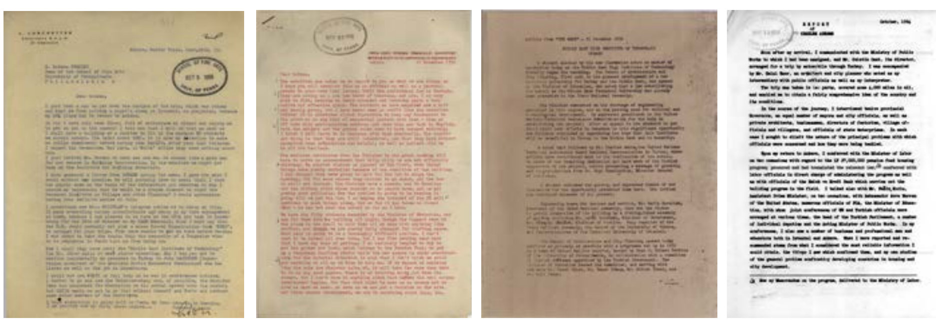


Figure 10: Selected documents from the archive.

[8] Michel Foucault, *The Archaeology of Knowledge* (2nd ed.), (London: Routledge, 2013), 7.

3.1.1.2.2. Visual Documents: Photographs and Drawings

3.1.1.2.2.1. Photographs

Photographs in this part are grouped in sections, which focus on the history of the selected area, in its making, its architecture, social life, cultural activities and academic events. Although fixed to a single view point, photographs are multifaceted in their documentary aspects. They gain a historical value in time and their producers give them an authority in the aesthetic realm. It is true that photographs have value as historical documents, which give information, form inventories and help the establishment of archives.[9] Each photograph can be conceived as an anecdote. Since its discovery, an assumption that considers photographs "as transparent representation of things and the most reliable evidence of facts and situations" has been scrutinized.[10]

The collection of the photographs related with the campus, particularly related with its establishment years, was initiated in 1999.[11] During the last twenty years, the photographical archive has been developed to include over twenty thousand images. In 2006, during the 50th year anniversary events, GISAM initiated a documentation project to expand the archives with digital photographs and films. The construction of an archive has been interpreted intellectually and physically.[12] Physicality refers to the space of the archive, in other words, the room, drawers, acid-free boxes and the envelopes. Humidity and temperature control, UV protection, dust and hazardous acids proofing, control of chemical interactions were the basic issues of the space. Physicality also refers to the classification of the archive. In this specific case, the space of the archive and the physical characteristics of the drawers, boxes, envelopes almost define the classification of the photographs. The first rule was not destroying the already established classifications. There were forty-one albums and approximately 3,000 photographs in nine different frame dimensions prepared during the construction phase of the campus at the site (figure 11). They were identified and dated to be treated as complementary construction diaries. All the photographs, starting from the first day of the University, help the construction of a fragmented chronology. This chronology formed one of the bases to understand the place and to assess its significance and values.

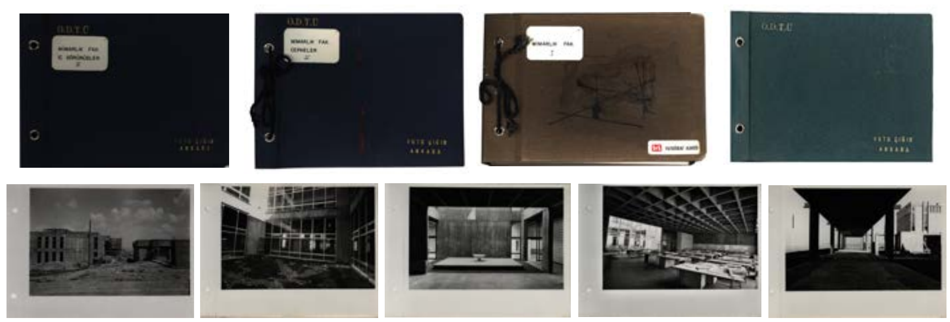


Figure 11: Selected albums and photographs from the archive.

In the current archive, there are two complete sets of photographs particularly related with the architectural aspects of the Faculty building. The first set was compiled during the construction period (1962-1965). The second set is composed of an ongoing systematic documentation process conducted as part of the conservation planning activities. In-between those two periods, there are incremental compilations of photographs of traditional events such as faculty balls, juries and lectures; and more aesthetic documentation performed to fulfill the requirements of specific courses such as Arch524 Architecture and Different Modes of Representation, Arch723 Advanced Design Studio, Arch511 Socio-Cultural Themes in Urban Architecture and Arch366 Fine Arts Techniques Workshop. All these documentation processes help to understanding the original idea(l)s of the architects, changes during the time (restitution) and the final conservation processes.

[9] Okwui Enwezor, "Archive Fever: Photography Between History and the Monument" in *Archive Fever: Uses of the Document in Contemporary Art* (New York: International Center of Photography, 2008), 11-51.

[10] Walter Benjamin et al., *Illuminations: Essays and Reflections* (New York, NY: Houghton Mifflin Harcourt, 1968).

[11] Ayşen Savaş METU Documented is the title of the catalogue prepared during the first exhibition conducted on METU visual history in 1999. A number of graduate studies were completed on this subject i.e. Melike Akyol, *Photography as an Architectural Document: A Visual Archive for METU Campus,* (Ankara: Middle East Technical University, September 2012); and Gökçeçiçek Savaşır, *Re-Framing Architecture: METU Faculty of Architecture and Its Photographic Reproductions* (Ankara: Middle East Technical University, 2001).

[12] Susan Sontag, *On Photography*, Kushiel's Legacy (New York, NY: Picador, 2001).

3.1.1.2.2.2. Drawings

Terrence Riley states that “at the time of its making, the drawing is part of a private process wherein an idea is given form”.[13] Architectural epistemology has long been established on the assumption that drawings are the primary referent for the interpretation of the architects’ intentions. Besides being projections to create images for the future buildings, they can be interpreted as documents giving historical information.[14] Today, it would not be wrong to claim that among all the different modes of architectural representation, drawings have been historically conceived as the main resources.

Among the other modes of architectural representation, the Çinicis favored the orthographic set to convey their ideas. This rather “technical” mode of representation has been associated with Modern Architecture to exceed its practical medium of implementation. The inherent neutrality or, in better terms, “objectivity” of this mode has been interpreted in different ways.[15] Functionalism was introduced as a remedy to stylistic choices of architects in the early 20th century. Rather than producing something “neo”, Modern architects wanted to design something new.[16] Çinici Architects never made their modernist references explicit. Therefore, no matter how Miesian, Aalto or Mondrian-esque their drawings were, these quick references were avoided in this report (figure 12).

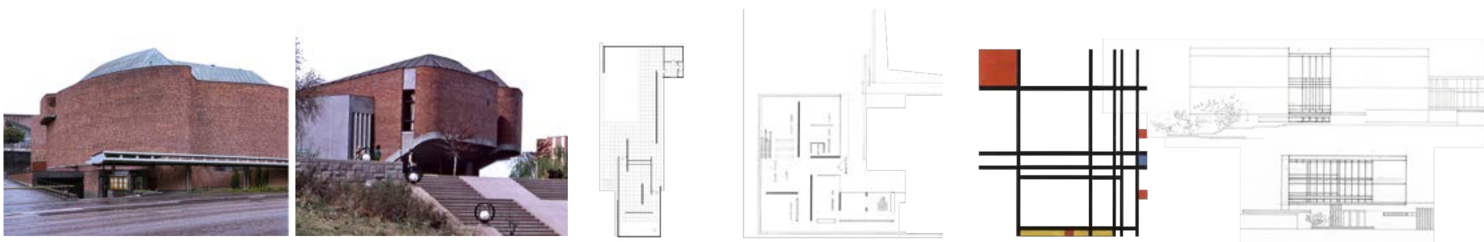


Figure 12: From left to right, House of Culture by Alvar Aalto, METU Physics Amphitheater, plan drawing of Barcelona Pavilion by Mies van der Rohe, basement floor plan of the METU Faculty of Architecture building in the competition project, “Abstraction” by Piet Mondrian, façades of METU Faculty of Architecture building in the competition project.

It is not in the teaching or the academic scientific approach of the conservation discipline to talk about unmeasurable subjective qualities, yet, each drawing executed by the Çinici architects is in fact “beautiful”, and this requires a thorough discussion. The aesthetics of the drawings had to be the clues to forthcoming discussion of the architectural significance of this building complex.

In this report, the architectural drawings of the METU Faculty of Architecture building are analyzed in a chronological order and under four main categories related to the design and construction phases of the building.

1. “Competition Drawings” that were the first set of drawings that are submitted to the competition jury in 1961 by the Çinici Architects. They represent the design intentions, or in better terms, the “dream of the architects”. These drawings include the orthographic set of not only the Faculty of Architecture building but also represent the main idea behind the overall campus planning and two other building complexes in the METU Campus: The Administration building and the Student Dormitory building (A Type).

2. The second set is the “Conceptual Drawings,” which were drawn during an intermediate stage between the application and competition phases. The most significant changes in the design idea developed by the architects can be observed in this particular set of drawings.

[13] Matilda McQuaid and Terence Riley, eds., *Envisioning Architecture: Drawings from the Museum of Modern Art* (New York, NY: Museum of Modern Art, 2002).

[14] Robin Evans, “Architectural Projection” in *Architecture and Its Image: Four Centuries of Architectural Representation* eds. Eve Blau and Edward Kaufman (Montreal: Canadian Center for Architecture, 1989), 19-36.

[15] Seray Türkay, “The Orthographic Set: Making Architecture Visible” (master's thesis Middle East Technical University, 2011).

[16] Reyner Banham, *Theory and Design in the First Machine Age* (Cambridge, MA: MIT Press, 1980). See also; Stanford Anderson, “The Fiction of Function.” *Assemblage*, no. 2 (February 1987), 18-31.

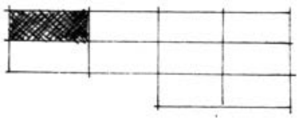


Figure 13: The board layout diagram.

Figure 14: Measurements of the original drawings.

3. After the previously mentioned phase, it is possible to say that there are rather minor changes in the main design idea. For this reason, the comparative analysis of the third set, which is the "Application Drawings", focuses on a selected area, the F Block. Another reason for the selection of a focus area was the practicalities of the preparation processes of the Heritage Building Information Model (For details, please see part 2.2). Therefore, in this report, the analysis of the third set, "Application Drawings", is limited to the focus area, the F Block. The "Architectural Decoration Project" drawings, which were prepared as a supplementary set of the application drawings by the Çinici Architects, were also reviewed and referred to under this part.

4. The last set is the "Published Drawings" that are composed of plans, elevations, sections and plan notes that were prepared and sent to the international architectural publications by the architects. Including the descriptive texts, detail drawings and the black and white photographs of the Campus and the Faculty of Architecture building, this set represents the most accurate data regarding the "as-built" phase of the building. The comparative analysis of the Application Drawings and the Published Drawings revealed the decisions behind the finishing details and the material choices of the architects.

3.1.1.2.3.1. Competition Drawings/Dream of the Architects - 1961:

The first set of the orthographic drawings including plan, section and elevations of the METU Faculty of Architecture building, was prepared as "competition drawings" by Altuğ-Behruz Çinici in 1961. During different phases of this study, this hand drawn orthographic set has been used as the main source of information to understand and assess the material and aesthetic values of the building. The traces of architects' intentions are indicated in the line quality, hatching technique, locations of the section planes, depiction of level differences, overlaps of partial sections on plans and the drawing notes. Moreover, the functional layout, location of the service and circulation areas, design and placement of the structural elements, choices in wall, ceiling and floor detailing, as well as the façade organization and the roof line, are the main evidence of the architects' objectives.

As indicated in the "board layout diagram" located at the right corner of each drawing, there are ten drawing boards submitted to the competition jury (figures 13,15). The scale of each drawing is written in metric units on the top or at the bottom of these drawings, yet, there is neither a scale bar nor measurements on the boards. Therefore, the scale of each architectural element is verified by measuring the original drawings that are preserved in the SALT, Altuğ-Behruz Çinici Archives, in Istanbul (figure 14).

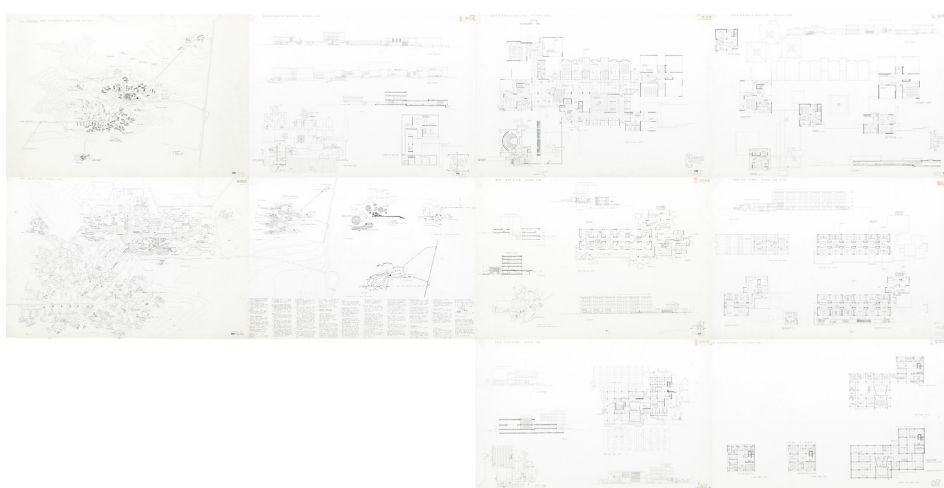


Figure 15: The ten boards submitted to the competition jury, in the order of the board layout diagram.

Architects illustrated a board layout diagram to communicate with the jury members and to indicate the order of the boards. This text follows the same order. It starts with the assumption that the 1/5000 site plan was placed to the top left corner and it was the first drawing to be viewed. Underneath there is the 1/2000 site plan, which is the second board, next to it the functional list and the diagrams, which would be the third board. The fourth board contains the elevation drawings. And the fifth board is the ground floor plan, followed by the sixth that contains the upper floor and sections. The rest are drawings for the administration building and one of the dormitories (Type A), which are not included in the scope of the report (figure 16).

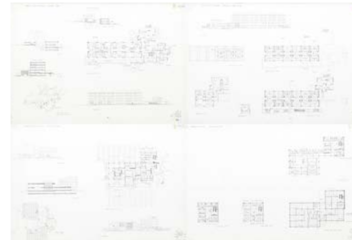


Figure 16: The last four boards containing the drawings of the administration building and a dormitory building (Type A)

The first board: Site Plan in 1/5000 scale:

Figure 17: The first board, general site plan (1/5000).

The first board contains a general site plan, a 101.7x67.5cm white cardboard, that is showing the future development of the overall campus in 1/5000 scale (figure 17). The drawing shows the placement of the building units on topography lines, immediate landscape elements surrounding the buildings, main roads and intercity connections, the main pedestrian path, housing units, a high-school and a prep-school, dormitories, a house for all religions, view terraces, a firehouse, storage buildings, a central heating building complex, staff housing, bus stops, sports facilities, a shopping center, a central library, an amphitheater, the Rectorate building, the Rector’s house, a central grove, a health center, an applied urban project for the development of a “model village”, fields for the Faculty of Agriculture and the future expansion areas. The Faculty of Agriculture has never been built, yet the other five faculties that are indicated on the plan, namely the Faculty of Architecture, Art and Sciences, Administrative Sciences, Engineering and Education were established and built subsequently.

The whole site plan presents a “rational” order guided by an invisible orthogonal grid, of which there are traces left particularly in the housing session (figure 18).

The abstract curves of the topography lines, the urban grid, the indication of educational units with rectangular prisms and the sharp corners of the traffic roads and the pedestrian paths suggest a strong aspiration for Modernism. Rather than drawing the borders of the functional units and landscape elements, architects use an unusual technique. They draw parallel lines to represent the rectangular prisms of functional units. A hatch pattern scale helps them to represent a hierarchical order in three dimensions (figures 17,19).

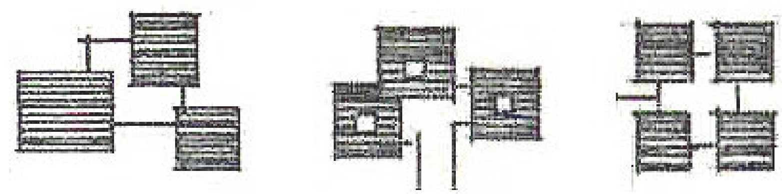


Figure 19: Hatching lines, representing the order in three dimensions, close up of figure 17.

The relatively high blocks are hatched with dense thick lines. The lower units, on the other hand, are indicated with thinner and less dense lines and the main pedestrian path is represented with rather thin lines in larger intervals. In order to be able to indicate the level differences along the pedestrian path, stairs are indicated with very dense thin hatching lines. This technique gives a three dimensionality to the drawing, supported with the dissolution of the border lines particularly at the corners, where the units are juxtaposed. In addition to its three-dimensionality, this unique technique is employed for drawings of particular building units such as auditoriums, where the hatching system represents the structural elements (figure 20).

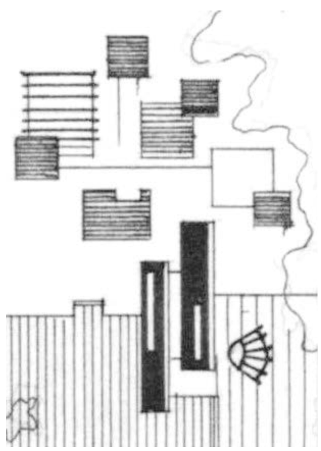


Figure 20: Hatches representing the structural elements close up of figure 17; interior view from the amphitheater, of Faculty of Architecture, SALT Research, Altuğ-Behruz Çinici Archives.

Figure 18: Traces of the grid in the housing section,close up of figure 17.

While retaining their spatial relationships in the drawing, almost all the architectural elements are superimposed, made transparent or penetrate one another. The parallel hatching lines representing the main pedestrian path dissolves into the masses to define their borders and indicate the main entrances to the faculty building complexes. The distribution of the masses suggests the fragmentation and the re-composition of the building units, which repeats like a stamp in the overall campus plan (figure 21). (The reason for the delay in stylistic nomenclature, in other words not using the stylistic jargon of abstract modernism, synthetic cubism etc., here is to expand the processes of architectural interpretation.)

The rectangular layout of the academic units is divided by a longitudinal pedestrian path and transversal landscape organization, which is composed of a ceremonial platform, the grove, the junction of the main pedestrian path and a secondary pedestrian axis. At the center of this rectangular layout, the main public buildings of the campus including a cafeteria, library, main auditorium and the rectorate building are located. Here, it has to be underlined that in this particular drawing, the location of the Faculty of Architecture building is at the center of the campus.

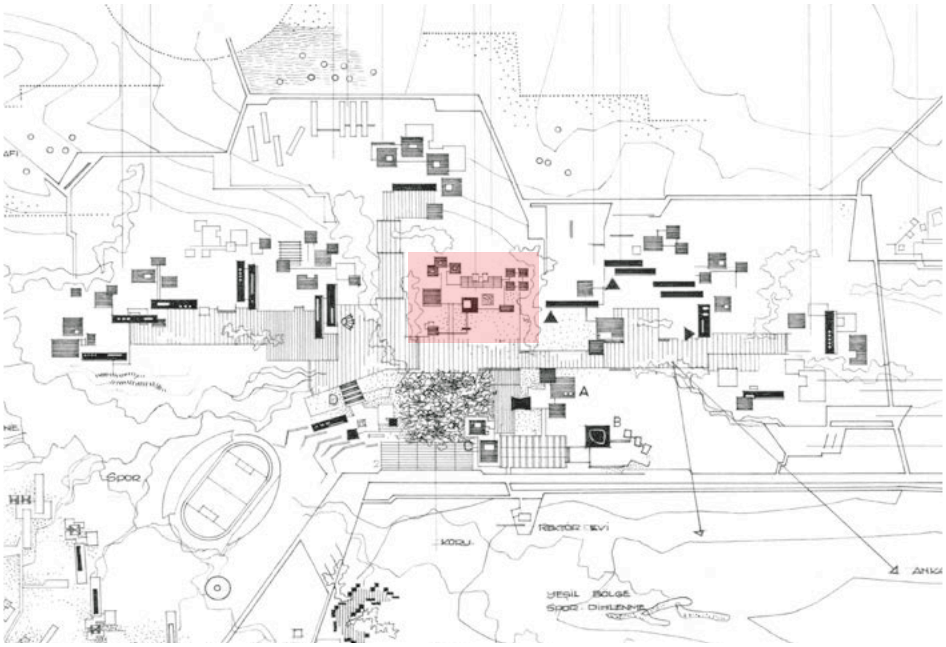


Figure 22: Faculty of Architecture Building, at the center of the academic zone, close up of figure 17.

One further significance of this drawing is the fragmented dotted line that shows the official borders of the campus area. One fragment of this indication repeats at every northeast corner of all the site related drawings in the competition entry (figure 23).

Figure 23: The borders of the campus area highlighted with the colour red, close up of figure 17.

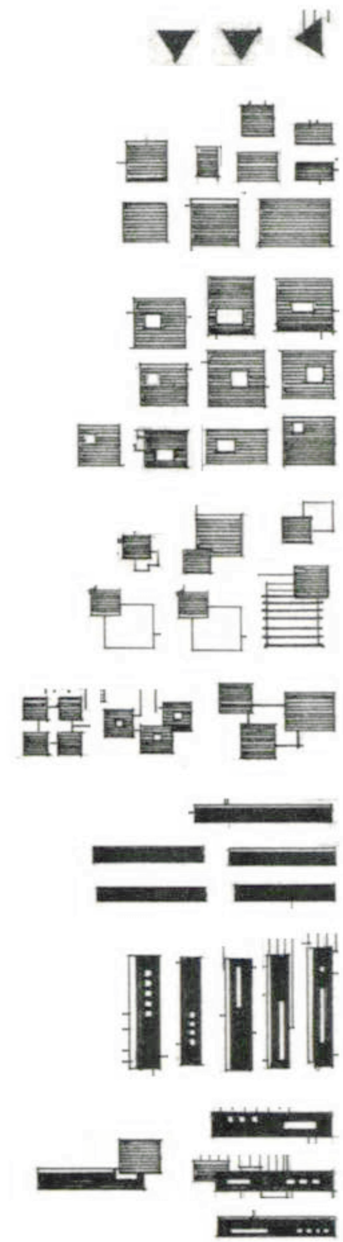


Figure 21: Repetitions of building masses like a stamp.

The second board: Site Plan in 1/2000 Scale:

The second drawing board has the same paper size and shows exactly the same site, but ironically enough with a different drawing scale. These two site plan drawings, one in 1/5000 and the other in 1/2000 scale, have different drawing techniques and line qualities. That indicates the possibility that they were drawn by two different architects. At first glance, although it is relatively easier to separate the building units from the landscape in the 1/5000 scale drawing, the dominating geometry and the scale of the main pedestrian path challenges that reading. The reason for this can be that the architects put a special emphasis on the main pedestrian path in their design.

The architects do not use the above-mentioned hatching technique in the second board, but still emphasize the three dimensionality of the units in plan by using increasing line weights. In this drawing, hatching is used in a more conventional way to depict the landscape elements. Particularly the dense lines of the retaining walls and stone garden walls repeat all through the drawing.

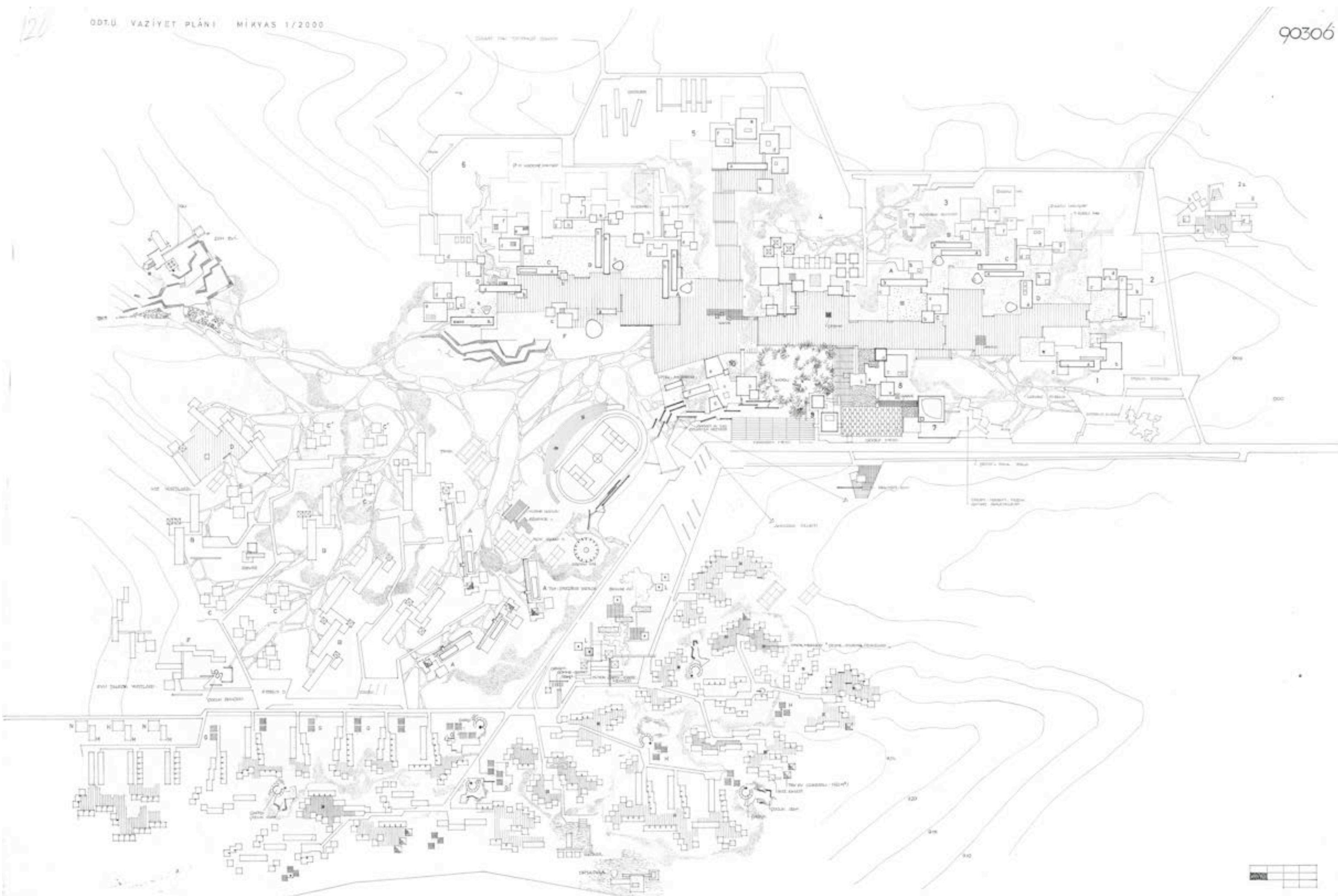


Figure 24: The second drawing board, general site plan of the campus (1/2000).

There are seven different line weights indicating seven level differences:

- arcades-trees
- one-storey blocks
- two-storey, blocks
- three-storey and higher blocks.
- topography lines
- payments-grass-bushes-pedestrian paths-parking cul de sacs
- main pedestrian path-ceremonial squares-staircases-pools-main entrance platforms into the blocks

In this drawing, natural elements are clearly differentiated from the architectural units, with the above mentioned, unusual drawing technique.

The third board: Site Plan in 1/2000 scale:

The third board is a 102x68cm white cardboard, illustrating four schematic diagrams of the campus layout. These diagrams are abstract representations that are used in order to map different urban zones and functions and show their complex interrelations.

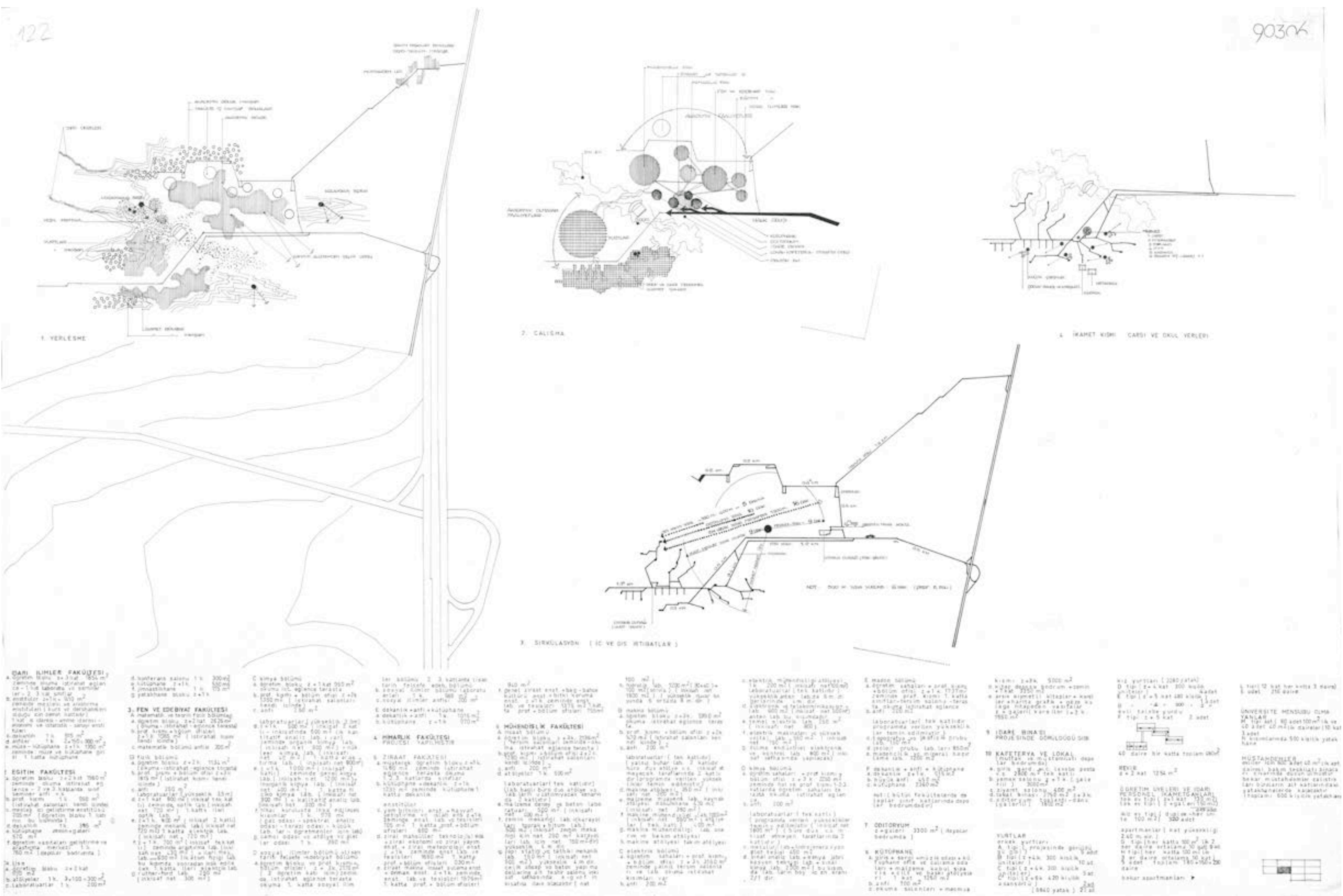


Figure 25: The third drawing board, schematic diagrams of the campus layout.

These diagrams codify space and represent vehicular, pedestrian and infrastructural movements. The very abstract quality of this representation technique is challenged by the L- shaped fragment of the dotted line that is used to indicate the exact location of the site.

The first diagram on this board is entitled "Settlement" and shows the separated zones of the main functions in the campus: rivers, green areas, dormitories, housing expansion zone, academic zone, academic expansion zone, the main pedestrian path (and the view of the city from this path), campus maintenance complex, firehouse, storages and staff lodgings. The hill, on which the academic zone of the campus was designed, was name the "*Kocayokuş* Hill" in this diagram.

The road junction connecting the Eskişehir intercity road to the METU exit is drawn here with the indication of the topography lines, which are connecting this third drawing board to the second drawing board. As these topography lines continue in the second board, they are evidence that these two boards (1 and 2) had to be viewed together (Figure 26).

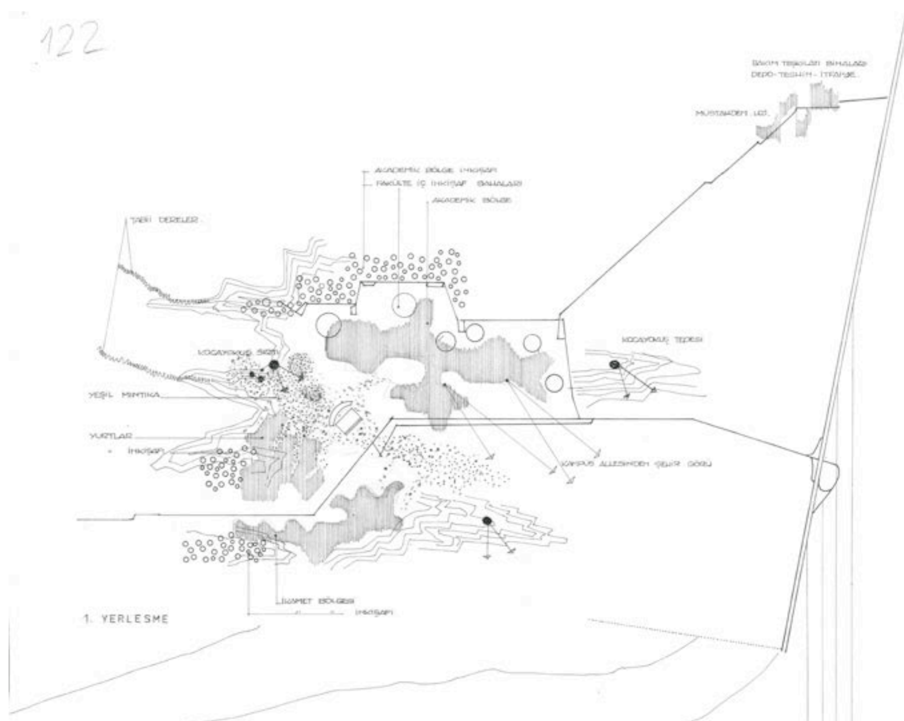


Figure 26: The first diagram, entitled as "Settlement".

The title of **the second diagram** is "Work" (figure 27). This bubble diagram is divided into three parts: 1- the academic functions 2- the non-academic functions and 3- a third part including sports and religious activities laid on a green band.

- The academic functions are indicated by six bubbles representing six faculties. A seventh bubble is divided into four smaller bubbles, which indicate the public functions: the library, auditorium, Rectorate building and cafeteria. The Rector's house is illustrated with a small black bubble on the east side of the main traffic road of the campus. This main road is called the "public approach/entrance" and sub-divided by three arrows which are oriented towards the public spaces of the campus. This bubble diagram represents the different scales of the functions with the varying dimensions of the circles. The department of architecture is here illustrated with as a medium-size bubble.
- The non-academic functions are dormitories, senior academic and administrative staff lodgings.

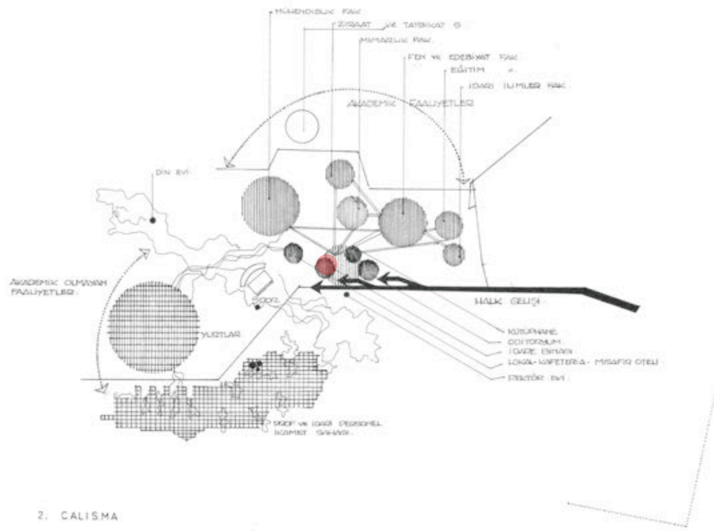


Figure 27: The second diagram, entitled as “Work”.

• The sport activities are represented with the main stadium. The religious complex is represented with a black circle and is called “religion house”. These functions are located on a long green band dividing the academic zone from the non-academic functions.

The bubble diagram is composed of different hatching patterns that are used to differentiate the academic functions from the non-academic functions. However, these functions are further connected with a set of irregular lines. A more structured interconnection pattern is suggested in the academic part to connect all the faculties to each other and to the public functions.

The third diagram is entitled “Circulation (internal and external connections)”. This diagram shows the vehicular and pedestrian traffic (figure 28). There are two main vehicular connections with the intercity road: a 1.6 km long service road approaching from the north-west corner of the site and a 0.5km traffic road approaching from the main exit from the north-east corner of the site. This road is divided into three parts at the junction of the campus service roads. There are parking lots located at every 0.4km on the west side of the campus and there are also two bus stops: one located near the dormitories and the other located at the main entrance junction. Parking lots, particularly at the dormitory and housing part of the campus, are designed as *cul-de-sacs* forming a complex web of movement.

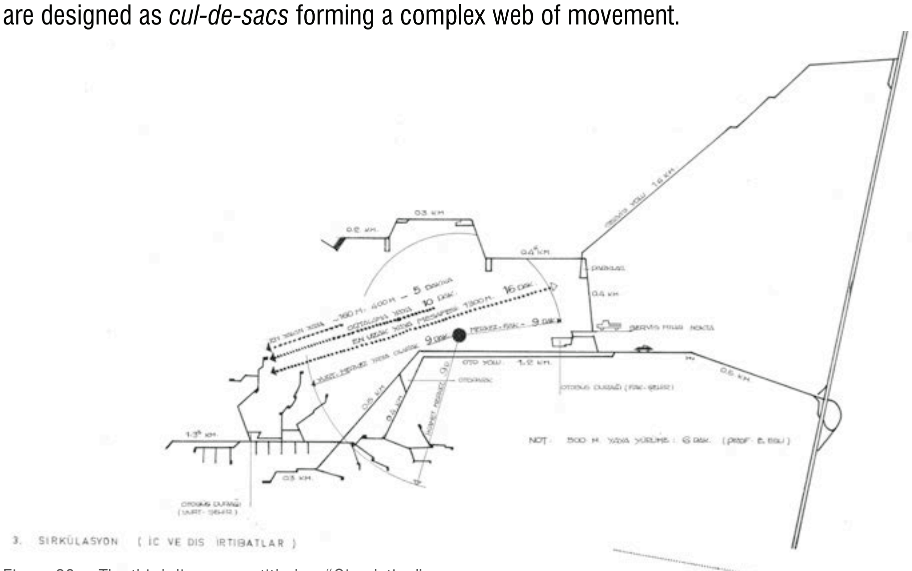


Figure 28: The third diagram, entitled as “Circulation”.

Figure 29: The reference to Ernst Egli indicated next to the diagram.

The pedestrian circulation is indicated with two arcs drawn from the same center. The center point is the actual public center of the campus and all walking distances from this point are limited to approximately six minutes. This scale takes its reference from Ernst Egli's city planning proposal and the architects write a note on the drawing to indicate that (figure 29).

The fourth diagram represents the housing area including the market and the elementary and prep schools. It shows the vehicular connections of the campus roads giving service to the public functions located at the south-east corner of the site. The triangular space defined by the roads is designed as a secondary center including a market, pharmacy, meeting point, post office, police department and a gas station.

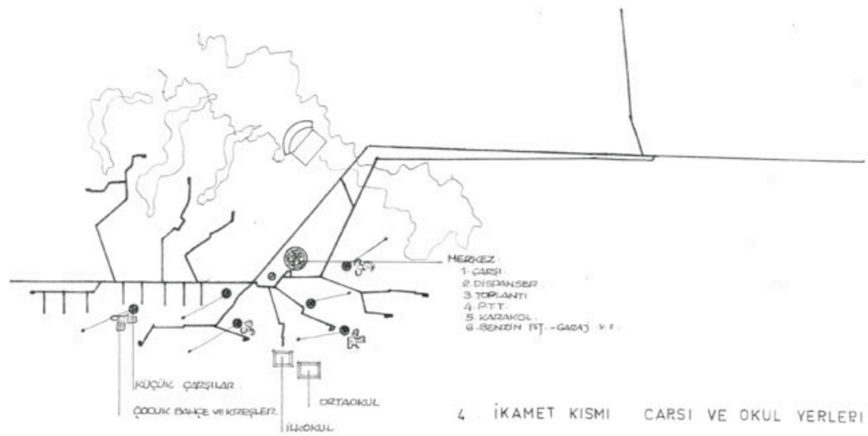


Figure 30: The fourth diagram, entitled as "Circulation".

Also in this drawing, there is a very detailed architectural requirement list, where the total surface floor areas and the number of the floors of the units are indicated using the metric system. This list is organized in 11 columns, divided in 15 subtitles: Faculty Administrative Sciences, Faculty of Education, Faculty of Arts and Sciences, Faculty of Architecture (there is no itemized list here and refers to the drawings), Faculty of Agriculture, Faculty of Engineering, Auditorium, Library, Rectorate Building, Cafeteria and Club, Dormitories, Health Center, Academic and Administrative Staff Lodgings, Guest House and Service Staff Lodgings.

The point that needs to be underlined here is that the second and the third boards are strongly related with each other. The obvious connection is that the third board contains the functional requirement list of the 1/2000 scale site plan in the second board. The less obvious, and in fact, the stronger connection is the seamless continuation of the main road of the campus between the two boards (figure 24 - 25).

The fourth board: METU Faculty of Architecture in 1/200 scale:

The fourth drawing board is a 100.5x67.4cm white cardboard and contains two 1/200 scale Elevations, one Section, one 1/500 scale Site Plan and a 1/200 scale Basement Floor Plan. There is a key map located on the right bottom corner, above the board layout, which indicates the positions of section and elevation lines. The guide lines show that the elevations and the section are drawn directly from the plan. Black hatched and comparatively thicker lines are used to show the cuts and the load bearing elements in the section and the ground floor plan.

The Elevation A-A (East) illustrates the approach from the main pedestrian path and includes: the linear organization of the façade that is following the topographical changes and descending gradually on the natural slope, the three-dimensional organization of the masses that are accommodating different functions, the main entrances, *brise-soleil*, and landscape elements.

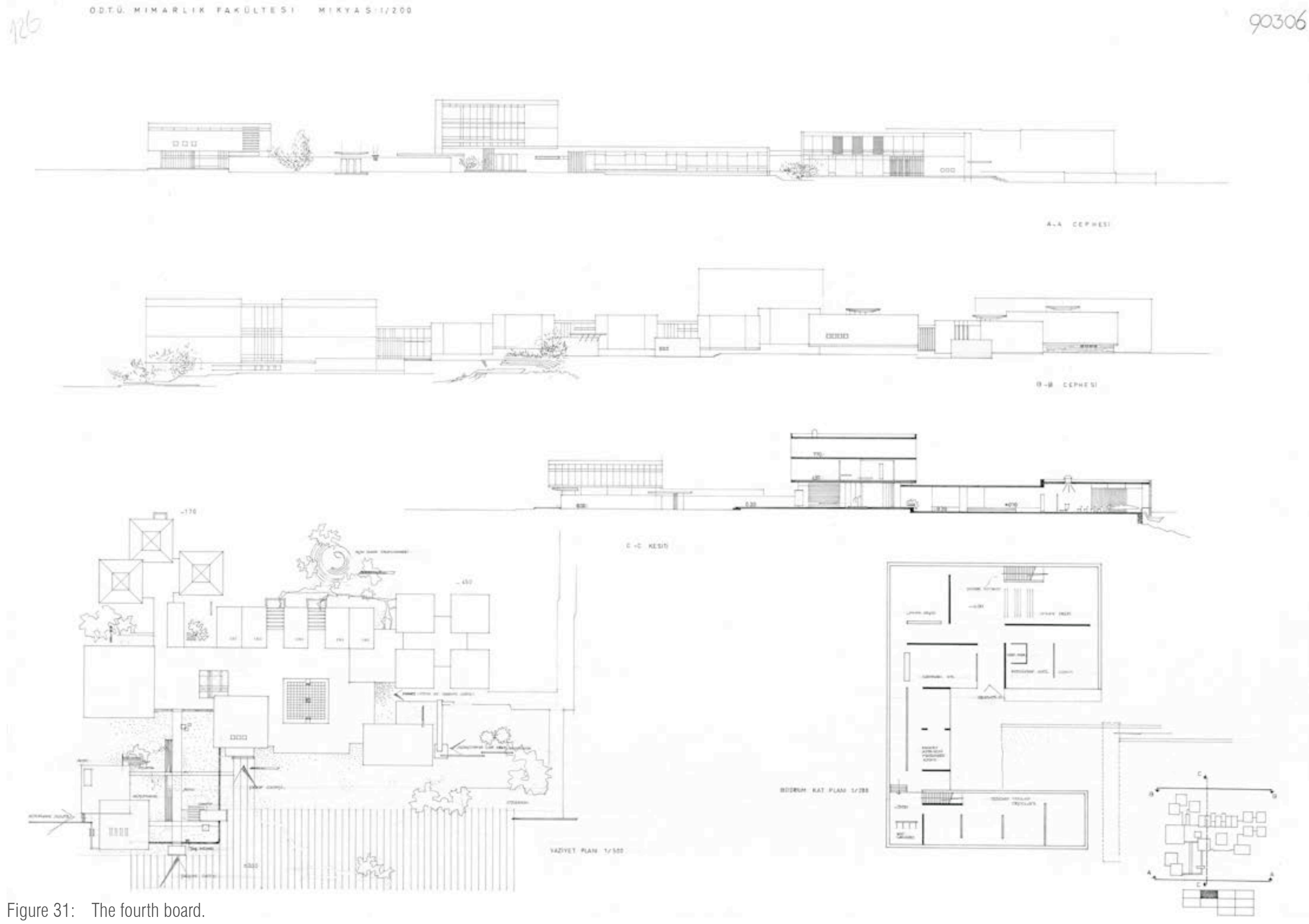


Figure 31: The fourth board.

The Elevation B-B illustrates the west façade and it has similar characteristics to Elevation A-A. This façade is limited in detailing, and emphasizes the skylights as elevated concrete surfaces. Following the traces of the glazed surfaces, it is possible to differentiate the main functions connected with an uninterrupted circulation in this drawing.

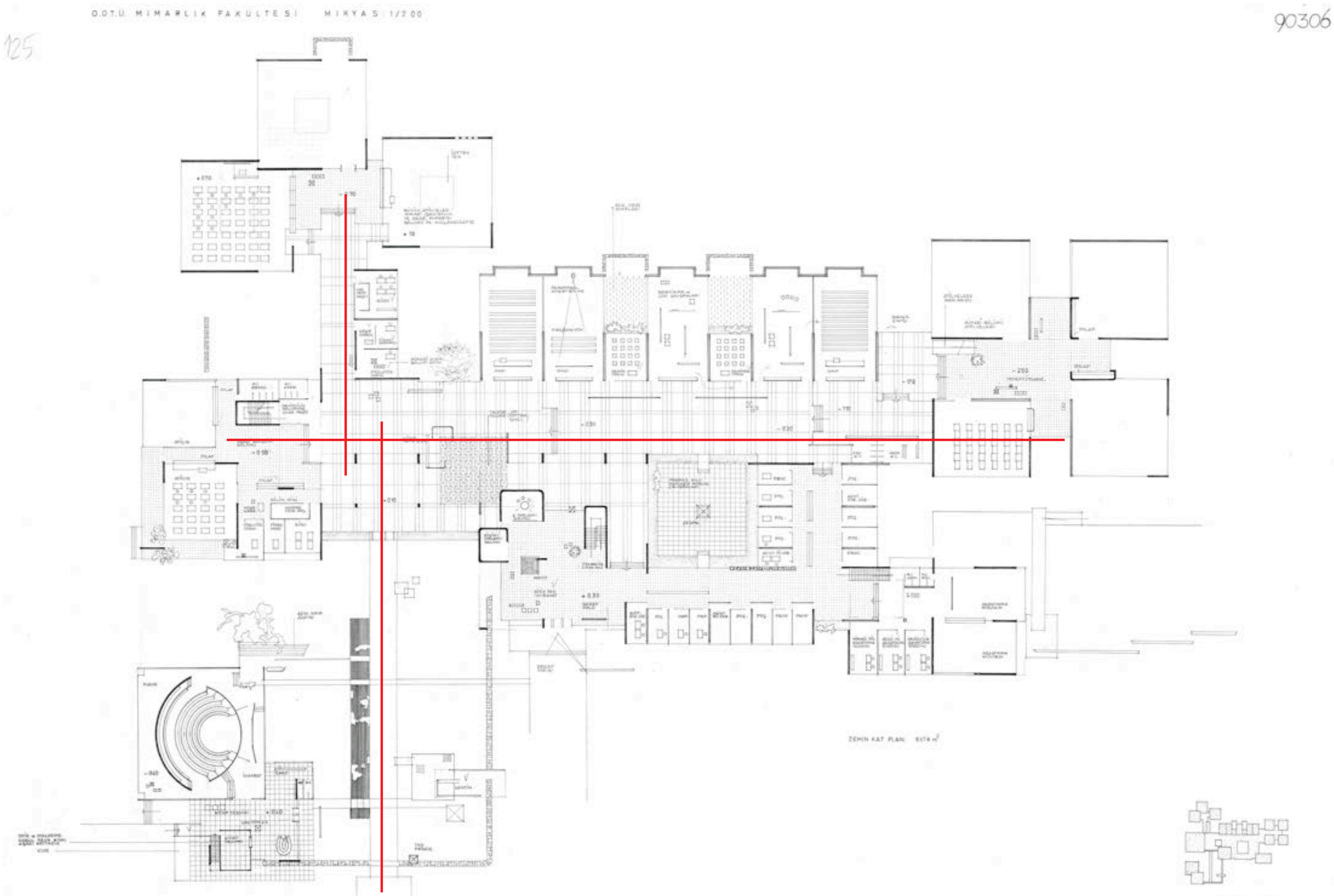
The Section C-C shows the level differences, natural light control, skylights, natural air circulation, internal façades, furniture, entrance eaves and the landscape elements, including the pool.

The Basement Plan: This U-shaped open-plan is divided with shear walls and temporary partitions to provide space for model making, welding and photography workshops, storage spaces, HVAC and services. It has direct entrance from the outside through a semi-open courtyard.

The Site Plan: This top view illustrates the main entrances and the figure-ground relationship of the landscape and the fragmented masses. The five main entrances are indicated as: Prof. Entrance, Student Entrance, Research lab. Entrance, Library Service Entrance and the Model/photo. Service Entrance. Here it is possible to see the integration of the masses with the one storey-high common circulation places. There is an open-air amphitheater that is located at the west side of the building connected to the semi-open courtyards between the classrooms. Between the main pedestrian path and the east façade, there is a narrow band dedicated to car parking.

The fifth board: METU Faculty of Architecture in 1/200 scale:

The fifth drawing board is a 102x68 cm white cardboard, which includes the ground floor plan of the Faculty of Architecture in 1/200 scale (figure 32). The total surface area of the main circulation spaces and the served spaces are almost equal in this drawing. The variety of spaces are identified with single lines, double lines, hatched double lines, hatched surfaces, dots, arrows and text. These lines represent the windows, walls - cupboards, shear walls - retaining walls, floor surface patterns, pool and the stairs. The functions are listed as: the student entrance with the stone lantern, library, closed and open-air amphitheaters, canteen, closed and open-air workshops, circulation and recreation halls, meeting rooms, closed and open-air classrooms, jury spaces and exhibition spaces, seminar rooms, bookstore and the reading space, staff rooms, courtyards/open-air model workshop, the ceremonial entrance and its hall with a waiting lounge and services.



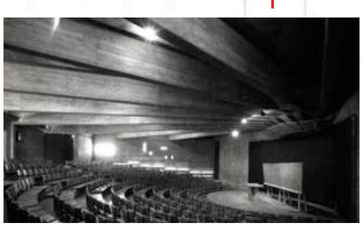


Figure 12: Interior view from the Amphitheatre, showing the structural system of concrete beams.

Figure 32: The fifth board, ground floor plan of the Faculty of Architecture building (1/200), main circulation axis highlighted.

At the first glance, it is possible to see similarities between this open-plan scheme and the general campus plan (Board no:1). The main circulation area and the perpendicular, west extension is hatched with alternating horizontal and vertical divisions that call back to the representation of the main pedestrian path in the campus. Moreover, the geometrical organization of this linear space, in both plan and three dimensions, resembles the formal aspects of the main pedestrian path (figure 33). The connection of the masses to the circulation paths both in the building and the campus present identical principles. The same method is applied for the

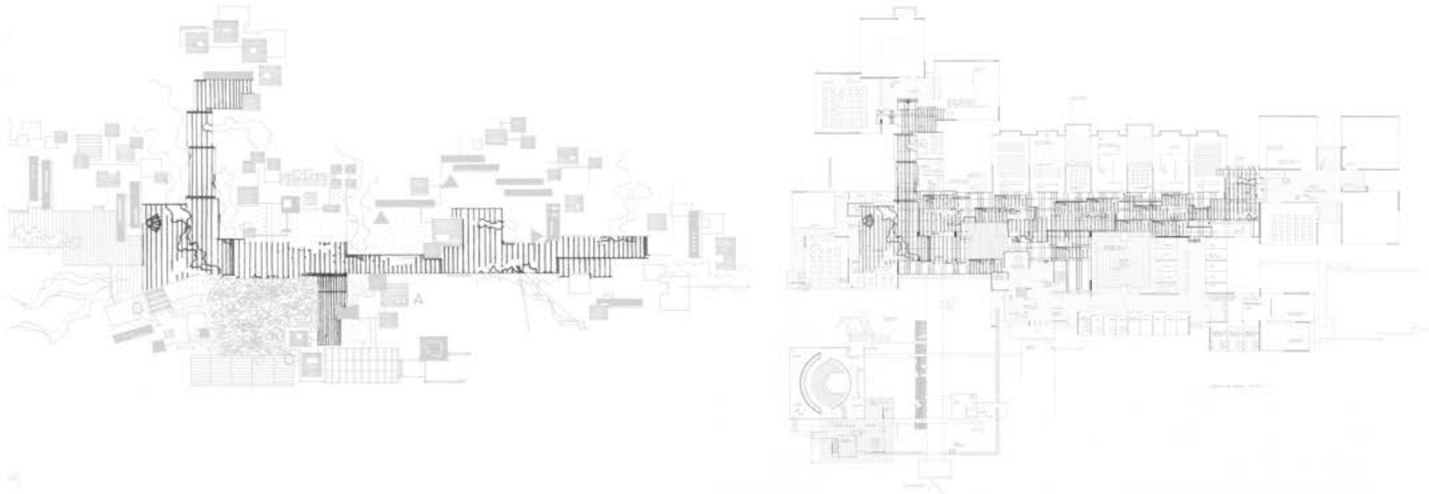


Figure 33: Campus main pedestrian road, Faculty of Architecture circulation platform.

application of the linear circulation and the fragmented masses on the inclining topography. Although drawn in different scales, the level differences have similar characteristics. The richness of the plan quality and the idea of open plan are clearly visible in both drawings.

This very detailed drawing powerfully represents the architects' intentions. The expression of each function into a different and specialized mass is very obvious in this drawing. Each function expresses itself with its own "box." The structural system and the shear walls are organized in such a way that the spaces accommodating different functions do not share the same wall. Whenever two masses have to function together, two methods apply: either the walls do not touch each other at all and get connected with a circulation platform or are juxtaposed the walls on top of each other from a corner. This system applies to whole campus design, and even to the design of the built-in furniture and art objects in the Faculty Building (figure 34, 35).

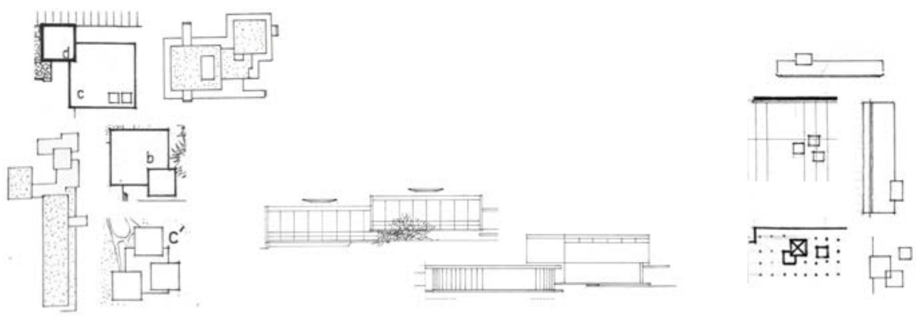


Figure 34: Corner to corner geometries.

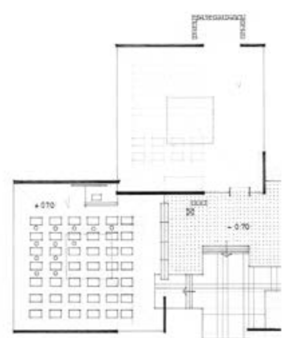


Figure 35: Free standing shear walls

Unlike in the elevation drawings, it is almost impossible to read the actual physical borders of the masses in the plans. The distribution of the spaces suggests the fragmentation and the re-composition of the masses in these drawings (figure 36). This process makes every unit a well-defined whole, as well as a well-functioning part of a larger whole. The organization of the open plan with shear and partition walls is supported by the strategic location of the linear temporary separators. These non-load bearing separators and temporary partition walls enhance the idea of the flexibility of spaces (figure 37).

Figure 36: Fragmentation and re-composition of the masses.

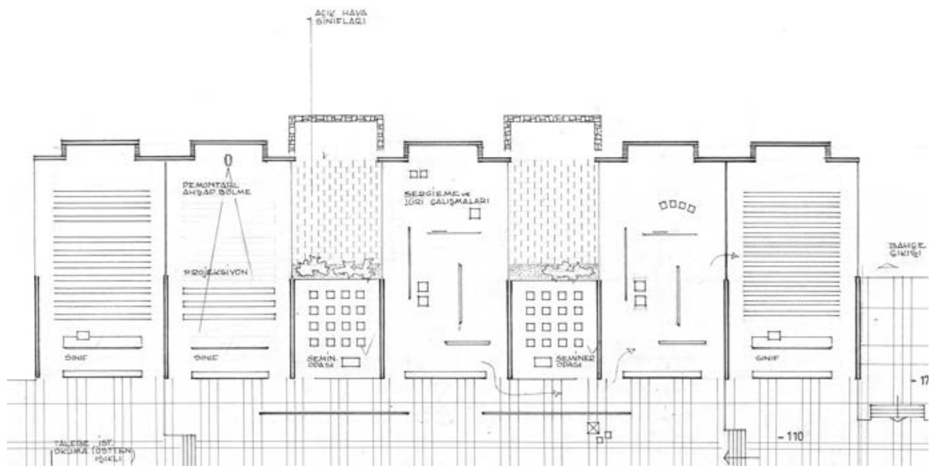


Figure 37: Classrooms on the west façade with flexible use, close-up of figure 25.

The sixth board: METU Faculty of Architecture in 1/200 scale:

This drawing, on a 99.8x68.6cm white cardboard, contains a façade, a plan, and a section drawing (figure 38). The south façade and the section drawing show similar characteristics with the abovementioned drawings of Board no 4.

The plan illustrates the upper floors of the two and three-storey units. The initial decisions of the architects regarding the massing and the continuity of the structural elements limit the spatial division of the upper floors, particularly in the workshop areas. The library detaches itself from the amphitheater at the first floor. A relatively smaller unit, the Dean's Office block, which is the only three-story mass in the building complex, shows a variety of spaces within a limited area. This might be explained with a probable freedom taken from the requirements of the structural system. Here the shear walls are indicated with black hatching, yet, they do not always reach the ground. These specialized spaces also have different ceiling heights (figure 38).

Except for the formal aspects of the key plans and the site plans (grid), the consistency of the idea of "open-plan" continues in the following four drawing boards. As they illustrate the Dormitory building and the Administrative building and not the Faculty of Architecture

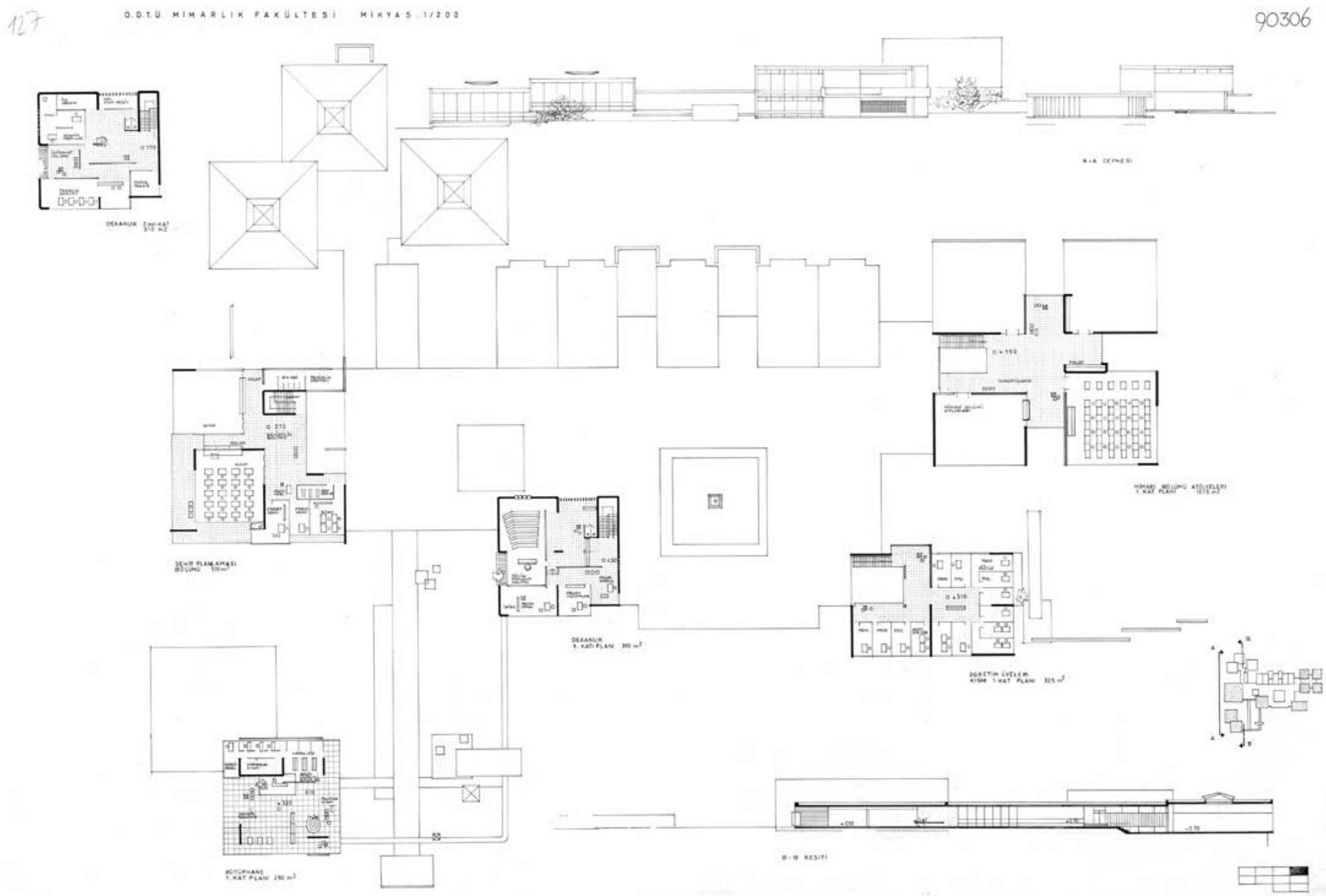


Figure 38: The sixth board.

building, they are not included in the report. These formal aspects repeat themselves in the plans of the Faculty of Architecture building and provides a tool to further analyze and understand the intentions of the architects (figure 39). The reading of the following architectural sets is comparative and limited in detailed description in order to avoid repetitions.

Figure 39: Typical dormitory building drawing in the competition entry, traces of the open-plan idea.

3.1.1.2.3.2. Concept Drawings

The second orthographic set includes the "Concept Drawings" of Çinici Architects. Rather than an architectural set, the drawings illustrate the electrical engineering project. Although the architectural set does not exist, it is possible to read the decisions given regarding the initial architectural concepts from these 1/100 and 1/50 scale drawings. It is very unusual to find the traces of architectural decisions in an engineering drawing, however, this particular set presents the required information. It contains the ground floor plan, first floor plan and the "-2.80" and "-3.55" level the plans, east-west section, other partial sections and interior elevations in four sheets (956.7x914.4 mm, 1087x914.4 mm, 984.2x914.4 mm, 1012.6x914.4 mm in dimensions) (figure 40).

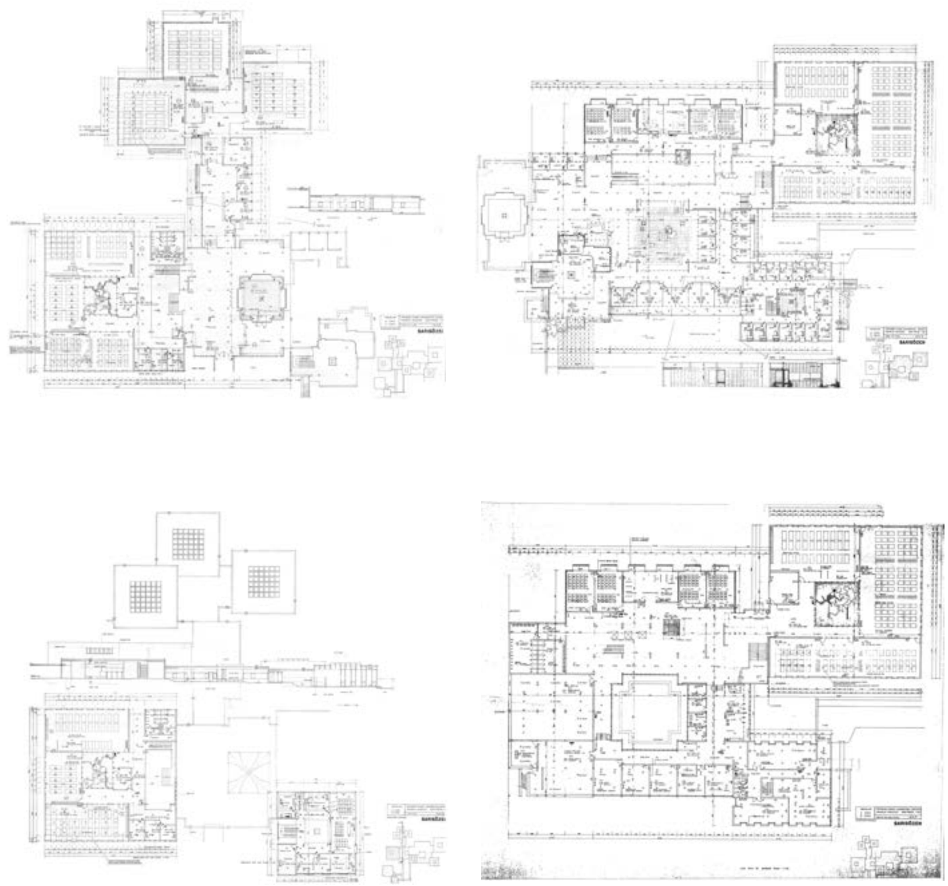
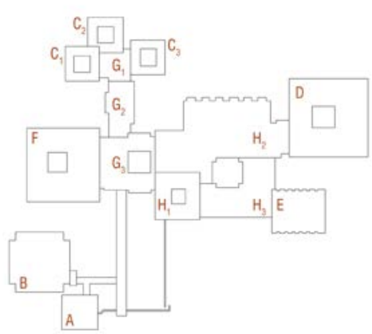


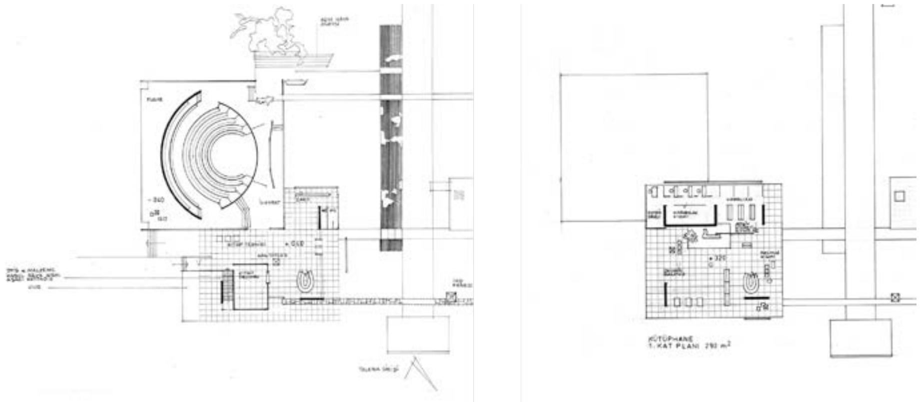
Figure 40: The four sheets representing the conceptual drawings of the Faculty building.



The block names in the building are given in the format of letters in an alphabetical order at the Application Drawing phase, however, to make the reading easier throughout different phases, these letters are also used in the explanation of all the following drawing sets:

- Conceptual drawings,
- Application drawings,
- Published Drawings,
- Survey Drawings.

The Concept Drawings are significant for another specific reason: they convey very similar information with the application and published/as-built drawings and the current state of the building. Compared to the Competition Drawings (the dream of the architects), the general layout and the design principles of the building do not change notably. In this particular set, however, the number of the functionally defined spaces increase and thus form a more compact plan layout. The heights of certain blocks, except the Dean's Office, are also increased to double-floor masses to accommodate more classrooms, seminar rooms, exhibition and jury halls, research labs, photography workshop, canteen, student club's room, first aid room, switchboard room and offices. The Dean's Office was reduced from three stories to a two story block and the studio units remained as single volumes.



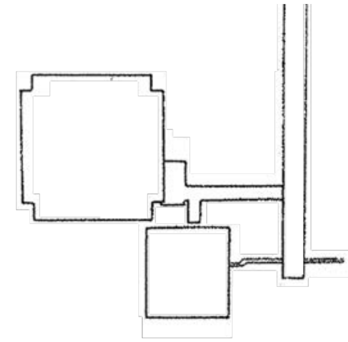


Figure 43: Schematic key plan drawings of the library and the amphitheater in the conceptual project.

Figure 41: Library and the amphitheater plans in the competition project.

The drawings of the **A and B blocks**, the library/museum and the amphitheater, are not present in this drawing set. Only the schematic key plan drawing of the building complex that is indicated at the lower right corner of the sheets shows these two blocks (figure 43). According to this simple plan, the once juxtaposed building blocks are now completely separated. Their connections with each other and the main building are provided by a secondary arcade, which is also connected to the main entrance arcade. Another pattern that does not exist in the Competition Drawings but appears in the Conceptual Drawings is the corner treatments of the B block and the amphitheater. The corners are carved out in square shapes and the same articulation is also applied at the corners of the central courtyard. The impact of this formal articulation is enhanced with the use of the same form for the retaining walls inside the courtyard (figure 42).

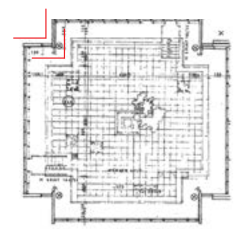
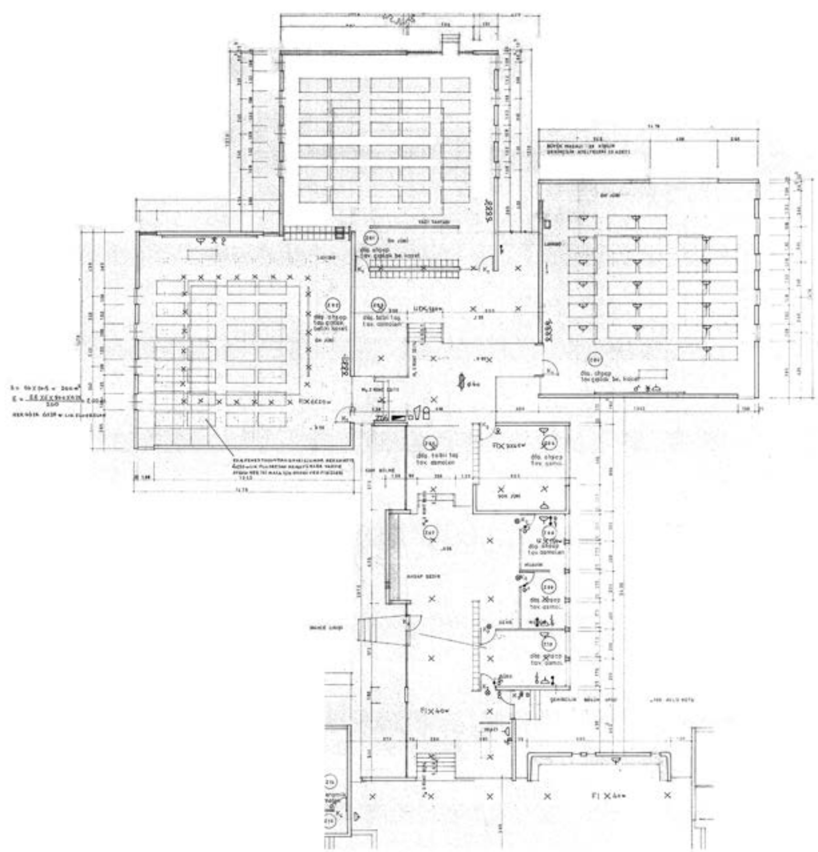


Figure 42: Corner treatment of the central courtyard in the conceptual drawings.



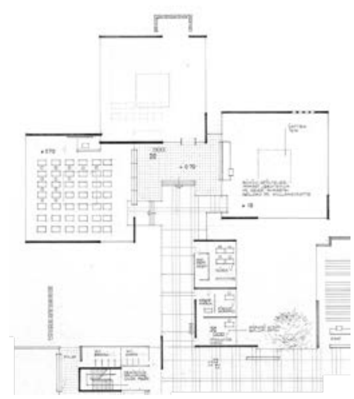


Figure 44: C1, C2, C3, G1, G2 Blocks plan in the conceptual drawings.

Figure 45: C1, C2, C3, G1, G2 Blocks plan in competition drawings.

The design decisions regarding the west studios that were depicted in single volumes **C1, C2, C3** and the lobby spaces in-between, **G1, G2**, do not change throughout the development of the different project phases (figure 44, 45). The main space distribution is maintained in the Competition Drawings, Conceptual Drawings, and the Application Drawings. The elevations of these five blocks, however, improved radically in plans. In the Competition Drawings, the window locations and divisions were not visible in the plan and they were represented in single lines. In the concept drawings, on the other hand, it is possible to read the horizontal band windows and large window openings. Particularly the pattern which shows the articulation of windows and shear walls in one-meter divisions (figure 44) becomes evident in these drawings. This pattern repeats itself on the east, west, south and north façades of these studio blocks (C1, C2, C3, D, F blocks) (figure 46).

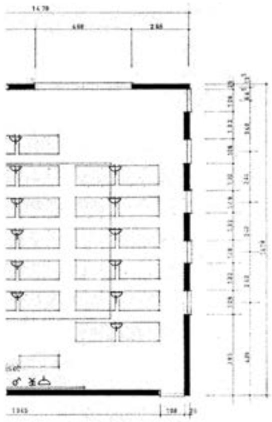


Figure 46: Window articulation, close-up of figure 44.

In the Competition Drawings, **G3 block** is not separated from H2. Although there is a five-step level difference, following the circulation pattern of the building, the hatching technique shows that G3 and even G1, and G2 blocks are designed as a single volume (figure 47). In the conceptual drawings, the borders of the G3 Block are clearly defined with level differences and expansion joint lines. In these drawings, the G3 block does not change volumetrically; it remains as a single story circulation hall punched with a sunken common space (figure 48), now called "*Kubbealtı*".[17]

Figure 47: Same hatch connecting G3 and H2, close-up of figure 25.

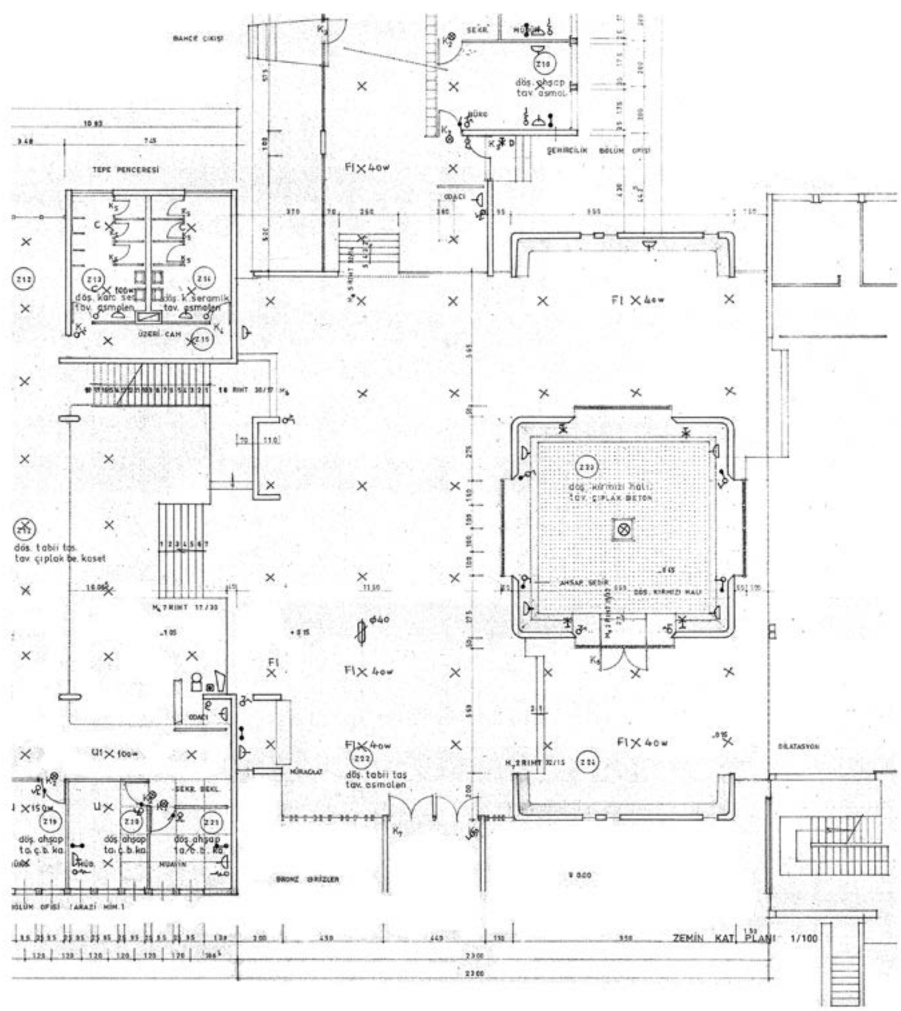


Figure 48: G3 Block plan in the conceptual drawings.

[17] Kubbealtı means under the dome, although the form is not a dome, the light quality that the skylight creates, calls for the existence of this traditional architectural element.

There are occasional U-shaped and L-shaped shear walls in the overall project; yet the G3 block is unique because it is composed of only these wall types (figure 49). Designed in different dimensions, they define secondary spaces particularly to subdivide the large circulation halls. Positioned in the west, north and south, the U-shaped walls emphasize the solid-void relations, indicate the entrances, and control the movement patterns. The L-shaped walls, on the other hand, define the sunken space which is originally designed as a reading room for the students. The idea of a skylight covering the ceiling of the reading space continues from the Competition Drawings. In these drawings, the space is attached to the Dean's Office (H1 block) from its north-east corner. The hatching technique used for the representation of this area was also used in the campus site plan for the "ceremonial square" located in front of the rectorate building (figure 50, 51). This may be interpreted as an indication of another ceremonial space within the Faculty Building complex.

In the Concept Drawings, on the other hand, the reading room (now called *Kubbealtı*, or "under the dome") is positioned at the center of G3 so as to become an autonomous unit. It has a symmetrical plan layout with L-shaped shear walls that are located on four corners. These walls strengthen the solid-void contrast that is a result of the U-shaped walls in the same area. Although all the elevations are treated in a similar manner, the entrance to the reading room is located on the east. A wooden "sofa (sedir)" circulates to define the edges of the sunken square (figure 48).

The plan note for this area indicates that the floor was first intended to be covered with red carpet and the ceiling would be made out of exposed concrete. Here, the juxtaposition of traditional and modern architectural elements, such as the sofa and exposed concrete, needs to be underlined. It should not be a coincidence that in the course of sixty years, certain spaces in the faculty building complex were named after traditional architectural elements such as "*Kubbealtı*/under the dome", "*Göbektaşı*/tummystone", "*Çeşme*/fountain" and "*Han Kapısı*/gate of the Caravanserai". While it was not the architects who named these spaces as such, the architectural qualities of these particular spaces evoked their historical precedence.

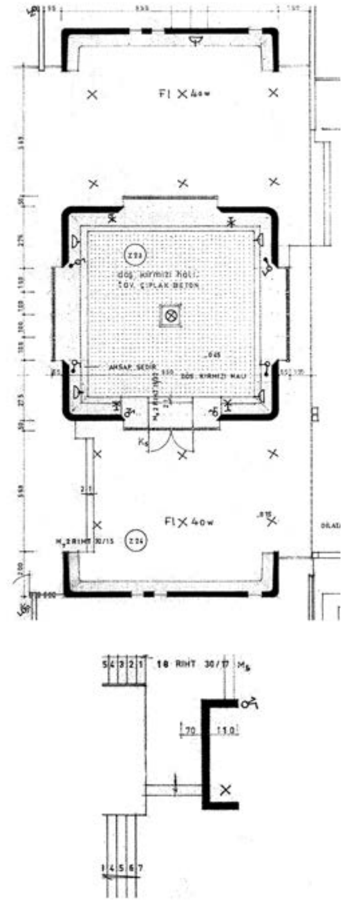
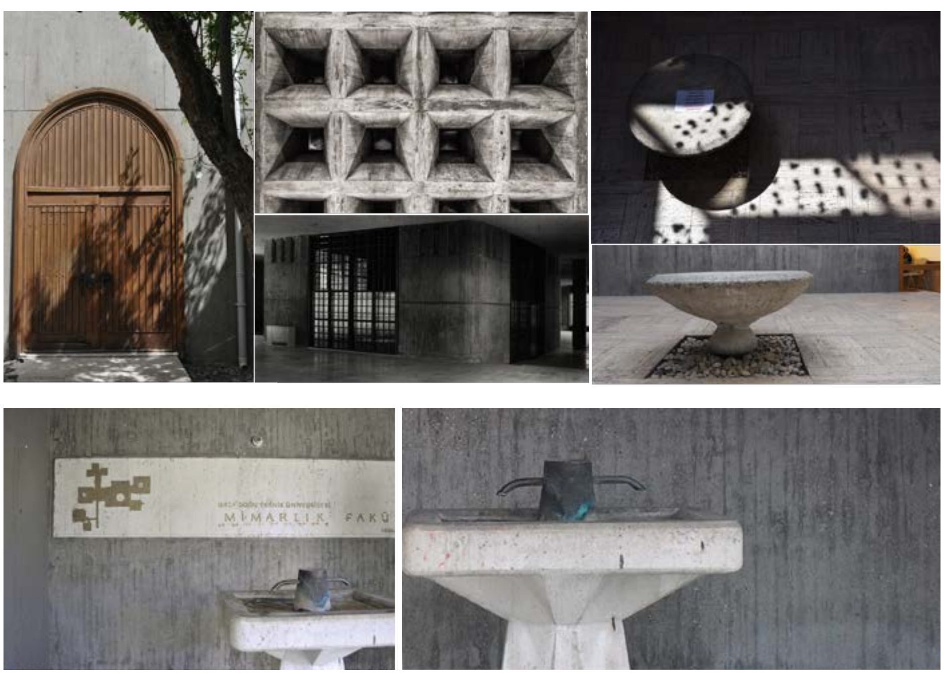


Figure 49: U and L shaped shear walls.



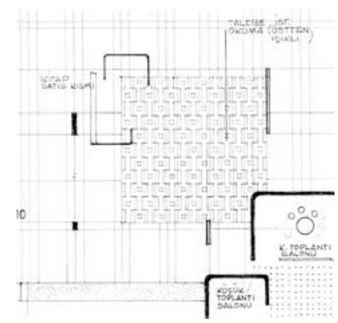


Figure 50: Plan of "*Kubbealtı*" in competition drawings.

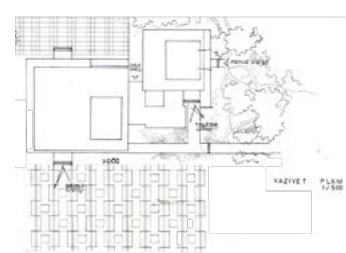


Figure 51: Same hatch representing the "ceremonial square" in front of the rectorate competition drawings.

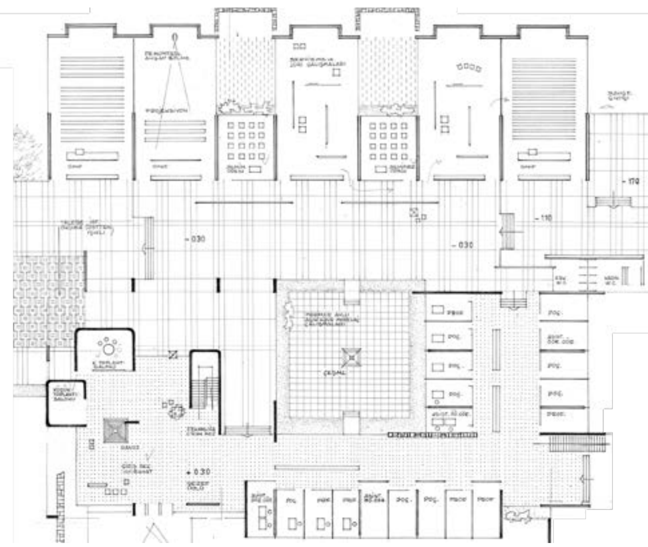


Figure 52: The H2 and H3 blocks in competition drawings.

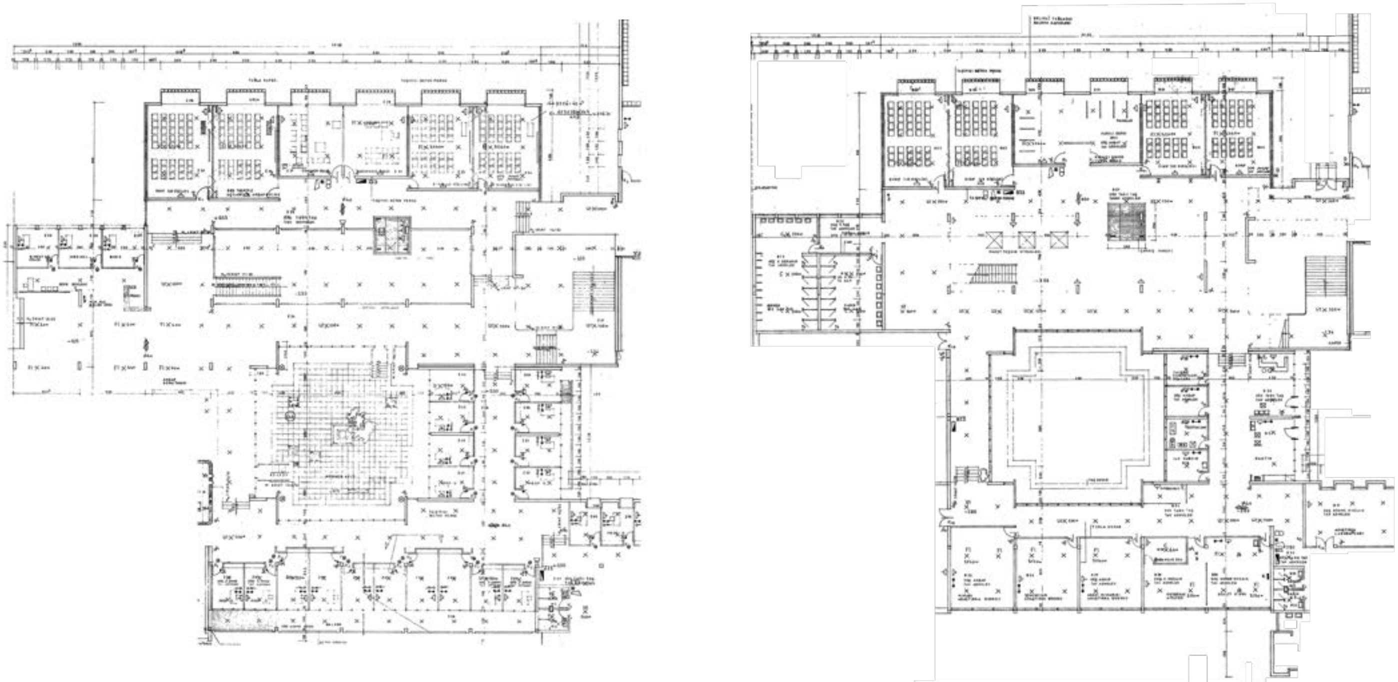


Figure 53: The H2 and H3 block plans in conceptual project.

As the plans are the major tools to understand the volumetric differences in the building, one specific alteration that they represent can be observed in the **H2 and H3 Blocks**. In the Competition Drawings, they were represented as single floor units and were combined to form a single rectangular space in plan. In the conceptual drawings, H2 and H3 are divided into two separate double floor units. The reason for this volumetric separation is the application of two different methods for the design of the double floor units. In the H2 block, a service staircase connects the two floors. In the H3 block, on the other hand, the ground floor slab defines a gallery hole, which volumetrically connects the two floors and this connection is also supported by two freestanding staircases. The courtyard in between H2 and H3 is located at half floors to accentuate the separation of H2 and H3 even more strongly. The level difference between H2 and H3 is further enhanced with a five-step level difference (from -3.55 to -2.80). This idea of separation of different circulation areas with a few step level differences originates from the Competition Drawings.

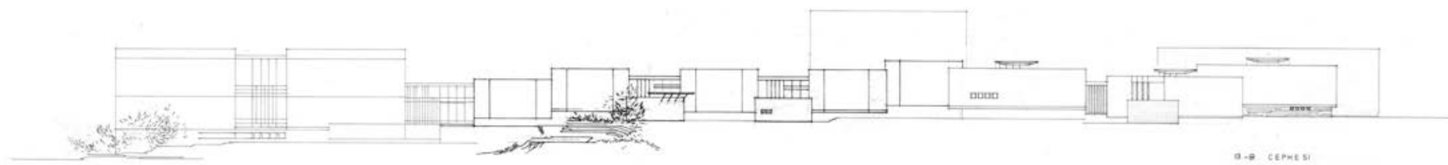


Figure 54: West façade in competition drawings.

In the Competition Drawings, the west façade of the H2 block is fragmented to move back and forth to create a physical three-dimensionality and to allow the formation of closed and open-air classrooms. A similar movement pattern can be observed in the placement of the masses on topography. Particularly on the west façade (figure 44), each classroom, seminar and exhibition room can be identified with its own autonomous mass.

The open plan organization and the flexible layout provide the possibility of further connections between these spaces. The relationship between these rooms and the circulation hall is managed by the partition walls. There are no conventional doors to enclose the classrooms and the seminar rooms. The arrows indicating the alternative movement patterns support this reading and differentiate them from the other spaces shown without doors (figure 52). In the Concept Drawings, the major difference in this part of the building is the addition of a floor, which is placed under the ground floor (-3.55) With this -3.55 level addition, while the number of the classrooms increases, the variety of space decreases and while the partition walls between the classrooms remain, the open-air seminar rooms disappear. The three-dimensional movement of the façade representing different masses for different functions transforms into a singular rectangular mass. The alterations on the façade surface, both in the exterior (west) and interior (east) remain almost the same. What is unique in the west façade of the classrooms is the introduction of *brise-soleil* made out of hollow concrete blocks. The idea of flexible space and open plan continues between the classrooms, with the introduction of flexible wooden partition walls that are also providing sound insulation. The formation of the gallery holes on the ground floor does not change the pattern of level differences in the main circulation hall. The idea of creating entrance halls like well defined “plates” with different heights is another repeating theme in the plan.

In the Concept Drawings of the H2 block, two unique architectural elements are indicated. The first is (again in contrast to the highly Modernist approach of the architects) a wooden bay/bow window, or rather a balcony-like protrusion called “*şahniş*” in Turkish. This protrusion was designed as part of the gallery hole, yet had never been built (figure 55). The second architectural element is the balustrade that surrounds the gallery hole. Although the material of this balustrade is noted as “hardwood” in the drawings, the balustrades were constructed in box section black iron elements/wrought iron studs (figure 55).

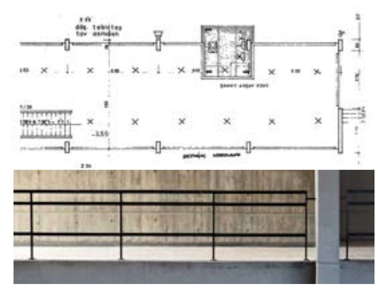


Figure 55: Plan drawing of the gallery hole in H2 block, and the applied balustrade.

In the Competition Drawings, rather than accommodating the **canteen**, service spaces, workshops and research offices, the H3 block is composed of only academic staff rooms. Similarly, in the Concept drawings, on the upper floor of the H3 block, there are academic staff offices with slight differences in the room articulations. In the Competition Drawings, these rooms that are located on the eastern part make a protrusion as a whole mass. In the Conceptual Drawings on the other hand, the east façade becomes a homogeneous surface enclaved by the placement of a closed balcony.

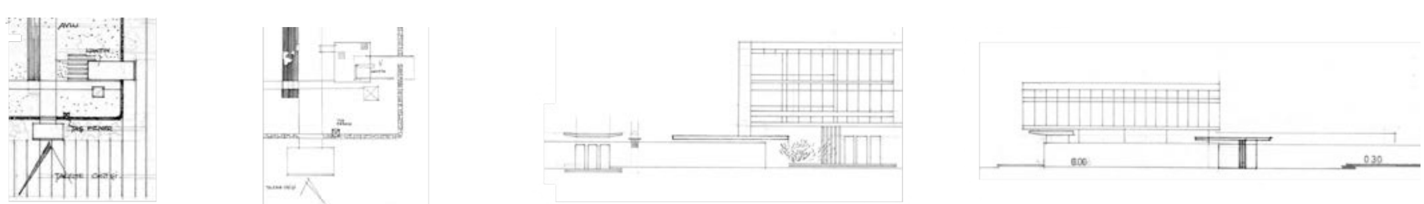


Figure 56: Drawings of the canteen in the competition project.

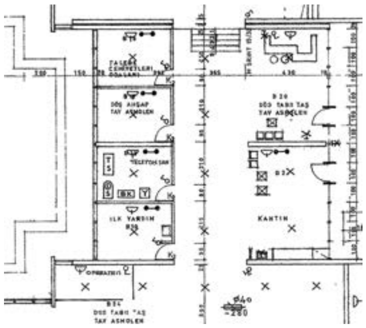


Figure 57: Canteen located on -2.80 level, close-up of figure 43.

One of the major differences between the Competition and Concept Drawings is the location and the conceptualization of the canteen. While it is located under the staff offices at the northern corner of the H3 block in the Concept Drawings, the idea represented in the Competition Drawings was to locate it as a separate unit in the garden, next to the library. In the Competition Drawings, the canteen is part of the library-amphitheater triangle that is connected with the main student entrance from the main pedestrian road, the arcade and the pool. Here, the canteen is represented as a simple, one floor rectangular prism with a flat roof (figure 56). In the Concept Drawings, on the other hand, the canteen is transformed into an integrated part of the H3 block, located on the -2.80 level. It has a glazed façade and is directly connected to the outside with two doors. Divided into two major parts, it shares the same volume and corridor with the student club rooms, switch room and the first-aid room (figure 57).

The **H1 block** is specifically designed to host the Dean's Office in the Competition Drawings. The idea of locating it as a separate block that is positioned at the entrance of the building complex remained the same throughout the different project phases. In the Competition Drawings, the hierarchy of masses is clearly indicated in the east facade and the Dean's Office occupied the highest level (figure 58).

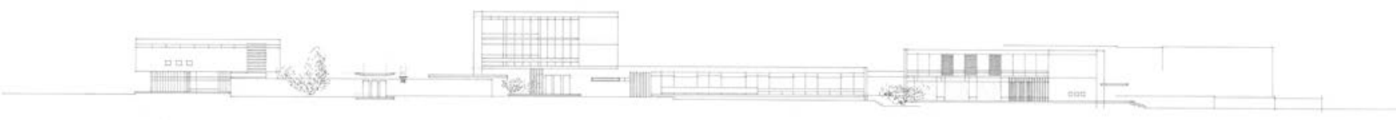


Figure 58: East façade drawing of the faculty of architecture in the competition project., the central block representing H1.

The "*Şeref Girişi* (Ceremonial Entrance)" connects the Dean's Office directly to the main pedestrian path. The entrance platform supports the idea of a free-plan, and connects the Dean's Office to rest of the faculty building. The off-centered location of the pool on the ground floor introduces a dynamic space organization to the entrance of the Dean's Office. The organization of the furniture supports this idea of decentralisation.

Figure 59: H1 Block plans in the competition drawings.

Starting from the closed staircase core, the upper floors act as single massive unit. As such, the Dean's Office becomes a self-sufficient building unit. The U, L and C-shaped enclosures such as the one defining the staircase, repeat in the rest of the volumetric organisations in this block. The small and large meeting rooms, the Dean's Office, Vice-dean's Office, visiting scholars' office and the Dean's staff rooms are all enveloped with these walls. According to the spatial requirements of each function, the form and the dimensions of the walls vary. In the Competition Drawings, on the first floor, there is a large meeting room, the Dean's and Vice-dean’s Offices. There is also a lounge separated with a four-step-level difference. On the second floor, the Dean’s staff offices, a file storage room, an archive and a room for visiting professors, surround a relatively larger circulation hall and a waiting room. Two small balconies act as expansions to the waiting lounge of the Dean’s Office and the waiting room.

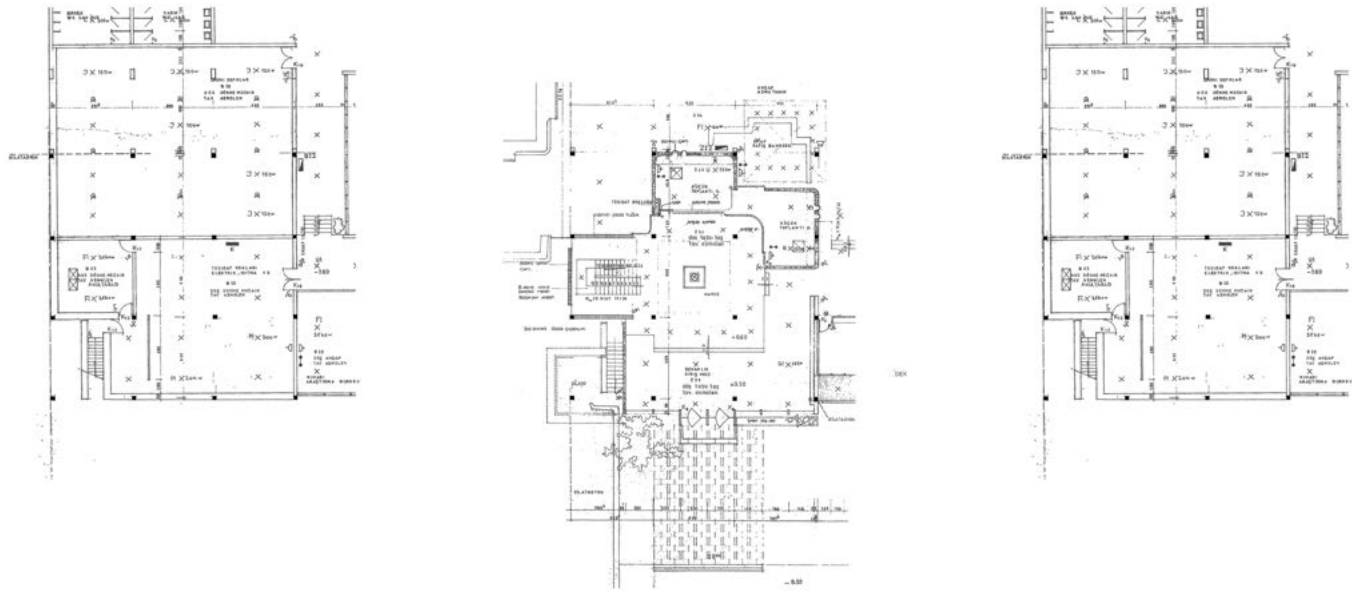


Figure 60: Basement, ground floor and first floor plans of the H1 block in conceptual project.

The major change in the Concept Drawings regarding the H1 block is the functional division among different floors. Although it remains as a three-floor mass, there is an underground floor to accommodate the mechanical rooms and the general storage rooms (*umumi depo*) with a separate entrance. This floor has two levels (-2.80 and -3.55) and is completely separated from the ground level. The entrance of the underground floor is defined by a raised platform, called “*plato*” by the architects. It acts like an open air entrance space for the connection of this floor with the underground spaces of the H2 and H3 blocks. The surface treatment of the entrance platform and the *plato* are completely different from the texture of the arcade floor leading to the student’s entrance, which then was conceived as the main entrance. The platform and the *plato* are juxtaposed, and form a sheltered space defined by fruit trees. Except the underground floor, the rest of the block becomes more compact and centralized in the plan drawings. The walls rendered as load-bearing concrete shear walls in the ground floor plan require further analysis, as they do not necessarily continue in the underground floor. Particularly the west walls of the small meeting rooms act as box structures. Besides these shear walls, there is a 3x3 grid structural system of nine square columns that are located six meters apart (figure 60). All the structural elements are designed and placed to support a square plan idea. The positioning and very small dimensions (30x30 cm) of the columns support the general idea of an open plan. The flying steps of the hanging staircase and the glass surface behind enhance the visual perception of transparency. The location, positioning and the material of the staircase changes radically in the Concept Drawings. The use of natural wood and cast iron makes the staircase a focal point as a free-standing entity. The wooden balustrade of the staircase here is unique for the fact that it is the only one executed in the material suggested in the detail drawings. The pool, which was located off-centered in the Competition Drawings, finds its place at a central position in the Concept Drawings. As the location of the staircase changes, so does the location of the small meeting rooms; but the idea of U-shaped walls remain. The velvet curtain that is dividing the two small meeting rooms is also another architectural decision unique to this plan. Besides the curtain, the architects suggest a wooden mesh surface and a solid wooden panel to separate these spaces from the entrance hall. The first floor accommodates the Dean’s Office, a Vice-dean’s office, a

Figure 61: Unchanged parts of the H1 block.

secretarial office, a supplementary office, an office for the guest professors, the meeting room, the archive and the toilets located around the central gallery hole. The stained glass artwork that is still present in the meeting room is also indicated in the drawing (figure 61).

The **E block** is conceived in three separate levels in the Competition Drawings. The underground plan is illustrated in the board no:4, attached next to the site plan in 1/200 scale. The peculiarity of this plan is its location next to the site plan in the fourth board, which reads like a last-minute addition. Located in-between the E, H2 and the H3 blocks, the underground floor has its own entrance from the north, connecting the storage areas, dark room, photography workshop, welding workshop, blue print room, mechanical rooms and the model workshop next to the carpentry. Enclosed with retaining walls, it is drawn as a C-shaped autonomous unit (figure 62). The upper floor, on the other hand, is connected by a staircase and expands towards the east. The load-bearing/shear walls divide this rectangular prism to accommodate two research workshops, their offices (3) and services. At this level, the E block is separated from the H3 block with two steps (from 0.00 to +0.30). On the first floor (+3.10 level), there is a gallery next to the staircase and an entrance lobby connected to it, which leads towards the academic staff rooms (figure 63).

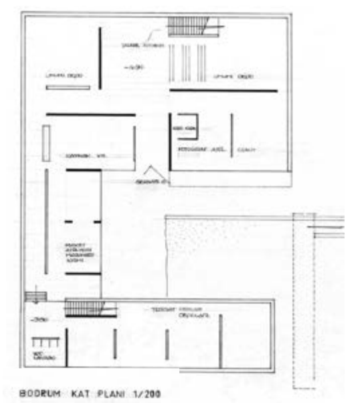


Figure 62: Basement plan (1/200), competition project.

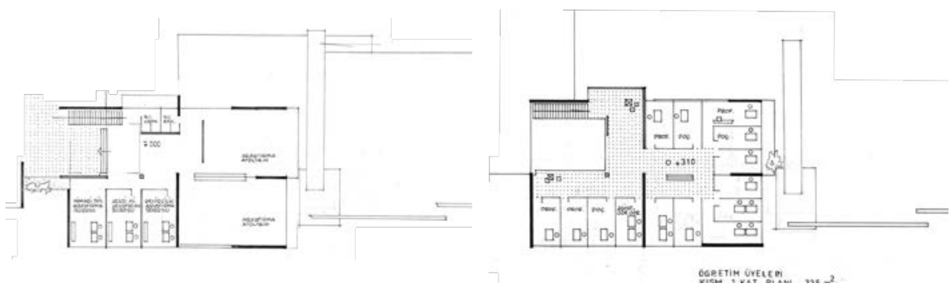


Figure 63: The E block plans in competition drawings.

In the Concept Drawings, the E block is composed of only two floors but expands its surface floor area towards the east. As the -2.80 level disappears, the ground level is raised almost one floor and has an entrance with a concrete staircase from level -0.97 to +0.90. This square shaped floor has a central hall named the "*Dinlenme Odası* (tea room/lounge)" with a skylight and service stairs attached to it. Around that there is a continuous corridor serving the academic staff offices and their service spaces. The E block is separated from the H3 block with 4 steps, from level +0.30 to +0.90. Under this floor, on the -2.80 level, there are research laboratories, model workshop, welding workshop and services with a service entrance. As the gallery space disappears, and the staircase remains within a concrete core, there is no connection suggested between these two floors.

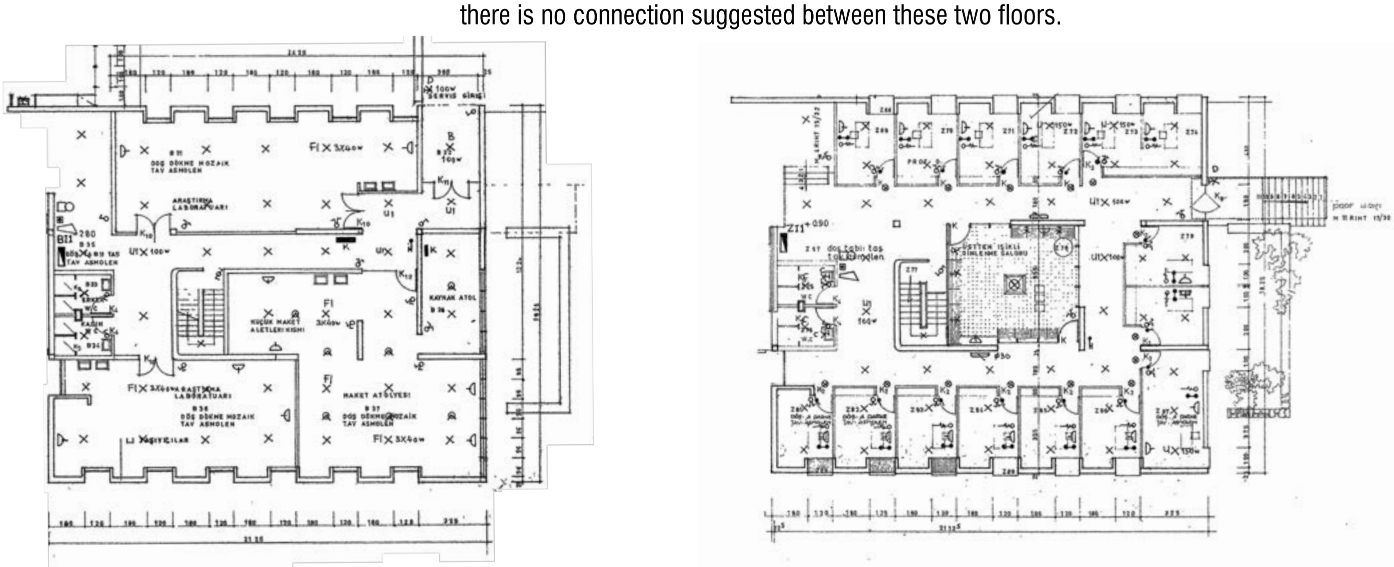


Figure 64: The E block plans in conceptual project.

What is unique for this plan is the east and west façade treatments of this block. In both façades, there are protrusions that are one meter apart. On the lower floor, they are simple glazing and concrete alterations; on the upper floor, on the other hand, the glazed surfaces open to small balconies. Here, the decisions regarding the placement of office furniture differentiates radically between the offices located at the east to west sides. The electrical equipment layout illustrated in the engineering drawings makes this alteration even more mysterious (figure 64, 65).

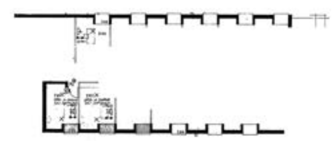


Figure 65: One meter protrusions on the east and west façades.

Both in the Competition and Concept drawings, the architectural studios are located at the north-west corner of the building. These studios are accommodated in a square plan two-floor block (the **D Block**). In the Competition Drawings, the four studios are positioned at the four corners of this square plan. They are connected with a circulation space that is called "*teneffüshane*", literally meaning a "breathing room" used mainly during the class breaks.

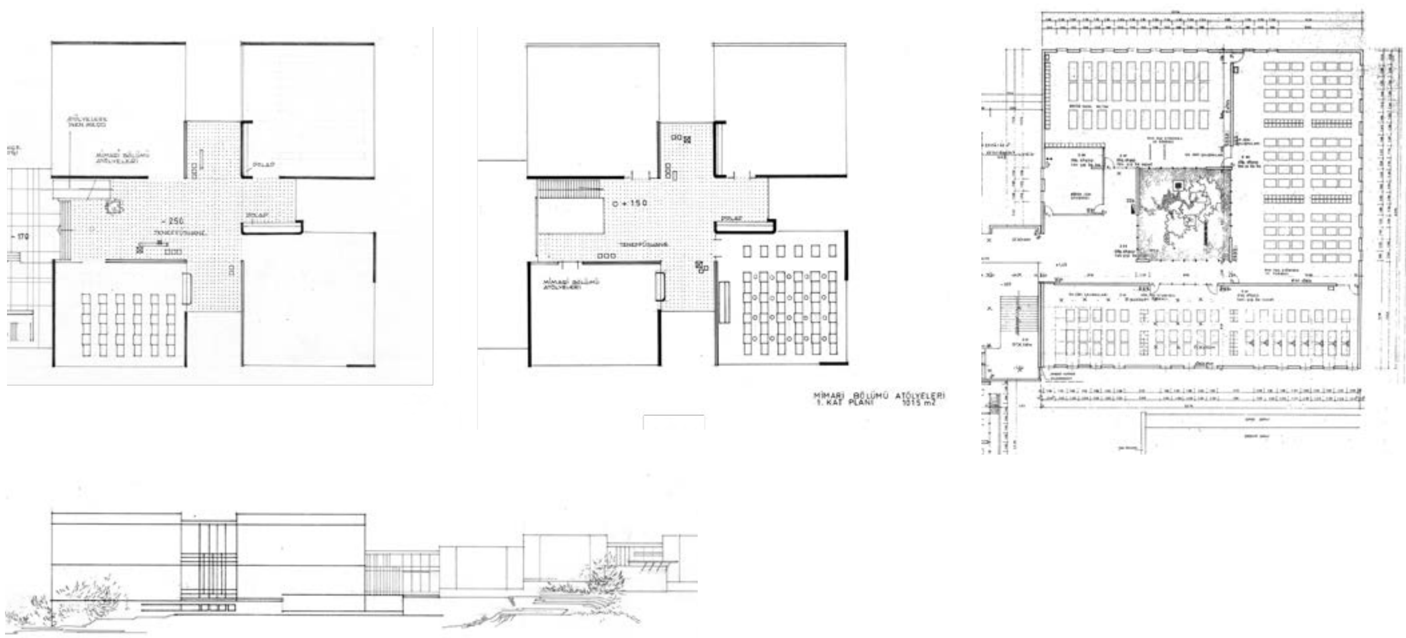


Figure 66: The D block plan drawings and west façade in the competition project, the first floor plan drawing of the D block in the conceptual project (repeating on the ground floor).

In the Concept Drawings, the borders of this block remain almost the same. However, the recessions of the façade, which separates the studio units and connects the circulation space to the outside, disappear. Instead, an open courtyard appears at the center of the block, surrounded by the studios. Instead of four, now there are three studios in varying sizes and proportions with direct contact to each other. A new and relatively smaller space is added to the plan composition, which is dedicated to the "grand jury studies".

Although there are no elevation drawings available for this phase, from the plan, it can be read that the fenestration pattern with one meter divisions is repeated in this studio block. The rotating shear walls defining each studio in the Competition Drawings disappear in the reorganization of the three studios in the concept drawings. The only reminiscence of this rather Miesian wall articulation can be seen in the structural elements defining the courtyard. Moreover, U-shaped walls that define studio storage spaces in the Competition Drawings also disappear in the conceptual phase. Except for the gallery hall next to the staircase in the competition phase, the first floor plan and the second floor plan have almost the same layout. Similarly, first floor and second floor plans are identical in the Concept Drawings.

The last block (F BLOCK) is the focus area of this project. Although the following analysis of the architectural drawings will be focusing on the pilot area, general remarks and comparisons will be made to include and illustrate the significant aspects of the rest of the building, when necessary. Unlike the other parts of the building complex, the selected area had been subject to several radical transformations throughout five defined phases of drawings (Competition, Conceptual, Application, Published, and Survey). The breaking point seems to be made by the architects during the transformation from the preparation of the competition projects to the development of the Concept Drawings. Thus, the Concept Drawings are especially important for this block since they represent an intermediary stage in the transition from the dream of the architects to the as-built project. One of the basic reasons of its significance is the radical change between the two phases, which is not the case for the rest of the building. A further analysis of the Application and As-built Drawings shows that architects continuously revise their ideas particularly in this stage of the project.

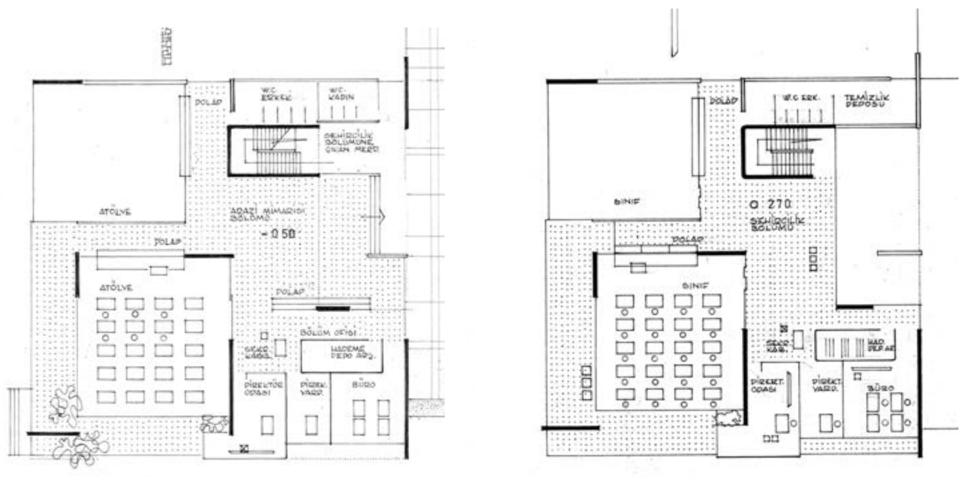


Figure 67: Plan drawings of the F block in the competition project.

In the Competition Drawings, the location of the central workshop is very crucial. Both the freestanding shear walls and the main circulation surrounding the space enhance its central position. The office spaces attached to this workshop, the secondary workshop and the service areas are all located, in a way, to define and serve to this space. The entrance next to this workshop and the furnishing also emphasize its significance. The toilets on the ground floor, the service spaces on the second floor and the distribution of the functions suggest that this was designed as an autonomous block to serve the "*Arazi Mimarisi* (Land Architecture Program)", in the ground floor and the "City Planning Program" in the upper floor. Three steps connect this block to the G3 block, which is otherwise detached from the rest of the building. The flat roof, large glazed surfaces, the flying linear balcony horizontally dividing the block into two and the transparency on the ground floor all indicate the modernized architectural inspirations for the architects. The separation of each mass according to departmental divisions and further separation of each block according to functional differences are clearly visible in this elevation (figure 68).

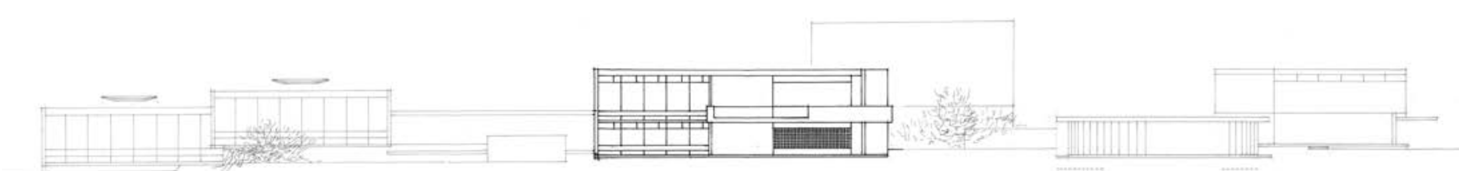


Figure 68: South façade drawing of the F block in the competition project.

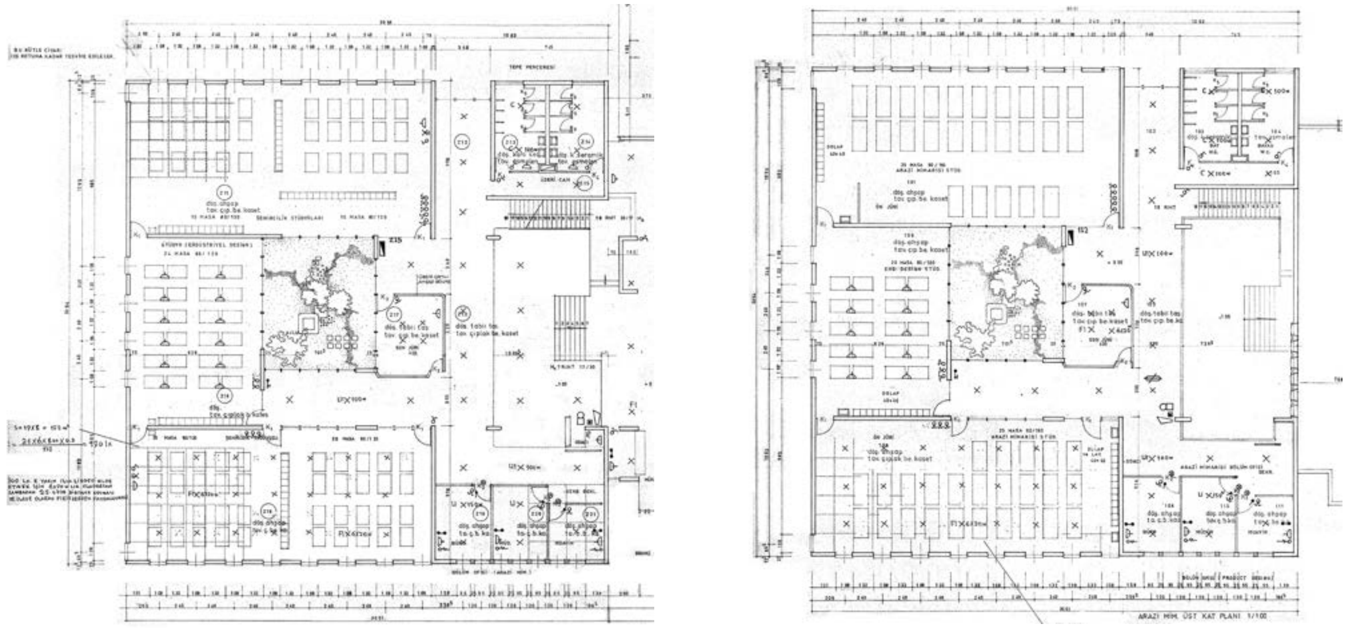


Figure 69: The F block plan drawings in the concept project.

What is maintained in the Concept Drawings is the original proportions of the mass; the rest of the architectural decisions change radically. The first major alteration is the expansion of the plan from both sides by three meters. The second alteration is the proposal of a central circulation system as opposed to peripheral organization in plan. In the Concept Drawings, a courtyard is located at the center and the studio spaces are organized around it. This spatial layout shows a great similarity with the D block; as a matter of fact, they are almost identical. Compared to the Competition Drawings, the Concept Drawings illustrate highly populated, relatively larger spaces. Moreover, the structural system changes where the column-like shear walls define the central courtyard instead of the studio spaces. Although the staff rooms and the service areas remain in their original locations, their scales, spatial qualities and interrelations change drastically. For instance, the main staircase, which connects the two floors and is located in an enclosed vertical concrete shaft in the Competition Drawings, frees itself from the walls and becomes transparent and visible from the gallery hole. The transformation of the plan from a peripheral organization into a central organization causes a radical shift in the control of the natural light. The corridors surrounding the classroom spaces in the Competition Drawings provide indirect light from all directions. In the conceptual drawings on the other hand, it is difficult to understand how the central courtyard becomes the major source of light. Surrounded by studios, the only way to obtain light to this space is from the skylight. As the façade articulation is not visible in the Competition Drawings, it is not easy to understand the major decisions regarding the orientation of the masses. In the Concept Drawings, on the other hand, detailed plan drawings indicate the establishment of a one-meter alteration of glass and exposed concrete surfaces in the façades of the studios. This pattern repeats in all studio spaces in the building complex, regardless of their orientation.

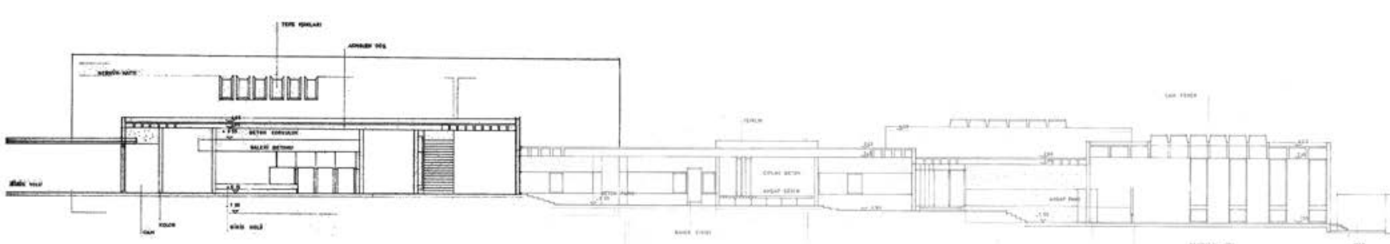


Figure 70: The east west section, representing the north façade of the F block, conceptual project.

3.1.1.2.3.3. Application Drawings

A complete set of drawings is available in the application phase. There are 64 sheets (approximately 1100x900 mm pdf versions of blueprints/transparencies) covering the information of the main building, amphitheater and the library (museum) in 1/200, 1/100, 1/50, 1/20, 1/10, 1/5, 1/2, 1/ 1 scales, and submitted to the rectorate on the 30th of June, 1962.

The set starts with a 1/200 scale site plan that is labeled as "*Umumi Yerleşme Planı*" (General Settlement Plan) (figure 71). It is a very unusual drawing in the way that it brings together different planes of the orthographic set. The plan, section and elevation are drawn onto each other with minimum detail, but with the indication of building dimensions and the level differences.

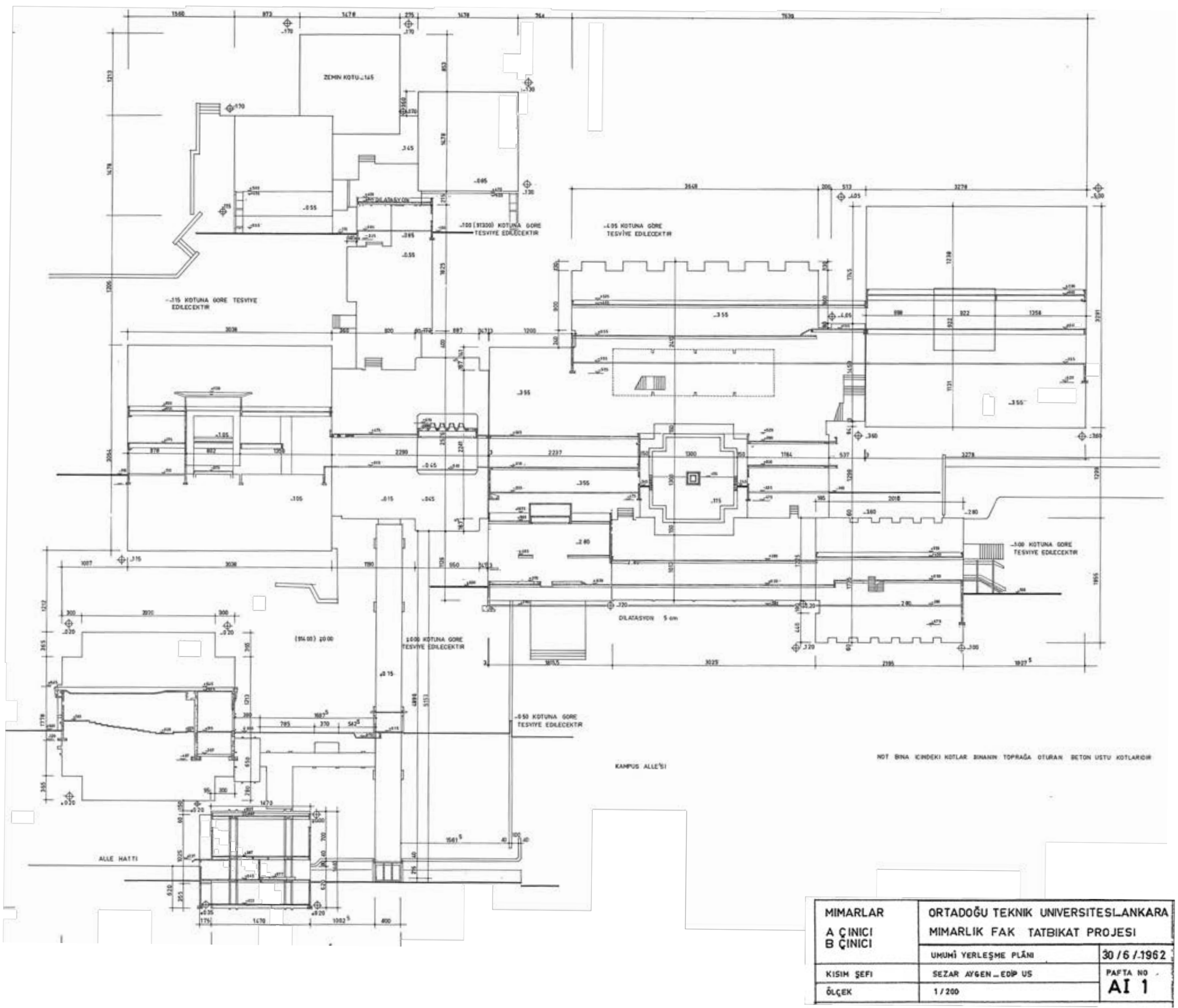


Figure 71: General settlement plan (1/200). On the right, the juxtaposed drawings of the orthogonal set is separated.

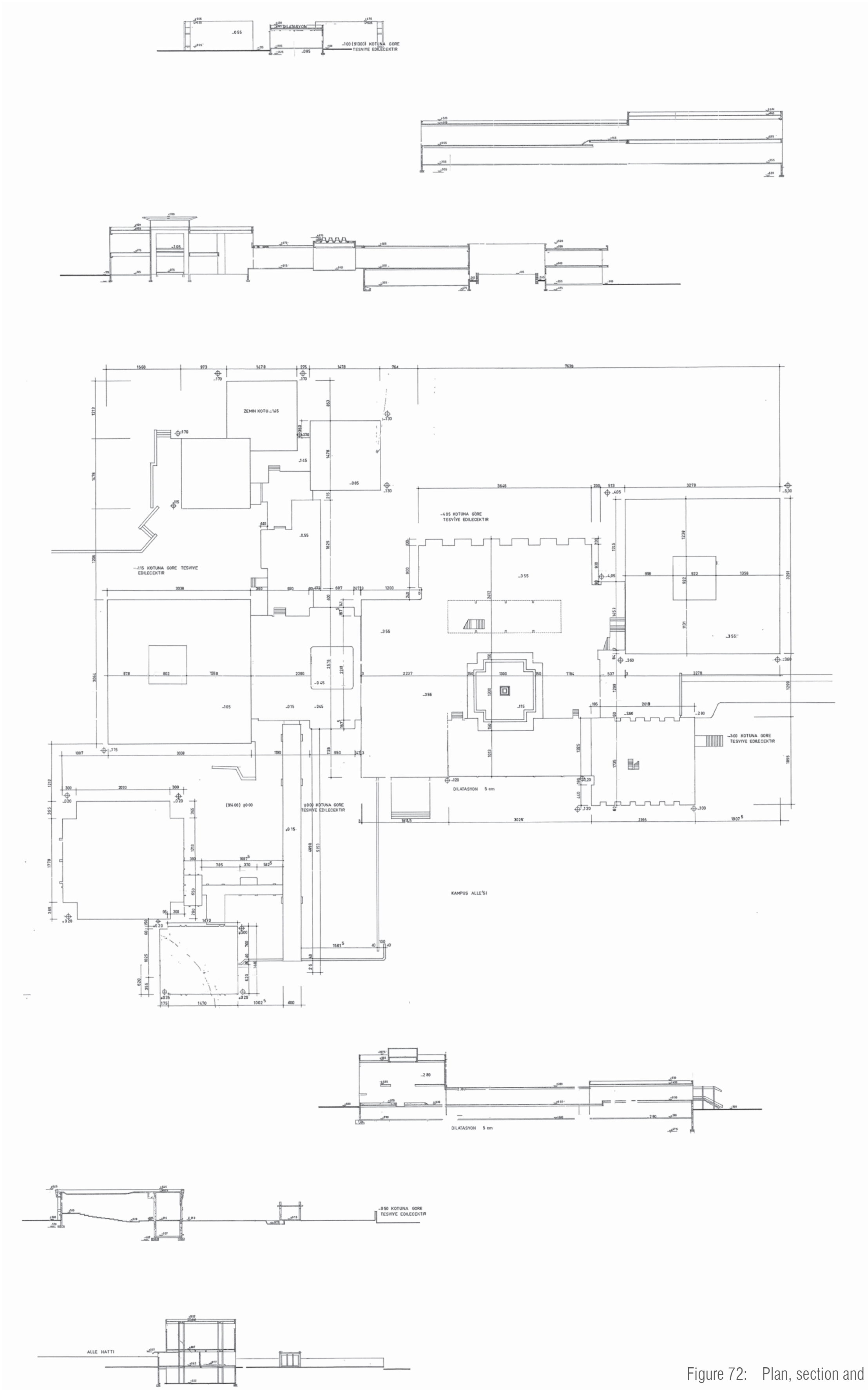


Figure 72: Plan, section and elevation drawings separated.

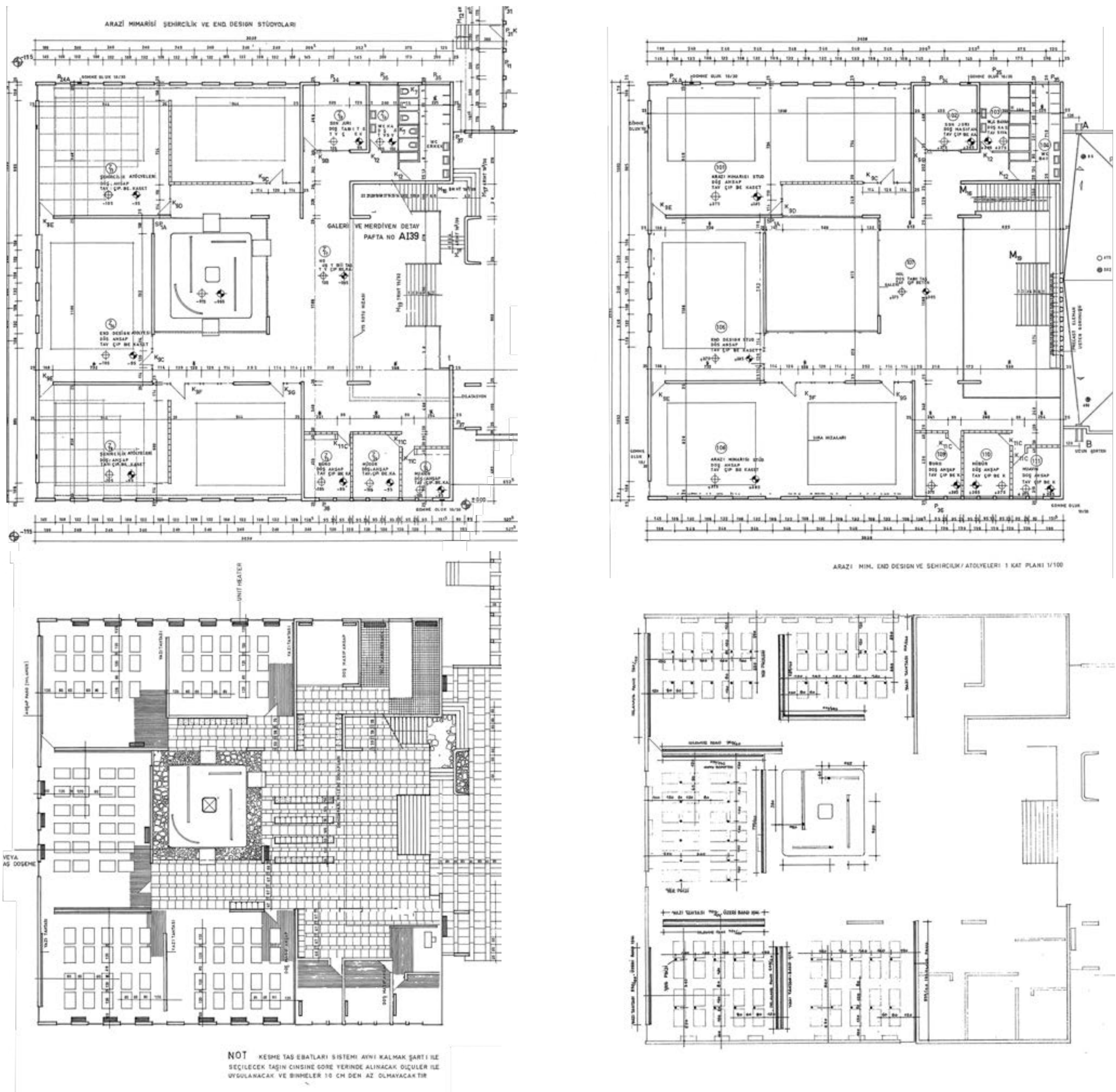


Figure 73: Ground floor and the first floor plans of the F block in the application drawings.

The F block had been conceived as an autonomous unit by the architects from the very beginning of the project with its specific function and even with its own entrance from the outside. It is represented in the following drawings: a ground floor and a first floor plan with supplementary sheets showing the furnishing and the flooring details (1/100); a roof plan (1/200), a north-south section (1/100); east, west and south elevations (1/100); and an east-west section cutting through G3 and showing F Block in elevation (1/100).

Compared to the conceptual phase, the major change in the Application Drawings is the transformation of the courtyard idea. In the Concept Drawings, this space is designed as an outdoor space and separated from the interior with continuous glazing, whereas in the Application Drawings, the glazing disappears and the courtyard becomes the focal part of the interior space. It preserves, however, the same volume as the courtyard. This volume

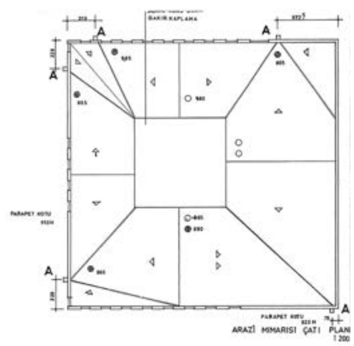


Figure 75: Roof plan of the F block.

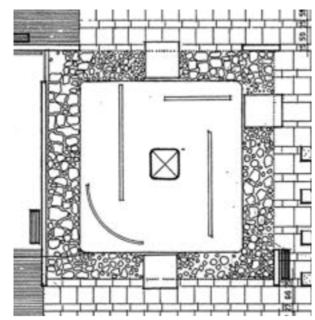


Figure 76: Flooring details

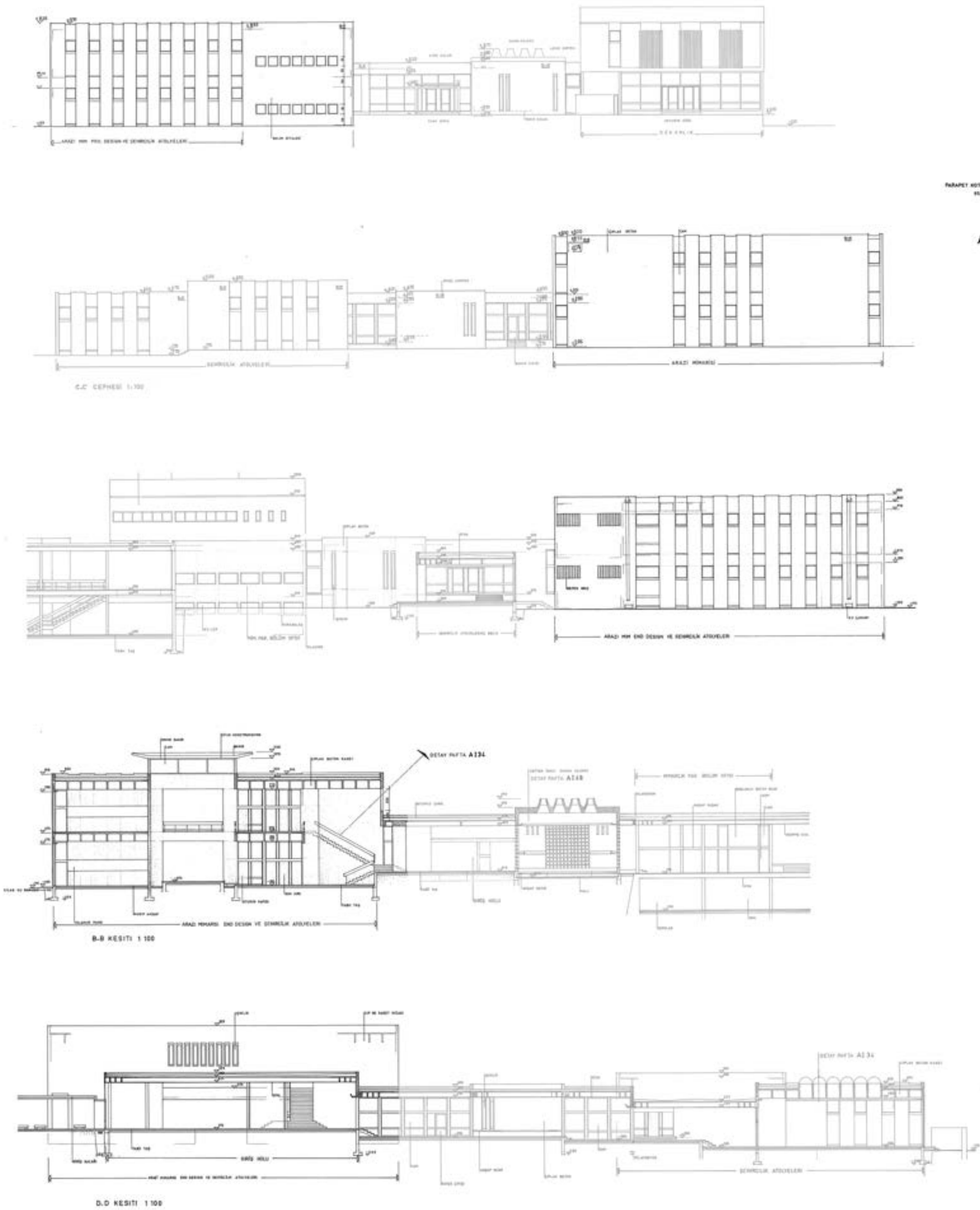


Figure 74: Elevations and sections depicting the F block in the application drawings.

is defined by shear walls, a second floor slab with a gallery hole and a skylight. The material treatment of the floor, the use of different marble and pebble patterns and the finishing details emphasize its physical borders (figure 76).

In addition to these 64 application drawings, a complementary set of drawings were found in the architects' office and donated to the SALT. These drawings are entitled "Architectural Decoration Projects" by the architects and they were executed between the years 1963 and 1964. Although they are not included in the original Application Drawing set, it is necessary to give a reference to a specific drawing in this collection. This particular sheet is entitled "*avlu tanzim ve detayları*" (courtyard organizations and details) with 1096x700mm dimensions. It contains the details of three existing courtyards in the building.

[18] For further information please see section 2.1 Focus of Research

The architects, while referring to these two drawings in this sheet as "courtyards", chose not to call the space at the center of the F block a courtyard. This may be read as an indication of a blurred nomenclature where this space is included in courtyards drawing sheet but not specifically entitled as a courtyard (figure 77). Rather, it is indicated as "the central part of the F block" in the drawing. As stated before, this is a unique space, which oscillates between inside and outside for the architects. Thus, it seems rather difficult to functionally categorize it.[18] As stated before, the skylight and the space it defines underneath - with the support of the reinforced concrete artwork at the center - have become one of the most symbolic spaces of the faculty building.

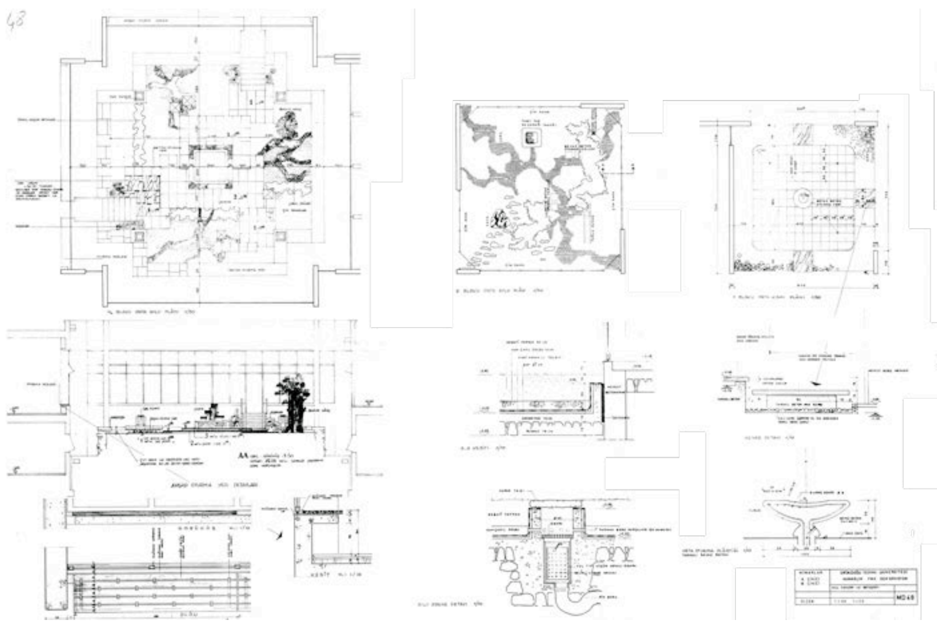


Figure 77: "*Avlu Tanzim ve Detayları* (Courtyard Organizations and Details)".

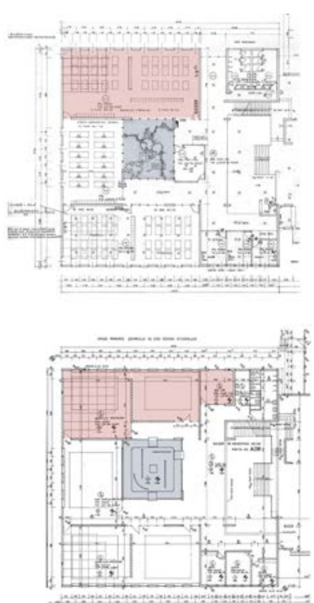


Figure 78: F block plan drawing in the conceptual and applicaion project.

Therefore, the major change after the conceptual phase of the project is related with the character of the courtyard. It was conceived as an open air area in the Concept Drawings and transformed into an interior space in the application phase. Consequently, the positions of the surrounding spaces, namely the studios, final jury hall, and the circulation areas also change (figure 78). In the Concept Drawings, the studio facing the west (Z11) is attached to the courtyard. In the Application Drawings, however, this studio is divided into two classrooms and the edge facing the courtyard has recessed two meters to allow entrance to the second classroom. The final jury hall (Z17) attached to the courtyard in the Concept Drawings is relocated next to the service areas in the application phase. After this relocation, the overall design of the west façade alters. The first alteration is the transformation of the glazed surface into a room façade and the second one is the elimination of its recession. As the final jury hall blocks the daylight, the significance of the central courtyard increases. The detachment of the spaces that share a side with the courtyard make this central part stand out as an autonomous space.

Detailed Application Drawings of the F Block:

There are two Application Detail Drawing sheets, detailing the skylight and the staircase in the F Block. These drawings are highly informative regarding the conception of this space by the architects. These two sheets can be used as exemplary cases, where the architects focus on certain architectural elements as autonomous entities. One reason can be their structural and functional qualities and the other reason could have been related with the possibility of the application of similar details in the other parts of the building. Although each staircase and skylight is designed with its unique details and materials in the building complex, these two sheets indicate their common design principles.

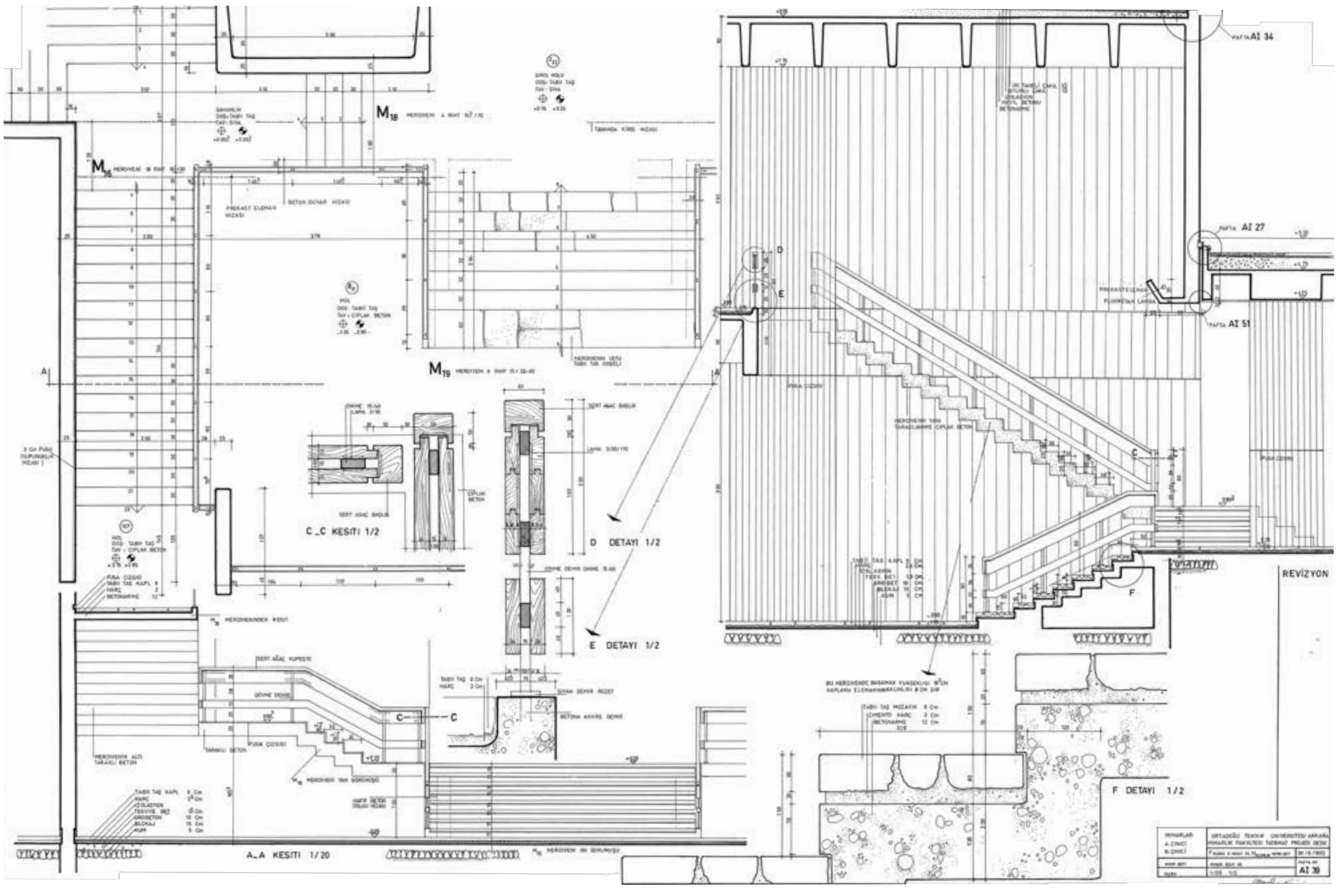


Figure 79: F block interior section and staircase details.

These detail drawings almost represent the as-built condition, except for the balustrade, which was never covered with wood panels (the only place to see the wood application on the balustrades is on the Dean's Office's stairs (H1). The complexity of this drawing also indicates its efficiency. It is possible to see all the aspects of the staircase in this single drawing. The first sheet (figure 79) includes five major architectural drawing subsets: The plan, section, and the elevation of the staircase and the balustrade details in plan and section. The plan of the staircase is located on the left corner. This partial drawing shows a top view, where even the texture of the stone could be represented in elevation. Moreover, it shows four different parts of the same staircase connecting the two floors and orienting the users to five different directions (figure 80). These parts find their unique spaces defined by the balustrades on one side and the exposed concrete walls on the other. The corners of the shear walls emphasize the turning points.

The section on the right corner of the drawing (figure 81) shows the side elevation of the staircase that is connecting the two main floors and the section of the eight steps connecting the ground floor (G3) to the courtyard area (Z17). This drawing also shows the concrete molding details and the lap joint lines in elevation (figure 81, 82). The lap joint lines act like a guideline system and define the dimensions of the main beam carrying the upper floor

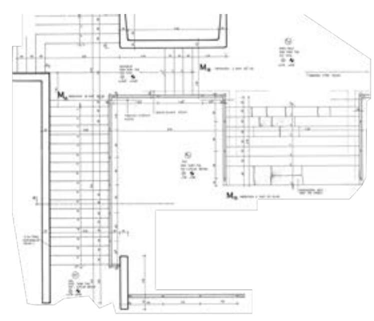


Figure 80: Plan of the staircase

Figure 81: Molding traces and the lap joint lines.

(1.10cm). The waffle ceiling section shows the conic form of each rib. In this section, it is also possible to see the expansion joint line and the roof details. The construction details of the unique “precast” lighting feature, however, require further analysis.

The drawing on the right bottom corner shows the ½ scale details of two steps that are made out of natural mosaic stone (6 cm) placed on concrete steps with cement mortar. The detail that shows the overlap of the stairs and the final step with the floor surface is worth underlining (figure 83).

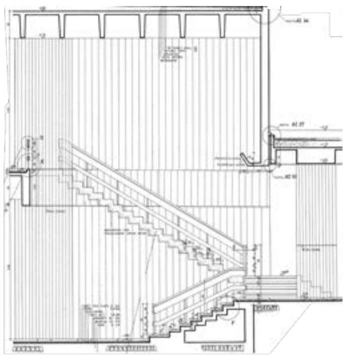


Figure 82: Section of the staircase.

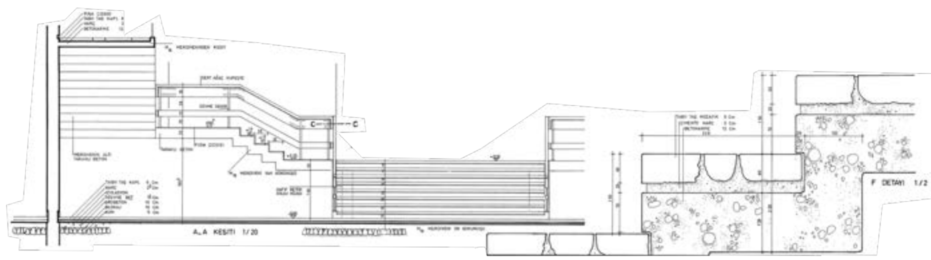


Figure 83: The elevation showing the façade details of the steps and the ½ detail drawings.

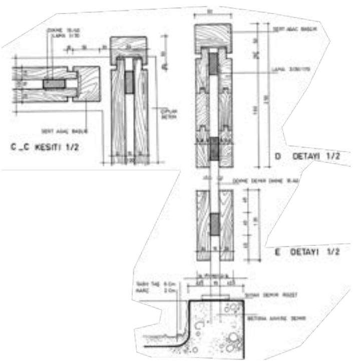


Figure 84: Plan and section of the balustrade in ½ scale.

The elevation on the left bottom corner shows all the façade details of the steps. Here it is possible to see the alternating natural stone (6cm), the mortar (2cm), and the concrete step (7cm) (figure 83). A project note on the drawing explains the application details for the concrete surfaces of the steps where the intention of the architects is to use lap joint lines and “combed concrete surfaces”. This surface treatment, however, was never applied (figure 85).

At the center of the drawing sheet, there is a plan and a section of the balustrade in ½ scale (figure 84). The handrail details show that the plan and the section of the handrails are the same. In fact, the section is designed to turn the corner and continue at the edges of the balustrade. The vertical rods of the balustrade are made out of 15x40 wrought iron. The three horizontal rods are made out of sheet iron and covered with hard wood pieces. The vertical rods are anchored to the concrete steps and covered with a rectangular black iron piece/ rosette (*rozet*). On the upper part, each wood piece is notched, leaving a 10mm gap, which reflects the thickness of the handrail.

The second detail drawing sheet includes the plans and sections of the skylight located above the central part of the F block (figure 86). The section drawing on the left corner illustrates the fact that architects had the idea of using copper both on the exterior and interior surface of the skylight roofing. The combination of I beams and wooden structural elements makes this skylight structurally complex but materially and visually extremely “light”. The main span of the skylight is 815 cm, the depth of the I beams is 22 cm, and the total thickness of the skylight roofing is 34 cm. The height of the glazed surface is 160 cm and the vertical framing elements are placed at every 143 cm.

The plan drawing is located at the left bottom corner and sliced diagonally, showing the different layers of the roof structure, unfolding from the left to the right. At the left upper corner, it is possible to see the copper covering with 0.5 mm thickness that is placed horizontally in linear sheets. Although it is not illustrated, this is where the bitumen felt (*ruberoit*) must be laid. This material is placed on a wooden surface with a thickness of 2.5 cm. This wooden surface is placed on a wooden structure made out of

Figure 85: Exposed concrete sidesurfaces of the stairs.

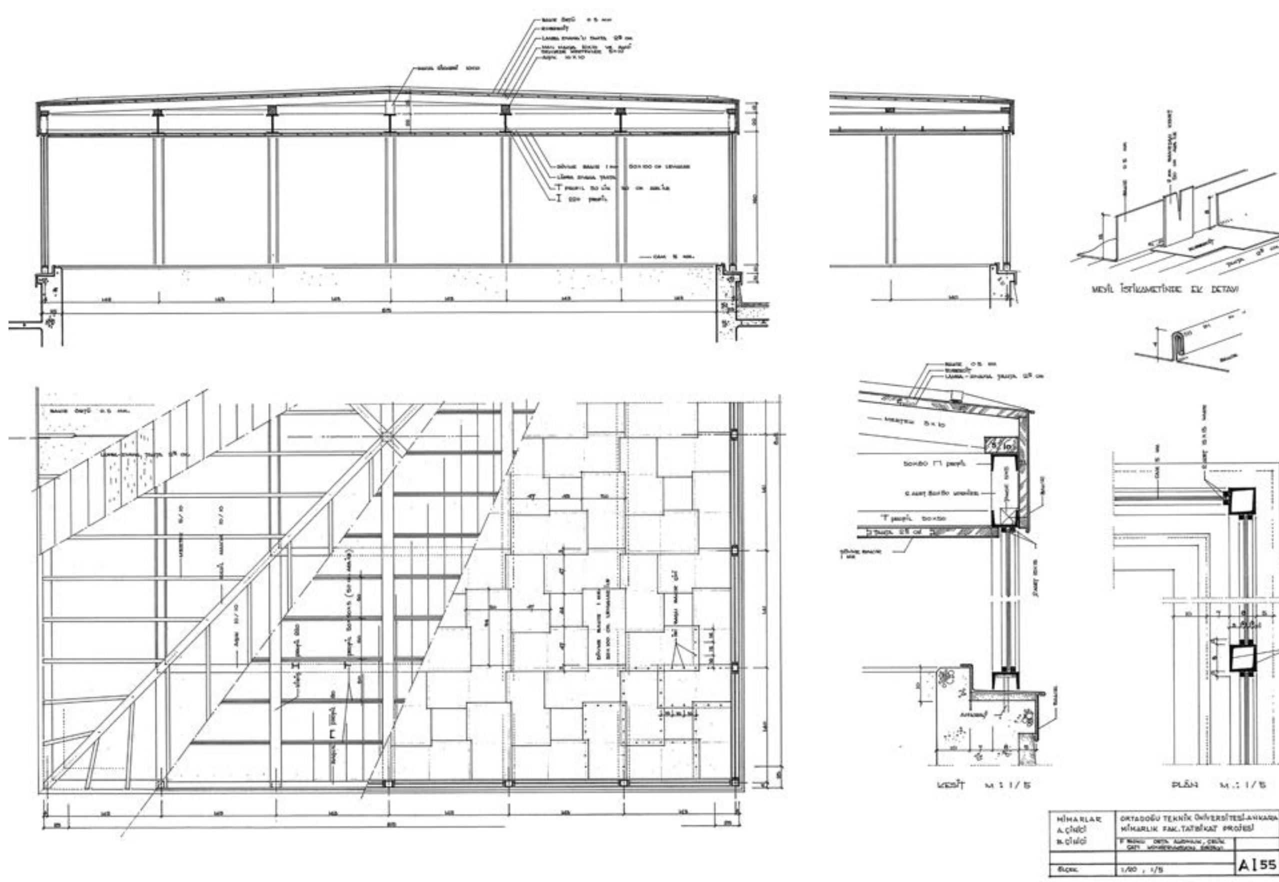


Figure 86: F block skylight, steel construction details.

10x10 roofing groyne supported by a 5x10 – 10x10 wooden grid. I, C and T profiles are used for the larger span. The 50x100 cm copper plates form a checkerboard pattern with a thickness of 1 mm covering the interior of the roof. Copper nails are used for the overlap of cover plates.

The detail drawing placed next to this unfolding roof plan shows the intricate relationship between the C beams and the wooden elements, copper plates and the wood surfaces. Copper is also used for the window sills and skirtings. The window frames are composed of two 80x80 mm L-shaped "*korniers*". Copper as a soft material was also used to seal the roofing surface. The detail drawing shows the precision of this waterproofing system.

Although all the materials are used as exposed and true to their nature in the building, a particular Architectural Decoration Project drawing sheet, otherwise very pale and uninteresting, indicates the fact that the architects proposed a suspended ceiling for the offices in the F block (figure 87). This suspended ceiling was proposed to be wooden surfaces made out of thin 4.3+0.55 cm matchboard stripes of pine wood with a thickness of 2,1 cm. This horizontal surface was particularly used for the placement of the custom-made lightning features made out of reflective metal surfaces and covered with translucent glass. The suspended ceiling implies the disguise of the real height of the office spaces and the existence of some sort of a cladding. This drawing sheet includes two more disguise elements. The first one is the wooden (oak) panel covering the frontal facade of the heating unit, radiator; and the second one is the wooden bands covering the curtain rail, which are placed at the height of 206 cm in every office space.

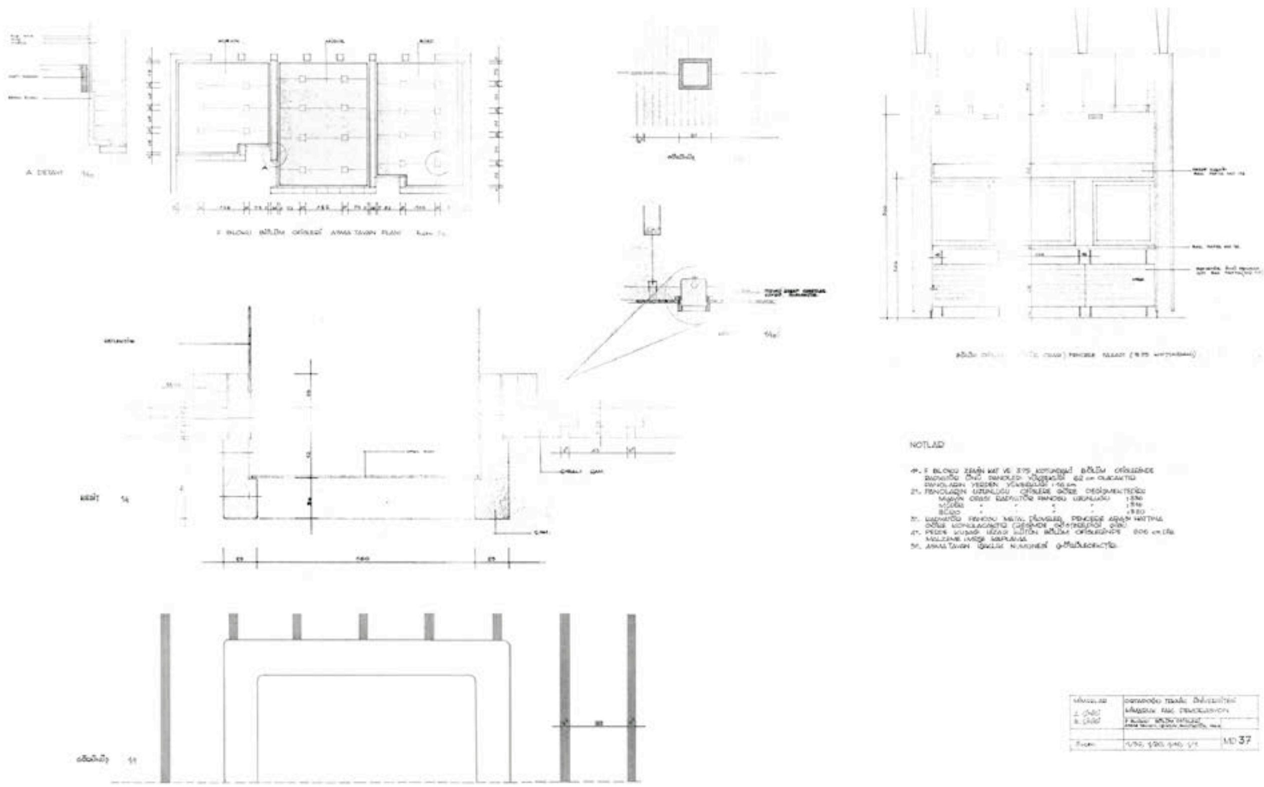


Figure 87: F block staff room details, Architectural Decoration Project.

3.1.1.2.3.4. Published Drawings/As-built

Between the years 1965 and 1969, the Faculty of Architecture building, was published in various international architecture periodicals.

Figure 88: Front covers of the magazines.

The first publication was in *L'Architettura*[19] (1965-n.114), entitled "*L'Universita del Medio Oriente presso Ankara*" by Luigi Piccinato. There, the university site plan was interpreted as divided into "three strips: to the east, the residential area for students and teachers; in the center the garden and the sports area; to the west, the separate academic buildings, with all major technical and social sciences schools. Among the buildings that were already completed, only the Faculty of Architecture building was illustrated with aerial photographs, plans, sections, black and white interior and exterior photographs."

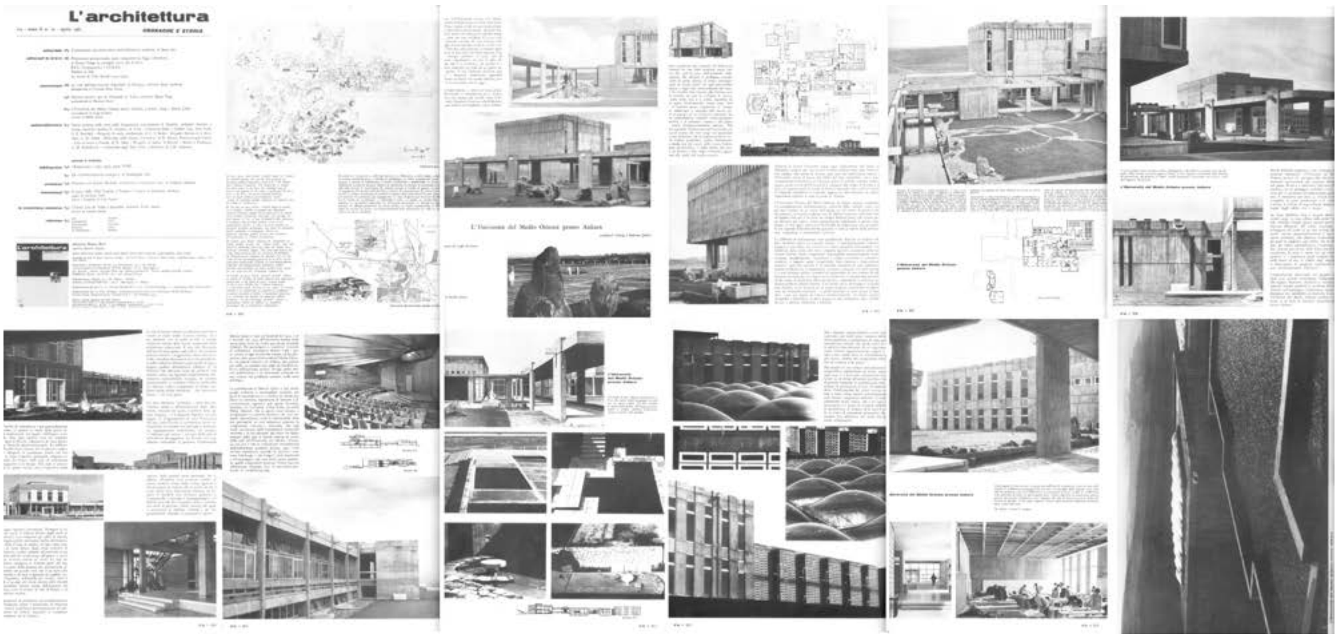


Figure 89: Pages related to METU in L'Architettura vol.114 no.12.

The second publication was in same year, in *Bauen+Wohnen=Construction+ Habitation=Building+Home Internationale*[20] within which a detailed article was written by Jürgen Joedicke and illustrated with black and white photographs of the building and selected drawings. After a brief description of the project, the building's "architectural organization" was summarized as follows:

> Plastic principle: high volumes enclosing central portions of low silhouette (cluster); example: department of architecture: lecture rooms and design shops on two levels surround a building on one level, lighted by skylights or facing on to interior courtyards. The few basic elements that are found everywhere are of raw construction materials: rough concrete, visible equipment, untreated surfaces, etc.[21]

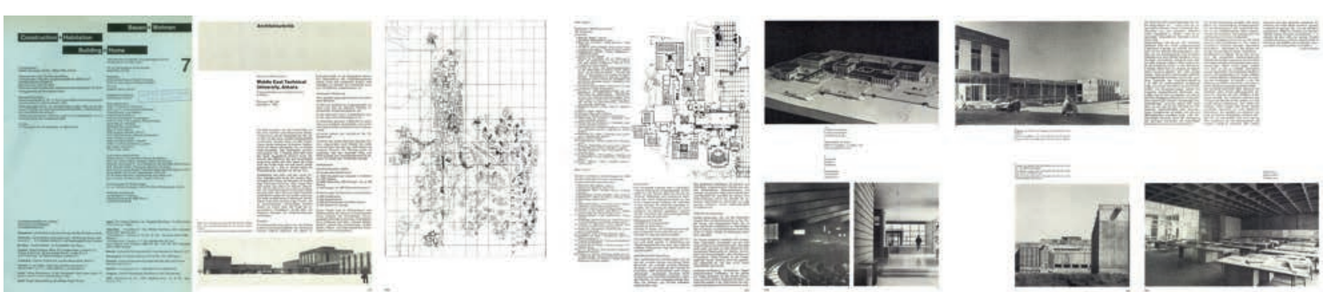


Figure 90: Pages related to METU in *Bauen+Wohnen=Construction+Habitation=Building+Home Internationale*

[19] *L'Architettura* vol.114, no. 12 (April 1965), 803-814.

[20] Jürgen Joedicke, *Bauen+Wohnen= Construction+Habitation=Building+Home Internationale* vol.19, no. 7 (1965), 275-280.

[21] *Ibid*. (Language edited by the team).

The following critical commentary in the same article located the Faculty of Architecture into the limits of mainstream brutalism and underlined its representative qualities regarding the modern architecture maturing in Turkey. The terms “Raumplan” and “flexibility” were used to describe the building to give reference to this architectural approach. While criticizing the overall campus plan as a completed work without any possibility of expansion, the Faculty of Architecture building was evaluated as significant with its spatial qualities:

> The volume plan, as well as the plans of the different buildings, which are more or less flexible on the inside, are conceived for the definitive State. Thus, there is no question here of a dynamic master plan which can be realized in accordance with growing needs, but rather of a Site plan, which does not allow for organic extension, except for the addition of later definite units.
>
> Aside from their lack of functional flexibility, these units have architectural and spatial qualities. Example: department of architecture: succession of spaces varied by means of articulation of volumes by passageways, halls, perspectives and views, differences of level and staggered arrangements. The passageways and paths, generously conceived and complex, are justified for public areas which are heavily frequented, but they become absurd if they end, for instance, in individual rooms for Professors of small dimensions. By assigning two sides of the large interior courtyard to individual rooms, the architects basically betray their Organization plan, which ties in autonomous volumes with common facilities.
>
> Formally considered, this architecture can be classified under the new “brutalism” (accentuation of autonomous functional elements to stress their aesthetic value): The influence of modern Japanese architecture is quite clear (gardens, passages, tying in of structural elements in the fashion of Tange).
>
> During the Thirties modern Turkish architecture followed very modern tendencies and gave promise of an original development; after the war, however, it reflected more traditional currents, but since the Fifties architects, both young and old, have again worked in the modern vein, drawing on Western and Far Eastern architecture. It now seems that modern Turkish architecture would gain in profundity if it relied on traditional Turkish building, of which there are examples of outstanding quality.[22]

The third publication was the 12th issue of the Germany based journal, *Baumeister* in 1965.[23] The black and white photograph of the interior view of the amphitheater was selected as the cover of the journal. Besides the Faculty of Architecture, the cafeteria building is also included in the photographic set.

Figure 91: Pages related to METU in *Baumeister* vol. 62, no.12.

In addition to these journals, there was also a conference proceeding: *Planung Wissensehafttlicher Hochscholen 1.Colloquim* (1965) followed by two brief reviews published consequently in *Connaissance du Monde* (1966) and by *L'Architecture Français*[24] (1969 n.323-324). The drawings and the photographs of the recently constructed Faculty building and the drawings of the campus plan were included in these publications with slight changes in their illustrations. It is not possible to verify the submission dates of the publication documents. Therefore, it is not easy to trace the ideas of the architects in the publication chronology.

[22] *Ibid*.

[23] *Baumeister* vol. 62, no. 12 (December, 1965), 1373-1375.

[24] L'Architecture Français no.323-324 (August, 1969).

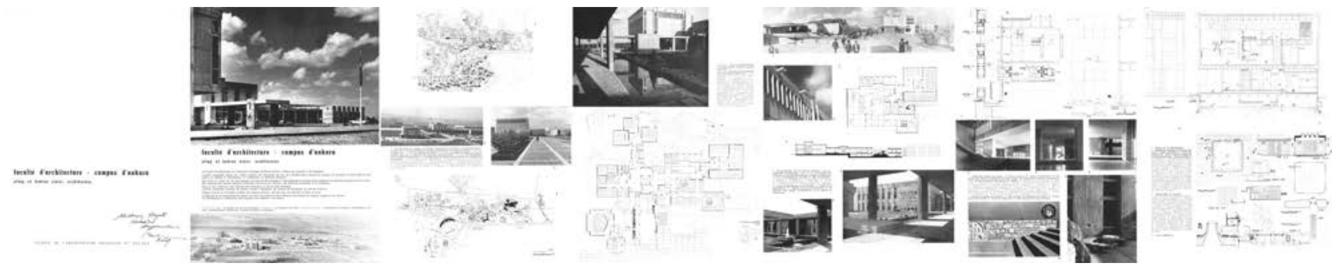


Figure 92: Pages related to METU in *L'Architecture Français* n.323-324.

However, one complete set of drawings which was most probably prepared for the submission to the French journal, *L'Architecture Français* (1969 n.323-324) was found in SALT, in Istanbul is important for this research. This set is composed of seven sheets (972x739 mm, 988x748 mm, 988x748 mm, 957x724 mm, 810x711 mm, 1057x695 mm, 1088x683 mm). All the descriptive text and notes on these drawings were in French (except one which includes a Turkish explanation). This complete set (Plates no.3 and 5 are missing) is interpreted as the fourth phase of the project. It was studied to follow the final development of architects' ideas and intentions.

All the publications listed above give more or less similar information except slight changes in the service space of the amphitheater, details of the canteen mezzanine floor, and the skylight of the F Block. The major changes in the site plan and the reason behind the choices of the architects regarding these site plans remain a mystery.

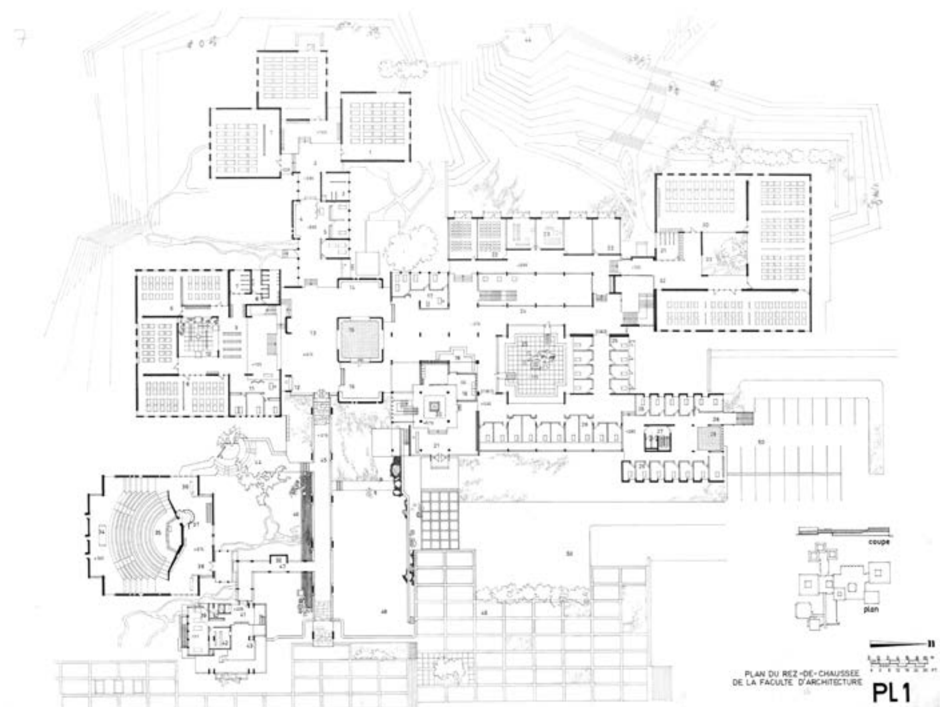


Figure 93: METU Faculty of Architecture, Site Plan, SALT Research, Altuğ-Behruz Çinici Archives.

Figure 94: F Block, first floor plan, SALT Research, Altuğ-Behuz Çinici Archives.

Due to its accuracy, the drawings prepared for the journal *L'Architecture Français* in 1969 are conceived as the as-built drawing set. Except the landscape elements which are the open-air amphitheaters on the east and west sides of the building and the wall between the main pedestrian path and the building complex that have never been constructed, these drawings represent the original condition of the building as it was built. There is no major difference between the Application Drawings and Published Drawings, except the final form of the skylight in the F Block.

Beside this as-built set in the SALT, there are civil engineering, electrical and mechanical engineering project drawings found in the Directorate of Construction and Technical Works Archives in METU. They can also be included in the as-built drawings because they give further information regarding the design and construction processes of the building in this final phase. The comparison between these and the drawings of the current state of the building, which are entitled the Survey Drawings, will be made in the following part of this report entitled "physical evidence".

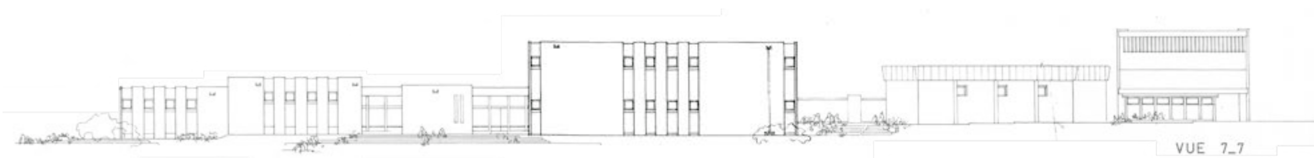


Figure 95: METU Faculty of Architecture, South Façade Drawing, F block highlighted, SALT Research, Altuğ-Behruz Çinici Archives.

Figure 96: METU Faculty of Architecture, South-North Section Drawing, F block highlighted, SALT Research, Altuğ-Behruz Çinici Archives.

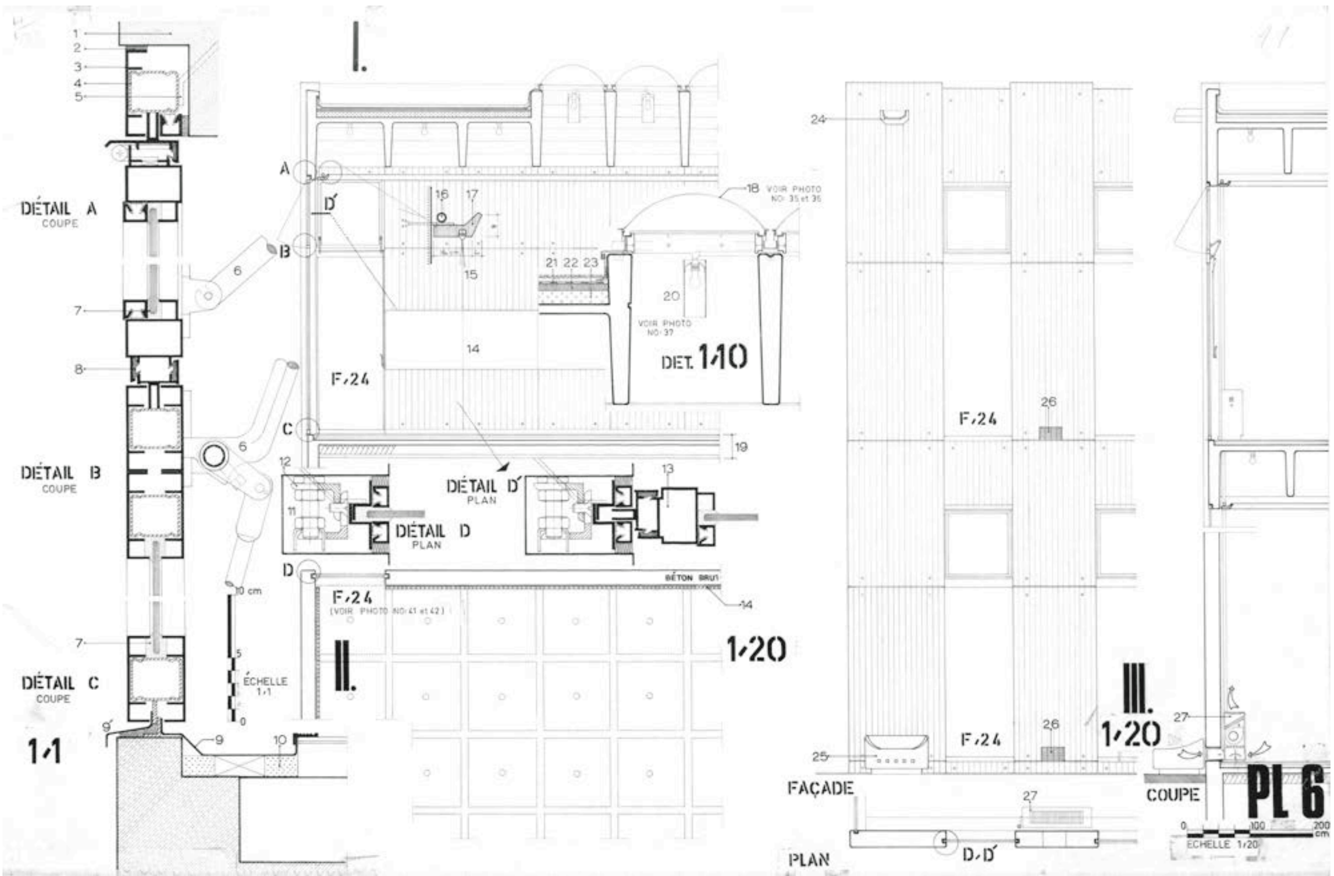


Figure 97: METU Faculty of Architecture, Window and fenestration details, SALT Research, Altuğ-Behruz Çinici Archives.

3.1.2. Physical Evidence - Building to Document

This research on the Faculty of Architecture building complex started with the claim that for comprehensive conservation planning, it is crucial to conceive it as distinct from mere building and study its cultural aspects that are bounded with historical, social, economic and political context. In other words, architecture has a discursive condition, different from the practical one of building. "A building can be interpreted, when its rhetorical mechanism and principles are revealed".[25]

The research into the faculty building was defined, therefore, as the documentation of the discursive and material qualities to reveal its architectural principles. Materiality here refers to the tactile elements that form the physical constitutions of a building. Besides concrete, wood, and stone, it also refers to "the substance of architectural integrity", which has been interpreted as "the manifestation of formal, structural, spatial, material and ultimately aesthetic qualities" of this architectural product. The phrase in the title "Building to Document" refers to the production of new documents based on the existing condition of the building. These documents include the "Survey Drawings", "Point Cloud Data", and the "Photographic Documentation", and focus particularly on the analysis and reproductions made with information gathered from the selected area, the F block.

[25] Beatriz Colomina and John Ockman, eds., *Architecture Production, Revision 2 Papers on Architectural Theory and Criticism* (New Haven, CT: Princeton Architectural Press, 1988).

Figure 98: Sparse point cloud model of *Göbektaşı*

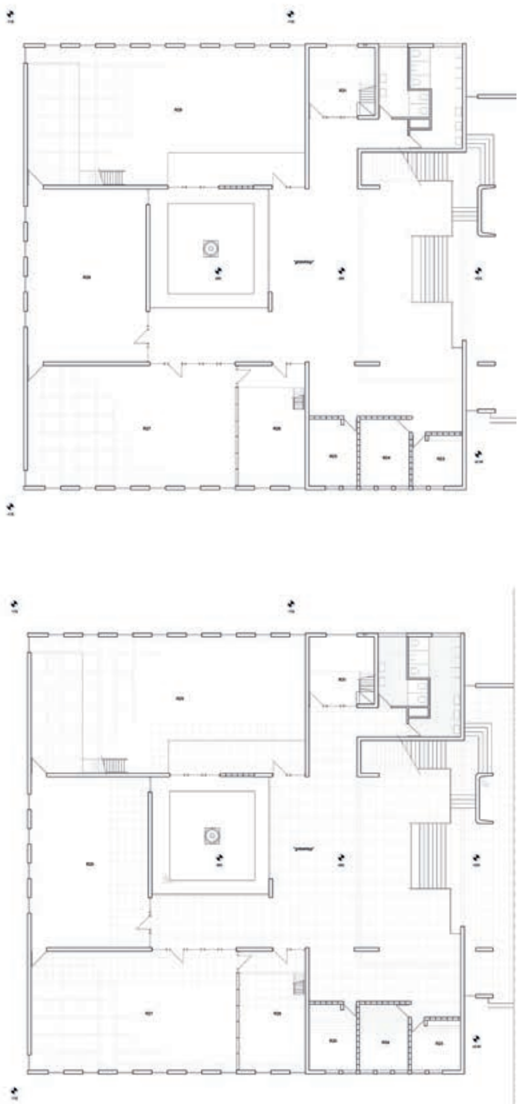


Figure 99: Ground Floor Plan drawings of the F block.

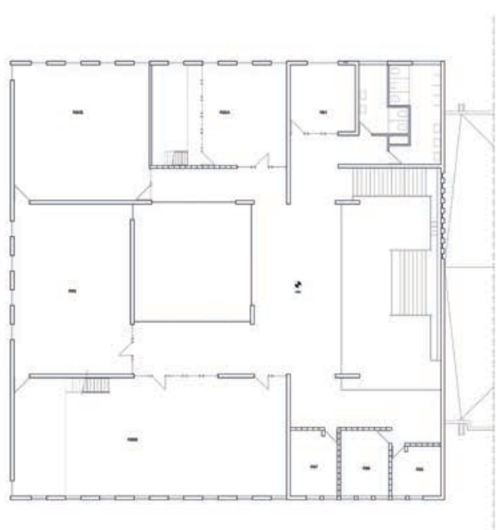


Figure 100: First Floor Plan survey drawing of the F block.

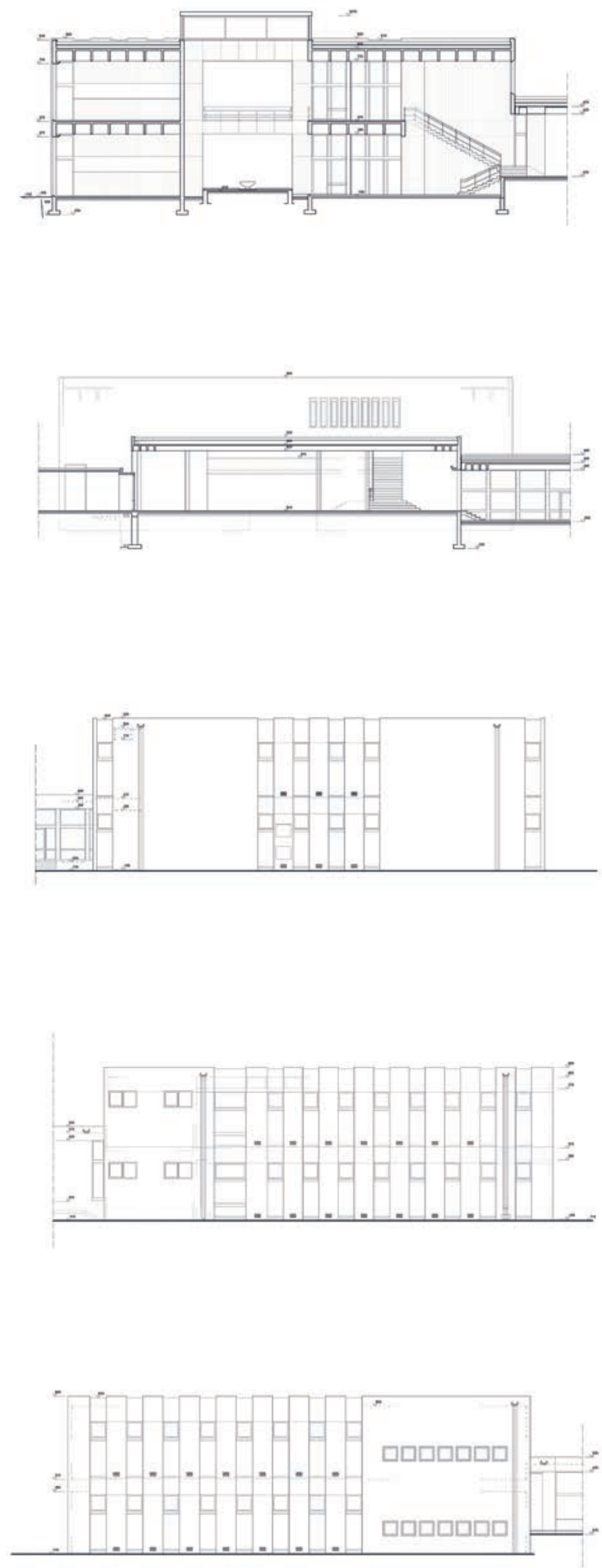


Figure 101: Section and Elevation drawings of the F block.

3.1.2.1. Survey Drawings

The abovementioned documentation of the existing condition of the focus area started with the reproduction of the final drawing set. Every reproduction and transformation of medium in architectural representation requires an interpretation and it is a production process of something “new”. During the re-drawing processes, it has been discovered that there is a difference between drawing an idea to explain how to make a building and copying a drawing to learn how a building was made. Throughout the reproduction process, a close analysis of the existing blueprints indicated the fact that the order of each sheet, the perfect render of the hatches, the meticulously drawn detail fragments and dimensioning, were referring to the existence of other “original” drawings prepared before the production of the transparencies.[26] These originals, however, are nowhere to be found today.

The Survey Drawings are produced in the vectoral medium by the architects in the research group. They tried to follow the same format that the Çinici Architects used in the production of the previous sets (figure 99,100,101). Focusing on the F block, the orthographic set was used as a comparative medium to understand the shifts, transformations and changes made after the construction of the building. Although the main medium for the representation of all the transformations that the building went through in time is thought to be represented in the HBIM in this project, the survey drawings were prepared to understand the major changes in the physical environment.

[26] Aysen Savaş and Agnes van der Meij, eds., *Diamonds in Sahara: METU Lodgings Documented* (Ankara: METU Press, 2018).

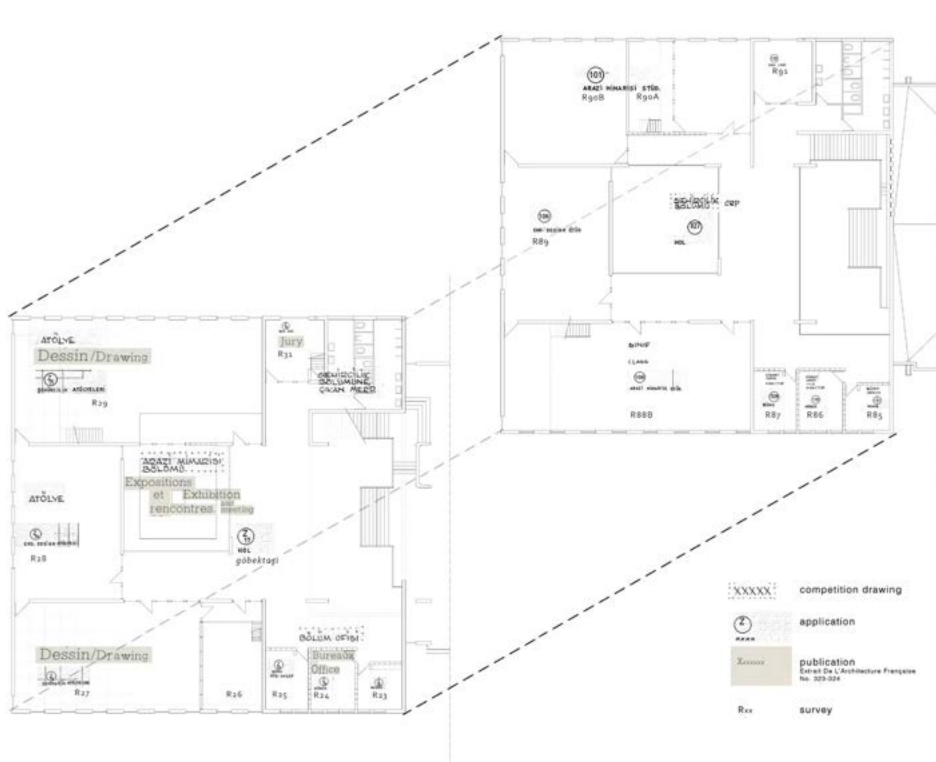


Figure 102: Changing nomenclature throughout different phases of the construction.

The Application Drawings, Published Drawings, and the early photographs of the building convey the most detailed information about the “as-built” form of the faculty building. These documents indicate that there are a number of changes, additions and transformations in the current condition of the building. There are two major reasons for the differences observed in these drawings and the current condition of the building. On the one hand, there are the later additions or changes made by the occupants of the faculty in the course of time and on the other hand, there are architectural elements which were designed by the architects, yet never built. These unrealized elements include the suspended ceilings in the office spaces, steps covered with natural stone (onyx), sunken surface surrounding the *Göbektaşı* platform and the wooden cladding of the balustrades (figure 103).

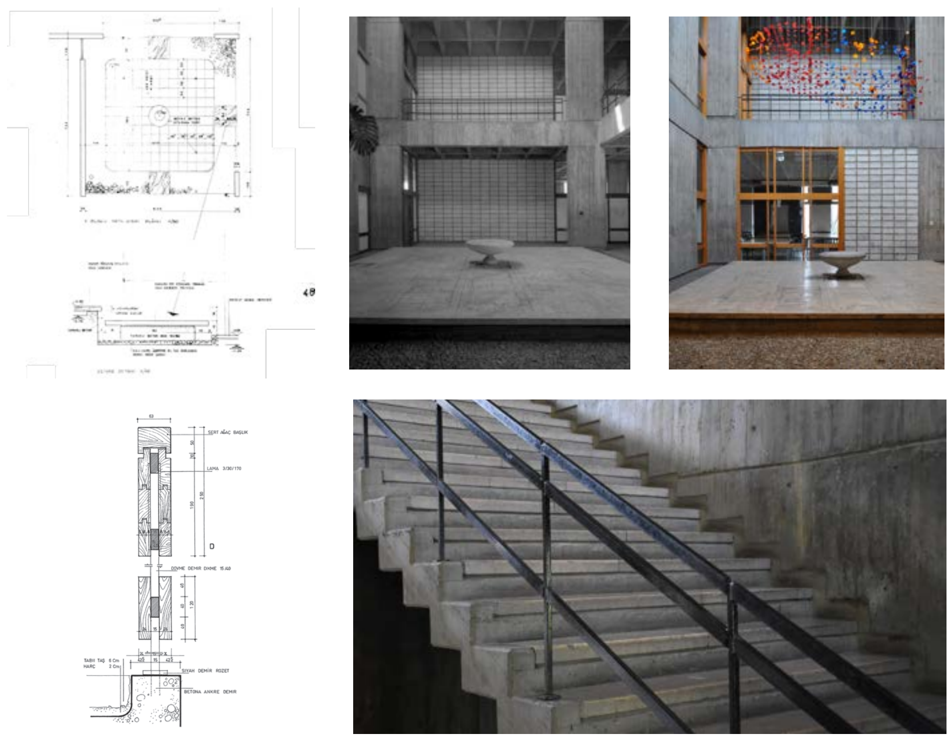


Figure 103: The actual design and current form of the *Göbektaşı* area and the balustrades.

Another unbuilt element is the set of windows located on the north façade of the F block. Although they are drawn to be located at the center of the façade, they were placed asymmetrically towards the west during the construction (figure 104).

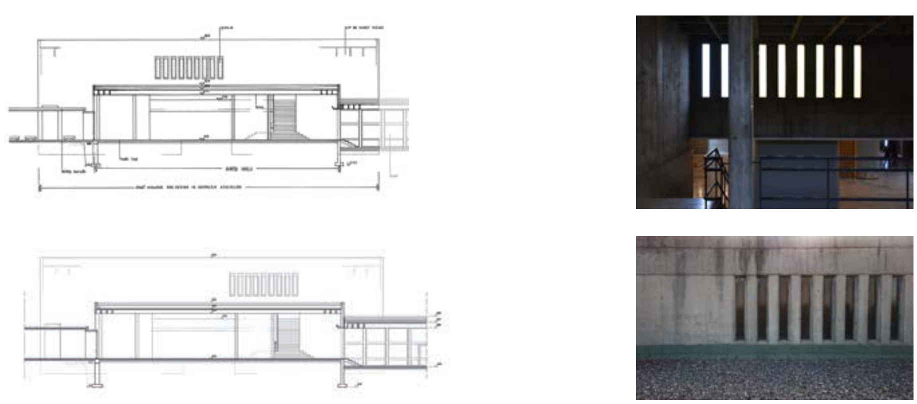


Figure 104: The changing position of the windows on the north façade of the F Block, the interior and exterior view of the current condition

The major change in the F block is the integration and the enlargement of the two classrooms located on the south-west, which are now designated R29 (Second Year City and Regional Planning Studio). The wall between the two classrooms was removed; and the separation wall on the east side of the first classroom, which is made out of wooden framed glazing and cement blocks, was moved two meters towards the circulation hall in 1991-92. One piece of physical evidence of the displacement of this wall can be observed on the floor finishing. The marble patch shows the original function of this part in R29, and the line between the marble and the ceramic tiles indicates the original location of the wall. This replacement changes the character of the circulation hall and eliminates the transitory space between R29 and the circulation area (figure 105).

Figure 105: The elimination of the transitory space between the classrooms and the *Göbektaşı* platform.

In a reverse manner, two of the studios have been divided into two to be named as R26-27, and R90A (Graduate Architectural Design Studio) in the upper floor. R27 now accommodates the third year industrial design studio while R26 is allocated to the meetings of the industrial design staff. R90A is divided by a wooden framed glazed surface and now accommodates the Getty Project architectural research group.

The second significant change in this block is the addition of the mezzanine floors. The need for the meetings of the teaching studio staff, preparation of lectures and assignments and grading processes are the major reasons for these additions. The mezzanine floors in the F block have different dimensions, different structural systems and are made out of different materials. They are located in two studios and one office space, in the F Block. The mezzanine floors in the studios are located in R29 and R88B (Third Year City and Regional Planning Studio). Both have steel structures with wooden slabs (figure 106). They have wooden facades that transform these platforms into closed boxes. The mezzanine floors in R90A and R26 are horizontal platforms. The office space, R31, is also divided with a mezzanine floor to accommodate three instructors in the same room. All these additional floors have an intentionally designed and built staircase. The idea of expanding the floor area continues in the rest of the building, such as in the studio spaces (R1, seminar room, R2, fourth year architectural design studio, R3 second year architectural design studio, R50, third year architectural design studio, R52, fourth year city and regional planning studio and in R52B urban design graduate studio). They are also made out of different materials with different architectural and structural details. Mezzanine floors, either suspended from the waffle system or supported from the ground, are adding extra irregular loads to the structural system. This issue will be discussed in detail in the following part of this study.

Figure 106: Mezzanine floors additions in the F block.

Figure 107: Additional heating pipes and AC units in the F block.

The original floor materials proposed by the Çinci Architects were not applied in the main education building. Except the halls that are covered with marble (H5 and G4), all the floor finishes are changed from solid wood to ceramic tiles, laminated flooring or vinyl floor covering. The use of natural wood as floor finishing was one of the main ideas of the architects', which was represented in the different sets of drawings. During the construction of the building complex, wood was transformed into grey-blue marley floor tiles (25x25), most probably due to financial limitations and workmanship problems. In the course of sixty years and particularly during the last ten years, marley, which is now known to contain hazardous chemicals, was replaced with ceramic tiles. The change in the floor finishing materials caused a radical infrastructural transformation. The original floor finishing included round grass electrical sockets and they were placed in a matrix of 3x3m in the studio spaces. During the replacement of marley surfaces, they were completely covered and are no longer in use today.[27]

Another major infrastructural change is the additions made to the mechanical heating system of the building complex. To overcome the deficiencies that occurred over time, new fan coil units were added and additional pipes were installed. The pipes were exposed and fixed to the ribs of the waffle slabs and installed on concrete wall surfaces, when found necessary. An ad-hoc, temporary solution used in order to be able to increase the comfort conditions of the some of the classrooms and offices in the F block has been the addition of air-conditioners. Their internal and external units were installed onto the exposed concrete surfaces and the roof. Their power cabling and piping were also directly applied onto the walls. Another additional infrastructural element is the extra piping installed in addition to the existing concrete water spouts, for the disposal of the water from the roof (figure 107).

The rotation of the teaching staff is minimal at METU and, as a result, both the teaching and the administrative staff tend to use the same room for more than 20-25 years. Thus, they make personal changes, additions, and transformations in their allocated spaces. They paint the walls, add shelves, cabinets, curtains and lighting fixtures, change the locations of the sockets and update the rooms with contemporary network systems. Nailing pictures, boards and personal items on the walls has also been a common practice. However, there are still unpainted exposed concrete surfaces protected in rooms R24 and R25 and the remains of original marley floor tile finishing can be found in R86 and R25. In rooms R87, R85 and R24, the wooden band hiding the curtain rail still exists and is in use. Another linear wooden element is installed on the shear wall and the concrete blocks to reach and define the door of the room R25 (figure 108). The original desk, that is indicated as type M2 in the Architectural Decoration Drawing set and designed particularly for the use of professors is still in use in the rooms R87, R25, R31 (figure 109).

[27] Based on the interview conducted with Prof. Dr. Adnan Barlas from METU City and Regional Planning Department.

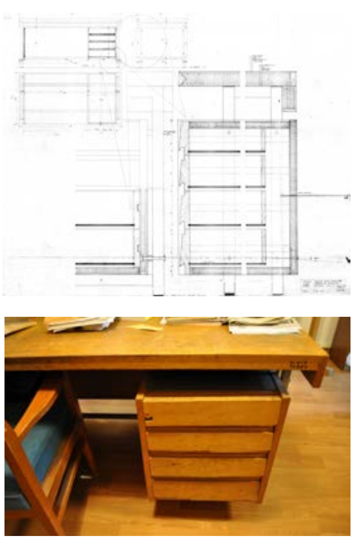


Figure 109: Drawing of the desk, M2 and the desk that is in use.

Figure 108: Remains of the exposed concrete surfaces and wooden bands in the F block

The F Block, in fact all the blocks in the building complex, is surrounded by a thick landscape. There is also a very dense ivy growth on the façades and particularly on the concrete surfaces of the arcades. On the east façade, at the top-right corner of the F Block, wild ivy growth causes moisture, affects the comfort level of the occupants and creates mold problems on the façade.

Figure 110: Current condition of the east façade of the F block, ivy growth respectively in fall and spring.

Besides the F block, the building and its annexes - museum, auditorium, garden - have been exposed to a series of physical interventions and started to lose their original qualities since 1975. The major alterations were due to the changes in the infrastructure and the finishing materials (figure 111). Yet, particularly the recent process of the removal of all the additions, ornaments, plants and posters, enhanced the architectural qualities of the building and the general condition of the building is very good at first glance.

Figure 111: Other alterations list.

• The application of an external piping system and the perforation of the original concrete and glass surfaces
• Refurbishment of service spaces including toilets, kitchenettes and storage spaces
• The introduction of split air-conditioning units to several staff offices
• Refurbishment of the existing window frames from embedded frames to thick exposed aluminum frames
• The addition of double doors (vestibule) to the entrances
• Refurbishment of floor materials in studios and staff rooms
• Refurbishment of roof insulation systems and materials
• Transformations of spatial functions and users
• Copper sheet cladding applications on expansion joint points
• Division of circulation spaces to create exhibition halls, research laboratories, lecture rooms, archive and storage areas
• Division of studio spaces vertically and horizontally to add mezzanine floors and create rooms for staff
• Construction of separation walls to create rooms for the teaching and management staff
• Application of sun blocking shades in staff rooms and refurbishment of the electrical appliances and light fixtures
• Application of paint and polishing materials on exposed materials, particularly on concrete, wood and brick walls
• Erection of pin up boards, signs and screens on wall surfaces
• Plantation of fruit trees and bushes in the courtyards and garden
• Addition of extra parking lots

3.1.2.2. Point Cloud Data

The Faculty of Architecture has an extensive infrastructure that will facilitate the archival, research and analysis activities. The advantage of being a university and having this extensive infrastructure composed of many diverse laboratories, libraries and the equipment (a detailed list is included in the application form)[28] supports the conservation management studies throughout the process. The Photogrammetry Laboratory (PL) of METU Department of Architecture was established in 1967. Being a pioneer in the field of architectural photogrammetry in Turkey, PL is one of the few educational and research centers developed by the Restoration and Preservation Program of the METU Department of Architecture.

Figure 112: Faculty facilities and the existing infrastructure within the METU Faculty of Architecture.

The main purposes of PL are training undergraduate and postgraduate students in architectural documentation and photogrammetry; providing theoretical, practical, and technical support to all researchers of METU in documentation of the physical environment, especially the historic environment; following the developments; and conducting research on new ways of documenting and analyzing architectural heritage in different scales. This lab provided the necessary equipment and the knowhow during the survey studies of the building complex. Starting with the two annex building, the museum and amphitheater, which were foreseen as the most vulnerable parts (open to transformations – considering the different management/ administration groups) – and the sample area, the visual documentation activities started in the December 11, 2017.

Two types of laser scanning devices were used for the visual documentation of the whole building complex. A high precision 3D laser scanning was conducted for the above-mentioned, vulnerable parts and the sample area. The device used in this phase is Faro Focus Laser Scanner 120. It is a stationary high-speed scanning device which covers a 360° x 300° field of view. The end result was a dense point cloud model which provides accurate information regarding the dimensions, textures, actual furnishing and also registers the RGB data. A rather low-precision 3D laser scanning was used for the rest of the building complex. ZEB-REVO, a hand-held 3D laser scanner, was utilized due to its ease of use, flexibility and speed of scan. Another point cloud model was obtained at the end of this phase which was used as reference for further stages of the generation of the as-is model. A more detailed discussion on point cloud data is available in the "Medium of Research" part of this study.[29]

[28] For the list please see Appendix A.

[29] Please see section 2.2 Medium of Research.

3.1.2.3. Photographic Documentation

The photographic and textual documentation of a historical building is a well-known and systematic method that involves a hybrid approach to visualization of physical aspects. This systematic data collection has been based on the assumption that each space is composed of or defined by "surfaces" that can be identified as "elevations"," floors", and/or "ceilings".

Recent developments in computational design and fabrication technologies, by creating seamless surfaces to cover space, are challenging the definition of façade, floor, and ceiling. These terms once used to describe the borders of architectural space have given way to new terms such as "fold" and "blob" and adjectives like smooth, supple, and morphed.

Today, as the definition of "historical heritage" has been revisited to include comparatively "new" edifices and definitely expanded its borders to include the 20th century architecture, ansimilar challenge has emerged. The term challenge here is used in a positive sense to refer to opportunities rather than constraints.

In the specific case of METU Faculty of Architecture, photographic and textual documentation of each space in the building motivated the researchers to understand the building with its volumetric and spatial specifications and necessitated the investigation of an untested terminology. The goal was the visual and textual survey of the "six sides" of each space forming the Faculty of Architecture building. The conservation experts indicated the fact that this analytical method necessitates the differentiation of "exterior and Interior elevations". Interior elevations would be identified counterclockwise starting from the main entrance door of each space. In fact, as long as the survey is done "systematically" and the preferred system is explained clearly, there should not be any dispute. Clearly it is a case specific methodology, which needs to be reconsidered before each "case". The METU Faculty of Architecture has proved to be a very complex case. Compared to historical palaces, archaeological sites and settlements, the faculty building seems very "straight forward" and a comparatively very "modest" case. By the same token, the photographic and verbal description seems to be the least complicated method. In fact, at the beginning, comparing it with the 3D scans and models, the research group treated this process as "redundant"; but the assessment process of all the values of the building proved completely the opposite.

Definition of each space in the faculty building with six surfaces, elevations, sides was the real challenge. The architect members of the research group spent some time to define the borders of the spaces in the building. Not only in plan but also in three dimensions the borders were open to interpretation. That was unexpected because the whole building was represented and most probably was designed in an orthographic medium. Plan, section and elevation drawings were the only tools used in its representation during the design process. Yet it was almost impossible to draw the lines that were separating the interior spaces. The given names, floor patterns and hatchings in the drawings were studied to understand the architects' intentions. Competition, publication, application and survey drawings were studied. The group spent some time to list the given "names" of the spaces and tried very hard not to use invented nomenclature. However, they ended up using invented terms such as: "void elevation", "platform", "cornice", "in-between space", and "relief space".

There are very specific reasons for that in this particular example of Modern Architecture:

- there are volumes as opposed to masses.
- all the structural elements, including the dilatations, define the borders of the masses but not interior spaces.
- all the interior spaces are divided by transparent surfaces and courtyards.
- even the flattest looking elements are in fact conceived and produced three dimensionally
- there is no symmetry but regularity in the facades yet the hidden symmetry axes passes. through the façades themselves.
- all the structural and infill materials are visible from the outside and they are true to material, there is no cladding

Besides the "tropes" of the "International Style", there is another aspect of Modern Architecture which makes this building a challenge for a photographical survey. This is the "open plan". The circulation areas cover 50% of the total surface area. The flow of circulation is uninterrupted in plan and in section. Rather than blocking the view and defining sub-spaces, the level differences in the continuous circulation increase the visibility.

The above-mentioned invented terms have been interpreted as master thesis subjects by the graduate students in the research group. That and all the discussions it has generated proved the value of this analytical method for documentation and its relevance to the assessment of significance.

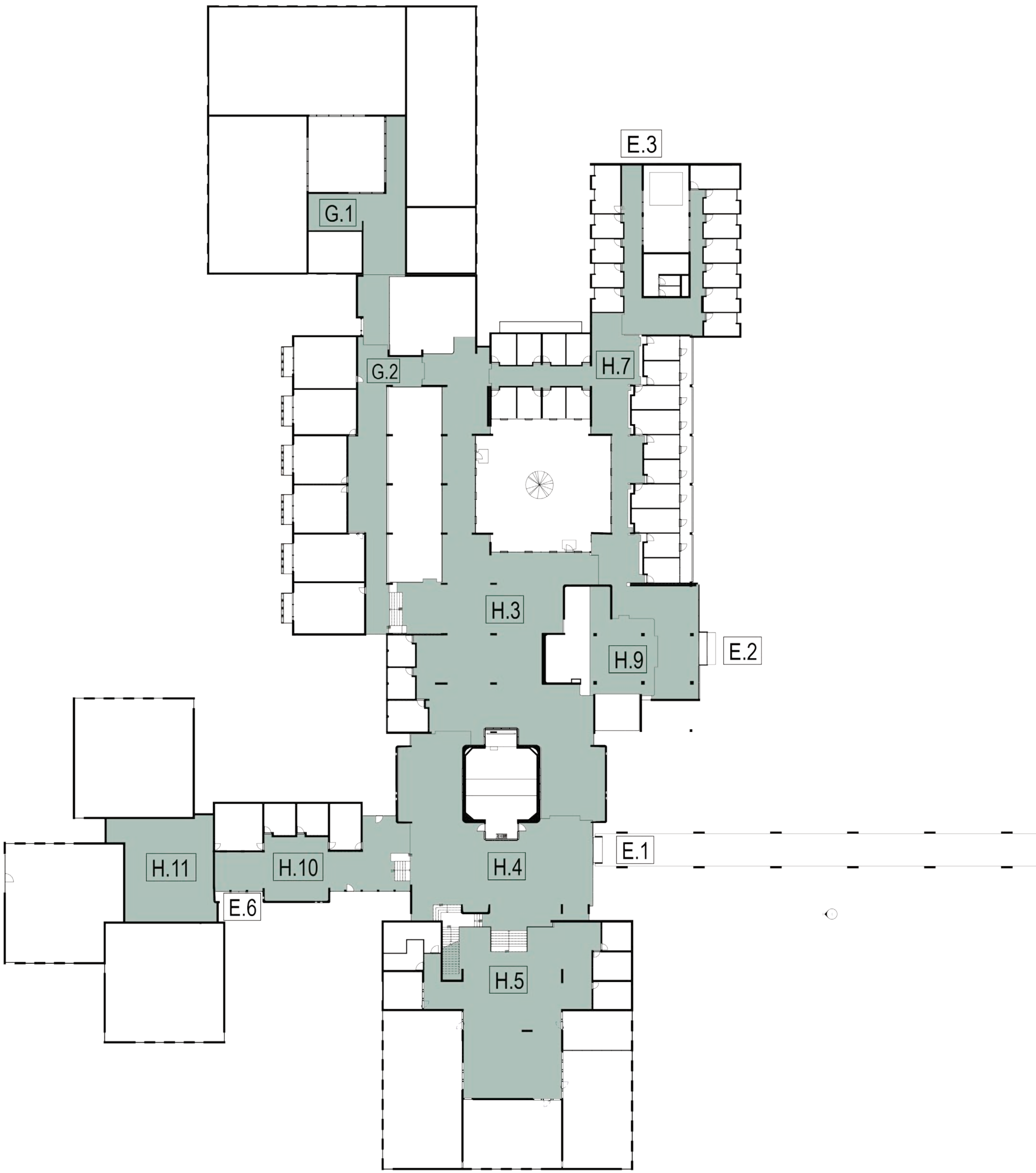


Figure 113: Division of the circulation area, during the photographic documentation.

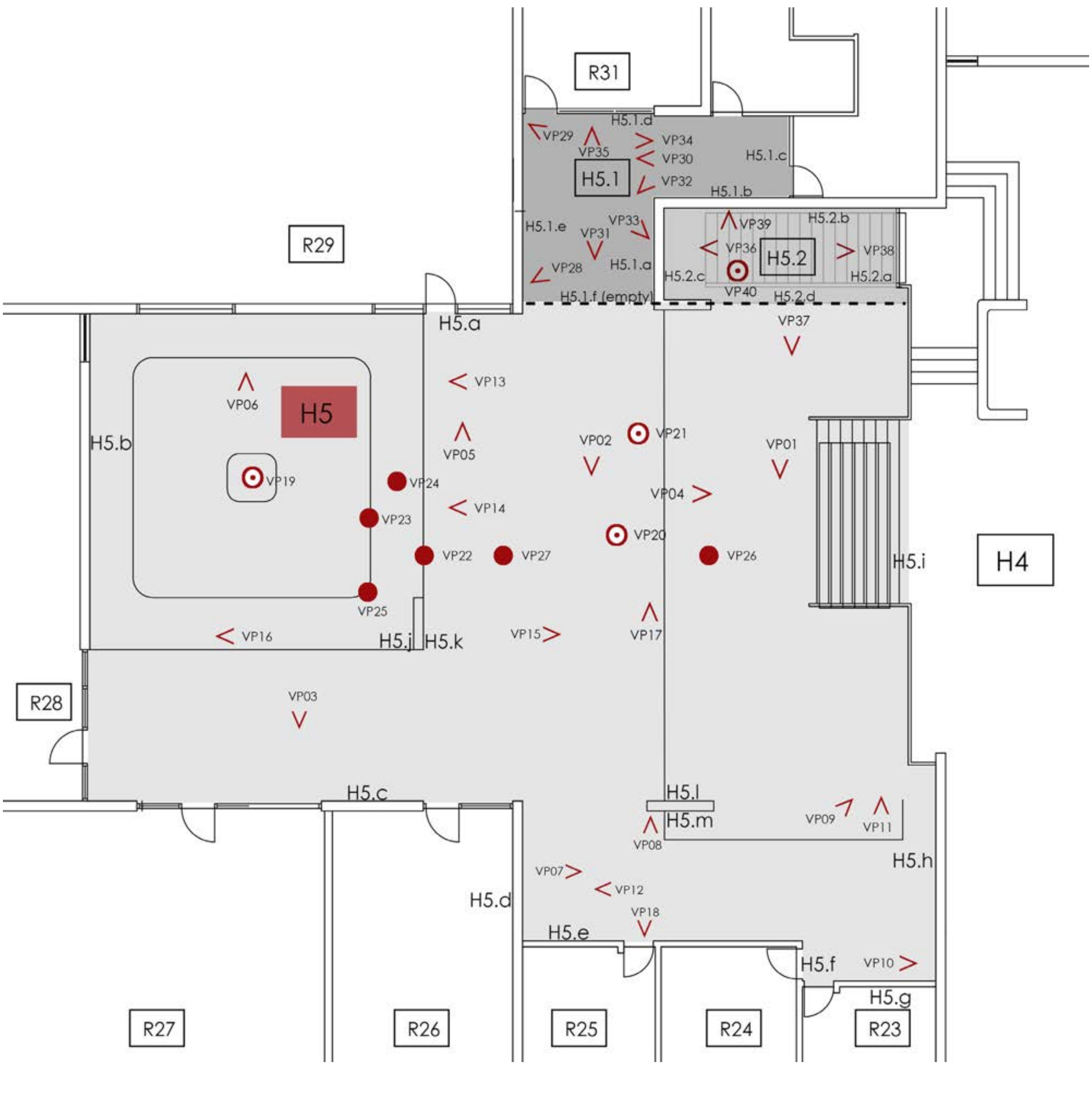
H5

PHOTOGRAPHIC SURVEY
VIEW **P**OINTS

Viewpoint <

Viewpoint - upward

Viewpoint - downward


R31
H5.1.d
VP29
VP35
VP34
VP30
VP32
H5.1.c
H5.1
H5.1.b
H5.1.e
VP31
VP33
VP39
H5.2.b
VP36
H5.2
VP38
VP28
H5.1.a
H5.2.c
VP40
H5.2.a
H5.1.f (empty)
H5.2.d
R29
H5.a
VP37
VP13
VP06
H5
H5.b
VP05
VP02
VP21
VP01
VP19
VP24
VP14
VP23
VP04
VP20
VP22
VP27
VP26
H5.i
H4
VP25
VP16
H5.j
H5.k
VP15
VP17
R28
VP03
H5.c
H5.l
H5.m
VP09
VP11
VP08
H5.h
VP07
VP12
H5.d
VP18
H5.e
H5.f
VP10
H5.g
R27
R26
R25
R24
R23

Elevation H5.a (North)

HALL 5 / H5

Hall number 5 (H5) is the main common space in the F block, which is composed of a two-storey high inner courtyard surrounded by four offices, two studios, a classroom and service areas. It includes the symbolic sculpture named after *Göbektaşı*, which gives its name to the whole surrounding platform and area (H5). Access to H5 is through H4 via a staircase that acts as a transitionary space between two common spaces separated with a level difference. Since the *Göbektaşı* platform functions as a gallery space with a skylight, H5 has two different ceiling heights. There is an installation hanging from the ceiling, which is designed in 2008, with reference to the existing spatial qualities of the *Göbektaşı* space.

The waffle slab provides a system for the division of elevations into one-meter wide units all through the building. The wooden framed glazing divisions, infill and load bearing elements are designed following the guidelines of this system. In H5, these guidelines can be followed very clearly.

Elevations

The north elevation (H5.a) is not a continuous surface. It has 3 sub-divisions (see VP01,02,03). It is composed of one solid part that defines the boundaries between H5 and Room number 29 (R29), and two “void-elevations” defining the boundaries between H5-H5.1 and H5-H5.2. The hall, H5.2, includes a stairwell and H5.1 is an entrance hall for the service areas. The elevation H5.a is made out of exposed concrete, cement-blocks, and wooden framed glazing. In between two exposed concrete shear walls, the partition is made out of 19x39,5cm cement blocks in 2/5 ratio and wooden framed glazing with 3/5 ratio of the total surface area. R29 has a wooden door frame at the right, which is perpendicular to a shear wall.

The wooden framed glazing division uses the above mentioned waffle slab system as its guide lines. It is divided by horizontal and vertical elements. The main elements form the general framework and sub-elements are grouped in two. The spacing between sub-elements is sequential, starting with 103cm and continues as: - 24cm -103cm – 24cm – 103cm. The horizontal element on the upper part is continuous. The horizontal elements on the lower part are divided with the same sequence above. The wooden frame glazing with a door has the same principle. The only difference is the replacement of the glass surface with a wooden door that opens to R29.

Figure 114: Göbektaşı

Figure 115: THOR | Spatial installation
2008, G. Kınayoğlu and E. B. Atatür

Figure 116: 1.20x1.20m waffle slab system

Figure 118: Exposed concrete

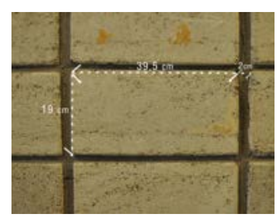


Figure 117: 19x39,5cm cement-blocks

Figure 119: Wooden framed glazing

Elevation H5.b

Elevation H5.c

Elevation H5.d

Elevation H5.e

Elevation H5.d, H5.e

HALL 5 / H5

Figure 120: Joint gap lines

The west elevation (H5.b) separates the common area (H5) from R28 and is made out of exposed concrete and wooden frame glazing (see VP04). On the right, there is a single opening with wooden framed glazing defined at the top with a joint gap line. On the left, there is a wooden framed glazing system with a door at the center. This framing system is the same with the one at H5.a. At the both sides of the wooden door, there are framed felt surfaces used as bulletin boards. In between these two wooden framed glazing, there is a 7 meters long exposed concrete shear wall. The slab thickness is indicated by the joint gaps. A fire extinguisher is mounted onto the left corner of the concrete shear wall.

The south elevation (H5.c) separates the common area (H5) from R26 and R27 (see VP05,06). In this elevation, exposed concrete and wooden framed glazing are used. On the right, there is a 5-unit wooden framed glazing. On the left, there is a wooden framed glazing system with a door.

On the left hand side of the H5.c, there is a transitionary hall, which serves to the instructor rooms (R26, R25, R24, R23. The elevations of H5.d, H5.e, H5.f, H5.g are in different directions, but they are continuous surfaces defining the same space.

The H5.d is perpendicular to the H5.c. It is an exposed concrete shear wall in 3 meters length.

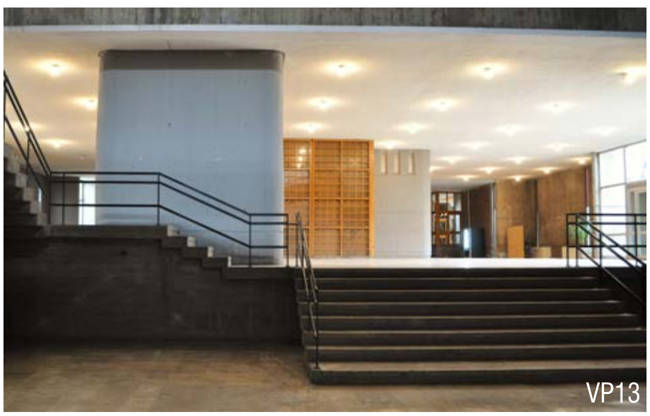
H5.e separates the transitionary hall from R25. It is a cement-block wall. 2 meters apart from the left, there is a wooden framed door opening to R25. This door has the same height with the cement-block wall.

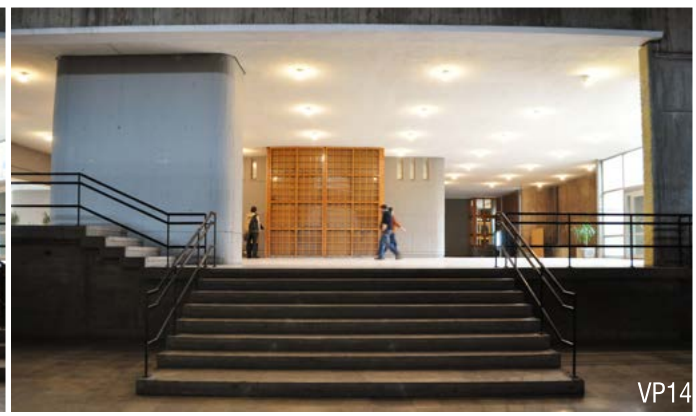
Figure 121: Wooden framed door - Waffle slab structure

Elevation H5.f

Elevation H5.g

Elevation H5.h

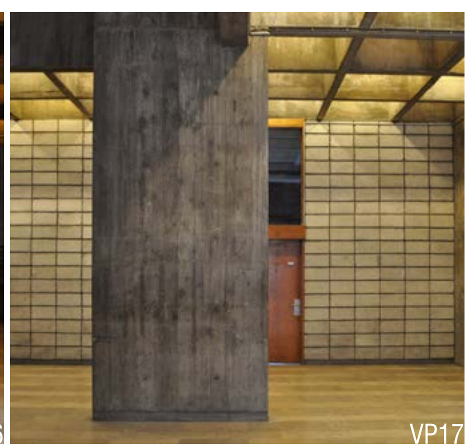




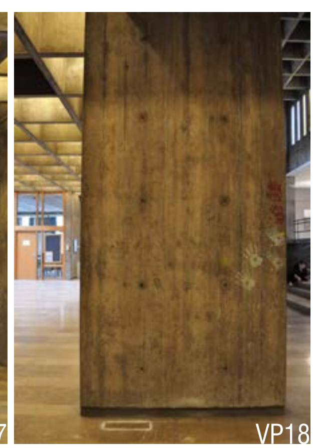
Elevation H5.i

Elevation H5.j

Elevation H5.k



Elevation H5.l



Elevation H5.m

HALL 5 / H5

H5.f has a door opening to R24, and has the same wooden framing as the other doors described above (see VP10). At the right of the wooden frame, the thickness of the cement-block wall of H5.e can be seen (VP10).

H5.g separates R23 from the transitionary space. It is a cement-block wall (see VP11). At the right corner, there is a door opening to R23.

H5.h is composed of a 5-meter shear wall and a wide opening providing access to H5 with an 8-step stairs (see VP12,13). The 3-meters-long part of the shear wall on the right is in one-storey height and the remaining part continues up to the lower level of the waffle system on the upper floor. A fan coil is placed in front of this wall. There are two heating pipes coming out of this fan coil and going up to the lower end of the waffle system (VP12). A single power outlet is placed at the right of the fan coil. Two fire extinguishers are mounted at the left. The slab thickness is indicated by a joint gap.

H5.i is a “void-elevation” looking towards the Kubbealtı area (H4) (VP13,14). There is a level difference of approximately 120cm between H5 and H4. The staircase has 8 steps and made out of reinforced concrete, cladded with marble units. It has thin black-painted iron balustrades. The stairs are connected with the wall surface with a very unique detail of a “negative skirting”.

H5.g separates R23 from the transitionary hall. The elevation is made out of cement-blocks (VP11). At the right of the elevation, there is a wooden framed door opening to R23.

H5j, k, l, m are 1 meter wide shear wall elevations (VP15,1617,18). H5.j is the east and H5.i is the west elevations of the shear wall, which is located at the axis of H5.c. H5 k is the north elevation and H5.l is the south elevation of the shear wall which is located with a perpendicular angle to H5.c.

Figure 122: Fan coils of the METU Faculty of Architecture -A reproduction of the first fan coil fabricated in Turkey

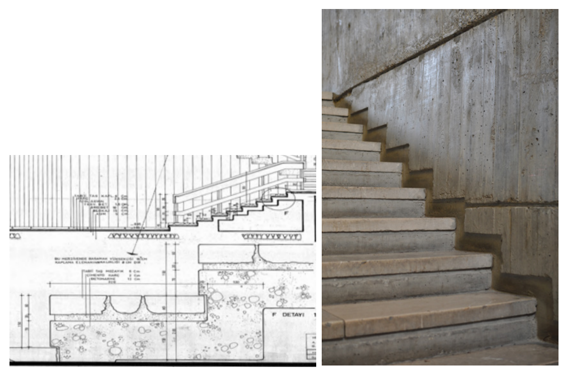


Figure 123: Reinforced concrete stairs cladded with marble units - connected with a “negative skirting”

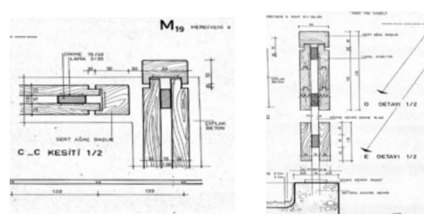


Figure 125: Detail drawings of wooden balustrades in the application project

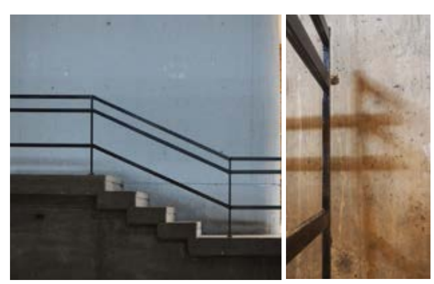
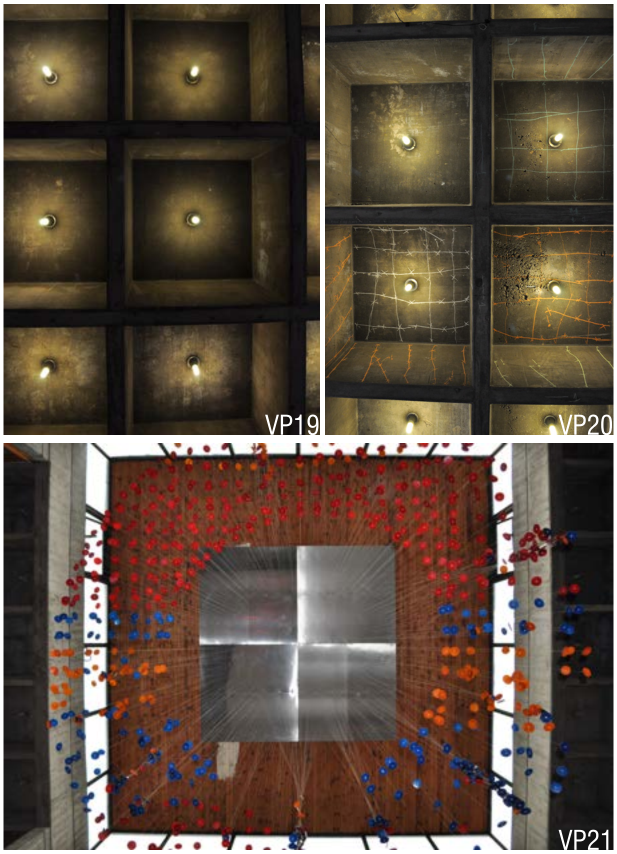
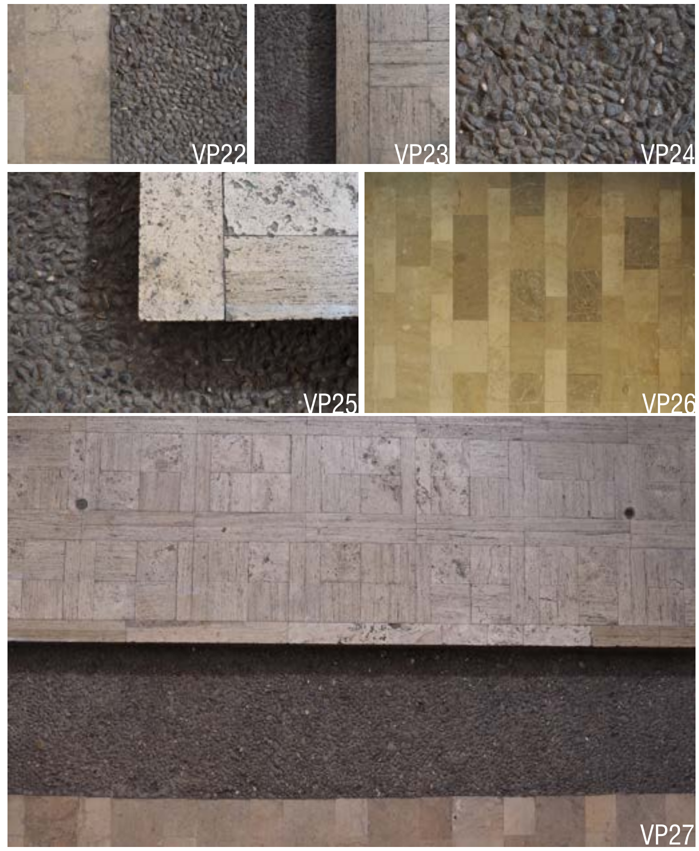


Figure 124: Black-painted thin iron balustrades- applied



H5 Ceiling



H5 Floor

HALL 5 / H5

Ceiling and Floor

The ceiling of H5 is a 1.20x1.20m waffle structure divided by two gallery spaces (VP19,20). Since there is a gallery space, the waffle structure of ceiling of H5 does not continue on the *Göbektaşı* platform. Above the platform, there is a two-storey high skylight ceiling (VP19).

The floor surface of H5 has three materials with different cladding and connection details (VP22,23,24,25,26). The surface where the sculpture of Göbektaşı is located is a 30cm high platform made out of concrete and cladded with travertine (VP22,23,25,27).The rest of the floor surface is composed of marble and gravel(VP22,24,26). The marble and travertine are laid in designed patterns. The patterns emerge from the footprints of the existing structural elements and their spatial compositions. With certain exceptions (i.e where the floor meets the shear walls), the floor patterns are composed of two different variable marble dimensions: 25x60cm (20x60cm) and 40x60cm. The thickness of the marble is indicated as 6cm in the detail drawings. As mentioned above the platform area is an elevated surface. The change of ceiling height from one storey to two storeys, the change of surface material from marble to travertine, and the skylight help the differentiation of the central space of H5 from its periphery.

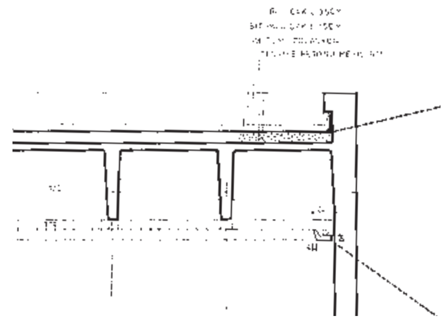


Figure 127: Detail drawing of 1.20x1.20m waffle slab structure

Figure 126: Designed marble patterns- emerged from the footprints of the structural elements and their spatial composition

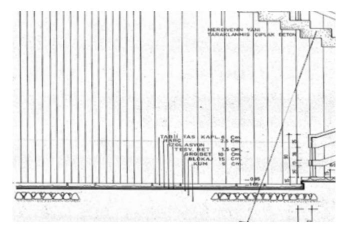
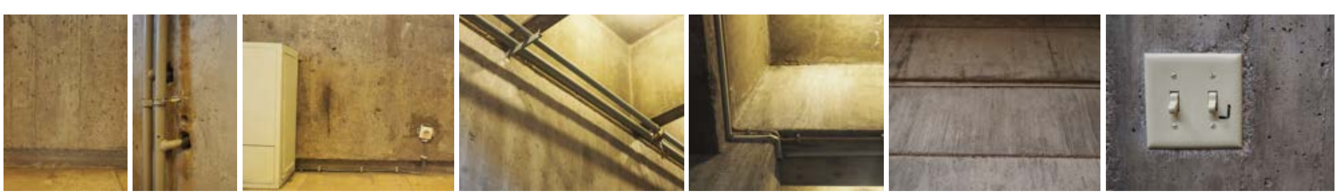


Figure 128: Detail drawings of marble cladding units



H5 Details

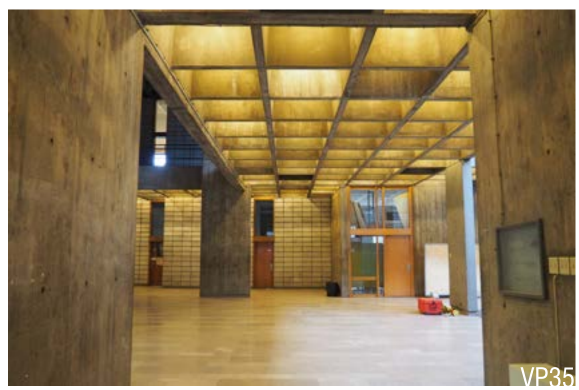
Elevation H5.1.a

Elevation H5.1.b


Elevation H5.1.c

Elevation H5.1.d

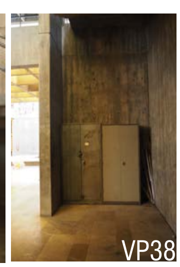
Elevation H5.1.e



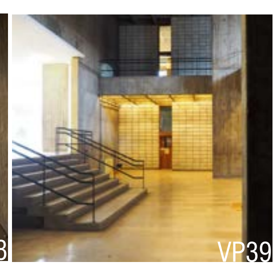
Elevation H5.1.f

Elevation H5.2.a

Elevation H5.2.b



Elevation H5.2.c



Elevation H5.2.d

H5.2 Ceiling

HALL 5 / H5

H5.1

This part is a transitionary space that has access to toilets and R31. This part consists the elevations H5.1a, H5.1b, H5.1c, H5.1d, H5.1e, and H5.1f. These elevations are similar in their material characteristics. H5.1d and H5.1c have the doors to toilets, and H5.1d has the wooden framed door which is the entrance to the R31. They are concrete walls. H5.1e has a fan coil and a fire distinguisher mounted on it. It also has an electric control panel. H5.1f is an “void-elevation” which looks through the main H5 space.

H5.2

This part is the space beneath the staircase going up to G4 space. The H5.2c elevation has storage wardrobes. H5.2b is shaped by the structure of the staircase above. H5.2d is a “void-elevation” looking through the main H5 space.

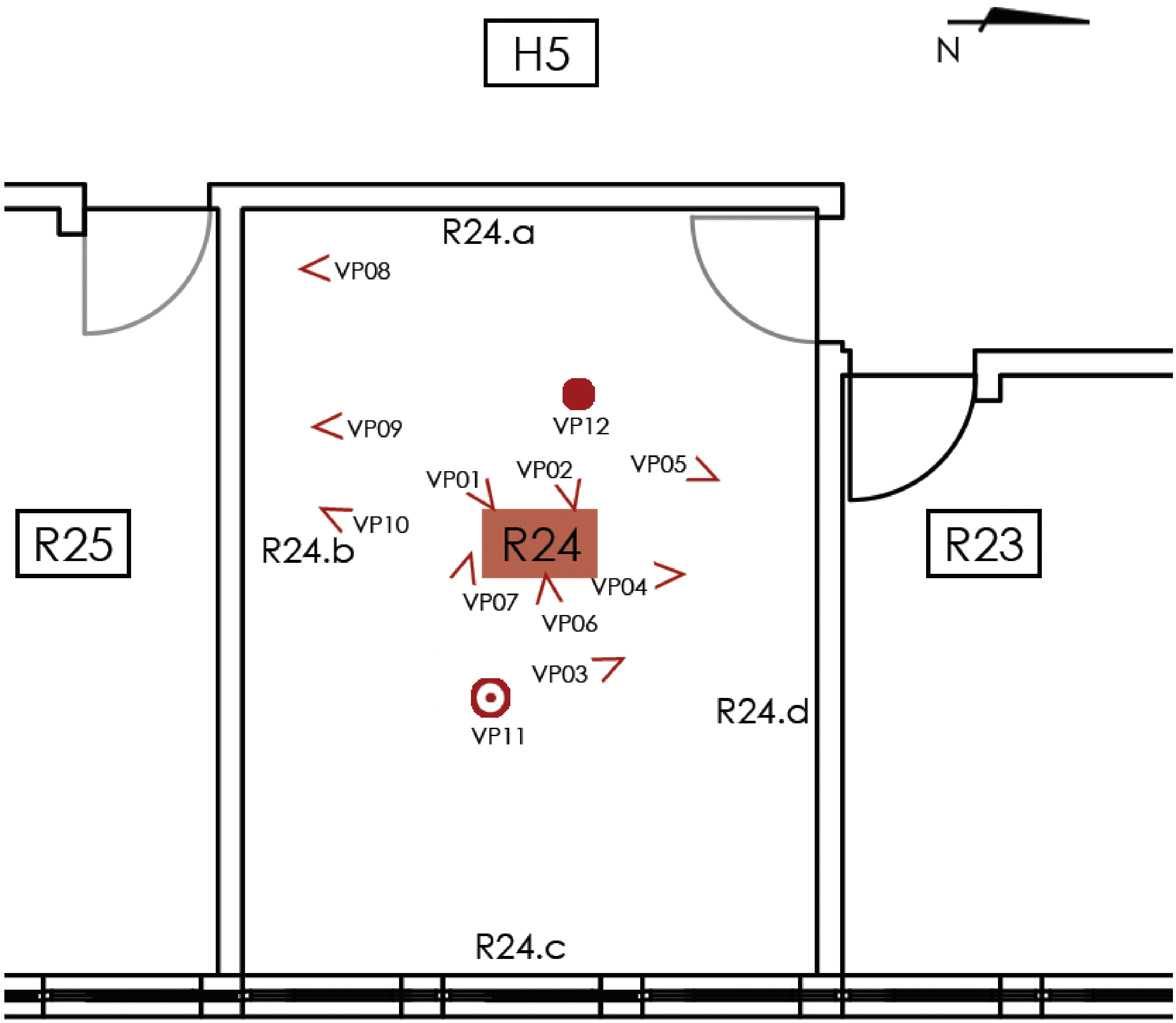
H5.1 and H5.2 Details

R24

Viewpoint

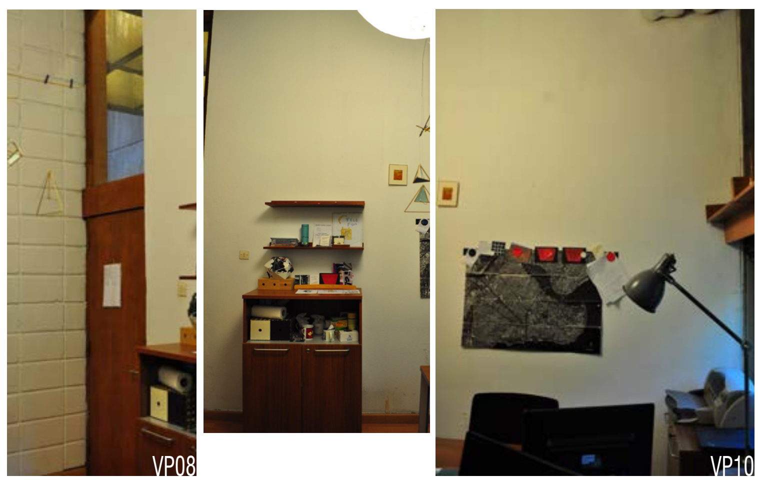
Viewpoint - upward

Viewpoint - downward


H5
N
R24.a
VP08
VP09
VP12
VP01
VP02
VP05
VP10
R25
R24.b
R24
R23
VP04
VP07
VP06
VP03
VP11
R24.d
R24.c

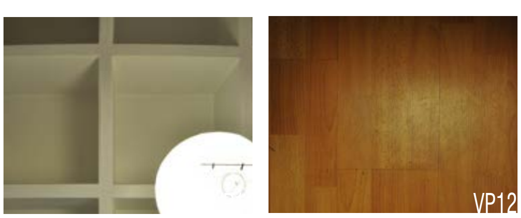
Elevation R24.a

Elevation R24.b



Elevation R24.c

Elevation R24.d



R24 Ceiling and Floor

R24 Details

ROOM 24/ R24

Room 24 (R24) is located in the *Göbektaşı* Area (H5). It is currently in use by two instructors. Although its physical specifications are the same with the other offices, there are minor changes made within the scope of personal choices of the user.

The west elevation, R24.a is made out of white painted cement-blocks (VP01,02). The lower part of the surface is recessed in 5cm depth for the skirting. A wooden skirting is inserted in this recessed part.

The south elevation, R24.b, is made out of infill material/brick painted into white (VP03,04,05). There are three heating pipes coming out from the right corner of the wall (VP03). Underneath the pipes, a white painted, iron cast radiator is placed. At the right side of the radiator, there are two power outlets (VP04). Between the power outlets and the wall, there is a wooden box. Cables coming from the power outlets are fixed on the wall with cable clamps. Wooden skirting continues throughout R24.b.

The east elevation of R24, R24.c is made out of reinforced exposed concrete (VP06,07). There are windows in a row of three units. They are placed with 25cm interval and located 1 meter above the ground. Dimensions of the windows are 95x95cm. Above these windows, there is a wooden panel. The window frame is made out of aluminium.

The north elevation, R24.d, is made out of brick painted into white (VP08,09,10). At the left corner of this elevation, a wooden door is placed (VP08). Two horizontal wooden elements are mounted on the wall to be used as shelves (VP09). Wooden skirting is continuous as in the R24c.

The ceiling is white painted waffle slab as in the other office rooms (VP11). A special lighting fixture is hanging from the centre of the ceiling. In order to be able to carry the three main heating pipes, a pipe bracket is mounted to one of the beams of the waffle slab.

The floor surface is covered with wooden parquet (VP12).

Figure 129: Wooden skirting inserted in recessed surface

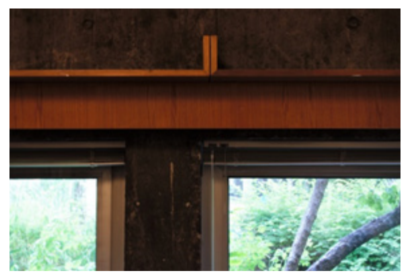


Figure 130: Wooden panel- located above the window rows

Figure 131: Dimensions of aliminium window

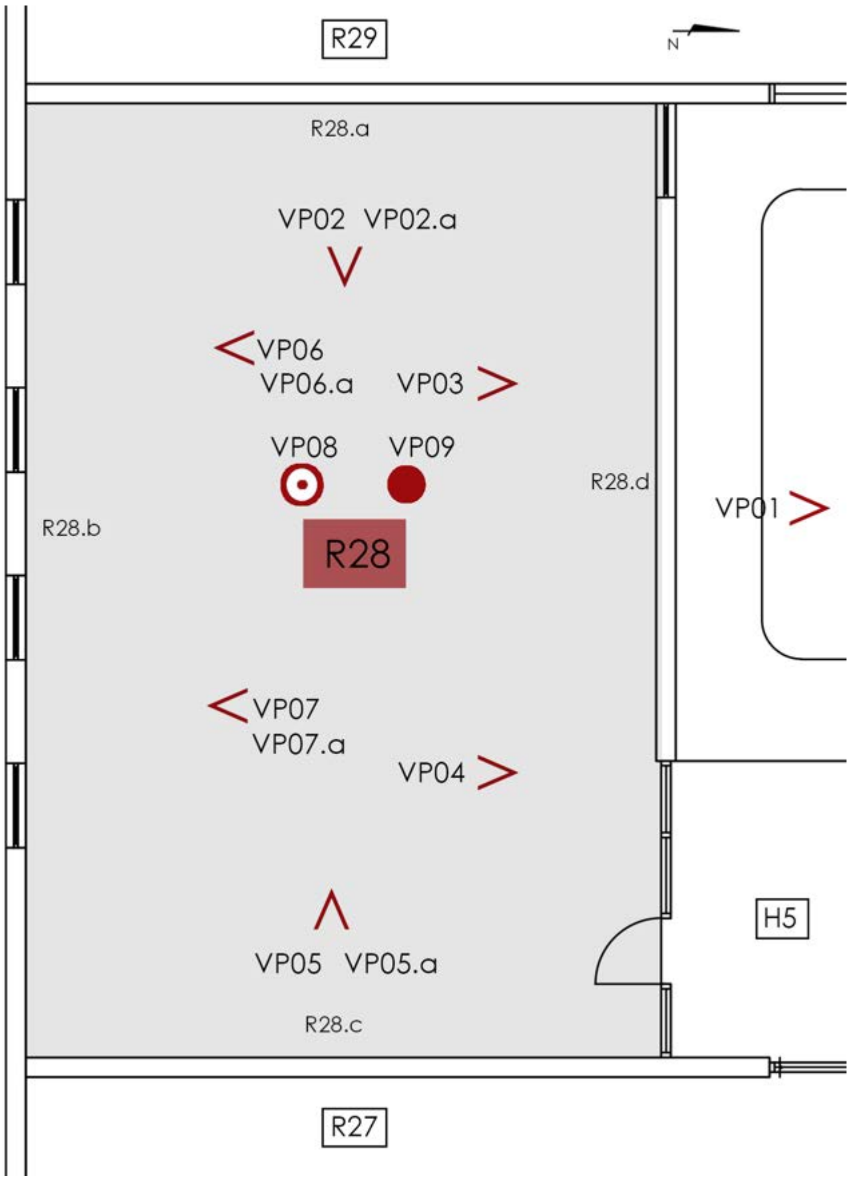
PHOTOGRAPHIC SURVEY
VIEW POINTS

Viewpoint

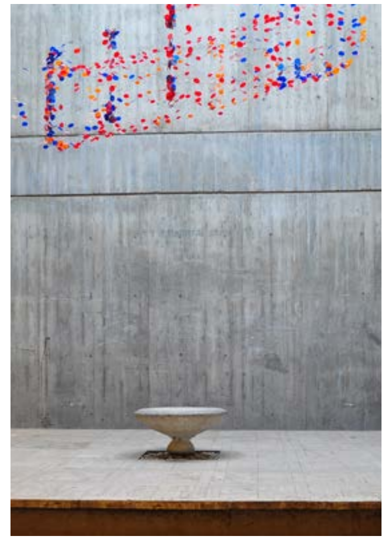
Viewpoint - upward

Viewpoint - downward

R28



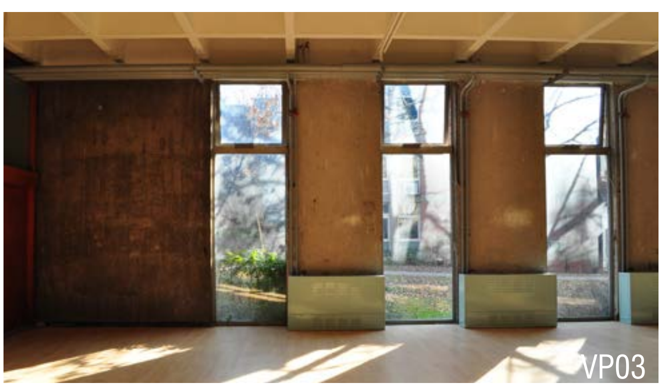
R29
N
R28.a
VP02 VP02.a
VP06
VP06.a
VP03
VP08
VP09
R28.d
VP01
R28.b
R28
VP07
VP07.a
VP04
H5
VP05 VP05.a
R28.c
R27



Entrance Elevation (H5)

Elevation R28.a

Elevation R28.a (without boards)



Elevation R28.b

ROOM 28/ R28

Room number 28 (R28) is one of the classrooms that has an access from H5.

R28a separates R28 from R29. It is a 9-meters long, exposed concrete wall. It has a wooden framed window and a door opening starting from the lowest finishing line of the waffle slab structure (see VP02). An approximately 6-meters long white board is mounted on the wall. There is a cut in the window surface to allow the flow of the mechanical infrastructure. 6 power outlets are mounted on the wall. The right bottom corner of the original exposed concrete wall is painted in grey to cover a fragment of graffiti (VP02). Photographs in this part includes images that are taken with and without the white boards (see VP02.a).

R28.b is the south elevation. It has three main openings placed in an interval of approximately 1 meter. The openings start from the right corner of a 2 meters long concrete wall. Fan coils are located in between the openings following the sequence of the intervals (see VP03,04). The infrastructural equipment takes the existing waffle slab as a reference and is supported by hangers.

Elevation R25.c

Elevation R28.d

Elevation R28.d (without boards)

R28 Ceiling and Floor

R28 Details

ROOM 28/ R28

R28.c is the east elevation. It separates R28 from R27. It is a 7 meters long concrete wall. At the right, there is a wooden framed opening (see VP05). A white board, a green board and a projection screen are mounted on the wall (VP05). There are 3 power outlets at the right bottom corner. Some part of the original exposed concrete wall is painted in grey. Photographs in this part includes images that are taken with and without the boards (see VP05.a).

R28.d is north elevation and it separates the R28 from H5. At the left, there is a single wooden frame opening. On the right, there is a wooden framed window and door opening providing a visual connection with the main space. A white board is mounted on the wall. There are total 6 power outlets at the bottom corner. A fan coil is located in front of the wall (see VP06,07).

The ceiling structure is concrete waffle slab, which is painted into white (see VP08). There is some material deterioration within the waffles. The floor surface is covered by laminated parquet (see VP09).

R29

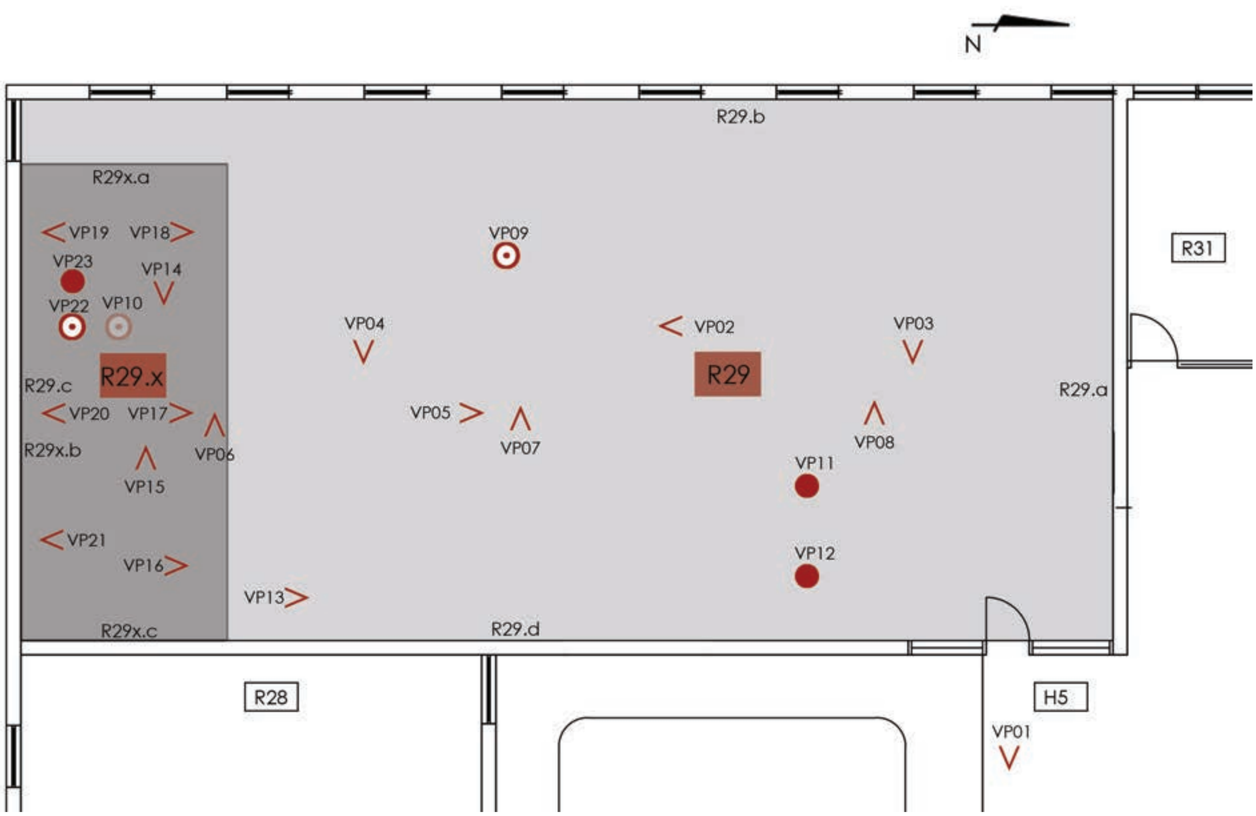
R29X

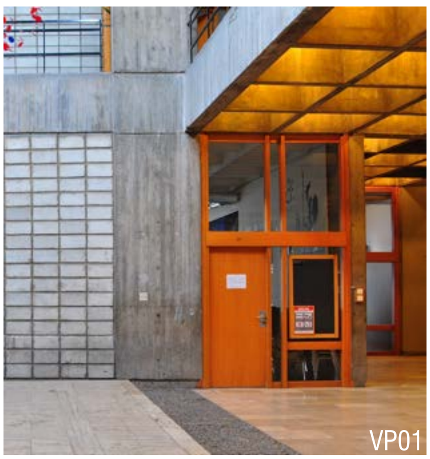
PHOTOGRAPHIC SURVEY
VIEW **P**OINTS

Viewpoint

Viewpoint - upward

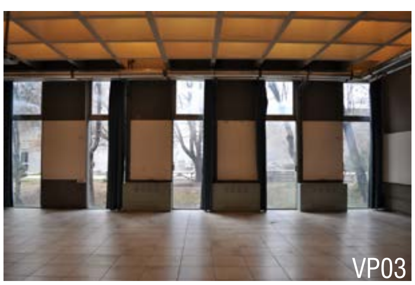
Viewpoint - downward


N
R29.b
R29x.a
VP19
VP18
VP09
R31
VP23
VP14
VP22
VP10
VP04
VP02
VP03
R29.x
R29
R29.c
R29.a
VP20
VP17
VP05
VP07
VP08
R29x.b
VP06
VP15
VP11
VP21
VP12
VP16
VP13
R29x.c
R29.d
R28
H5
VP01



Entrance Elevation (H5)

Elevation R29.a



Elevation R29.b

Elevation R29.c

ROOM 29 - 29x/ R29 - R29x

Room number 29 (R29) has an entrance from H5 (see VP01). It is in use as a design studio by the City and Regional Planning Department. On the south, there is a mezzanine floor that covers 1/5 ratio of the total surface area, constructed to provide extra work space.

Elevations

R29.a, the north elevation, separates R29 from H5.1 (see VP02). It is an exposed concrete wall painted in grey. White boards cover most of this elevation. At the bottom, there is a gap left intentionally for the placement a skirting board. At the centre, towards the ground, there is a single power outlet. On the right, next to the door, there are lighting switches. Above the switches, there is a white plastic cable tray entering from H5.1 and continuing behind the white boards. Underneath the ceiling, at the centre of the wall, there are three heating pipes penetrating from the wall, two of them are in the same size and covered with an insulation material. The pipes are installed to the waffle slab with the aid of pipe hangers (VP02).

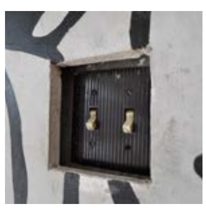
In the west elevation, R29.b, the same wall window alteration system is applied (see VP03,04). In front of each 1 meter wide shear wall, there is a fan coil unit. Over the fan coil units, there are whiteboards with power outlets. The heating pipes continue on this elevation and they are connected to the fan coil units with secondary vertical pipes. There is a concrete cornice below the lower line of the waffle slab (VP03,04).

The south elevation, R29.c, is composed of an exposed concrete wall and a window on the right. On the left of the window frame, the elevation is divided into two because of the mezzanine floor (see VP05). At the bottom finishing line of this elevation, the skirting line continues. At the lower centre of the wall, there is an electrical junction box. The upper part of this elevation is covered with white boards and there are power outlets mounted on them (VP05).

Elevation R29.d

R29 Ceiling

R29 Floor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R29 Details

ROOM 29 - 29x/ R29 - R29x

R29.d is divided into two because of the existence of the mezzanine structure later addition constructed in 1989. On the right, there is a locked door that is designed to provide connection between R29 and R28 (see VP06). Above the door, the white cable tray continues. Next to the wooden frame of the door at the left there is a vertical water pipe entering from the ground floor and passing through the mezzanine floor. There is a wash basin installed next to the door with a 40x40cm beige ceramic-tile background. Next to the door, respectively from right to left, there are exposed concrete wall painted in grey, 3-unitswooden framed glazing, cement-block wall, exposed concrete wall painted in grey and another 2-unit wooden framed glazing (see VP07,08). This 2-unit wooden framed glazing contains the entrance door connecting R29 to H5. The stairs of the mezzanine floor are installed into the exposed concrete wall. Underneath the stairs, there is a triple power outlet close to the ground level. At approximately 90 cm height, there is a white board. Under the whiteboard, there is a fan coil unit and a triple power outlet. At the right corner of the white board there are two vertical heating pipes connected to the fan coil unit. On the cement block wall, there are a green and a whiteboards mounted (VP07).

Ceiling and Floor

The ceiling is composed of waffle slabs painted in white. A data projector and a projection screen are mounted (see VP09). The ceiling of the mezzanine floor is composed of box-profiled steel beams and plywood panels painted in white (VP10).

The floor surface is covered with beige coloured 40x40cm ceramic tiles (VP11). However, on the eastern side, next to H5 the floor finishing changes in to beige marble. It is the same marble and pattern used in H5 continues here (VP12). There are no connection elements between the tiles and this marble surface, which covers a 2,20x9,50m floor area.

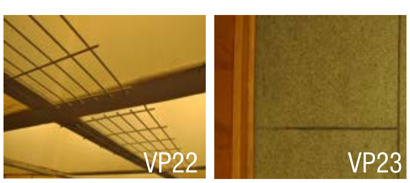
Entrance

Elevation R29x.a

Elevation R29x.c

Elevation R29x.b

Elevation R29x.d



R29 Ceiling and Floor

R29 Details

ROOM 29 - 29x/ R29 - R29x

Room 29x

Room 29x (R29x) is a relatively small space created with the addition of the mezzanine floor to R29.

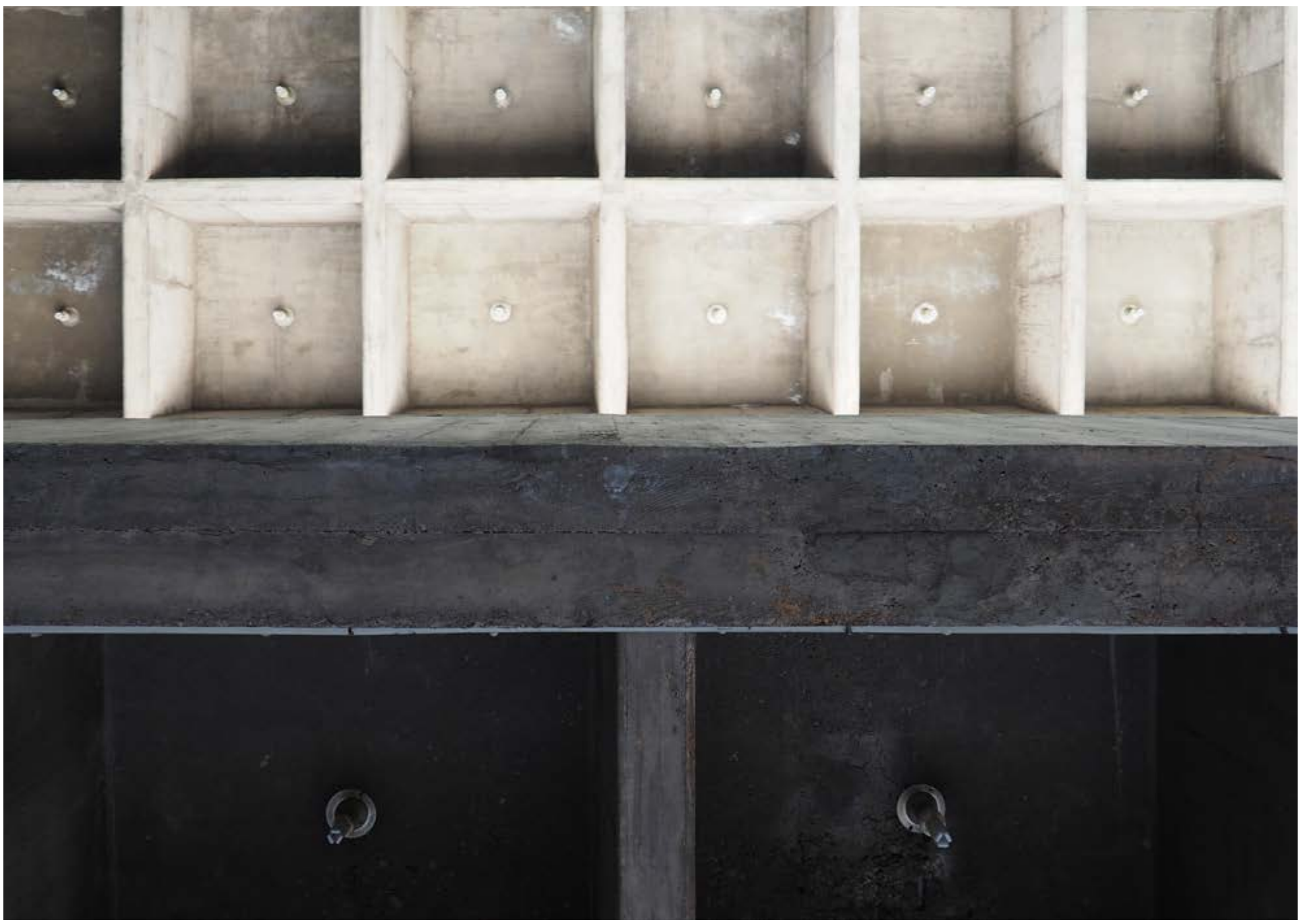
The west elevation, R29x.a, is composed of wooden elements. The division of the wooden framed glazing does not repeat the overall system applied in the elevations of H5. In between the horizontal and vertical wooden frames, the surface is covered with wooden panels on the lower division and the upper divisions are transparent (see VP14). The upper division of the opening at the left is also covered with a wooden panel. The panel is punched to allow the transmission of the heating pipes (VP14).

The south elevation, R29x.b, is the upper section of the elevation R29c. It is an exposed concrete wall. A wooden desk is attached to the wall, cantilevered with box-profiled steel beams and crossings (see VP16,17,18). On this desk, there is a horizontal white plastic cable tray with power outlets, installed on the wall. On the left, there is an electricity panel mounted to the wall. On the top, there are heating pipes installed (VP16,17,18).

The east elevation, R29x.c, is the divided part of the south elevation described in R29. It is composed of the transom part of the door on the right and the exposed concrete wall on the left (see VP15). The glass of the window is cut on the top to allow the flow of the infrastructural elements. On the left corner of the window, there is a vertical pipe painted in brown. On the top, there are secondary pipes installed under the waffle slab. There are some fragments of graffiti on the exposed concrete wall (VP15).

The north elevation, R29x.d, is composed of wooden elements, wooden panels and box-profiled steel elements supporting the mezzanine floor (see VP19,20,21). On the left, there is the entrance door of R29x which directly opens to the stairs of this mezzanine floor (VP21).

The ceiling is the same with the ceiling of R29. Additionally, there is a 10x20cm metal grid installed to the beams of the ceiling (see VP22). The floor surface of the mezzanine is covered with greyish dotted PVC (see VP23).



3.2. Structural Documentation and Assessment

The Motivation for the Structural Assessment of Historic Structures:

Aging infrastructure faces numerous challenges such as material degradation, differential settlement, misuse, and similar undesirable actions while identification of their location, nature, and extent may not always be possible. Determination of current condition from a structural engineering point of view is also important because of changing codes. Japanese and US earthquake codes have changed especially after the Kobe and Northridge earthquakes. Turkish earthquake design code had major revisions after the 1998 Duzce and Kocaeli earthquakes although there were also code changes in 1960 and 1975. Design code changes in 1998 and 2007 brought additional requirements and became compatible with international changing earthquake codes.

Since the design and construction stages of the Faculty of Architecture Building at METU took place in 1960s, the design procedure could not possibly account for future code changes. Each change of the calculation methods and principles leave an existing structure requiring exploration of whether the current design would meet and match the requirements of a new code. If any critical weaknesses are identified which might jeopardize the safety of the building and occupants, then the building needs to go through strengthening or base isolation works to achieve safety. Many buildings in Turkey are going through renovation or demolition-rebuilt

Figure 1: Waffle slab in F block.

studies since they are found to be weak against earthquakes as they were built earlier than the modern improved codes. A historic structure or building with architectural significance may not be easily replaced and other remedies should be sought first. As a first step, there is a need to systematically assess the current structural condition, which involves both the investigation of possible changes in structural element properties over time and whether these properties would satisfy new code requirements.

Another challenge for existing structures is the possibility of missing documentation, which may relate to technical drawings, calculation reports, assumptions made in design, soil related parameters at the construction site and similar information. It would be impossible to compare the current properties against original values if original values are not known and sources of design decisions are not available. Obtaining current structural properties without causing harm to the existing structure is also another challenge.

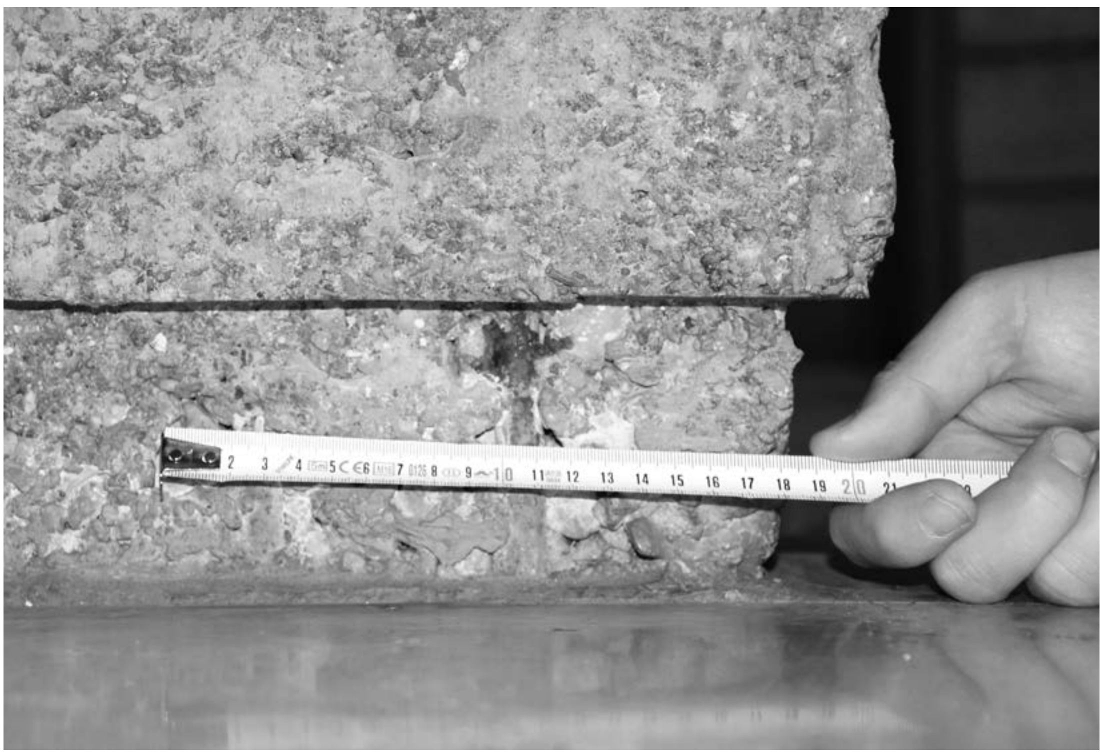
Figure 2: Schmidt hammer test, January 21, 2018.

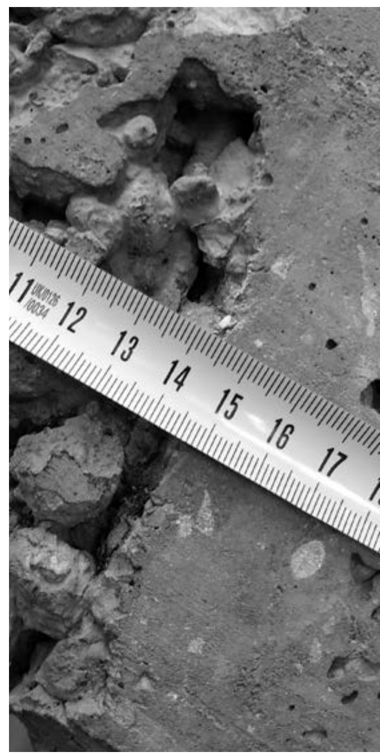
Standard techniques such as taking core samples and steel bar samples by removing the concrete cover of beams and columns, then cutting reinforcement samples to test in the laboratories are destructive methods proposed by the code to check against earthquake loads, that are not applicable to existing structures with historic or architectural value.

Therefore, special “non-destructive” evaluation methods are required for historic heritage buildings when there is a major reason not to conduct semi-destructive testing. Ambient dynamic testing might also be considered as a nondestructive method to indirectly obtain specific structural properties. This document lists the approach, techniques and results obtained regarding the structural assessment of the Faculty of Architecture Building at METU. Each study is further described under relevant headings below.

Figure 3: Non-destructive methods for structural assessment.

3.2.1. Studies on Structural Documentation





3.2.1.1. Visual Evaluation of Structural Load Bearing System

The initial evaluation of the Faculty of Architecture Building started with a visual inspection of the entire building complex. Different structural parts of the building are investigated by putting special emphasis on each element.

The floor load bearing system is dominantly waffle slab, also referred as two-way joist concrete slab. In this system, the slab is composed of closely and evenly spaced thin beams in both horizontal directions forming square void areas in between. The structural significance is a result of the fact that larger distances can be spanned with this technique due to reduced total slab weight. Moreover, the visual aspects of this architectural pattern have advantages over a conventional beam and column system which organize, for instance, the artificial lighting system of the building complex. However, larger spans with small beams come with a precaution that shear forces around the columns may easily exceed member capacity. Shallow beams and infilled gussets are used around columns to avoid such shear forces (figure 4).

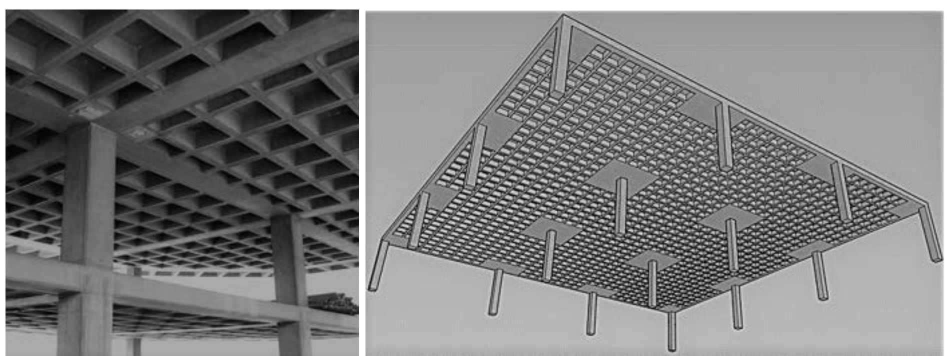


Figure 4: Common practice for Waffle Slab (also referred as Two-Way Joist Concrete Slab) Floor.[1,2]

The visual inspection of the building complex revealed a potentially hazardous shear weakness around the columns and the shear walls, since there were not gussets or shallow beams to transfer relatively large shear forces or wide waffle slab spans (figure 5).

Figure 5: Waffle slab view on the selected part of the building, taken by Cemal Emden, retrieved from http://www.cemalemden.com/.

One advantage of the waffle system in this building comes from the fact that the slab is connected to relatively long shear walls or columns with one dimension much larger than the other. In this case, more than one waffle beam (joist) is connected to one column (figure 6), which would increase the member area transferring shear forces and reducing shear stresses.

[1] Retrieved from http://www.kasetdoseme.com/

[2] Retrieved from https://www.structurepoint.org/pdfs/Two-Way-Joist-Concrete-Waffle-Slab-Floor-Design-Detailing.htm

Nevertheless, a number of structural cracks are observed at the section of the building with a skylight. Diagonal cracks show that the shear strength has been reached (figure 7) in at least one of the side beams and yielding moment (M_y) is reached at a consistent section of the first floor where maximum span bending moment is expected (figure 8). Similar bending tension cracks are also observed in another nearby span as well as at the negative bending zone towards the supports indicating that the first floor's slab (in the form of a bridge) is close to its ultimate capacity and poses a structural threat. A more detailed structural analysis is necessary to estimate the the bending capacity-to-demand ratio. More sophisticated investigations should be made on reinforcement to estimate actual capacity of this section. As a precaution, extreme live load focused on this part of the slab is avoided until a through structural evaluation is made, and if necessary, strengthening work is completed.

Figure 6: Waffle slab to column connection at the selected part of the building.

When the design studios are analyzed, it was seen that some of them are overpopulated and had extended working areas in the form of mezzanine floors. There is a variety of hanger bar systems applied in different studios (figure 9). This variety adds to the architectural value. Furthermore, different methods used to attach the rods to the ceiling provides a medium for the education of students in regard to structural load carrying mechanisms. However, mezzanine floors (later additions in 1995-2000) are attached to the ceiling with tension rods that would apply extra dead and live load to the waffle slab, which was not initially considered in the original design of the slabs. The additional weight and mass hanging from the ceiling not only creates extra vertical load on the delicate members of the slab, but also generates extra horizontal forces which can be dangerous in the event of an earthquake. The safety of the mezzanine floors hanging from the waffle slabs should be carefully investigated and, if necessary, strengthened. However, sophisticated material tests and detailed structural analyses for these mezzanine floors are are suspended, since removing the mezzanine floors hanging from the waffle slabs is one of the main policies of this project. Although their mass is not critical and can be safely carried by the building, their functional necessity, low quality material choices, and their aesthetic aspects support the decision to removing.

Figure 9: Different types of mezzanine hanger bars attached to the waffle slab of one of the 3rd year design studio, designed by a former instructor, Arda Düzgüneş.

Figure 7: Shear crack on side beam, F block

These later additions harm the original decisions regarding the homogeneous daylighting and artificial lighting systems particularly within the studio spaces, and interfere with the airflow due to natural ventilation through the glazing. The recycled materials used as the flooring material produce dust, which creates an unclean and unhealthy working environment underneath. As the parapet design does not meet the requirements of the standards, there is always a possible danger of falling objects.

Besides the waffle system, there are other structural systems at work in the building complex, such as one-way ribs of the library (now Museum), the radial deep beams of the amphitheater (figure 10) and a one-way joist slab with hollow filler blocks. Beams are not frequently used in the circulation area of the main educational unit, most probably because of architectural concerns. A few deep beams spanning large distances that are difficult to discern from structural walls can be observed in specific parts of the building. Relatively smaller spaces and especially service spaces with sewerage plumbing etc. have thicker slabs, which are regular flat decks.

Figure 8: Positive bending moment related tension cracks in the 1st floor waffle slab of the selected part of the building.

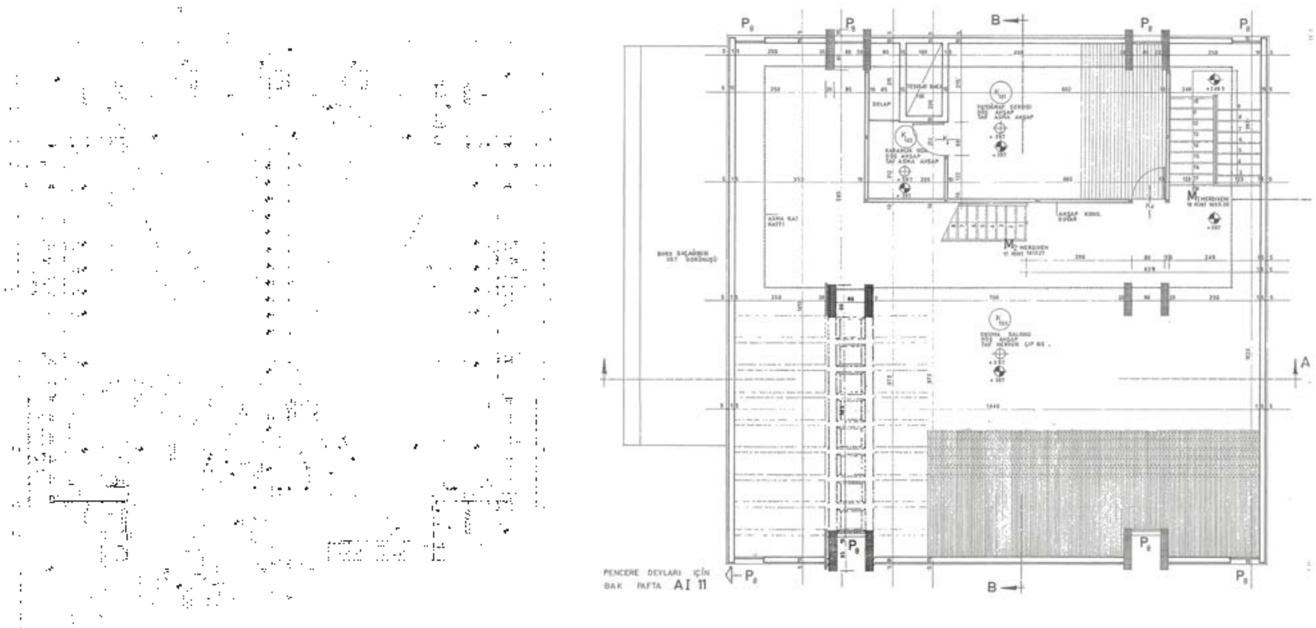


Figure 10: Plan of the Amphitheatre and Museum.

Focusing on the pilot area, the visual inspections made clear that a special attention was required in the skylight (figure 11). This central opening was designed to let direct sunlight in from the windows that are supported by about 36 vertical cold formed steel profiles such as L shaped angles or box sections with about 80mm on one side (e.g. L80x80x5mm or box 80x5mm). The suspended portion is about 6m x 6m (36 m^2) and made out of a light-weight material (figure 12). Detailed investigations could be made by using advanced non-destructive methods to obtain the cross-sectional and material properties of this part of the building. A dynamic test can be made to observe the primary vibration mode's period. The suspended weight of the skylight ceiling can be measured by a structural sectional investigation combined with the measured characteristics.

Figure 11: Skylight of the selected part of the building.

Figure 12: Details from the skylight.

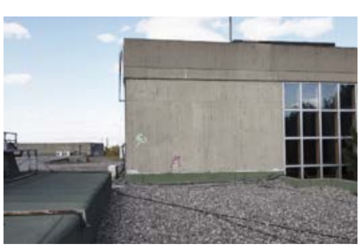


Figure 13: View from the roof.

Considering the unlikely possibility of the collapse of this skylight, further analysis should be made in parallel to the others that are listed in the future studies section of this report. As structural and water-tightness problems are observed in the skylight and it has never been built according to original ideas of the architects, its renewal can be one of the policies of this project (figure 14).

The roof of the skylight is flat, covered with water insulation material. A thin layer of roofing felt is applied on this insulation material to protect it from the damage that could be caused by the stone chipping laid on it. The stone chipping is used to reduce damage from extreme sun exposure. The choice of the color of the stone chipping was made to reflect solar radiation, particularly during the summer months. Ultraviolet light and oxygen in the air can quickly damage the water insulation layer and this fabric. The stone chipping, or in other words the rounded stone and sand mixture, has the capacity to protect the roof for extended periods (figure 13).

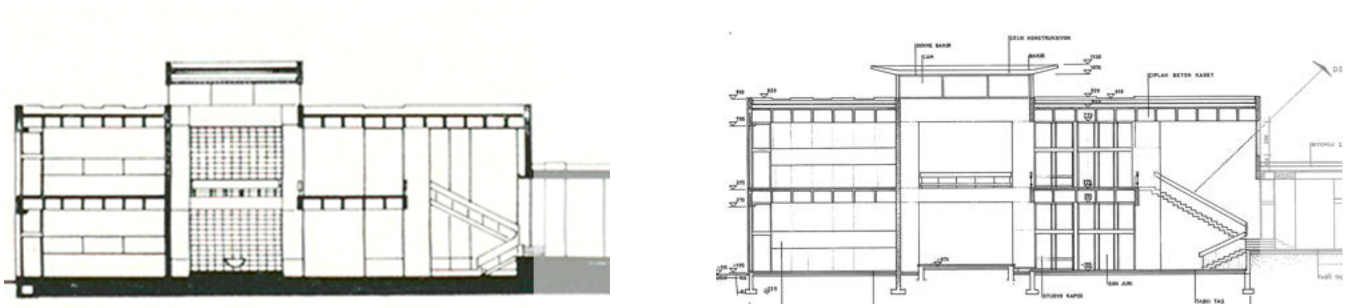


Figure 14: Detail drawing of the roof.

Over the years, routine repair work has been carried out on this roof surface. The original drawings (figure 15) indicate the application of a thin water insulation layer on the flat roof; the application of the thermal insulation layer is a later addition. It is needless to say that the later ad-hoc application of the electrical wiring on the roof surface is unacceptable.

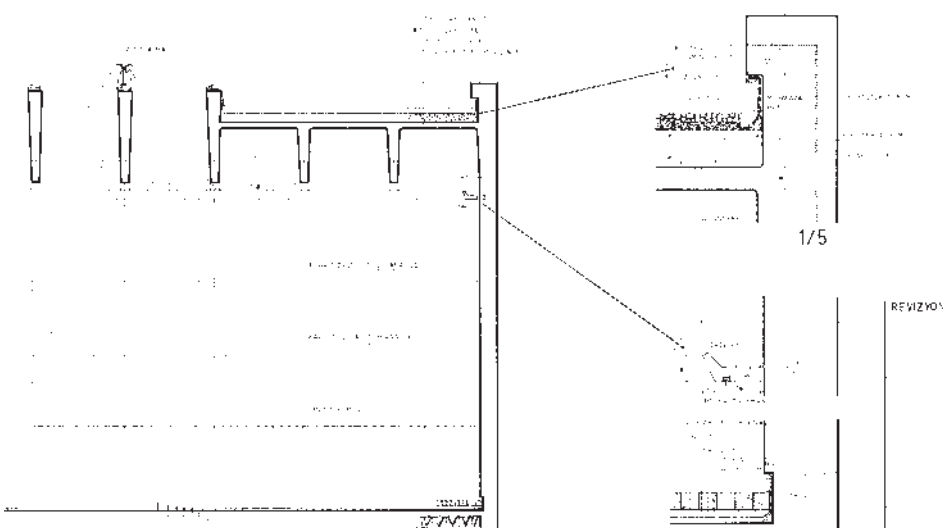


Figure 15: Different versions of the skylight in F Block.

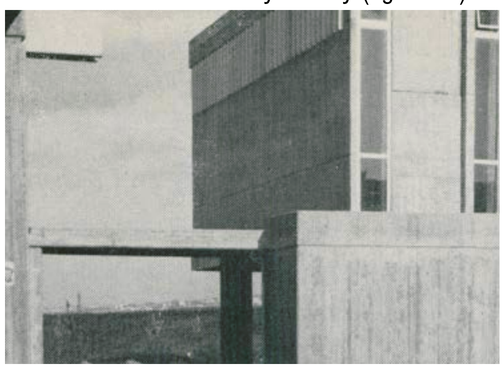
The air handling units on the roof, although few in number, have to be assessed within the framework of the final policies developed by this report. A detailed material assessment and thermal performance assessment of the roof can be found in the Material Assessment section and the Environmental Assessment section respectively in this report.

When it comes to the specificity of the structural system, it can be observed that the vertical load-carrying members are very seldomly used in the building (figure 16). The majority of these columns are either of a large aspect ratio such as 3 to 5 times the narrow dimension or even longer. This unusual ratio transforms the “columns” into “shear walls”.

Figure 16: Plan showing the structural system and shear walls in darker lines.

The Turkish seismic code refers to vertical load carrying members as “shear walls” if the aspect ratio is larger or equal to 6 times its narrower side. Shear walls are extremely useful when lateral earthquake loads are concerned. This is one of the main significances of this building. Moreover, the central core supports this logic. Many modern codes require a central core or external members with large aspect ratios (long and thin walls) that will dominantly carry the base shear in shear deformations rather than bending deformations. Due to their high rigidity and large shear load carrying capacity, shear forces can be attracted to shear walls. This low-rise building complex with many shear walls is extremely resistant against earthquakes and often remains within linear range and suffers no or very small damage during large earthquakes.

The use of large-scale exposed concrete surface could be seen as an architectural objective, yet, it also supports the engineering concerns. They transform the building into an invincible structure against earthquakes. Even without making any manual calculations or structural analysis, the general size and the distribution of the shear walls within the building complex indicate high resistance against earthquakes. On the other hand, the asymmetrical distribution of shear walls and columns in different parts of the building complex creates an unbalanced situation in the stiffness symmetry (figure 17).



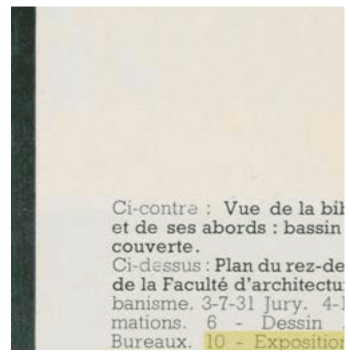


Figure 17: Asymmetrical distirubition of shear walls in the different parts of the building respectively; C1, C2, C3, G1, G2.

As a result, there is a possibility for the building parts to rotate around its shifted rigidity center, since the center of gravity is also at the center of the slab and is much less affected by the vertical load carrying system. The systematic separation of the functional masses of the building complex is mirrored in the structural separation provided by the dilatation joints (figure18).

The partition walls that are made out of concrete blocks and exposed red bricks are not considered as structural elements in this report and kept outside the scope of this section. Some partition walls were masonry walls made out of concrete blocks (briquette), instead of frequently observed thin wooden posts and large glazed surfaces. Those concrete block walls, however, are expected to generate a decent compressive capacity. By creating diagonal compression struts during an earthquake, they can transfer a significant amount of shear force from slab level to the ground. Since these walls are unreinforced, they can lose their stability and collapse towards their out-of-plane direction in strong earthquakes. As a result, they cannot provide tensile stresses; yet they are still very useful at the early stages of an earthquake. If the duration or amplitude of an earthquake is not too large, which would be the likely scenario according to the seismicity of Ankara, these briquette masonry walls can do a decent job. Preliminary non-destructive Schmidt hammer readings on the briquette members of partition walls yielded very high strengths of as much as 50 to 60 MPa (about 8 ksi) that was not expected from these units. Further verification analyses on these preliminary results are needed for a reliable assessment of their performance during an earthquake.

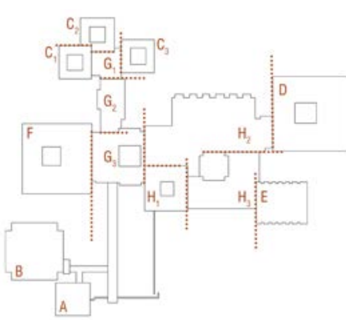


Figure 18: Structural separation provided by the dilatation joint.

The existing shear and bending cracks on the waffle slab were observed at more than one location in the selected area (*Göbektaşı*), but not anywhere else in the building. This unusual instance in the construction does not contradict the initial decision of using a waffle system and its structural design, but rather points to possible application problems or flaws on the site during construction. The span of the first-floor waffle slab is particularly narrow and long. This is the only bridge-like structural element in the building complex. As all the slabs were designed and constructed in the same manner throughout the building, that bridging condition played a negative role in the slab's structural performance. Detailed structural assessment of the whole building as well as particular members (comparisons between structural plans and current status of members) is necessary to understand why damage occurred to certain slabs of the building but not others.

Additional cracks were observed at the "coupling beams" that connect two large shear walls. The reason for these cracks was mainly the openings above and below these beams. Although they act as coupling beams, it is not expected to find diagonal reinforcement inside. Figure 19 shows the difference in between.

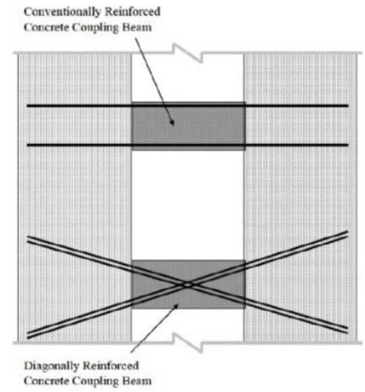


Figure 19: Schematic view of coupling beam and types retrieved from https://www.researchgate.net/publication/290607751_Optimum_Degree_of_Coupling_for_the_Efficient_Seismic_Response_of_Reinforced_Concrete_Coupled_Walls/figures

3.2.1.2. Non-destructive Material Tests and Results

One of the frequently used non-destructive testing methods in civil engineering practice involves the use of Schmidt hammers. These instruments are composed of a metal rod that is pulled back with a spring system, which hits the concrete element with a certain speed and energy upon being released. The metal piece's rebound value is obtained at a higher amount if the concrete has a higher strength; because the material does not deform plastically but rather elastically. If the concrete has relatively lower strength, it goes through some minor plastic deformation and absorbs energy. At the same time, the rebound deflection will be smaller because of this plastic behavior and nonlinearity. In general, Schmidt Hammer testing can leave a small dent on the wall, when the material is too weak. In the tests conducted at the faculty building, no such deformation was observed, which is another indication of the strength of the walls.

The results of the concrete strength measurements via the Schmidt Hammer test vary from place to place in the selected area (figure 20). Moreover, the dispersion of the concrete strength measurement is relatively large. Any consistent reduction in the strength and a large standard deviation can be an indication of poor workmanship, improper ratios of cement or water, and adverse environmental conditions such as too low or high temperatures during concrete casting and curing.

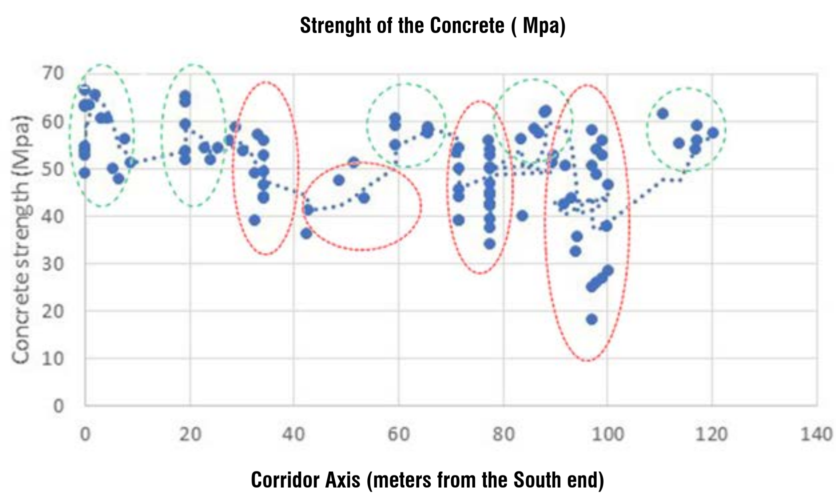


Figure 20: Measured concrete strength on the major corridor axis from South towards North side.

As the building was constructed in the 1960s, concrete was manually mixed on the site. Therefore, it is expected to observe relative concrete weakness at some parts of the building. Other possible reasons for weak concrete strength may be due to water damage over time, alkali-silica reaction in the aggregate, or in-situ application of the concrete. Hand-mixed concrete, when dropped from an elevated location, causes segregation between the aggregate, sand, and cement paste. Some parts of the concrete elements are subject to minor segregation at various locations in the building (figure 21). Currently, these defects are invisible due to plaster layers applied over the concrete material.

When a 20th century heritage building is being evaluated, its structural properties present significant importance because the whole structural capability needs to be checked and verified. However, the technical drawings are often times found to be partially or completely missing. One of the major missing information regarding the technical drawings is the reinforcement layout. Furthermore, there is the possibility of having a different steel layout, different bar diameters, and possibly even the use of different steel types (e.g., s220 or s420). It is almost impossible to obtain every detail about steel reinforcement and confinement bars but some of the features are possible to be measured. For example, the vertical and horizontal bar locations can be quite accurately obtained using a ferrometer or profometer as shown in Figure 22. Some versions of these devices can be used to locate electric wires and water pipes (even plastic ones).

Figure 21: Example of segregation

For a thorough investigation, one of the typical columns and a portion of waffle slab are selected to be able to locate the rebars and the electric wires by using a profometer as seen in Figure 22.

Figure 22: Rebar location of a column, waffle slab in F Block.

The longitudinal bars in the selected column are found to be located about 25cm apart as 4 lines and the transverse confinement bars are found to be located about 20cm apart from each other. However, it was not possible to obtain information regarding the diameters of the rebars and the steel type used with this method. The type (plain or deformed bars) can be identified by using x-ray imaging, however this method is extremely impractical and very dangerous due to its high radioactivity when large doses of x-rays are used to penetrate into the walls. Even if this device has been used, it would not be possible to obtain the strength characteristics of the bars. At his stage, it is possible to reach a conclusion based on two information sources. One of them is the construction year of the building. In the early 60s, the bars are expected to be plain S220 bars with 220 MPa yielding strength.

The second source is the “construction diaries” kept during the construction of the building, which are from the personal collection of Şebnem Yalınay Çinici. In one of the diaries, a note indicates that the architects proposed to use St-III (420 MPa yield strength) type of steel, particularly in the construction of the beams of the amphitheater. The architects also suggested the use of 24m of steel bars in one piece which would eliminate concrete placement issues and overlaps.

Obtaining material properties of concrete and reinforcing steel and the layout of reinforcement are important issues in historic concrete structures. Moreover, information regarding the structural condition of rebars should also be obtained. If the rebars are incapable of carrying tensile forces due to their possible corrosion, then the information regarding the dimensions, layout, and the material characteristics becomes redundant. One way of finding out the corrosion level is selecting the problematic locations where, for example, it is possible to trace

water marks on concrete.
Service areas and spaces below the roof or ground level may be under the risk of continuous exposure to corrosive water. In this case, problematic locations can be visually investigated by taking off the concrete cover, which is about 5 cm thick. Due to the initial decisions taken by the team, breaking the cover concrete was considered as an invasive technique, which could partially damage the material integrity of the surface.

There are some non-destructive (NDT) techniques such as electric resistivity, Resipod, Torrent, etc, which could have been an option. Moreover, there are also other sensors and devices, however with known issues like limited use and applicability. Pointing out the problem does not necessarily mean that there will be an easy solution. Such an issue should be discussed in detail by the conservation team.

Within the scope of the first-level structural assessment work package in this report, selected elements of architecture were thoroughly investigated. An overall scan of the building was never considered due to the reasons outlined in the introduction of this report. Thus, fundamental material analyses of a sample area have been completed. These studies and the methodology followed can be accepted as a guideline for further efforts to investigate the material properties of the whole building.

3.2.1.3. Partial Finite Element Modelling

Although only a first-level assessment of the building was considered to be within the scope of this work package, an object-based model is created by SAP2000, which is a general-purpose analysis and design software. This model has been used as a prototype for linking the information gathered in this project to the detailed structural assessment procedures. The geometrical data of the structural members in the building is obtained from 3D CAD drawings.

The shear walls, columns, waffle slab members were the primary concern of this prototype model. For the reasons explained previously, partition walls were not included in this model.

The preliminary SAP2000 model is shown in figure 24. This model has only the members defined with their size and material features but further meshing is necessary for detailed assessment analysis. Upon completion of the meshing work, the model can be used to simulate earthquake effect in Ankara, Turkey.

Nevertheless, the preliminary (the version with coarse meshing) Finite Element Model (FEM) created in this study has been used to investigate the validity of quick assessment methods discussed in the following sections. The bi-directional data integration between HBIM developed in this study and SAP2000 models is an ongoing process and will be explored further in the future.

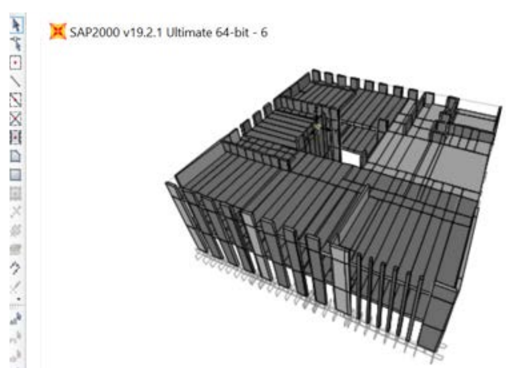


Figure 23: Preliminary SAP2000 Finite Element Model of the building upper view.

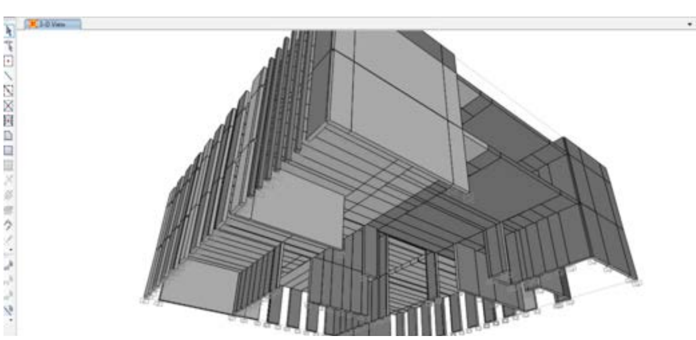


Figure 24: Preliminary SAP2000 Finite Element Model of the building lower view.

3.2.1.4. Footing Related Investigations

The load carrying mechanism of a reinforced concrete building is usually from slabs to beams, from beams to vertical load carrying members such as columns and shear walls, from vertical members to the footing, and finally from footings to the ground. This flow of forces should be followed from the roof to the ground and any weakness should be spotted. Since the footing drawings of the building complex were not available, an on-site investigation was proposed. The excavation of the pit hole was monitored by an interdisciplinary group in the team.

For footing investigation, the soil was carefully excavated by workers paying particular attention not to damage the walls and the footing. The selected point was the corner of the C3 block (figure 25) and was about 1.4m to 1.5m from the ground level.

Figure 25: General view of the observation hole.

The cold-joint marks on concrete indicate that the 1.45m lower part was cast separately from the upper shear wall, including a 0.25m extension at the base. Just below the corner of the footing extension, there was a weaker blinding-concrete-like formation, which was thought to be soil mixed with cement. The exposed part was under a shear wall, therefore it was a continuous footing. Since the shear wall above the footing is continuous for the whole facade and the building has only one storey, the relatively small footing width is enough to transfer the load of the single-storey building to the ground.

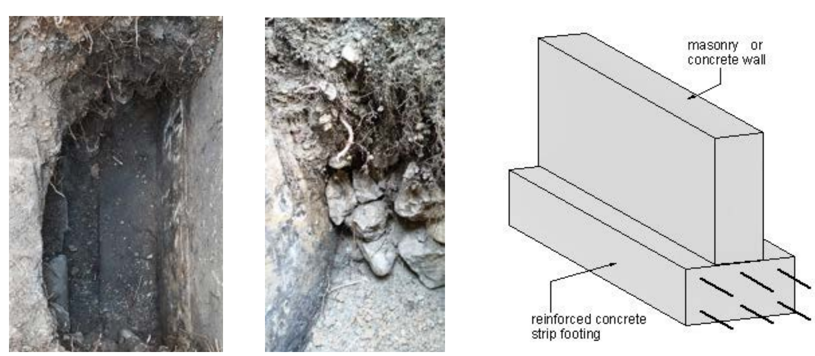


Figure 26: Footing investigation

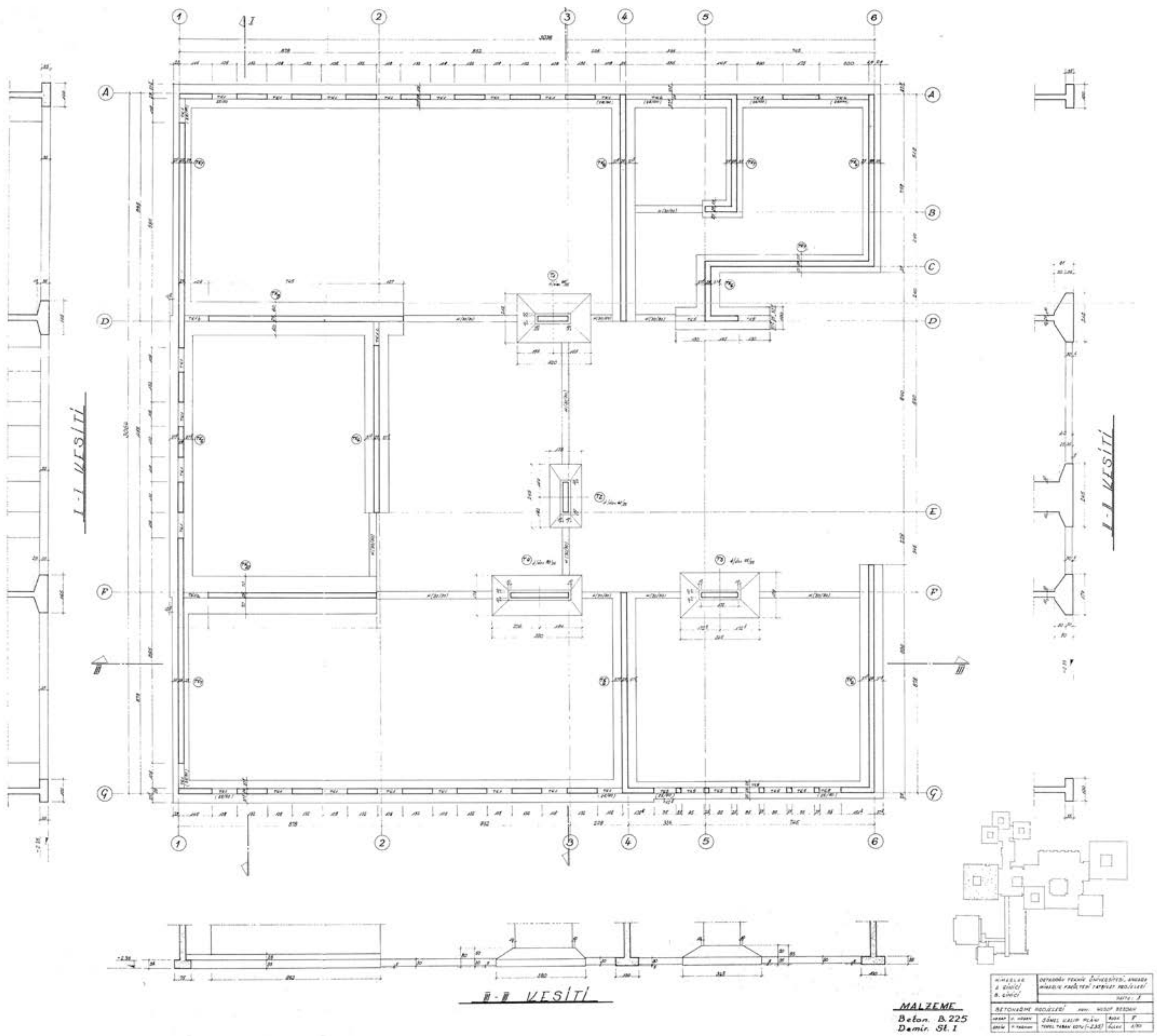


Figure 27: Formwork plan drawing, Application Drawings, 1962.

The width of the continuous footing is 25cm in transverse direction and about 35cm in depth (figure 26). The application drawings also indicate these dimensions. (figure 27, 28). Although the wall section between the footing and window is separately cast in place forming a cold joint, the footing continues under the window section at the corner. Even though the selection of the excavation site was due to a crack observed on the shear wall, the cold joint has no indications of distress.

A concrete pipe was observed at the base level of the pit hole with an outer diameter of 24cm and 3cm wall thickness. It looked as if it has not been operational for quite some time. The roots found inside can be the indicator of the existence of water in the past. Since it had no perforations on it, the purpose should not be related to drainage of the water around the footing.

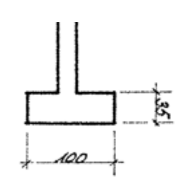


Figure 28: Footing dimensions in application drawing

Figure 29: Gap underneath the slab.

A number of Schmidt hammer readings have been taken on the site at this corner. The footing and footing wall showed relatively large strength in the range of 40 to 60 MPa. Relatively lower readings at the water related discolored section were observed mainly due to the loss of cement between fine sand on the surface.

Even sub-millimeter loss on the surface might affect the Schmidt hammer readings. For instance, a small surface area was smoothed using grinding stone, and indicated that the same spot has shown strength readings larger than 50 MPa after surface smoothing.

Another on-site footing research took place during the maintenance of the amphitheater entrance. Following a visual inspection:

- The footing could not be observed, since it is about 3.5 meters below the excavation level.

- There was a gap underneath the slab of main entrance to the Amphitheatre building (figure 29). This gap could have occurred because of a fresh ground fill. Since the fill material was not properly compacted, it had consolidated over time and left a gap between the upper surface of the soil and the slab concrete.

3.2.1.5. Waffle Slab Span Crack Evaluation

There are structural cracks observed in the main educational unit, which has been one of the main interests of structural evaluation in this research. The cracks located at the mid-span of the bridge-like waffle slab on the first floor are also accompanied by negative bending moment cracks (figure 30). Figure 30 indicates the cross-sectional capacity was exceeded in positive and negative bending regions. Similar cracks were also observed towards the eastern side of the building (R88, R89) where large number of students come out of their studios.

Figure 30: Negative bending moment region and tension cracks at the slab level.

The slab width is 5.88m and length is around 9.6m with some skewed end on the east side. The Turkish Standard (TS498) recommends considering about 500 kgf/m^2 (5 kN/m^2) live load for crowded corridors. If the span is fully loaded, the distributed load should be about 30 kN/m length of the slab.A uniformly loaded fixed beam has $wL^2/24$ at mid-span and $wL^2/12$ at supports. A simply supported beam would have $wL^2/8$ at mid-span and zero moment at the ends. A continuous beam, which is the case in the faculty building, is expected to have a moment between these two extremes and may be fairly assumed as $wL^2/12$ from experience.

The bending moment acting on the cross section is therefore;

$$30 \text{ kN/m} \times (9.6)^2 / 12 = 230 \text{ kN.m},$$

which is supported by four narrow waffle beams at the center and two side beams which are 25x80cm and 25x100cm in cross section. The self-weight of the span is calculated by using the dimensions;

$$(0.72\times0.12\times4 + 0.25\times0.72 + 0.25\times0.92 + 0.08\times5.88)\times2.5 =$$
$$1.226 \text{ m}^2 \times 2.5 \text{ t/m}^3 \approx 3 \text{ ton/m} = 30 \text{ kN/m},$$

which will double the moment to 460 kN.m. TS500 describes the effective slab width as 60% of the span length multiplied by 0.2 added with the beam width.

In the following case, the length is

$$0.6\times9.6\text{m}\times0.2+0.12 = 1.15+0.12 = 1.27\text{m}$$

which is larger than 6 times the slab thickness ($6\times8\text{cm}=48\text{cm}$) as shown in the drawing below (Figure 31). Therefore, the effective length has been taken as 0.48m. The neutral axis of the cracked section is thought to be inside the slab level, which is 8cm thick. The waffle beams are 72 cm deep, excluding the 8cm thick slab. If the main reinforcement was laid towards the bottom of the beam about 4cm above from the base, the moment arm would be expected to be around 0.60m, which would yield a tensile force of 460 kN.m / 0.60m = 767 kN.

This force is distributed between the end-beams and middle beams and the distance is larger for the end-beams. Considering the end-beams as two inner beams, the total force might be approximately divided between 4+4 beams and each waffle beam might attract 96 kN of tensile force at the rebar level.

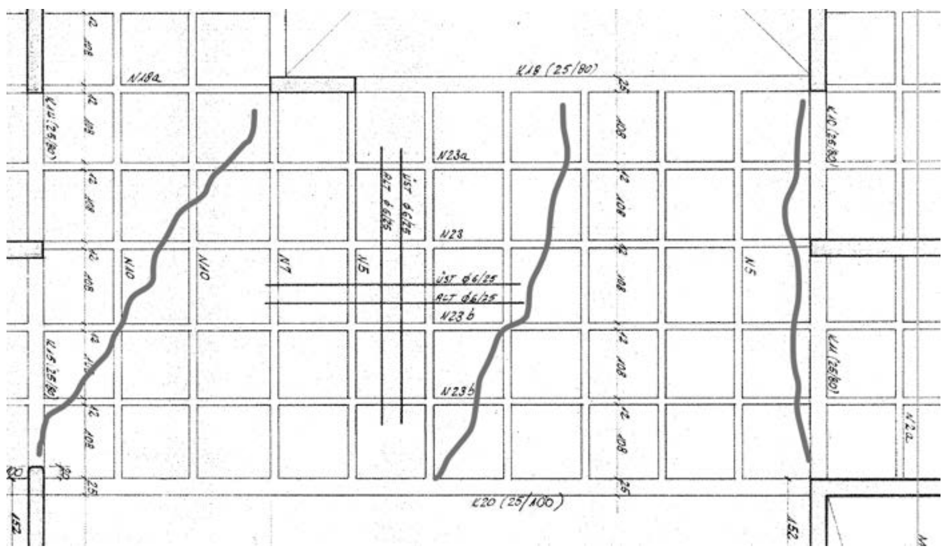


Figure 31: Plan view and cracked negative – positive – negative bending moment regions.

Figure 32: Close-up picture of vertical crack at the base of waffle beam.

In the 1960s, in Turkey, St-I was the commonly used steel grade with 220 MPa of yielding stress. The allowable stress design approach considers 60% of the yielding stress and would require about 6.7 cm^2 of rebar area, although the ultimate strength method is used with load factors and material factors. An approach to find a reasonable rebar section yields a single ø30mm bar or 2ø22mm bars. K20 has 6ø22mm bars and K18 beam's and waffle beams technical drawings are missing and could not be found in the archives.

An attempt to locate and measure the diameters of waffle beam tension rebars by visual screening of the cracks, taking close-up pictures and video unfortunately did not reveal any information on tension reinforcement (Figure 32). Electromagnetic rebar location identification gave unrepeatable and inconsistent rebar locations on either side of the crack, which should have given signals at the same height since rebars are horizontally continuous. A wedge opening at one side of the crack could be an option to see tensile rebars. Opening portions of concrete along the cracked section would not affect the strength in an adverse manner since the beam is already cracked and a cracked concrete section cannot carry any tensile load. Nevertheless, such an intervention is still quite questionable in a historical structure. Thus, this has been postponed until it is thoroughly discussed by engineers and conservation architects.

3.2.1.6. Structural Health Monitoring and Load Testing Results

The crack formation at the waffle beam was one of the major concerns of this research. A Structural Health Monitoring (SHM) program was executed to monitor crack width changes over a year. Monitoring structural cracks over a duration of year enabled investigation of crack width changes over time. 4 x LVDTs (Linear Variable Differential Transformers), A-cluster, were placed on the main span in the selected area. 2 x LVDTs (B-cluster) were placed on the waffle slab to monitor long and short-term measurements (figure 33, 34). Two temperature sensors were placed on cracks in the sample area (*Göbektaşı*). Temperature changes between seasons affect the crack width significantly. Furthermore, other parameters such as sun exposure, corrosion of the rebars due to water exposure, and the internal heating system would also affect the deformations and the crack widths. The changes in different cracks were monitored all year long and cyclic crack width changes were studied. The cracks not only responded to the seasonal changes, but also reacted to the daily temperature changes. The displacement gages have anchors on either side of the crack to monitor crack width changes with about 0.001mm accuracy.

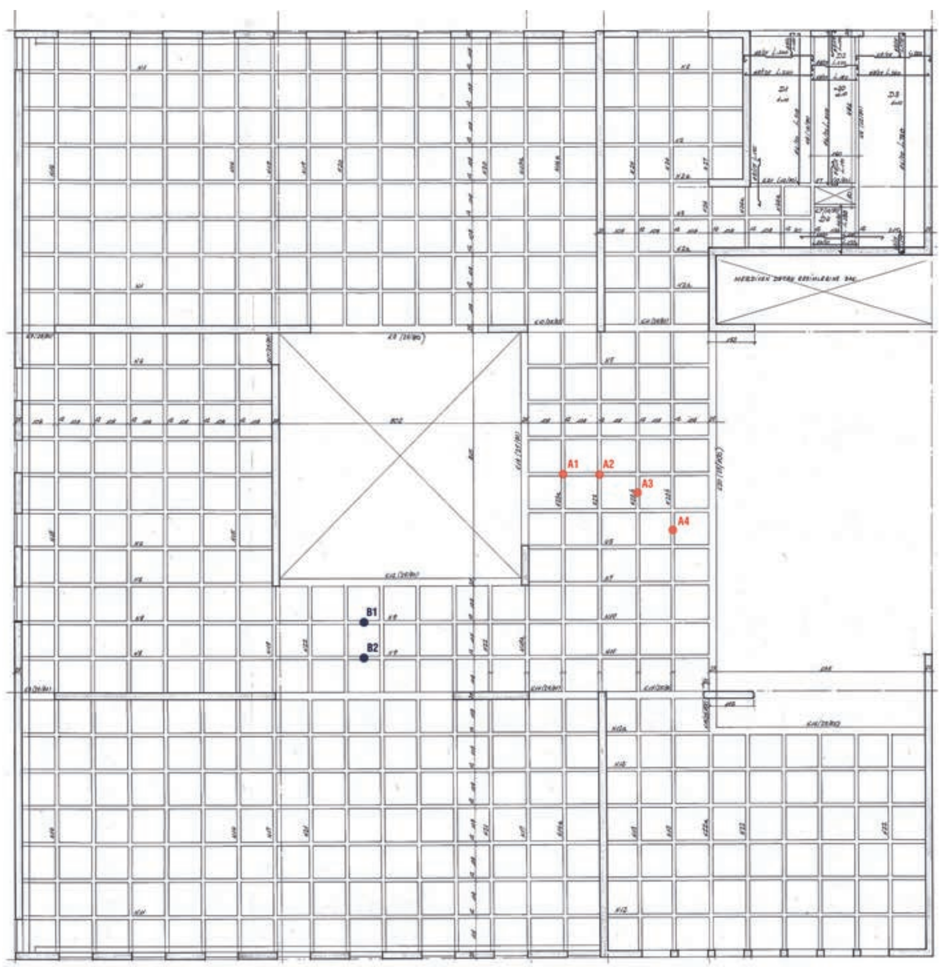
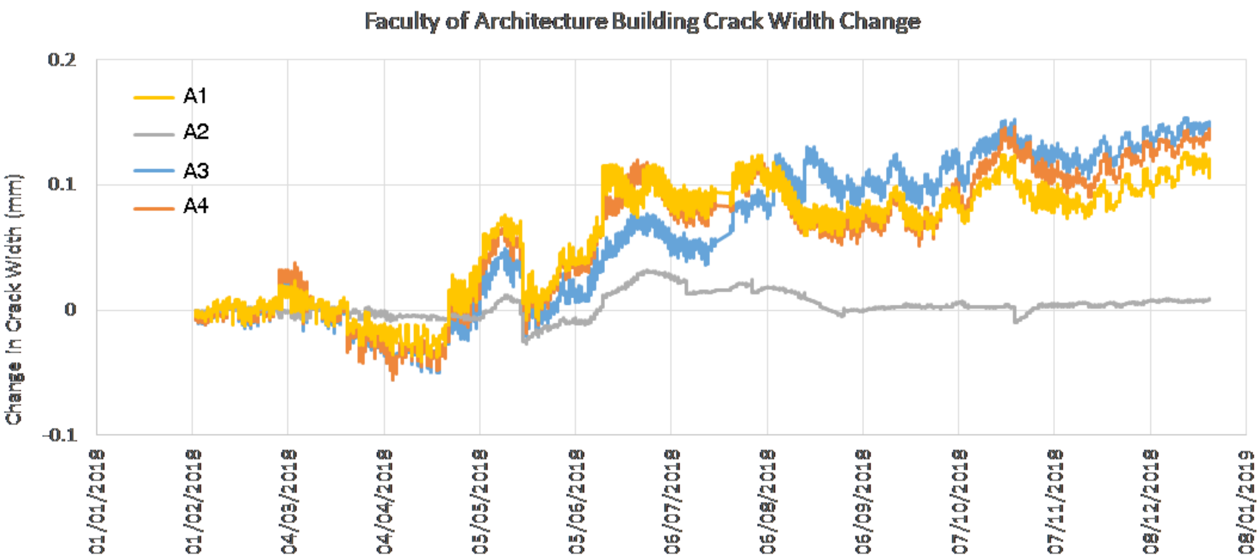


Figure 33: Locations of LVDT devices.

Figure 34: LVDT devices.

LVDT measurements are taken across the cracks every 1 minute and recorded to the memory of data logger. The monitoring system was developed by a METU research company, installed in place and remotely monitored. The instruments were placed on the cracks on the 2nd of February, 2018 and since then they have been monitoring minute changes throughout the year.



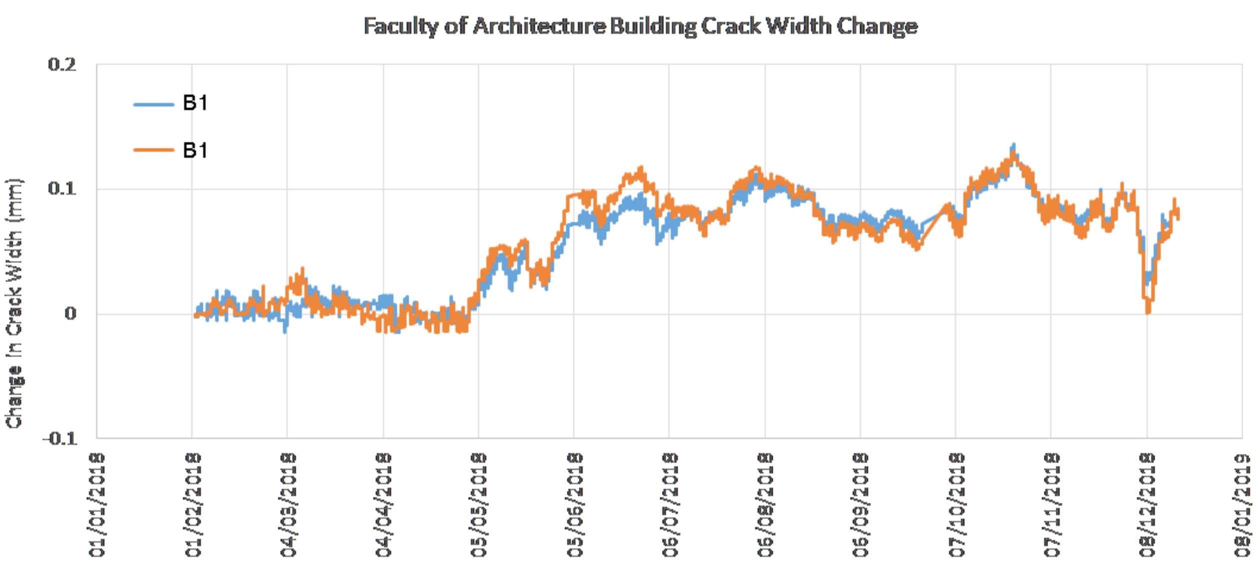


Figure 35: Change in crack width during monitoring period.

Long term SHM studies regarding the waffle slab cracks at the F block (*Göbektaşı*) have yielded important results. Vertical crack formation at the maximum positive moment region indicates that the section is having difficulty carrying dead load and occasional live load acting on it. It is not likely that this bending related crack was formed due to other actions such as earthquake. The gravity load has been the primary effect causing this crack, since similar but opposite cracks were observed towards the end of the hall where waffle slab is joined to a more rigid section close to the vertical supports. Negative bending moment caused the slab to crack on the upper side and cracks get narrower towards low end of the waffle beams.

The monitoring studies have shown that there is a common trend that points to expansion of the cracks. Crack width in the A-cluster permanently opened an average of 0.1 mm (0.004”) during the course of last year. The cracked section of the B-cluster permanently opened about 0.075 mm (0.003”) over the same period. The crack openings mainly took place during months May to July. Figure 35 presents the change in crack width during the monitoring period.

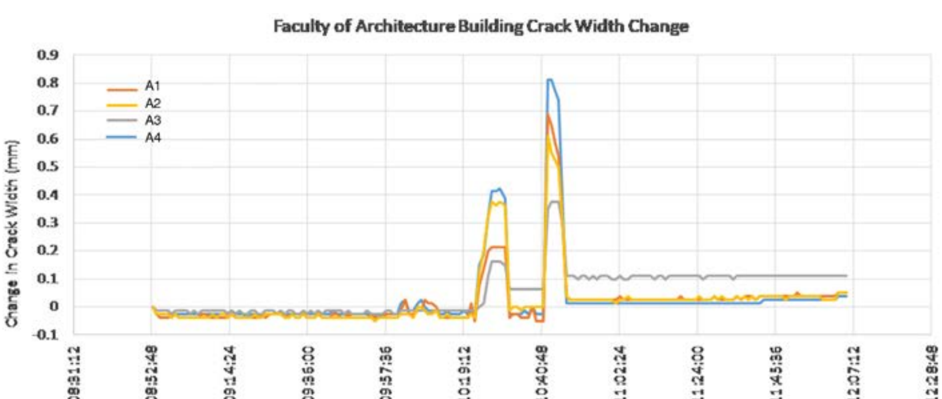
In addition to these continuous measurements to observe the long-term changes in the crack widths, a short-term live load testing on July 11th, 2018 was executed. About 100 students participated in the experiment as volunteers before entering their summer practice class at the architecture department. The students were asked to stand on the middle of the slab where the crack is located. The number of students was increased with pairs of 10 and laser readers (figure 36, 37) were used to measure the vertical deflection of the slab as well as the measurement of crack width changes using sensitive LVDTs.

MEASUREMENT 1						
		Nobody	20 people	40 people	100 people	Nobody
Height	laser meter 1	3887	3887	3887	3887,5	3.887
	laser meter 2	3857	3858	3857	3857	3.857
	laser meter 3	3647	3646	3646	3.646	3.647

MEASUREMENT 2					
		Nobody	40 people	100 people	Nobody
Height	laser meter 1	3863	3863	3864	3864
	laser meter 2	4590	4590	4589	4589,8
	laser meter 3	3867	3867	3866	3867

Figure 36: Laser meter readings during the short-term loading test.

Figure 37: Location of laser meters.



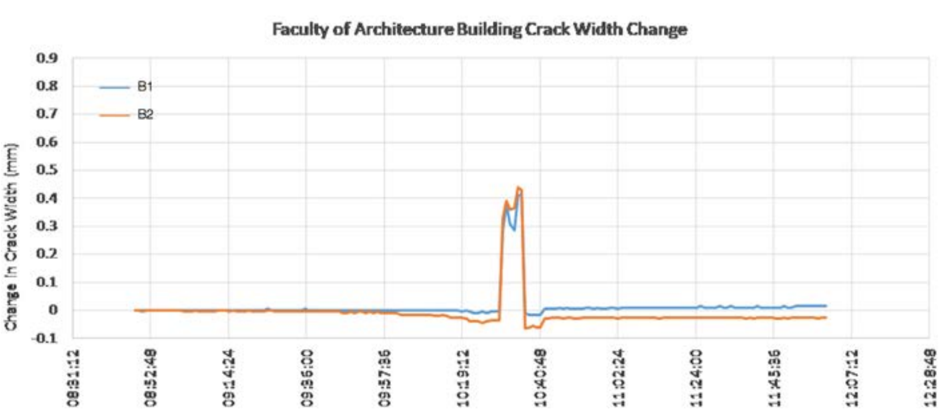


Figure 38: LVDT measurement readings during live load testing.

The load test lasted about half an hour. During the loading, the crack width measurements yielded detectable but very small changes and results indicated that there had been no permanent deformation except for one beam with 0.1mm permanent deformation. The graphs shown in Figure 38 have 0.1mm grids in the vertical direction and 4.2mm grids in the horizontal direction. The vertical direction displacements were made by using high-resolution laser meters at three locations. The measurements with the help of the students indicated a few mm deflection which was turned back to its original condition without permanent deformations (figure 36, 38).

Figure 40: Loading Test, July 11, 2018.

A limiting serviceability deflection would be in the order of 1/250. Since the span is about 10m long, the maximum permissible deflection would be about 40mm while maximum deflection took place in the order of 1mm. Approximately 7500 kg (75 kN) load was applied by 100 students. The distributed design load (5.88m 9.6m 500 kgf/m^2 (5 kN/m^2) = 282 kN, which was about 4 times the tested load. In this live load testing activity, the students of the Architecture Department made a valuable contribution to the project (figure 39).

Long term monitoring of cracks on waffle slab indicated a permanent deformation, which is up to 0.1mm for some cracks. Most of the other cracks had much smaller LVDT permanent deformation over the course of the last 11 months.

For a building with a life span of 60 years, a total 4 mm deformation at one of the most problematic locations can be evaluated as negligible. The steel type used in the building is known to be quite ductile and would elongate up to 20% or more before it snaps and totally fails under tension. Total of 4mm elongation being considered at least 20% leads to an original length of 20mm. If the elongated portion of the waffle beam reinforcement is about 20mm or so, then it may be considered to be reaching the highest strain rate before it fails. Therefore, it is a very good idea to keep monitoring the cracks on the slab. Possible methods of retrofitting will be discussed in the policies part of this report. For instance, Carbon Fiber Reinforced Polymer is usually considered not suitable for historic masonry structures, but a reinforced concrete structure might be quite applicable since the intervention is difficult to identify with the naked eye, and the color change is possible.

The deflections being small does not necessarily mean the slab is safe against live load. This observation has to be confirmed with the existing rebar information for the waffle slab. As the initial decision of the research group was the application of non-hazardous techniques, the surface removal and rebar investigation remain to be completed. Moreover, a beam section analysis would also support the outcomes of this research.

Although 0.1 mm of permanent crack opening is not a major deformation, cumulative effect of such deformation might slowly lead to collapse of the slab and SHM studies on the slab cracks should be extended until proper strengthening work is conducted.

3.2.2. Studies on Structural Assessment

Structural evaluation of reinforced concrete structures is a multi-level approach that requires interdisciplinary expertise. The approach to the problem of structural evaluation of reinforced concrete buildings with historical value is somewhat different from ordinary buildings, since each one of those historic structures has special values and features that require particular attention. Structural condition evaluation studies in Turkey mostly concentrate on earthquake safety, since Turkey is located on a highly seismic region. The North Anatolian Fault (NAF) has similar properties to the San Andreas Fault (SAF) and crosses our country at the northern part parallel to the Black Sea region reaching all the way to Istanbul and the Marmara Sea. Another major fault line the East Anatolian Fault (SAF) is also active at the south eastern part of Turkey capable of generating large earthquakes.

Furthermore, there are multiple small fault lines in the Aegean Sea region also generating large damaging earthquakes. The earthquake zoning map is provided further down with five levels of zones: zone 1 being the worst seismic activity with peak ground acceleration of 0.4g. Comparison against the Europe Seismic map and the Global Seismic Hazard map shows that Turkey does indeed suffer from earthquakes (figure 40).

Condition assessment of 20th century structural heritage is especially critical since common problems with this era in Turkey are well known. The seismic code has changed over the years and major change was made in 1998 following world trends and code improvements following the January 17, 1994 Northridge earthquake in California, USA and the Kobe earthquake on January 17, 1995 in Japan.

Reinforced concrete structures usually have frame type of load carrying mechanism which is relatively weaker compared to wall based structural systems. Heavy slabs constitute the majority of the mass lumped at floor levels and weak slender columns usually lack lateral load carrying capacity and steel reinforcement detailing necessary for a ductile behavior that will deform but not collapse during an earthquake.

Common structural condition related problems with buildings in Turkey are:

- Poor reinforcement and detailing. Confinement reinforcement without enough spacing, 90 degree hooks instead of 135 degree hooks, shear reinforcement in beams are being inadequate

- Poor concrete quality as the majority of the concrete used in the 1900s was mixed on site and sometimes without proper care and cure after casting

- Lack of shear walls against earthquakes

- Soft story at the first floor, heavy overhangs, short columns, mezzanine floors

- Poor soil conditions combined with a large number of floors (earthquake resonance issues)

- Hammering effect between too closely spaced buildings with different floor levels pounding each other’s columns by slabs.

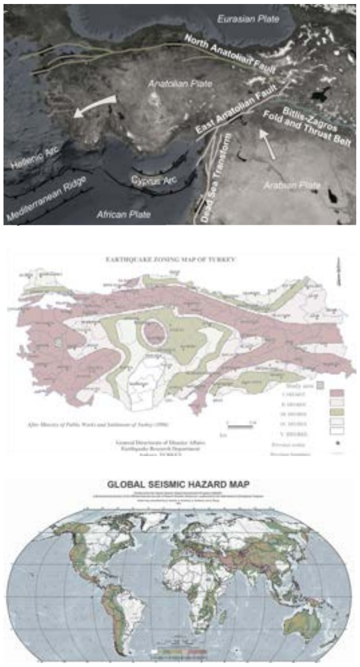


Figure 41: The major fault lines and the relative movements of plates, Turkish Earthquake Hazards Map, Global Seismic Hazard Map.

- High ground water level and humidity causing rebars to corrode and further weaken buildings that already have problematic details.

- Plumbing, heating pipes, or clean water pipe damages, roof and drainage related water problems causing weakened concrete and corroded rebars.

- Occupants causing harm to the load carrying system (for example cutting a column to open space at ground floor car gallery, removing a load carrying wall or cutting rebars of structural beams).

- Buildings located on slopes with the risk of support settlement or landslide.

The structural evaluation of a historic reinforced concrete building makes use of several methods with different levels of sophistication. These approaches mostly involve a) soil conditions, b) material type and properties, c) load carrying mechanisms (walls, columns, arches, beams, vaults, domes, etc). Among different levels of assessment, the first level evaluation is quite practical and common.
Other advanced methods may be categorized as follows:

- Consideration of reinforcement (rusting, section loss, yielding capacity, minimum requirements, ductility, confinement reinforcement and existence of closely spaced ties used in the region at the column ends, etc.)

- Approaches concentrating on concrete condition and strength (degradation of concrete strength because of weathering, freeze and thaw, alkali-silica reaction, sulfate attack, cracking because of settlement or excessive rebar rusting, etc.). Studies related to concrete strength might be non-destructive tests (NDT) such as the Schmidt hammer, ultrasonic pulse velocity, micro sampling or semi-destructive such as core sampling of ø10cmx20cm (ø4”x8”) which might be dangerous if rebars are cut during the core sampling process. Core samples with partial rebars in them usually yields significantly lower strength compared to samples without rebars in them. Relatively smaller core samples might be taken, however, smaller core samples are not standard and may have a large variety in strength since aggregates might be too large for the smaller diameter size of core samples.

- Evaluation of earthquake performance, existence of adequate shear walls, new code requirements such as more ties/stirrups at column-beam connections. This evaluation should be combined with Finite Element Modeling (FEM) where structural modeling and analysis would be conducted.

- Soil considerations (geotechnical and geological evaluations, relative support settlements).

- Neighboring (adjacent) buildings or buildings separated with expansion joints that pose threat during earthquakes (pounding of floors).

- Aging of non-structural systems such as plumbing, water pipes, roof water insulation, basement water insulation, heat insulation, heating-cooling system, etc. that might have an impact on structural integrity. Cracked water pipes in heating, plumbing, tap water, showers, roof causing rebar corrosion and concrete strength degradation, old electric cables causing sparks or short circuits leading to fire in the building and causing structural damage may be considered in this category.

3.2.2.1. First Level Evaluation

The first level assessment was developed based on a structural assessment technique frequently used for reinforced concrete structures in seismic zones and referred to as walk-down survey. Questions about construction year, general appearance, soil type and condition, interaction with nearby buildings (sharing common walls, slabs being at different levels, etc), irregularities in horizontal and vertical directions, and similar questions are used to categorize buildings into risk groups against collapse. The purpose of preliminary screening is to determine the overall visual condition and quantify this condition in a methodological way.

The Faculty of Architecture building first level evaluation reveals the following results and scores:

Building construction type and materials used in the building
The load-bearing system of buildings such as masonry (adobe, stone, brick, rammed earth, timber lintels as well as wooden bond beams, diagonal or vertical confinement, sill and lintel bands), frame (reinforced concrete with/without shear walls, central core, steel, timber), truss-like, dome shaped etc. plays an imported role in earthquake performance. Besides, the type of slab has a quite important role. Masonry buildings may commonly accommodate timber beams spanning shorter direction of rooms between walls and they fail to perform a diaphragm action to distribute slab forces to the stronger walls and keep all vertical load carrying members together. Slabs in frame type buildings are commonly reinforced concrete but may be categorized as slab with beams, flat slab, waffle slab, hollow-tile floor slab etc. Slabs with beams are commonly used for residential buildings but flat slab or hollow-tile slab may be preferred for architectural design concerns. Flat slabs are prone to punching problems and sometimes have to be improved using column capitals or drop panels to prevent brittle punching failure. Waffle slabs may span relatively larger spans of slab but may lead to punching problems around columns.

Regarding the information given above, the Faculty of Architecture building is a reinforced concrete structure and it has large shear walls distributed along the structure. Architectural concerns of using large concrete walls is one of the reasons for its earthquake safe design. Although symmetry is disturbed at some points, the existence of massive shear walls enhances the resilience of the building. Slabs are commonly waffle type that can span large spaces.

Due to architectural choices, there are no column capitals which may pose punching deformation risks under heavy loads. The evaluation of the Faculty of Architecture building in terms of building construction type and structural material yields a score of 4.5 out of 5 in light of the information given above.

Quality and condition of the construction materials
The strength of material which can be categorized as low, moderate, or high is an important indicator of structural assessment. Further observations about the condition of the materials as the spalling, decay, cracking, corrosion, color changes, segregation, etc. are also used as inputs of evaluation studies.

The tests on the Faculty of Architecture building showed that the concrete quality is superior compared to other buildings constructed in the same era. Although segregation was determined at few locations, those were left untouched to provide the integrity of exposed concrete architecture. The material analyses in this research also support that the cement used in the construction is very high quality and the aggregate distribution is proper. Any conclusive remarks regarding the overall material based structural quality requires further investigation of the type of steel used in the construction. According to the information given above, 4 out of 5 can be assigned to the Faculty of Architecture building in terms of quality and condition of the construction material.

Symmetry and the existence of irregularities

Symmetry is a very important aspect for balanced flow of forces such as self-weight, live load, wind/snow load, and earthquake induced forces. If the symmetry is disturbed, one part of the building may be subject to excessive level of forces which would eventually cause cracking, creep, deformations, sagging, etc. in time.

Horizontal irregularities may also be considered under this category since buildings with a circular, rectangular or double sided symmetrical plan have relatively better performance during earthquakes and their support settlement or lateral load responses are better. On the contrary, L shaped, and one sided symmetrical, such as T shaped, buildings face more problems in the long run. Similarly, irregularities in the vertical direction affect structural performance negatively. For instance, the existence of mezzanine floors, abrupt changes in the floor plan, such as reduced floor area or large balconies or overhangs, can be damaging during earthquakes. Discontinuous columns and sudden changes of column dimensions may also cause similar problems.

Symmetry is not always used and was not the primary design idea of the Faculty of Architecture building. However, the low-rise character of the building and the use of large shear walls enhance its structural capacity. Abrupt changes are observed in cross section of the building such as the use of courtyards and gallery openings. Considering symmetry and the existence of irregularities, a score of 4 out of 5 can be assigned to the Faculty of Architecture Building.

Stiffness changes throughout the height of the building

Stiffness differences caused by partitioning walls, short columns, soft story at the ground floor, coupling beams, small gaps next to large shear walls are usually indicative of structural troubles. In the Faculty of Architecture building, rapid stiffness changes exist at rare occasions. Although few cracks can be observed, they do not pose any threat of collapse. There are short columns at the service spaces which affect the building earthquake performance in a negative manner. Overall shear walls used in excess and distributed over the building reduces these irregularities' significance. Therefore, the evaluation of The Faculty of Architecture building in terms of stiffness changes yields a score of 4.5 out of 5.

Structural alterations

Structural alterations are sometimes very important for the general response of buildings against forces. In the Faculty of Architecture building, there are very few structural alterations. Major alterations are the addition of mezzanine floors in studio spaces. These floors are attached to the beams of waffle slab by means of steel anchors. This addition would generate extra load on the waffle slab which was not designed for.

The original waffle slab, in addition to its initial design loads, has to carry the self-weight of the mezzanine floor as well as the live loads on it. These mezzanine floors are sometimes placed on supports from the floor, generating extra load on the ceiling of the lower floor. Nevertheless, no signs of distress were observed on the waffle beams carrying mezzanine floors. A score of 4 out of 5 can be reasonable due to the mezzanine floors which create continuous gravity loads as well as causing extra lateral loads during an earthquake.

Past damage due to water leakages

Water leakage can lead to damage in buildings. This problem is caused usually by leaking roof and damaged water pipes. Old steel pipes in buildings with more than 20 years of service life are prone to cracking at the peak pressure times such as early morning hours. These pipes lose cross section by rusting from inside and may even experience fatigue by dynamic loads of water. Water from clean water pipes, heating system pipes, or sewerage generates short or long term wetting of the load carrying members, reduce the service life and safety of buildings and at the same time cause health risks and appearance problems.

Past damages due to water leakage was observed at few specific points in Faculty of Architecture building although some color changes were observed on concrete surfaces where water spouts were damaged and rain water washed down over the concrete surface. Past water damage had never been significant due to the high strength intact concrete. Thus the evaluation of the Faculty of Architecture building in terms of past damage due to water leakage yields a score of 5 out of 5.

Number of floors

The number of floors is one of the most important parameters that affect the soil-structure interaction and earthquake response of buildings. For example, tall buildings, in general, are not recommended for soft ground conditions since earthquake waves resonate by matching with the building modes in frequency domain. Shorter buildings on the other hand, usually have less problems with settlement and earthquake response.

The number of floors of the Faculty of Architecture building is generally 2 and seldom 1 and 3 with a general shallow construction that spreads horizontally. The combination of this low floor with massive shear walls generates a favorable condition from a quick evaluation perspective which results in 5 out of five 5 as the evaluation score of the building with respect to the number of floors.

The year of construction

The construction year of any type of building is an important parameter in quick assessment since design codes may drastically change in time. For instance, earthquake codes have been significantly improved in Turkey with the 1998 and 2007 editions in which earthquake forces have been increased by almost 4 times.

Buildings designed and constructed in the 20th century are usually critical against earthquakes, not only because of the design codes differences but also the material quality which is inferior before the 1990s as ready mixed concrete was not very broadly used and site mixed concrete had commonly poorer strength and capacity.

Besides, rebars used in the construction sector have greatly improved as straight bars with St-I quality (220 MPa) had been commonly using in the construction sector until the 1970s after which deformed bars with St-III quality (420 MPa) started to be used. These bars have higher strength and generate better bonding with concrete due to their deformed texture.

The Faculty of Architecture building was constructed in early the 1960s with on-site concrete mixing and undeformed straight rebars. However, the measurements indicated superior concrete quality compared to the other buildings constructed in the same era. Besides, the large shear walls that are used throughout the building can reduce the significance of the construction year.Thus, 5 out of 5 can be assigned to the Faculty of Architecture Building in terms of construction year.

Conclusion

In the first level evaluation, a building can be assessed as excellent if it has an average score larger than 4 whereas poor can be assigned to a building with an average score less than 3 and good, otherwise. The average score being 4.5 indicates that the first level quick assessment of the Faculty of Architecture building yields “excellent”. The term excellent has to be evaluated in its context. Comparing the building with others constructed in the same years with similar materials, this building can be attributed to a level of ultimate excellence.

3.2.2.2. Comperative Analysis

One valuable resource concerning the conservation of concrete is the report of the “Conserving Concrete Heritage Experts Meeting” that took place at The Getty Center, Los Angeles, California on June 9-11, 2014.[3] The report highlights numerous important issues in the conservation of concrete heritage such as “conservation of concrete”, “creation and dissemination of literature”, and “education and training”. Investigation, diagnostics and analysis are discussed; conservation and repair methodology and processes are mentioned; repair materials are listed; and case studies are given.

A structural engineering approach would go deeper into the analysis and evaluation process but repair methods are often limited to local and temporary fixes. Conservation of historic structures is mostly untouched in the curriculum of engineering departments while the main research in the heritage and conservation programs of the faculties of architecture is mostly involved with less challenging engineering approaches. Realistically, for a low-rise reinforced concrete structure with excellent material and structural quality, in this region the remaining major threat besides wars and political violence is earthquake.

The research team gave additional emphasis on this significance as Turkey is a seismically prone country. The comparative analysis of methods applied breaks down in the general literature into three alternative methodologies for this specific building complex. The application of these methodologies can have been tested in the sample area (*Göbektaşı*).

A practical approach for determining the performance of a building in an earthquake is proposed by Hassan and Sözen (1997) where the ratio of shear wall to total floor area and column area to total are determined as critical indexes.[4] This study is based on observed damage in earthquakes and plotting damage amount on an x-y graph where the column and shear wall percentages are entered. In both cases, a column and shear wall area percentage of more than 0.5% would yield successful results. In the Hassan and Sözen (1997) method, 10% of the brick wall areas are included together with the shear wall areas since they contribute to strength as well.

The Column Index (CI) and the Wall Index (WI) defined as follows:

$$CI = \frac{\sum A_c}{2 * \sum A_f} \times 100$$

$$WI = \frac{\sum A_{wc} + \frac{\sum A_{mw}}{10}}{\sum A_f} \times 100$$

where,

$\sum A_w$: Sum of cross-sectional areas of reinforced concrete walls in a given plan direction

$\sum A_{mw}$: Sum of cross-sectional areas of masonry infill walls in a given plan direction

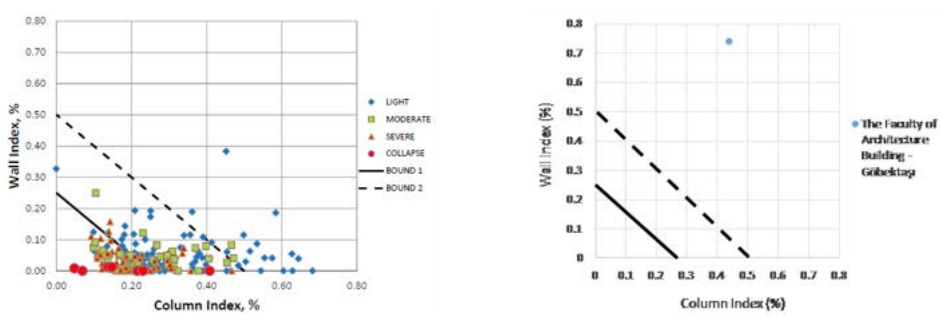


Figure 42: Column and Wall index boundaries for assessment of buildings.

[3]Alice Custance-Baker and Susan Macdonald, *Concrete Heritage Experts Meeting* (Los Angeles, CA: Getty Conservation Institute, 2015).

[4] Mete A. Sözen and Ahmed F. Hassan, “Seismic Vulnerability Assessment of Low-Rise Buildings in Regions with Infrequent Earthquakes,” *ACI Structural Journal* Vol.94 No.1(January, 1997), 31-39.

An earlier study in a paper by Shiga, Shibata, and Takahashi (1968) states similar equations based on the aftermath of the Tokachi-Oki Earthquake of 1968 in Northern Japan. [5]

These two equations state structures will stand if

$$\frac{W}{\sum A_c + \sum A_w} \leq 1.2\ MPa$$

$$\frac{\sum A_w}{\sum A_f} \geq 0.3\%$$

where,
W: Total weight of building above base
$\sum A_c$: Total cross-sectional area of columns at base
$\sum A_w$: Total cross-sectional area of reinforced concrete walls in a given plan direction, continued over building height, at base
$\sum A_f$: Sum of tributary floor areas above base.

Similar studies have also being repeated by other researchers such as Burak and Çömlekoğlu (2013)[6] who state that at least a 1.0% shear wall ratio should be provided in the design of mid rise buildings to control the drift demand. Furthermore, increasing the shear wall ratio beyond 1.5% would have no further significant improvement of the seismic performance.

These methods are highly dependent on the concrete quality, amount and class of reinforcement, development length and overlapping of rebars, irregularities in the floor plan and elevation, stirrups and confinement in columns, lack of tie interval reduction towards column ends, problems such as short-column, lack of symmetry, lack of regular frame formations, strong beam – weak column, etc. As stated before, the location of the structure and seismicity of that region is of utmost importance. Furthermore, soil conditions are not a factor in this evaluation and soft soil versus rocky base would make a difference in the earthquake vibrations' frequency content and the way they interact with buildings' natural vibration modes.

The research team's technology incubation group at METU Technocity developed a web based quick assessment tool for reinforced concrete buildings that would incorporate irregularities, soil conditions, and problems such as strong beam – weak column, short column, etc. The assessment of the Faculty of Architecture building had been made by this web-based software program. The outcome of this tool indicated excellent results regarding the building's structural significance.

Other technical papers in the literature discuss more visual approaches which have value but shortcomings as discussed above. Some of these sources are Brueckner and Lambert (2013)[7] and Al-Nimry, Resheidat and Qeran (2015).[8] Besides, SAHC conferences[9] are generally good sources for evaluating historical structures and some 20th century reinforced concrete buildings also to be found in SAHC2012.[10]

Statistical approaches exist in addition to deterministic methods but are often hazy and site specific conditions prevent them from being applied globally. So, these methods have been excluded from the scope of this study.

[5] T. Shiga, A. Shibata and T. Takahashi, "*Earthquake Damage and Wall Index of Reinforced Concrete Buildings*" (paper presented at Tohuku District Symposium, Architectural Institute of Japan, Japan and 1968) 29-32 (in Japanese).

[6] Burcu Burak and Hakkı G. Çömlekoğlu, "*Effect of Shear Wall Area to Floor Area Ratio on the Seismic Behavior of Reinforced Concrete Buildings,"* Journal of Structural Engineering vol.139 No.11, 1928-1937.

[7] Rene Bruekner and Paul Lambert, "*Assessment of Historic Concrete Structures,"* STREMAH 2013 Conference (June, 2013) Vol.131, 25-27.

[8] Hanan Al-Nimry, Musa Resheidat and, Saddam Qeran, "Rapid Assessment for Seismic Vulnerability of Low and Medium Rise Infilled RC Frame Buildings," *Earthquake Engineering and Engineering Vibration* vol.14 No.2, 275-293.

[9] Retrieved from, http://www.hms.civil.uminho.pt/sahc/#proceedings in April, 2018.

[10] Retrieved from, http://www.hms.civil.uminho.pt/sahc/2012/ in April, 2018.

Conclusion

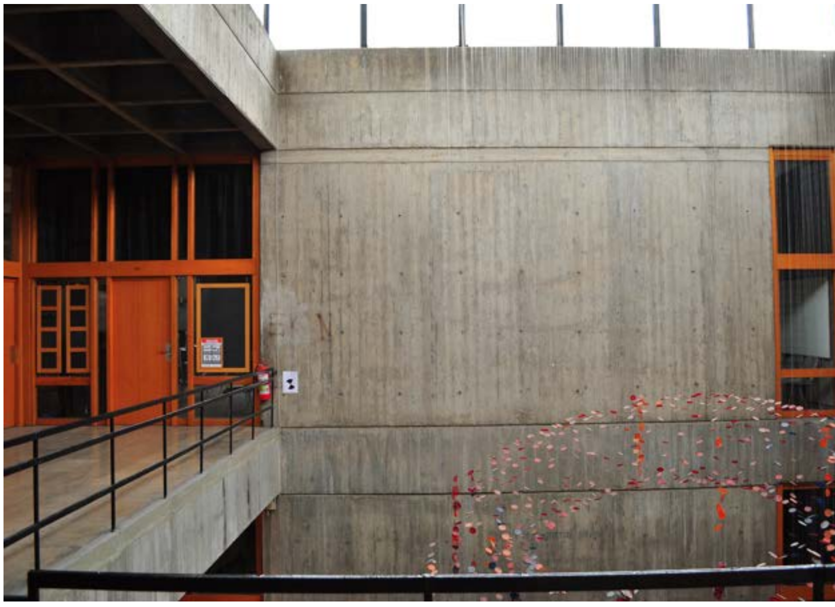
Based on the research discussed above, ratios of column and shear wall area to the total area as well as weight of the Faculty of Architecture building have been calculated. The results showed that building has 0.75% and 0.44% for the shear wall and column area, respectively, to total area and is considered to be safe against earthquakes in Ankara, Turkey.

Besides, based on the procedure proposed by Shiga et.al. (1968)[11], the weight over total column and shear wall area is 0.20 MPa which is much smaller than 1.2 MPa.

Approximate and preliminary methods that are based on mostly visual data are superficial and lack the in-depth analysis that should include material sampling-testing and detailed modeling-analysis.

Advanced FEM analysis methods are tested in the southern part of the architecture building; where earthquake forces are calculated using response spectrum analysis and considering 0.2g for peak ground acceleration (PGA) in Ankara. Although the model needs further meshing for increased accuracy, corresponding results are also satisfactory and verify preliminary assessment techniques listed here.

[11] T. Shiga, A. Shibata and T. Takahashi, "*Earthquake Damage and Wall Index of Reinforced Concrete Buildings*" (paper presented at Tohuku District Symposium, Architectural Institute of Japan, Japan and 1968) 29-32 (in Japanese).



3.2.3. Summary and Future Studies

The basic conclusions reached at the end of this work package are listed below in summary bullet list format.

- The visual inspection results indicate that the structure is in a very good shape with negligible cracks at the focus area in the building.

- Scanning work using Schmidt Hammer is made and the results showed that concrete strength is in a superior state. It is usual to find concrete strengths between 10 MPa and even lower for structures of the same age in Ankara, Turkey while the average concrete strength of the building is 50 MPa with standard deviation of 10 MPa. This superior strength when compared to existing buildings of the same age should be further investigated at other parts of the building with alternative verification methods.

- The structural load carrying system of the focus area is mainly large shear walls and waffle slab systems. In the Faculty of Architecture building the waffle slabs are connected to wide shear walls/columns with enough shear transfer capabilities and have not shown any distress.

- Although obtaining information regarding the diameter, the type (plain or deformed), strength, and corrosion status was not possible, preliminary work on the identification of the location of vertical and horizontal rebars showed successful results. Semi-destructive tests might be useful but have not been applied according to the advantages and disadvantages of semi destructive tests that have been discussed thoroughly.

Figure 43: Concrete surfaces, dilatation and lap joint line.

•In addition to the superior concrete quality listed in the section (that is also listed in the second bullet), existence of large shear walls in all directions and low-rise nature of the building generate an “earthquake-safe” pattern. Therefore, a major problem is not expected, although a detailed and field calibrated SAP2000 FEM would provide more insight information when used to conduct response spectrum analysis for earthquake loading. Nevertheless, preliminary results of response spectrum analysis made by using SAP 2000 model with coarse meshing are in good agreement with the results of quick assessment methods.

•The building is a shallow and wide building on relatively soft soil and the pressure on the ground is not expected to be too high.

•Short and long term monitoring of cracks including live load testing have shown that the propagation of crack width is slow, about 4mm in 60 years. Estimation of the breaking point for waffle beam rebars is not certain but large cracks and large deformations are common warnings given by reinforced concrete structures.

3.3.Material Documentation and Assessment

3.3.1. Visual Analyses of Materials' Decay Forms

Studies related to the condition assessment of the Faculty of Architecture Building aim to discover the decay problems of its materials for the purpose of building maintenance and materials conservation studies. Visual analyses of the decay forms are the first stage of the building inspection for the diagnosis of its major decay problems and maintenance and conservation issues related to those problems. It is an important non-destructive analytical method that needs to be further-associated with other non-destructive methods, such as ultrasonic testing and infrared thermography. The visual analysis involves:

- the description of main decay forms observed in the building materials and their relationship with the degree of damage,
- mapping of those decay forms observed on building surfaces by their recording on elevation drawings.

The visual analysis of decay forms identifies the problem areas and their distribution in the structure as well as their probable sources. Therefore, the data achieved is expected to act as a guide for the planning the diagnostic and monitoring studies for the purpose of maintenance and conservation of the building materials and the building itself. The maps of decay forms are useful documents for long-term monitoring of decay forms, such as the progress of deterioration on building surfaces as well as the success of conservation treatments.

At this stage, the decay forms representing the types of deterioration were identified for concrete, brick and stone and documented with digital images of the typical problem areas. Those documents show the visually-sound and problem areas that will be useful for representative sampling and further *in-situ* and laboratory analyses.

The decay forms were identified and categorized under four main groups, namely “material loss”, “detachment”, “discoloration/deposits” and “surface fissures and cracks” depending on the particular materials problems observed in the building. The individual decay forms in those main groups were defined with a focus on concrete material while decay forms of brick and stone material were also covered. The analyses of those individual decay forms under the main categories gave concise information about the state of preservation of the materials and the building. The analyses of the visual decay forms observed in the building are summarized as follows:

Material loss: Loss in concrete surfaces may occur when concrete gets wet and is exposed to many weathering cycles, especially freezing-thawing and salt crystallization cycles. Therefore, deteriorated concrete surfaces suffering from material loss indicate severely damaged areas. Concrete loss may occur in the forms of aggregate loss (cavity formation), outbursts, rounding of edges, roughening (change in surface morphology) and back weathering (material loss parallel to the concrete surface). Here, the depth of loss becomes a critical factor. In the building under investigation, material loss is observed at some concrete elements such as waterspouts (Figures 1-3), *brise-soleil*, and the edges and balustrades of the balcony projections (Figure 4 and Figure 5) where the concrete elements are directly exposed to rainwater and atmospheric weathering conditions. Most material loss areas in concrete are observed together with other decay forms such as detachments, discoloration, deposits and sometimes cracks. Although material loss in concrete is a severe decay form, it is not yet abundant in the structural reinforced concrete elements in the whole building and deterioration in concrete is restricted to the areas with dampness problems (Figure 6). Considering the quite good state of most exterior concrete walls, which have been open to the atmospheric environment for a long period of time, it is worth pointing out that the original exposed concrete materials of the building are of good quality with considerable durability. The material loss in concrete observed in some locations on the building is not yet seen as a threat or posing a danger of structural failures. However it has to be taken as one of the problems to be tackled during the maintenance and conservation studies.

In the structure, where concrete material loss seems to have started, there is a need for local concrete repair work, particularly to pecprotect reinforcement bars against direct exposure to atmospheric conditions and corrosion (Figure 1, Figure 3, Figure 4 and Figure 6). In this regard, further laboratory analyses are needed to describe the composition and performance properties of compatible repair mortars to cover the material loss areas in the concrete.

Material loss is observed at exposed brick masonry units at only few localities, in the form of outbursts together with detachments in the forms of flakes and scales (Figure 7). That type of material loss is attributed to inherent problems of those individual bricks, sourced from their production. The absence of severe decay in those 60 years-old brick units verifies their good state of preservation and signals that they are brick materials of quality.

Figure 1: Material loss in concrete at waterspout in the forms of outburst together with crumbling which results in exposure of reinforcement bars to the atmospheric conditions and their corrosion. Material loss associates with salt deposits on deteriorated concrete surfaces.

Figure 2: Material loss in concrete at the parapet of the arcade in the form of outburst together with depositions as biological growth on exposed concrete surfaces in the forms of moss and lichens (yellow-colored surfaces).

Figure 3: Material loss in concrete at waterspout in the forms of outburst, which results in exposure of the reinforcement bars to atmospheric conditions and their corrosion. Material loss associates with detachments in the form of flakes together with longitudinal cracks and deposits as biological growth in those cracks and salt deposits on deteriorated concrete surfaces.

Figure 4: Material loss in concrete at exposed balustrades in the forms of outburst and aggregate loss which results in exposure of reinforcement bars to atmospheric conditions and their corrosion. Detachment on exposed concrete surfaces in the form of crumbling and flakes showing that such detaching surfaces are areas that are at risk of, loss and require urgent intervention.

Figure 5: Material loss in concrete at the bottom surface of a waterspout and balcony edges in the form back weathering due to exfoliation (on the right top) and flakes (on the right bottom). Salt deposits are visible on those concrete surfaces.

Figure 6: Detachment on exposed concrete surfaces which have started in the form of flakes (on the left) while reinforcement bars remained exposed due to the loss of concrete cover (on the right). Detaching surfaces are the priority areas getting ready to be lost.

Figure 7: Material loss at the edge of structural reinforced concrete column in the forms of aggregate loss, surface roughening and edge rounding that results in exposure of reinforcement bars to atmospheric conditions and their corrosion.

Detachment: The concrete surfaces where there are detachments in fragments and in layers are at risk of loss, and therefore are priority areas requiring intervention. Detachment may occur on concrete surfaces in the forms of *exfoliation* (detachment in sheets parallel to concrete surface), *flakes* (detachment in thin layers), *multiple flakes*, *scales* (detachment in thicker layers), *multiple scales*, *crumbling* (detachment in concrete fragments), or *granular disintegration* (detachment of concrete fragments in fine particles) (Figure 1, Figures 3-5, Figure 8 and 9). Concrete surfaces suffering from material loss were observed together with detachments and those areas are susceptible to frost damage and salt crystallization cycles, especially when they get wet. This means that further material loss is expected on detached areas. That is, some exposed concrete waterspouts, *brise-soleil* and balustrades which have detaching deteriorated surfaces are under risk of further material loss (Figure 8). To prevent decay formation, detachment areas need to be stuck to the main body by gap filling and surface treatments, if necessary. Those surfaces should be protected against water penetration. Comprehensive materials analyses are needed for the purpose of diagnosis and description of conservation treatments and their monitoring.

Figure 8: Material loss rarely observed at exposed brick masonry units in the form of outbursts together with detachments in the forms of flakes and scales.

Figure 9: Detachment on exposed concrete surfaces in the form of multiple flakes and scales showing that detaching surfaces are the priority areas at risk of loss.

Figure 10: Exposed concrete surfaces suffering from material loss together with detachments are susceptible to frost damage, especially when they get wet.

Discoloration and deposits: The changes in color and texture on the concrete surfaces are visible in the forms of *staining or discoloration*, *damp patches*, *salt deposits*, *microbiological growth* or *crust formation*, and refer to slightly deteriorated surfaces. On the other hand, if any defect is visible, it means that this defect is the indicator of quite severe influence of some weathering factors. Therefore, the presence of discoloration and/or deposits signal the presence of active weathering mechanisms. Common discoloration and deposits, seen on concrete surfaces are *dark-grey* and *yellow staining*, *biological growth* in the forms of lichens and moss, plant root spreading on concrete surfaces, and florescence (deposits of salts on the surface or at its sublayers) (Figures 11-13). In addition to the natural deterioration forms, there are man-made interventions, such as graffiti, grey paint partially applied to concrete surfaces to cover the graffiti and grey paint applied on large surfaces of concrete walls (Figure 12 and Figure 13). Such interventions damage the aesthetics of the original concrete surfaces.

Dampness in the concrete material is the main weathering agent that triggers the soluble salt problem and biological growth. In other words, visible forms of decay start with discoloration and deposits and then progress in time towards detachments and material loss. Rising damp is not the risk observed at the immediate periphery of the building. However, rainwater penetration through the roof surfaces is the main source of dampness problems in the building and its impact is visible on concrete surfaces, especially at the upper parts of the structure, in the forms of salt deposits, yellowish staining and biological growth (Figures 11-13).

A few brick surfaces also suffer from salt deposits and salt decay. They are visible on the upper parts of exterior brick walls where the concrete roof slab/parapet is in contact with brick wall (Figure 14) and at the edges where exterior concrete wall and brick wall meet (Figure 15). The rainwater penetration at those localities causes transfer of sulphate salts in the cement jointing mortars to the brick body. Crystallization of the soluble salts in the brick body, namely florescence, results in material detachments in the forms of flakes, and scales and progresses in time towards material loss.

Figure 11: White and yellow discoloration on exposed concrete surface signaling the local dampness problem at the upper part of the building due to the roof drainage fault resulting in water seepage through the roof level. The presence of salt deposits with yellowish color staining indicates that the reinforced concrete roof slab suffers from continuous dampness problem and corrosion of reinforcement.

Figure 12: Dark-grey and yellowish staining on exposed concrete surfaces of the roof parapets that are continuously-washed with rainwater and partially coated with grey-colored paint to cover graffiti.

Figure 13: Dark-grey staining and microbiological growth on exposed concrete parapet surfaces in the forms of dirt patina and lichens (yellow-colored surfaces) (on the right top). And grey paint in several layers applied to cover/hide the graffiti (on the right bottom).

Figure 14: Salt deposits in the form of efflorescence on interior surfaces of exterior brick walls and subflorescence causing material loss on brick surfaces that progresses in time in the forms of flakes, scales and outbursts which are mostly observed at upper parts of the building where the reinforced concrete roof parapet and brick wall are in contact with each other. That signals the roof drainage faults are causing water penetration into the brick units.

Figure 15: Salt deposits in the form of efflorescence on interior surfaces of exterior brick walls which are mostly observed at the edges where reinforced concrete exterior wall and brick wall are in contact with each other. That signals water penetration into the brick units through the edges which causes transfer of sulphate salts in cement jointing mortars to the brick body.

Since the main source of water penetration is due to the roof drainage faults that are causing water seepages, the primary concern should be given to the corrective and then periodic maintenance of the existing roof drainage system to restore its proper function a and eliminate the water seepages into the structural roof slab. In addition, desalination methods have to be developed in order to extract soluble salts from deteriorated areas of concrete and brick surfaces. Studies for the development of compatible repair mortars are needed to cover the concrete loss areas in order to eliminate the water penetration from exposed surfaces.

Yellowish and dark-grey colored stains, graffiti and grey-colored paint on exposed concrete surfaces as well as dirt patina on travertine floor surfaces are the other important problems that disrupt the aesthetics of the original building surfaces. Stains, graffiti and paint coats, each, need separate techniques for their removal from the surfaces without causing damage to the original concrete, brick and stone surfaces. Cleaning both inside and outside the building will require a certain amount of time. Such work, therefore, has to be developed and defined by comprehensive analyses that pioritise to the efficiency of the method(s) as well as to the safety of conservation practitioners and everybody using the building. For the removal of dirt from travertine floor surfaces, a trial was previously carried out of a cleaning gel prepared with carboxymethyl cellulose and some chemicals. Preliminary results showed that the gel mixture prepared in the METU-MCL laboratory is quite promising while further studies are needed for its practical use.

Surface Fissures and Cracks: The presence of cracks in exposed concrete structural walls and slabs may signal structural failures in buildings, whether at the early or advanced stage (Figure 16). Cracks stemming from structural failures are observed occasionally and placed under investigation for the structural safety of the building. Surface fissures and tiny cracks are the material decay forms that were observed at exposed surfaces of concrete elements, such as waterspouts and balustrades that are directly exposed to rainwater (Figure 3, Figure 4, Figure 6, Figure 8, Figure 9). Their presence is more damaging especially at places where the concrete material gets wet. In wet conditions, water penetrates into deeper parts of reinforced concrete by capillary suction through the cracks and cause corrosion of reinforcement in time and concrete material loss in several forms, especially due to the exposure to freezing-thawing cycles (Figure 10). Therefore, the start of corrosion in reinforcement bars is a serious problem for reinforced concrete that will lead to severe material failures in the future.

Considering those problems, water penetration to the deeper parts of exposed concrete by means of surface fissures and tiny cracks should be eliminated with concrete repair works. For that purpose, further analyses are needed to develop concrete conservation treatments using compatible fine cement grouting which can penetrate into the crack by means of injection techniques. Preparation of nano dispersive solutions compatible with the original exposed concrete body is the other alternative that need to be developed as a remedial treatment for fissures and cracks .

Figure 16: Diagonal crack observed in the exposed concrete shear wall at the ground floor of the building which may be due to differential settlement movement over time while the expansion joint seemed to provide complete separation between two shear walls since no cracks are observed at the neighboring shear wall.

3.3.2. Material Sampling and Analytical Methods

Materials characterization studies on concrete, brick and natural stone, which have priority importance for the Faculty of Architecture Building, involve comprehensive materials analyses. At this stage, introductory materials analyses were conducted on randomly collected materials samples where available in order to determine some of their basic performance properties and compositional properties with a focus on types of original concrete. The knowledge achieved by those analyses are guiding for further comprehensive analyses needed for the state of preservation assessment and planning of conservation treatments.

Due to the practical limitations in sample collection for heritage buildings, only few samples representing the building materials are collected in limited number and sizes. Those samples were relatively small in size most of which with irregular shape. Those samples were taken from less visible locations not to disrupt the visual impact of the building. In this regard, some concrete samples representing the exposed concrete of shear wall, white concrete solid block, waterspout, *brise-soleil* and concrete mosaic ground slab were examined in terms of their compositional properties while only one sample representing the red brick units could be analyzed. Some limestone samples representing the floor finishing slabs at the courtyards and green-colored terrazzo floor tile used at the ground floor level were investigated to define their basic physical properties and mineralogical compositions. In addition, some original and repair ceiling plaster samples were also examined. The codes and definition of the materials samples were given in the relevant subheadings where their materials analyses data were given.

The preliminary materials analyses involve the laboratory tests on basic physical and physico-mechanical properties and compositional properties of concrete, brick and limestone samples. The basic physical and physicomechanical properties of the building materials were determined in terms of density (ρ, kg/m3) and porosity (Θ, % by volume), ultrasonic pulse velocity (UPV, m/s) and modulus of elasticity (MoE, GPa). Cross-sections of some concrete samples were examined by optical microscope at high magnification to view shapes and sizes of aggregates and pores in concrete and interfaces between binder and aggregates. The instruments for those purposes were the Leica Z16 APO A and HDS-5800 Huwitz digital microscopes. The mineralogical composition of building materials were investigated mainly by means of XRD (X-Ray Diffraction) analyses supported with FTIR with ATR (Fourier Transform-Infrared Spectroscopy with Attenuated Total Reflection), XRF (X-ray Fluorescence) TGA (Thermogravimetric Analysis) and SEM (Scanning Electron Microscopy) analyses. The instruments used for XRD analyses were an Ultima IV (XRD) diffractometer in METU Central Laboratory and Bruker D8 ADVANCE Diffractometer in METU Materials Conservation Laboratory. The instruments used in other microstructural analyses were a Rigaku ZSX Primus II XRF spectrometer, a 400 FT-IR spectrometer with an ATR attachment from Pike Technologies, a SDT 650 Simultaneous DSC/TGA thermogravimetric analyzer and a Quanta 400F Field Emission SEM scanning electron microscope, existing In METU Central Laboratory.

In addition, some non-destructive testing methods, namely Rebound Hammer Test (Schmidt hammer test) and Infrared Thermography were conducted on the selected parts of the building. The Rebound hammer indices of building wall surfaces made of exposed concrete, red brick and concrete block were measured and gave information about the surface hardness of those materials. The thermal images taken in some parts of the building were interpreted briefly and given in the relevant subheading “3.4.7. Introductory Infrared Thermography (IRT) Analyses”.

3.3.3. Material Analyses of Concrete

Four concrete samples representing the exposed concrete used in the reinforced concrete structural elements and one concrete sample representing the yellow-colored concrete mosaic slabs used in the courtyards were analyzed to determine their basic physical, physicomechanical and compositional properties. Other types of concrete used as white concrete of *brise-soleil* units and white concrete of solid blocks were examined only in terms of their basic physical properties.

The bulk density, effective porosity, water absorption capacity of the exposed concrete samples taken from the structural elements were found to be 2241±91 kg/m3, 13.1±1.1% (by volume) and 5.9±0.6% (by weight), respectively (Table C1). The ultrasonic pulse velocity of the exposed concrete sample (C3.X) was measured as 2609±516 m/s measured with the 54kHz probes and 2757±508 m/s with 220kHz probes. By using ultrasonic pulse velocity and bulk density data, the modulus of elasticity values of the exposed concrete samples were calculated as 14.9±5.7 GPa and 16.7±7.0 GPa, respectively (Table C2). The basic physical properties of other concrete types were observed to vary in a certain range. For instance, the yellow colored concrete mosaic slab and white concrete solid blocks were found to have the lowest density in the range of 2017-2100 kg/m3 and the highest porosity in the range of 16-17% by volume. Among all concrete types, white concrete used as brise-soleil units has the highest density with the average value of 2303 kg/m3 and lowest porosity with the average value of 8% by volume. The ultrasonic pulse velocity and the calculated modulus of elasticity of the concrete mosaic sample from the yellow colored concrete mosaic slab were found to be 2127±277m/s (measured with 220kHz probes) and 8.3±2.1 GPa, respectively (Table C2). When compared with exposed concrete used at structural elements, concrete mosaic has lower values of bulk density, ultrasonic pulse velocity and modulus of elasticity which conforms with its function used as a floor finishing layer at the courtyard.

Concrete samples	Bulk density (kg/m^3)	Effective porosity (% by volume)	Water absorption capacity (% by weight)
Exposed concrete used at structural elements	2241±91	13.1±1.1	5.9±0.6
White concrete brise-soleil units (sun breakers)	2303	8.1	3.3
White concrete solid blocks	2100	16.2	7.7
Yellow-colored concrete mosaic slab	2017±24	17.4±0.6	8.6±0.4

Figure 17: Table C1. Basic physical properties of concrete materials

Concrete samples	Bulk density (kg/m^3)	Ultrasonic pulse velocity (m/s)	Modulus of elasticity (GPa)
Exposed concrete used at structural elements	2241±91	2609±516 (*)	14.9±5.7(*)
		2757±508 (**)	16.7±7.0(**)
Concrete used at yellow-colored concrete mosaic slab	2017±24	2127±277 (**)	8.3±2.1 (**)
(*) measured with 54kHz probes; (**) measured with 220kHz probes			

Figure 18: Table C2. Basic physicomechanical properties of concrete materials

Preliminary data achieved by the non-destructive Schmidt rebound hammer testing show that the exposed concrete surfaces present variable rebound hammer indices in the range of 29-54. At some positions, the rebound hammer indices were measured in the range of 18-27 at lower levels of a wall (at 30cm height above finish floor level) while being in the range of 49-58 at upper levels (at 1.0-1.5m height above finish floor level). Neighboring to those measurement areas, rebound hammer indices around 27 were measured at the surfaces of the reinforced concrete slab of the balcony. Such a variety observed in rebound hammer indices signals the necessity for further measurements. The rebound hammer indices measured from the surfaces of some white concrete blocks and white concrete *brise-soleil* units were around 30-40 and around 52, respectively. Those values give an idea about the surface hardness of concrete elements and the overall data imply that the 60-year-old exposed concrete still has good mechanical strength at present. The rebound hammer indices at lower values measured at some localities may signal some deterioration which reduced the surface hardness of the concrete. It should be mentioned that further analyses are needed to correlate the rebound hammer indices with the mechanical properties of concrete and its state of deterioration. For that purpose, the combined use of Schmidt rebound hammer testing, ultrasonic testing and infrared thermography is suggested for the in-situ non-destructive examination of concrete and its long-term monitoring.

The compositional and mineralogical properties of exposed concrete material were examined in detail with the core sample C3.X which represents the concrete type used in the exposed concrete shear wall as shown in Figure 19, together with the other exposed concrete samples C3.I.H10, C6.E.AE and C7.E.AE.

Figure 19: General view of the exposed concrete wall (on the left) and the cross section of the exposed concrete core sample (C3.X). (on the right).

In the concrete matrix, the use of very large-sized aggregates reaching 7.0 cm in dimension is observed while aggregates with the grain sizes of 2.5 cm - 4 cm are abundant (Figure 19). Those aggregates are various rock fragments of sedimentary and igneous origin. Their presence forms an attractive colorful texture in the concrete. In addition to large aggregates, the presence of very fine aggregates is also observed in the concrete mixture. The higher magnification views of the interfaces between two large aggregates show the presence of very fine aggregates within the hydrated cement binder (Figure 20). The good adhesion between aggregates and binder matrix is revealed in all cross-section images (Figure 19 and Figure 20). In cross-section images, the comparison of the total area and the area covered with aggregates indicate quite a low portion of binder used in the concrete mixture (Figure 19).

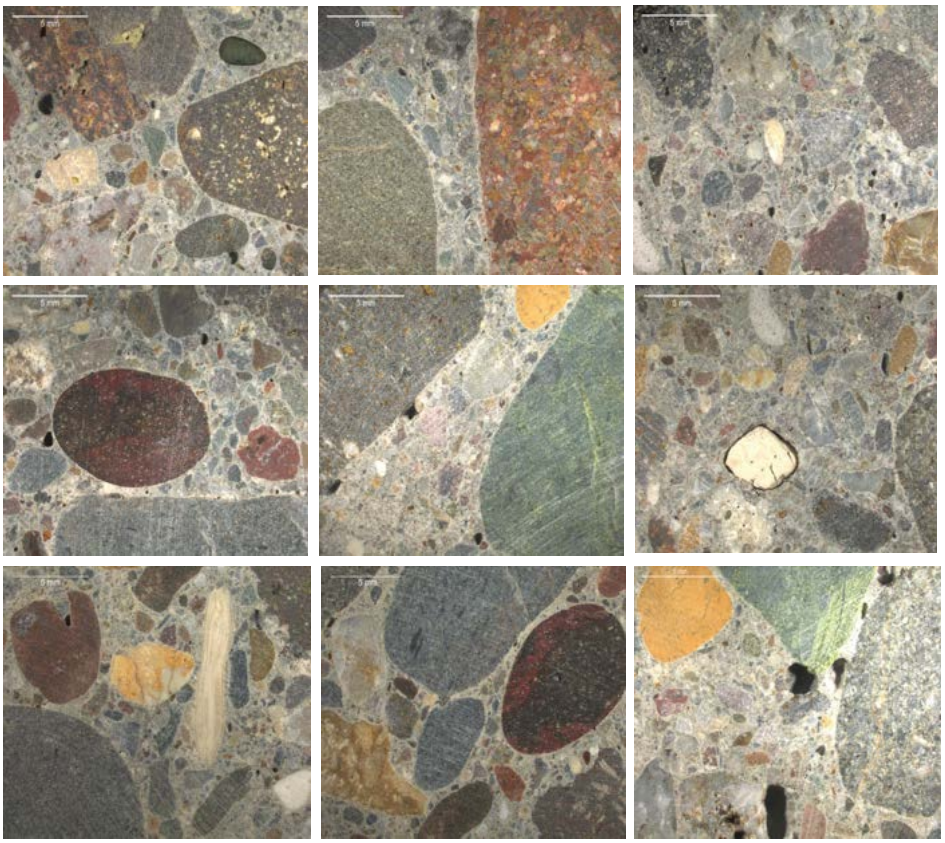


Figure 20: . The cross-section images of the exposed concrete sample (C3.X) showing the aggregates of different origin and concrete matrix (taken by Leica Z16 APO A optical microscope)

Concerning the porosity characteristics of exposed concrete, cross-section images give quite a lot of information. The presence of very large and large pores is visible in the macro views of the concrete matrix and in cross-section images. Very large pores are observed in macro views reaching to 7 mm in dimension (Figure 22) while the large pores within the sizes of 100 μ (microns) to 980 μ are abundant (Figure 22, Figure 23 and Figure 31). The particular properties of exposed concrete, such as its total effective porosity being about 13% by volume, the abundance of individual large-sized pores and aggregates and quite a low portion of cement binder, are expected to contribute to lower thermal transmittance performance of exposed concrete in comparison to today's concrete. In addition, the high effective porosity around 13% and the presence of circular pores observed in various diameters are the other particular characteristics of the exposed concrete which should have contributed to the long-term durability of the structure, especially its durability against freezing-thawing cycles. The quite good state of the exterior concrete walls, open to the harsh climatic conditions of Ankara for almost 60 years, confirms the good quality of the concrete.

Relatively high porosity and presence of circular pores of various diameters signal the use of an air-entraining additive in the exposed concrete mixture in order to achieve a pore structure resistant to freezing-thawing cycles. It should be pointed out that the builders of the Faculty of Architecture building made efforts to use good quality concrete of its time. In other words, they have tried to use high-performance concrete mixes in the construction of this building.

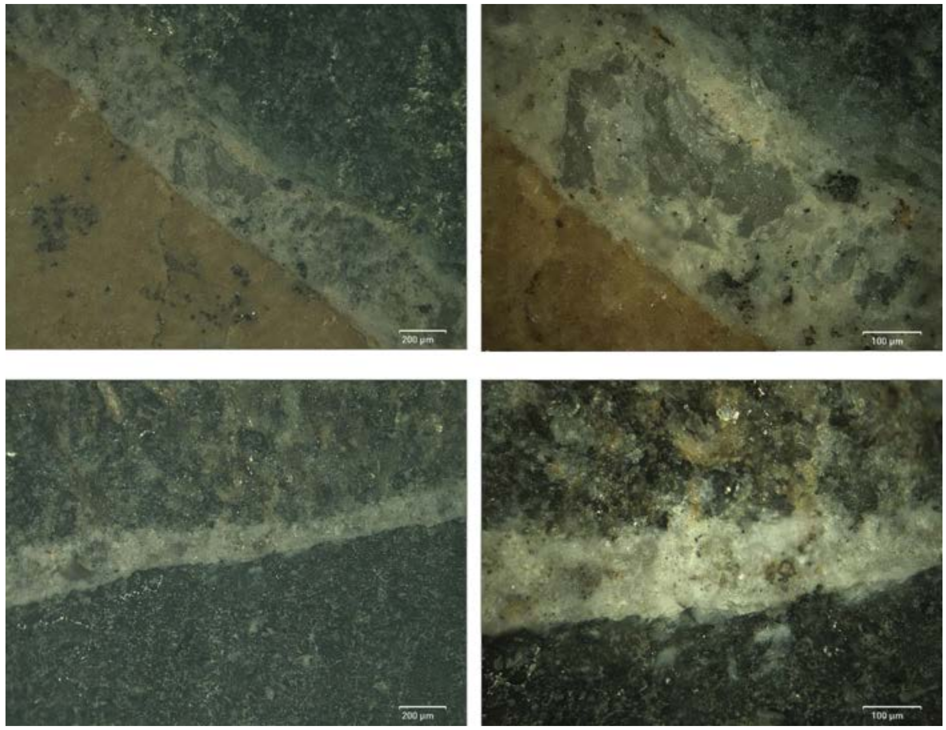


Figure 21: . The cross-section images of the exposed concrete sample (C3.X) showing the interface between two large aggregates involving hydrated cement binder and very fine aggregates. The images on the right are the higher magnification views of the ones at the left (taken by HDS 5800 Huvitz digital microscope)

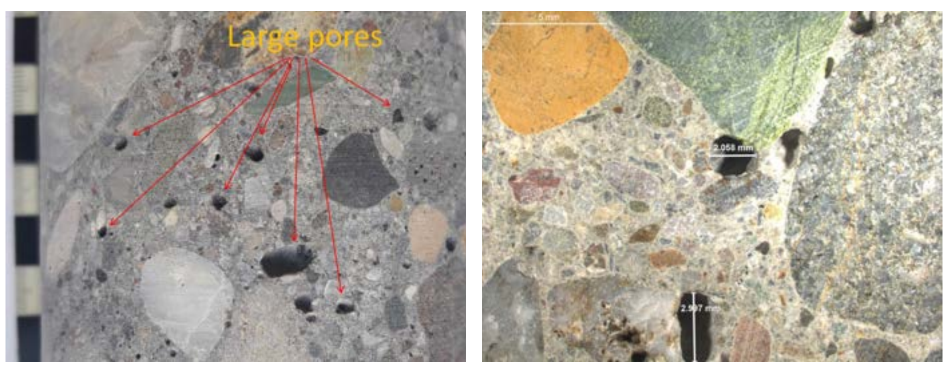


Figure 22: A macro view (at the left) and a cross-section image (at the right) of the exposed concrete sample (C3.X) showing the presence of very large and large pores in various sizes in the concrete matrix.

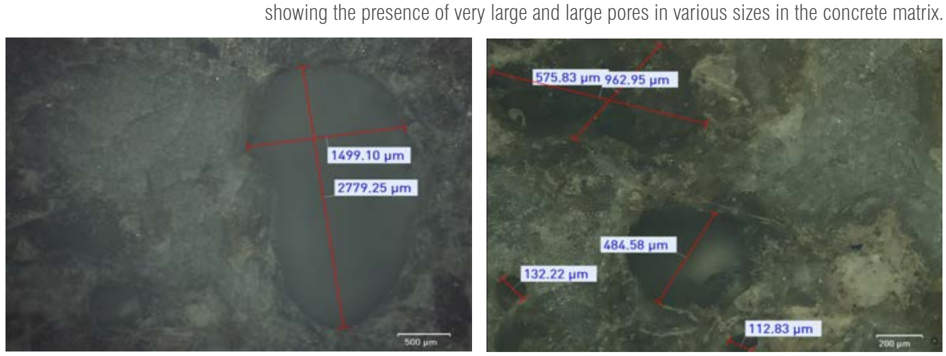


Figure 23: The cross-section images of the exposed concrete sample (C3.X) showing the presence of large pores in various sizes in the concrete matrix (taken by HDS 5800 Huvitz digital microscope).

The major mineralogical and elemental composition of the exposed concrete samples was examined by XRD, XRF, FTIR, TGA and SEM-EDX analyses. During the preparation of the powdered samples for XRD analyses, a special care was given not to include the coarse aggregates. However, the inclusion of fine aggregates was inevitable. The XRD traces of the exposed concrete samples (C6.E.AE and C7.E.AE) show that the mineral composition of the concrete powder is mainly calcite, quartz, and plagioclase feldspar (Figure 24 and Figure 25). Those data are related to the varieties of rock fragments of sedimentary (travertine types, etc.) and igneous (andesite, basalt, etc.) origins, used as aggregates in the concrete mixture. The rich variety of aggregates is also visible in cross-section images (Figure 20). The FTIR spectra of the concrete samples showing the presence of calcite and quartz support the XRD data (Figure C8). The TGA peaks belonging to the same exposed concrete samples show that the calcite decomposition is prominent and calcite ($CaCO3$ - calcium carbonate) is an important mineral in the composition originating from the limestone aggregates in concrete mixture (Figure C9). The presence of various limestone aggregates is visible in cross-section images as light-colored aggregates which also supports the TGA data (Figure 20). The elemental analyses of the concrete powder samples by XRF reflect the mineralogical composition of the concrete samples (Table C3). The rich variety of aggregates in the exposed concrete mixture exhibit the rich varieties of geological formations that contribute to the natural aggregate resources of Ankara.

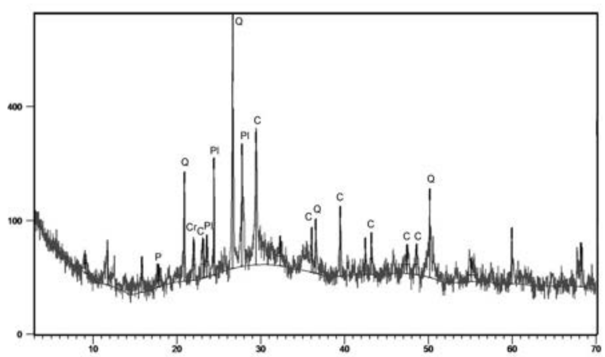


Figure 24: XRD trace of the exposed concrete sample (C6.E.AE) (P: Portlandite, Q: Quartz, C: Calcite, Pl: Plagioclase, Cr: Cristobalite)

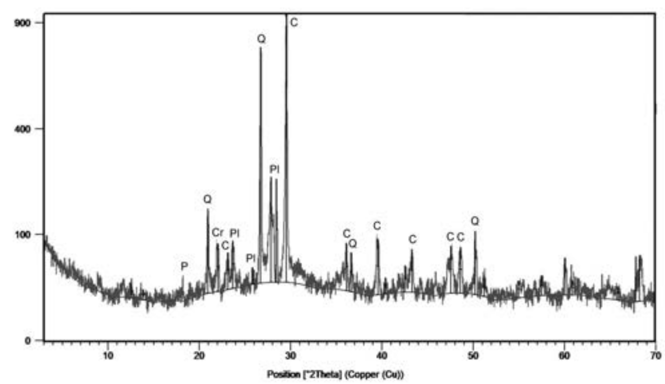


Figure 25: XRD trace of the exposed concrete sample (C7.E.AE) (P: Portlandite, Q: Quartz, C: Calcite, PL: Plagioclase, Cr: Cristobalite)

The spectra of XRD and FTIR analyses representing the whole exposed concrete composition did not give information about the hydrated cement products that form the binder. Therefore, efforts were made to take powder samples by scraping the binder-rich areas and the large pore interiors of the exposed concrete sample C3.X and labelled as C3.X.b. The XRD traces of the powder sample (C3.X.b) taken from binder-rich part of exposed concrete showed the presence of portlandite and tobermorite together with minerals sourced from the aggregate such as calcite, quartz, plagioclase feldspar (Figure 29). The presence of portlandite and tobermorite peaks belongs to the well-formed hydrated cement products. Concrete sample tested with wet PH indicator paper also presented the basic nature of the concrete mixture and the presence of portlandite (Figure 30). The basic nature of concrete is considered a protective factor against corrosion of the reinforcement. Those cement hydration products indicate the good quality of concrete composition. The EDX spectrum taken from the exposed concrete sample (C3.I.H10), similar to the C3.X exposed concrete sample, indicates the presence of calcium, aluminum and silisium elements in the composition together with some iron element (Fe) (Figure 31). In addition, SEM analyses have verified the presence of tobermorite crystals due to their well-known needle-like form and its elemental composition by EDX, while its identification is difficult with XRD analyses unless its concentration in the mixture is high (Figure 32). These data support the formation of principal cement hydration products such as tobermorite (CSH) and portlandite.

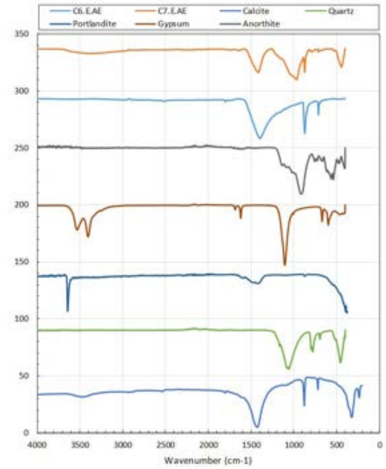


Figure 26: FTIR spectra of the exposed concrete samples (C6.E.AE and C7.E.AE)

Oxide	(% by weight)		
	C3.I.H10	C6.E.AE	C7.E.AE
CaO	50.0	38.8	34.9
SiO_2	32.1	41.8	45.0
Fe_2O_3	6.70	4.7	4.1
Al_2O_3	6.24	9.7	10.0
MgO	1.16	1.5	1.1
K_2O	1.14	1.1	2.0
Na_2O	0.93	0.9	1.4
SO_3	0.84	1.5	1.5

Figure 27: XRF data showing the major oxide composition of the exposed concrete samples (C3.I.H10, C6.E.AE and C7.E.AE)

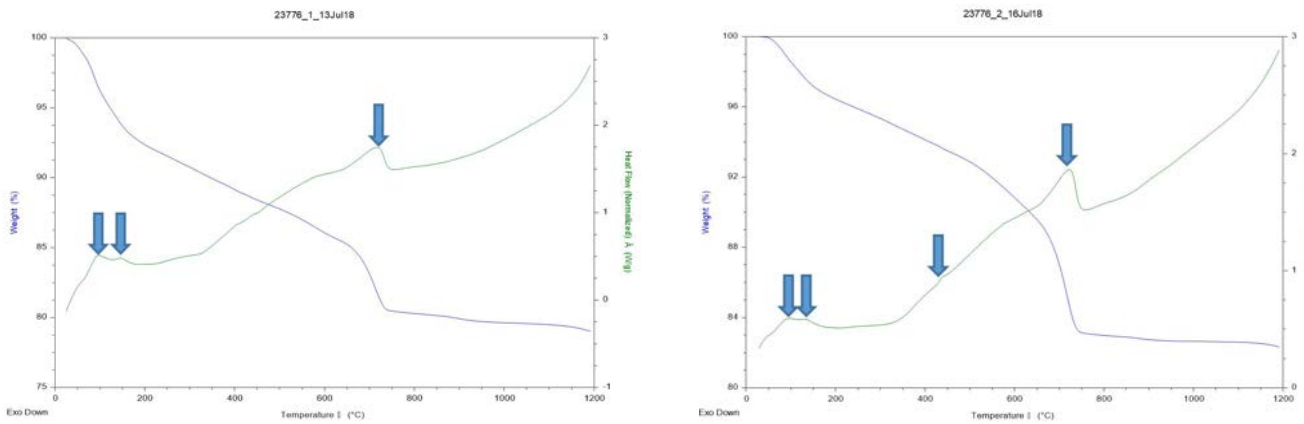


Figure 28: TGA peaks showing the presence of calcite as the major mineral in the composition of the exposed concrete samples (C6.E.AE and C7.E.AE)

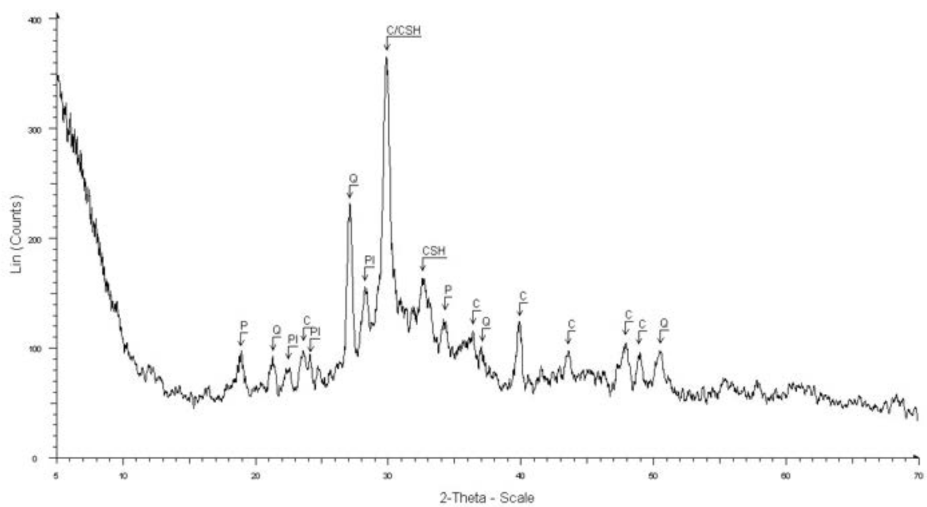


Figure 29: . XRD trace of the binder-rich powder of exposed concrete sample (C3.X.b) (P: Portlandite, Q: Quartz, C: Calcite, CSH: Tobermorite-Calcium Silicate Hydrate, Pl: Plagioclase)

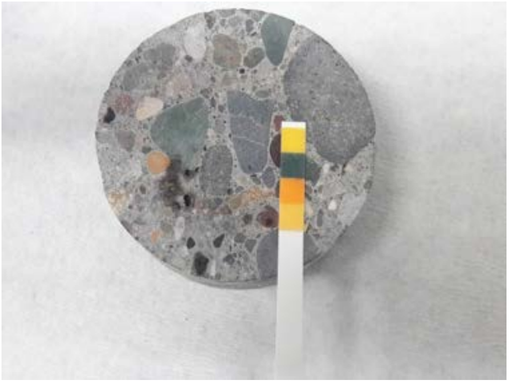
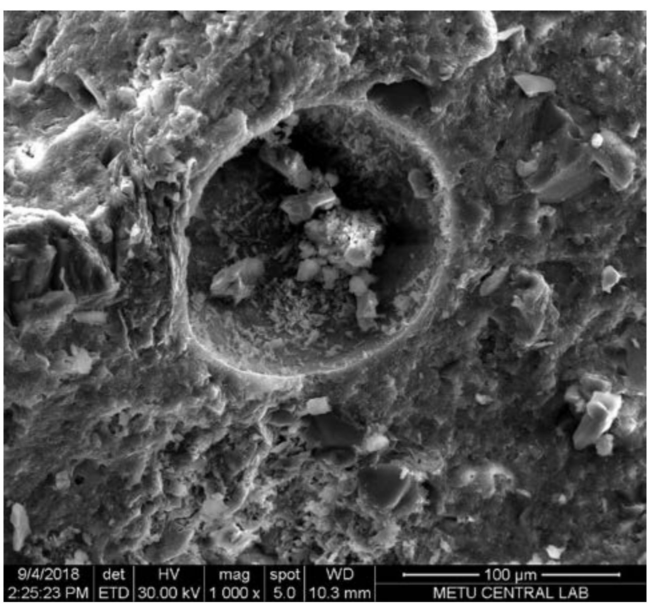
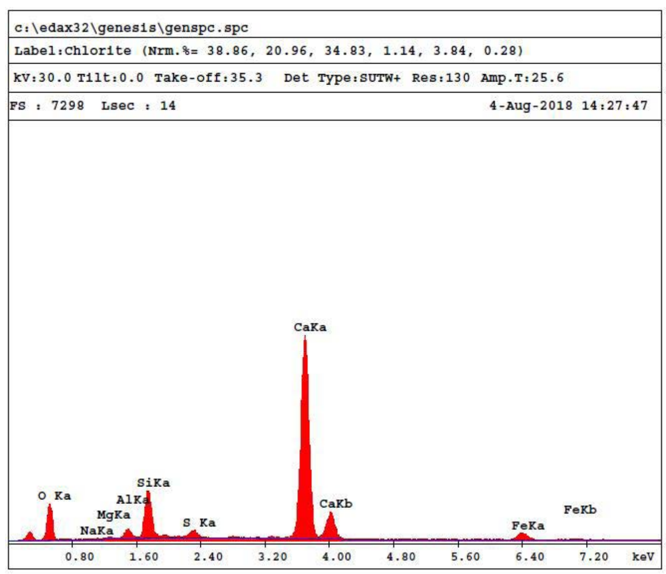


Figure 30: Exposed concrete sample ((C3.X) tested with wet PH indicator paper showing the basic nature of concrete mixture (dark bluish green color indicates PH around 10).

The cross-section images and XRD analyses of the concrete mosaic sample (C8.E.E4) gave brief information on the compositional and mineralogical properties of the yellow-colored concrete mosaic slab used as floor finishing at the courtyard (Figure 33).

In the concrete mosaic sample (C8.E.E4.), aggregates are mostly the crushed travertine particles composed of coarse-sized (7-15mm), medium-sized (3-7mm) and fine-sized (1-3mm) sand (Figure 34). The higher magnification views of the binder-rich part in the concrete mosaic matrix show the presence of very fine aggregates within the hydrated cement binder (Figure 35). In cross-section images, the comparison of the total area with the area covered with those aggregates indicates that a lower portion of the binder was used in the concrete mixture. The good adhesion between aggregates and binder matrix is also observed in all cross-section images (Figure 34 and Figure 35). The XRD traces of the concrete mosaic sample show that its mineral composition is mainly calcite and portlandite (Figure 36).





EDAX ZAF Quantification (Standardless)
Element Normalized
SEC Table : Default

Element	Wt %	At %	K-Ratio	Z	A	F
O K	44.00	64.13	0.0566	1.0299	0.1248	1.0003
NaK	0.48	0.48	0.0009	0.9674	0.2023	1.0024
MgK	0.75	0.72	0.0022	0.9927	0.2916	1.0046
AlK	2.28	1.97	0.0090	0.9645	0.4064	1.0079
SiK	9.86	8.19	0.0512	0.9936	0.5192	1.0075
S K	1.41	1.03	0.0094	0.9873	0.6593	1.0207
CaK	38.15	22.20	0.3482	0.9672	0.9420	1.0017
FeK	3.07	1.28	0.0253	0.8931	0.9239	1.0000
Total	100.00	100.00				

Figure 31: SEM image of exposed concrete sample (C3.I.H10) showing a pore with a diameter around 100microns and an EDX spectrum next to the pore indicating the presence of calcium, aluminum and silisium elements in the composition together with some iron element (Fe).

Calcite corresponds to travertine fragments as aggregate and portlandite is a constituent of the hydrated cement binder in the concrete mosaic mixture. The presence of light-colored travertine fragments in the concrete matrix provides an attractive yellowish texture to the concrete mosaic (Figure 34). The powder sample prepared by scraping the binder-rich areas of the concrete mosaic sample (C8.E.E4) was labelled as C8.E.E4.b. The XRD traces of that powder showed the presence of portlandite and tobermorite in the binder as the well-formed hydrated cement products (Figure 37). Those cement hydration products signal the good quality of concrete mosaic composition. The binder-rich part of the concrete mosaic matrix is dark yellow-colored and involves very fine aggregates within the sizes of 10 μ to 100 μ, large and circular pores within the sizes of 250 μ to 2 mm and abundance of very fine pores about 2 μ in diameter (Figure 35). The yellow color of the binder was probably obtained by adding a very low percentage of yellow iron oxide powder into the binder, around 1% by weight.

The yellow-colored finishing floor slabs represented by the examined concrete sample (C8.E.E4) are still in good state even though they are in the courtyard and have been exposed to atmospheric weathering conditions almost for 60 years. That good performance proves the good quality and durability of concrete mosaic, similar to the exposed concrete of this building.

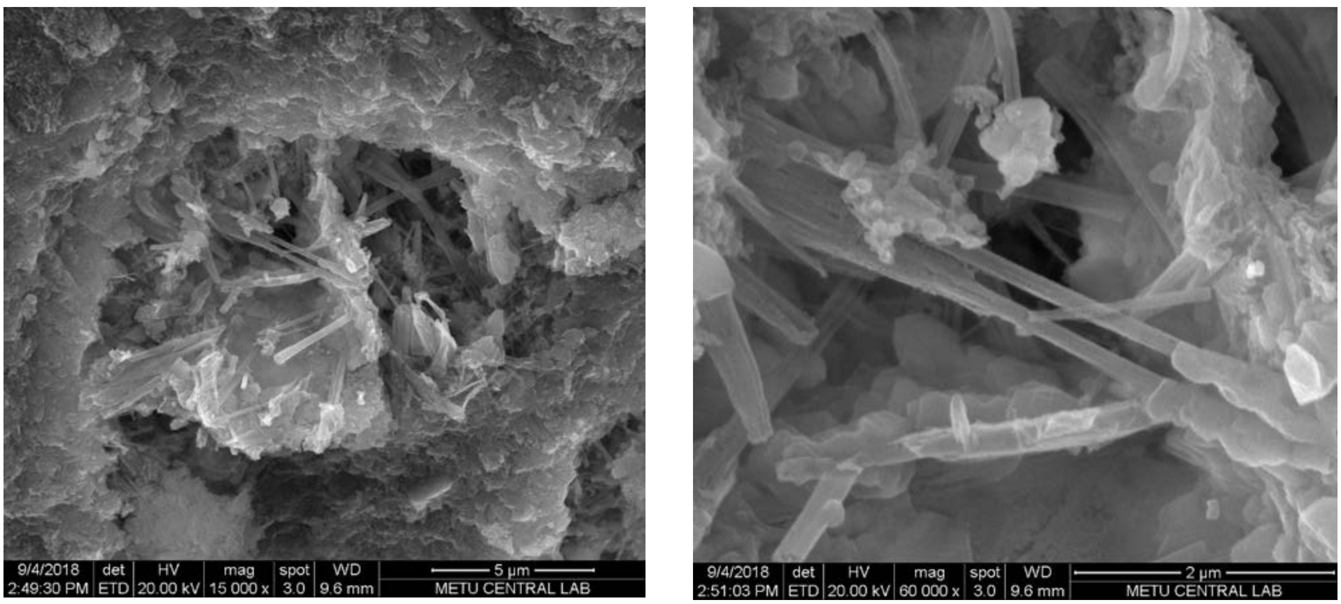


Figure 32: SEM micrographs of a fracture surface in concrete sample C3.I.H10 showing the presence of needle-like tobermorite crystals at high magnification which is verified by its EDX data given in Figure C12.

Figure 33: General view of the yellow-colored concrete mosaic slab used as floor finishing at the courtyard (on the left) and the cross section of concrete mosaic sample (C8.E.E4.)(on the right)

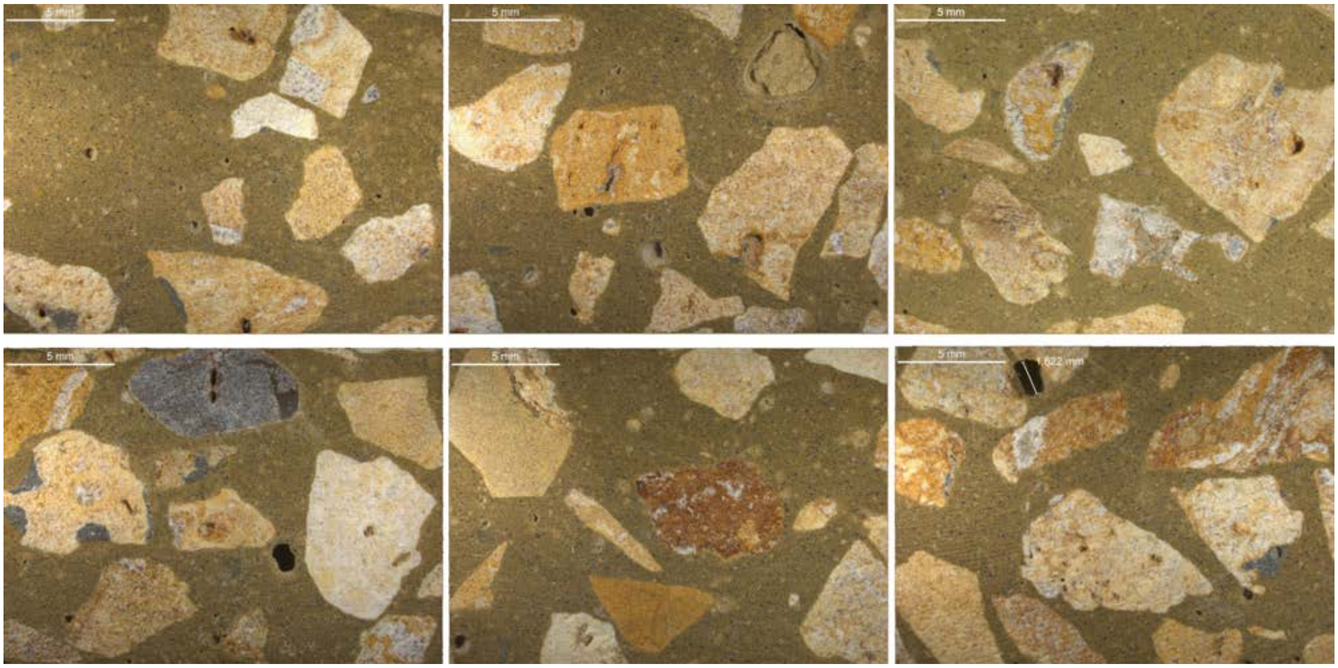


Figure 34: The cross-section images of the concrete mosaic sample (C8.E.E4) showing the aggregates of travertine origin in various sizes and the binder with very fine aggregates (taken by Leica Z16 APO A optical microscope)

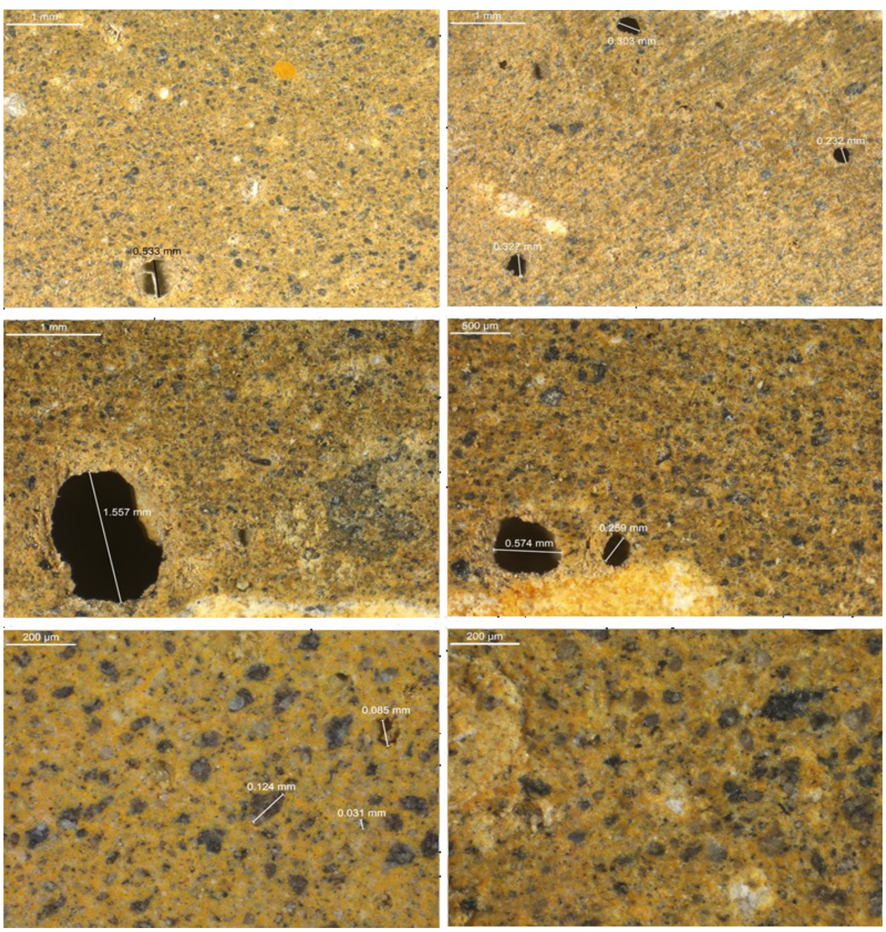


Figure 35: The cross-section images of the concrete mosaic sample (C8.E.E4) at higher magnification showing very fine aggregates in the hydrated cement binder, large pores in various sizes in the binder matrix and good adhesion of aggregate and binder (taken by Leica Z16 APO A optical microscope)

The concrete mosaic sample has particular features, such as the total effective porosity around 17% by volume which is higher than the porosity of exposed concrete, aggregates in crushed forms of coarse-, medium- and fine-sized travertine fragments, large and circular pores in its matrix together with abundance of very fine pores. Similar to the exposed concrete, those features signal the use of an air-entraining additive in this type of concrete mosaic mixture. Further analyses are needed to discover the additives that contributed to the good quality of concrete types used in the Faculty of Architecture building.

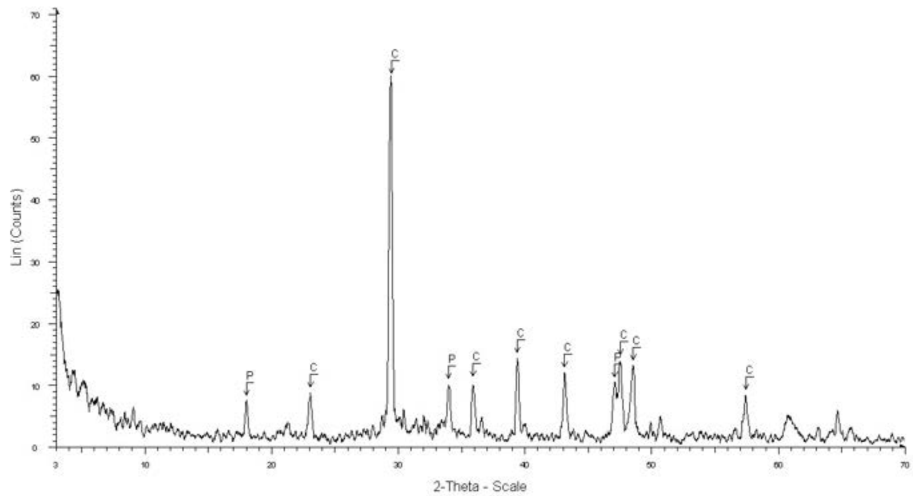


Figure 36: XRD trace of the concrete mosaic sample (C8.E.E4) showing the calcite of travertine aggregate and portlandite as the constituent of its hydrated cement binder (C: Calcite, P: Portlandite)

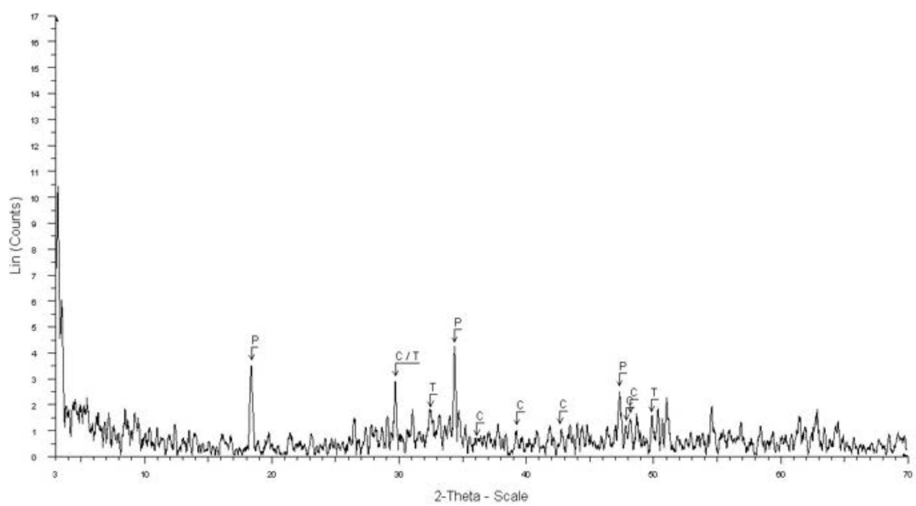
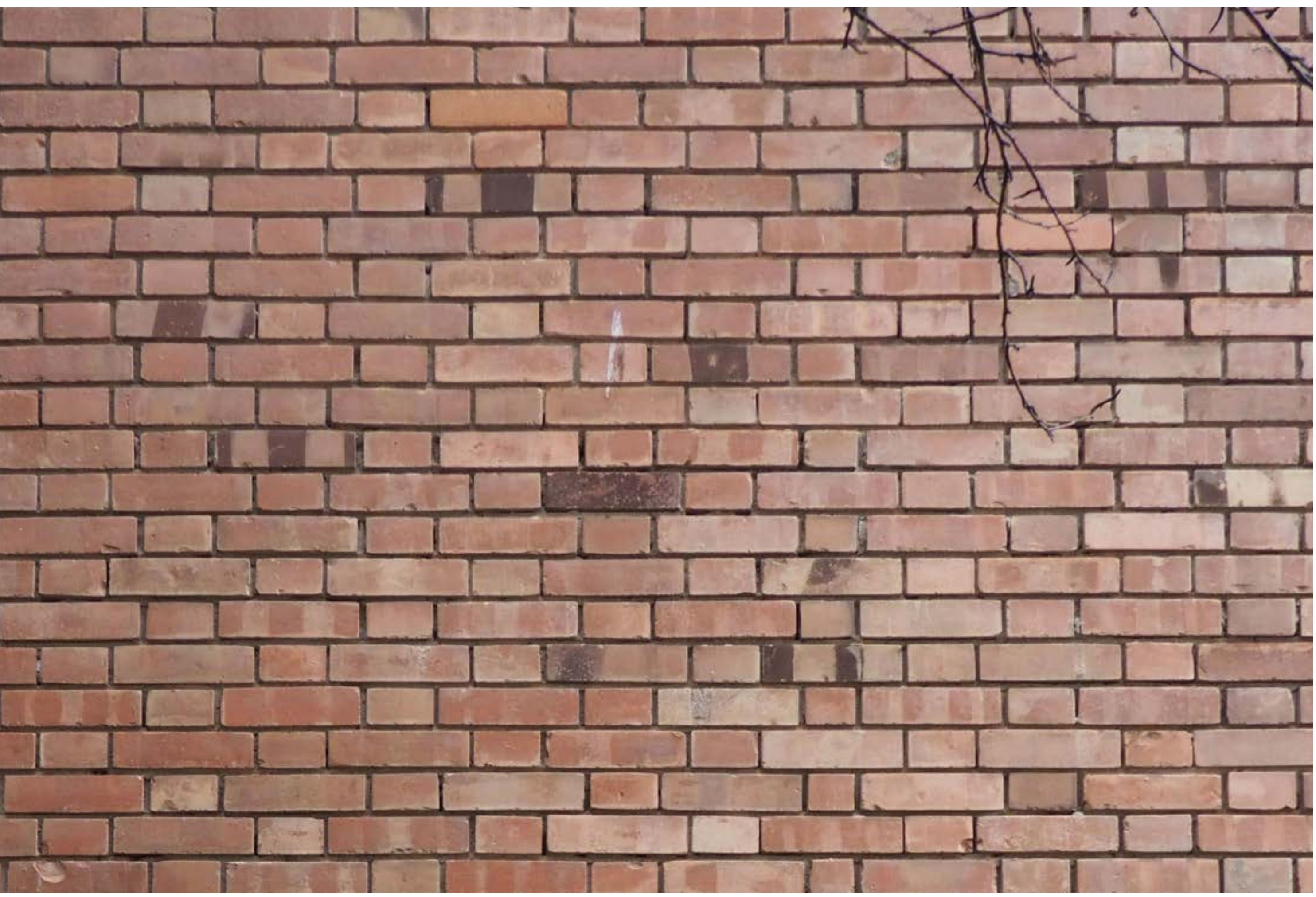


Figure 37: XRD trace of the hydrated cement binder (C8.E.E4.b) showing the portlandite and tobermorite in the binder (P: Portlandite, C: Calcite, T: Tobermorite-Calcium Silicate Hydrate)



3.3.4. Material Analyses of Red Brick

Alongside concrete, red brick is the other common building material that plays an important role in the Faculty of Architecture building. It is used as exposed brick masonry units for exterior and interior walls. One red brick sample (B1.E.E5) representing the brick masonry wall was examined to determine its basic physical properties, surface hardness and compositional properties.

The bulk density, effective porosity, water absorption capacity of the exposed brick sample were found to be 1930 kg/m3, 32% (by volume) and 17% (by weight), respectively (Table B1). Preliminary data obtained by the non-destructive Schmidt rebound hammer test show that the exposed brick surfaces present rebound hammer indices in the range of 40-50. This value gives an idea about their surface hardness and confirms the good state of preservation of the 60-year-old exposed brick masonry units. However, further analyses are needed to correlate the rebound hammer indices with the mechanical properties of brick and its state of deterioration, especially for the deteriorated surfaces suffering from salt deposits and material loss. Salt deposits together with material loss are observed only in exterior brick walls suffering from rainwater penetration problems. Those problems are not common in the Faculty of Architecture building. They are observed occasionally on the upper parts where the brick wall is in contact with the exposed concrete roof parapet and at the edges where the brick wall is in contact with the exterior exposed concrete walls (Figure 14, Figure 15 – positioned at the subsection 3.4.1). The rainwater penetration at those localities cause transfer of sulphate salts from cement jointing mortars to the brick body. Crystallization of the soluble salts in the brick body, namely subflorescence, and crystallization on brick surfaces, namely efflorescence, causes material loss that progresses over time in the forms of flakes, scales and outbursts.

Brick sample	Bulk density (kg/m^3)	Effective porosity (% by volume)	Water absorption capacity (% by weight)
Exposed brick used at exterior masonry wall	1930	32	17

Figure 38: Table B1. Basic physical properties of red brick material

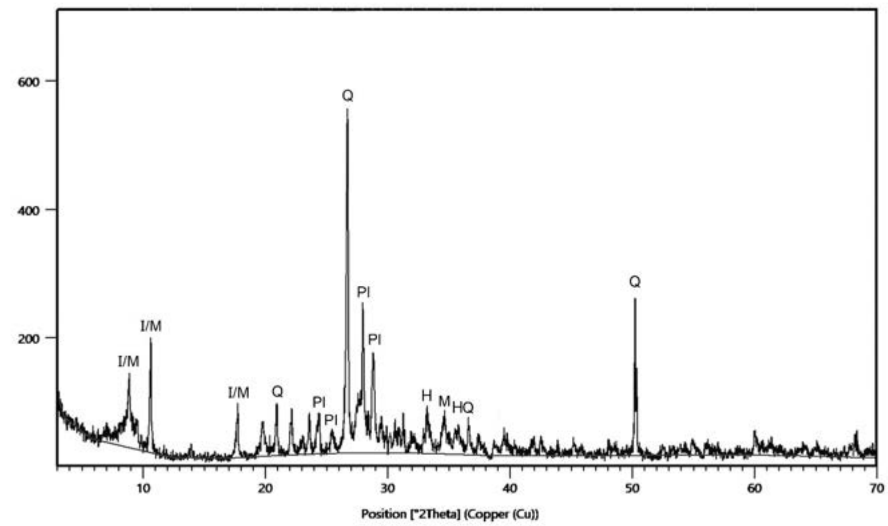


Figure 39: XRD trace for the red brick sample (B1.E.E5) (I/M: Illite/Mica, Q: Quartz, Pl: Plagioclase, H: Hematite)

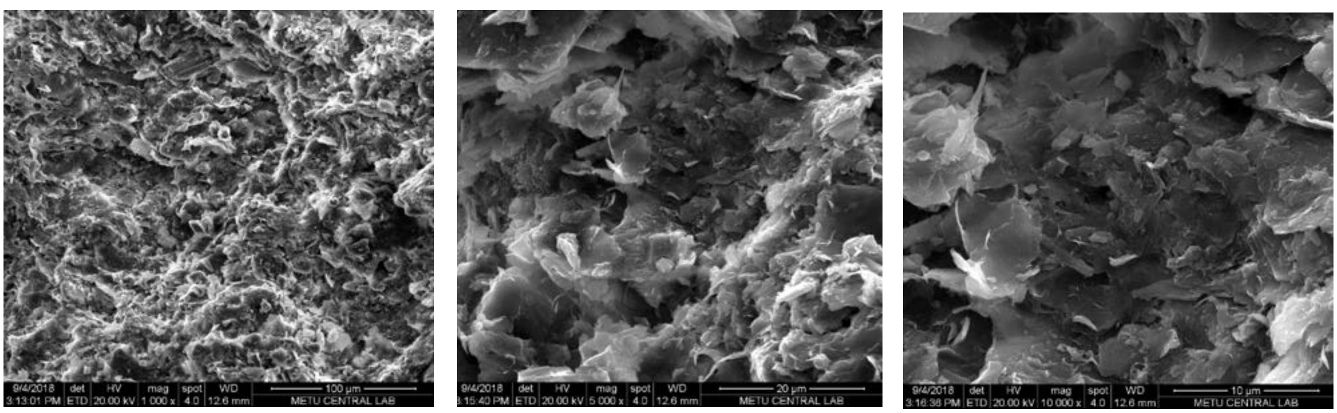


Figure 40: SEM views taken from the fracture surface of brick sample (B1.E.E5) at various levels of magnifications showing intermediate vitrification in the brick matrix formed during firing.

The major mineralogical and elemental composition of the exposed brick sample was examined by XRD, XRF, SEM analyses. The XRD trace of the brick sample (B1.E.E5) shows that its mineral composition is mainly illite/mica, quartz, plagioclase feldspar and hematite (Figure 39). The presence of hematite and absence of calcite observed in XRD traces and intermediate vitrification observed in SEM views of the brick matrix at high magnification (Figure 40) show that brick firing temperature is was around 800-900ºC. The elemental analysis of the brick powder sample by XRF reflects the main mineralogical composition of the brick sample and supports the XRD data (Table B2).

Oxide (% by weight)	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	TiO_2	K_2O	Na_2O	SiO_2	Al_2O_3
B1.E.E5	46.50	18.00	13.70	7.95	7.60	2.09	2.03	1.00	46.50	18.00

Figure 41: Table B2. XRF data showing the major oxide composition of the red brick sample (B1.E.E5)

The physical properties of the red brick, such as its high porosity of around 30% by volume, bulk density about 1900 kg/m3, together with considerable surface strength performance and firing temperature around 800- 900ºC indicate that this sample represents a factory (machine-moulded) brick manufactured without extrusion or pressing of the clay mixture. Similar results were already derived from the materials analyses of the exposed brick masonry units used in villa houses at METU campus, which were designed and built by Çinici Architects. In the METU Campus, brick masonry of the early 60's still keeps its sound and fresh look and exhibits rich variety in colour and texture. The brick used in the Faculty of Architecture building made an important contribution to creation of aesthetic and attractive spaces while representing the best of production technology of its period. Therefore, further studies for the discovery of a comparable local brick production technology including its raw materials resources will be useful for the maintenance and repair purposes as well as be inspiring for the contemporary brick production and exposed brick masonry construction.

3.3.5. Material Analyses of Limestone

Three samples representing the limestones (T4.E.AE, T5.E.AE, T1.E.E6) used as floor finishing at the courtyards were analyzed to determine their basic physical and compositional properties.

The basic physical properties of limestone samples vary within a certain range. The bulk density, effective porosity, water absorption capacity of two limestone samples (T4.E.AE and T1.E.E6) taken from the exterior floor finishing elements were found to be 2449±55 kg/m3, 2.0±0.5% (by volume) and 0.8±0.2% (by weight), respectively (Table L1). The third limestone sample (T5.E.AE) has lower bulk density, higher effective porosity and water absorption capacity than the other two samples with values of 2122kg/m3, 7.9% (by volume) and 3.7% (by weight), respectively.

Limestone samples used as exterior floor finishing	Bulk density (kg/m^3)	Effective porosity (% by volume)	Water absorption capacity (% by weight)
T1.E.E6	2488	1.6	0.7
T4.E.AE	2410	2.4	1.0
T5.E.AE	2122	7.4	3.7

Figure 42: Table L1. Basic physical properties of limestones

The major mineralogical and elemental composition of the limestone samples was examined by XRD, XRF, FTIR and TGA analyses. The XRD traces of all limestone samples show that calcite (Calcium carbonate – $CaCO_3$) is the only abundant mineral in their composition (Figure 44). The FTIR spectra of the limestone samples also confirm the presence of calcite and absence of quartz, which support the XRD data (Figure 45). The TGA peaks belonging to the same samples show that the calcite decomposition is prominent at 800ºC and confirm the calcite composition of limestones (Figure 46). The elemental analyses of the limestone samples by XRF reflect their mineralogical composition mainly composed of calcium carbonate with minor impurities of SiO_2, MgO, Al_2O_3 and SO_3 (Table L2).

The elemental composition of the three limestone samples is quite similar lthough one of the samples (T5.E.AE) has higher porosity and lower density than the other two. That beige-colored limestone is more likely a travertine. The other two limestone samples (T1.E.E6, T4.E.AE) with very low porosity and higher density are appropriate materials to be used as polished floor finishing with an attractive surface look.

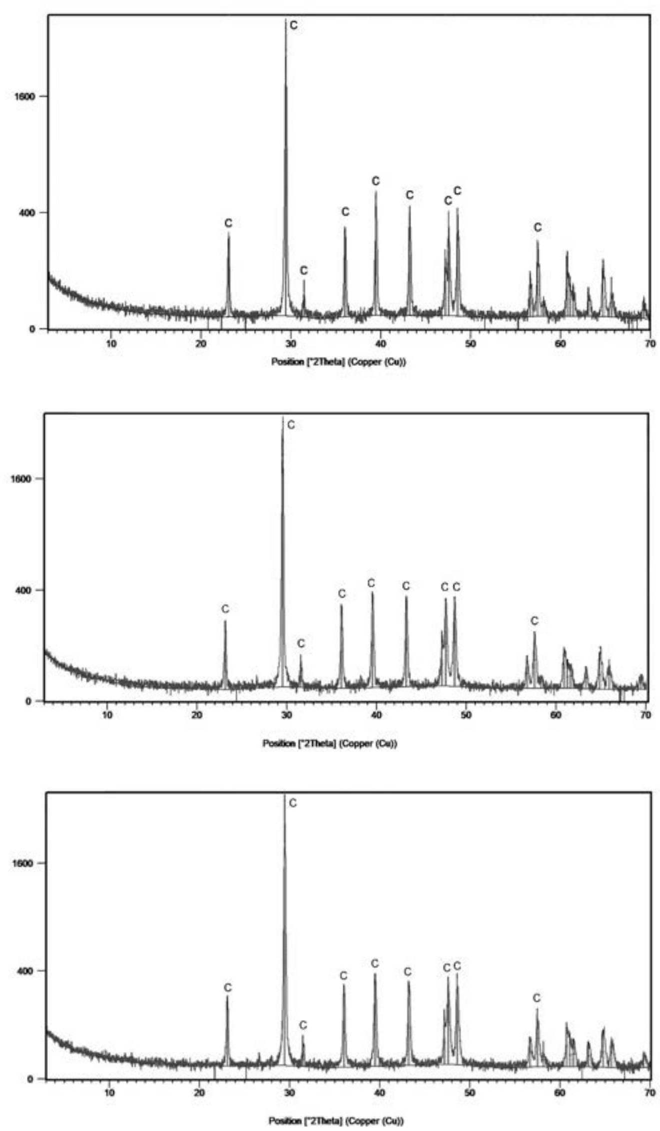


Figure 43: .XRD traces of the limestone samples, namely T1.E.E6 (at the top), T4.E.AE (in the middle) and T5.E.AE (at the bottom) showing that all samples are composed of calcite mineral (C: Calcite)

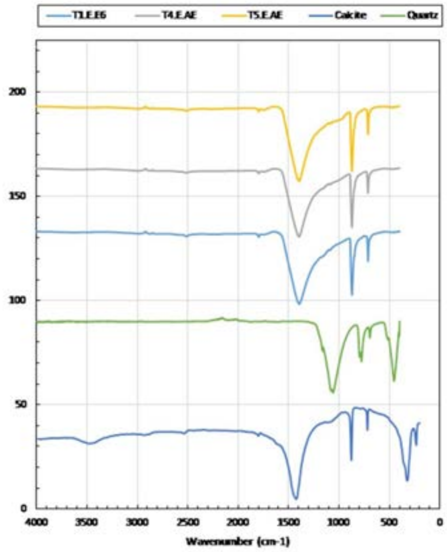


Figure 44: FTIR spectra of limestone samples and reference spectra of quartz and calcite

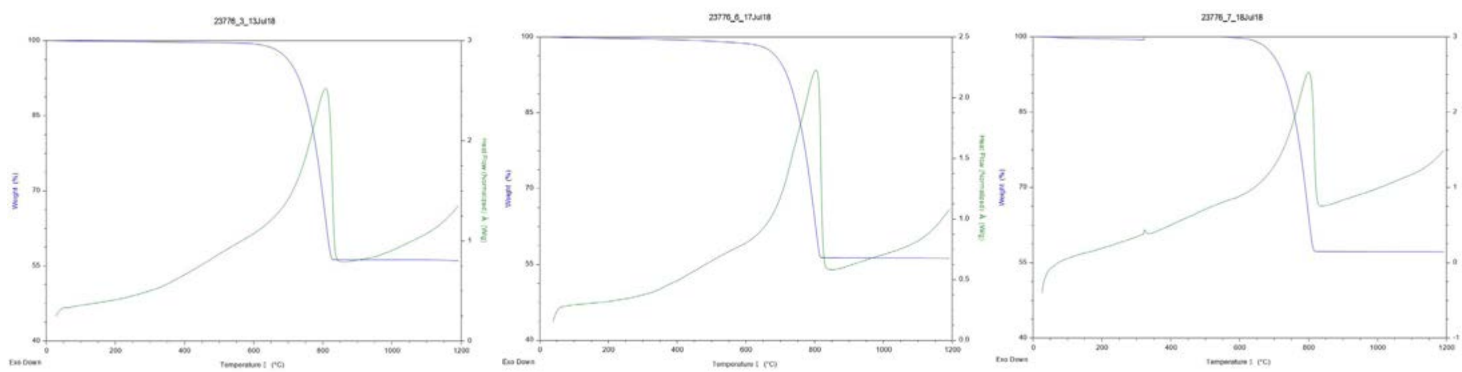


Figure 45: TGA plot for the limestone samples, T1.E.E6 (on the left), T4.E.AE (on the middle) and T5.E.AE (on the right)

Oxide (% by weight)	CaO	SiO_2	MgO	Al_2O_3	SO_3	Fe_2O_3
T1.E.E6	98.1	0.54	0.42	-	0.41	-
T4.E.AE	95.0	1.61	1.60	0.50	0.38	-
T5.E.AE	95.1	2.17	1.09	0.60	0.46	-

Figure 46: Table L2. XRF data showing the major oxide composition of the limestone samples

3.3.6. Analyses of Ceiling and Floor Finishing Materials

The results of introductory materials analyses on ceiling plaster samples and green-colored terrazzo tile samples are summarized in this section.

Two ceiling plaster samples, one representing the original ceiling plaster (F2.I.H11) and the other representing the ceiling repair plaster (F1.I.R48), used as ceiling finishing coat were analyzed to determine their major mineralogical and elemental composition.

The major mineralogical and elemental composition of the ceiling plasters were examined by XRD, FTIR, XRF, and TGA analyses. The XRD traces of the ceiling plasters show that the original ceiling plaster is composed of mainly calcite, gypsum and quartz (Figure 47) while the ceiling repair plaster is composed of calcite with some portlandite (Figure 48). The elemental analyses of those ceiling plasters by XRF reflect the mineralogical composition mainly composed of calcium carbonate with minor impurities of SiO_2, MgO, Al_2O_3, SO_3, TiO_2 and Fe_2O_3 while SiO_2 and SO_3 are higher in amount in the original ceiling plaster (Table O1). The FTIR spectra of the original ceiling plaster show the presence of calcite and some quartz (Figure 49). The TGA peaks of the same sample show the considerable weight loss at 800ºC due to the decomposition of calcite (Figure 50). Considering all data, it is concluded that original ceiling plaster is a lime-based plaster with some gypsum while the ceiling repair plaster is more likely a lime-based plaster mixed with some cement.

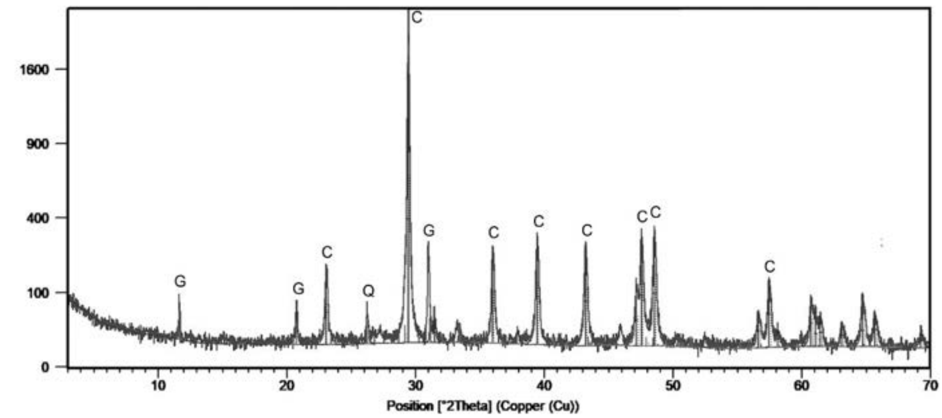


Figure 47: XRD trace of the original ceiling plaster (F2.I.H11) showing presence of calcite, gypsum and quartz (C: Calcite, G: Gypsum, Q: Quartz)

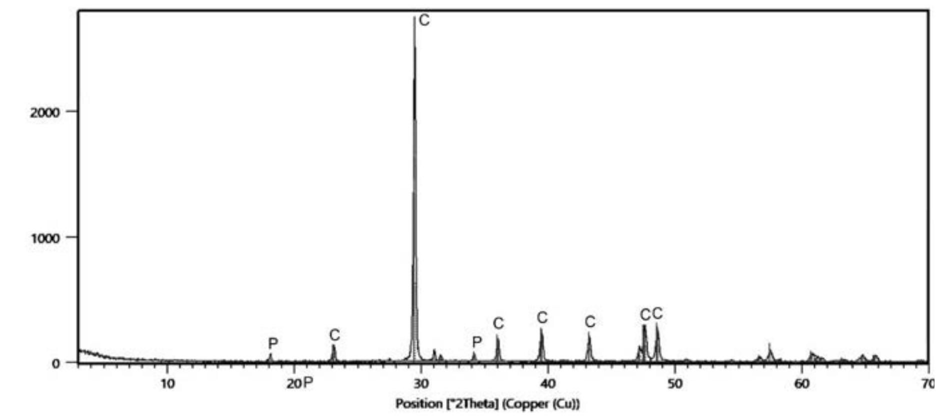


Figure 48: XRD trace of the ceiling repair plaster (F1.I.R48) showing the presence of calcite and portlandite (C: Calcite, P: Portlandite)

Oxide (% by weight)		CaO	SiO_2	MgO	Al_2O_3	SO_3	TiO_2	Fe_2O_3
Original ceiling plaster	F2.I.H11	82.1	9.36	0.889	3.31	2.838	0.279	0.406
Ceiling repair plaster	F1.I.R48	92.6	2.41	1.06	1.04	0.962	0.753	0.737

Figure 49: Table O1. XRF data showing the major oxide composition of the ceiling plaster samples

The green-colored terrazzo tile used as interior floor finishing at the ground floor level (Mo.1.I.R16) was analyzed to determine its basic physical and compositional properties. The bulk density, effective porosity, water absorption capacity of the terrazzo tile were found to be 2270 kg/m3, 9.1% (by volume) and 4.0% (by weight), respectively. The major mineralogical and elemental composition of the terrazzo floor tile sample was examined by XRD, XRF, FTIR and TGA analyses. The XRD trace of the terrazzo tile sample shows that the mineral composition of the tile is mainly antigorite/lizardite, quartz, calcite, and portlandite (Figure 53). These data indicate the presence of serpentine rock minerals (antigorite/lizardite) that are responsible for the green color of the terrazzo together with calcite and quartz as well as the presence of portlandite coming from the cement binder. The FTIR spectra of the terrazzo tile sample showing the presence of calcite, quartz and portlandite supports the XRD data (Figure 54). The TGA peaks of the same sample show the weight losses at 480°C and 800ºC due to the decomposition of some portlandite and a prominent amount of calcite respectively. The elemental analyses of terrazzo floor tile sample by XRF reflect the mineralogical composition mainly composed of SiO2, CaO and MgO and some Fe2O3 and Al2O3 (Table O3). Considering all data, it can be concluded that the green terrazzo tile is a sort of concrete mosaic product mainly composed of serpentine rock fragments giving the dark green color, and the cement binder.

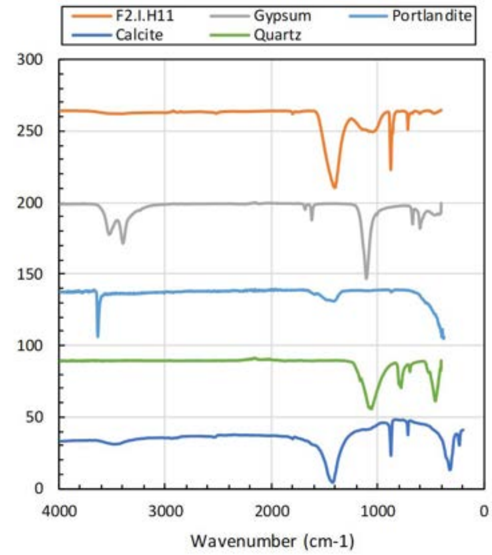


Figure 50: FTIR spectra of the original ceiling plaster (F2.I.H11)

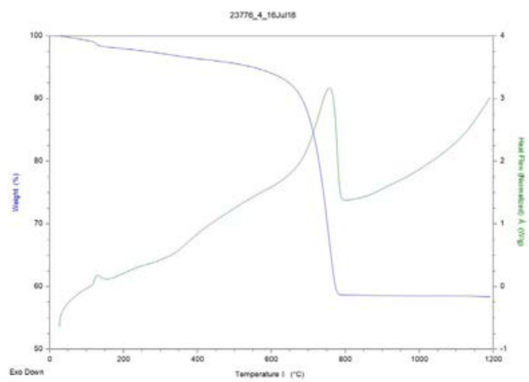


Figure 51: TGA plot for the original ceiling plaster sample (F2.I.H11)

Green-colored terrazzo floor tile sample	Bulk density (kg/m^3)	Effective porosity (% by volume)	Water absorption capacity (% by weight)
Mo.1.I.R16	2270	9.1	4.0

Figure 52: Table O2. Basic physical properties of green colored terrazzo floor tile sample

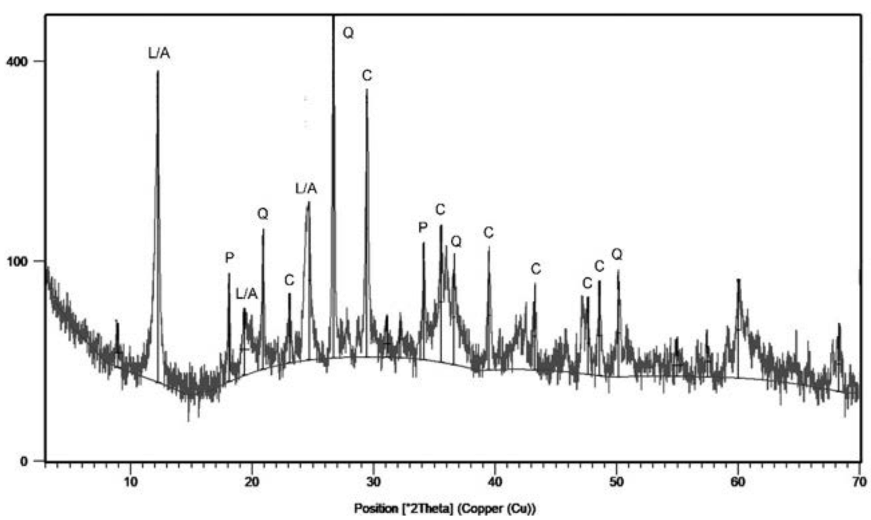


Figure 53: XRD trace of the green-colored terrazzo floor tile sample (Mo.1.I.R16) (P: Portlandite, Q: Quartz, C: Calcite, L/A: Lizardite/Antigorite)

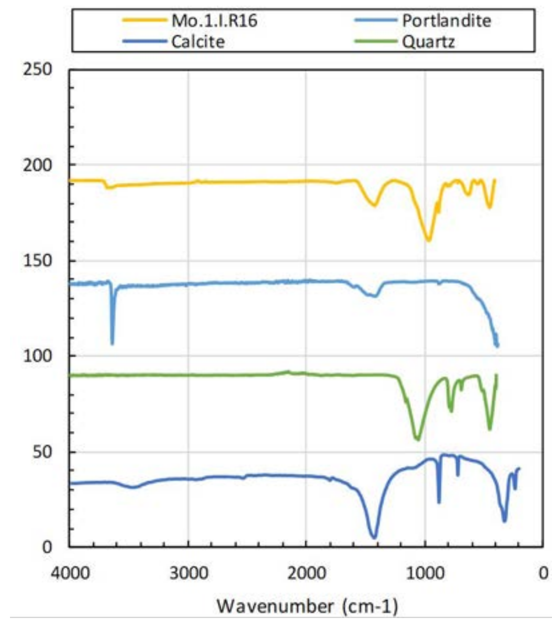


Figure 56: FTIR spectra of the green-colored terrazzo floor tile sample (Mo.1.I.R16) showing the presence of calcite, quartz and portlandite

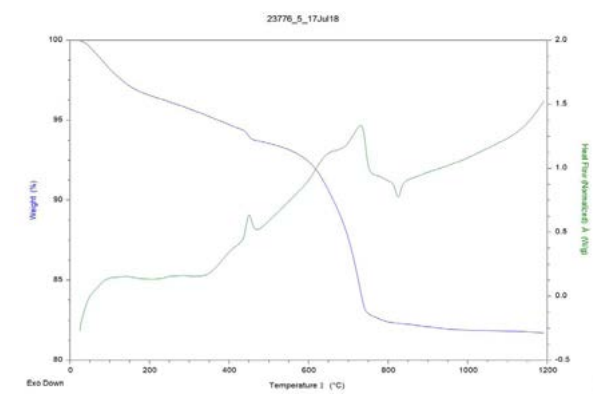
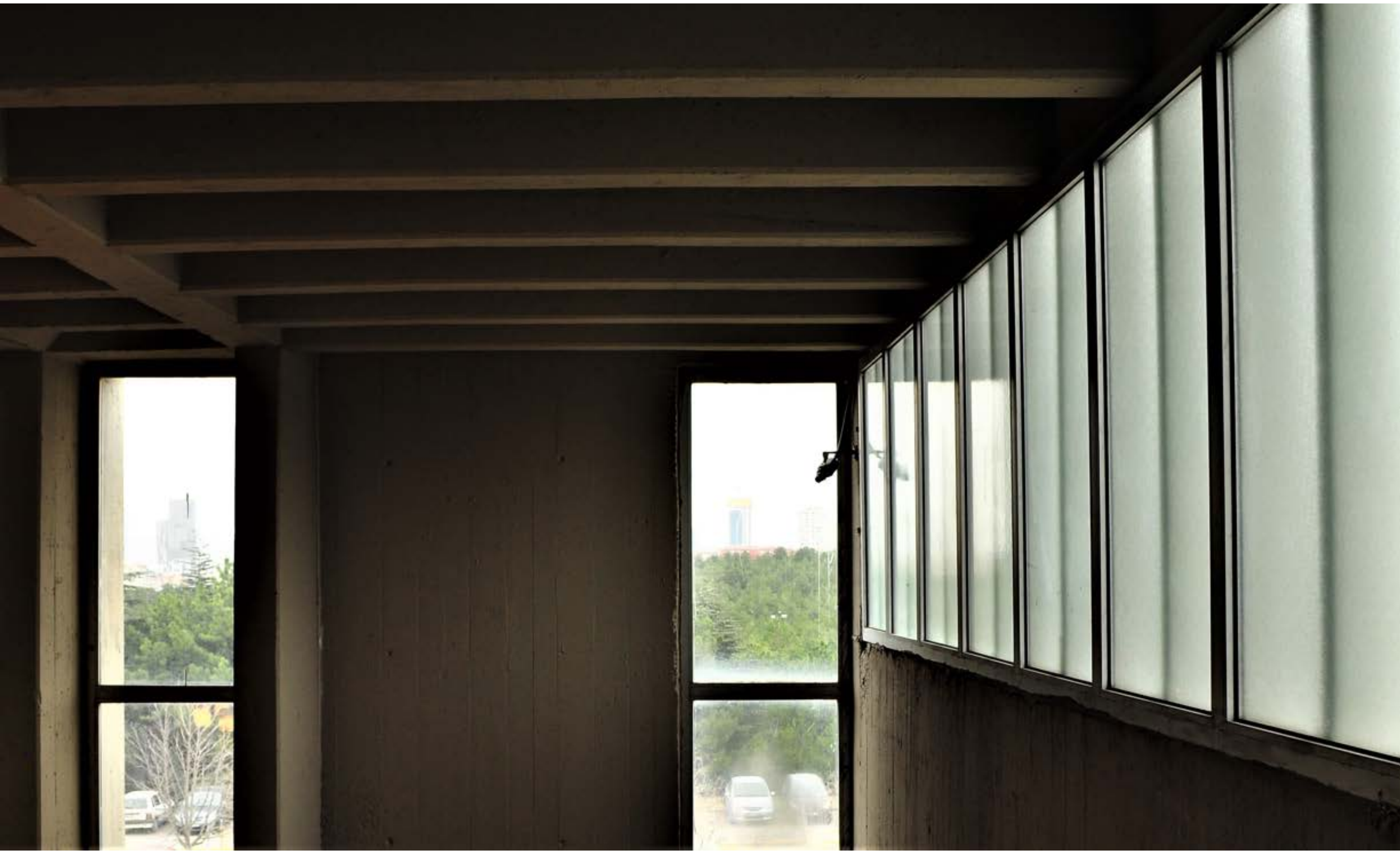


Figure 54: TGA plot of the green-colored terrazzo floor tile sample (Mo.1.I.R16)

Oxide (% by weight)	SiO_2	CaO	MgO	Fe_2O_3	Al_2O_3
Green-colored terrazzo floor tile sample	37	29.3	18.6	6.98	5.12

Figure 55: Table O3. XRF data showing the major oxide composition of the green-colored terrazzo floor tile sample (Mo.1.I.R16)



3.3.7. Infrared Thermography (IRT) Analyses

Thermal images were taken at the selected parts of the building with a Fluke Ti480 PRO thermovision camera. Those images were taken from inside and outside of the building in winter when the outside was very cold with a temperature below -10ºC and the heating system was functioning inside.

The exposed reinforced wall surfaces which are considerably warmer than outside temperature (<-10ºC) indicates the heat loss through exposed concrete surfaces which is due to the low thermal resistance of exposed reinforced concrete walls (Figure 57). Metal window frames act as thermal bridges accelerating heat loss through wall surfaces (Figure 57 and Figure 58). Heat loss is locally the highest where heating pipes are located behind the wall, visible in the thermal image of the exterior wall with a surface temperature difference more than 5°C while the neighboring wall has colder surface temperature with an even surface temperature distribution (Figure 57). It is observed that the expansion joint between those two crossing shear walls provides a thermal break and heat transfer to the neighboring shear wall by conduction is prevented. That signals that the expansion joint lifetime still functions well after almost 60 years of service and provides total separation with its thermal insulation infill.

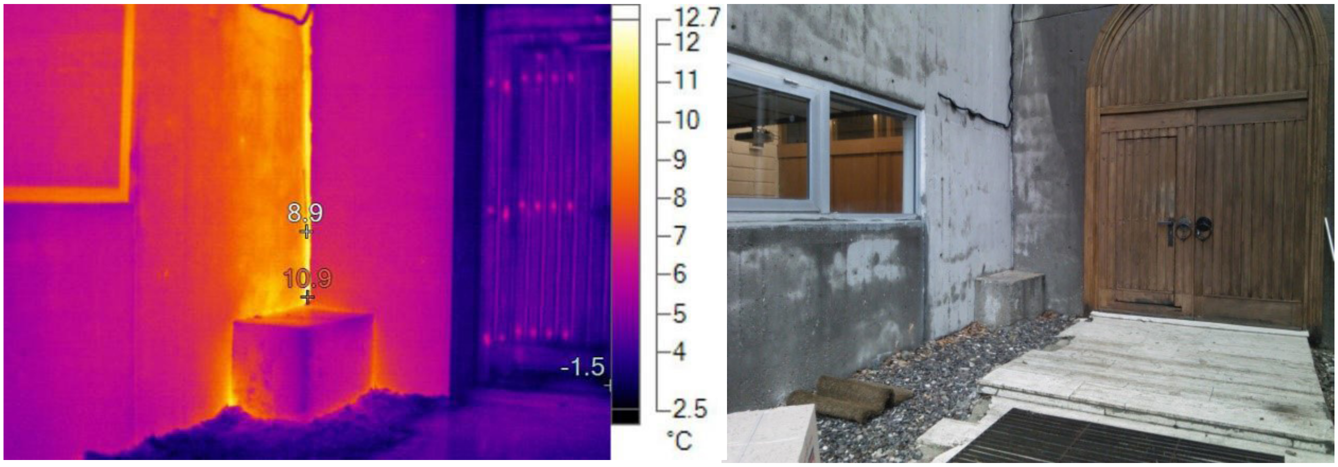


Figure 57: The thermal image (IR_00031.IS2) taken from the exterior (colder) side of the exposed reinforced concrete wall surfaces showing heat loss areas through the exposed reinforced concrete walls, mostly where the heating pipes are located behind, the expansion joint between two reinforced concrete walls acting as a thermal break and the metal window frames acting as thermal bridge areas.

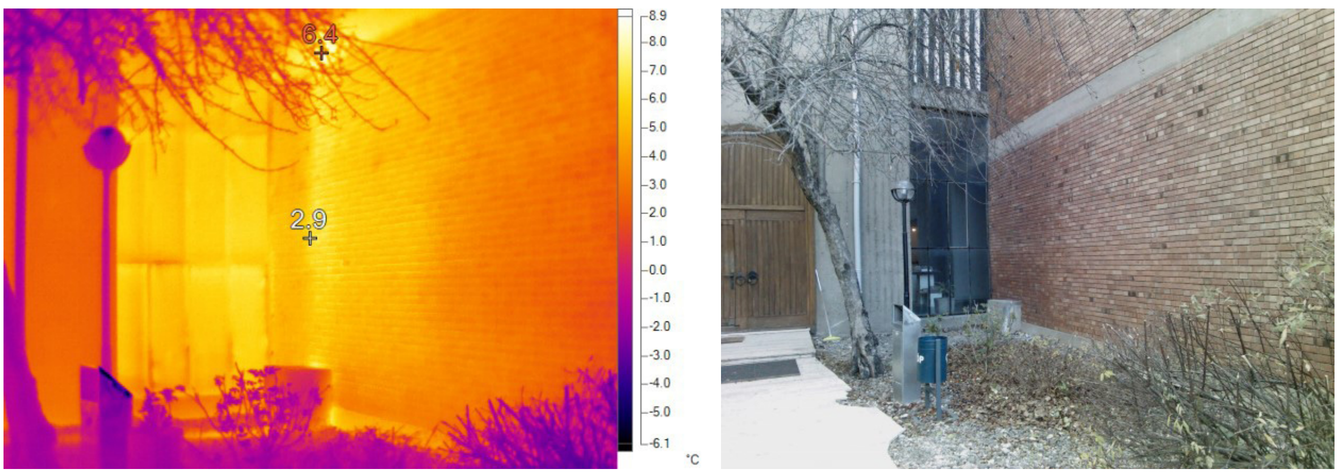


Figure 58: The thermal image (IR_000X.IS2) taken from the exterior (colder) side of the building wall surfaces showing excessive heat loss through the metal window frames and glazing acting as thermal bridge areas.

The presence of walls with partially warmer and partially colder surfaces reaching to a difference of 5°C signal the presence of air currents in the space (Figure 59 and Figure 60). In addition, the heat flow through the partition wall (through the warm space to colder one) made of wooden frame, wooden panels and glass is visible in thermal images indicating that microclimate of two neighboring interior spaces are different (Figure 60). The reasons of temperature fluctuations on interior building surfaces need to be investigated and the potentials of air circulations caused by heat exchange between neighboring spaces should be assessed particularly for encouraging natural ventilation inside.

The temperature gradient through the white concrete block wall exhibited a cellular surface temperature pattern which showed that those blocks are not solid and might have two voids in their cross section (Figure 59). The voids in the white concrete blocks presenting higher thermal resistance than the solid parts of the concrete blocks, should have contributed to the thermal performance of the overall white concrete block walls.

This introductory IRT survey showed the presence of heat loss areas through the building envelope made of exposed reinforced concrete walls and through the metal window frames acting as thermal bridges. The study also presented the further research topics into the Faculty of Architecture building that can be done by the use of quantitative IRT analyses.

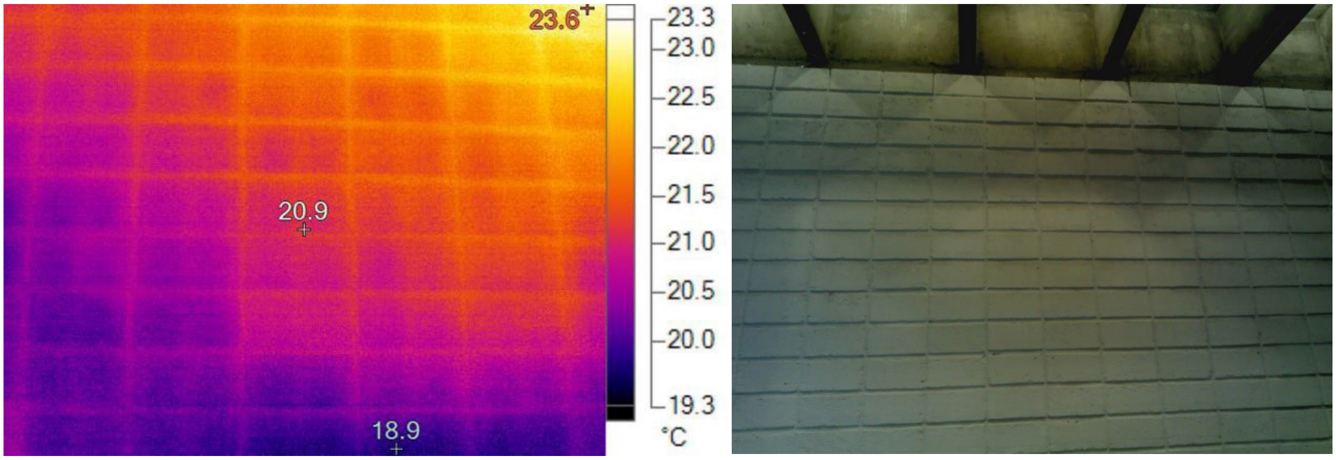


Figure 59: The thermal image (IR_00024.IS2) taken from the colder side of an interior white concrete wall showing that the wall with partially warmer and partially colder surfaces reaching to a difference of 4^oC signal the presence of air currents in the space. The surface temperature pattern of the white concrete masonry units show that there is a hollow structure inside composed of two large voids.

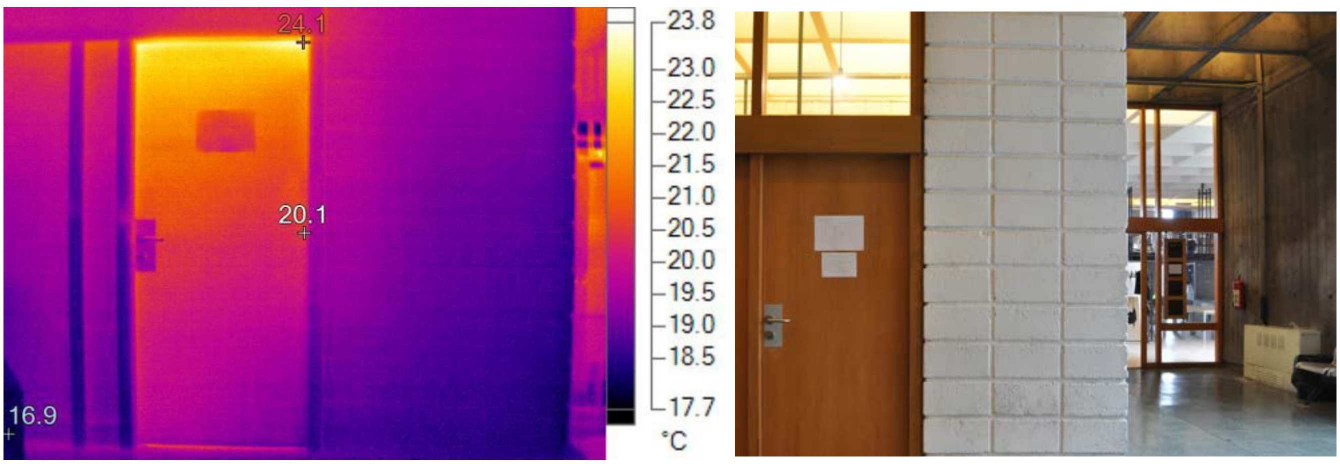


Figure 60: WThe thermal image (IR_00007.IS2) taken from the colder side of a partition wall, made of wooden frame, wooden panels and glass, showing that microclimates of two neighboring spaces are different and there is considerable heat flow through the partition wall causing surface temperature differences above 5^oC in a space. These are the situations that encourage air circulations in the building.

Those research topics can be summarized as the assessment of air circulations in the building and adequacy of natural ventilation, and the monitoring of the thermal failure areas observed in the building envelope and further maintenance studies that will be carried out for their elimination. In addition, types of white concrete solid blocks and *brise-soleil* units can be better-analysed by the use of Quantitative IR Thermography for measuring the actual thermal resistance performances of concrete elements and for assessing the actual thermal performance of the building envelope.

3.3.8. Main Conclusions and Proposals for Further Maintenance and Conservation Studies of Building Materials

The main conclusions and proposals are summarized here in the light of the results obtained from introductory materials analyses with a focus on concrete and red brick in terms of their significance and deterioration problems that they inherited during the lifetime of the building.

Introductory materials analyses revealed that the original concrete has good mechanical strength, relatively high effective porosity with the abundance of individual large-sized circular pores, a large portion of aggregates in coarse and fine grain sizes and quite a low portion of cement binder including well-formed cement hydration products. Relatively high effective porosity and abundance of large-sized circular pores in the concrete matrix signal the use an air-entraining additive in concrete mix. Based on the analyzed physical, physicomechanical and microstructural features of concrete, the lower thermal transmittance performance is expected from the original exposed concrete of the Faculty of Architecture building in comparison to the today's high-strength concrete. Those particular features and the quite good state of most exterior concrete walls confirm that the original concretes were produced with good quality and durability.

Introductory materials analyses revealed that the red brick has high effective porosity, considerable surface strength and firing temperature around 800-900ºC. Those properties show that it is a factory (machine-moulded) brick manufactured without extrusion. The good preservation state of 60-year-old brick without severe decay confirms that the red bricks are of good quality and durability.

Material loss in concrete observed in the building at some localities is not yet seen as a threat or danger of structural failures. However it has to be taken into account as one of the problems to be tackled during the maintenance and conservation studies. Dampness is the major weathering agent that causes deterioration triggering the soluble salt problem and biological growth. Rising damp is not the risk observed at the immediate periphery of the building. However, rainwater penetration through the roof surfaces is the main source of dampness problems in the building and is visible on concrete and brick surfaces, especially at the upper parts of the structure.

The proposals are based on the results obtained from the visual analyses of decay forms and introductory laboratory analyses on building materials. The proposals involve further studies that are essential to be done for the maintenance and conservation that the building needs. Those further studies are expected to provide definitions for those conservation works. The development of remedial treatments and conservation procedures for the topics defined below, has to be done in a research laboratory devoted to conservation of historical structures where the researchers have sufficient background on materials conservation science. The materials conservation issues of the Faculty of Architecture building, as a cultural heritage building, have to be dealt in this context. The topics related to the remedial treatments and conservation procedures are summarized as follows:

Elimination of dampness problem: Materials suffer from dampness problems, particularly due to the roof drainage faults. Roof drainage faults at upper parts of the building need to be eliminated. That can be achieved by providing proper and fast removal of rainwater from flat roof surfaces and by ensuring water tightness through roof surfaces and discharge components. The problem areas suffering from water seepages through roof level should be identified by means of further IR thermography studies conducted on interior roof surfaces and then repaired with the appropriate water proof materials. A checklist showing the problem localities will be useful for monitoring the damp areas.

Repairs for material loss, detachments and fine cracks (fissures) on concrete surfaces: There is necessity for local concrete repair works with the use of compatible repair mortars, gap filling mortars, grouting injection and surface consolidation treatments, to protect deteriorated concrete surfaces and exposed reinforcement bars from further corrosion.

The studies for the control of material loss involve a number of laboratory and *in-situ* analyses. Firstly, the original concrete needs to be analyzed in detail to identify specifications for production of compatible and qualified repair mortars. Following this, further laboratory analyses should be done to describe the composition and performance properties of compatible repair mortars for covering the material loss areas in concrete. The performances of the repair mortars should be checked before their application.

Detaching areas and fine fissures on concrete surfaces need some conservation treatments to stop their progress towards material loss. Therefore, detaching parts need to be stuck to the main body by gap filling, fine injection grouting and surface consolidation treatments with nano dispersive solutions. Comprehensive materials analyses are needed for the definition of conservation treatments, testing their effectiveness and monitoring their performances.

Before starting the concrete repairs at material loss and detachment areas, where the reinforcement bars are corroded and exposed to atmospheric conditions, development of some remedial treatments, such as cleaning and strengthening methods for the corroded reinforcement bars, may be necessary.

Development and application of repair treatments are expected to stop the further decay by hindering the water penetration to damage areas and securing the reinforcement against corrosion. The use of hydrophobic coatings/treatments on concrete surfaces is not recommended due to long-term side effects of coatings on exposed concrete. The experience of hydrophobic coatings in the field of cultural heritage conservation formed a resistance to their use. In almost all cases, those coatings lost their effectiveness in quite a short period of time and ended up with dark-colored (black) staining due to microbiological growth accelerated with a micro greenhouse effect of the hydrophobic agent. Therefore, the use of hydrophobic coatings has to be regarded with hesitation and it is necessary to follow up of the advances in this field of research.

Removal of salt deposits from exposed concrete and brick surfaces and their sublayers: The methods for the cleaning of salt deposits from concrete and brick surfaces and for their extraction from sublayers of those materials need to be studied in detail in order to define practical procedures.

Control of biological growth: Biological growth is concentrated on damp areas. Once the dampness is eliminated with the correction of roof drainage faults, wet surfaces will dry out and biological growth will also dry out and be self-eliminated. In some localities, such as in moss growth areas it may be necessary to remove them with fine mechanical tools.

Removal of dirt, graffiti and grey plastic paint layers from concrete and stone surfaces: Stains, graffiti and paint coats, each need separate techniques for their removal from the surfaces without damage to the original concrete and stone surfaces. Cleaning of the Faculty of Architecture building will need a lot of time and trained operators. Cleaning procedures have to be developed in the light of comprehensive analyses that give a lot of concern to the efficiency of the method(s) as well as to the safety of conservation practitioners (operators) and everybody using the building. It has to be noted that in spite of its efficiency at cleaning some surface dirt, the use of steam cleaning can be a danger for the reinforcement bars beneath concrete cover causing their corrosion in time since the hot water vapour is able to penetrate into the deeper parts of the original concrete with relatively high porosity.

Figure 1: Main entrance during summer time.

3.4. Environmental Performance Documentation and Assessment

Figure 2: Passive shading elements on the west façade.

3.4.1. The Motivation for the Environmental Assessment of Cultural Heritage Buildings and the METU Case

The European Council in 2008 identified energy performance as an essential part of its strategy on climate change and energy security, and stressed the need to achieve reduced energy consumption by 2020.[1] Similarly, the EPBD mandates energy-saving measures in the EU, calling performance issues of both new and existing buildings into focus. As every member state is expected to introduce national laws to meet the EPBD requirements, many initiatives that internalize and implement this legislation as a part of organizational work processes are being introduced.

The building industry has hitherto focused on new building construction, aiming to replace the aging energy-poor building stock with a new generation of buildings. However, the rate of new building construction, especially in the developed countries, is too low to reduce building energy consumption significantly in the near future. Annual building construction in Europe accounts for less than 2%of the existing building stock[2] while construction and demolition combined generate 32% of total waste activities in the European Economic Area (EEA) countries.[3] As opposed to the production of new buildings, stock-oriented efforts to maintain building performance recognize the significance of adaptation, maintenance, and retrofit.[4] Extending the building service life and sustaining the existing stock through renovation and maintenance is a viable alternative to new construction, which has a huge ecological burden embedded in it.[5,6,7]

The situation with Modern heritage buildings is quite similar. Mid-century modern buildings, due to their sheer size of their stock and their current state of maturation, have a great potential in reducing the environmental impact.[8] The Modern era, where energy was fossil-based, inexpensive, accessible, produced buildings that relied on much energy to construct

[1] Commission of the European Communities (CEC), “First Assessment of National Energy Efficiency Action Plans,” *Directive 2006/32/EC on Energy, End-Use Efficiency and Energy Services* (Brussels: 2008).

[2] United Nations Economic Commission for Europe (UNECE), “*Bulletin of Housing and Building Statistics for Europe and North America,”* (Geneva: 2002).

[3] Pawel Kazmierczyk, Almut Reichel, Ioannis Bakas, Stéphane Isoard, Peter Kristensen, Beate Werner, André Jol, Blaz Kurnik, Lars Fogh Mortensen, Teresa Ribeiro, Martin Adams, Anke Lükewille, Trine Christiansen, Andrus Meiner; Arwyn Jones, John van Aardenne, Ricardo Fernandez, Rania Spyropoulou, Robert, *The European Environment - State and Outlook 2010* (Copenhagen: European Environment Agency, 2010).

[4] Niklaus Kohler and Uta Hassler. “The Building Stock as a Research Object,” *Building Research and Information* 30, no. 4 (2002): 226–36.

Figure 3: Industrial design studio’s south façade

and operate. Moreover, building codes (such as the International Building Code (IBC) of the International Code Council (ICC) in the US or the Energy Performance of Buildings Directive (EPBD) of the European Union) that regulate energy use and environmental impact of the built environment were very few, if not non-existent, at the time. This results in higher energy consumption, higher anthropogenic environmental impact and lower occupant comfort. As a result, many Modernist buildings constructed during 1950s-1980s are unsustainable, not energy-efficient and sometimes practically uninhabitable. Moreover, the global energy crisis and the impact of climate change attract further attention to the key role of sustainable conservation approaches.

Climate change is one of the defining problems of the 21st century, as multiple lines of evidence provide basis for its reasons and possible consequences. There is general scientific consensus that global climate change is largely due to increased greenhouse gasses resulting from human activities. The estimated climate change impact on the environment include higher temperatures, flooding, reduced water resources, health hazards and reduced biodiversity. [9] The built environment is a high-priority area for climate change due to the complex and sensitive balance that they maintain with their environment. According to The International Energy Agency (IEA), the greenhouse emissions and the total energy consumption of the built environment constitute 30% of the total global anthropogenic emissions.[10] According to IPCC, the global average temperature is expected to increase 4.1–4.8°C and the change in CO2eq emissions compared to 2010 will reach 74-178% in 2100 if emissions continue to increase with the same rate.[11] To be able to keep global warming below 2°C, CO2 emissions need to be reduced by 77% in the buildings sector by the year 2050.[10] On the other hand, climate change has a huge environmental impact on buildings; it shifts energy use from heating towards cooling, causes HVAC system inefficiency and malfunction due to changing thermal operational conditions, and leads to increased precipitation, flooding and wind.[12] Furthermore, extreme heat waves becoming longer, stronger and more frequent are expected to have a negative influence on human lives. Climate-induced environmental change may threaten human activities, both indoors and outdoors, and pose serious problems regarding occupant discomfort, health, productivity and even displacement. Due to the impact of the built environment on climate change, buildings and the ways in which they will respond to climate change is a crucial problem.

[5] Bart Poel, Gerelle Van Cruchten, Constantinos Balaras, "Energy Performance Assessment of Existing Dwellings," *Energy and Buildings* 39, no. 4 (2007): 393-403.

[6] Andre Thomsen, and Kees van der, Flier. "Understanding Obsolescence: A Conceptual Model for Buildings," *Building Research & Information* 39, no. 4 (2011): 352–62.

[7] Andre Thomsen, Frank Schultmann and Niklaus Kohler. "Deconstruction, Demolition and Destruction," *Building Research & Information* 39, no. 4 (2011): 327–32.

[8] Mark Brandt Thompson, "Buildings and Stories: Mindset. Climate Change and Mid-Century Modern," J*ournal of Architectural Conservation* 23, no. 1–2 (2017): 36–46.

[9] Robert Wilby, "A Review of Climate Change Impacts on the Built Environment," *Built Environment* 33, no. 1 (2007): 31–45.

[10] International Energy Agency, *Transition to Sustainable Buildings: Strategies and Opportunities to 2050*, (Paris: 2013).

[11] Intergovernmental Panel on Climate Change, "Summary for Policymakers." *Climate Change 2013 – The Physical Science Basis: Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change,* (Cambridge: Cambridge University Press, 2014): 1–30.

[12] Pieter de Wilde, and David Coley, "The Implications of a Changing Climate for Buildings," *Building and Environment* 55, (2012): 1-7

[13] Mustafa Balat, "Turkey's Energy Demand and Supply," *Energy Sources*, Part B, 4, no. 1 (2009): 111-121.

3.4.1.1. Turkey's Environmental Commitments for Sustainability Development and Climate Change Building Performance Standards in Turkey

Turkey has been implementing new environmental commitments and legislation due to the environmental pressures it faces as a result of its rapid economic growth, industrialization and urbanization. Growth is paralleled by a consistent 6% increase in primary energy demand per annum[13] and a 125% increase in CO2 equivalent emissions from 1990 to 2014. In 2015, Turkey submitted an Intended Nationally Determined Contribution (INDC) to the United Nations Framework Convention on Climate Change (UNFCCC), pledging up to 21% reduction in GHG emissions from the Business as Usual (BAU) level by 2030[14]. Turkey's Tenth Development Plan for 2014-2018[15] and Republic of Turkey Climate Change Strategy for 2010-2023[16] both stipulate improvements in energy efficiency, emission reduction, environmental protection and sustainable growth in the long term. To be able to fulfil these commitments, Turkey needs to focus on energy-efficient buildings, both new and existing- by means of design, technological equipment, building materials and the use of renewable energy sources. Under the pressure of climate change, a key step is the impact assessment of global warming on existing buildings both in terms of energy use, greenhouse gas (GHG) emissions and occupant comfort.

3.4.1.2. Building Performance Standards in Turkey

Turkey receives 73% of its energy from foreign countries[17]. Therefore, there is critical importance on the efficient use of energy in buildings. New buildings in Turkey are subject to comply with building codes and standards in line with the EU. TS 825 (The National Standard of Thermal Insulation Requirements for Buildings) was issued in 1999, and was recently revised in 2003. At the moment, TS 825 is the mandatory building code related to issues regarding energy performance. TS 825 specifies the calculation procedures for heating energy requirements of both existing and new buildings, as well as the building envelope thermal transmissivity values for the four distinct climates of Turkey, calculated according to heating degree days. Similarly, the European legislation on buildings (particularly the Energy Performance of Buildings Directive (EPBD)) has an effect on the Turkish legislation as well. The Building Energy Performance (BEP) Regulation was adopted recently, which mandates the utilization of district heating and/or renewable energy for all buildings (except industrial and temporary buildings) above 2000 m2. Building Energy Performance Certificate (EPC) has taken effect in January 2011 under the "Regulation on Energy Performance in Building.

[14] NFCCC, Republic of Turkey Intended Nationally Determine Contribution, accessed on January 10, 2019.

[15] MOD (Ministry of Development of Turkey), *"Tenth Development Plan 2014-2018,"* (Ankara: 2013).

[16] MEU (Ministry of Environment and Urbanization of Turkey), *"Republic of Turkey Climate Change Strategy 2010-2023,"* (Ankara:2010).

[17] Oğuz Türkyılmaz, "Ocak 2015 itibariyle Türkiye'nin Enerji Görünümü ve Raporu," TMMOB Makina Mühendisleri Odası, *Bülten* 200, (2015):1-20.

3.4.1.3. METU Agenda for Sustainable Campus

Similar to the regulations in Turkey, METU has also prioritized environmental concerns in its agenda. According to the 2018-2022 Strategic Plan:

> "The physical resources of the university should be used effectively and in a manner that does not harm the environment, promotes sustainability and benefits the community. It is expected that examples of rational and sustainable applications of energy consumption will become widespread".

In the same document, one of the primary goals of the plan was stated as:

> "To meet the needs related to spatial use within the framework of sustainable, intelligent, durable, and unobstructed campus approaches by preserving the unique spatial and architectural structure of the campus."

> Objective 17.1: Enhancing the campus built-environment in accordance with the current legislation and by preserving its unique architectural qualities,
>
> Objective 17.2: Improving the on-campus transportation system in an environmentally sensitive, energy efficient, intelligent, unobstructed, accessible, safe manner with a mass transportation system by reducing private vehicle traffic; providing the necessary physical infrastructure to encourage pedestrian and bicycle circulation,
>
> Objective 17.3: Renewing and improving the education, research and technical infrastructures of the campus in an environmentally sensitive, energy efficient, intelligent and economical manner,
>
> Objective 17.4: Adding new structures to the campus in accordance with "METU Ankara Campus-The Guide to Spatial Strategy and Design" document by preserving its unique spatial and architectural structure

In line with the strategic Plan, METU's "Spatial Strategy and Design Guideline" also underlines the key role of natural sustainability as one of the key principles guiding the future design applications under the following terms:

> Definition of nature and construction conditions together with nature,
>
> Developing recommendations to minimize CO2 emissions and conducting repair works by considering the ecosystem inside and outside the campus as a whole,
>
> Developing onto what already exists,
>
> Reforestation of unused land,
>
> Developing of alternative energy production-use techniques.

As a research university, METU also has been investing in initiatives that transform the campus by means of sustainable approaches. An ongoing project titled "Technical Assistance for the Smart Intelligence, Energy, Aquatic (Water), Security, and Transportation Campus (iEAST)" funded by the U.S. Trade and Development Agency (USTDA) has been seeking to develop a strategic plan and feasibility analysis to implement smart and sustainable technologies in the campus. Energy, transportation, water, buildings and information & communication technologies have been placed into the focus in the project. In the buildings, specifically, it is aimed to determine how to evaluate current conditions and develop roadmaps to implement smart-building measures. The initial recommendations include the characterization of the performance of two selected campus buildings of electricity, water and thermal energy consumptions:

- Install whole building interval electric meter to measure the electricity consumption of buildings

- Install whole building water meter to measure the total water consumption of the building

- Install whole building BTU meter to measure the total thermal consumption of the building

- Initial Building Code Recommendations include:

    - 2018 International Building Code (New Constructions)

    - 2018 International Existing Building Code (Renovation of existing buildings)

    - 2018 International Energy Conservation Code® (IECC®) envelop, mechanical, and illumination systems of buildings (Renovation and New Construction)

    - 10th Edition of the Illumination Engineering Society Lighting Handbook (illumination levels for lighting upgrades)

3.4.1.4.Sustainability in the Context of Modern Heritage Buildings

In the context of Modern heritage buildings, there is an urgent need to restore the existing buildings into a high-performance state while preserving their heritage values. Several institutions and resources have already addressed the need for sustainable conservation of Modern heritage buildings. The report[18] of the Canadian National Conservation Standards advocates improving the performance of cultural buildings while maintaining the heritage value through sustainable rehabilitation. Similarly, Association for Preservation Technology International's Technical Committee on Sustainable Preservation developed an online tool[19], aims to support that activities of conservation specialists' with a special focus on sustainability.

A conservation planning process that focuses on environmental performance mandates that conservation interventions take into account sustainability issues and meet environmental targets for the current and future climate. In this direction, building energy-efficiency, environmental impact and occupant comfort (especially for those buildings that are still being actively used) need to be considered through quantitative analysis. The technologies and methods that can address these needs include performance modeling, energy simulation and the quantification of different performance metrics, the development of alternative scenarios that can improve the current conditions and the identified problems. Finally, a critical evaluation on the ways in which interventions can be realized while preserving the cultural and spatial qualities need to be made.

[18] Federal Provincial Territorial Ministers of Culture and Heritage in Canada, "Building Resilience: Practical Guidelines for The Sustainable Rehabilitation of Buildings in Canada," (2016).

[19] OSCAR, "Meet OSCAR – your Guide for Sustainable Preservation," accessed January 22, 2018.

3.4.2. Climatic Analysis of Ankara and Future Climate Projections

Turkey lies in-between the sub-tropical and mild climates. Although it is mainly considered in the Mediterranean climate region, significant differences in climatic conditions are observed. There is a strong north-south temperature gradient together with an elevation gradient towards Central Anatolia. The coastal regions have temperate climate with warm summers and mild-to-cool winters. The Black Sea region belongs to the temperate oceanic climate and has high levels of annual precipitation throughout the year. The western and south costs that border Aegean and Mediterranean Sea belong the west Mediterranean climate with dry and hot summers. The inland regions, in contrast, experience a dry continental climate with hot summers and cold, snowy winters, where both seasonal and diurnal temperature differences are high.

Turkey is located in one of the regions that strongest warming trends are to be observed. In this region, a robust and consistent climate change process is expected, with increasing temperatures and a pronounced decrease in precipitation especially in summer[20]. Moreover, projections point out to an increase in the frequency and magnitude of heat waves[21] and in daily temperature extremes[22]. A decreasing trend is expected for the number of frost days[23], the change in diurnal temperatures and winter precipitation[24]. The scarcity of fresh water and intensifying heat waves, coupled with population growth and economic development, are expected to have consequences for human health, energy use and economic activity[25]. Other negative concerns include poor air quality, occasional droughts, decreasing crop yields and an increased risk of vegetation fires.

[20] Filippo Giorgi and Piero Lionello, "Climate Change Projections for the Mediterranean Region," *Global and Planetary Change* 63, no. 2 (2008): 90-104.

[21] Franz Kuglitsch, Andrea Toreti, Paul Della-Marta, Elena Xoplaki, C. Zerefos, Murat, Türkeş and Jürg Luterbacher, "Heat Wave Changes in the Eastern Mediterranean since 1960," *Geophys. Res. Lett.,* 37 (2010).

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Figure 4: Concrete water spout

Ankara is located in the mid-Anatolian region, and belongs to the Csb category of the Köppen climate system. The region is surrounded by mountains on all sides, which gives rise to warm and dry summers, and long and cold winters. Due to the continental climate, the climate is dry with average rain drop of 400 mm and the diurnal temperature variation is typically very high throughout the year. The current climate characteristics of Ankara based on statistical data and two future climate change scenarios can be found in the table below (figure 5).

Longitude / latitude	Köppen climate type	Climate characteristics
39.93°N, 32.85°E	Csb (Warm-summer Mediterranean)	Warm and dry summers; long and cold winters; diurnal temperature variation.

Figure 5: Ankara's climate characteristics

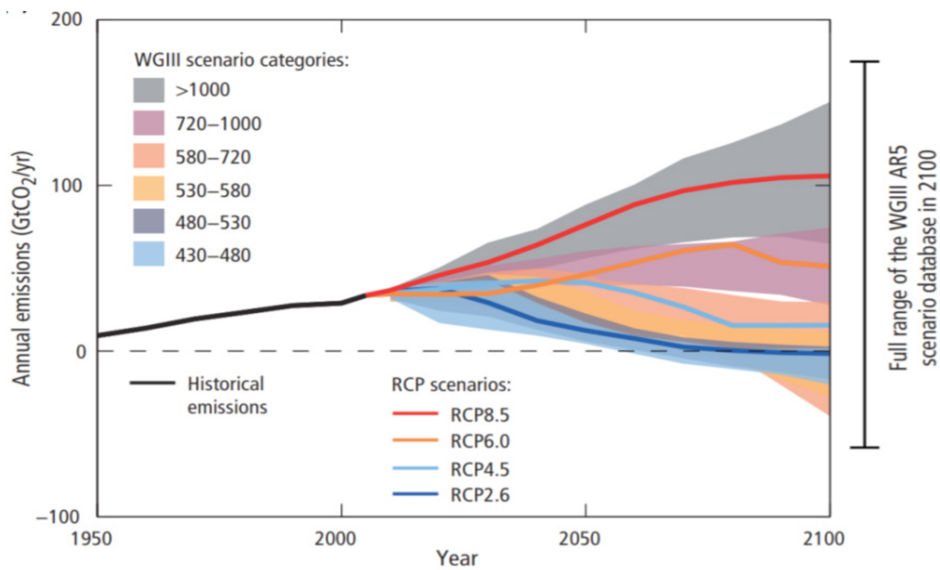


Figure 6: Annual anthropogenic CO2 emissions

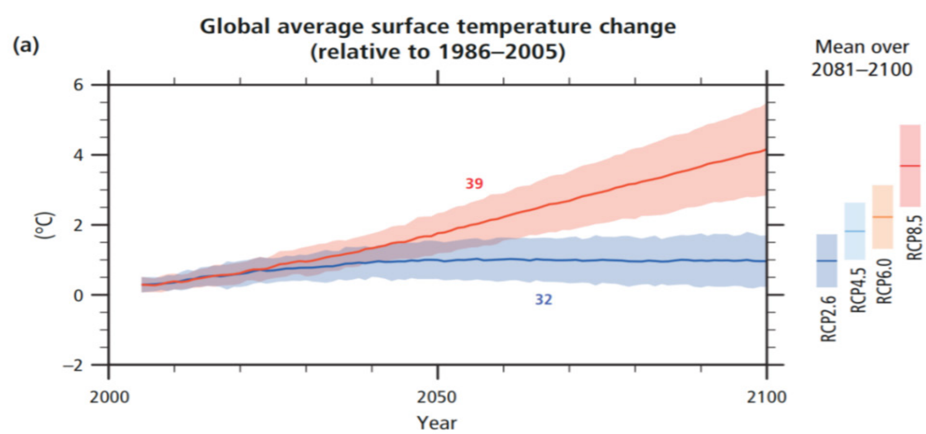


Figure 7: Global average surface temperature change relative to 1986–2005 according the different climate change scenarios

The impact of climate change on existing buildings is expected to be mainly in its thermal performance. The future climate data is calculated with the help of Weathershift™, a weather shifting tool that is based on Belcher's methodology with several modifications[26]. A set of climate projections generated by Coupled Model Intercomparison Project Phase 5 (CMIP5) models are used to calculate the monthly offsets for two Representative Concentration Pathways (RCP), 4.5 and 8.5. RCP 4.5 is a relatively low-emission reference scenario, in which greenhouse gas emissions stabilize by 2050 and the total radiative forcing is stabilized shortly after 2100 (figure 6,7). RPC 8.5 represents unabated emissions and increasing temperatures. While RPC 4.5 is a rather optimistic prediction that assumes an increased use of strategies and technologies for limiting greenhouse emissions, RCP 8.5 is a non-mitigation case that represents the worst case climate change scenario. For each pathway, a number of variables that include mean daily temperature, maximum daily temperature, minimum daily temperature, relative humidity, daily total solar irradiance, wind speed, atmospheric pressure and precipitation are calculated.

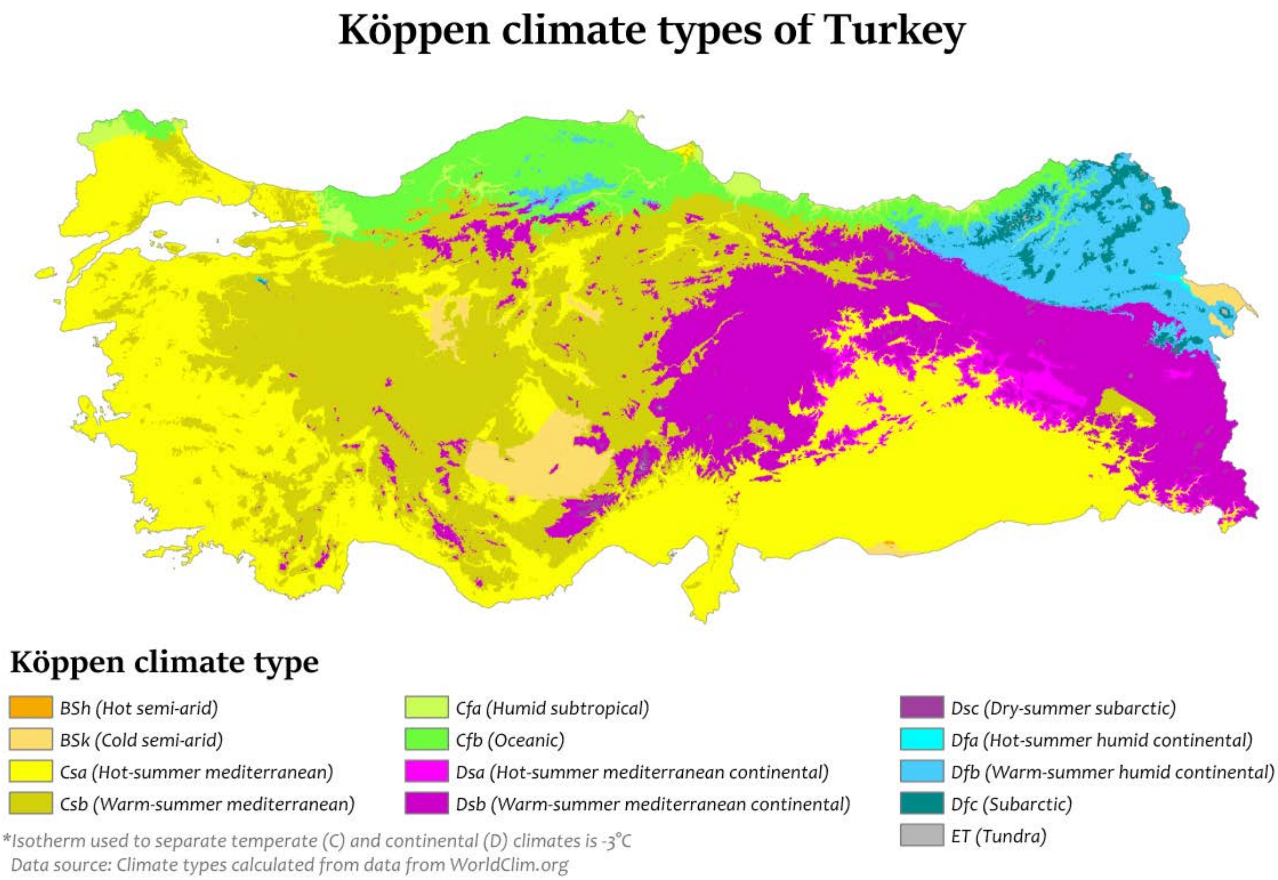


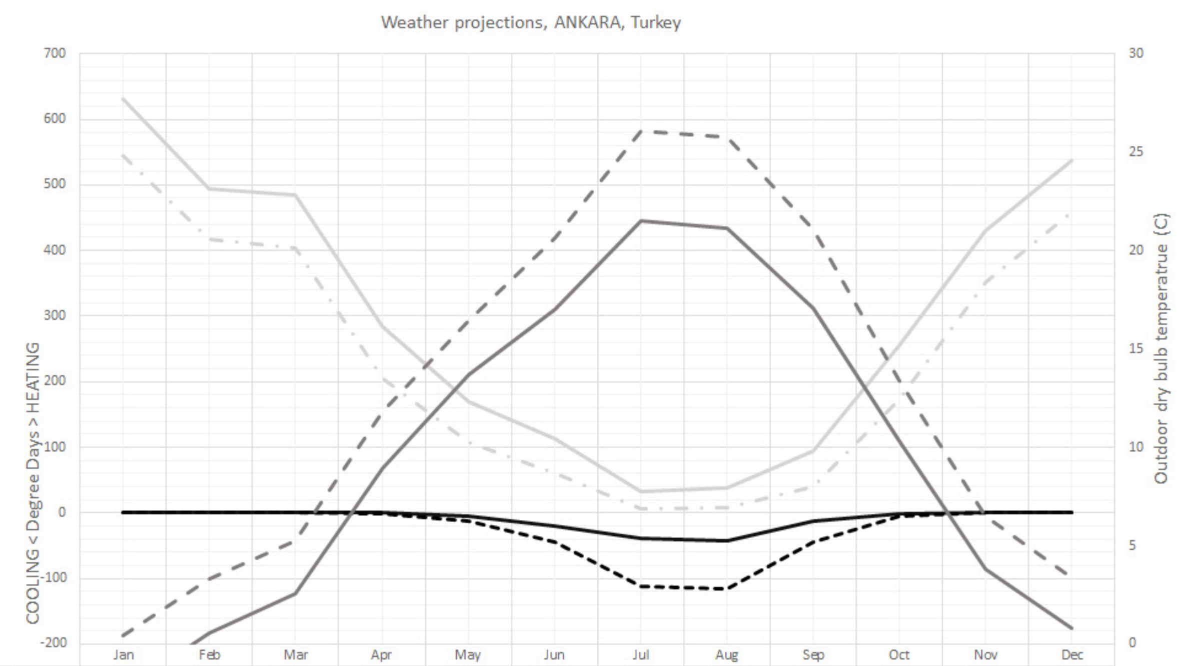
Figure 9: The Köppen climate types of Turkey

Yearly average weather data	Current	2060 RCP 4.5 Scenario	2060 RCP 8.5 Scenario
Global horiz. radiation (Wh/m2)	169.40	177.68	177.28
Direct normal radiation (Wh/m2)	125.55	133.83	133.43
Diffuse radiation (Wh/m2)	88.59	96.86	96.47
Dry bulb Temperature (C)	9.63	11.87	12.89
Wet bulb Temperature (C)	2.24	3.76	4.63
Relative humidity (%)	63.70	62.02	61.77
Diurnal temperature difference (C)	11.88	12.47	12.47
Heating degree days	4372.97	3756.58	3488.43
Cooling degree days	53.7	134.44	184.87

Figure 8: Climate data, Ankara and future climate change scenarios (calculated from the weather files)

The weather data of the current and 2060 weather can be found in Figure 10. In line with the continental climate, Ankara's daily and seasonal temperature difference is high, due to the continental climate. Summers are dry and hot, winter and cold and long. Ankara is to experience 3.2 C temperature increase by the year 2060, according to the severe (RCP 8.5) climate change scenario. This is to reduce the heating demand and increase cooling demand. Given that only a limited number of rooms are mechanically cooled in the building, the remaining rooms are to experience extreme overheating during summer. However, at the same time, the occupancy rate during mid and late summer are very low, which reduces the impact of overheating.

The comparison of the results of the weather data show that:
(a) The solar radiation values (horizontal, direct and diffuse) are to increase slightly in 2060, which will lead to increased indoor temperatures through transparent surfaces and through the building fabric. This is expected to decrease the heating load during the winter, but increase overheating during summer.
(b) Temperature levels, both dry bulb and wet bulb, are expected to increase. The temperature difference between the current weather and the climate change scenarios will be at its highest during summer, which will contribute to overheating problems. The thick concrete building envelope of the building is to delay the heat transfer until mid-summer; therefore, it can be said that overheating and summer discomfort will be experienced later in the summer.
(c) As a result of the increasing temperatures and solar radiation, the heating degree days are to decrease, and cooling degree days are to increase. Due to the fact that the building has very limited use of mechanical cooling in several spaces, the overall energy consumption due to heating and cooling is expected to decrease.
(d) As a result of the increasing temperatures, the relative humidity is expected to decrease slightly. This will have influence on thermal comfort, both indoors and outdoors during the Predicted Mean Vote (PMV) calculation regarding comfort analysis.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
HDD Current_HDD	631.55	494.4	484.65	284.125	170.2	112.375	32.85	38.925	93.675	256.05	430.75	537.3
HDD 2060_HDD	544.617508	416.739654	403.467221	204.283464	107.895583	60.649191	6.184206	8.447019	40.733323	173.977017	351.693668	457.624373
CDD Current_CDD	0	0	0	0	-4.45	-19.475	-39.5	-41.75	-12.1	-1.75	0	0
CDD 2060_CDD	0	0	0	-0.750249	-12.336249	-44.555944	-111.946573	-115.389998	-44.627971	-5.792637	0	0
Temperature Current	-2.391801	0.550595	2.590457	8.925972	13.668952	16.994028	21.52957	21.116398	17.0675	10.302419	3.798611	0.821371
Temperature 2060	0.411646	3.322522	5.252175	11.84029	16.435331	20.654535	26.062933	25.775053	21.062981	13.388626	6.511995	3.399483

Figure 10: The current and future (RCP 8.5) weather of Ankara; dry bulb temperature, heating degree days (HDD) calculated according to 18,3 C and cooling degree days (CDD) calculated according to 23,1 C

Figure 11:   Waffle slabs of the faculty

3.4.3. Current Condition

3.4.3.1. Initial Assessment of the Building

3.4.3.1.1. Building Occupancy

The Faculty of Architecture Building complex is used primarily for educational functions. With its museum and the amphitheatre, it serves for the purposes of a rather mixed use throughout the year. It combines multiple occupancy types including the students, academic and administrative staff, and the visitors. The details of the partial occupancy driven building performance assessments can be found in the following parts of this section. Here it is important to underline the fact that except the summer months, the building is heavily used. The number of visitors is observed to be high, due to the popularity of the building among the students in the campus. The annex units, -museum and the amphitheatre- are regularly visited with students, researchers, and the audience of the activities conducted by the student clubs of the university. Originally designed for around 600 people, as of September 2018, it accommodates 1853 students, 158 academic and 20 administrative staff.

Figure 12: The first year design studio of the Department of Architecture during a class critique

The faculty building is currently facing problems regarding the shortage of classrooms for both education and studying, and overcrowding of the rooms. The number of students occupying a classroom can well exceed 100, sometimes limiting the unit area per person to 0.7 m2/person. Overcrowding has negative effects on occupant comfort, especially in the design studios (figure 12). Studios are usually in use for extended periods of time during studio days, starting from the morning hours until late in the afternoon. It is also typical that students extend their study hours in the studio throughout the night and into the weekends. During summer, the first year summer practice is partially carried out at the faculty building until mid-July. Between mid-July to mid-September, the building is very sparsely occupied.

An existing research project titled SISER, led by Assoc. Prof. Ipek Gürsel Dino, focuses on energy improvement of existing buildings and studies the Faculty of Architecture building as a case study for development and testing. SISER, as mentioned above, aims to develop a novel method for the automated capture of building information by means of computer vision technologies. Specific to building occupancy, the project focuses on the quantification of the number of occupants and their activity profiles in the selected spaces (Thermal zones) in the building by means of video analytics algorithms. To this end, five IP video cameras were installed into the first year design studio of the Department of Architecture. The video recordings of these cameras were used for (1) head counting, (2) person counting, and number of people entering / existing the studio. The initial findings of the research can be found in Figure 13(figure 13), where different algorithms are run to count the number of people present in the studio during the whole day of 11 October 2018. The initial findings highlight the expected occupant presence during the studio hours (10:40 – 16:40) and during the times outside class hours.

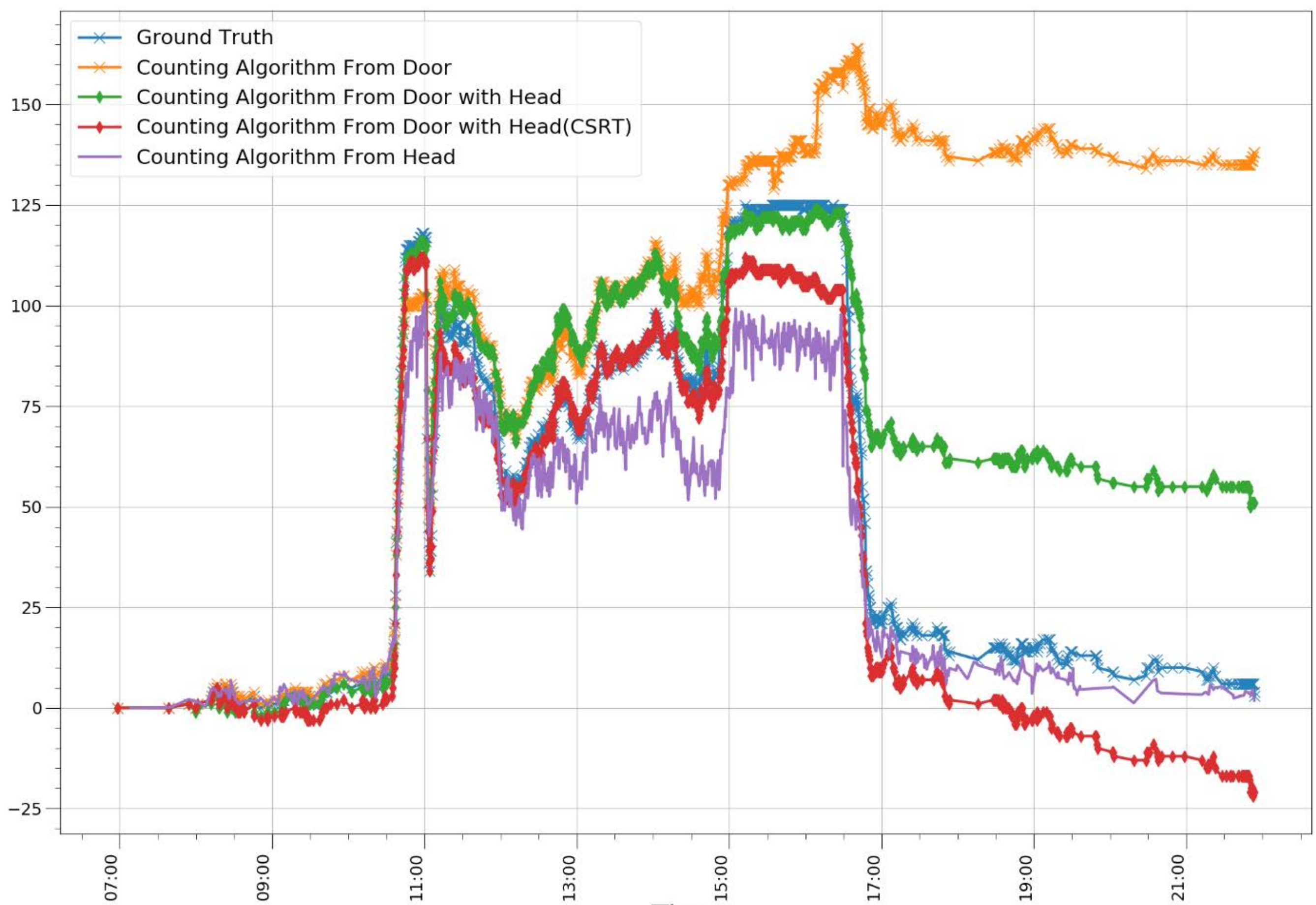


Figure 13: The occupant counts as computed by the SISER algorithm

3.4.3.1.2. Building Form

The building has a very fragmented form that horizontally expands in the north-south direction. A virtual bounding box of the building would have 90.08-meter width in the east west direction, and 141.56-meter length in the north-south direction. The building is 17.91 m in height, from the lowest level to the rooftop. The fragmentation of the overall form results in large external surfaces exposed to the morning and afternoon sun on the east-west facades. Fragmented building forms are typically avoided in climates that require the minimization of heat loss in winter. The increase in external surface contributes to conductive heat loss through the envelope, negatively influencing the heating energy use during winter. On the other hand, the horizontal building form results in a very large contact area with the ground. The ground acts as a stabilizing component in the heat balance between the building and its environment, especially during summer.

The use of glazed surfaces is a defining visual characteristic of the Faculty building. When the total window and wall areas calculated, it is observed that the west and east-facing windows constitute the largest window-wall ratio with 33.74% and 29.41% respectively. The east and especially west-facing windows are expected to experience indoor overheating and visual glare due to the direct exposure to sun. The south façade, which is typically favored for window placement, has a window-wall ratio of 20.06%, while the north facade, wherein the total window area is usually minimized to reduce heat loss, has a window-wall ratio of 11.18%. These results indicate that the building does not follow the main principles regarding building and window orientation of solar building design.

	Total	North (315 to 45 deg)	East (45 to 135 deg)	South (135 to 225 deg)	West (225 to 315 deg)
Gross Wall Area [m2]	1175.21	193.06	326.05	330.05	326.05
Window Opening Area [m2]	293.71	21.58	95.91	66.20	110.02
Gross Window-Wall Ratio [%]	24.99	11.18	29.41	20.06	33.74

Figure 14: Window and wall surface areas

Figure 15: Ivies on the east façade

3.4.3.1.3. Building Envelope

Concrete

The most determinant building material for building energy performance is the exposed concrete that is widely used in the building. Concrete is used without insulation on the outer façade. The high thermal mass, high specific heat capacity, moderate thermal conductivity and high density of the concrete wall material can help to moderate internal temperatures for buildings. This results in heat being transferred between two surfaces of a material at a rate that is in tune with the daily heating and cooling cycle of buildings. Thermal mass can increase the responsiveness of the building envelope to changing outside temperatures in both heating and cooling seasons. Thermal mass has a positive effect on thermal performance during spring and fall, especially when the diurnal temperature change is above and below the balance point of the building. During summer, overheating can be eliminated by avoiding an excessive temperature rise during the day. This increases the importance of night ventilation to remove the built-up heat in the thermal mass during colder night temperatures. However, with a warming climate, summer peak load can be delayed until late summer, but cannot be avoided. Therefore, summer overheating is expected to be a problem that needs to be resolved in the near future. In winter, thermal mass can be used to absorb thermal gains from incoming solar radiation and also internal thermal gains. During the night, the stored heat can be released to keep the spaces warm and to reduce the heating loads.

The diurnal temperature variation during summer of Ankara is suitable for night ventilation. When use effectively, the need for cooling can be eliminated in the building due to its high thermal mass. Other strategies need to be coupled with night cooling for the thermal mass to take effect, such as the elimination of solar gains during the summer by means of shading devices and keeping the windows shut when the outside air temperature is warmer than the inside air temperature. This underlines the importance of the correct operation of the building components both by the daily occupants and the operational team of the building.

The thermal conductivity of the external walls plays an important role in building energy balance. Thermal transmissivity of existing walls is usually difficult to predict. A previous study on the thermal transmittance assessment of the walls in the faculty building was carried out by Assoc. Prof. Ayşe Tavukçuoğlu. In this study, quantitative analyses of temperature data obtained by passive infrared thermography was performed, and as-it thermal transmittance values of concrete walls (Uwall) in a studio of the faculty building was calculated.[26] According to this study, the theoretical transmittance value is calculated as 3.70 W/m2K, as opposed to the in-situ measurements, which estimates this value as 2.07 W/m2K (figure 19). A possible explanation is given as the high porosity of the aggregate in the concrete mixture. The in-situ measurements that estimate the lowest U value are still considerably higher than that specified for Ankara in TS 825, which is 0.50 W/m2K (The thermal transmissivity values according to the Turkish standard "TS 825 Thermal Insulation Requirements in Buildings" are given in figure 16). This means that the external walls fail to comply with the determined performance benchmark in the Turkish standards.

[26] Murat Sayın and Ayşe Tavukçuoğlu, "Quantitative Assessment of Thermal Transmittance in Buildings Walls by *in-situ* Infrared Thermography," in *Interdisciplinary Perspectives for Future Building Envelopes - ICBEST 2017 International Conference on Building Envelope Systems and Technologies*, (Istanbul: 2017):202-215.

Region	**City**	**Recommended U_{max} (W/m^2K)**			
		External wall	***Roof***	***Ground floor***	***Glazing***
1	Izmir	0,70	0,45	0,70	2,4
2	Istanbul	0,60	0,40	0,60	2,4
3	Ankara	0,50	0,30	0,45	2,4
4	Erzurum	0,40	0,25	0,40	2,4

Figure 16: Climate data, Ankara and future climate change scenarios (calculated from the weather files)

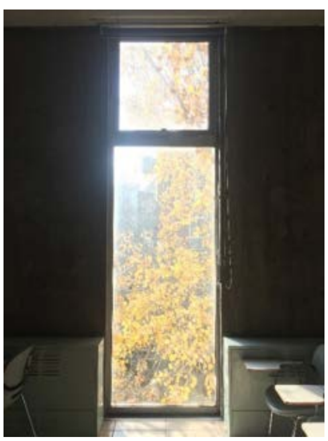


Figure 17: Typical window openings in office spaces and classrooms / studios in the target area.

Glazed areas are critical in building thermal performance in that their orientation, surface area, construction and operation have a great influence on energy use and occupant comfort. During the winter, the transparent envelope surfaces constitute almost half of the heat losses, depending on their total area. Heat transmittance through windows is therefore important for climates such as Ankara, wherein extremely low temperatures (up to -20C) are expected during winter nights. In summer, in contrast, high solar radiation that enters the building through these transparent surfaces result in overheating problems, leading to high cooling loads and/or reduced occupant comport in naturally ventilated buildings. Window orientation is a critical issue, in that windows that are directly exposed to the sun require solar control techniques such as low-e glazing or shading devices. An assessment on the distribution of the windows on different envelope directions points out that window placement is indifferent to orientation (see above). This is in contrast with typical environmental building envelope design, wherein south window orientation is favored, while east and especially west window orientation is regarded as problematic due to their direct horizontal solar exposure.

On the building, the envelope construction is a single layer of concrete, which is regarded as the topmost architectural and material quality of the building. Therefore, windows present an important opportunity to improve thermal performance. The building windows have been replaced with double glazing and aluminum frames by the beginning of 2000s. The performance values of the window material can be found in Figure 18(figure 18). In the standard "TS 825 Thermal Insulation Requirements in Buildings", the highest U value for glazing is specified as 2.40 W/m2K. Similar to the concrete walls, the windows also fail to meet with the thermal transmissivity values in the standards, however with a negligible difference. The other glazing characteristics, however, can play an important role in building performance. The solar heat gains coefficient (SHGC) value indicates the ratio of transmitted solar radiation to incident solar radiation on the window, and determines the solar gain. High solar gain can reduce heating loads in summer, but also can lead to indoor overheating in summer when not effectively controlled. Weather statistics show that the number of cloudy days is very limited in Ankara, and high degrees of solar radiation is emblematic in the region. Lower SHGC values can help maintain comfortable indoor temperatures in warm months in Ankara. However, with a smaller portion of solar radiation admitted indoors, lower SHGC values are expected have a negative effect on the building heating energy use. The weather statistics estimate an average of 150 w/m2 solar irradiance for the winter season in Ankara, which positively contributes to passive building heating. Therefore, a careful balance needs to be considered for SHGC values. Similarly, the visible transmittance (VT) value of the glazing determines the visible light admitted to the indoor environment. This value is determinant in the daylighting performance of the building, and can influence the lighting energy use.

U-value (W/m^{2}K**)**	**SHGC**	**VT**	**Glazing Model**
2.6	0.75	0.89	ISICAM-C-L

Figure 18: The technical properties of the window glazing used in the building

In the material assessment procedures in this research (WP3), the aluminum window frames were identified as thermal bridges with accelerated heat loss through the envelope as a result of thermographic imaging. Moreover, detailing at the edges between concrete walls and windows frames are problematic in heat loss. Watertight and thermally-resistant sealants are recommended as in minimizing heat loss and thermal bridges. Moreover, the aluminum frames that replaced the original window frames are also identified as incompatible with the architecture of the building.

Operable windows are important for buildings without air conditioning, as they constitute the most important opportunity for cooling. In the Faculty building, the majority of the windows are outward-opening and opened from the bottom with the hinges at the top. These windows have a very limited opening angle, which seriously limits natural ventilation.

Roof and ground

In low-rise buildings such as the Faculty building, the roof constitutes a large proportion of the building’s outside surface that is exposed to external conditions such as sun, wind and water. Originally the building roof layers were concrete slab (8 cm), leveling concrete (5 cm), waterproofing membrane, stone chipping with bitumen and large stone chipping (figure 20). An additional layer of thermal insulation (XPS - CO2 blowing) and a new waterproofing membrane were applied at the beginning of 2000s. Effective thermal insulation in roofs therefore contribute to the thermal performance of the building in minimizing unwanted heat losses and gains during the year. An assessment of the condition of the roof is provided in the previous section. The most critical problem is roof drainage, which is advised to be eliminated by providing means of removal of rainwater from the flat roof, and improving water tightness in the roof and discharge components. The ground has remained in its original form (figure 20). It consists of levels of concrete (12 cm), cement mortar (2 cm) and natural stone (6 cm).

Envelope summary

The envelope materials used for simulation and the TS 825 standard that specifies the maximum thermal transmittance values of envelope materials are summarized in the table below.(figure 19) The results show that the recently renovated materials, such as the glazing and roof, are to a certain degree comparable with the current standards. However, both the reinforced concrete walls and the ground floor, which have remained in their original condition since the building construction, fail to meet the standard. A summary of the thermal transmittance values can be found in Figure 19(figure 19).

	External wall	**Roof**	**Ground floor**	**Glazing**
TS 825 (for Ankara)	0,50	0,30	0,45	2,4
METU Faculty of Architecture	3,55 (used for simulations); 2.07 (in-situ measurements)	0,578	2,708	2,6

Figure 19: The thermal transmittance values of the external concrete wall material

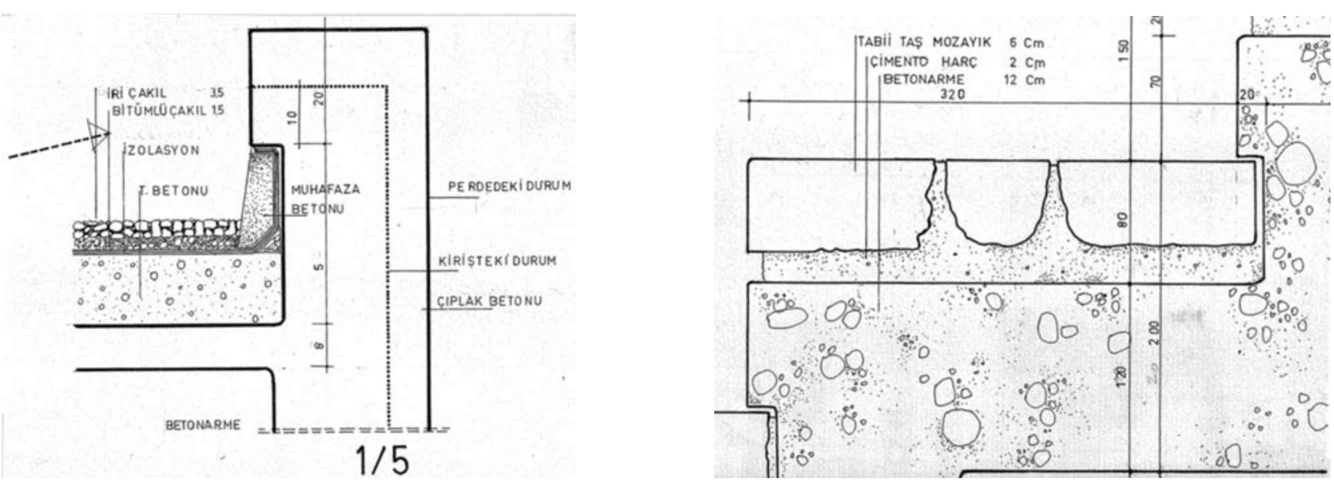


Figure 20: (1)The original as-built drawings. Additional XPS thermal insulation has been applied in the 2000s, (2) The original as-built drawings. The flooring remained unchanged to this date.

3.4.3.1.4. Solar Control

Figure 22: Brise-soleil shading elements on the west-facing classrooms

For buildings that have large glazed surfaces and low glazing performance, solar control is a critical factor that can maintain building thermal performance. The Faculty building provides solar control on some of the spaces of the building. The balconies of the classrooms on the west façade have shading devices (*brise-soleil*) made of hollow concrete blocks. The horizontal shape of these elements seem to be a result of a motivation for maintaining a similar grid-based visual language with the building layout. However, the horizontal solar direction on the west façade makes it difficult for the brise soleil to block most of the afternoon sun. This results in both glare problems due to the exposure to afternoon sunlight throughout the whole year, and indoor overheating during the summer.

Other types of solar control include concrete eaves acting as overhang shading on the administrative offices on the east façade. However, similar to the western *brise-soleil* façade, horizontal solar exposure cannot be blocked by means of horizontally placed overhang shading. Alternative solutions to solar control include curtains and louvers in the rooms that are individually operated by the occupants. These rooms include staff offices and studios. Staff offices, due to their individual occupancy, are more effectively controlled for solar shading. The studios, on the other hand, require that the occupants actively need to participate in the operation of both the curtains and windows. Vertical concrete shading elements are used in various area, such as the lounge room on the north façade or near *Han Kapısı* on a glazed surface that is already shaded by the building itself. Therefore, it can be concluded that the use of these vertical shading elements seems to be a stylistic choice rather than functional necessity.

Figure 21: Brise-soleil shading elements on the west-facing classrooms

3.4.3.1.5. Trees

Figure 23: The landscape elements in the campus (from tag.arch.metu.edu.tr)

The building is surrounded by deciduous trees on all sides. These trees provide solar shading from mid-spring until late fall to the spaces located on the ground floor on the building. This allows for the low winter sun penetrate into the building through the windows, providing solar exposure when needed. A recent study conducted at METU Department of Architecture by Dr. Funda Baş Bütüner and Dr. Pelin Yoncacı Arslan provide useful information on the landscape elements surrounding the buildings. The project, METUTAG, was developed within the scope of the Scientific Research Project titled “An Interactive Plate System for Allied Wood and Sculptures” was completed in December 2016 the project aimed to identify the works of art, monuments and landscaping at the Middle East Technical University Ankara Campus. Detailed information on the trees in the campus can be found at tag.arch.metu.edu.tr.

Figure 24: Ivies on the curtain wall of the industrial design studios

3.4.3.1.6. Heating System

The heating system is central to the whole campus, and it runs on natural gas. The annual fuel consumption is approximately 11.000.000 m3/yr. Buildings in the campus are not individually monitored for their energy consumption. Only the temperature of the steam entering the building is known, which is insufficient to make an estimation on the building energy performance. The campus buildings, including the Faculty building, are heated from late fall to late spring using a central heating system. To heat the building, fan coil units are used for larger spaces with high ceilings such as classrooms, studios and common hallways. These fan coils were refurbished ten years ago (exact date unknown), and generally are in good condition. In other spaces such as staff offices, radiators are used instead of fan coil units. Only a few administrative offices at the Dean’s Office are mechanically cooled during summer with air conditioning units. These units are individually controlled by the users. Although much heat loss takes place in the central heating center of the campus, it is not expected a refurbishment will take place in the near future.

3.4.3.1.7. Natural Ventilation

Figure 25: The identified natural ventilation areas

The building is naturally ventilated through its windows and doors. Ventilation is carried out to provide fresh air to the indoor environment (throughout the year) and to cool the building (during summer). Windows are typically opened by the building occupants as needed, and –if left open- are closed by the cleaning staff before 17:00. Natural ventilation cannot be effectively operationalized due to the limited window opening area that allows fresh outside air indoors.

As mentioned above, the building is experiencing indoor overheating and stuffiness due to the overcrowding of education spaces, such as classrooms and studios. Moreover, the need for cooling the building thermal mass during the night in summer by natural ventilation is critical to remove the heat that has been absorbed during the day. Natural ventilation is therefore important to ensure adequate air flow and to effectively cool the thermal mass in summer. Moreover, naturally ventilated buildings have shown to increased occupant comfort due to the increased thermal tolerance that the occupants have. Considering that the building's architectural, visual and aesthetical significance requires that minimal intervention should be

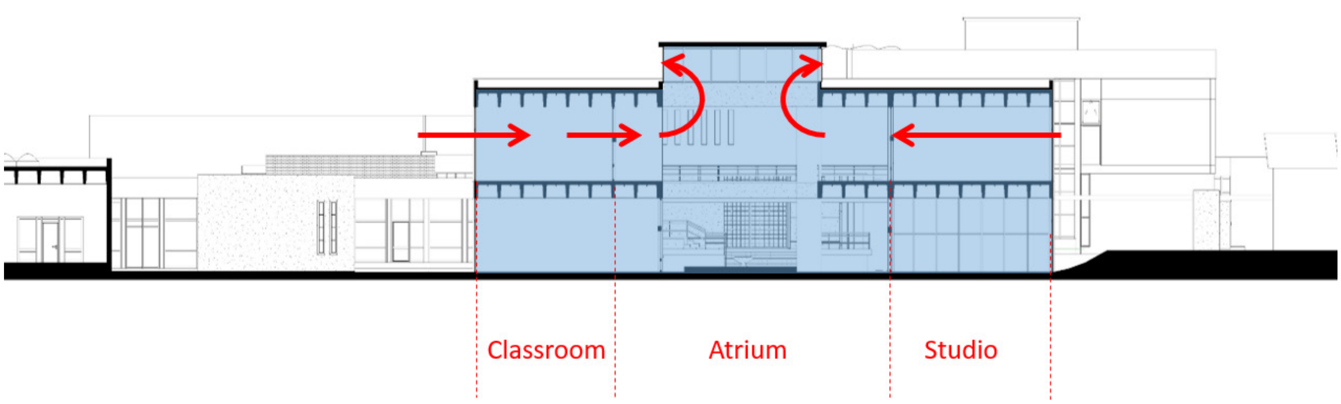


Figure 26: Section BB; Natural ventilation air flow.

made on the building, mechanical ventilation is not an acceptable solution for space ventilation. Therefore, it is necessary to improve the effectiveness of the existing building systems to increase natural ventilation throughout the year.

Figure 27: Photo showing Section BB.

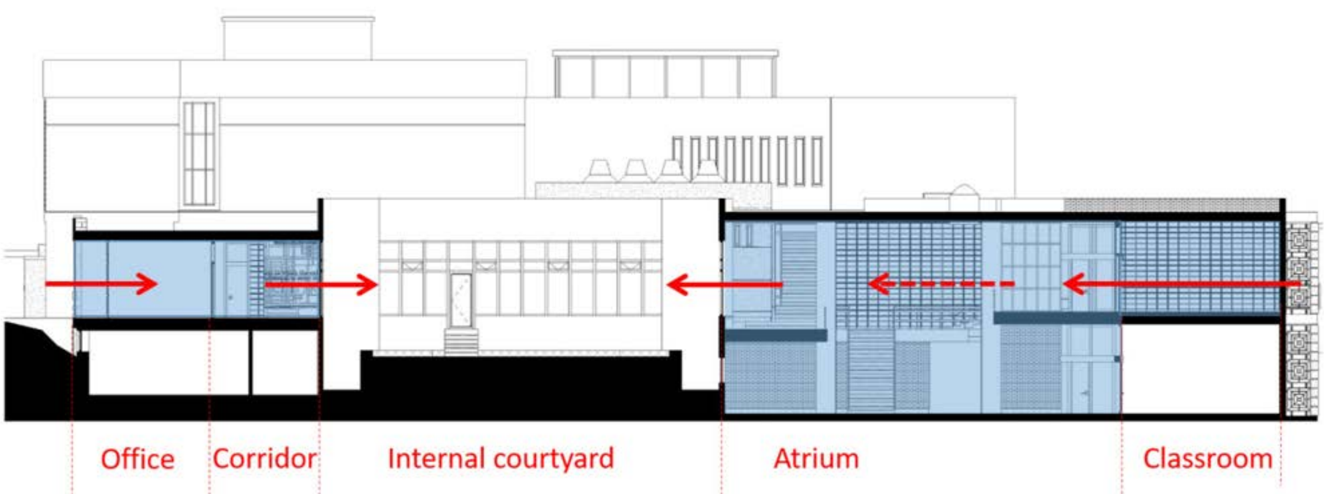
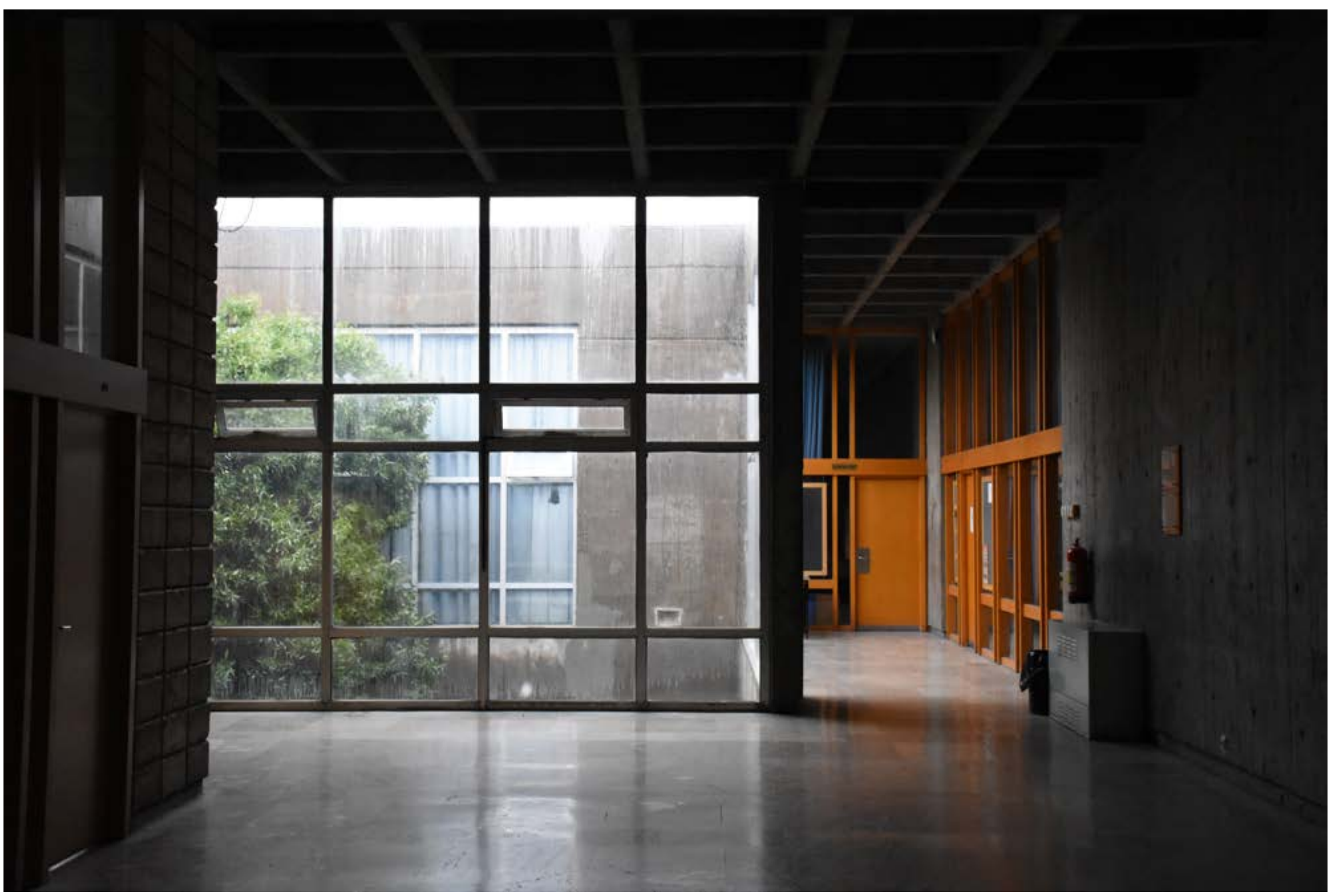


Figure 28: Section EE; Natural ventilation air flow.

Figure 25 shows the identified natural ventilation air flow schemes in several section drawings in the building. The skylight in the Göbektaşı area in Section BB (figure 26, 27) has much potential in forcing air out the atrium using chimney effect. In this case, air can be introduced indoors by means of the peripherial windows and can exit through the skylight. The skylight openings, in this case, need to remain open thruoghout the summer to allow a continous vacuum effect. The two internal courtyards, as seen in sections BB, DD and CC, are effective means to provide daylight and fresh air into spaces with large horizontal depth. It is important that occupants and building operators act upon indoor air problems such as overheating or stuffiness timely by opening windows when required.

Cross ventilation, in all cases, remains the most effective strategy. Cross ventilation requires an inlet (a window, door or skylight) that allows the outside wind force fresh cool air into the indoor spaces, and an outlet (again a window, door or skylight) that exhausts the indoor air towards the outside. As such, air flows from the high pressure windward side towards the low pressure leeward side. However, cross ventilation is less reliable for cooling during the hot, still days. Moreover, for cross ventilation, it is suggested that the room depth should not exceed 4-5 times the room height. Therefore it is more preferred for narrow buildings. While the majority of the building somehow satisfies these conditions and benefit from cross ventilation to a certain extent, section AA is an extreme case where the space depth is too high in comparison with the space height and the ventilation opening size. What adds to these negative conditions is that: (a) these rooms are heavily occupied during studio hours (resulting in increased internal loads), (b) they are exposed to the west direction and (c) the skylights in the studios do not provide any shelter from the sun. As a result, the three studios suffer the worst overheating problems in the building.

Figure 29: Atrium view from the design studios' corridor



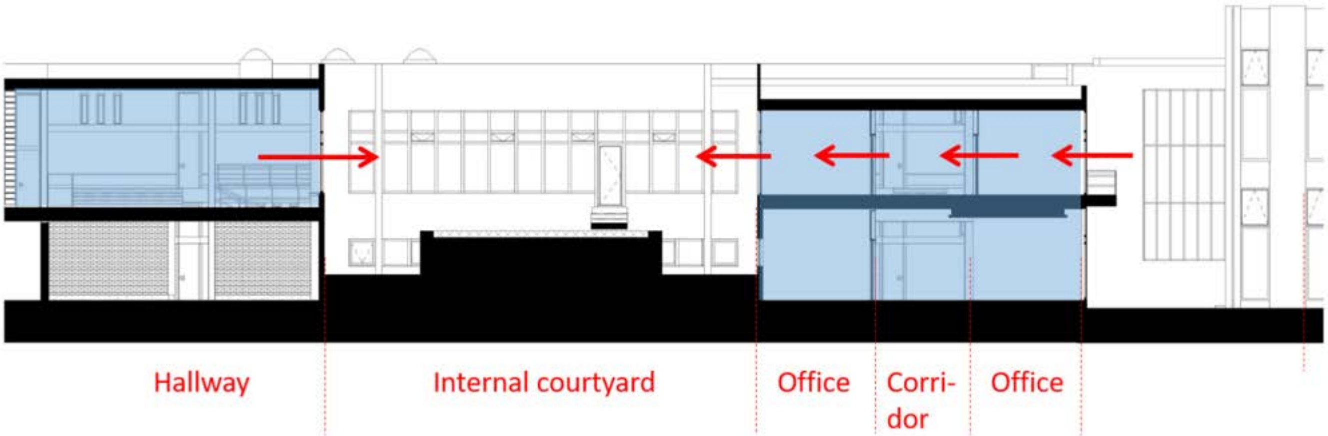


Figure 30: Section CC; Natural ventilation air flow

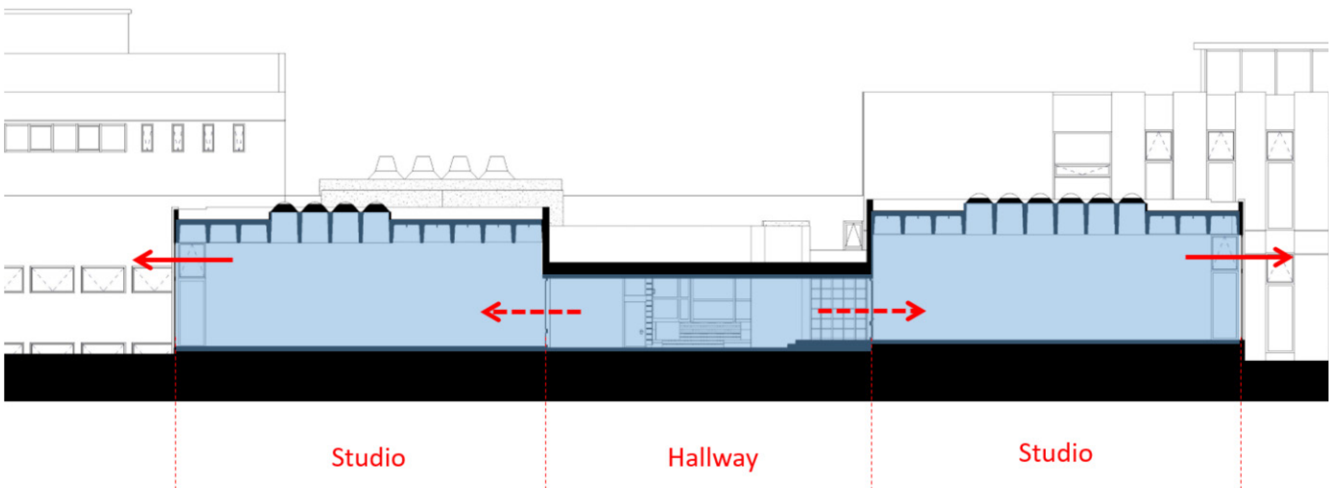


Figure 31: Section AA; Natural ventilation air flow

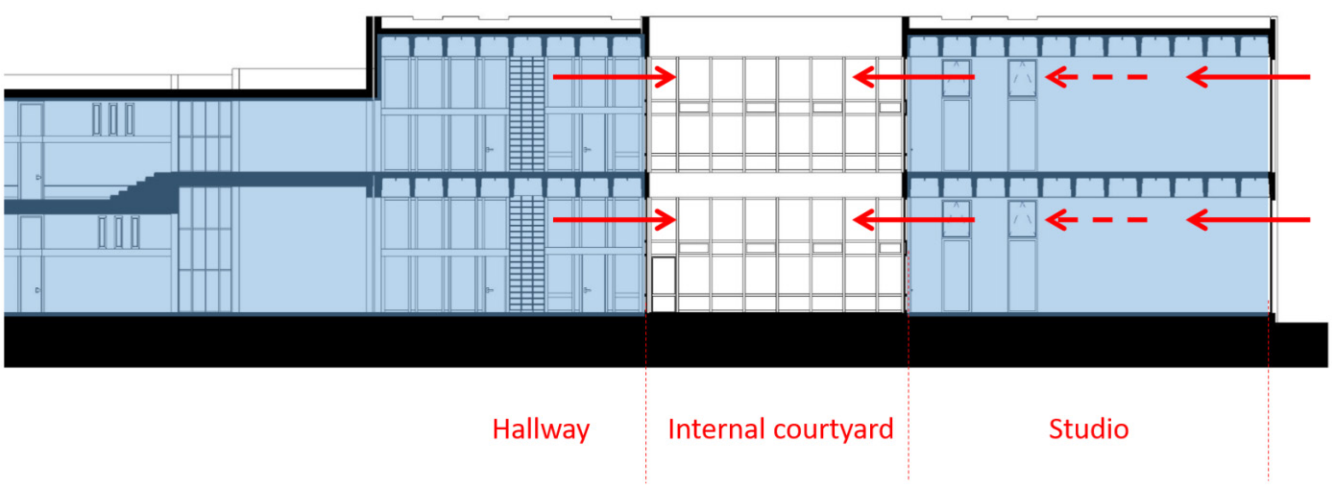


Figure 32: Section DD; Natural ventilation air flow

3.4.3.2. Field Measurements

The indoor air quality of a room (90-A) in the selected focus area was measured by means of a Climate Measurement Tool (Testo 480) that measures air temperature, relative humidity and air flow (figure 33). The measurements were taken during the hottest months in Ankara for 7 weeks, from 26 July 2018 to 13 September 2018. The room was largely unoccupied and locked during the measurements, which restricts the occupant operation of windows for natural ventilation and curtains for solar shading. The room is facing the west direction, and during the measurement duration that curtains were partially closed and windows were closed.

Figure 34(figure 34) shows the correlation between measured outside dry bulb temperature (To) and the measured indoor dry bulb temperature (Ti). The average values for Ti and To are measured are 27.96 C° and 23.95 C°. This indicates that the building envelope cannot delay or prevent the increased outdoor temperatures having an effect on the indoor temperatures. This is due to the room's direct exposure to the warm afternoon sun and the lack of air flow that can pull the warm air outside the room. Moreover, it is evident that the thermal mass works in disadvantage for the indoor temperatures, where heat build-up in the concrete mass results in excessive overheating.

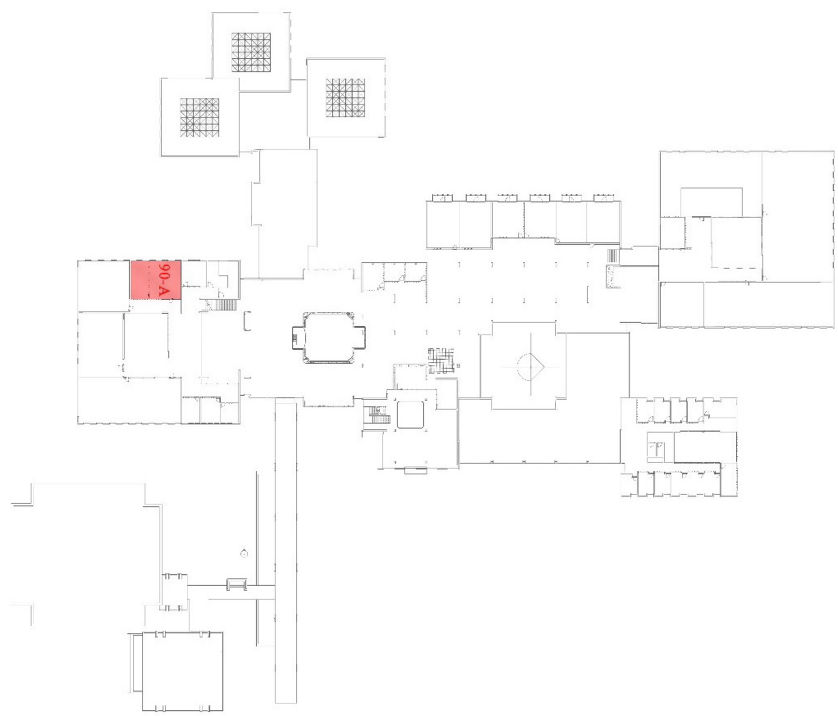


Figure 33: The room selected for field measurements

A study on the adaptive comfort in the same room was carried out using the measurement data. The adaptive comfort calculations are well-established in building codes such as the USA standard ANSI/ASHRAE Standard 55: Thermal Environmental Conditions for Human Occupancy and the European Standard EN 15251: Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics. The adaptive approach aims to capture the occupants' thermal sensation in situations that they can actively restore their comfort by adapting to their environment. Adaptation can take place through behavioral (changing clothing and air speed), physiological (acclimatization) or psychological (shifting expectations) processes.[27]

[27] Richard Dear, Donna Cooper and Gail Brager, "Developing an Adaptive Model of Thermal Comfort and Preference," *ASHRAE Transactions,* vol.104, (1998):145–167.

[28] Simone Ferrari and Valentina Zanotto, "Adaptive Comfort: Analysis and Application of the Main Indices," *Building and Environment,* vol. 49 (2012):25–32.

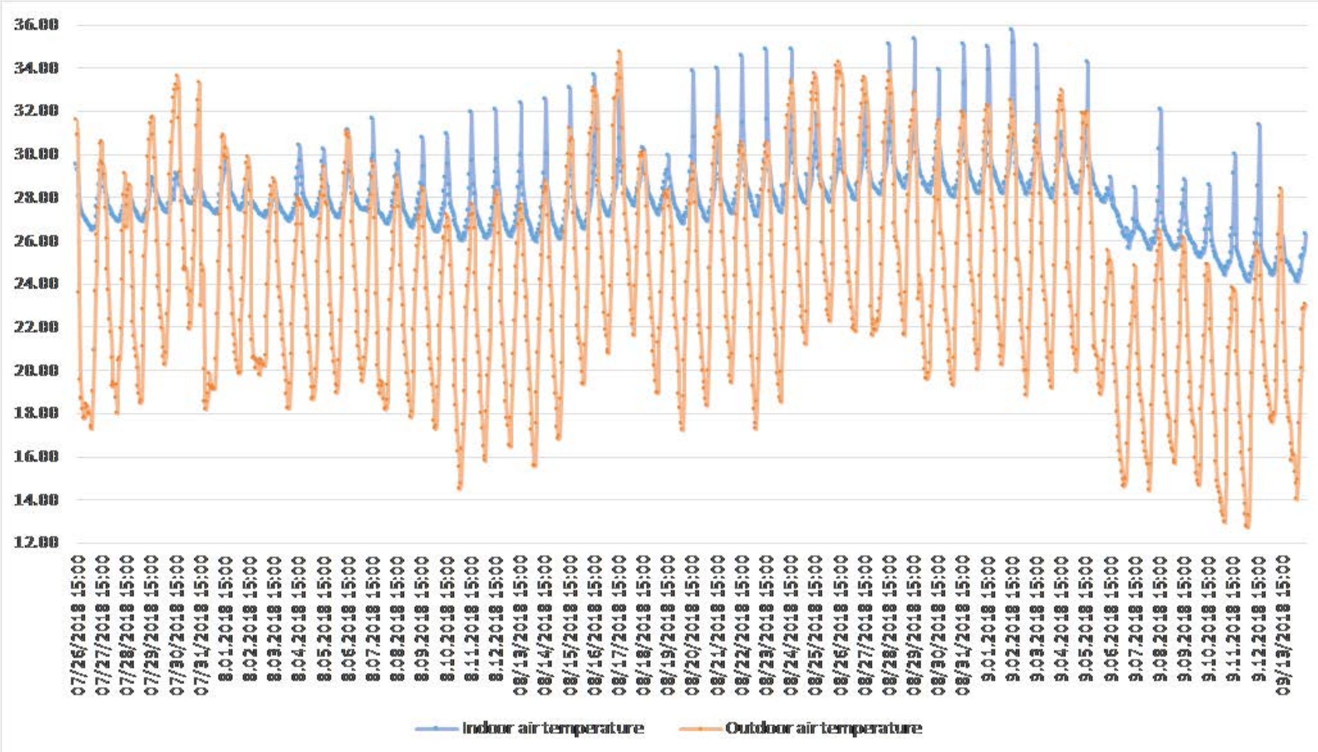


Figure 34: The results of the Climate Measurement Tool (Testo 480) installed in the Room 90-A.

Adaptive comfort calculations are based on[28]:

(a) a linear function that relates a neutral temperature of comfort (Tn) to long-term outdoor temperatures (Te,ref)

(b) variables a and b that show the “adaptiveness” of the function,

(c) the outdoor reference temperature, Te,ref, which represents long-term outdoor temperatures,

(d) an acceptability range, delimited by the upper and lower comfort temperatures that are predicated by the percentage of dissatisfied people (PPD).

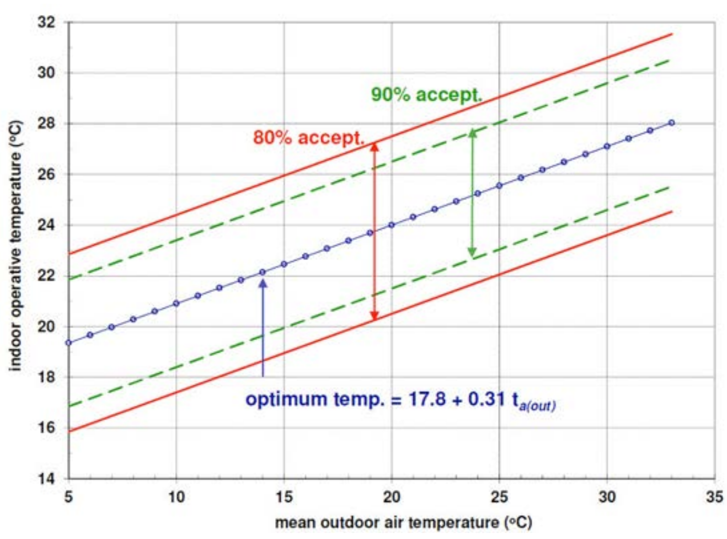


Figure 35: The ASHRAE 55 adaptive comfort standard in naturally ventilated spaces (ASHRAE (2010))

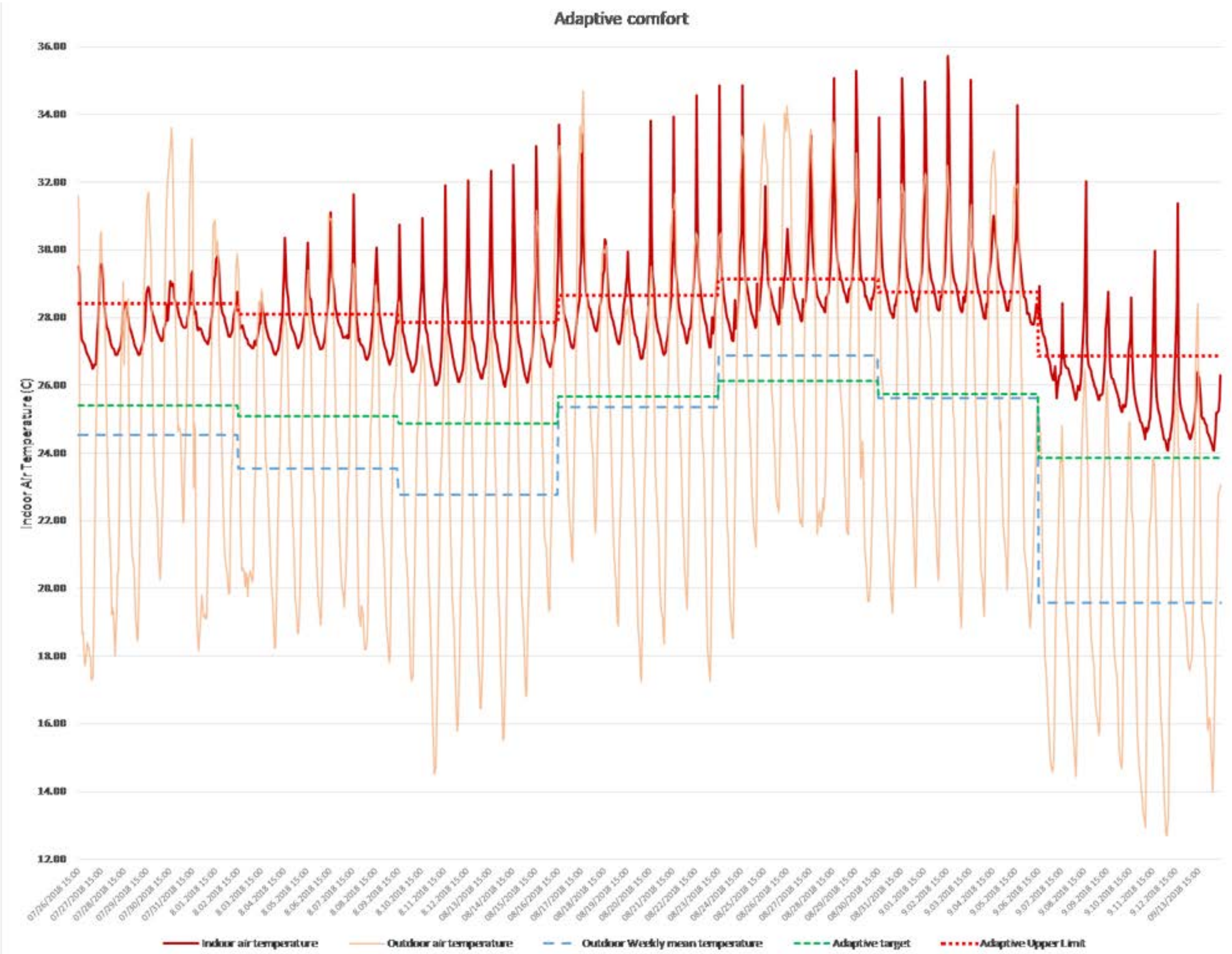


Figure 36: The results of the Climate Measurement Tool (Testo 480) installed in the Room 90-A.

ASHRAE 55 Tn is calculated following the ASHRAE 55 standard as follows:

$$T_n = 0.31T_{e,ref} + 17.8°\mathrm{C}$$

Te,ref is calculated by averaging the outdoor air temperatures of the last three days prior to the calculated time, as follows:

$$T_{e,ref} = \frac{T_{today} + 0.8T_{today-1} + 0.4T_{today-2} + 0.2T_{today-3}}{2.4}$$

The upper adaptive temperature limit of a room Z is calculated as follows:

$$ATL_Z = T_n + \omega\alpha$$

Where the acceptability range values are considered as $\omega = 7°\mathrm{C}$ for 20% Predicted Percentage of Dissatisfied (PPD)[29]; and $\alpha = 0.7$ as suggested by Peeters et al.[30] The lower limit is not calculated for this study, as only the upper limit value is indicative of indoor overheating problems.

[29] Nigel Oseland, "Predicted and Reported Thermal Sensation in Climate Chambers, Offices and Homes," *Energy and Buildings*, vol. 23 (1995):105–115.

[30] Leen Peeters, Richard Dear, Jan Hensen, and William D'haeseleer, "Thermal comfort in Residential Buildings: Comfort Values and Scales for Building Energy Simulation," *Applied Energy,* vol. 86 (2009):772–780.

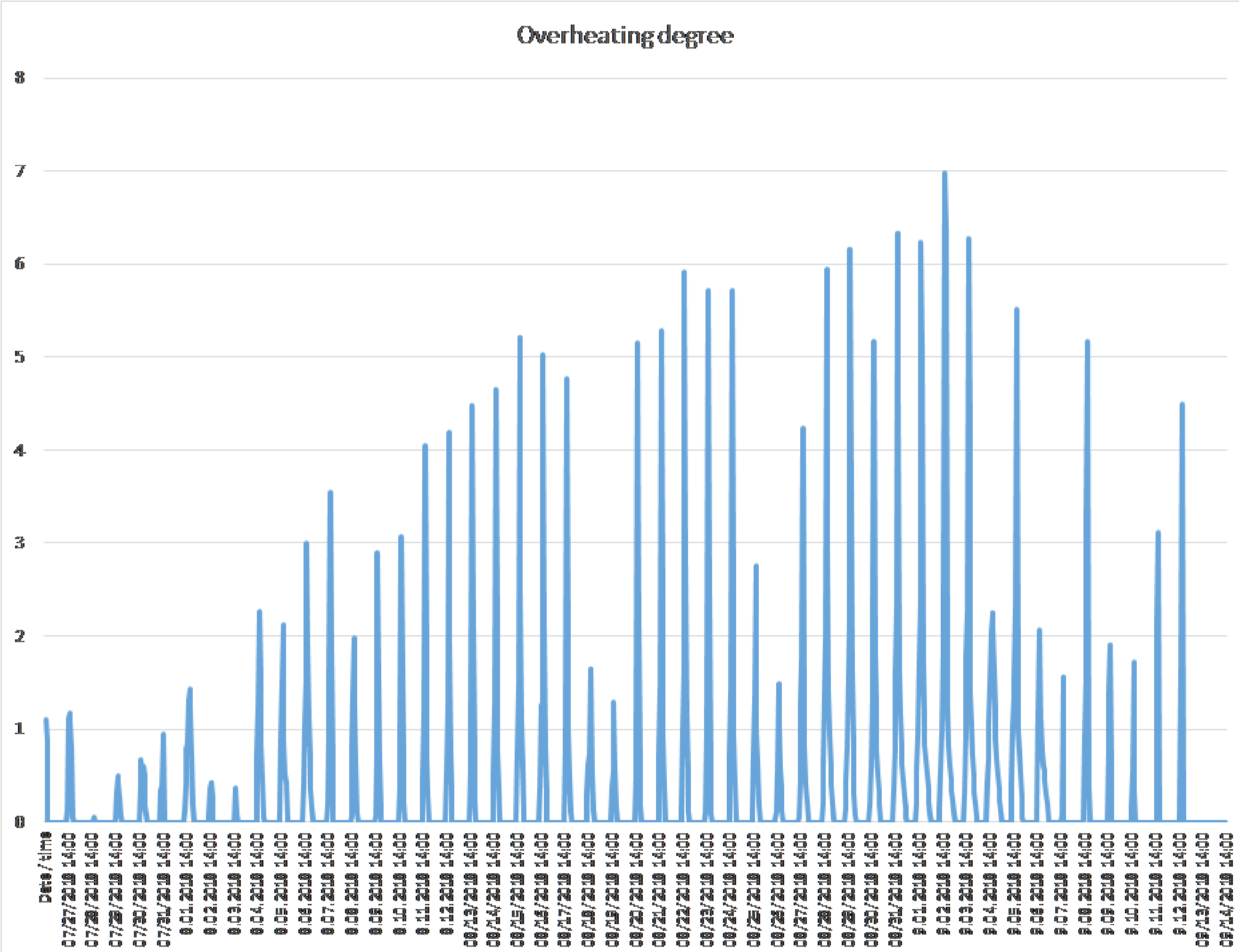


Figure 37: The results of the Climate Measurement Tool (Testo 480) installed in the Room 90-A.

Following, the indoor overheating degree (IOD) of a given room Z is calculated as follows:

$$IOD = \frac{\sum_{i=1}^{N_{occ(z)}} [max\{OT_{i,z} - ATL_{i,z}, 0\} \times t_{i,z}]}{\sum_{i=1}^{N_{occ(z)}} t_{i,z}}$$

Where z: zone, i: occupied hour, Nocc(z): total occupied hours of z in a given calculation period, t: time step (1 hour), OTi,z: operative temperature at the time step i in the zone z.

In Figure 34, the indoor air temperature (Ti), outside dry bulb temperature (To), the outdoor reference temperature (Te,ref), the adaptive neutral temperature (Tn) and the adaptive upper limit (ATL) values are shown for the measured weeks for 90-A. The results show that maximum indoor air temperature exceeds adaptive temperature limits except for three days (28 July, 12 September and 13 September). This exceedance takes place starting as early as 12:00 and lasting as long as until 22:00 in exceptionally warm days. Moreover, at its extreme, overheating degree can reach 6.99 degrees (2 September 2018, 16:00).

Figure 38: Illumination analyses performed during night.

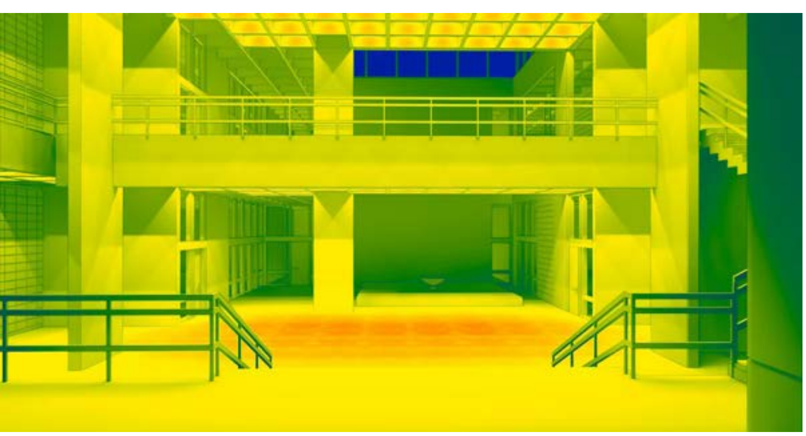
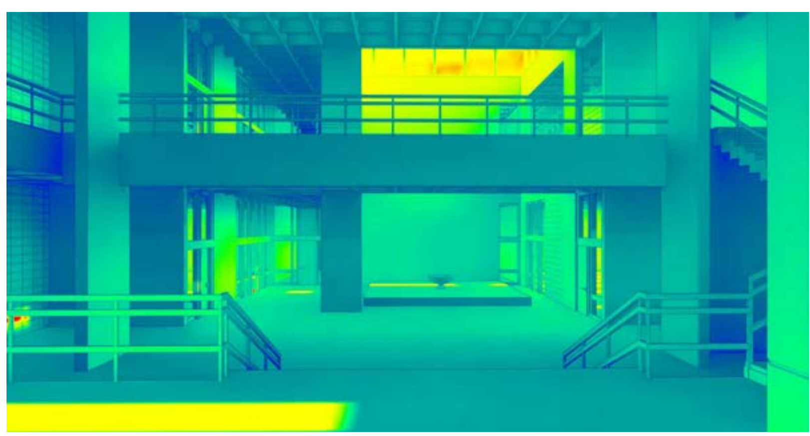


Figure 39: Illuminance analysis of the *Göbektaşı* area during day time.



3.4.4. Simulation Based Analyses

To provide deeper insight into the thermal behavior of the Faculty building, simulation-based analyses were made using DesignBuilder interface, and the integrated simulation engines including an energy simulation engine, Energyplus and daylighting simulation engine, Radiance. EnergyPlus™ is a building energy simulation program that engineers, architects, and researchers use to model and predict energy consumption—for heating, cooling, ventilation, lighting and plug and process loads—and water use in buildings. Energyplus can calculate hourly and sub-hourly results for a wide range of performance measures and parameters such as energy use, heat balance, greenhouse gas emissions, and illuminance and glare analysis. Energyplus can also model various complex building components with conventional and advanced technologies. DesignBuilder is an EnergyPlus based software tool used to support modeling with easier-to-use user interfaces and a 3D modeling interface.

The main purpose of the simulation-based analyses is to quantify some performance metrics such as energy use, CO2 emissions and occupant comfort. The first step in energy model development is to export the previously built Heritage Building Information Model (only the selected target area) to DesignBuilder as a raw geometry. This allowed the building geometry to be drawn in the neutral file format of DesignBuilder. In Designbuilder, a number of objects need to be defined necessary to be able simulate energy performance:

(a) Rooms. Each room in the HBIM model was converted into a separate thermal zone. The internal loads for each zone type was determined by a process of field observations that took place during October 2017 – October 2018 by the project team.

Level	Room Name	Area (m2)	Zone Type
Ground Floor	Gallery Ground Floor	335.69	Circulation Area
	Room 23	12.13	Academic Office
	Room 24	15.78	Academic Office
	Room 25	15.67	Academic Office
	Room 26	160.65	Design Studio
	Room 28	98.42	Classroom
	Room 29	182.23	Design Studio
	Room 31	21.11	Academic Office
	Staff WC - Women	12.43	Restroom
	Student WC - Women	21.02	Restroom
First Floor	Gallery First Floor	170	Circulation Area
	Room 85	12.13	Academic Office
	Room 86	15.78	Academic Office
	Room 87	15.67	Academic Office
	Room 89	98.42	Classroom
	Room 89 B	160.65	Design Studio
	Room 90	21.11	Academic Office
	Room 90 A	65	Classroom
	Room 90 B	90.96	Classroom
	Staff WC - Men	12.43	Restroom
	Student WC - Men	21.02	Restroom

Figure 40: Room numbers and zone types of the selected area

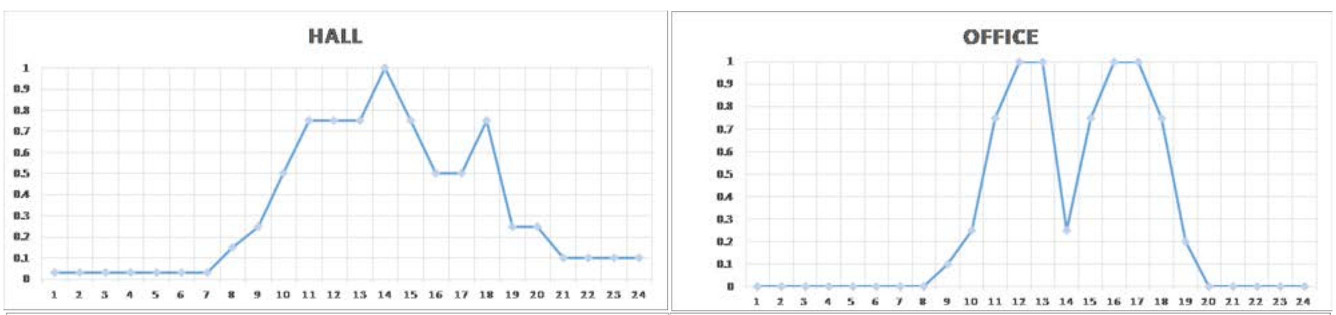
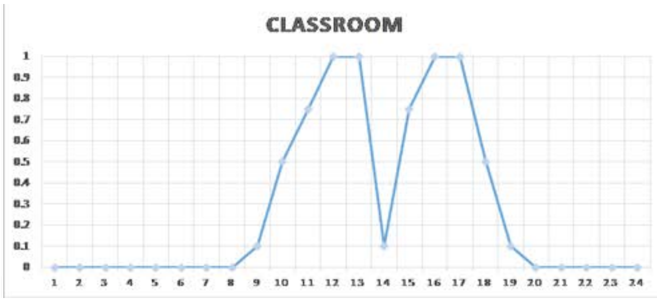


Figure 41: Occupancy density fraction values used for occupancy schedules for weekdays during the education period

(b) Internal loads: For each thermal zone, internal loads were defined for People, Equipment and Lighting. The number of people in each thermal zone (room), and other information related to the activity level schedules, clothing level schedules and work efficiency levels are determined by hourly observations throughout the day and week. The same observations were made for lighting and equipment so to be able to make precise calculations for internal loads and the eventual heat balance in the building. The occupancy patterns of the faculty building were observed during the project period, and the maximum number of people (PMAX) as well as their annual fraction gradients (fT) were identified. Accordingly, the number of occupants for a given time T (PT) is calculated as PT = PMAX fT. The heating/cooling setback temperatures are activated when a room is unoccupied. Occupant clothing is set to 0,5 in the period 1 April – 30 September, and set to 1,0 otherwise. The activity level for the whole rooms is set to seating / studying.



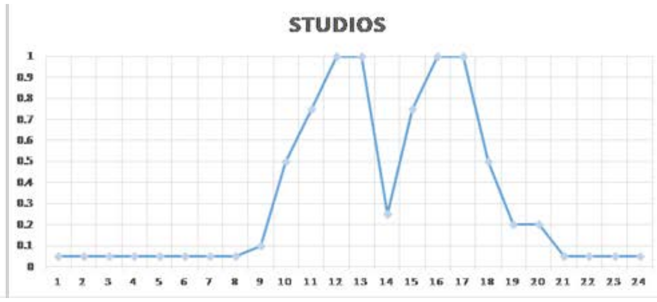


Figure 42: Occupancy density fraction values used for occupancy schedules for weekdays during the education period

(c) Materials: The building makes use of a limited material palette that includes xposed concrete, red brick and glass on the façade and concrete sun breakers (brise soleil) on the west façade. All the listed façade materials contribute to the thermal balance of the building, whereas the sun breakers act as solar control devices that restrain the solar illuminance and radiation on the façade and the spaces.

The following materials were considered in the simulations:

Walls

The two types of walls identified in the building are concrete walls and Block Partition Walls. The exposed concrete is identified as one of the significant architectural characteristics. The following tables show their thermal characteristics used in the simulations:

-Concrete Walls (Interior and Exterior)

	Material	Thick-ness (mm)	Condu-ctivity (W/m-K)	Specific heat (J/kg-K)	Density (kg/m3)	Embodied carbon (kgCO2/kg)	Embodied carbon eq. (kgCO2e/kg)
1	Concrete, cast-dense, reinfor-ced	250	1,90	840,00	2300,00	0,31	0,33

-Concrete Block Partition Walls

	Material	Thickness (mm)	Conductivity (W/m-K)	Specific heat (J/kg-K)	Density (kg/m3)	Embodied carbon (kgCO2/kg)	Embodied carbon eq. (kgCO2e/kg)
1	Plaster, lightweight	13	0,16	1000,00	600,00	0,12	0,13
2	Concrete Block, Medium	200	0,51	1000,00	1400,00	0,08	0,08

Roof

	Material	Thickness (mm)	Conductivity (W/m-K)	Specific heat (J/kg-K)	Density (kg/m3)	Embodied carbon (kgCO2/kg)	Embodied carbon eq. (kgCO2e/kg)
1	Concrete, Reinforced	130	2,5	1000	2400	0,31	0,33
2	Waterproofing membrane	-	-	-	-	-	-
3	XPS - CO2 blowing	50	0,0340	1400	35	2,88	9,58
4	Roofing felt	4	0,19	840	960	0,96	0,96
5	Stone chipping	10	0,96	1000	1800	0,02	0,02

Floor

	Material	Thickness (mm)	Conductivity (W/m-K)	Specific heat (J/kg-K)	Density (kg/m3)	Embodied carbon (kgCO2/kg)	Embodied carbon eq. (kgCO2e/kg)
1	Marble, White	60	2,77	802,00	2600,00	0,11	0,12
2	Cement mortar	20	0.71	920	1648		
3	Cast Concrete, Dense	120	1,4	840,00	2100,00	0,08	0,08

Windows

The windows, as mentioned above, has been replaced in the beginning of 2000s. Both the single-glazing and the original frames were replaced. Windows are modeled with a frame that is 0.04 m width, 9,5 w/m2K conductance, with a 0.02-meter divider with the same thermal conductance value. The current glazing properties are as follows.

	Material	u-value (W/m^{2}K)	SHGC	VT
1	Double-glazed window	2.6	0.75	0.8

(d) Thermostat setpoint and setback temperatures: As described above, the building is centrally heated by radiators and fan coil units, and some administrative spaces are cooled during summer. Although heating or cooling is not activated by thermostat, a set point of 22 C° and a setback temperature of 18 C° is assumed for office spaces, classrooms, and studios. Setback temperatures are valid when the zone is unoccupied. The heating set points of service spaces are set to 19 C° for service spaces. Heating is inactive in the period of 15 April – 15 November.

(e) Shading: The selected target area does not contain shading elements as part of the building. However, there are deciduous trees on all three sides of the building, as well as another building towards the west of the building. These are modeled as external shading in the energy model. Additionally, the trees were associated with a light transmittance schedule that determines the amount of light passing through the tree annually as a result of dropping leaves. This transmittance value varies from 0 to 1, where 0 indicates full transmittance and 1 indicates complete solar obstruction.

(f) Natural ventilation: As described previously, the building does not consist of mechanical cooling or ventilation. Therefore, it complete relies on natural ventilation to both provide fresh air into the rooms as well as for cooling during summer. The selected building part of the faculty building has repetitive vertical big rectangular windows for classrooms and studios, square windows for offices and toilets and both square and stained thin rectangular clerestory windows for the main gallery hall. Among all the windows located in the selected portion of the faculty, only several windows are operable with limited aperture area. The limitation in openable area of the window and aperture size creates an obstacle in order to let the fresh air penetrate to the building. Appropriate aperture sizes and openable window areas are quite crucial for natural ventilation of the buildings.

[31] Mat Santamouris et al.,"Using Intelligent Clustering Techniques to Classify the Energy Performance of School Buildings," *Energy and Buildings,* vol. 39 (2007): 45-51

[32] Niki Gaitani, Christoph Lehmann, Mat Santamouris, Giouli Mihalakakou, and Panagiotis Patargias, "Using Principal Component and Cluster Analysis in the Heating Evaluation of the School Building Sector," *Applied Energy,* vol. 87 (2010):2079–2086.

[33] Elena Dascalaki and Vasileios Sermpetzoglou, "Energy Performance and Indoor Environmental Quality in Hellenic Schools," *Energy and Buildings, vol.* 43 (2011): 718-727.

Exterior Windows Operability	Exterior Windows Free Aperture	Interior Windows Operability	Interior Windows Free Aperture	Cross Ventilation Possibility
Yes	% 15	No	% 0	No

In order to conduct energy simulations, baseline case for natural ventilation is generated with the data gathered from existing condition of the opening areas. Designbuilder's calculated ventilation method which is based on window openings, opening directions, cracks, buoyancy, wind driven pressure differences and etc., is applied and used for more precise natural ventilation modelling. According to as built conditions, the overall free aperture of windows is determined as %15 for the openable windows. Even though all of the rooms, except toilets, have connections to the gallery hall with curtain walls, there were not any operable windows on curtain walls at the building. The lack of operable interior windows reduces the possibility of cross ventilation throughout the selected area.

Exterior Windows Operability	Exterior Windows Free Aperture	Interior Windows Operability	Interior Windows Free Aperture	Cross Ventilation Possibility
Yes	% 15	No	% 0	No

Baseline Simulation Results

The energy model detailed above was simulated with DesignBuilder for a whole year. The annual energy use intensity (kWh/m2), or in other words energy use Per Conditioned Building Area, and the energy use categories can be found below. The monthly thermal loads can also found in the following figures.

Total Energy use Per Conditioned Building Area [kWh/m2]:	114.53
Heating Intensity [kWh/m2]:	60.97
Lighting Electricity Intensity [kWh/m2]:	33.50
Equipment Electricity Intensity [kWh/m2]:	20.06

The Faculty building's heating energy use simulation results are benchmarked with educational buildings in a similar climate, Greece, by several recent studies by Santamouris et al.(2007)[31], Gaitani et al. (2010)[32] and Dascalaki & Sermpetzoglou (2011)[33]. The values represent the normalized mean heating energy consumption (kWh/m2) and mean electricity energy consumption (kWh/m2) regarding external climate and operational period for typical buildings. The results indicate that the faculty building heating energy use is comparable to other educational buildings, while the electricity energy consumption is twice and four higher than the benchmark studies this can explained with the increasing use of electric equipment such as computer and laptops in the students and staff in the building.

	Mean Heating Energy Consumption (kWh/m2)	Mean Electricity Energy Consumption (kWh/m2)
Santamouris et al.(2007)	68	27
Gaitani et al. (2010)	57	-
Dascalaki & Sermpetzoglou (2011)	57	12
METU Faculty of Architecture building	60.97	53.56

The monthly heating energy use shown below is in line with the actual existing operational pattern of the Faculty building, which is heated between mid-October and mid-April. Following the same trend, overheating problems occur from May to September, while reaching its peak point in July. Despite the apparent severity of overheating degree hours in the faculty building and the possible occupants comfort and health problems they might entail, the building is operational in its full capacity only for a short duration during the cooling period and a limited number of occupants are expected after July until mid-September. As the number of occupants exposed to summer overheating are rather limited, simple measures that can prevent overheating can be explored in the next phase.

Overheating is calculated for a fixed temperature limit annually for all the zones using the following equation:

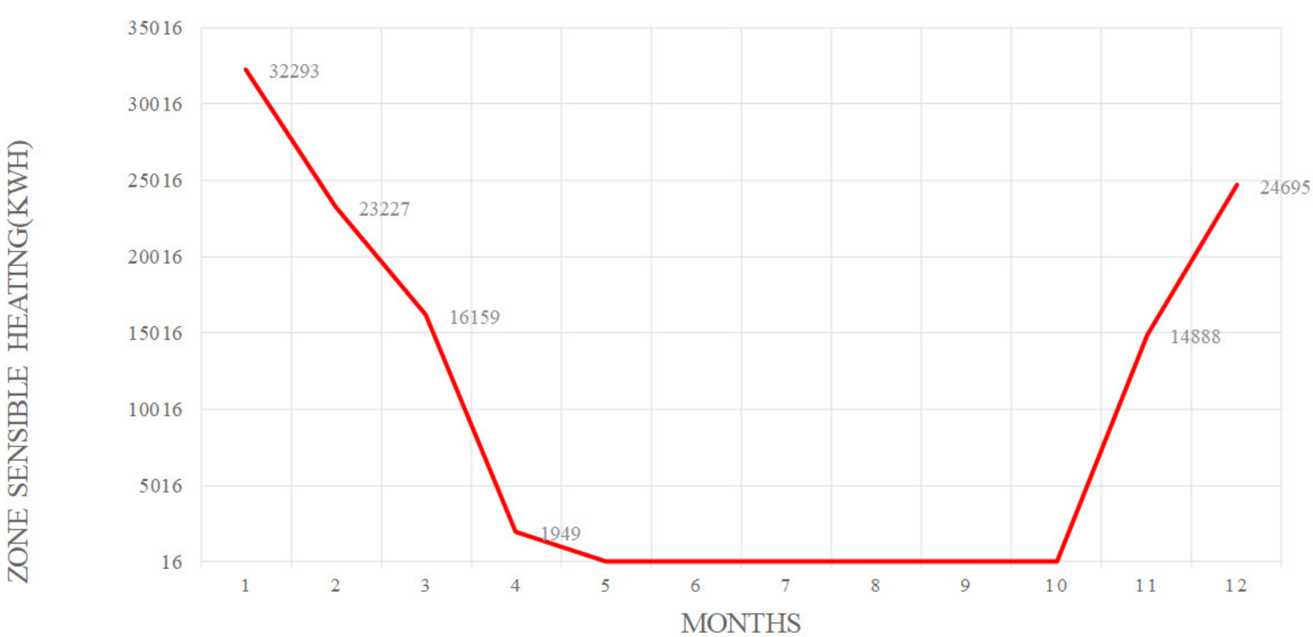
$$ODH = \sum_{h=0}^{8760} \sum_{z=1}^{n} \max(0, T_{z,h} - FTL)$$

Where ODH is overheating degree hours, h is the hour of the year (calculated for the whole year), z is the zones in the building, Tz,h is the indoor air temperature of zone z in hour h, FTL ,s fixed temperature limit, which is considered as (28 C°).

As mentioned above, the building part focused in this study does not use air conditioning for cooling, but relies only on natural ventilation. natural ventilation is also used to provide fresh air into the building throughout the year, based on the number of occupants present in a zone. In the simulation model, it is assumed that the occupants can correctly operate the windows when and where necessary throughout the year. The annual natural ventilation rates in the figure below shows an increase in the air change per hour during the year to cool the building as indoor temperatures increase.

The heat loss through the envelope from the walls, windows, roof and ground can be seen below. The most striking result is the comparatively high rate of heat loss from the ground surfaces during summer. The building's horizontal growth and its high surface area in contact with the ground has a great influence on the building's thermal balance (the ground temperature is considered as 18 C°). This acts as a balancing force in dampening the extreme increase in the outside air temperature and the increased solar heat gain during summer. In contrast with the ground, heat loss through the external walls is at its peak during winter months, gradually approaching zero during summer. External concrete walls, therefore, present themselves as an opportunity to reduce heat loss, and therefore heating energy use during winter.

Figure 43: Zone sensible heating chart for the baseline simulation



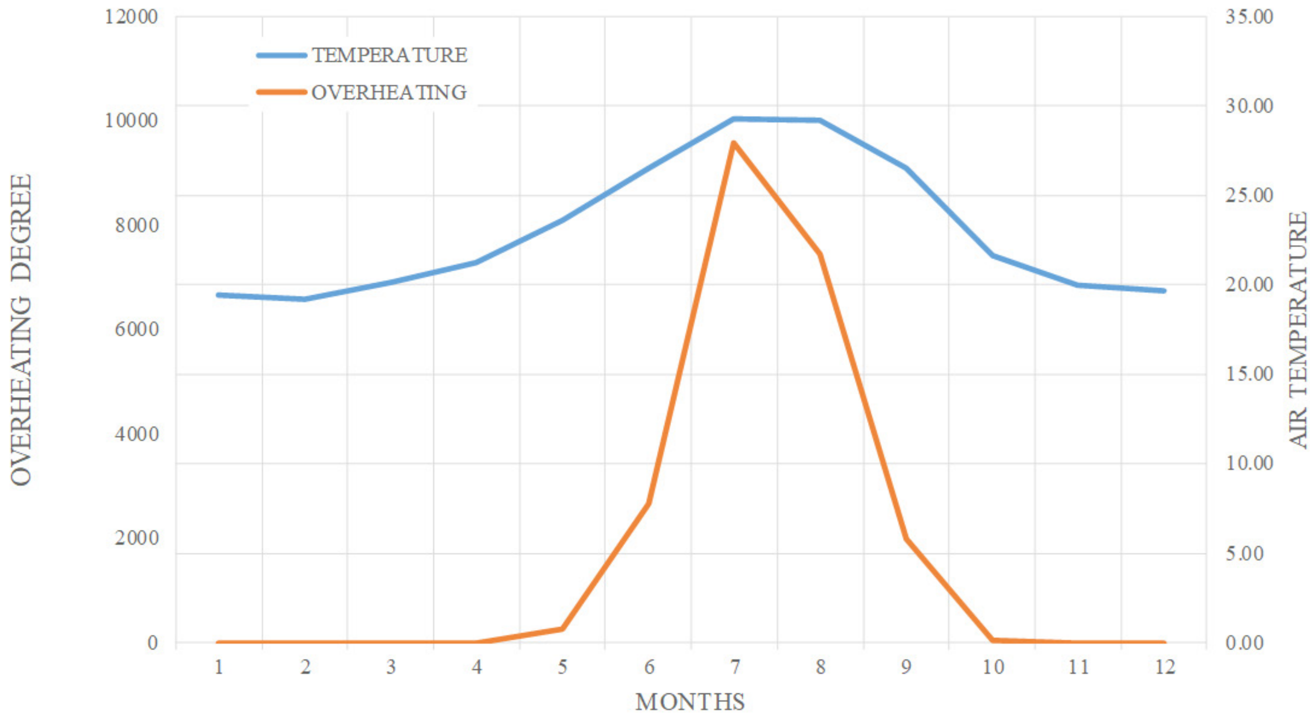
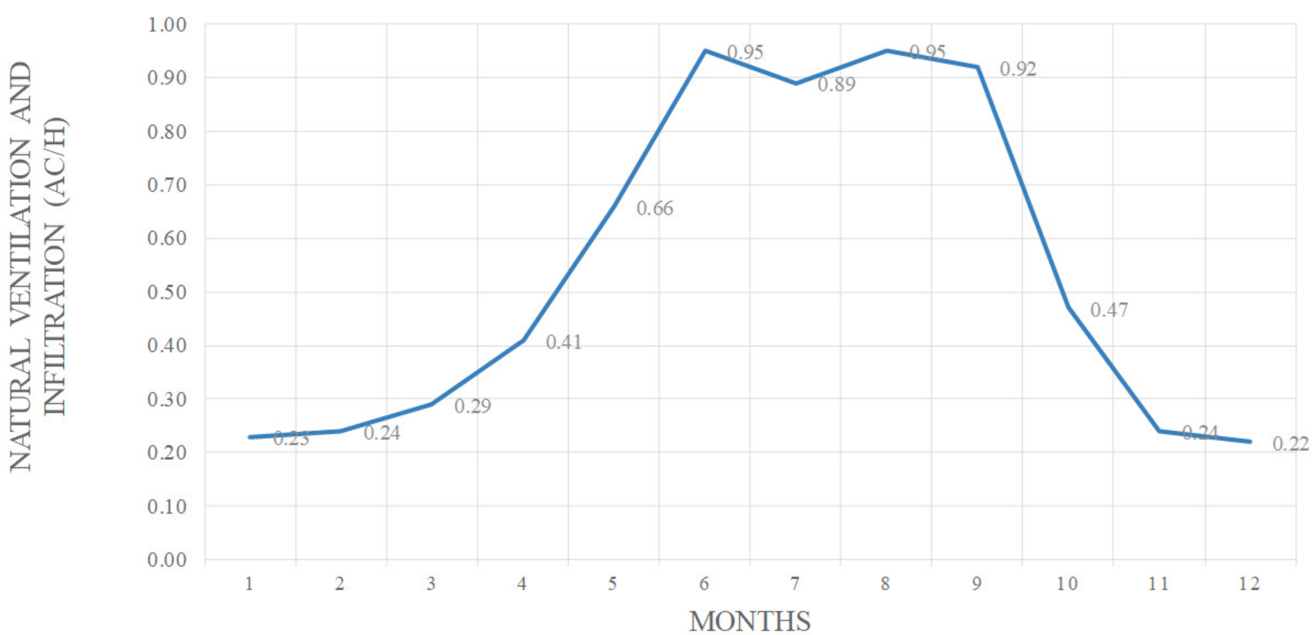


Figure 44: Overheating degree chart for the baseline simulation

The gross areas of the opaque envelope elements are calculated as flows: ground floor = 930 m2; external walls = 1170 m2; roof = 9302. Although the roof and the external walls are comparable in their sizes, the walls have greater potential for making meaningful impact for energy conservation.

Figure 45: Natural ventilation and infiltration chart for the baseline simulation



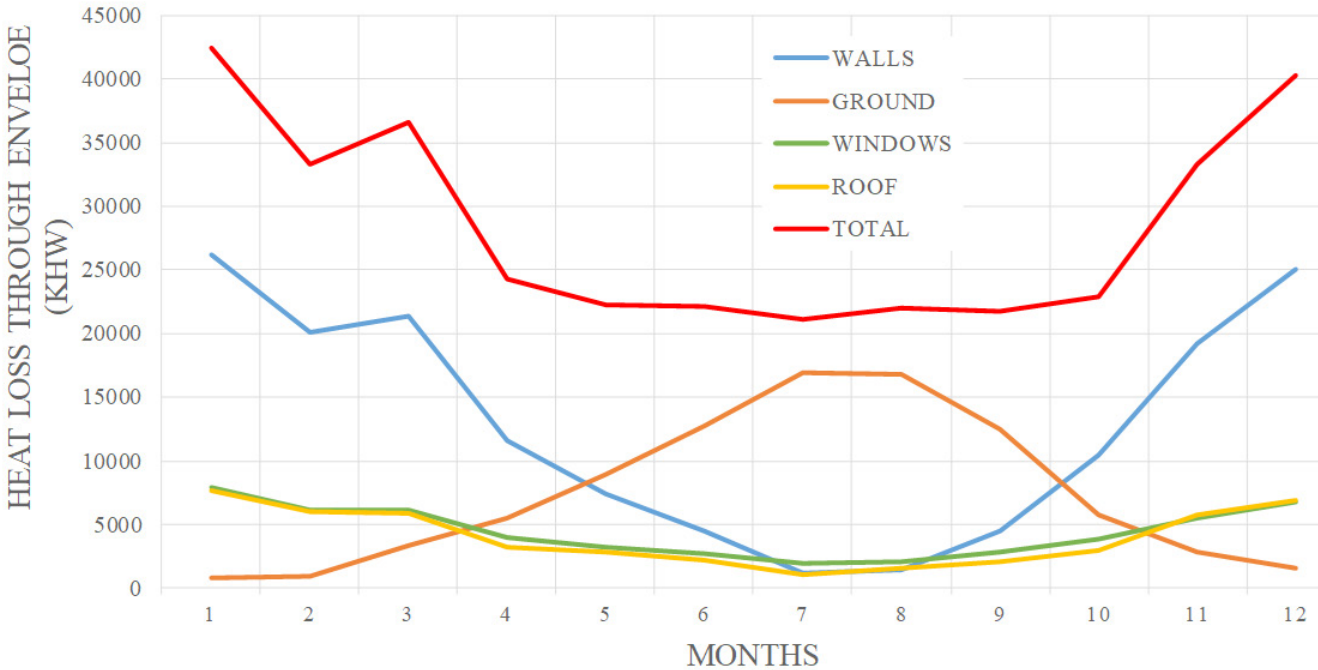
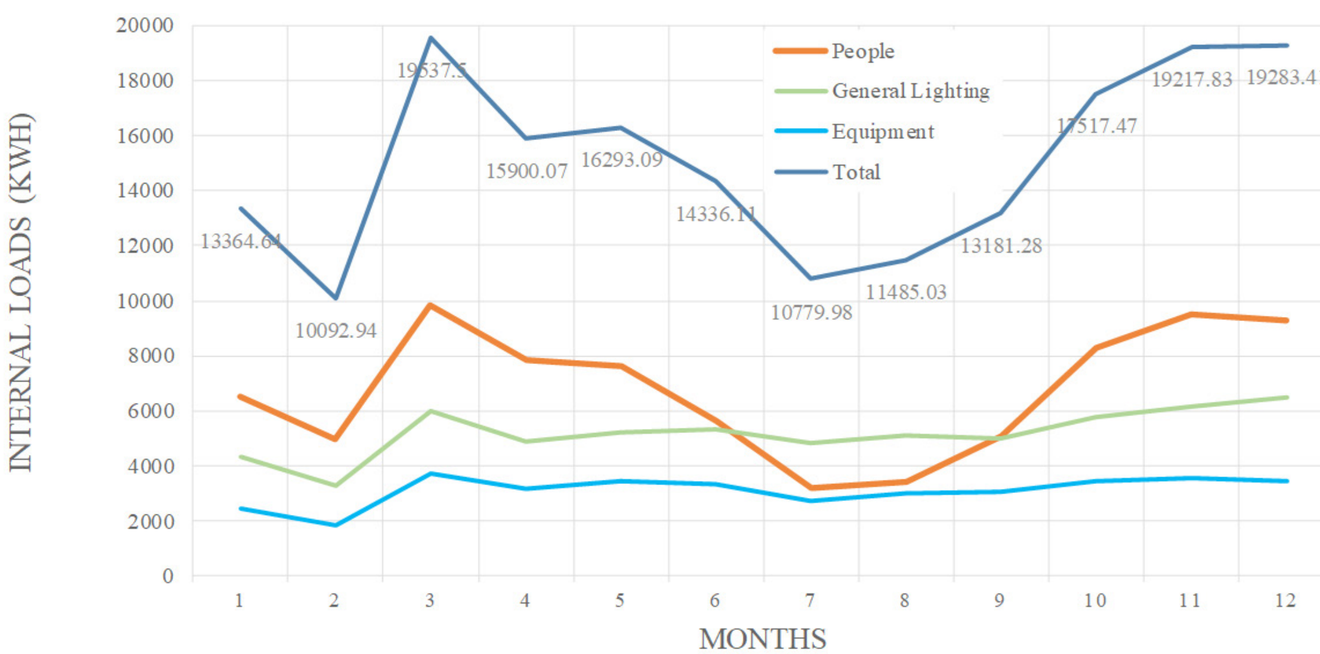


Figure 46: Heat loss from building envelope chart for the baseline simulation

The internal loads due to people, lighting and equipment can be found in the figure below. Internal loads due to people constitute the largest share of the internal loads during the education period. which changes throughout the year (winter holiday is from 20 June – 20 September; winter holiday is from 10 January – 10 February). The annual change remains insignificant in the other internal loads. The scarcity of people during the hottest months also is significant in terms of comfort, in that a relatively lower number of occupants are affected by indoor overheating during summer.

Figure 47: Internal loads chart for the baseline simulation



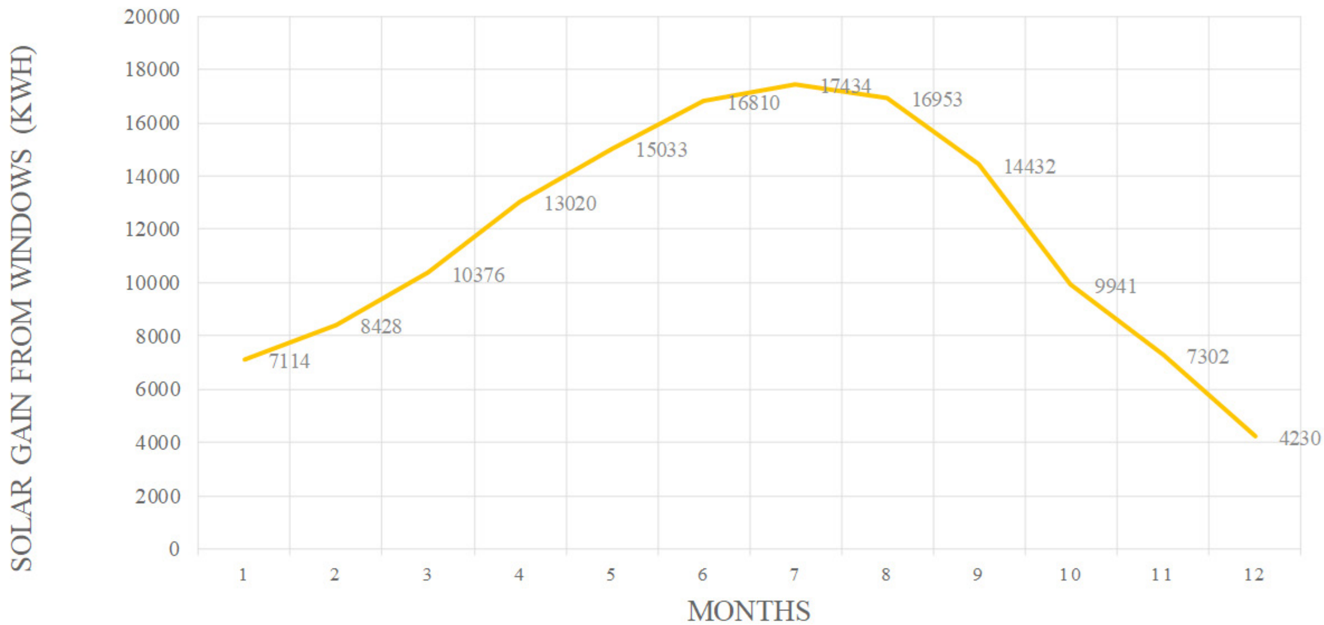
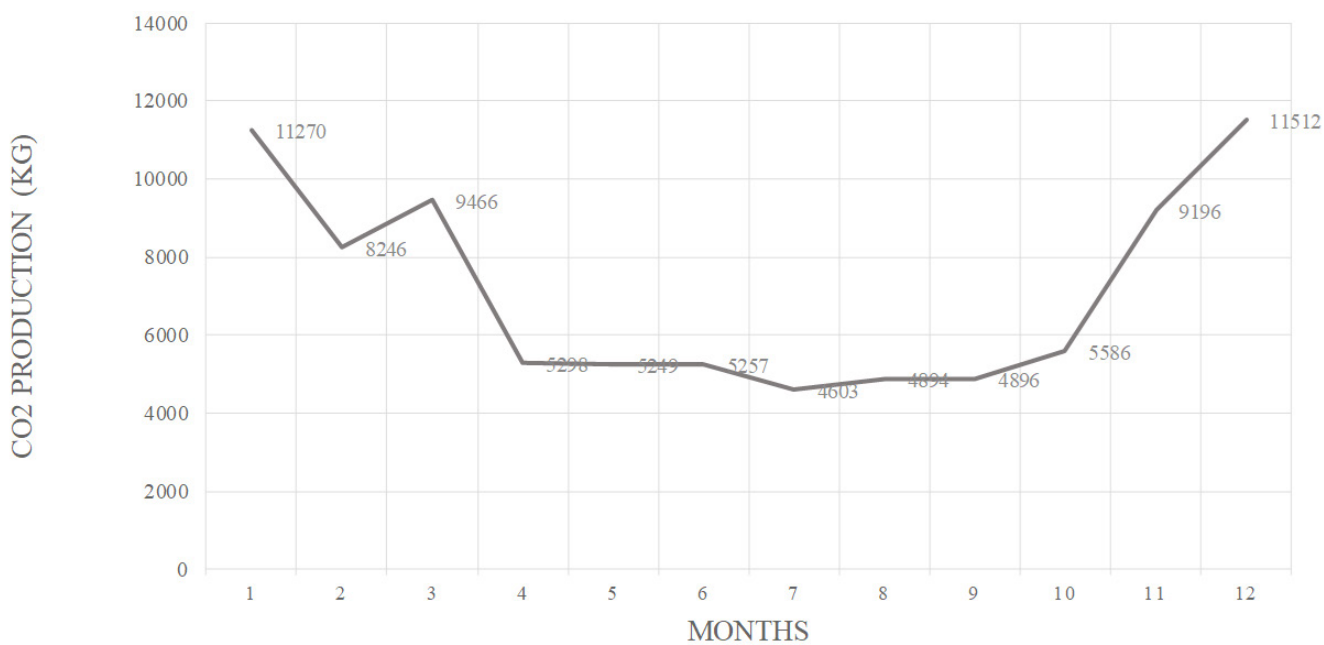


Figure 48: Solar gain from the windows for the baseline simulation

The solar gain from transparent envelope surfaces, such as glazed windows, show and expected increase due to the increased solar radiation during summer. A comparison between the total solar gain and heat loss though the ground during the hottest month, July, shows that they are comparable. Similarly, the total solar gain is roughly 70% higher than the total internal gains.

Figure 49: Carbondioxide production chart for the baseline simulation



The annual CO2 emissions of the building are show in the figure below. These emissions are due to Fuel totals (due to heating) and electricity (due to lighting and equipment). The graph indicates that the CO2 emissions roughly mirror the heating energy use, but never zeroes out due to the electricity energy use due to equipment and lighting.

A summary of the thermal balance of the faculty building can be found below. In this graph, the thermal gains (heating, solar gain through windows, occupants, equipment, lighting, external air) are placed to the top of the horizontal axis, while the thermal losses are placed to the bottom of this axis (conductive heat loss through roof, ground floor, walls and glazing). It should be noted that for each month the gains and the losses are equal to each other so to maintain the building thermal balance. This graph will be used to benchmark between the alternative energy / comfort improvement interventions to be developed in the following section.

Conclusions

• Some previous improvements have been made due to the previous problems. These include the application of XPS thermal insulation on the flat roof, and double glazing windows with aluminum frames.

• The recently renovated materials, such as the glazing and roof, are to a certain degree comparable with the current standards. However, both the reinforced concrete walls and the ground floor, which have remained in their original condition since the building construction, fail to meet the standard.

• *In-situ* measurements previously performed by Assoc. Prof. Ayşe Tavukcuoğlu indicate that the thermal transmittance of the reinforced concrete walls is lower than the theoretical values. This indicates that the building wall has reduced heat transfer through its walls, and is more effective at preventing heat transmission between the inside and the outside of a building.

• Summer overheating is encountered especially in west-facing rooms. The lack of effective shading and natural ventilation for cooling are the primary reasons. However, this problem is not experienced by the occupants at its most severe, because the building is only partially used during summer (July - August).

• Low indoor air quality (especially stuffiness) due to the lack of ventilation and overcrowding in classrooms and studios.

• Natural ventilation is not effectively utilized. However, the original design has great potential to improve.

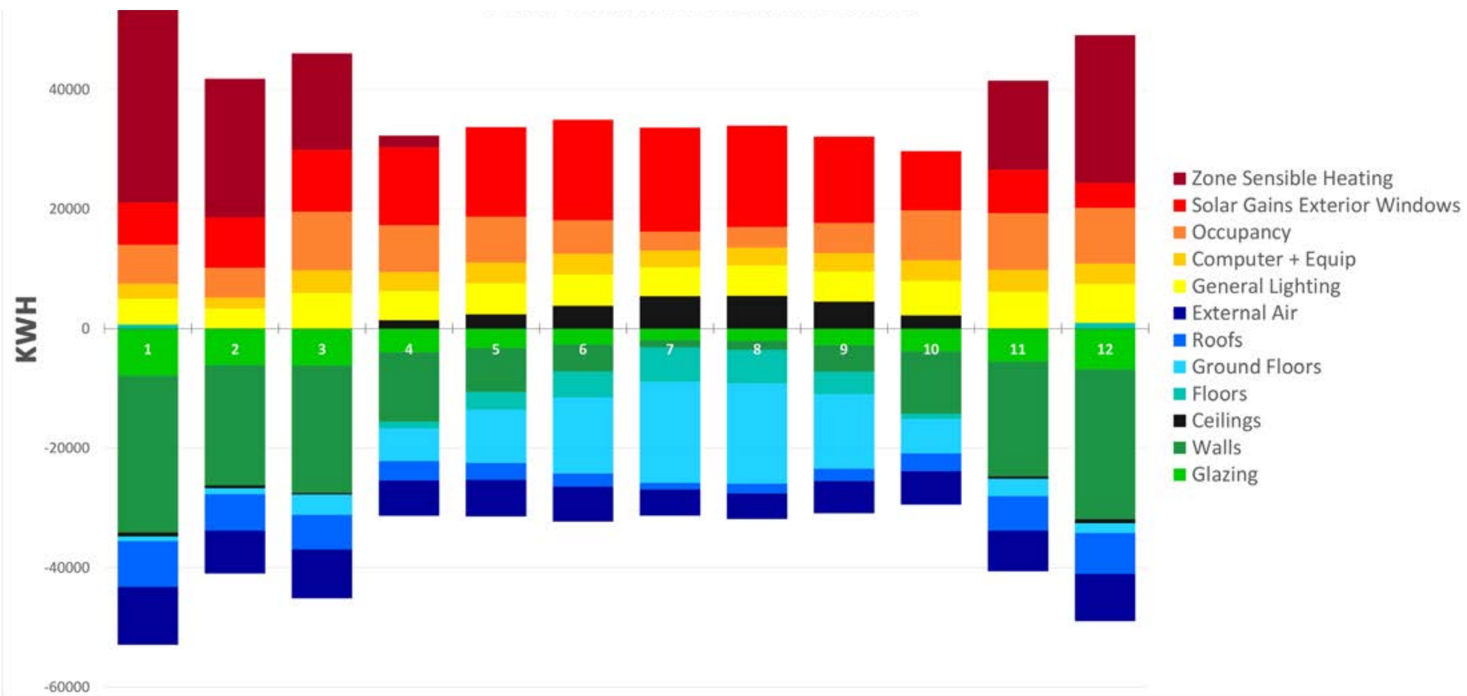


Figure 50: Heat balance chart for the baseline simulation

3.4.5. Retrofit Scenarios and Analyses

A detailed quantitative analysis of the energy use items, Co2 emissions and indoor comfort conditions are provided in the previous section. This section presents a number of alternative scenarios for energy / comfort improvement interventions and discusses their impact of energy use and indoor occupant comfort.

The scenarios were developed by considering the significance of the building, as detailed previously. The building is considered as a masterpiece of late Modern Architecture in Turkey. Its architectural and material significance are due to the excellence in the design and implementation of some features including the reinforced concrete material, transparent facades, the building's overall geometric rigor and the free-flowing spaces. In this project, it is aimed to ensure that the day-to-day activities and/or future physical interventions to the building do not threaten or diminish Çinicis' vision on the **extraordinary architecture form, character, approach and arrival experiences**. Moreover, it aims to ensure that activities and/or physical interventions to the building do not threaten or diminish its **primary use as a significant architectural school**.

In line with the identified significance values and conservation goals, the building interventions for improving environmental performance of the building need to maintain a balance between measures regarding resource-efficiency and ensuring occupant indoor environmental quality. It is also of upmost importance that the building sustains its original function as an architectural education building in the building. Therefore, **minimum visual interventions that have the maximum performative potential** is to be sought as a general principle for the current study, as well as for the general long-term policies.

Figure 51: Concrete planting pot

In the previous section, it has been identified that the original building envelope materials, such as the reinforced concrete walls and the ground floor, fail to meet the TS 825 standard that came into force in the 2000s. However, it must be stressed that the current building standards on energy efficiency in Turkey are quite recent endeavors, and were not in effect during the design of the faculty building. The roof and the windows have been replaced previously, but still are slightly below the current standards. During the summer, indoor overheating is widely reported by the occupants and also calculated in the building energy simulations in this study. General principles of building physics maintain that overheating is due to excessive heat gain through external loads (i.e. solar) or internal loads (i.e. people), or the inability of the building to dispose of the heat gain either by mechanical means (i.e. air conditioning) or passive means (i.e. natural ventilation). Similarly, in the faculty building, the lack of effective shading and natural ventilation are identified as the primary reasons for overheating. Moreover, it has been observed that overcrowded studios and classrooms experience low indoor quality during the education period (late-September to mid-June). Although natural ventilation is currently not effectively utilized, the original design has been identified to have potential for improved cross-ventilation.

Figure 52: Courtyard view from the gallery

By considering the performance problems, the existing potentials and the architectural / material significance values, a number of intervention scenarios are developed (figure 53). These interventions are related to the window materials (both glazing and frame), window opening, solar shading, lighting fixtures, the application of phase changing materials (PCM), the application of Infrared Reflective Coating (IRC), the application of Photovoltaics (PV) panels. Moreover, the influence of the trees surrounding the building are evaluated as an additional case. Each scenario is then benchmarked with the existing building, which is the **"benchmark"** case, using the performance metrics presented in the previous section. Finally, the scenarios that have the maximum impact on building energy efficiency and occupant comfort are selected and combined into two additional scenarios, S-BEST-E and S-BEST-C respectively.

Target Element	Scenario Code	Description
Multiple	S-BEST-C	Multiple scenarios combined to have maximum impact on occupant comfort
Multiple	S-BEST-E	Multiple scenarios combined to have maximum impact on energy

Target Element	Scenario Code	Description
Window	S-WI-1	Replacing windows with better u -value typed windows (+)
	S-WI-2	Replacing windows with better u -value typed windows (++)
	S-WI-3	Replacing windows with high reflective windows (+++)
Window Frame	S-FRA-1	Application of thinner frames on the windows
Window Aperture	S-OPE-1	Expanding the free aperture of exterior windows %15 to %50
	S-OPE-2	Expanding the free aperture of exterior windows %15 to %90
	S-OPE-3	Expanding the free aperture of exterior windows %15 to %50 and placing openable windows on top of interior windows with %50 free aperture
	S-OPE-4	Expanding the free aperture of exterior windows %15 to %90 and placing openable windows on top of interior windows with %50 free aperture
Infiltration	S-INFILT-1	Good refinement in Improvement of the envelope in building's cracks and joinery cavities to an *excellent* condition
	S-INFILT-2	Good refinement in Improvement of the envelope in building's cracks and joinery cavities to a *good* condition
Shading	S-SHA-1	Application of window shading on west facing windows that operate with indoor temperature and schedule
	S-SHA-2	Application of window shading on west facing windows that operate with schedule
Roof	S-RISO-1	Adding extra fine insulation layers to roof construction
	S-RISO-2	Replacing roof's outmost layers to brown roof construction
Lighting Fixtures	S-LIGHT-1	Application of high-efficiency light fixtures
Photovoltaics	S-PV-1	Application of PV panels on the rooftop
Phase Changing Material (PCM)	S-PCM-1	Application of PCMs onto waffle slabs of the building
Infrared Reflective Coating (IRC)	S-REF-1	Application of infrared reflective painting on the building's exterior walls
Trees	S-TRE-1	The shading influence of the surrounding trees
Air Conditioning	S-COOL-1	Air conditioning system in occupied rooms

Figure 53: The proposed scenarios for energy retrofitting

3.4.5.1. Window Types

The window glazing types were selected for the following performative objectives: To improve the thermal performance by means of reduced thermal transmissivity; To reduce solar heat gain by reducing the Solar Heat Gain Coefficient (SHGC); To reduce daylight transmittance through glazing by reducing the visible Transmittance (VT). The three glazing types were selected from the product catalogue of Şişecam's Isıcam series, (ISICAM-C-S, ISICAM-C 3+ and ISICAM-K 3+). This is because glazing characteristics are very much dependent on the producing company's specification, and arbitrarily defined performance characteristics cannot be realistically achieved. The glazing properties of the three scenarios can be found below:

Scenario Code	U-value	SHGC	VT	Glazing Model
BASELINE	2.6	0.75	0.8	ISICAM-C-L
S-WI-1	1.1	0.56	0.79	ISICAM-C-S
S-WI-2	0.6	0.48	0.69	ISICAM-C 3+
S-WI-3	0.6	0.39	0.63	ISICAM-K 3+

3.4.5.2. Window Frames

As mentioned before, all the windows and the original frames in the faculty building, except for a very limited area, has been replaced during the early 2000s. The new frames are aluminum material, and are found to be visually inconsistent with the building's architectural qualities and design decisions. Therefore, improving the glazing provides an opportunity to visually improve the frames. In this scenario, the frame width is changes from 40 mm to thin frames of 5 mm wide, with 9.5 w/m2K.

Scenario Code	Exterior Window Frame Thickness	Frame Material
BASELINE	40 mm	Aluminum
S-FRA-1	5 mm	Aluminum

3.4.5.3. Window Opening Aperture

The problems with indoor air quality and summer overheating has been previously associated with ineffective natural ventilation. Moreover, cross-ventilation opportunities have not been sufficiently fulfilled in the original design. These problems are due to the limited opening angle of the exterior windows, and the lack of the possibility of the external air flowing through the building depth from the closed spaces (offices, classrooms and studios). The first two scenarios explore two window opening angles that can provide a larger volume of outside air inwards by increasing the opening angle from 15% (in the existing windows) to 50% and 90% respectively. The latter two scenarios build upon this increased angle of the exterior windows, and additionally consider the possibility of cross ventilation by allowing the upper windows of the closed spaces by 50%.

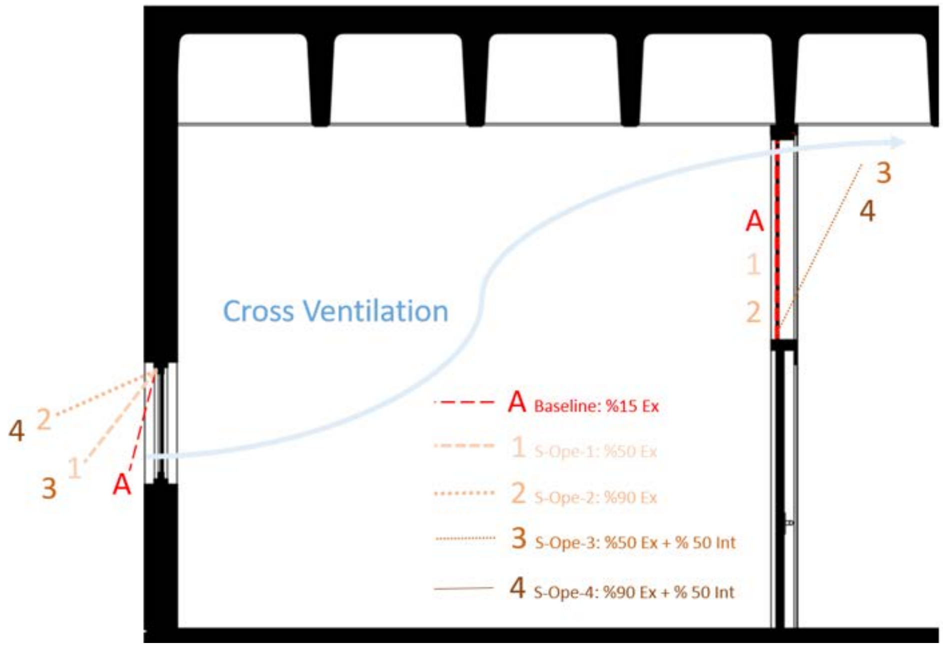


Figure 54: Opening aperture scenarios' diagram

Scenario Code	Exterior Window Operability	Exterior Window Aperture	Interior Window Operability	Interior Window Aperture	Cross Ventilation Possibility
BASELINE	+	15%	-	0%	-
S-OPE-1	+	50%	-	0%	-
S-OPE-2	+	90%	-	0%	-
S-OPE-3	+	50%	+	50%	+
S-OPE-4	+	90%	+	50%	+

3.4.5.4. Infiltration

Uncontrolled infiltration through the window envelope has been known to influence building heating energy use in the building. Although field tests were not conducted, in the simulation the baseline case is selected as in poor condition, whereas the other two scenarios consider good and excellent infiltration conditions. The Crack Templates already specified in DesignBuilder was used to construct the infiltration parameters. In these DesignBuilder templates, every surface has a crack and its size (characterized by flow coefficient and exponent) is determined by Airtightness. These templates contain the infiltration conditions regarding the windows, doors, vents, walls, floors and roofs, as can be found below.

Scenario Code	Crack Template
BASELINE	Poor
S-INFILT-1	Excellent
S-INFILT-2	Good

3.4.5.5. Shading

The excessive solar gain and excessive /direct daylighting during the year can be controlled by shading devices. In both of the scenarios, high reflectance, low transmittance, light diffusing blinds are explored. In the first shading scenario, a combination of temperature-activated operation and a schedules operation (as can be seen below for daily and annual conditions) was tested. In the second scenario, user-control over shading operation was removed.

Scenarios	Window Shading Type	Operation Control	Schedule	Applied on
BASELINE	-	-	-	-
S-SHA-1	Diffusing Blinds: High reflectance, low transmittance shade	Interior Temperature Set Point: 24 C°	+	West Façade
S-SHA-2	Diffusing Blinds: High reflectance, low transmittance shade	Schedule only	+	West Façade

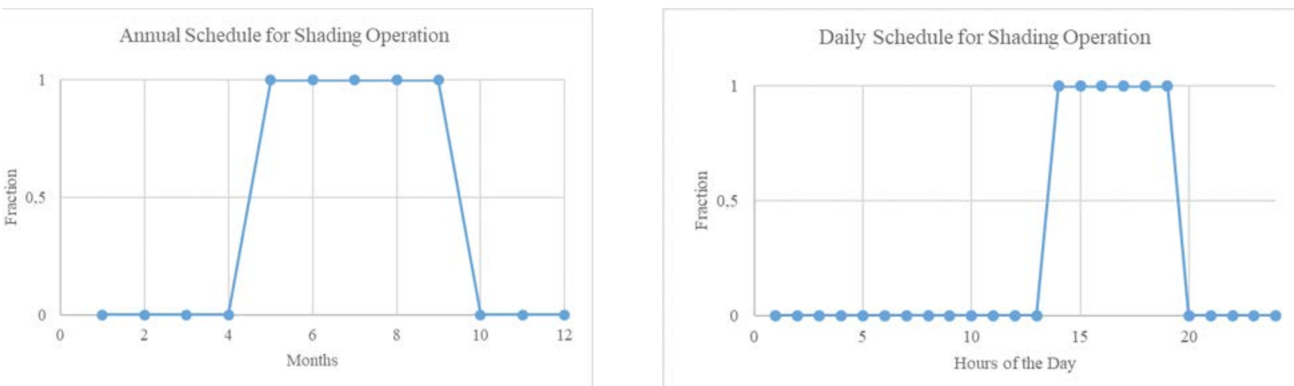


Figure 55: Annual and daily shading schedules

3.4.5.6. Roof

Improvement on the Insulation Layer was first considered by increasing the insulation thickness from the existing value (50 mm) to 100 mm. the insulation material is XPS - CO2 blowing. Following, blown roof application was considered using the construction layers shown below. A brown roof contains a substrate surface that is allowed to self-vegetate from windblown dispersal. Brown roofs are viable alternatives to green roofs in that they require no or very little maintenance, offer a greater diversity of species and do not need irrigation.

Scenario Code	Material Layers				
	Concrete, Reinforced	Waterproofing membrane	XPS - CO2 blowing	Roofing felt	Stone chipping
Baseline	150 mm	-	50 mm	10 mm	10 mm
S-ROOFISO-1	150 mm	-	100 mm	20 mm	10 mm

	Brown Roof
Material Layers	100 mm Brown Roof (soil+grass)
	10 mm Thermalite (high strength)
	160 mm XPS - CO2 blowing
	5 mm Roofing felt
	6 mm Waterproofing membrane
	150 mm Concrete, reinforced %2

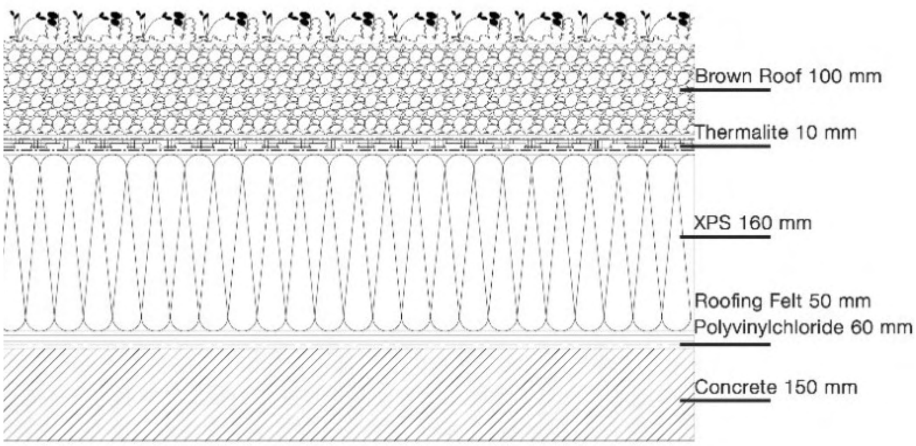


Figure 56: Brown roof section detail

3.4.5.7. Trees

The faculty building is currently surrounded by a variety of different tree species. It is well known that deciduous trees have the potential to reduce building energy use and CO2 emissions. During summer, trees act as shading elements, while in winter, after defoliation, they can still provide much useful solar radiation indoors due to their higher light transmittance values. For the simulations, each tree surrounding the faculty building was accounted for, and their light transmittance schedules throughout the year was used to calculate their shading potential. In this scenario, the positive effect of the surrounding trees on building performance was calculated by comparing it with the hypothetical case without trees. However, it must be stressed that this hypothetical case is not intended to act as an improvement scenario, but only a means to assess tress' impact on performance.

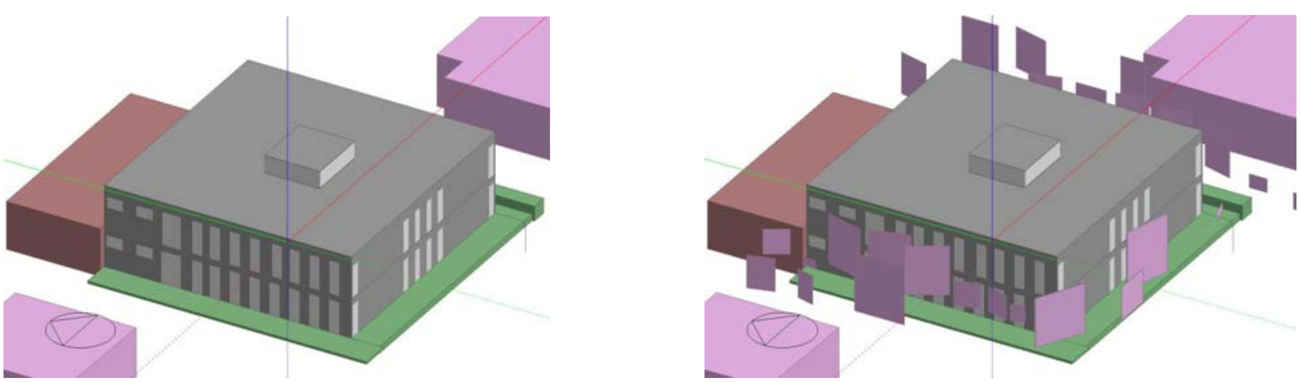


Figure 57: The Designbuilder views for the baseline and s-tre-1 scenario

3.4.5.8. Lighting Fixtures

In the baseline simulations, lighting constitutes 30% of the total building energy use (33.50 kWh/m2). The normalized power density in W/m2/100 lux is improved for each rooms, as in the table below.(figure 58)

Level	Room Name	Baseline Normalized Power Density (W/m2-100 lux)	S-LIGHT-1 Normalized Power Density (W/m2-100 lux)
GROUND FLOOR	Gallery Ground Floor	7,000	3,500
	Room 23	7,000	3,500
	Room 24	5,000	2,500
	Room 25	5,000	2,500
	Room 26	12,000	6,000
	Room 28	5,000	2,500
	Room 29	5,000	2,500
	Room 31	15,000	7,500
	Wc Women	5,000	2,500
	Wc Women Student	5,000	2,500
FIRST FLOOR	Gallery First Floor	15,000	7,500
	Room 85	7,000	3,500
	Room 86	5,000	2,500
	Room 87	5,000	2,500
	Room 89	13,000	6,500
	Room 89 B	12,000	6,000
	Room 90	7,000	3,500
	Room 90 A	5,000	2,500
	Room 90 B	5,000	2,500
	Wc Men	5,000	2,500
	Wc Men Student	5,000	2,500

Figure 58: Normalized power density chart for the baseline and s-light-1 scenario

3.4.5.9. Photovoltaics

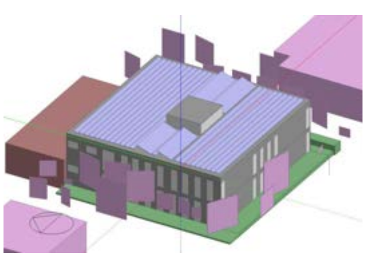
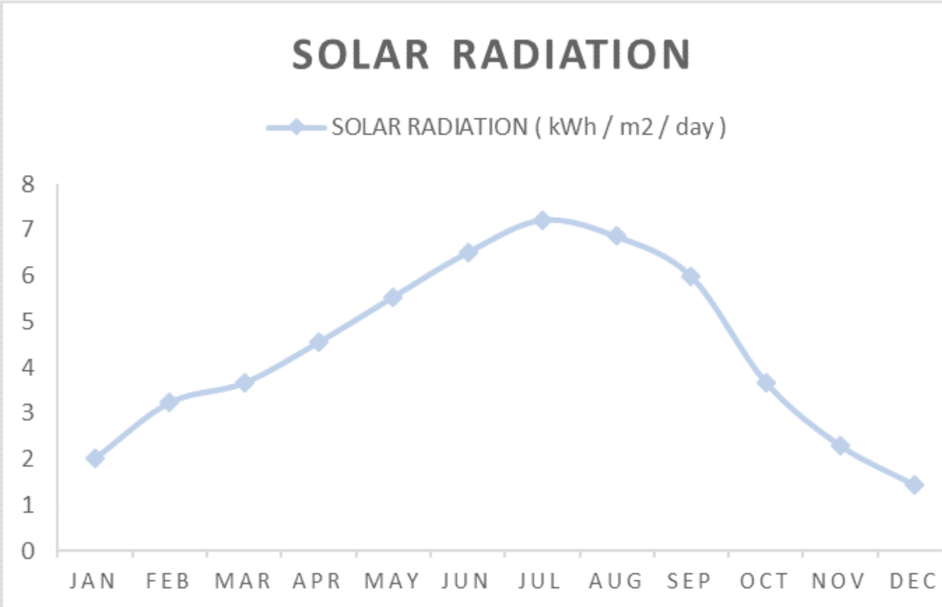


Figure 59: Designbuilder view for the s-pv-1 scenario

The application of photovoltaic panels in buildings offer a unique opportunity to introduce renewable energy production to offset the energy consumption of the building. PV panels typically can be manufactured in any dimensions, which gives them much flexibility in installation. For the simulations, a commercially available PV panel was selected. The technical specification can be found below. The rooftop of the selected building part was used in 80% capacity. The array tilt is 20°, array azimuth angle is 180°, the system losses are 14.08%, the inverter efficiency is 96% and DC to AC Size Ratio is 1.2. The electricity generation potential on a rooftop PV system with the given specifications can be found below.



MONTH	SOLAR RADIATION (kWh / m2/ day)
JAN	2.01
FEB	3.23
MAR	3.66
APR	4.55
MAY	5.54
JUN	6.51
JUL	7.22
AUG	6.86
SEP	5.99
OCT	3.68
NOV	2.29
DEC	1.43
ANNUAL	**4.41**

Figure 60: Pv watt calculation chart for Ankara region

PERFORMANCE UNDER STANDARD TEST CONDITIONS (STC)*

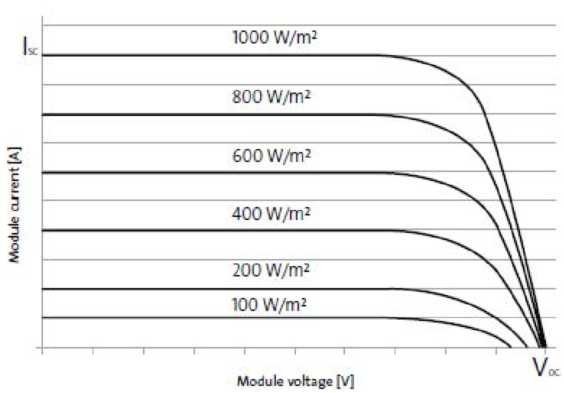
Maximum power	P_{max}	100 Wp
Open circuit voltage	V_{oc}	44.2 V
Maximum power point voltage	V_{mpp}	37.6 V
Short circuit current	I_{sc}	3.02 A
Maximum power point current	I_{mpp}	2.75 A
Module efficiency	η_m	13.61 %

*STC: 1000 W/m², 25 °C, AM 1.5

1) Measuring tolerance (P_{max}) traceable to TUV Rheinland: +/- 2% (TUV Power Controlled).

THERMAL CHARACTERISTICS

NOCT	46 °C
TC I_{sc}	0.051 % / °C
TC $_{Voc}$	-0.31 % / °C
TC P_{mpp}	-0.41 % / °C
Operating temperature	-40 to +85 °C



PERFORMANCE AT 800 W/m², NOCT, AM 1.5

Maximum power	P_{max}	72.7 Wp
Open circuit voltage	V_{oc}	38.9 V
Maximum power point voltage	V_{mpp}	33.1 V
Short circuit current	I_{sc}	2.46 A
Maximum power point current	I_{mpp}	2.20 A

Minor reduction in efficiency under partial load conditions at 25 °C: at 200 W/m², 100% (+/-2%) of the STC efficiency (1000 W/m²) is achieved.

COMPONENT MATERIALS

Cells per module	72
Cell type	Polycrystalline
Cell dimensions	2.04 in x 6.14 in (52 mm x 156 mm)
Front	Tempered glass (EN 12150)
Frame	Clear anodized aluminum
Weight	17.6 lbs (8.0 kg)

SYSTEM INTEGRATION PARAMETERS

Maximum system voltage SC II		1000 V
Maximum system voltage NEC		600 V
Maximum reverse current		15 A
Number of bypass diodes		2
*Design Loads**	*Two rail system*	113 psf downward 50 psf upward

*Please refer to the Sunmodule installation instructions for the details associated with these load cases.

ADDITIONAL DATA

Power sorting	+/- 10 %
J-Box	IP65
Module type (UL 1703)	1

Figure 61: Specifications fot the applied solar panel module

3.4.5.10. Phase Changing Materials

Phase changing materials (PCMs) are energy storing systems that can be effectively utilized in buildings due to their unique melting and solidification properties. PCMs can increase a building thermal performance by reducing the dependence on the heating and cooling systems. In this scenario, PCMs are used integrated with the waffle slab construction, which is intended to have minimum visual effect ıf the architecture of the building. Two different PCM melting temperatures were used; 21 C° and 27 C° in the two scenarios.

Scenario Code	**PCM Type**	**PCM Melting Point**	**Thickness**
S-PCM-1	BioPCM® M182/Q27	27 C°	74.2 mm
S-PCM-2	BioPCM® M91/Q21	21 C°	37.1 mm

3.4.5.11. Infrared Reflective Coating

Infrared Reflective Coating (IRC) is an additional layer on the outermost layer of the wall or roof construction, which reduces heat conduction by reflecting infrared solar rays (about 700 to 2,500 nm) with high reflectance pigments they contain. Wavelengths in the infrared region is one of the primary sources of cooling load due to the sun on exterior surfaces. By reflecting – instead of absorbing- the infrared wavelength, the IRC material limits the temperature increase on the outer surfaces exposed to the sun. The IRC material that is applied on the exposed concrete walls of the faculty building in the simulations can be found below.

Scenario code	**Thermal Absorbance**	**Solar Absorbance**	**Visible Absorbance**
BASELINE	0.9	0.6	0.6
S-REF-1	0.79	0.196	0.062

3.4.5.12. Mechanical Cooling with Air Conditioning

The faculty building currently is not equipped with air conditioning (AC), except for several administrative offices, none of which are in the selected building area. It is estimated that the current problems of indoor overheating as a result of increasing outside temperatures or overcrowding can necessitate such interventions. However, it must be noted that AC is not a preferred system due to the visual discord between the AC units and the building. Nonetheless, an AC scenario that is operational under the following conditions were modeled.

-Cooling setpoint: 26.0 C°
-Natural ventilation operational between: 23.5° – 25.5 C°
-AC operational for: all occupied rooms except for the common hallways
-AC active for: all occupied hours during summer

3.4.5.13. Mechanical Cooling with Air Conditioning

A number of measures described above were selected and combined to calculate the resulting performance. These measures are:

For maximum energy efficiency (S-COOL-E):
S-WI-2, S-RISO-2, S-LIGHT-1, S-INFILT-1, S-FRA-1, S-PCM-1, S-SHA-2

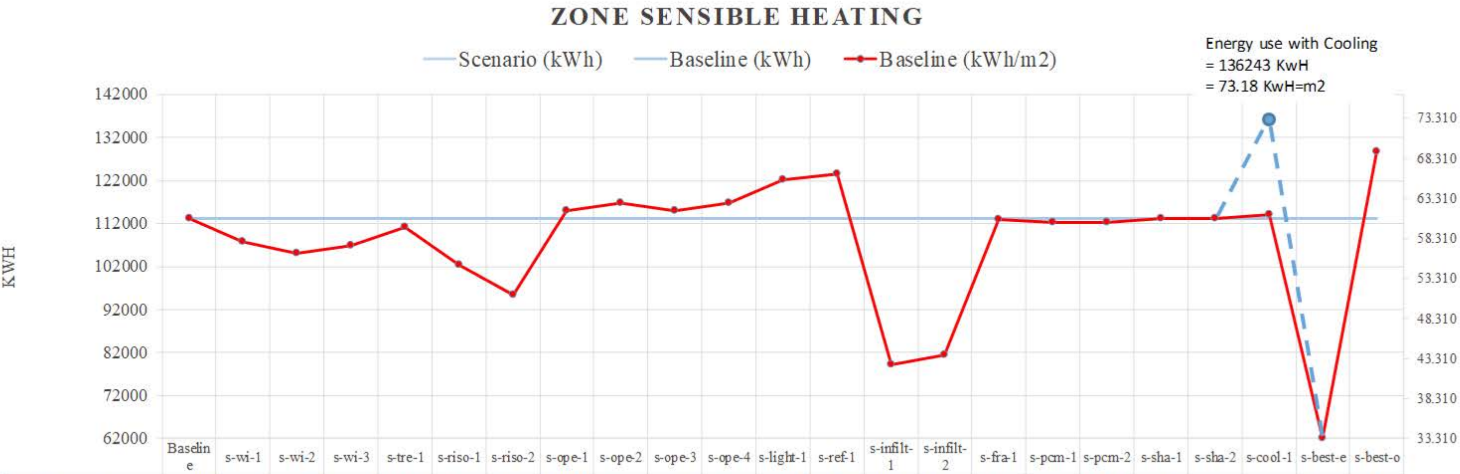
For maximum occupant comfort (S-COOL-O):
S-WI-3, S-OPE-4, S-LIGHT-1, S-REF-1, S-FRA-1, S-SHA-2

3.4.6. Results

Figure 62: Relics in the garden

Annual Zone Sensible Heating Summary

The simulation results regarding building heating energy use for all scenarios can be found below. Scenarios that improve natural ventilation efficiency (S-OPE-1, S-OPE-2, S-OPE-3, S-OPE-4), reduce internal loads due to energy-efficient lighting (S-LIGHT-1) and reduce solar gain through concrete walls by infrared coating (S-REF-1) have increased the energy use in the range of 2% to 9%. These are scenarios, which aimed to improve summer indoor comfort by applying passive techniques, has an undesired effect during winter on heating energy use. The scenario with AC had heating energy use that is only insignificantly higher than the baseline scenario, but when cooling energy use is included, a 20% increase was observed, from 113211 kWh to 136243 kWh. On the other hand, all other scenarios reduced the need for heating energy use to different degrees. The most effective decrease was observed in roof interventions that increase thermal resistance (S-RISO-1 and S-RISO-2) with -10% and -16%, and improving the airtightness of the building (S-INFILT-1 and S-INFILT-2) with -30% and -28%. The shading scenarios have no effect on heating energy use, as they were considered operational only from Late-Spring to mid-Fall. Both PCM scenarios, which intended to reduce summer overheating, was only slightly effective in reducing heating energy use as well.



	Baseline	s-wi-1	s-wi-2	s-wi-3	s-tre-1	s-riso-1	s-riso-2	s-ope-1	s-ope-2	s-ope-3	s-ope-4	s-light-1	s-ref-1	s-infilt-1	s-infilt-2	s-fra-1	s-pcm-1	s-pcm-2	s-sha-1	s-sha-2	s-cool-1	s-best-e	s-best-o
Scenario (kWh)	113211	107709	105110	106909	111186	102297	95511	114931	116860	114919	116808	122128	123482	79149	81464	113004	112252	112268	113211	113211	114114	62213	128764
Baseline (kWh)	113211	113211	113211	113211	113211	113211	113211	113211	113211	113211	113211	113211	113211	113211	113211	113211	113211	113211	113211	113211	113211	113211	113211
Baseline (kWh/m2)	60.811	57.856	56.460	57.426	59.724	54.949	51.304	61.735	62.771	61.729	62.743	65.601	66.329	42.515	43.758	60.700	60.296	60.305	60.811	60.811	61.296	33.418	69.166

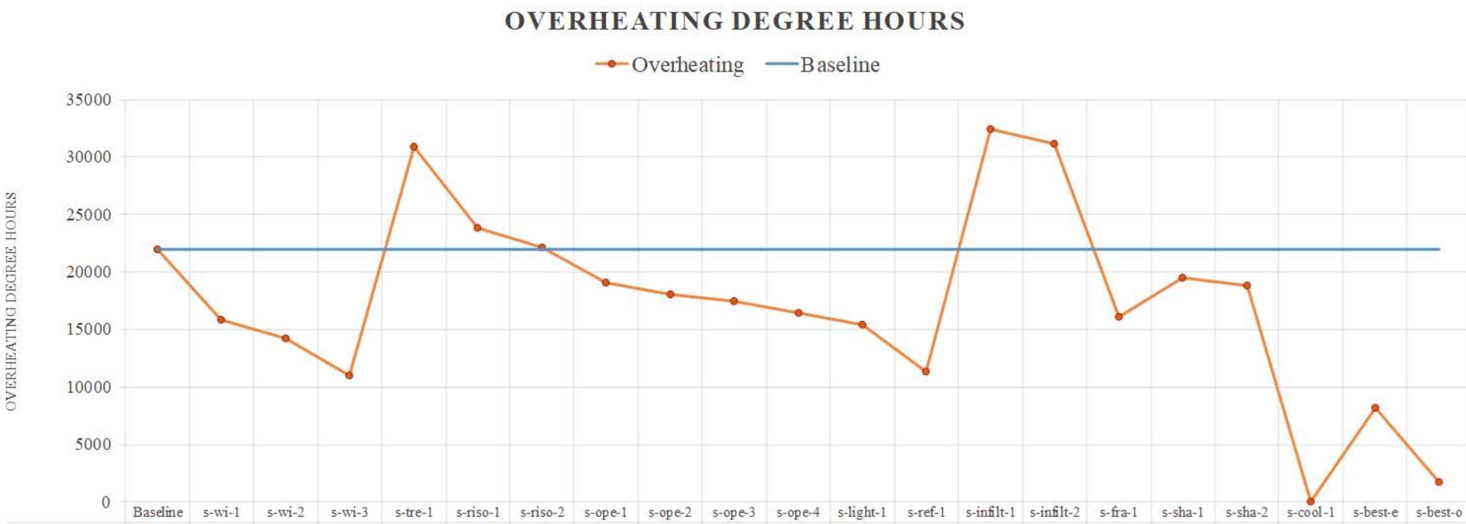
Figure 63: Annual zone zensible heating summary graph for all scenarios

The most energy-efficient combined scenario (S-BEST-E), which consisted of S-WI-2, S-RISO-2, S-LIGHT-1, S-INFILT-1, S-FRA-1, S-PCM-1, S-SHA-2 and S-PV-1, reduced the total heating energy use by 45%, from 113211 kWh to 62213 kWh. On the other hand, the comfort-prioritized scenario (S-BEST-O) resulted in an increase in energy use of 14%, reaching up to 128764 kWh

Occupant Thermal Comfort

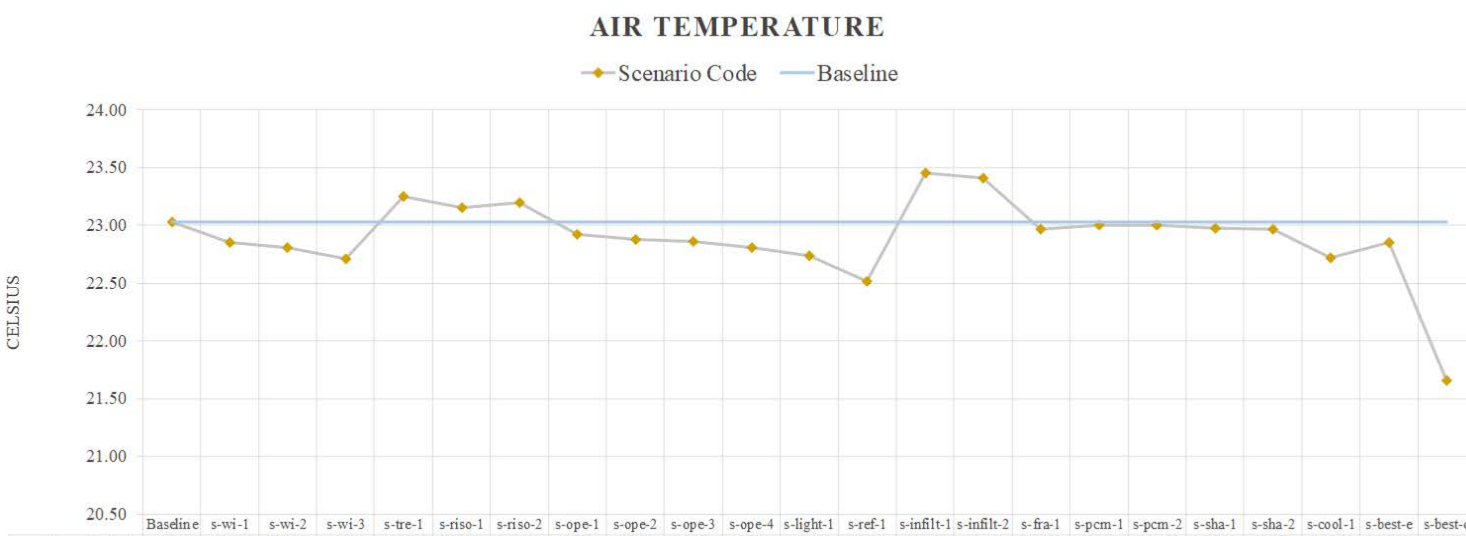
To quantify occupant comfort, the discomfort hours were aggregated on the basis of overheating degree hours for the period 1 May – 30 September for all occupied zones. The results indicate that the most significant change is in the two infiltration scenarios (S-INFILT-1 and S-INFILT-2) with a 31% and 29% decrease respectively. This is due to the building's reduced capacity to lose the heat build-up inside the building though infiltration through the façade. Moreover, it is observed that the trees have a great impact on controlling overheating as a result of reduced solar irradiation. Improved roof isolation scenarios (S-RISO-1 and S-RISO-2), increased window aperture (S-OPE-1, S-OPE-2), as well as the possibility of cross-ventilation (S-OPE-3, S-OPE-4) all contribute to increased summer comfort. Moreover, the reduced window frame width also has shown to help decrease discomfort hours slightly. Expectedly, the air conditioned scenario (S-COOL-1), which maintains an indoor temperature of 26 C° during summer, has shown the greatest positive impact on comfort. However, this scenario it is also observed to have increased total energy use as a result of added cooling. In addition, this scenario is expected to have a greater environmental impact due to its increased CO2 emissions as a result of added cooling systems (see the following sections for a detailed discussion on this issue). The other two combined scenarios both were observed to improve comfort; however, the S-BEST-O scenario's comfort improvement is rather significant in that the overheating degree hours is only insignificantly higher that e cooling scenario. This indicates that building interventions with passive means have a very similar impact to active cooling systems that consume energy and emit CO2.

The average indoor dry bulb temperatures indicate that all the scenarios that have reduced comfort have experienced increased indoor temperature. The most extreme upwards change is again in infiltration scenarios (0.42 C° and 0.38 C° increase), followed by roof isolation (0.12 C° and 0.17 C° increase). On the other hand, the glazing properties, effective window apertures, increased lighting efficiency, infrared reflective coating have all potential to reduce temperatures of to 0.50 C°. A much larger impact is achieved by the combined comfort scenario, where the mean temperature is reduced much more effectively that the cooling scenario. The comparative analysis of the monthly average temperature values of the baseline, S-COOL-1, S-BEST-E and S-BEST-O scenarios indicate that all three improvement scenarios have the potential to reduce the indoor temperatures. The AC scenario and the most energy-efficient combined scenario follow the same trend to a great extent, reducing the mean temperature during the hottest two months (July and August) up to 1 C°. The S-BEST-O scenario, which combines that scenarios with highest comfort impact, operates differently as compared to the previous two scenarios, in that, it dampens the impact of increased external loads (outdoor temperature and incoming solar radiation) from April on. This is in contrast with the AC scenario, where the AC is abruptly activated as the dry bulb temperature exceeds the threshold value, 26 C°. Therefore, it can be said that the S-BEST-O scenario can maintain comfort temperatures before the setpoint is reached during the hottest months, resulting in a more effective comfort strategy.



	Baseline	s-wi-1	s-wi-2	s-wi-3	s-tre-1	s-riso-1	s-riso-2	s-ope-1	s-ope-2	s-ope-3	s-ope-4	s-light-1	s-ref-1	s-infilt-1	s-infilt-2	s-fra-1	s-sha-1	s-sha-2	s-cool-1	s-best-e	s-best-o
Overheating	21969	15854	14253	10967	30895	23854	22152	19086	18013	17486	16466	15453	11337	32441	31133	16104	19487	18811	0	8217	1724
Baseline	21969	21969	21969	21969	21969	21969	21969	21969	21969	21969	21969	21969	21969	21969	21969	21969	21969	21969	21969	21969	21969

Figure 64: Annual overheating degree hours summary graph for all scenarios.



	Baseline	s-wi-1	s-wi-2	s-wi-3	s-tre-1	s-riso-1	s-riso-2	s-ope-1	s-ope-2	s-ope-3	s-ope-4	s-light-1	s-ref-1	s-infilt-1	s-infilt-2	s-fra-1	s-pcm-1	s-pcm-2	s-sha-1	s-sha-2	s-cool-1	s-best-e	s-best-o
Scenario Code	23.03	22.85	22.80	22.71	23.25	23.15	23.20	22.93	22.88	22.86	22.81	22.74	22.51	23.45	23.41	22.97	23.00	23.00	22.98	22.96	22.72	22.85	21.66
Baseline	23.03	23.03	23.03	23.03	23.03	23.03	23.03	23.03	23.03	23.03	23.03	23.03	23.03	23.03	23.03	23.03	23.03	23.03	23.03	23.03	23.03	23.03	23.03

Figure 65: Annual average air temperature summary graph for all scenarios.

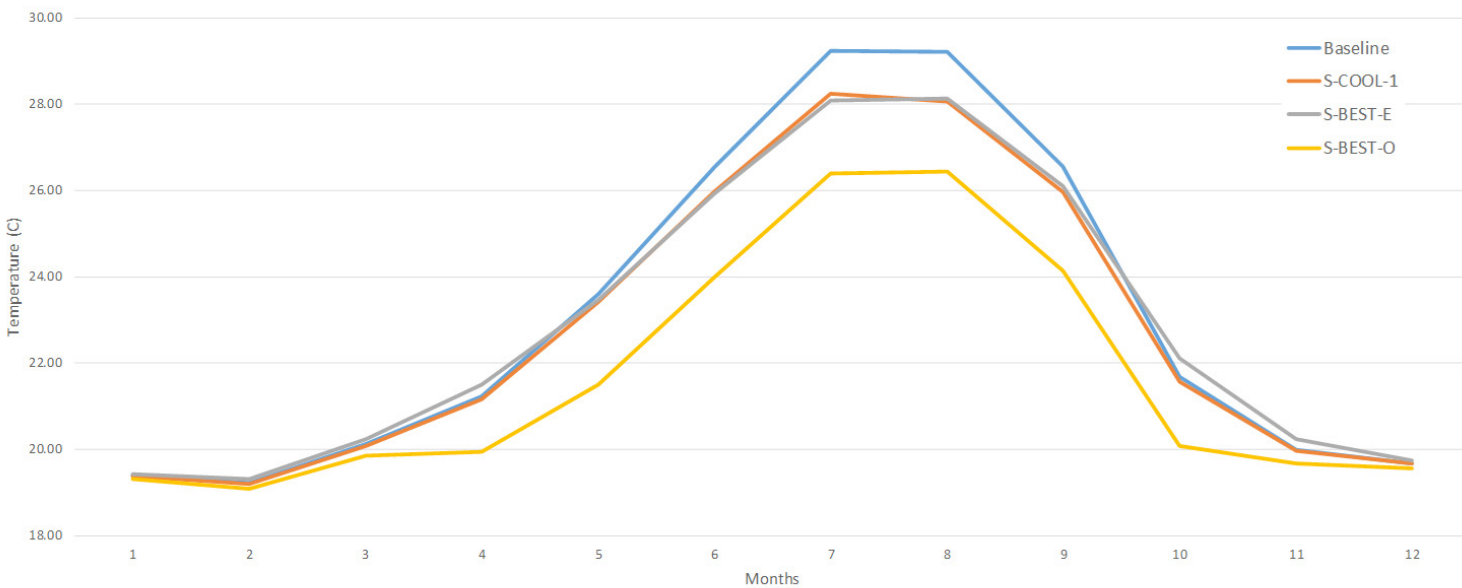
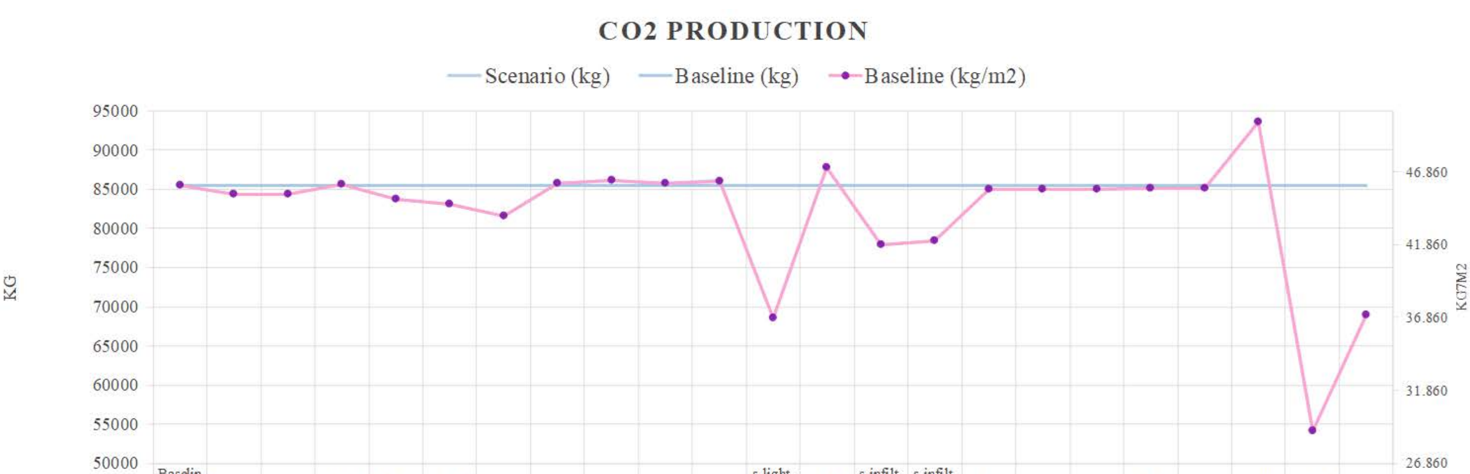


Figure 66: Annual average temperatures for s-best-e, s-best-c, s-cool-1 scenarios

Annual CO2 Emissions

The CO2 emissions, and the environmental impact, of the faculty building vary significantly with respect to scenarios. The highest impact is the high-efficiency lighting fixtures, which has shown to reduce emissions by 20%. This is seconded by the two infiltration scenarios, which show a declining CO2 emission trend due to the reduced heating load (9% and 8% decrease). The roof isolation improvements and window glazing efficiency improvements also contribute positively toward reduced CO2 emissions. The absence of trees, as suggested by the S-TRE-1 scenario, would have resulted in increased incoming solar radiation on the peripheral spaces, which has reduced heating energy use and CO2 emission. On the other hand, improved natural ventilation and cross ventilation scenarios have an effect on heating, thereby increasing also the emissions. Similarly, reflective infrared coating has previously shown to increase heating loads, which is mirrored by the emissions. The S-COOL-1 scenario has shown the most



	Baseline	s-wi-1	s-wi-2	s-wi-3	s-tre-1	s-riso-1	s-riso-2	s-ope-1	s-ope-2	s-ope-3	s-ope-4	s-light-1	s-ref-1	s-infilt-1	s-infilt-2	s-fra-1	s-pcm-1	s-pcm-2	s-sha-1	s-sha-2	s-cool-1	s-best-e	s-best-o
Scenario (kg)	85472	84321	84421	85632	83707	83057	81555	85792	86092	85790	86082	68536	87816	77935	78452	85052	85050	85054	85194	85122	93650	54084	68936
Baseline (kg)	85472	85472	85472	85472	85472	85472	85472	85472	85472	85472	85472	85472	85472	85472	85472	85472	85472	85472	85472	85472	85472	85472	85472
Baseline (kg/m2)	45.911	45.293	45.346	45.997	44.963	44.614	43.807	46.083	46.244	46.082	46.239	36.814	47.170	41.862	42.141	45.686	45.685	45.687	45.762	45.723	50.304	29.051	37.029

Figure 67: Annual CO2 production summary graph for all scenarios.

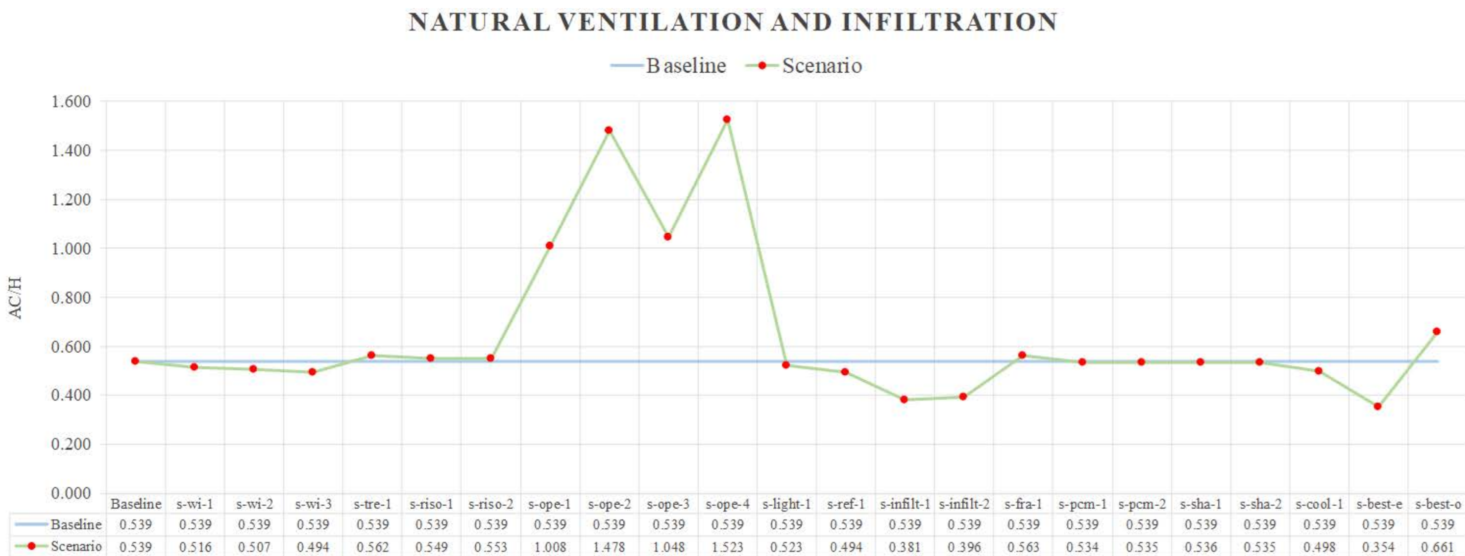
extreme increase, which can be directly attributed to the cooling loads. The most energy-efficient scenario (S-BEST-E) expectedly has the lowest emission value, and therefore the lowest environmental impact.

Annual Average Ventilation and Infiltration Graph for Scenarios

In Ventilation and Infiltration, two scenarios types show significance change from the baseline simulation. The window aperture changes and cross ventilation have expected influenced the air change rate. The infiltration scenarios, on the other hand, have shown to reduce this value.

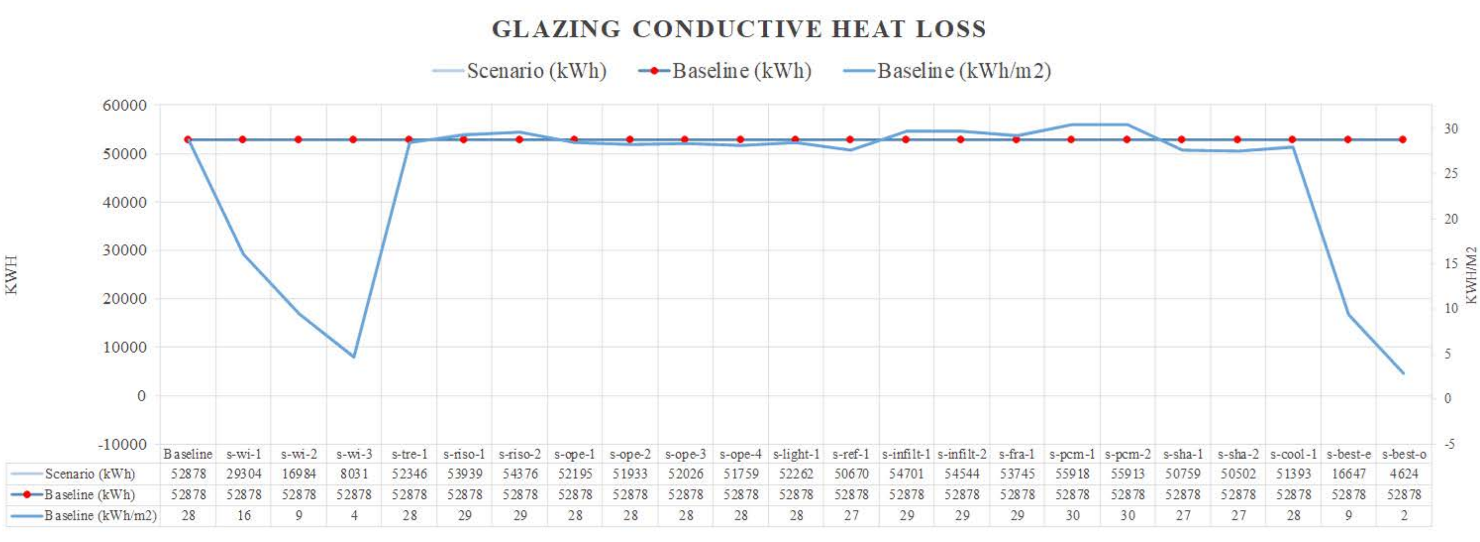
Glazing Performance: Conductive Heat Loss and Solar Gain

The resulting building performance due to glazing conductive heat loss and solar gains can be foun in the following two figures (figure 71, 72).



	Baseline	s-wi-1	s-wi-2	s-wi-3	s-tre-1	s-riso-1	s-riso-2	s-ope-1	s-ope-2	s-ope-3	s-ope-4	s-light-1	s-ref-1	s-infilt-1	s-infilt-2	s-fra-1	s-pcm-1	s-pcm-2	s-sha-1	s-sha-2	s-cool-1	s-best-e	s-best-o
Baseline	0.539	0.539	0.539	0.539	0.539	0.539	0.539	0.539	0.539	0.539	0.539	0.539	0.539	0.539	0.539	0.539	0.539	0.539	0.539	0.539	0.539	0.539	0.539
Scenario	0.539	0.516	0.507	0.494	0.562	0.549	0.553	1.008	1.478	1.048	1.523	0.523	0.494	0.381	0.396	0.563	0.534	0.535	0.536	0.535	0.498	0.354	0.661

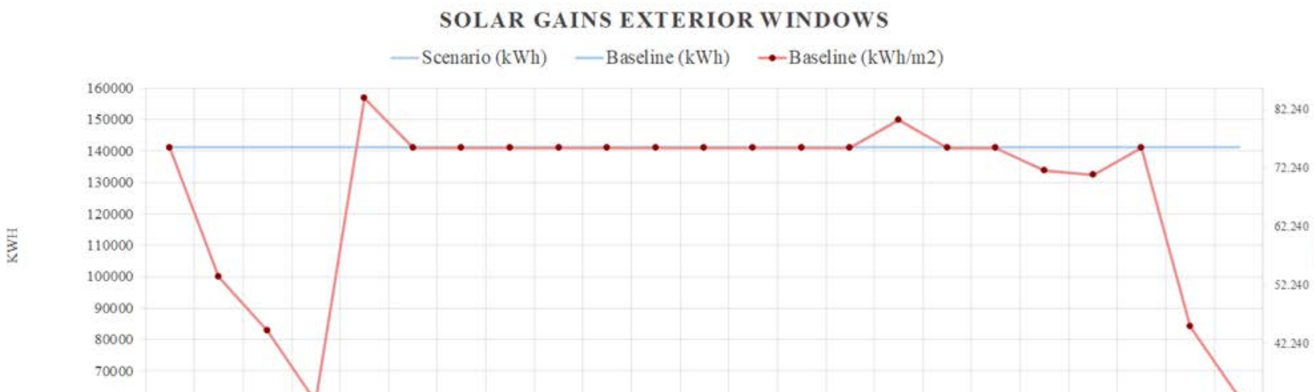
Figure 68: Annual natural ventilation and infiltration summary graph for all scenarios.



	Baseline	s-wi-1	s-wi-2	s-wi-3	s-tre-1	s-riso-1	s-riso-2	s-ope-1	s-ope-2	s-ope-3	s-ope-4	s-light-1	s-ref-1	s-infilt-1	s-infilt-2	s-fra-1	s-pcm-1	s-pcm-2	s-sha-1	s-sha-2	s-cool-1	s-best-e	s-best-o
Scenario (kWh)	52878	29304	16984	8031	52346	53939	54376	52195	51933	52026	51759	52262	50670	54701	54544	53745	55918	55913	50759	50502	51393	16647	4624
Baseline (kWh)	52878	52878	52878	52878	52878	52878	52878	52878	52878	52878	52878	52878	52878	52878	52878	52878	52878	52878	52878	52878	52878	52878	52878
Baseline (kWh/m2)	28	16	9	4	28	29	29	28	28	28	28	28	27	29	29	29	30	30	27	27	28	9	2

Figure 69: Annual glazing conductive heat loss summary graph for all scenarios.

The change in glazing U-value in the first three scenarios (S-WI-1, S-WI-2 and S-WI-3) have dominated all other scenarios. The reduced conductive heat loss results in reduced heating requirement during summer, and therefore reduced environemntal impact. In parallel with the U-value, the window scenarios also improve the solar heat gain coefficient, such that there is reduced solar gain. The most efficient window scenario could reduce the solar heat gain from 52878 kWh/m2 to 8031 kWh/m2. Reduced heat gain can improve summer heating, but also increase demand for heating during winter. Both shading scenarios have made an impact on reducing solar gains, with -5.15% and -6.17%. However, when compared to the glazing improvement scenaros, the impact of shading was rather limited.



	Baseline	s-wi-1	s-wi-2	s-wi-3	s-tre-1	s-riso-1	s-riso-2	s-ope-1	s-ope-2	s-ope-3	s-ope-4
Scenario (kWh)	141075	99835	82844	60236	156652	141075	141075	141075	141075	141075	141075
Baseline (kWh)	141075	141075	141075	141075	141075	141075	141075	141075	141075	141075	141075
Baseline (kWh/m2)	75.778	53.626	44.500	32.356	84.145	75.778	75.778	75.778	75.778	75.778	75.778

	s-light-1	s-ref-1	s-infilt-1	s-infilt-2	s-fra-1	s-pcm-1	s-pcm-2	s-sha-1	s-sha-2	s-cool-1	s-best-e	s-best-o
Scenario (kWh)	141075	141075	141075	141075	149925	140989	140989	133815	132377	141075	84188	61424
Baseline (kWh)	141075	141075	141075	141075	141075	141075	141075	141075	141075	141075	141075	141075
Baseline (kWh/m2)	75.778	75.778	75.778	75.778	80.532	75.732	75.732	71.879	71.106	75.778	45.222	32.994

Figure 70: Annual olar gains from exterior windows summary graph for all scenarios. .

Renewables: Insolation Analyses

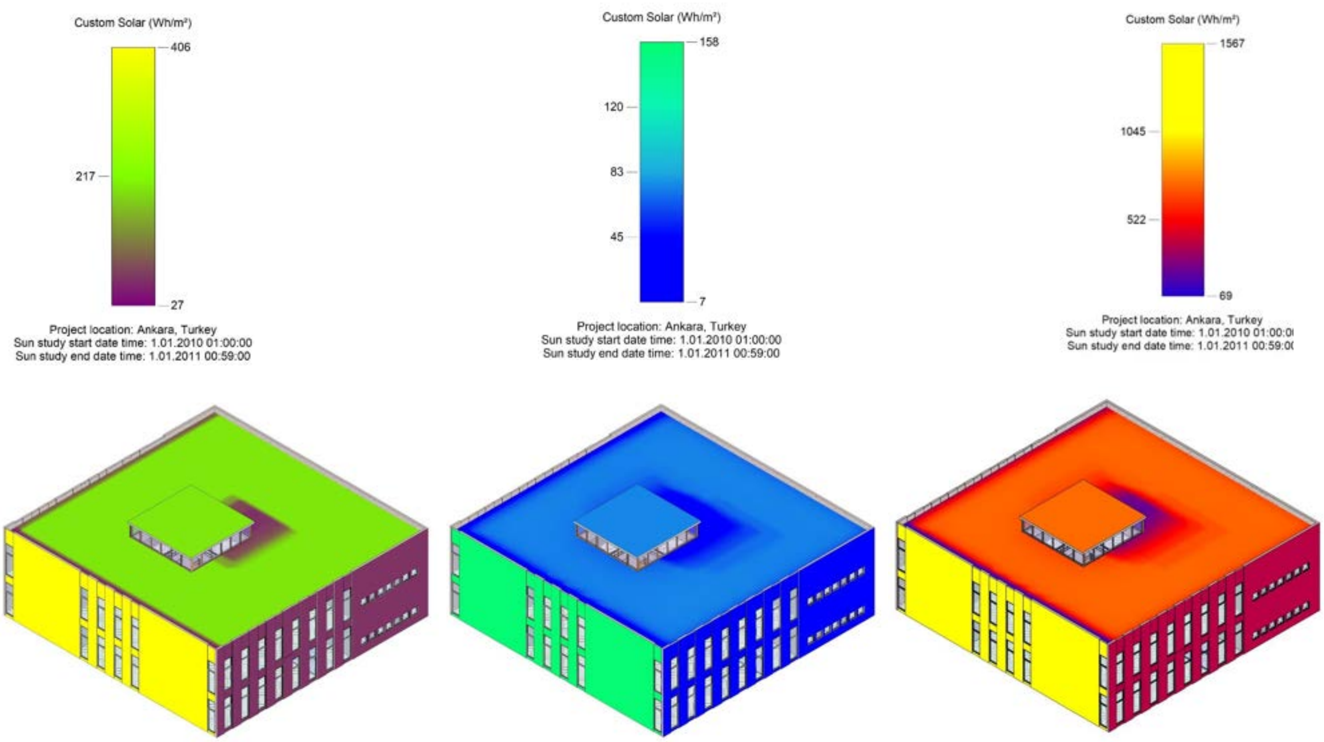
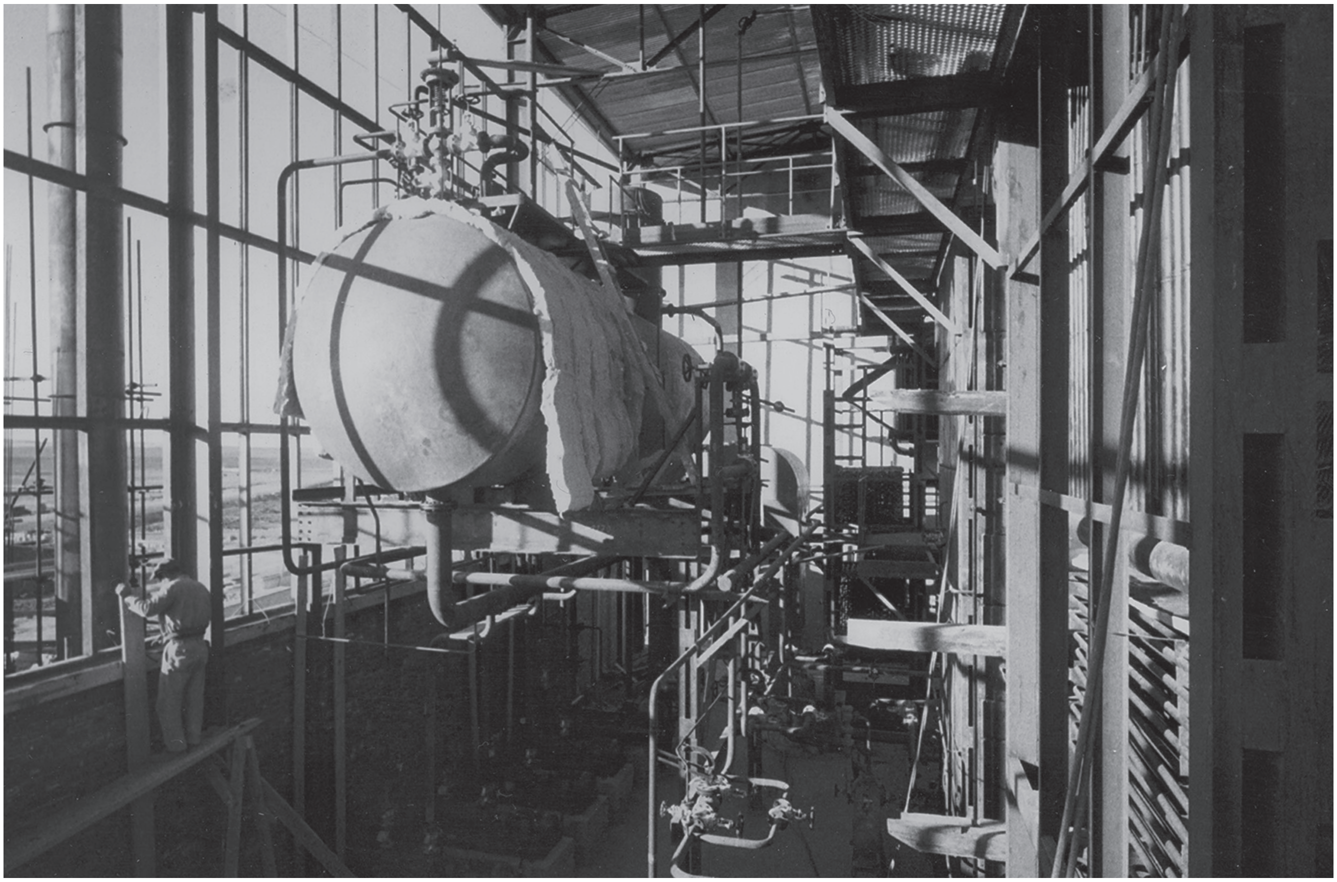


Figure 71: Insolation analyses for the selected area(left to right): Simulated peak insolation(1), Simulated average insolation(2), Simulated cumulative insolation(3) .

Conclusions

The building scenarios that have the potential to improve energy use and occupant thermal comfort have been identified previously. This section presented the results of the simulation-based analyses of the scenarios, as well as the building's potential for renewables (Photovoltaic panels). The results are benchmarked against the baseline building, which is representative of the current building state, and also against each other. The combined scenarios that have been identified in the previous section were evaluated as the eventual cases that could be realistically implemented in the future. Three key performance metrics were considered: energy consumption for space conditioning (heating and cooling if applicable), occupant thermal comfort and CO2 emissions.

The heating energy use of the focus area of the faculty building has been found comparable to educational buildings in a similar climate (Greece) previously. The simulation results indicate that improving the airtightness of the building, improving the roof isolation by increasing the insulation thickness and using high-performance glazing have the maximum impact on energy efficiency. Here it must be noted that performative measures such as infrared coating should be recommended and implemented with extra precaution, due to their lack of test data in exposed concrete surfaces. The combined scenario for energy efficiency reduced the total heating energy use by 45%. The use of air conditioning for cooling resulting in an 20% increase in energy consumption. The thermal comfort calculations based on the overheating degree hour metric indicate that window glazing solar heat gain coefficient, reflective infrared coating and shading devices can improve comfort and reduce summer indoor overheating. The combined scenario can reduce the overheating degree hours from 21969 to 1724 degree hours. In is also important to note that a very similar degree of improvement could be achieved with AC, but with the disadvantages of additional energy consumption and CO2 emission. This points out to the possibility to achieve comfort only by means of passive measures.



3.5. Infrastructural Notes

The Initial Assessment of the Electrical and Mechanical/Plumbing System

A shared transformer center with 630KVA power output capacity, supplies energy to the Faculty of Architecture Building complex. The Faculty of Architecture uses approximately 320 KVA. The power demand per capita for the faculty can briefly be estimated around 25-30W. Since the transformer center is located within the close vicinity of the building, power is transferred via low voltage systems. The building does not utilize any sort of renewable energy source such as solar power, wind power, or other green energy alternatives.

As the building is designed according to standards in practice during 1960s, the electrical design includes grounding systems only for main distribution panels, and the building does not have a lightning protection system. It is not equipped with earth leakage circuit breaker (ELCB). Lighting fixtures in the building are still active after over 60 years, and half of the switches in use are the originals. Use of daylight in the building is very efficient by virtue of large façade openings, courtyards, and skylights proposed in the architectural design. The building does not have emergency lighting systems. Exterior lighting is planned in accordance with the campus scheme, and is controlled by a central command center. Socket outlets fell short due to changes in user requirements over the years, thus the total number of outlets have been increased using surface mounted cable conduits or hubs, specifically in densely used areas such as studios and labs. The original design proposed red colored indicator fixtures on

Figure 1: Power plant, interior view 1960s.

Figure 2: The original lamp over the door frames.

Figure 3: The original utility box in Professors' Tea Room.

Figure 4: Photos from the original gallery, captured during the infrastructural inspection trip.

top of the doors of staff offices, which are intended to inform service staff about housekeeping requests. Over the years, the faculty replaced malfunctioning fixtures with reproductions of the original design. Since the organizational culture of METU places great importance on the notion of equality for all of its residents, the housekeeping fixtures have hardly been used. In this sense, rather than the daily routines, these fixtures hold a symbolic value as a part of the original architectural design.

Since there were no fire detection systems in place in the years of construction, fire safety system features manual fire alarm buttons and horns. There is no central controlled CCTV system. Individual systems have been installed in specific locations such as the main entrances, studio spaces, and the main halls according to changing requirements. Internet access is provided via wireless modems throughout the building, and cable connections are present in academic staff offices. Although the original electrical systems design features electrical snow melting systems, they have not been realized in construction.

In brief, the architectural organization of the Faculty of Architecture building is observed to be adaptable to the contemporary electrical-electronics systems. Spatial requirements of low current systems may easily be fulfilled within the existing structure. It is possible to restore lighting fixtures, power outlets, power distribution and other low voltage systems by paying proper attention to the material and functional values of the architectural design.

The central infrastructural system of the building was designed by Suleyman Demirel, who served as the 9th president of the country in the mid-1990s. For the first time in the country, all the infrastructure services (electricity, heating, communications, water, etc.) were buried underground in the METU campus project. For this, a 12 km gallery was excavated. The original gallery was a hybrid vaulted stone and reinforced concrete structure, and the later additions are made out of concrete. In the project where the thermal power plants were connected to each other and to the buildings by the channels laid out in the channels, the 13 bar high pressure steam distribution was heated to 90 °/ 70 ° C hot water in the buildings and heating was provided.

Figure 5: The original gallery construction, black and white photographs, METU Faculty of Architecture archives.

The university campus has a central heating system. The heat plant consists of four boilers that produce 65 tn/hr, 280 C steam. The heat plan is operational during the winter for space heating, hot water and steam generation purposes. The vapor is released to the pipes which have a diameter of 350 mm. The released vapor turns back without any need of reverse pumping. During winter, it is used only for hot water and steam production. Currently, the heating system in the campus runs on natural gas. The annual fuel consumption is approximately 11.000.000 m3/yr. The produced steam is transferred to the buildings using the above mentioned gallery system. Steel-seamless pipes which were brought from Germany are still in use for the vapor distribution. Underneath every building, there is a steam pressure reducing station and a heat exchanger station, making it ready for final consumption. The capacity of the system remained the same since the METU Campus was first founded because it was designed with a certain reserve. In the 1960s, the number of the occupants of the campus 5000. Currently, the main campus accommodates approximately 25000 people daily. At the moment, the system operates in full capacity.

Figure 6: Central power plant, black and white photographs, METU Faculty of Architecture archives.

The central heating system is connected to the system of the Faculty of Architecture building form the basement floor of the Dean's Hall by a stem pipe of 100mm. The pressure reducer, heat exchange station, and the air conditioning stations are located in the technical service room placed at the basement floor of the amphitheater. The Faculty of Architecture Building complex is heated from late fall to late spring. As stated before, fan coil units are used for larger spaces with high ceilings such as classrooms, studios and common hallways. The use of fan coils in this scale was one of the first examples in Turkey, and required advance mechanical engineering expertise. Kevork Çilingiroğlu, the conductor of the mechanical works, talks about this process in one of his interviews as follows:

> In 1961, we (Çilingiroğlu Engineering) made the first fan-coil application in METU Faculty of Architecture. In this project, Mr. İhsan Önen was working for the administration and we were working for the architects. The building was "naked", therefore, it was going to behave as a glass box. When I calculated heat loss and place the radiators to the project, I realized that the length of radiators exceeds the width of the walls. In order to solve this rather problem, it was necessary to give heat in very large capacities from a point source. I did a lot of research on the subject. We had a consultant friend, Mr. Süheyl Decan. We explained our problem to him and ask for his advice. He was the representative of TRANE in Turkey. He suggested to use TRANE's belt sheave and pulley fan-coil. We decided to use these devices because they had capacities of 10-12 thousand kcal/hour and we did not have to use more than 3-4 fan-coils in each space. At the end, we installed 212 fan-coils in METU Faculty of Architecture. ALARKO manufactured them and the owner of the company was grateful to us because we rejected their devices 8 times. The reason was the noise they units were producing. But in the end, they found the appropriate parts in Italy,and managed to reduce the sound. The founder of ALARKO , Mr. Üzeyir Garih thanked us in person and said that "it is a good thing that you rejected several times; we have worked hard and solved the secret of it and we gained an industrial legislation". Indeed, at the end they became the major producers of these devices not only for local market but also to export it to the other countries in the region.[1]

As indicated in the interview of Çilingiroğlu, this was the first application of fan-coil system in Turkey and the METU Faculty of Architecture, in that time, worked as an experimental site, where innovative applications are realized to meet international standards.[2]

These fan coils were refurbished ten years ago, in compliance with their original design. In relatively smaller spaces spaces such as the service areas and staff offices, radiators were used instead of fan coil units. These units are in very good condition and mostly kept in originals (except six staff rooms). Today, only a few administrative offices are mechanically cooled during summer with air conditioning units. These units are individually controlled by the users. The spaces that have no mechanical cooling rely on natural ventilation. However, the limited opening range of the windows hinder sufficient air flow through the façade openings (See page 280).

During this research, a series of meetings with the METU Directorate of Construction and Technical Works have been held in order to gather information on the systems and the interventions that have been made throughout the years. A blueprint set of technical drawings dating 1968 show the mechanical and plumbing systems proposed by the engineers. The information related to alterations made over the years had never been recorded systematically.

[1] Translated from *Tesisat* Magazine, no. 123, (2006), 44.

[2] The Coastal Laboratory in METU was also designed and constructed by the Çilingiroğlu Engineering. It was the first application of radiant ceiling heating in the country. *Tesisat Mühendisliği* Magazine, no. 154 (2016): 91.

4. ASSESSMENT OF SIGNIFICANCE

Conservation is a value based process. Hence, establishing the significance of the METU Faculty of Architecture Building complex is based on assessment of its material and cultural values by the interdisciplinary research of a group of architects, engineers, social scientists, historians, conservation experts and technicians, as well as the owner of the building and the managers of the institution.

This section of the report has been developed following a re-assessment process motivated by the CMAI-Conservation Management Planning Workshop that took place in London, in July 2018 and guided by the methodology outlined in the ICOMOS ISC20 report. This methodology is based on the principles and processes described in the "Cultural Heritage Policy Documents of ICOMOS Burra Charter, 1999 and Practice Notes (Understanding and Assessing Cultural Significance, and Developing Policy), and the book Conservation Plan: A Guide to the Preparation of Conservation Plans for Places of European Cultural Significance written by James Semple Kerr.

Prior to this, there were no published or unpublished guiding documents prepared on matters relating to the conservation and management of the significant values of the Faculty of Architecture Building complex.[1]

Figure 1: Temporary building that was assigned for the Faculty of Architecture with the sign board “Middle East High Institute of Technology” and the first students, 1955, METU Faculty of ARchitecture Archives.

4.1. Historical, Cultural and Social Significance

[1] Previously, this research item has partially been addressed through three books that were published by the Faculty of Architecture. The first book, *METU Documented* by Ayşen Savaş (1999), aims to catalogue the photographs of the events, individuals, architecture and ideals in order to develop a better and informed vision of the academic landscape of METU. The second book titled *The History of the METU Faculty of Architecture* collects the written, visual and verbal documents from the period of 1965-1966, towards the organization of the individuals, units and groups in documentation and archival initiatives. Finally, the book titled *Anılar (Memories)* edited by Sevgi Aktüre, Sevin Osmay and Ayşen Savaş (2007), aims to document the oral history gather through the focus groups to understand and archive the 50 years of history of the Faculty of Architecture.

It is no coincidence that the first academic branch to launch an education program in the newly established university, in 1963, was the Faculty of Architecture. Originally planned as a UN project, METU was structured under the supervision and the academic assistance of the University of Pennsylvania. The Departments of Architecture, City and Regional Planning, and Industrial Design, incorporating research institutes focusing on building construction and housing, were established to operate as applied research platforms aimed at providing alternative urbanisms to the rapidly developing country.

While the Faculty of Architecture was established as a center for the cultivation of ideas that would eventually help the country face up to the challenges posed to urbanism by modern society, its graduates were thought to be the decision-makers and the leaders of the "new society". These predictions came true, and today the alumni of the Faculty are known to have been behind the urbanization and industrialization of Turkey. Its graduates are also known as the founders of the first architectural corporations, institutionalized art galleries, and the first private architectural institutions in the country.

Therefore, besides its spatial and material qualities and stylistic maturity as a genuine interpretation of Modern Architecture, the social values crafted, cherished, and disseminated by this modernist school are also the reason for its prominent position.

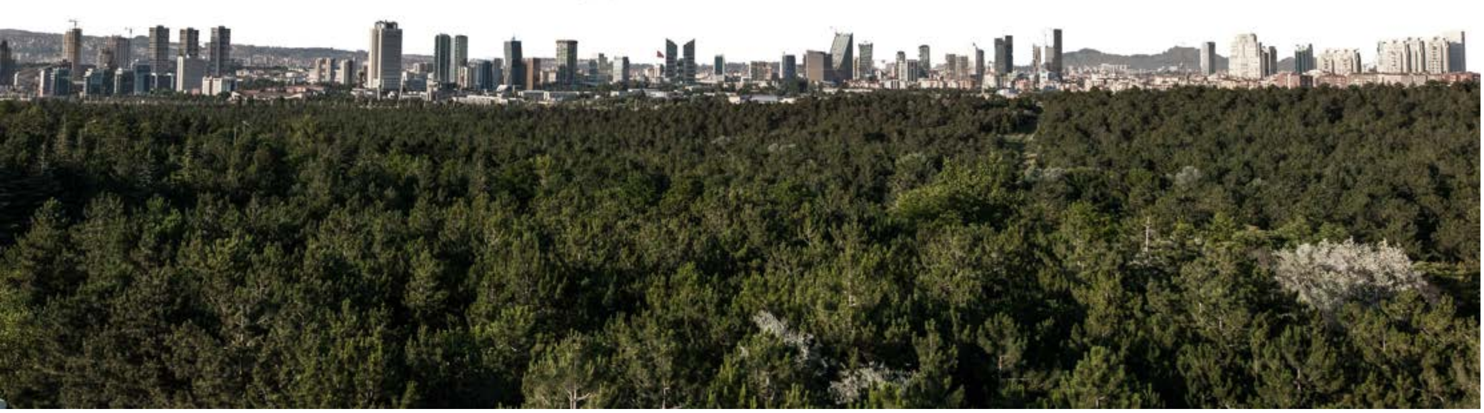
Figure 2: Bare land, *tabula rasa* and after construction, 1978.

4.1.1. University as A Society[2]

Besides its architectural values, the Faculty of Architecture served as the foundations for the development of a community spirit; essentially, the university was designed as a “total entity” to accommodate the new academic society. The issue of what is and what should be Modernity today can still be found in the institutional presence of the campus, partly in its architectural image and partly in the unity between this image and the University’s democratic, inclusive and liberal social life.

One of the major accomplishments of METU is the initiation of a forestation project, construction of an artificial pond and the application of an endemic landscaping to bare land covering 45 hectares. Sustaining the forestation project and the flora and the fauna it accommodates, have always been the highest priorities, while Modernism, its ideology and architecture are still the guiding instructions for the University “community”.

[2] *“University As a Society”* from title of the article: Ayşen Savaş and Güven Arif Sargın, “University as a Society: An Environmental History of METU Campus,” *The Journal of Architecture,* vol.18, no.1 (February 2013): 79-106.



4.1.2. Socio-political and Infrastructural Threats

Although the METU Forest is listed as a “National Forest Protection Area”, neither this building nor the campus can be included in the National Heritage lists in Turkey, a situation that has overshadowed this entire conservation process. As stated in the introduction, 20th century architecture is of no particular interest to Turkish governance authorities, where the definition of historical heritage is quite narrowly set within a time limit of the late 19^{th} century. Today, this modern architectural heritage is at considerable risk for more specific reasons as the premises of Modernity and thus Modernism/Modernist architecture now face open challenges in Turkey’s highly volatile cultural climate. METU faces a series of material and socio-political threats and it is probable that the government will not apply for any international heritage conservation lists in the near future.

In parallel to the ideological treats, the rapid growth of the city with its new roads, underground transportation systems and additional urban functions are threatening the integrity of this building complex. Ankara’s rapid urbanization and its expanding infrastructure have reached the borders of the campus on all sides. The location of the main campus is now particularly fragile following the construction of new highways by the Ankara Metropolitan Municipality starting from October 2013. The laying of new roads along the eastern and western edges of the University Campus destroyed a border section of METU Forest.

Figure 3: The border line of the rapidly growing city and the METU Forest.

Figure 4: Personal transformations and damaging acts.

4.1.3. Site-specific Threats

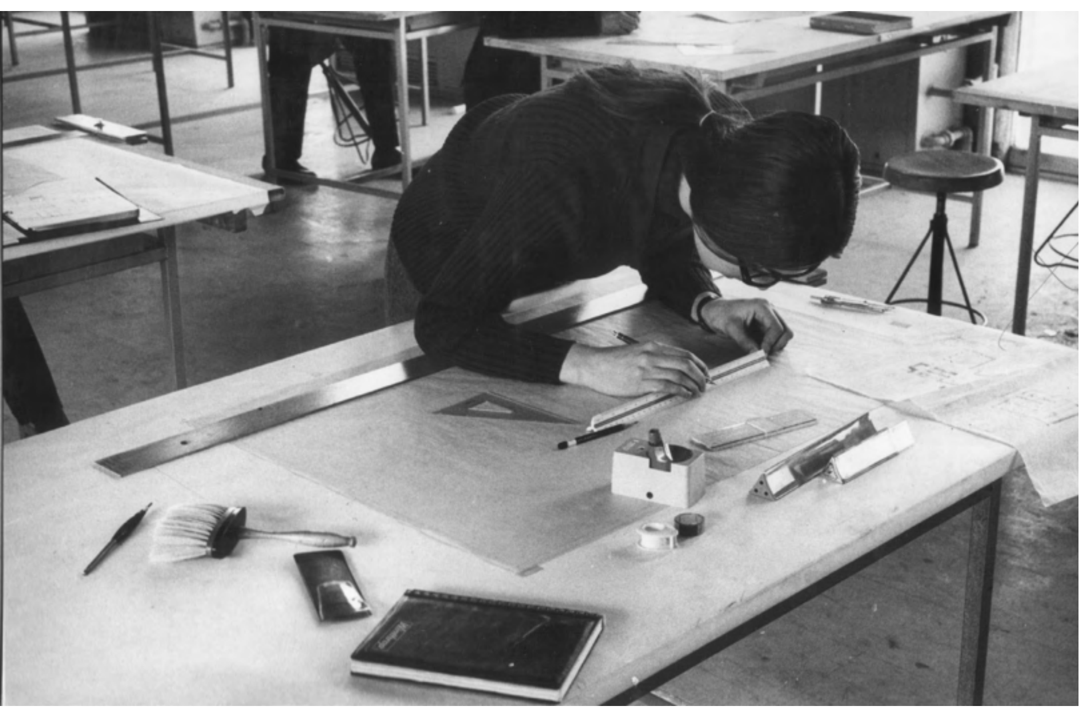
Besides the rapid urbanization and contemporary economic and political pressures, the METU Faculty of Architecture has come to face very unique, site-specific threats over the years. The natural growth of certain trees from seeds, such as fig and poplar trees with wide spreading roots, have the potential to disrupt underground structures, foundations and retaining walls particularly in the courtyards. The continuous irrigation of the grass planted all around the building and the pool that runs next to the arcade cause the growth of moss and damages the structural and material integrity of the retaining walls, pavements, and the foundations.

As environmental issues dominate the scientific research in many disciplines today, METU engineering departments and research centers are also focusing on sustainability projects. These large scale projects have chosen the campus and the campus buildings as their case studies, for experimental applications.

The main users of the building are the students; and their cultural habits such as using every horizontal surface as a cutting mat and putting out cigarettes on the walls, continuously damage the surfaces of the exposed building materials. The teaching staff, on the other hand, use the same space for long periods and thus alter their offices according to personal preferences. The staff responsible for the cleaning of the building cannot appreciate the unique architectural functions of regular building materials. Concrete, in particular, is the main construction material in Turkey but is used almost always cladded or painted in contemporary architecture. Exposed concrete and washed concrete surfaces are the indications of unfinished construction sites for regular users.

METU is a state university, therefore the budget of the any restoration project has to be approved by the government agencies. According to the legal restrictions of Court of Accounts and the Ministry of Finance, every construction and repair work is subject to open bidding system and the procedure selection necessitates the cheapest offer. Here, cheap is used purposefully to refer to finance and workmanship of the restoration procedures. There is also lack of vocational schools training craftsmen adept at masonry, wood and metal works. Moreover, legal job descriptions do not include construction and application surveillance. In better terms, there are two separate procedures in the bidding system; one is related with the design process and the other one is related with the construction process. The design team according to the procedure, could not control the quality of construction and workmanship of the construction group. The inhouse control mechanisms are either random or insufficient. Therefore, any act regarding the physical improvement of the edifice, “restoration”, can pose an unexpected threat.

Figure 5: METU Faculty of Architecture students; developing a project, discussing on a project, and in jury.



4.2. Functional Significance

4.2.1. A Building and an Architectural Program

The architecture of the Faculty of Architecture Building complex displays a mature modernity remarkably designed and implemented by the architect couple Altuğ and Behruz Çinici. It is the first building to be constructed on what was then bare land in Ankara and became the emerging focal point of a Modernist university campus with a 40 thousand population and an award-winning forestation project that is spread over 45 hectares.

Merging the International Style with a local rationalism, the building and campus create a “place” in the prairie. With its unique landscape, symbolic architectural elements, local materials and art works, it is more than a Modernist “replica” in Anatolia. This significant building complex is an outcome of the creative intellect of post-war architectural engineering and became the laboratory of new materials, mechanical equipment and construction techniques in Turkey. Starting from the use of waffle slab system to the production of fan coil units, it marked a number of “firsts” in the country. The building has been used to illustrate the different aspects of Modern Architecture in the history, design, and theory courses given by the Faculty staff. After this research, it has been stated by the civil engineers and material experts that it can also be used as a “laboratory” for their structure and material courses.

The Faculty of Architecture building is also significant for its function: it is a school of architecture which still retains its authenticity of use and function. The METU Faculty of Architecture is one of the best architecture schools in the region, producing graduates who have become well-known architects and architectural educators. It has long been listed as one of the top institutions in many of the respected ranking systems world-wide.

Architecture is the founding faculty of the original establishment and had a significant role in research and education as it radically changed the course of the country's architectural culture and its social and physical planning program. The Department of Industrial Design was established in 1979 to lead Turkey’s design culture. The first industrial design course was conducted at the faculty by David K. Munro as an elective course (ARCH361) in the fall of 1969. The Faculty of Architecture also has a very strong cultural heritage preservation program supported by specialized research laboratories. The Material Analysis and Conservation Laboratory was established in 1964 and developed extensive experience in on-site and laboratory investigations in historic structures and archaeological sites. Moreover, sustainable building design, analytical tools for performance assessment and the use of digital media, such building information modeling or advanced computational tools, are well-developed research fields of the Department of Architecture. These topics are also already integrated in the undergraduate and graduate curriculum of the Department of Architecture through instructional and exploratory means.

Figure 6: Second year architecture studio, 1960s, METU Faculty of Architecture archives.

4.2.2. New Technologies and Techniques: Construction Site as a Learning Laboratory

In the early 1960s, the construction site of the Faculty of Architecture, was appraised as a "learning laboratory, a workshop of the 'new architecture' in the country". A German expert, the architect-engineer Erwin Heinle (1917-2002) was invited in 1962 to consult on the structural systems that are used in different parts of the faculty building. This consultancy particularly focused on the waffle slab system used in the main education unit and the radial concrete beam system applied in the auditorium.

The use of exposed concrete at this scale and the application of these structural systems were unprecedented in Turkey. The whole concrete production process was experimental, and the construction site of the Faculty of Architecture building was used as a "laboratory" for the trial-error phases of the different concrete mixtures and formwork/mould applications. The performance, visual quality, and the character of the concrete mix were tested in sample blocks (some are still in use as flower pots in the building, (figure 8) before the construction of load bearing walls. The high-quality cement was provided and tested by the representatives of the new establishing industry.[3]

[3] The Turkish Manufacturer's Association (TCMA) was formed in 1957 to represent the interests of the growing industry.

Figure 7: METU Faculty of Architecture, construction phase.

The Turkish cement industry traces its history back over more than a century to 1911, the establishment year of the Aslan Çimento plant in the then-capital Istanbul. Until 1950, little development was seen in the industry with just four new plants at Ankara, Zeytinburnu, Kartal and Sivas. The industry settled in 1953, when the Turkish Cement Industry Company (ÇISAN), a public enterprise, was set up to commission 15 new cement plants throughout Turkey. A total of 17 more were added between 1963 and 1980 by the national and regional governments in order to help regional development.

Figure 8: METU Faculty of Architecture, construction phase.

Even the water used in the mixture was tested. In the architects' construction report dated 15.09.1962, it is stated that the exposed concrete was first applied and tested in the shear walls of the Amphitheatre; and it was found appropriate to the set criteria and qualified as a sample for further applications in the rest of the building.[4] The real challenge was the construction of the waffle concrete slabs, which in certain parts did not fulfill the criteria and had to be re-casted multiple times.

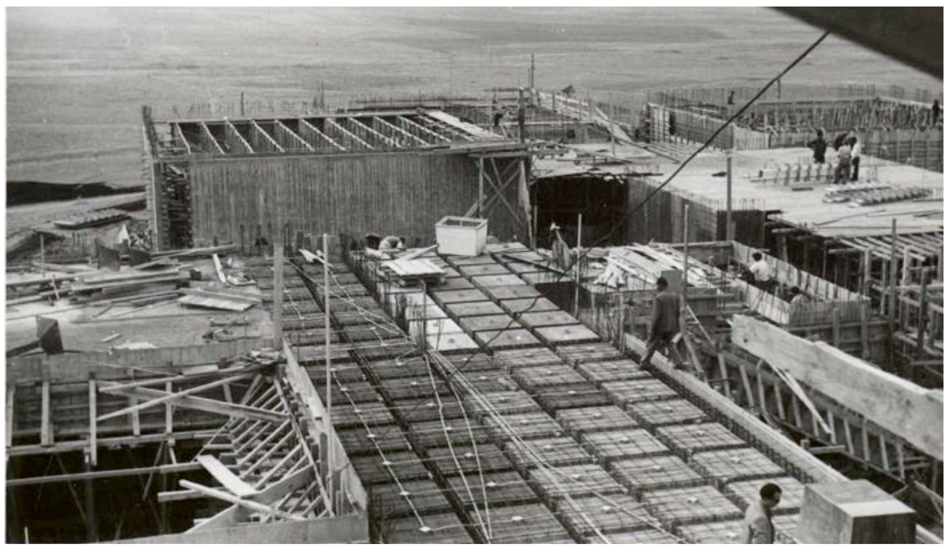


Figure 10: METU Faculty of Architecture, construction phase, ould for waffle slab of F block.

Besides being a kind of research laboratory for high-quality production and different applications of concrete, the mechanical and electrical equipment which was used in the construction of the building was also high-grade.

Figure 9: Transparent plastic glazing, used for skylight.

[4] Behruz Çinici, Mimarlık Fakültesi İnşaatı Seyir Raporu (METU Faculty of Architecture Construction Progress Report), no.3 (September 1962).

In addition to the underground galleries and fan coil units, there were a number of first applications regarding the infrastructural system of the METU Campus. An outdoor weather compensation system was produced in Sweden, by the Bilman company, and executed in METU Faculty of Architecture for the first time.

Plexiglass is another material used at its experimental stage in the construction of the Faculty of Architecture building. As a transparent plastic glazing, it was used for dome skylights in three studios and the small lecture hall, “Kubbealtı” (literally means Under the Dome). The production procedures involved the meticulous production of the moulds and the transportation of these fragile construction elements from Şişli/Bomonti in İstanbul to Ankara.

Figure 11: Original Fan coil units.

4.3. Architectural Significance: A Masterpiece of Modern Architecture in Turkey

This report started with the claim that the METU Faculty of Architecture building is the best product of Modern Architecture in Turkey. It is a masterpiece of the decisions given at all architectural scales. Starting out with its location and site plan, and all subsequent decisions made regarding its functional layout, infrastructural system, building mass articulations, solid-void relations and material choices, have been deemed optimal over the last 60 years. In the late 1950s the METU project was anticipated to become a "model" for architecture and urban planning throughout the Middle East, and today it remains as one of the most outstanding icons of Modern Architecture in the region. The built-in furniture and the art works located at different parts of the building, support the significant architectural value of the interior spaces. The Faculty of Architecture building constitutes a coherent part of METU Campus that is actually representative of the whole, in which the main architectural idea is embed and ready to be cultivated.

The qualities of in-depth refinement and minimalism can be experienced both in the interiors and exteriors of the building complex. The perfect surfaces of the exposed concrete and red brick walls, large transparent surfaces and concrete blocks result in an elegant architecture that is both functional and aesthetic, and connected at all levels. The building is the product of exceptional precision and unyielding pursuit of excellence through material application. Rough materials such as concrete, natural stone brick, wood and pebble are used in such a way that their precision implies an industrial production process. The application of the finishing materials is very successful due to the meticulous detailing in architectural drawings. There are unique details in the building such as the recessed lines in the exposed concrete walls making space for the wooden floor skirts, the wooden panels hiding curtain details or the precast elements providing indirect artificial lighting. The seamless detailing excludes all the additional joint materials such as the mortar between natural stones and metal sheets between floor finishing surfaces. The holistic view of the architects is evident in their architectural drawings. Çinici Architects produced very similar details with similar material application and techniques both in plans and sections.

Figure 12: METU Faculty of Architecture, SALT Research, Altuğ-Behruz Çinici archive.

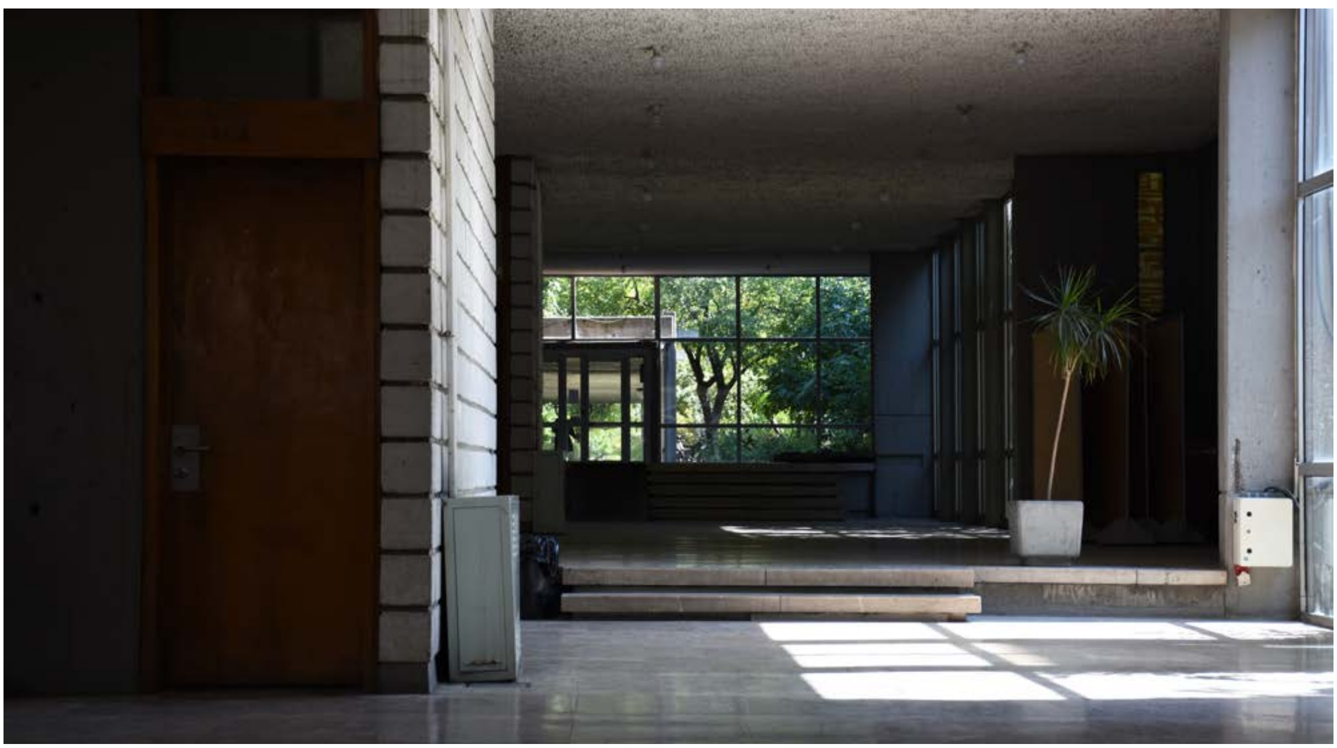


Figure 13: The view from G2 to Kubbealtı area (G3).

4.3.1. Tectonic Qualities

The building is presented as a physical manifestation of the "Tropes of Modernism"[5] in this research. "Flat roof" is interpreted as a stylistic choice due to the fact that its application is almost unprecedented and considered as a challenge in the Anatolian plateau, where the steppe climate brings heavy rains, snow, and a great temperature difference between day and night. Both in the exterior and interior façades, large window openings, glass partitions and glass doors are utilized. Besides the large glazed façades, one of the major sources of "transparency"[6] is the placement of courtyards at strategic locations in the building. These courtyards not only provide light to the adjacent spaces, but also give a perfect sense of orientation with their glazed surfaces. Transparency is understood here in its 'literal' sense, as the main façades, the arcade and the courtyards of the building complex connect all of the interior spaces to each other, and make the surrounding landscape visible.

[5] Sarah W. Goldhagen, "Something to Talk About: Modernism, Discourse, Style," *Journal of the Society of Architectural Historians*, vol. 64 no.2 (2005): 144-167.

[6] Colin Rowe and Robert Slutzky, "Transparency: Literal and Phenomenal," *Perspecta*, (1963): 45-54.

Although the preference of the architects is a limited palette of materials: concrete, red brick, wood and natural stone, all these are utilized in a significant variety within the building. True to their nature, they all are used in their authentic state without any paint or claddings.

Figure 14: Pallette of materials.

Exposed concrete is the major element which gives the main identity of the building. Almost all the wall surfaces are made out of exposed reinforced concrete either with or without a structural necessity. Cement is used not only in precast concrete load-bearing elements and waffle slabs but also in partition walls made out of cement blocks and *brise-soleils*, water spouts, seating units, tables, and sculptures. All of them are casted with a distinct type of mould.

Figure 15: Different usages of cement: partition walls, brise soleils, water spouts, seating units , tables and sculptures.

There are six different types of exposed concrete mould textures made out of different wood from different tree types. Natural stone is used as a floor material to cover the circulation areas, canteen floor, the Dean's Office entrance platform and the *Göbektaşı* area. The variety in color, type, and dimensions of natural stones create homogeneous yet alternating floor patterns. Exposed red brick is used both in the interior and exterior walls of the building. Although the use of wood in build in furniture, doors, and frames is limited to a single type (oak), the dimensions of the floor skirting, the roof of the skylight, curtain and cable covers, seating units and particularly the mold textures create a variety in their application. Pebble stone is used as a boundary material around the stairs, at the base of the vertical structural elements and under the *Göbektaşı* platform and applied as washed-concrete surfaces. The source of the pebbles is the same river although their dimensions and color vary according to their applications within the building.

The unique connection details between different materials such as the seamless connection of exposed concrete walls and the wooden skirting boards, the pattern of tie rod holes and joint gaps and the custom-made details of the build in furniture, enhance the significance of the Faculty of Architecture building.

Figure 16: Unique connection details.

Figure 44: Interior and exterior views from the faculty of architecture.

4.3.2. Spatial Qualities

"Grid" is used as a guiding tool by the architects for their design decisions at every scale. The plan of the overall campus, landscape design, structural elements in the building and the placement of finishing elements on the wall and floor surfaces are all guided by the invisible lines of a strong grid-iron system. As a mapping device and a tool for abstraction, this system also guides the dimensions and the locations of all the landscape and architectural elements, including the waffle system of the ceilings, façade divisions, window and door dimensions and the layout patterns of the concrete blocks and the natural stone flooring.

The composition of the fragmentation of the masses represents a "geometric rigor"[7] and defines the zones of different functions in the building. Design studios, classrooms, administrative offices and service spaces are all indicated by volumetric divisions that are clearly expressed from the outside. The meticulous positioning of the masses and the complex plan layout creates a variety. There is a complex circulation pattern and different functions flow into each other with varying proximity. The "open plan" idea is articulated with this uninterrupted circulation layout. The "dynamically asymmetrical distribution of spaces"[8] and the meticulous placement of the structural elements also support this plan decision.

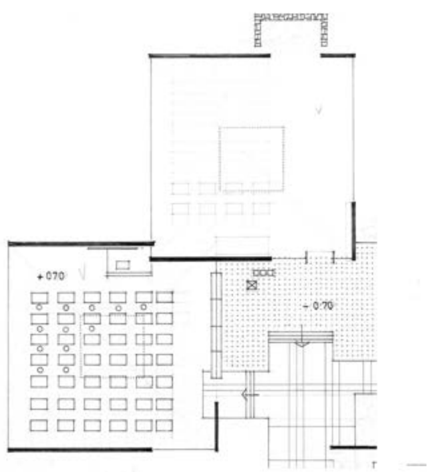
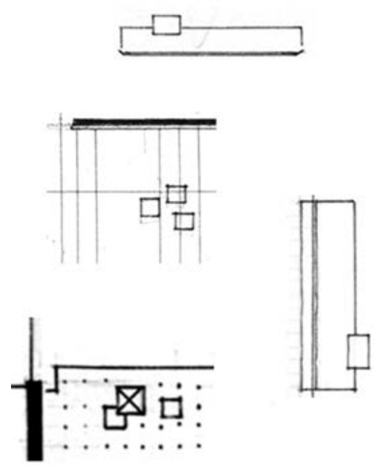
Moreover, the large glass surfaces transform the cubical masses of the faculty building into floating volumes. The explicit open plan of the interior intensifies the visual and physical continuity of the spaces and provides light sources for the circulation areas and common spaces. These particular spatial characteristics of the METU Faculty of Architecture are the indication of a Modernist architectural approach.

[7] Sarah W. Goldhagen, "Something to Talk About: Modernism, Discourse, Style," *Journal of the Society of Architectural Historians*, vol. 64, no.2 (2005): 144-167.

[8] *Ibid.*


MİMARLIK FAKÜLTESİ



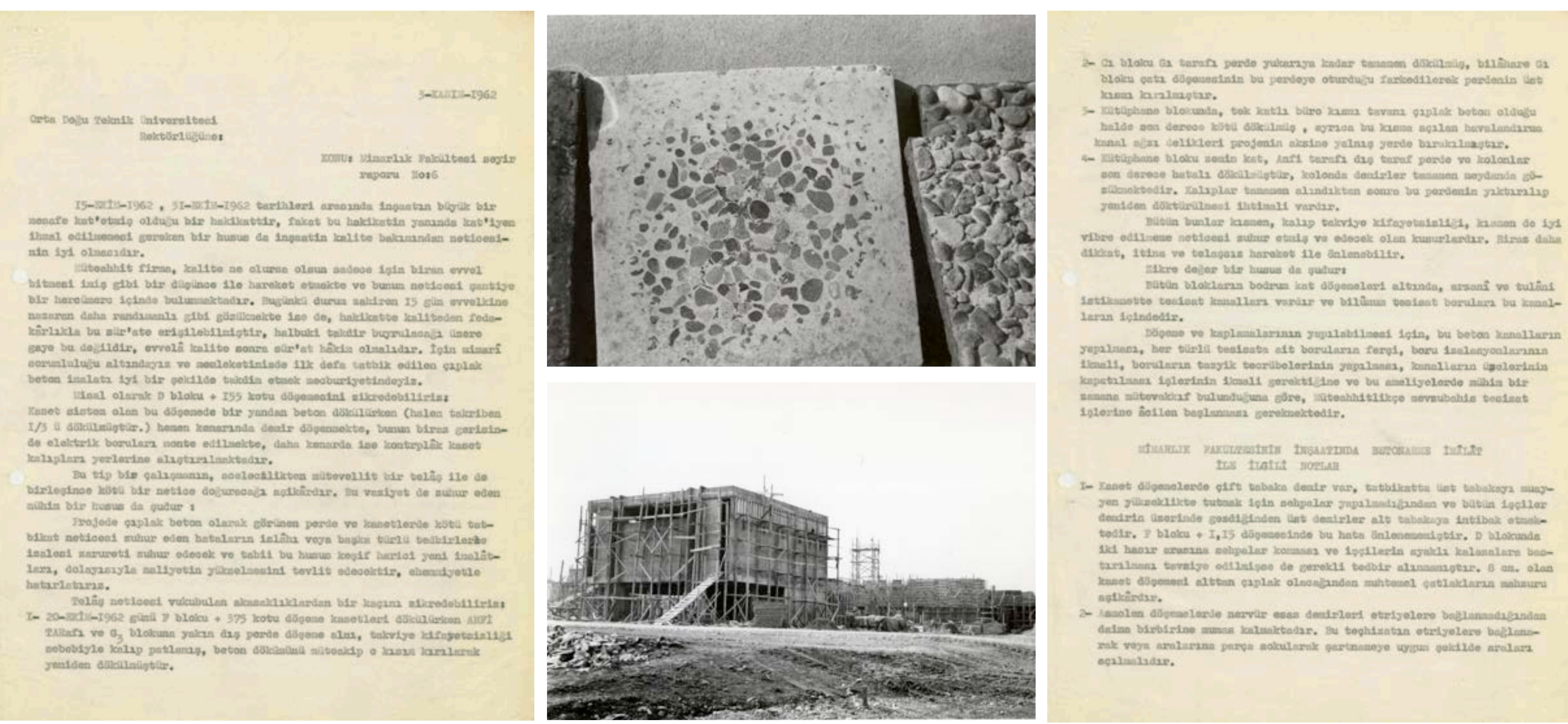
4.3.3. Built-in Furniture, Abstract Murals, Art Object

Architecture in the Modern period or more specifically in the International Style was believed to be independent of both the context and the place. Yet the METU Faculty of Architecture building is "placed" in such a manner that its location could no longer become "anyplace". A series of art works, built-in furniture, and murals help in the making of this building complex site specific and context bound. Local artists and sculptors made their contribution to transform these otherwise "self-referential" masses into unique volumes. Stained glass is used as the only source of color and a means of "decoration" in the building complex. Its application, particularly in the auditorium openings, changes the light quality of the interior throughout the day. The fountain placed in a U-shaped shear wall under the arcade marks the entrances of the museum and the auditorium. The fresco including the plan of the Faculty of Architecture forms a background to this fountain, which is now called "lovers' fountain" as it requires two people to be able to drink water from it. This fountain, and particularly the plan of the building, has been perceived as the signature of the architects.

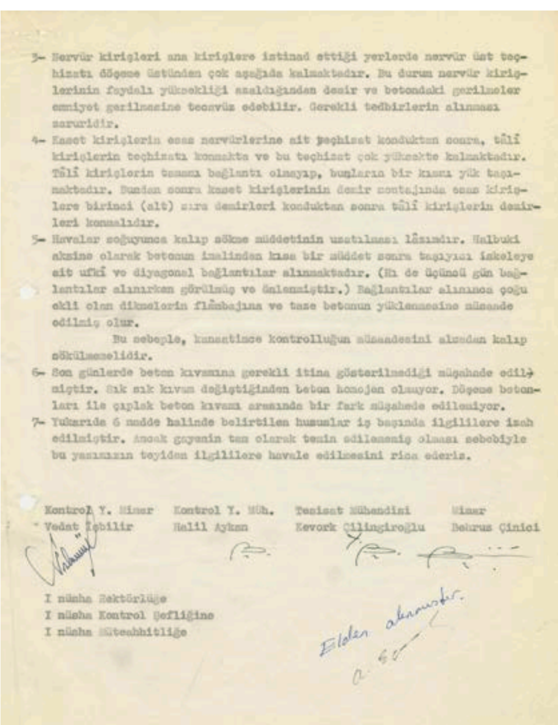
A second fountain is located in one of the inner courtyards of the main education building. Its plastic form, scale and positioning create a contrast with the rest of the building. The linear concrete seating units project from the glazed surfaces of this courtyard. Cladded by narrow wooden stripes, they provide space for chess games, studio critics, student protests and become the meeting point for the users of the building. The concrete pots that are placed randomly in the faculty building are mostly original test blocks, the remains of the concrete quality tests made on the site during the construction of the building. The reinforced concrete tables and sitting units and the *Göbektaşı* are the representatives of architectural decisions made by the architects for the whole building. The method applied to bring two squares together in plan at every scale and the surface quality of the exposed concrete units, are two main examples of this fact.

Figure 17: Built-in furniture, abstract murals and art objects.

Figure 18: Construction process reports, SALT Research, Altuğ-Behruz Çinici Archive.



4.4. Material-Technical Significance



3- Nervür kirişleri ana kirişlere istinad ettiği yerlerde nervür üst teçhizatı döşeme üstünden çok aşağıda kalmaktadır. Bu durum nervür kirişlerinin faydalı yüksekliği azaldığından demir ve betondaki gerilmeler emniyet gerilmesine tecavüz edebilir. Gerekli tedbirlerin alınması zaruridir.

4- Kaset kirişlerin esas nervürlerine ait teçhizat konduktan sonra, tâli kirişlerin teçhizatı konmakta ve bu teçhizat çok yüksekte kalmaktadır. Tâli kirişlerin tamamı bağlantı olmayıp, bunların bir kısmı yük taşımaktadır. Bundan sonra kaset kirişlerinin demir montajında esas kirişlere birinci (alt) sıra demirleri konduktan sonra tâli kirişlerin demirleri konmalıdır.

5- Havalar soğuyunca kalıp sökme müddetinin uzatılması lâzımdır. Halbuki aksine olarak betonun imalinden kısa bir müddet sonra taşıyıcı iskeleye ait ufkî ve diyagonal bağlantılar alınmaktadır. (Bu de üçüncü gün bağlantılar alınırken görülmüş ve önlenmiştir.) Bağlantılar alınınca çoğu ekli olan dikmelerin flâmbajına ve taze betonun yüklenmesine müsaade edilmiş olur.

Bu sebeple, kanaatimce kontrolluğun müsaadesini almadan kalıp sökülmemelidir.

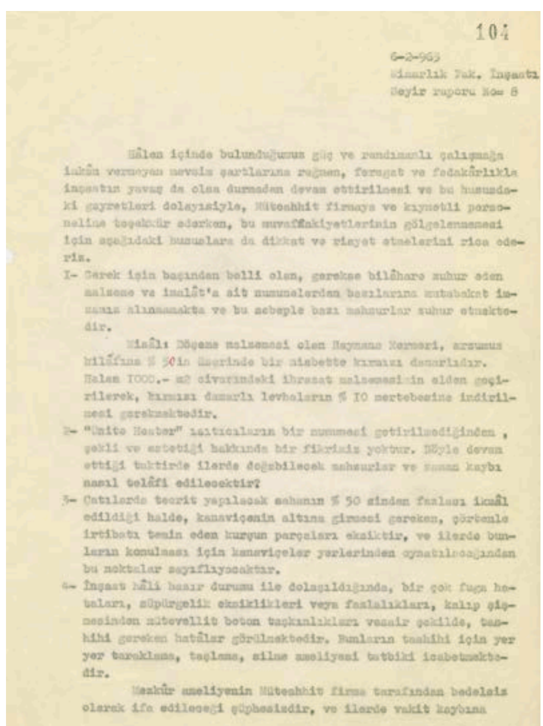
6- Son günlerde beton kıvamına gerekli itina gösterilmediği müşahade edilmiştir. Sık sık kıvam değiştiğinden beton homojen olmuyor. Döşeme betonları ile çıplak beton kıvamı arasında bir fark müşahede edilemiyor.

7- Yukarıda 6 madde halinde belirtilen hususlar iş başında ilgililere izah edilmiştir. Ancak gayenin tam olarak temin edilememiş olması sebebiyle bu yazımızın teyiden ilgililere havale edilmesini rica ederiz.

Kontrol Y. Mimar	Kontrol Y. Müh.	Tesisat Mühendisi	Mimar
Vedat İşbilir	Halil Aykan	Kevork Çilingiroğlu	Behruz Çinici

I nüsha Rektörlüğe
I nüsha Kontrol Şefliğine
I nüsha Müteahhitliğe

Elden alınmıştır.
a. 6?



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Mimarlık Fak. İnşaatı
Seyir raporu No: 8

Hâlen içinde bulunduğumuz güç ve randımanlı çalışmağa imkân vermeyen mevsim şartlarına rağmen, feragat ve fedakârlıkla inşaatın yavaş da olsa durmadan devam ettirilmesi ve bu husustaki gayretleri dolayısiyle, Müteahhit firmaya ve kıymetli personeline teşekkür ederken, bu muvaffakiyetlerinin gölgelenmemesi için aşağıdaki hususlara da dikkat ve riayet etmelerini rica ederiz.

1- Gerek işin başından belli olan, gerekse bilâhare zuhur eden malzeme ve imalât'a ait numunelerden bazılarına mutabakat imkânı alınmamakta ve bu sebeple bazı mahzurlar zuhur etmektedir.

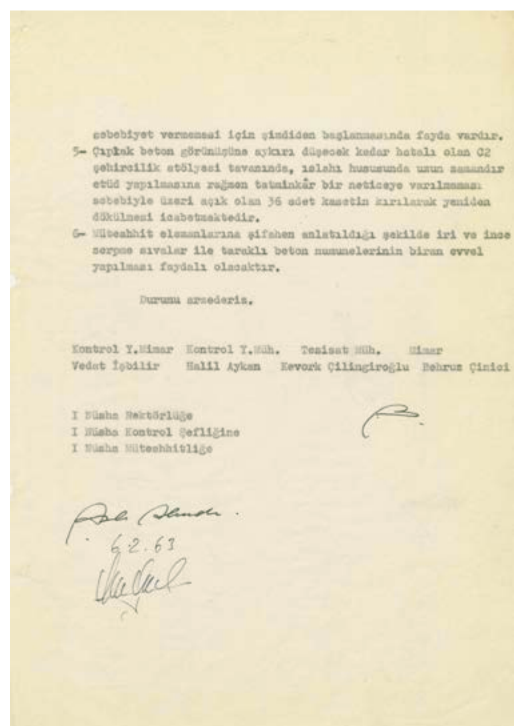
Misâl: Döşeme malzemesi olan Haymana Mermeri, arzumuz hilâfına % 50'in üzerinde bir nisbette kırmızı damarlıdır. Halen 1000.- m2 civarındaki ihrazat malzemesinin elden geçirilerek, kırmızı damarlı levhaların % 10 mertebesine indirilmesi gerekmektedir.

2- "Ünite Heater" ısıtıcıların bir numunesi getirilmediğinden, şekli ve estetiği hakkında bir fikrimiz yoktur. Böyle devam ettiği taktirde ilerde doğabilecek mahzurlar ve zaman kaybı nasıl telâfi edilecektir?

3- Çatılarda tecrit yapılacak sahanın % 50 sinden fazlası ikmâl edildiği halde, kanaviçenin altına girmesi gereken, çörtenle irtibatı temin eden kurşun parçaları eksiktir, ve ilerde bunların konulması için kanaviçeler yerlerinden oynatılacağından bu noktalar zayıflıyacaktır.

4- İnşaat hâli hazır durumu ile dolaşıldığında, bir çok fuga hataları, süpürgelik eksiklikleri veya fazlalıkları, kalıp şişmesinden mütevellit beton taşkınlıkları vesair şekilde, tashihi gereken hatâlar görülmektedir. Bunların tashihi için yer yer tarakl ama, taşlama, silme ameliyesi tatbiki icabetmektedir.

Mezkûr ameliyenin Müteahhit firma tarafından bedelsiz olarak ifa edileceği şüphesizdir, ve ilerde vakit kaybına



sebebiyet vermemesi için şimdiden başlanmasında fayda vardır.

5- Çıplak beton görünüşüne aykırı düşecek kadar hatalı olan C2 şehircilik atölyesi tavanında, ıslahı hususunda uzun zamandır etüd yapılmasına rağmen tatminkâr bir neticeye varılmaması sebebiyle üzeri açık olan 36 adet kasetin kırılarak yeniden dökülmesi icabetmektedir.

6- Müteahhit elemanlarına şifahen anlatıldığı şekilde iri ve ince serpme sıvalar ile taraklı beton numunelerinin biran evvel yapılması faydalı olacaktır.

Durumu arzederiz.

Kontrol Y.Mimar	Kontrol Y.Müh.	Tesisat Müh.	Mimar
Vedat İşbilir	Halil Aykan	Kevork Çilingiroğlu	Behruz Çinici

I Nüsha Rektörlüğe
I Nüsha Kontrol Şefliğine
I Nüsha Müteahhitliğe

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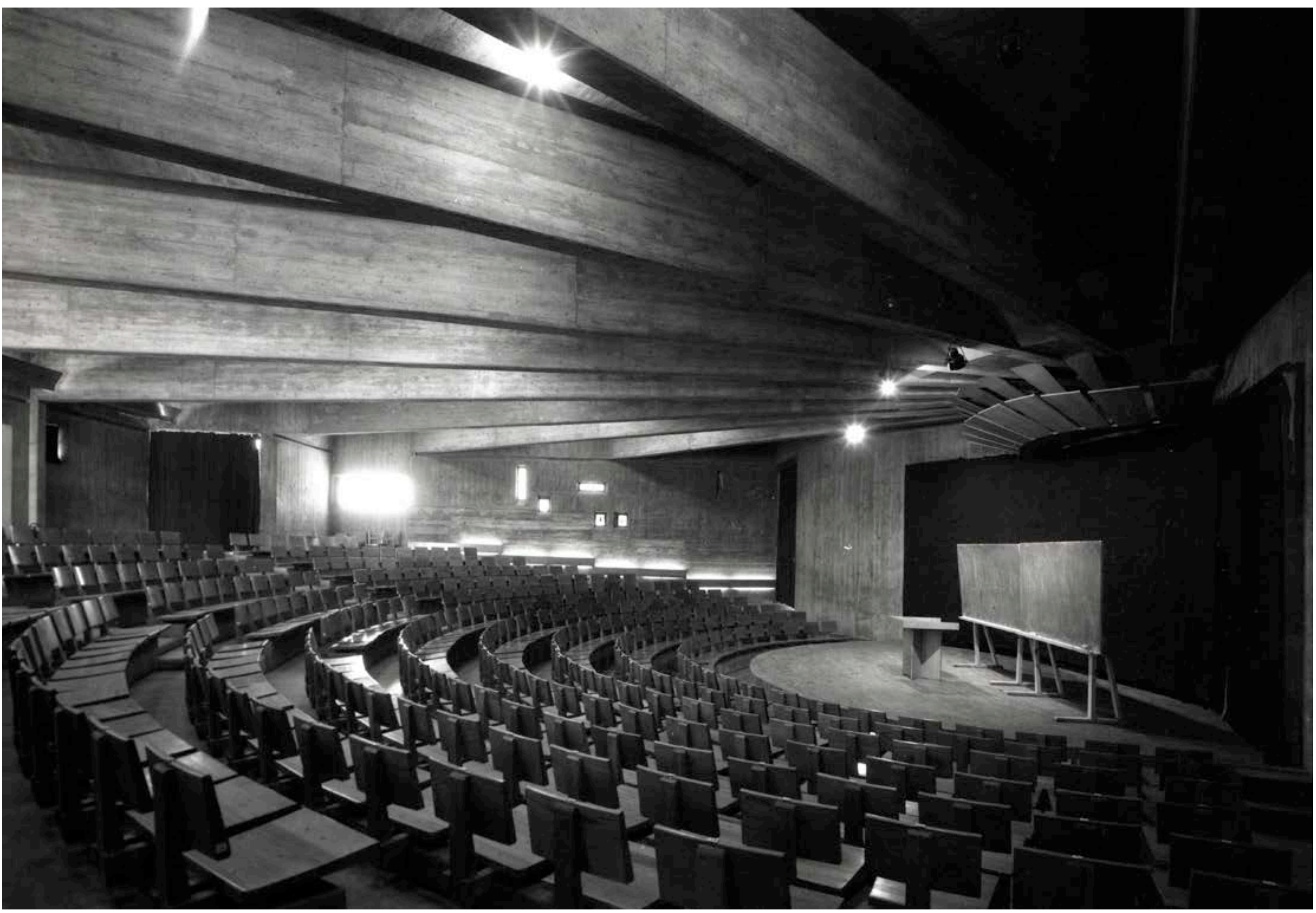


4.4.1. Structural Significance

"Beton dökümünde telaş ve heyecana lüzum yoktur"
(There is no room for hastiness and rush during the concrete casting.)
Behruz Çinici - Construction Reports

"Memlekette ilk defa tatbik edilen çıplak beton imalatı"[9]
(This is the first application of exposed concrete in Turkey.)
Behruz Çinici - Construction Reports

Çinici Architects kept a "diary" starting from the first day of the construction of the Faculty of Architecture building complex (figure 19). This book is used as the main source of information to understand the decisions taken on the site. Besides the "Construction Diary", the architects' construction reports, interviews and the black and white photographs of the construction site give data regarding the significance of the structure.

Çinici Architects noted in these documents that the shear wall design was made according to the American Concrete Institute (ACI) standards. These standards are high and the overall quality of the walls in the faculty building was interpreted as an "art work" compared to the national standards valid in the 1960s. This was also supported by the concrete material analyses conducted in this research. The same standards apply to the waffle slabs, which are one of the most characteristic components of the structural system. During their production in the construction site, two main application strategies were significant: the quality of the mould/formwork and the characteristics of the fresh concrete.

[9] METU Faculty of Architecture Building Construction Reports, SALT Research Altuğ-Behruz Çinici Archive.

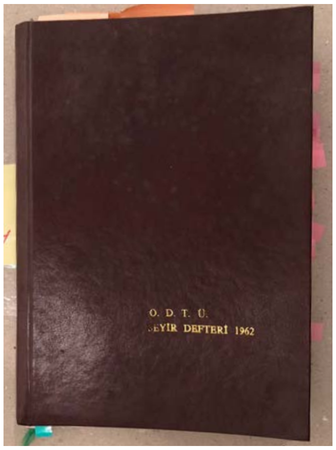


Figure 19: Çinicis' Construction Notebook

[10] METU Faculty of Architecture Building Construction Reports, SALT Research, Altuğ-Behruz Çinici Archive.

Throughout the construction of the building, the mould/formwork, which ensures both the quality and the load bearing capacity of the structural members, had been scrutinized and revised when necessary.[10] Moreover, specific additives such as "PLASTOCRETE-N", were used to achieve best results particularly for perfect surface quality which is also verified in material analyses.

The architects asked for the use of St-III steel for the construction of radial beams of the amphitheater and their use was very exceptional in the 1960s, in Turkey. Moreover, they particularly asked for continuous, 24m long St-III steel bars to eliminate the construction and concrete placement issues due to the extensive use of overlapped bars. Several waffle slab applications were demolished and re-produced following the inspections made by the architects. Besides structural performance quality, architects were monitoring the aesthetic outcomes of the construction details. The tie rod holes and the joint gap lines of the formwork of the shear walls have been placed with great care. The dimensions and the texture of the wood used for the production of the formwork was selected by the architects. In other terms, the engineering concerns and decisions supported the "architectural desire".

Low water-cement ratio, reduced concrete slump, and relatively long duration of vibration have been applied for an uninterrupted and fine texture of structural members, particularly for the shear walls and the waffle slabs. The increased amount of cement also yielded high concrete strength which has also been observed in Schmidt Hammer readings. The observed segregation, which is found very rarely in the faculty building, may be a side effect of the elongated vibration periods.

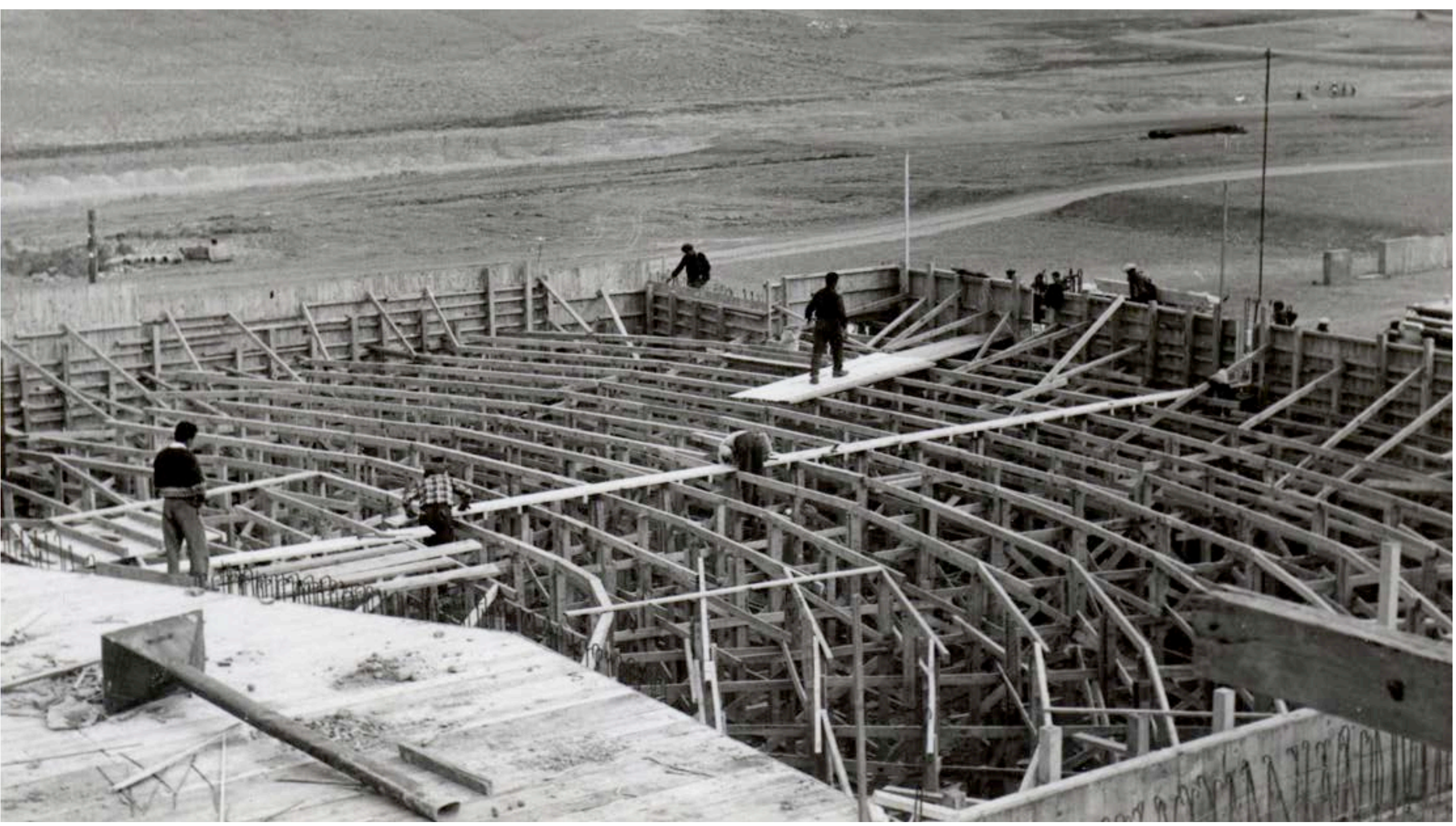


Figure 20: Construction process of METU Faculty of Architecture Amphitheater, SALT Research, Altuğ-Behruz Çinici Archive

All the prefabricated members of the aluminum window frames had to be placed precisely into the formwork before the concrete moulding process. The architects indicated in their notes that scheduling the different components of the construction on the site was very important so as not to harm the aesthetic and structural qualities of the exposed surfaces. Concrete of the shear walls and the stairs connected directly to those shear walls have been poured simultaneously to achieve the proper structural load transfer mechanism and avoid cold forming.

The ratio of the shear walls is very effective in resisting the lateral earthquake forces in the building. This ratio can be considered as comparatively very high which helps the identification of the building as a "resilient building". Therefore, it can be expected that the building will be at "immediate occupancy performance state" just after an earthquake. The footing system of the building complex enhances its structural significance. The use of continuous footing is inevitable in the single formation of masses divided by expansion joints. In other words, each unit in the building complex was carried by its perimeter. The rare instances of columns were supported by single footings which eliminate the need for further separations.

Figure 21: Construction process of METU Faculty of Architecture Amphitheater, SALT Research, Altuğ-Behruz Çinici Archive.
"There should be no more than 50-80 cm between the funnels used in the curtain castings."[11]

Figure 22: Construction process of METU Faculty of Architecture Main Building, METU Archive.
"The horizontal bars have been placed as 8/20."[12]

[11] METU Faculty of Architecture Building Construction Reports, SALT Research, Altuğ-Behruz Çinici Archive.

[12] Ibid.

4.4.2. Material Significance

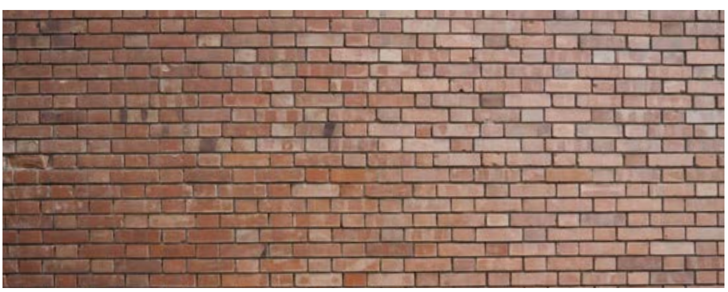
As stated in the previous parts of this report, the Faculty of Architecture building complex is one of the first buildings in Turkey built in brutalist aesthetics with the dominant use of exposed concrete (fair-faced reinforced concrete) structural elements and exposed brick masonry units. Together with a rich variety of concrete used as white concrete solid blocks, white concrete *brise-soleils* and concrete mosaic floor slabs, it is also the first building constructed in the METU Campus with the same genre. Plexiglas sheets used as the transparent component of the skylight lights on the roof are also representative of a pioneering and innovative approach for Turkey in the 1960. The rich variety of concrete, as well as red brick and Plexiglas, specifically produced for this building, reflect the unique production technologies of those years in the country that deserve further comprehensive research particularly focusing on the detailed material production specifications.

The building exhibits the combinations of a rich variety of building materials with excellent aesthetics. These materials have been preserved in good state due to their very good material quality and durability.


The particular properties of 60-year-old exposed concrete, such as:
- the good mechanical strength in present situation,
- the relatively higher effective porosity around 13% by volume,
- the abundance of individual large-sized circular pores,
- the rich variety of aggregate types in coarse and fine grain sizes,
- the quite a low portion of cement binder including well-formed cement hydration products,

highlight the good quality of the concrete that is used in the building complex and signal the use of specific additives including an air-entraining additive in concrete mixes.

The good quality of the exposed concrete is confirmed with its good state of preservation in the harsh climatic conditions of Ankara for almost 60 years. It is important to point out that the builders of the Faculty of Architecture building complex made efforts to use the best quality concrete of the time. In addition, all interior and exterior surfaces of fair-faced reinforced concrete components bear the imprint of the wooden formwork at high precision resulting in a remarkable texture. This also shows the special efforts of the architects to form that texture on concrete surfaces during its casting.




The exposed brick used in the masonry walls of the building made an important contribution to the creation of an overall architectural and structural aesthetic in the building. While representing the highest production technology of its period, the alteration of the building materials helps further to create attractive spaces. The particular properties of the red brick, such as:

- its high porosity,
- considerable surface strength performance, and
-firing temperature around 800-900^{o}C,

indicate that it is a factory (machine-moulded) brick manufactured without extrusion or pressing of the clay mixture. Absence of severe decay in those 60-year-old brick units verifies their good state of preservation and signals that they are brick materials of high quality.

4.5. Environmental Significance

Buildings are under increasing pressure, due to their large share in the total energy consumption and environmental impact, primarily CO2 emissions. Therefore, there is much emphasis worldwide on maintaining building performance of the existing stock and recognizeing the significance of adaptation, maintenance, and retrofit.

Mid-century Modern buildings relied on much energy to construct and operate, as they were during an era when energy was fossil-based, inexpensive, and accessible. Moreover, environment-related building codes that regulate energy use and environmental impact of the built environment were very few, if not non-existent, at the time.

As a result, many Modernist buildings constructed during the 1950s-1980s are unsustainable, inefficient in energy use and sometimes practically uninhabitable. Modern buildings have a great potential in reducing the environmental impact, due to their sheer size of their stock and their current state of maturation.

Figure 23: Behuz Çinici, visiting METU Campus, METU Faculty of Architecture Archives.

The Climate

The METU Faculty of Architecture building is environmentally significant due to its climatic context. Ankara is located in Central Anatolia, which experiences a dry continental climate with hot summers and cold, snowy winters, where both seasonal and diurnal temperature differences are high. The climate change projections for the year 2060 in this region predict an annual average temperature increase of 3.2 C°, while the cooling degree days are expected to triple. In line with this, the heating load of buildings are expected to decrease as a result of warmer winters. It is also predicted that the intensity, frequency and duration of heat waves and drought will be on an increasing trend. The climatic pressure is expected in have an impact on building resource use, environmental impact and occupant comfort.

METU Re-forestation

METU has been afforested since the early 1960's with the efforts of the University employees and students and now it is surrounded by 41 hectares of forest. The trees, the lake and the overall landscape have been designed, implemented and maintained during the course of the life of the building. Today this man-made forest is the largest green area in Ankara. Since the establishment of the campus, the plantation of trees has been an annual event organized by the rectors of the university that has formed a strong tradition. This natural heritage is important for micro and macro ecology in the city and the METU Forest won the Aga Khan Award in 1993-95 cycle. It is an outstanding example of landscape design with a growing variety in fauna and flora.

Figure 25: METU Reforestation, 1960s, METU Faculty Archives.

Water Supply to the Campus

Water is supplied to the campus from three wells in Eymir Lake. This includes 50km of potable water pipe and 23 km of wastewater. METU is also connected to the city water grid. The campus, in total, consumes 1.2 million m3 water per year. The university also maintains a 2,000 m3 water tank in the nearby neighborhood- Oran. The system is installed with several smart meters and a water treatment center. The preservation of the water resources, waste-water treatment, storm water and gray water storage and environmental monitoring are currently prioritized in the water vision of the university. The original project was designed by Suleyman Demirel, the 9th president of the country.

Figure 24: Water supply to the campus.

The Energy Systems in the Campus

The METU Campus project is unique in terms of its infrastructural system. As stated before, it is the first application of central heating system at this scale in the country until the 1960s. The underground tunnel system is also a "first" in Turkey. Since its establishment, the capacity of the planned system has never been increased. According to the information gathered for the abovementioned USTDA Smart campus project that is currently being carried out at METU, the Main Campus heating load is provided by the central heating plant. Water necessary for heating/cooling and a portion of the daily water usage are supplied from Eymir Lake (100 Liter/second). Thirty percent of the daily water usage is supplied from wells in the campus.

For heating purposes, hot water and steam is generated using natural gas. The annual natural gas consumption is approximately 11,000,000 cubic meters. However, monthly utility bills showing building energy consumption of the campus buildings are non-existent. There is no central electrical power source on campus and all electricity is provided from the electric grid. The use of renewable energy for electricity generation, especially by use of Photovoltaic (PV) panels, is a priority area for the campus. There is a 50kW PV panel implementation on the roof of the Ayaslı Research Center at the Electrical and Electronics Engineering (EEE) Department, and another 50kW roof-top PV implementation at the Mechanical Engineering Department. An R&D project, which is supported by EMRA of Turkey (EPDK), is ongoing in collaboration with Başkent EDAŞ and METU. The project scope proposes to deploy a microgrid at the Ayaslı Research Center. In addition, 50kW PV panels will be installed on the A-Building roof in the EEE department with the support of GAMA Energy Co. in Turkey. These projects will enable a significant infrastructure for microgrid implementations in METU.

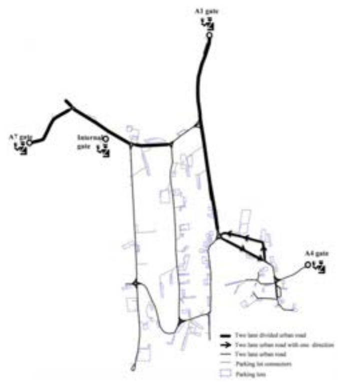


Figure 26: METU campus study road network structure.[14]

Traffic in the Campus

The campus was originally designed as a pedestrian-friendly environment with strict separation of vehicular and pedestrian traffic, and there are access limitations at the entries. There are a number of different modes of transportation to and from the campus, including *dolmuş*, buses, services, private vehicles, and pedestrians. According to a recent study, it was found that 41 % of passengers came to campus by public transport, 39 % of them came by private car and 13 % of them preferred to use *dolmuş* and 7% walked to the campus.[13] The same study also calculates the total number of vehicles entering the campus in working hours as 6,491. Following the increase in automobile ownership and use in Ankara, the number of vehicles entering the METU campus nowadays exceeds 15,000 per day (10492 vehicles during the work hours). This increase in the vehicular traffic has started to threaten both campus walkability and also increases the carbon output. The lack of sufficient car parking is another problem that the campus faces.

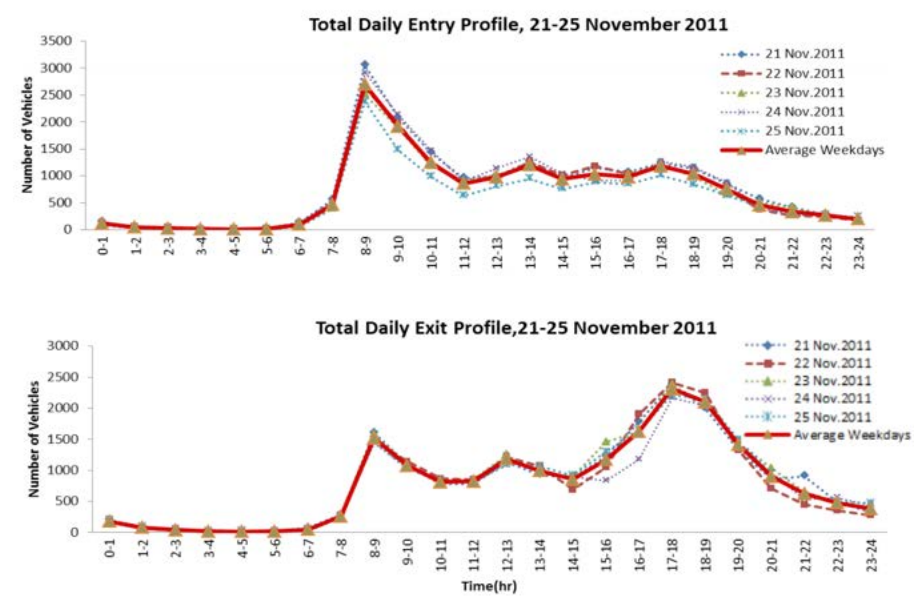


Figure 27: Total daily Entry and exit profiles to and from the campus by motor vehicles.[15]

Figure 45: METU DSI 50th year pond.

METU DSI 50th Year Pond

This shallow freshwater lake was constructed in 2006 during the 50th year celebrations of the University. Since then, it has been used as a laboratory for comprehensive experiments exploring the harms of microplastics to fresh water resources and as a training site for student clubs. It also helps the development of a micro environment for the naturally growing flora and fauna.

[13] Oruç Altintaşı, "Assessment of Scenarios For Sustainable Transportation At Metu Campus" (master's thesis, Middle East Technical University, 2013).

[14] *Ibid.*

[15] *Ibid.*

Archaeological Sites in the Campus

METU is unique also for its archeological sites dating back to the Early Bronze and Phrygian periods. The first archaeological site to be investigated within the METU Campus is located at Ahlatlıbel. Koçumbeli and Yalıncak archaeological sites located on the skirts of the highlands 2km north of Ahlatlıbel, have drawn the attention of the archaeological communities due to the research and excavations carried out in the 1960s. As a result of the excavations carried out in the METU Campus in recent years, new archaeological sites have been recognized. Among these sites, a Hellenistic period farm settlement with a fortification wall found on the bank of Eymir Lake and a late Roman/Byzantine period settlement exposed during extension works of the Konya Highway are significant. Founded in 1969, METU Archaeological Museum hosts various archaeological objects recovered from the sites of Koçumbeli and Yalıncak. It is the first university museum in the country with a growing collection enriched by archaeological findings from its own campus.

Occupancy

The Faculty of Architecture building is actively used throughout the education season by the students, academics and administrative staff as well as the visitors. Throughout the years, both the number of students admitted to the faculty as well as the staff have tripled in number. The faculty building is currently facing problems regarding the lack of space for both education and studying, and overcrowding of the existing rooms. Overcrowding has negative effects on indoor air quality and occupant comfort, especially in the design studios that are in use for extended periods of time. Maintaining the expected comfort levels of the occupants remains a critical challenge for the building in a warming climate, with an increasing number of occupants and raised expectations regarding indoor environmental conditions.

The Building form

The horizontal spread of the building complex over the inclining topography is one of its defining characteristics. The building form expands in the north-south direction. A virtual bounding box of the building would have 90.08-meter width in the east-west direction, and 141.56-meter length in the north-south direction. The orientation of the building is in conflict with the conventional passive building design strategies, in which the main building orientation should be within 30° of south. Therefore, the east and west facades of the building are exposed to direct sunlight during the mornings and late afternoons. This results in indoor overheating in the rooms on the east and west facades, and the need for solar control for problems of visual glare.

The building has a very fragmented form. Fragmented building forms are typically avoided in climates that require the minimization of heat loss in winter. The increased external surface area of the building contributes to an increase in conductive heat loss through the envelope, negatively influencing the heating energy use during winter. Moreover, the horizontal building form creates a very large contact area with the ground. The ground acts as a stabilizing component in the heat balance between the building and its environment, especially during the summer. The horizontality also produces increased spatial depth throughout the building, leading to reduced daylighting levels and reduced natural ventilation potential. The strategic positioning of unique architectural elements such as the internal courtyards and skylights have the potential to introduce daylight and fresh air into the building, contributing to the indoor environmental quality.

The windows contribute not only to the building's architectural significance, but also to its environmental performance. The window-wall ratios of the north, east, south and west facades are 11.18%, 29.41%, 20.06% and 33.74% respectively in the focus building area (the F block). While sustainable building practices aim to reduce windows' exposure to the east and west, the Faculty of Architecture building has its largest window area on these orientations. Moreover, the majority of the classrooms and studios are facing the west façade, where solar control is difficult. The field measurements in a west-facing classroom indicate extreme overheating during the hottest six weeks of 2018. The *brise-soleil* on the west and overhang on the east facing windows fall short of providing shade. On the other hand, the deciduous trees in the immediate neighborhood can help provide solar shading from mid-spring until late fall to the spaces located on the ground floor on the building. The lack of effective shading and natural ventilation for cooling are identified as the primary reasons for overheating. However, this problem is not experienced by the occupants at its most severe, because the building is only partially used during summer (July - August).

Materials

The exposed concrete used in external walls do not comply with the thermal transmissivity (U-value) values specified in the "Thermal Insulation Requirements in Buildings" standard. This results in increased rate of heat transfer through the wall section. On the other hand, the high thermal mass, high specific heat capacity, moderate thermal conductivity and high density of the concrete wall material can help to moderate internal temperatures for buildings. The original single-glazing window material was replaced in the beginning of the 2000s to a double-glazing window with aluminum frames, which is slightly above the values mandated by the same Turkish Standard. Uncontrolled infiltration through the façade is expected to be high. The roof, originally uninsulated, was given XPS thermal insulation, which reduces the heat loss during winter.

Simulation-based analyses

A number of simulation based analyses were made to assess energy use, CO2 emission and occupant comfort for different building interventions. Results indicate the importance of reducing uncontrolled infiltration, increasing roof insulation thickness and improving glazing thermal transmissivity to reduce heating energy use. The primary source of CO2 emission after heating energy in the building is lighting, which can be improved with higher-efficiency light bulbs. Occupant comfort due to overheating can be improved by reducing window solar heat gain, increasing the rate of natural and cross ventilation, applying reflective coating on concrete and the use of solar shading devices.

4.6. Summary of Significance

Social, Cultural and Historical Significance

A. The ongoing urban development, particularly the construction of the new highways, is damaging the integrity of the campus. The campus is also under continuous threat by the policy makers of the local/central governments and their infrastructural projects.
B. METU Faculty of Architecture is a state university. Therefore, it is the responsibility for the government to submit an application for the international listing of the building. However, this doesn't seem probable in the foreseeable future due to the current political disputes.
C. The understanding of conservation strategies applied in Turkey are mostly limited to the pre-Modern periods, mainly due to the multiple layers of history in Anatolia. Modern buildings are not considered as part of this historical heritage.
D. There is a lack of previous systematic studies regarding the architecture and history of the building.
E. The building has potential to act as a model for future developments in the campus and in the country.

Architectural Significance

A. The building is a masterpiece of Late Modern Architecture in Turkey. It is the physical and spatial manifestation of the "Tropes of Modernism", with specific properties such as the flat roof, exposed materials, transparency, open plan/continuous circulation, large glazed surfaces, invisible frames, asymmetrical distribution of spaces, grid-iron organization and functional zoning.
B. The building is unique in its integrity and consistency of design decisions, as well as its built-in furniture, abstract murals, and art objects.
D. The building is significant in its high quality of materials, the treatment of spatial qualities and the consistency in meticulous detailing.
E. The architectural intentions of the architects are supported by the engineering solutions in the building.
F. The building is part of a coherent unity of the campus.
G. The separation of pedestrian circulation and vehicular traffic in the campus is a primary design decision.
H. The building is in a listed, award-winning forestation area. The natural environment, in which the campus is located is significant with its flora and fauna, Lake Eymir and it archeological sites.

Functional Significance

A. The building functions as a school of architecture with a very high reputation in the country and in the region.
B. The Faculty of Architecture houses the first established Conservation of Cultural Heritage Graduate Program in the country.
C. Apart from the central material and structure laboratories in the university, the Faculty of Architecture has many research laboratories in various expertise areas, such as Building Simulation Laboratory, Building Materials Library, Computer Lab, Digital Design Studio, Modelmaking Workshop, Materials Conservation Laboratory, Photogrammetry Laboratory and Photography Laboratory.

Material-Technical Significance

A. The first and unique applications of specific structural systems (concrete waffle slab, radial beams), fan coil system, water purification center, central heating and infrastructural tunnel in Turkey.
B. It is identified as a resilient building. The ratio of shear walls in the building, that are very effective in the lateral earthquake forced, is comparatively high.
C. The footing system of the building complex enhances its structural significance.
D. The recently mandated legislations and codes are likely to necessitate physical interventions on the building, which can threaten the architectural qualities and integrity.
E. Exposed concrete used in external walls results in increased rate of heat transfer through the wall section.
F. Rapid growth of METU Technopolis and the lack of sufficient parking spaces threatens the campus forest.
E. Together with a rich variety of concrete used as white concrete solid blocks, white concrete *brise-soleil*, and concrete mosaic floor slabs, it is the first building constructed in reinforced concrete using ACI standards in Turkey.
F. The rich variety of concrete as well as red brick and Plexiglas, specifically produced for this building, reflect the unique production technologies of those years in the country.
G. The building exhibits the combinations of a rich variety of building materials in an excellent aesthetics. These materials have been preserved in good state due to their very good material quality and durability characteristics. high precision in concrete and other materials.

Environmental Significance

A. The increased needs and expectations of the occupants are placing additional pressure on the aging campus infrastructure and buildings. Moreover, the overcrowding of spaces negatively influences the functionality and occupant comfort in the building.
B. Some key design decisions (form, orientation, opening placement) are in conflict with sustainable building design practices.
C. The environmental impact of the infrastructure and buildings is high, due to the lack of sustainable practices such as low-carbon mass-transportation system, energy efficient buildings, and the low rate of non-renewable energy use.
D. Climate change and global warming are expected to have a negative impact on building comfort.

5. DEVELOPING POLICIES

When the research group at METU Faculty of Architecture submitted their project proposal to the Getty Foundation in 2017, their policy statement was very clear. Aware of the political conditions in the country and very rapid infrastructural urban developments in the city, the research team identified two emergency strategies for the conservation of the building: Conservation by Documentation and Creating International Awareness. The documentation process was also one of the major requirements of a conventional conservation plan. Therefore, in this case, documentation procedures served the purpose of the actual conservation of the building. During the course of this two yearlong research, the political context had been relatively stable in the country, which provided the necessary environment for a thorough investigation of the structural, material, and the environmental qualities of the edifice. That also created the hope that the actual conservation of the building would, after all, be possible. Maintain the original function as a school of architecture, sustaining the integrity of the campus and protecting at least a part of the surrounding landscape seemed probable. Thus, the initial conservation strategy, "Local Silence and International Awareness" was re-evaluated by the research team. After this reassessment, the decision was taken to expand the scope of this "awareness" policy to the local stakeholders and seek the possibility of the actual physical improvement of the building.

First and foremost, a Conservation Management Plan should establish the principles for conservation and management of the building, as a modern heritage place, based on its character, values and significance. From the very beginning, the team members developed their research on the premise that the Faculty of Architecture building complex could not be included in any national or world heritage conservation list (see the Assessment of Significance part of this study). Another presupposition was related with the quality of maintenance and workmanship available for the conservation and the restoration of the building. The maintenance workmanship is very poor in the university; and the outsourcing of maintenance facilities is restricted with a very strict bidding system, which mandates the selection of the lowest offer given by the applicants and provides a budget that excludes application control and surveillance mechanisms. The ongoing maintenance and improvement of the faculty building is under the learned surveillance of the Dean's Office. The meticulous control mechanism that was established at first hand by the Dean, who is also an architect and an active participant in this research, may not be sustainable in the current political context.

Therefore, at the beginning, the research team choose to avoid applying hazardous material sample collection and other destructive procedures in the building complex and did not consider physical "restoration", in the most general sense of the term, as an option for the future. All activities and actions had the documentation of the building and its context as their primary goal. In accordance with the founders'/architects' most important design principles, they managed to initiate an awareness campaign and organized a series of academic and social events.

Policies are proposed corresponding with the "Assessment of Significance" chapter. As stated before, the premises below are the introductory policies regarding the two main strategies of the project: "Conservation by Documentation" and "Conservation by Creating Awareness".

- Becoming a model in the preservation of Modern Heritage in the country

- Developing a strong and sustainable relationship among the stakeholders, particularly with the local government

- Maintaining the primary function of the School of Architecture and its building parts

- Maintaining the building's authenticity and integrity, primarily by developing policies for daily maintenance and updating the Dean's Office's Spatial Planning Report

- Following the necessary changes in the legislation to seek the possibilities of being part of national and international "conservation lists" (particularly, UNESCO, DO.CO.MO.MO., National Immovable Cultural Property Registration Lists)

5.1 Conservation by Documentation

The documentation procedures and the formation of the archive (DOME) has been conceived and designed as processes. Rather than the construction of an institution, the idea was to initiate a process of archiving in which “archivization” was seen as a way of preservation. The end product therefore, rather than being a frozen entity, will be a “progressive collection” that is based on a series of collection processes. With respect to the abovementioned needs for information documentation, a Heritage Building Information Model (HBIM) was developed particularly to provide a medium to ensure the sustainability of this process (See Part 2.2). The purpose of the model is the documentation of the building, including the three-dimensional geometry, architectural significance, and the results of the assessment activities; data sharing between the work packages during the project; and data interoperability with the third party analysis tools, such as structural analysis tools and energy performance simulation tools.

The HBIM also has the potential to be used as a long-term digital medium that supports future implementations regarding long-term management activities, including operations and maintenance, major renovation or analysis. This interactive and sustainable medium allows further additions, corrections, and subtractions. The simultaneous visualization of the geometry and the semantic data is useful both for assessment activities and also for sharing the architectural heritage values with a wider audience.

Figure 1: Research group composed of graduate architecture students, working on the archive project.

The HBIM model can be considered as a virtual replica of the building that evolves in time. To ensure the model’s sustainability, a dedicated staff that is responsible for the model maintenance, such as making the additions or transformations to the model in parallel with the actual building, is required. Therefore, the training of the HBIM staff members and their continuous involvement in the physical intervention activities in the Faculty building is important. The future role of HBIM staff is also important to maintain the building’s heritage values, such that the architectural significance (as captured in HBIM) is taken account of during decision-making and actual interventions.

5.2 Conservation by Creating Awareness

Similar to "documentation", the second major policy of the project, "creating international awareness" has already become part of the research processes. The METU Faculty of Architecture building is exhibited in the Venice Architecture Biennale, Greek Pavilion, in Deutsches Architekturmuseum (DAM) and published in the "SOS Brutalism. A Global Survey", in 2017. The project is already part of the Casablanca-KIM Workshop in February, DO.CO.MO.MO. Conference in Berlin and is exhibited in TUDelft in May 2019. Besides international recognition, the research team has already initiated a series of activities such as the social media project #HugtheFaculty, an alumni day exhibition, Keeping It Modern wall, and a website for the Keeping It Modern project.

The following section includes a list of fulfilled and planned activities, collaborations and research, which are presented more in detail, in the following chapter "Research Activities and Media Coverage".

[1] For further information see the section: 6. Research Activities and Media Coverage

Figure 2: Circulation model of the faculty building in the Greek Pavillion Venice Architecture Biennale, 2018.

Exhibitions
• SOS Brutalism - Exhibition in Deutsches Architekturmuseum (DAM), 2017
• Venice Architecture Biennale, Greek Pavillion, May - October 2018
• SALT- Commissioners' Exhibition, March 2018
• Representing Itself | METU Lodgings Documented, 2016
• Archive I Exhibition: Aesthetization of the Invisible | Carving the METU Archive out, 2017
• Archive II Exhibition: Moment, Memory and Memoir | '67 Summer Internship, 2017
• Alumni Day Exhibition, September 15, 2018
• Archive III Exhibition: First Year Design Education at METU, November 2019
• Archive IV Exhibition: Representing Itself | METU Faculty of Architecture, January 2019
• TUDelft Research Week Campus Exhibition, May 2019
• Archive #11, Opening Ceremony of the Faculty Archives, January 2020.

Panels, Conferences, Symposia, Workshops and Initiatives
• SALT Research: METU Campus Panel
• Meetings with Goethe Institut
• Keeping It Modern London Workshop
• First Year Design Education at METU Symposium
• An Open Call for Faculty Archive
• METU Library Digital Archive
• The Development of a 3D Database of METU Campus
• # Hug the Faculty
• 3rd RMB and 16th Docomomo Germany Conference, Berlin - Germany
• "Modern Heritage Under Pressure", Casablanca - Morocco
• TUDelft Research Week Conferences- METU Campus: Cultivating Grounds for Modernity
• CEAA Conference, Portugal

Workshops and Social Interactions
• Orientation Workshops
• Oral History Workshop: "Memories"
• Oral History Workshop: "'67 Internship"
• Puzzle-Model Workshop
• Representation Workshops
• Structural Assessment-Loading Test w/First year students
• Questionnaire
• SISER (A Stakeholder-Oriented Intelligent System for Building Energy Retrofitting) for METU Faculty of Architecture Building Complex - Workshops

Media Coverage
• Archdaily - Worldwide architecture website
• Newspaper: Hürriyet - Nationwide newspaper
• CNNTürk TV - News channel
• Mimarlık Dergisi - Chamber of Architects' Journal of Architecture
• Arkitera - Architecture portal
• Mimarizm - Architecture and design media platform,
• t24 - An independent online newspaper
• Vbenzeri - Web portal for creative disciplines,
• mimdap - Architecture portal

Publications

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http://www.bauhaus-imaginista.org/articles/5600/for-the-faculty-of-architecture-at-metu

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• Savaş, Ayşen, İpek Gürsel Dino. "Constituting an Archive: Documentation as a Tool for the Preservation of the METU Faculty of Architecture", DOCOMOMO-Germany, 2019. (in the process of publication).

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Ongoing Graduate Research

Master & Doctorate Theses

• Akın, Şahin. "Immersive Design Environments for Sustainable Architecture: A BIM-based Approach". Supervisor: Assist. Prof. Dr. İpek Gürsel Dino.

• İnan, Fatma Serra. "In-Between Spaces: METU Faculty of Architecture Building Complex". Supervisor: Prof. Dr. Ayşen Savaş.

• Sarıca, Sezin. "Relief-spaces: Trans-positions In Display Environments". Supervisor: Prof. Dr. Ayşen Savaş.

• Derebaşı, Bengisu. "Façade-Wall: An Architecture for Knowledge Representation". Supervisor: Prof. Dr. Ayşen Savaş.

• Akman, Sıla. "Conserving and Managing Modern Campus Heritage: "Alley" as the spine of METU Campus, Ankara". Supervisor: Assoc. Prof. Dr. Güliz Bilgin Altınöz, 2016.

Related courses

ARCH 723: Advanced Architectural Design Research (2015-2016 Spring)
AH 516: Architectural History Digital Humanities Lab (2017-2018 Fall)
ARCH 524: Architecture and Different Modes of Representation (2016-2017 Fall)
ARCH 524: Architecture and Different Modes of Representation (2017-2018 Fall)
ARCH 524 : Architecture and Different Modes of Representation (2018-2019 Fall)
ARCH 524 : Architecture and Different Modes of Representation (2019-2020 Fall)
ARCH 505: Design by Research w/ collaboration of TUDelft (2019-2020 Spring)

5.3 A New Research Laboratory for Innovative Applications for Heritage Building

Located in a campus that represents progressive ideals, both socially, culturally and technologically, the METU Faculty of Architecture building also bears the responsibility of acting as a model for the future initiatives regarding conservation buildings. As explored during the assessment activities of this project, the building is a very important part of the Modern architectural heritage in Turkey. At the same time, it still acts as a school of architecture, which is considered as a pioneer in modern education with its innovative approach to learning and research. This main function of the building complex must be preserved and this is one of the major policies of this management plan, carrying the utmost importance.

The policies that the Faculty of Architecture needs to develop and follow should not merely consider the conventional conservation measures, but also those that aim to integrate novel techniques and technologies. The site makes the building a unique case for exploratory heritage conservation practices that combine conservation with innovation. Such practices can be supported by the university's innovative character and a strongly established culture of interdisciplinarity, collaboration and progressive research. The university conducts cutting edge research in technology and engineering. METU recently has been prioritizing sustainable and smart practices towards the campus and the built environment, through several research projects, primarily the Smart Campus project funded by The U.S. Trade and Development Agency (USTDA). Another ongoing research project (SISER), is a collaborative initiative supported by the Scientific and Technological Research Council of Turkey (TUBITAK) and the British Council (UK) (See page 426). The research aims to develop novel methods using artificial intelligence and computer vision methods in support of decision-making for energy-efficient improvement for existing buildings. The research development and testing is currently being carried out at the Faculty building, where video and still images are being processed for the design, development and validation of an automated, intelligent system that can be used also for heritage buildings. The HBIM development process in this project can also be considered as an innovative research initiative, which –to our knowledge- was the first implementation of building information modeling for Modernist heritage building planning.

The university and the building still have an enormous responsibility in their home geography as a role model, and also due to its critical role in architectural education. The building can also act as an exemplary case for the other heritage buildings worldwide in its unique approach that prioritizes experimentation and technology development. Based on the previous and ongoing research work at the campus and at the Faculty, it can be argued that the building and the campus can act as a testbed for the design, development, implementation and testing of building technologies for energy-efficiency, sustainability and resiliency. A number of different expertise areas, such as computer science, artificial intelligence, material science and engineering, and mechanical engineering have the potential to be included in this project.

Therefore, the policy can be the establishment of a research laboratory housed by the Faculty of Architecture, with strong interdisciplinary collaboration with other departments, research centers and research laboratories that carry out relevant research at the campus. The research focus of such a laboratory is believed to be unique for METU in its primary focus on intelligent and innovative technologies applied to existing buildings. The Getty-funded project has shown that expertise is required in various areas such as both passive architectural means, as well as technologies of renewable energy and intelligent evaluation and control technologies for the assessment, modeling and computational analysis of buildings.

5.3.1 Maintenance Standards

In buildings with heritage value, routine inspections and regular maintenance are required for the timely identification of problem, which can help extend the life of the building components and the building itself. The correct implementation of the Maintenance Standards and Guidelines help maintain the building's architectural integrity and heritage significance, as can be found in the previous sections. These maintenance procedures are also necessary to avoid the need for disruptive and potentially costly repair work that may damage the building's daily use, occupants' activities and -most importantly- its heritage value. The maintenance procedures listed in this section should be used as guidelines to be used during both routine and preventive maintenance procedures. The considerations and procedures listed here should be reviewed and followed carefully, which will help conserve the character-defining elements of the building as well as the building's heritage value. In addition, maintenance work should be carried out by those staff members who have detailed knowledge of the building and its elements (especially with heritage value).

General guidelines to be followed during maintenance are as follows:

• All maintenance actions should be non-destructive, invisible and reversible. Especially when dealing with the character-defining materials in the building, such as the exposed concrete elements, concrete blocks should be handled with utmost care.

• All maintenance work should aim to expand the life expectancy of the building elements with significance.

• All maintenance work should be thoroughly recorded and the relevant information should be made available to be referred to during future maintenance processes. The use of the HBIM is critical in the structured and systematic documentation of any type of building intervention and maintenance. The information captured within the HBIM should be the basis on which maintenance actions are given. In this model, maintenance procedures should regard:

- The heritage values of the building elements to be operated on.
- Any conflicts with other elements that can be disruptive to the current maintenance work or can be harmful in the long run.
- The previous history of the building elements that can be useful for decision-making for maintenance interventions, especially the major ones.

• Maintenance procedures and materials that have been proven to be suitable and un-damaging to the existing building elements should be used.

• Trees and shrubs that can cause a problem to concrete and other materials should be controlled.

• For cleaning, heavy chemicals that can damage building elements should be avoided.

• After the identification of the source of the problem that necessitated maintenance, the root cause should be identified so as to mitigate the cause of deterioration.

• Maintenance work should be prioritized according to its urgency. Immediate and reactionary actions that do not perform soundly-grounded analysis of problems and causes should be avoided as much as possible.

• Only materials and techniques that have been previously tried and tested should be used or implemented in the building.

The seasonal routine maintenance activities are as follows:

• During rainy periods, the rooftop, gutter, flumes and the insulation layers should be regularly inspected against blockages and leaks.

• Before winter, the heating system, the fan-coil units and radiators should be inspected. The snows needs to be cleaned regularly.

• In spring, basement spaces should be examined for rot, mould and dampness.

• External walls, windows, paved surfaces, stairs and other architectural elements exposed to the outside conditions should be inspected annually.

Standards and Guidelines for occupant interventions:

• During rainy periods, the rooftop, gutter, flumes and the insulation layers should be regularly inspected for blockages and leaks.

• Before winter, the heating system, the fan-coil units and radiators should be inspected. Snow needs to be cleaned regularly.

• In spring, basement spaces should be examined for rot, mould and dampness.

• External walls, windows, paved surfaces, stairs and other architectural elements exposed to the outside conditions should be inspected annually.

• Destruction of the building elements, such as drilling, should be discouraged.

Standards and Guidelines for Occupant Interventions

The building is in active use by the staff, students and visitors. Therefore, it is acknowledged that the needs and expectations of the building occupants should be met. However, the following points need to be followed during any occupants' interventions:

• Any intervention to individuals' spaces should be with the consent of the Dean's Office.

• The daily maintenance activities carried out by the expert staff should be supported.

• The painting of building elements with heritage value should be strictly discouraged.

• Destruction of the building elements, such as drilling, should be discouraged.

• An educational program should be provided for the occupants, especially students and cleaning staff.

• Material-specific and space-specific guidelines should be prepared for the occupants.

5.3.2. Physical Improvement (Corrective)

Physical improvement policies are proposed corresponding with the material, structural and environmental specifications of the “Assessment of Significance” chapter. The premises highlighted below are the introductory policies regarding the physical improvement decisions, which will be specified accordingly in the following section:

• Establishing an interdisciplinary conservation committee for the preservation of the building (and the campus, its buildings, the forest and the lake)

• Assuring the priority of workmanship in further applications

• Using HBIM to provide a list of urgent interventions: roof insulation, prevention of water leaks from the window frames, removal of hazardous plantation within and outside the building

• Using HBIM to locate and remove all the ad hoc additions such as the vending machines, studio separators, mechanical and electrical infrastructure elements, floor coverings and curtains, information boards, mezzanine floors

• Using HBIM information for the refurbishment using non-intrusive (visual and physical) building technologies

• All the proposed interventions must be re-evaluated to reach maximum performative potential with minimum interventions.

Possible Implementations Regarding the Current Structural Condition

• Developing a more detailed Finite Element Model for the entire building

• Excavating the footing and soil properties for a more detailed observation

• Further monitoring of the cracks

• Examination of the movement of the dilatation joints as a part of settlement investigation

• Removal of the cover concrete and the examination of the tension rebars

• A strength-capacity assessment of the rebars

• Based on the HBIM information strengthening the waffle slab in H5-F block

• SHM studies on the slab cracks should be extended until a proper strengthening work is conducted

• Alarm systems can be implemented on the other structurally critical points of the building

Possible options, such as a carbon fiber plate based strengthening system or post-tensioned strengthening shave been discussed for the critical waffle slab in the focus area. A temporary support placed at the midspan can provide an extra margin of safety.

Possible Material Improvements

• The freeze-thaw damage and inefficient repair efforts at some locations are evident in the rather thin, non-structural exterior concrete elements such as rain gutters on the roof. The retrofit/replacement of these thin sections must be developed.

• The exterior surfaces of the building are more vulnerable due to the weathering and freeze-thaw cycles. Therefore, they require extra attention and additional maintenance.

• For the deterioration types observed in the building, remedial treatments must be developed. Thus, a laboratory including experts on conservation of historical structure should be established and supported by the Dean's office.

• Dampness problems must be eliminated. Problematic areas must be detected via IR thermography and repaired with appropriate materials. Monitoring of the problematic areas must be continued.

• For the corroded reinforcement bars, cleaning and strengthening methods must be applied.

• Compatible repair mortar, gap filling mortars, grouting injections, and surface consolidation methods must be applied for the concrete surfaces where detachment is observed.

• Formation of salt deposits on brick and concrete surfaces must be studied in detail and a method must be developed for cleaning.

• Microbiological growth must be brought under control and treated together with the dampness problem in the roof drainage.

• Dirt and graffiti on the surfaces must be eliminated. For the removal, a deeper analysis and trained operators are required. Using the method of cleaning with steam can pose a danger for the reinforcement bars.

Possible Interventions Regarding the Energy Efficiency and Occupant Comfort

•Improving the on-campus transportation system in an environmentally sensitive, energy efficient, intelligent, unobstructed, accessible, safe manner with a mass transportation system by reducing private vehicle traffic; providing the necessary physical infrastructure to encourage pedestrian and bicycle circulation.

• Renewing and improving the education, research and technical infrastructures of the campus in an environmentally sensitive, energy efficient, intelligent and economical manner.

• Installment of the interval electric meter, water meter and BTU meters, in order to be able to control the consumption rate of whole campus.

• Removal of the mechanical interventions and improvement of natural ventilation sources.

• Replacing window glazing with materials with a lower solar heat gain coefficient, coating exterior walls with reflective infrared painting.

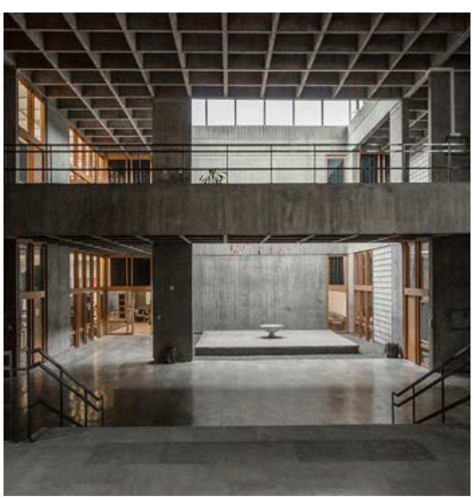
• Refurbishing shading devices with high reflective, low transmittance blinds.

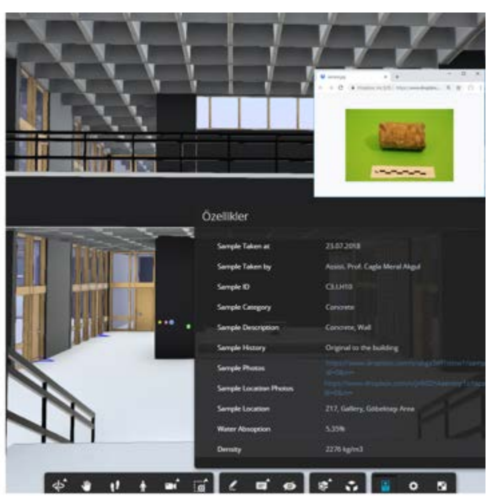
• Replacement of aluminum window frames with thin members.

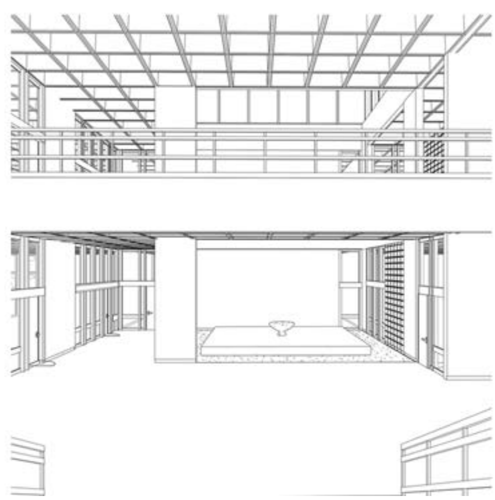
• Creating means of night ventilation.

• Replacement of the existing artificial light sources with high efficient lighting features for energy efficiency and higher occupant comfort.

• Conducting a case specific research on the environmental retrofit scenarios of a brown roof.







The HBIM development activities that were carried out during this research constitute an inseparable part of the conservation planning processes. HBIM is considered not as a static end result that is merely used within the limits of this projext, but as a critical medium that has the capacity to support a wide range of functionalities for representation, information modeling, and visualization, as previously implemented during this research. Other potential benefits that can be used for heritage buildings should be considered in the future as part of the long-term policy:

• Multidisciplinary Coordination: The conventional workflows in the heritage building conservation are based on paper-based activities focusing on a single specialty, which transfer the design documentation from one discipline to another in a sequential manner. The lack of a shared medium for communication between different disciplines, such as architects, heritage conservation specialists, engineers, policy-makers, results in ineffective collaboration, the lack of a shared understanding into the heritage building's architectural and heritage values, and leads to misunderstandings and mistakes during conservation planning and implementation processes. HBIM, when specifically customized for heritage buildings, can function as the common medium through which interdisciplinary collaboration and coordination can be carried out. This METU project initiated the use of HBIM as the common ground for information-sharing, communication and decision-making across the project team members. In the future, HBIM can maintain this function with the involvement of other stakeholders, disciplines, conservation activities and contexts unforeseen at the moment.

• Clash Detection: Clash detection occurs when physical building elements are in spatial conflict. BIM allows the automated detection of physical clashes, especially for those elements that require the involvement of different disciplines such as structural engineers, mechanical and electrical engineers or environmental engineers. For heritage buildings, clashes also occur conceptually, when an intended intervention to a building element is in conflict with the heritage values of the building. When heritage information is embedded into the HBIM model, both physical and conceptual clashes can be detected in the future.

• Development of Structural and MEP (mechanical, electrical, plumbing) models: Each discipline; MEP (mechanical, electrical, plumbing) engineering, structural engineering and etc. forms a model independently from all others, based on the architectural model which sets up a layout for other professions. For the preparation of the HBIM model, structural and MEP BIM models were modelled for the focus area, the F blcok. The final HBIM inherits unique 3D geometries along with their associated HBIM data for the relevant fields. In the future, the structural and MEP models can be developed in detail to support conservation activities, such as clash detection and analytics.

• Cost estimation: a BIM model can quantify the modeled materials and as a result can provide cost information in an automated way. Therefore, work processes based on BIM can be performed more effectively and accurately. For heritage buildings, the generation of quantities can assist decision-making when building interventions are considered, and inform the decision-makers in the exploration of different design alternatives and concepts.

The HBIM platform enables interoperability and communication between different professions and prevents conflictions and clashes that are very common in the most of the modelling processes. The users can instrumentalize HBIM model as a guiding tool for the management and maintenance of the faculty building throughout its lifecycle. Moreover, the users can have access to see and interpret “hidden” elements such as rebars, ducts and plumbs that are not visible in the physical reality. The created HBIM model is anticipated to be used actively in case of need and to be kept up-to-date according to emerging developments by the stakeholders. The HBIM model is visualized in different platforms such as virtual reality and web-based applications by using state-of the-art software programs. The tested platforms revealed different visualization possibilities of HBIM. The allows the users to interact with the model, including its elements and data in multiple scales.

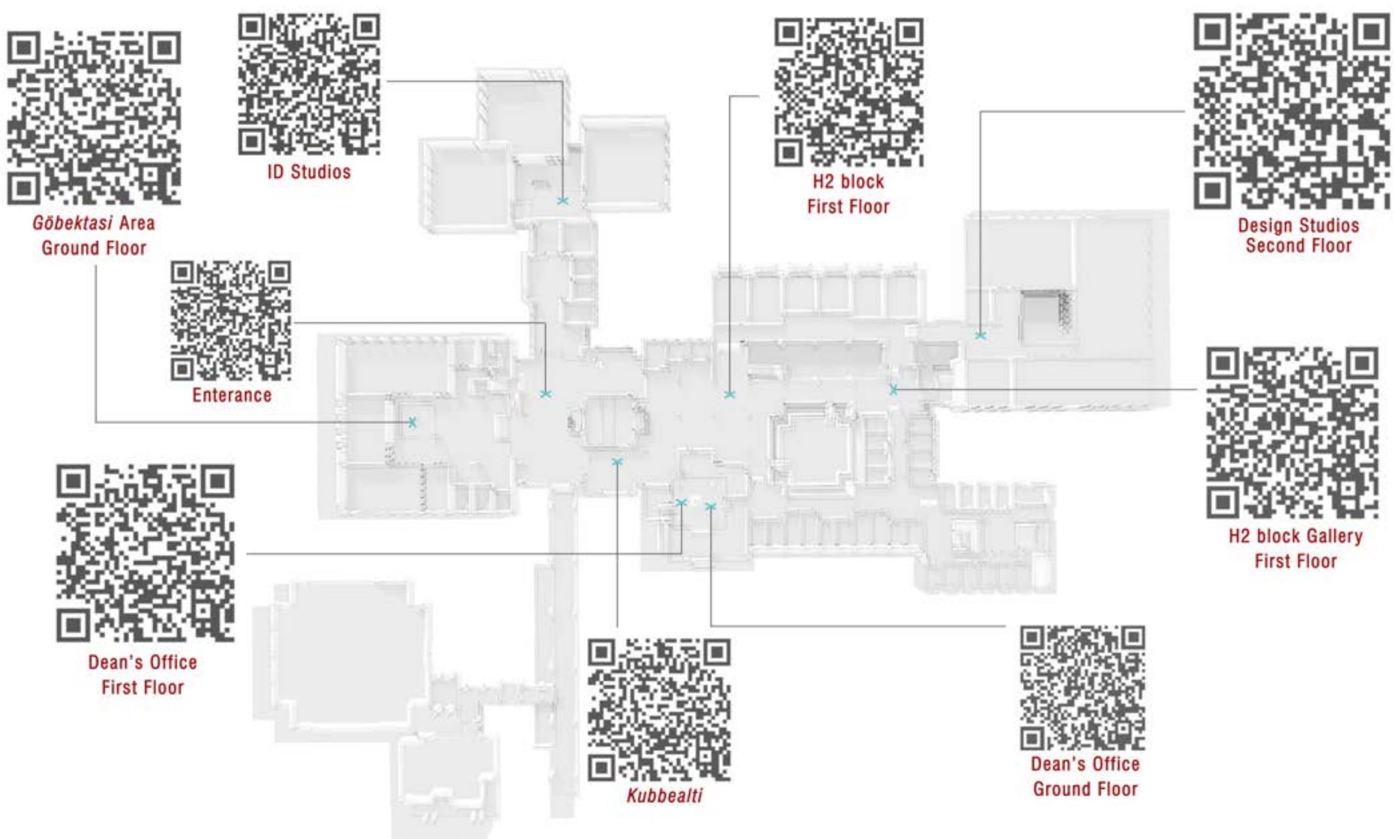


Figure 2: Stereo panorama views from the faculty building.

6. RESEARCH ACTIVITIES AND MEDIA COVERAGE

6.1. Exhibitions
6.2. Panels, Conferences, Symposia and Initiations
6.3. Workshops and Social Interactions
6.4. Ongoing Graduate Research
6.5 Media
6.6 Publications

6.1 Exhibitions

Regarding one of the main overarching policies of the Project, "Conservation by Creating Awareness", METU Faculty of Architecture took its place within various international and national exhibitions.

- SOS Brutalism - Exhibition in Deutsches Architekturmuseum (DAM), 2017

- Venice Architecture Biennale, Greek Pavillion, May - October 2018

- SALT- Commissioners' Exhibition, March 2018

- Representing Itself | METU Lodgings Documented, 2016

- Archive I Exhibition: Aesthetization of the Invisible | Carving the METU Archive out, 2017

- Archive II Exhibition: Moment, Memory and Memoir | '67 Summer Internship, 2017

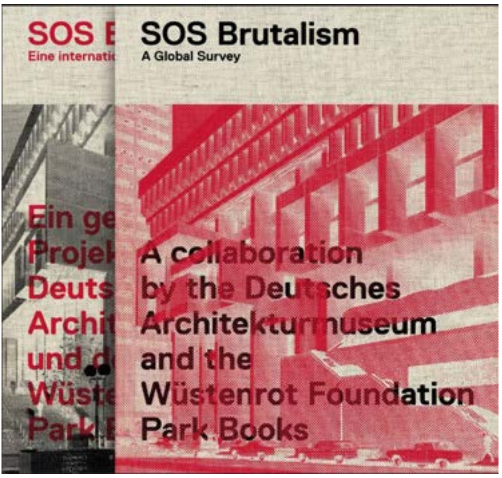
- Alumni Day Exhibition, September 15, 2018

- Archive III Exhibition: First Year Design Education at METU, November 2019

- Archive IV Exhibition: Representing Itself | METU Faculty of Architecture, January 2019

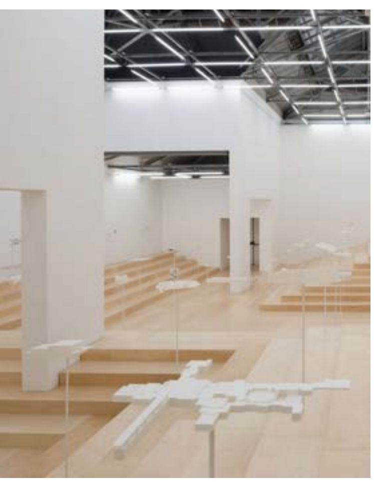
- TUDelft Research Week Campus Exhibition, May 2019

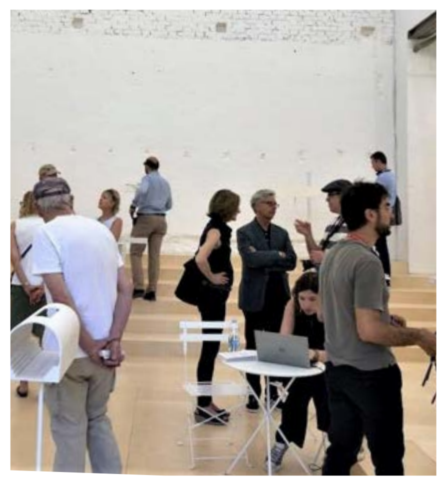
- Archive #11, Opening Ceremony of the Faculty Archives, January 2020.



SOS Brutalism - Exhibition in Deutsches Architekturmuseum (DAM):

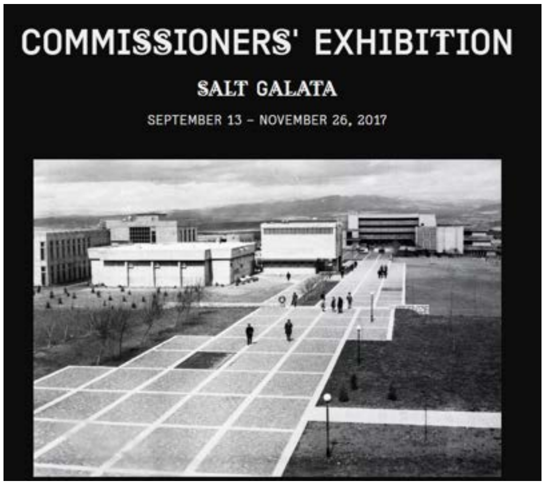
SOS Brutalism is a database that currently contains over 1000 Brutalist buildings. SOS Brutalism has organized an exhibition that has been jointly programmed by the Deutsches Architekturmuseum (DAM) and the Wüstenrot Stiftung. The exhibition included METU Faculty of Architecture Building. The drawings and photographs of the building were on display between November 2017- April 2018 in Deutsches Architekturmuseum (DAM).





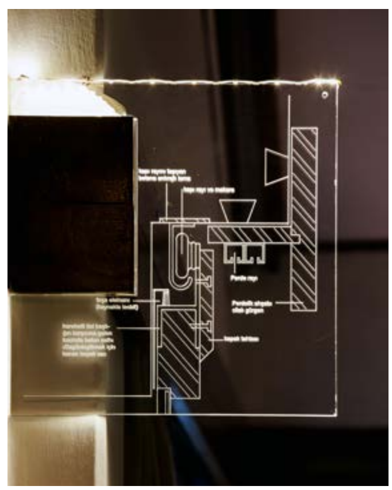
Venice Architecture Biennale, Greek Pavillion:

Under the theme of “Free Space”, Greek Pavilion hosted an exhibition entitled as “The School of Athens”. Curators configured the pavilion space as a depiction of a “Free Space” for learning and common spaces of the universities from all over the world and history, starting from Plato’s Academy, are represented with 3D-printed models. Regarding one of the main overarching policies of the Project, Conservation by Creating International Awareness, METU Faculty of Architecture took its place within the participant schools such as; Bauhaus Dessau, MIT and Harvard Graduate School of Design.



SALT- Commissioners' Exhibition:

The "Commissioners' Exhibition" organized by SALT was held in Çankaya Contemporary Art Center in Ankara on March 2018. METU Department of Architecture, Getty-KIM presentation was invited to organize a symposium as the commissioner of the METU Faculty of Architecture building for the opening of the exhibition.

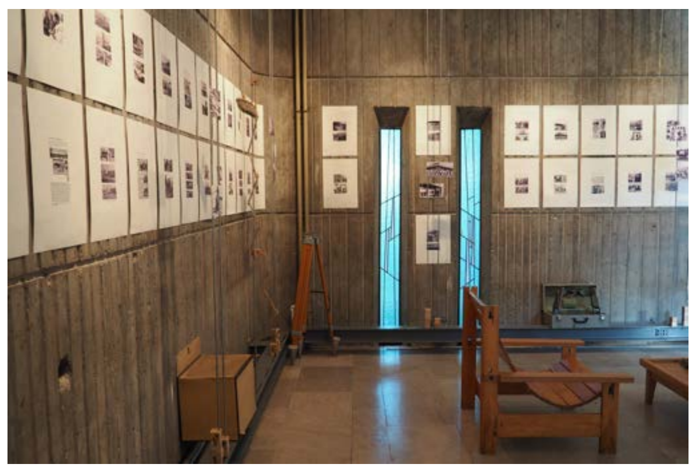


Representing Itself | METU Lodgings Documented

The "METU Lodging DOCUMENTED" exhibition and its catalogue are products of an ongoing research project that launched in February 2013, to make a comprehensive documentation of a relatively unknown Modernist Housing project. The preparation process of the exhibition was supported by a group of graduate students during the spring of 2016 and the opening was held on the July 23 with the participation of university staff. The exhibition was planned to be open for only one hour, and lodging#5, in which the exhibition was held, and transformed the house into a "house museum" for only one day. The ultimate goal of this exhibition was to protect these houses; the method of conservation by documentation was proposed in this exhibition to generate an awareness for their architectural and social values.

Archive I Exhibition: Aesthetization of the Invisible | Carving the METU Archive out

The aim of the exhibition was to display and aestheticize the presence of the archive. The concept of transparency is not only the apertures in the process of diffusion, but also it is a tool for the representation of archive. Aesthetization of the invisible is through the "transparency" that is both the material and the concept of the exhibition. Hereby, with the "phenomenal" and "literal" transparency, the archive is aimed to be carved out to become visible. Archive I is the first exhibition of "DOME" - the "new" archive of METU Faculty of Architecture.



Archive II Exhibition: Moment, Memory and Memoir | '67 Summer Internship

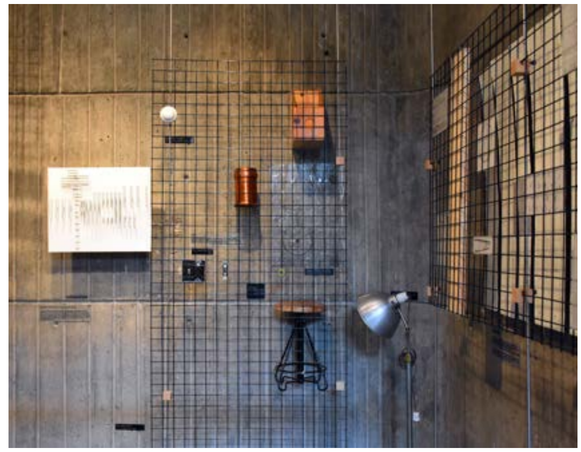
The exhibition is focused on 67 Summer Internship of Architecture students. The summer internships of METU Faculty of Architecture, reflect the social and historical relationships. The documents of these internship culture may help to perceive another layer of the history. In this exhibition, documents, photographs and letters are exhibited as moments, memories and parts of a memoir.

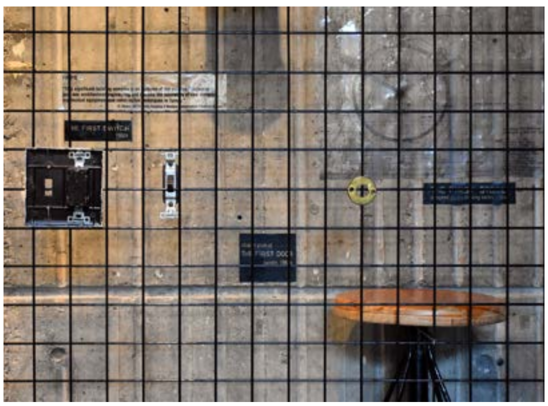
Alumni Day Exhibition, September 15, 2018

Alumni Day is seen as an opportunity to reach a broader METU community. A wall in the focus area, the F block, is transformed into an interactive exhibition space that informs and communicates with the elder and possible youngest community members in order to be able to involve them as stakeholders.

Archive III Exhibition: First Year Design Education at METU, November 2018 - January 2019

METU Faculty of Architecture is known for its profound educational system and outstanding building complex. With its architectural elements and established curriculum, it is the material and symbolic manifestation of the Modernist approach in the country. The first-year design course in the school, “basic” and highly intricate, has been the foundation of the faculty’s four-year education. In this exhbition, Türel Saranlı’s System Theory, students’ Basic Design works from different years, Bilgi Denel’s book: "Method for Basic Design" and a twofold display of the same assignment given in METU and Bauhaus were on display.

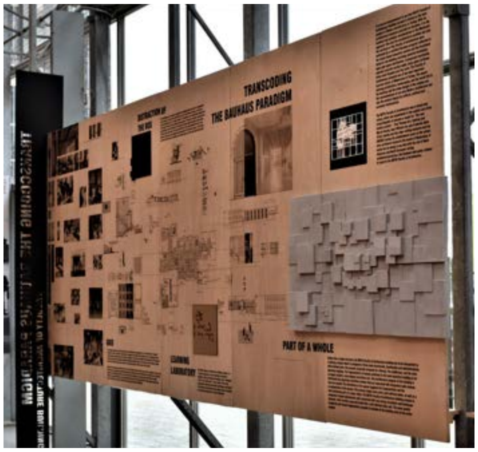



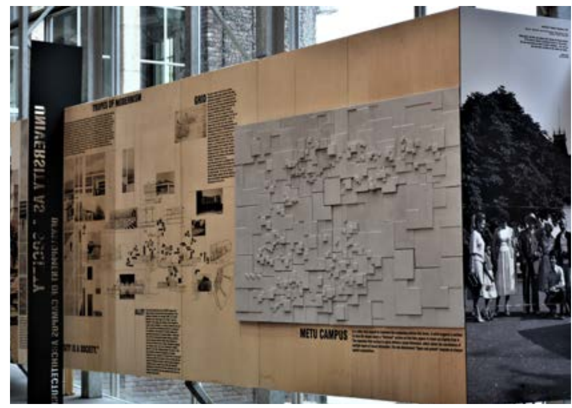

Archive IV Exhibition: Representing Itself | METU Faculty of Architecture, January 2019

The exhibition is organized as one of the “Archive” exhibition series. In this exhibition, the main goal is to display the architectural qualities of METU Faculty of Architecture within its space.

This last “Archive” exhibition is curated under the scope of ARCH-524 Architecture and Different Modes of Representation course. Throughout the semester, the participants were encouraged to produce diverse and advanced representations of the Faculty of Architecture in order to be able to display the significance of the building. Using both the conventional techniques of architectural representation (namely the modelling, drawing, diagram, photograph) and the creative methods (relief, film-collage, texture survey); the building is documented and ‘the architecture of the exhibition’ is designed collaboratively. The students, who are both users of the building and the curators of the exhibition, were incorporated into a critical academic environment in which the critique is derived from the processes of architectural production.

Since the specific media of architecture inevitably contextualizes, the representations that are produced by students correlates with the historical and discursive frameworks of the existing conditions. The exhibition in this sense, is not focused on displaying the end product, but it is in pursuit of creating a ground for the architectural research that shifts its focus from the built work to its conception and reception by the users. In Eve Blau’s words: ‘From Form to the Idea.’ ‘Representing Itself’ welcomes the audience of the exhibition and the users of the faculty to reinforce the relationship between the processes of thinking, producing and interpretation via the tools of representation.





TUDelft Research Week - METU Campus Exhibition, May 2019

The “METU CAMPUS EXHIBITION: Representing Itself” is held in May 2019 as part of the annual TU Delft Research Week activities. The Technical University of Delft hosted the exhibition, which was accompanied with a panel discussion with the participation of an international group of historians, conservation experts, architects and graduate students. This traveling exhibition is one of the outcomes of an ongoing research project that was launched in 1999, to make a comprehensive documentation of the relatively unknown Modernist University Campus project in Ankara. The major goal behind this exhibition is the collection of the archival material that is focusing on the establishment years of the university and the formation of its physical environment. The documentation procedures, preparation of the exhibition and the formation of the archive have been conceived and designed as analogous processes. Rather than the construction of an institution, the idea was to initiate a process of archiving in which “archivization” is seen as a way of conservation. The end product therefore, rather than being a frozen entity, is conceived as a progressive collection, that is based on a series of representation processes. Preparation of a living archive is a “critical operation”, using the Tafurian terminology. It is a continuous interpretation process, effective even after the completion of the conservation planning procedures. Thus, the ultimate objective of this exhibition is to protect the campus and its outstanding architectural elements. In an architectural context in which nothing is permanent and nothing is indispensable, and in a socio-political environment in which everything is possible, unconventional ways of “preservation” become essential.

The METU campus exhibition is composed of three major parts: “University as a Society”, “Transcoding the Bauhaus Paradigm” and “Diamonds in Sahara/Museum for one hour”. Each part is divided into subtitles to represent a series of themes including the grid, alley, part of the whole, distraction of a box, diagrams, house vs housing and “Keeping It Modern”.


THE FIRST YEAR
DESIGN EDUCATION
at METU
SYMPOSIUM and
EXHIBITION

6.2. Panels, Conferences, Symposia and Initiations

- SALT Research: METU Campus Panel
- Meetings with Goethe Institut
- Getty Conservation Institute - London Meeting
- First Year Design Education at METU Symposium
- An Open Call for Faculty Archive
- METU Library Digital Archive
- The Development of a 3D Database of METU Campus
- # Hug the Faculty
- 3rd RMB and 16th Docomomo Germany Conference, Berlin - Germany
- "Modern Heritage Under Pressure", Casablanca - Morocco
- TUDelft Research Week Conferences- METU Campus: Cultivating Grounds for Modernity
- CEAA Conference, Portugal

Meeting with Goethe Institut

SALT Research: METU Campus Panel

Getty Conservation Institute London Workshop

First Year Design Education at METU Symposium

This symposium is organized with the participation of all the first-year studio instructors and assistants of METU Department of Architecture and the Department heads of the City and Regional Planning and the Industrial Design, on the 16th of November 2018. This event was planned to become an open platform to discuss the first year architectural education and different approaches in the Faculties' history and their "archival" value. This event is recorded both in the medium of video and photograph in order to be able to be used as a document on METU First year architecture Education. The participants of the symposium shared the related materials as a contribution to the continuous archive project.

An Open Call for the Faculty Archive

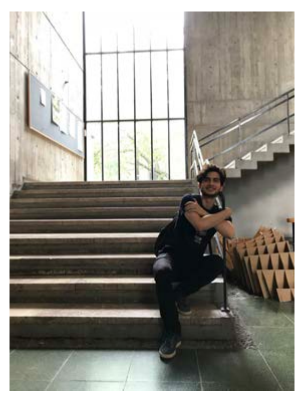
In order to be able to extend the presence and impact of the "METU Faculty of Architecture Archive: Dome", there is/will be a search for new documents and related sources about the Faculty building, METU Campus, and their history. The aim is to reach out people in order to be able to "disseminate" and "retrieve" knowledge upon the existing and becoming archive.

METU Library Digital Archive
One of the main objectives of the project is to give an order to faculty archive, digitalize the physically available materials and make it available for further research activities. Regarding this objective, studies are conducted. These studies include the research on ARCHES software, categorization of the archival material and development of BIM as a retrieval interface where the information and the space are interrelated and the end-user conducts a research based on bilateral matrix defined with coexistence of spatial and textual/visual data. With the impact of the study, METU Library initiated a more comprehensive project covering mostly the visual and auditory materials related to the whole campus, its educational and social history. Similar to the Getty Project, the main objective of the project is to create a web-site with different access options available.

The Development of a 3D Database of METU Campus
This project is related with other research initiatives at the university. In a project titled "the Development of a 3D Database of the METU Campus" funded by the METU Rectorate, it is aimed to realize data acquisition using advanced imaging devices to develop a 3D database of the campus. The project is led by Prof. Dr. Yasemin Yardimci from the Informatics Institute of METU. The project uses through devices including 3D laser scanning devices and high resolution images from drones. The resulting 3D database is expected to contribute to the cataloging of the campus buildings. In the following steps of the project, it is planned to collaborate on the modeling of high resolution modeling of the university buildings towards the implementation of the processes and methods developed in this project on a wider range of Modernist campus buildings.






 # Hug the Faculty
A social media project is initiated in order to be able to create an social awareness amongst the users of the building.

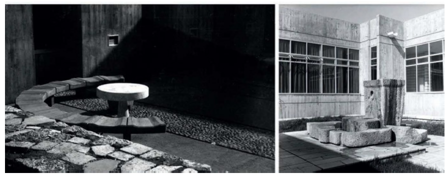
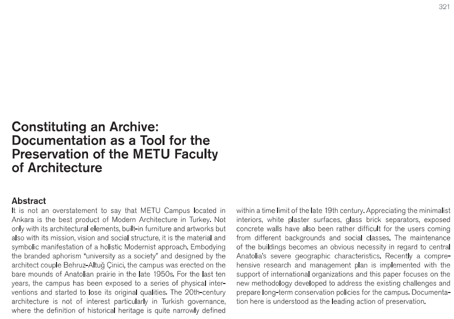


Fig. 1: Altuğ-Behruz Çinici, METU Faculty of Architecture, Ankara, Turkey, 1961, Built-in furnitures placed in courtyards. © Salt Research, Altuğ-Behruz Çinici Archive, 1963.



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Constituting an Archive: Documentation as a Tool for the Preservation of the METU Faculty of Architecture

Abstract

It is not an overstatement to say that METU Campus located in Ankara is the best product of Modern Architecture in Turkey. Not only with its architectural elements, built-in furniture and artworks but also with its mission, vision and social structure, it is the material and symbolic manifestation of a holistic Modernist approach. Embodying the branded aphorism "university as a society" and designed by the architect couple Behruz-Altuğ Çinici, the campus was erected on the bare mounds of Anatolian prairie in the late 1950s. For the last ten years, the campus has been exposed to a series of physical interventions and started to lose its original qualities. The 20th-century architecture is not of interest particularly in Turkish governance, where the definition of historical heritage is quite narrowly defined within a time limit of the late 19th century. Appreciating the minimalist interiors, white plaster surfaces, glass brick separators, exposed concrete walls have also been rather difficult for the users coming from different backgrounds and social classes. The maintenance of the buildings becomes an obvious necessity in regard to central Anatolia's severe geographic characteristics. Recently a comprehensive research and management plan is implemented with the support of international organizations and this paper focuses on the new methodology developed to address the existing challenges and prepare long-term conservation policies for the campus. Documentation here is understood as the leading action of preservation.

3rd RMB and 16th DO.CO.MO.MO Conference 100 years of Bauhaus

The conference is held in Berlin, March, 2019 associated with the 100th anniversary of the Bauhaus. The significance of modernity is discussed under the topics of Education and Theory, Register, Urbanism and Landscape, Technology, and Industrial Design. The METU Faculty of Architecture is presented with the title of "Constituting an Archive: Documentation as a Tool for the Preservation of the METU Faculty of Architecture" in the Session 3: Education & Theory moderated by Aslıhan Ünlü Tavil.

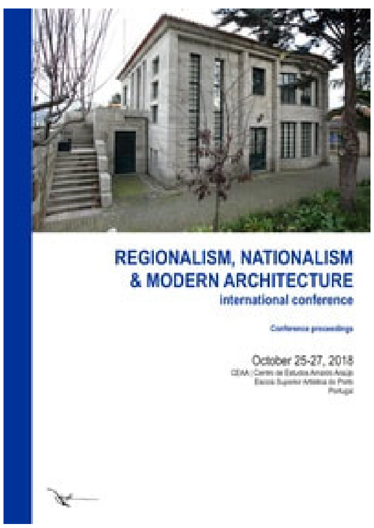
"*The International Conference in Berlin takes the 100th anniversary of the Bauhaus as an opportunity to discuss the significance of modernity in the 21st century: 'What interest do we take in the Modern Movement today? The conference focus lies on the concepts, visions, and impulses emanating from Modern Movement and how they can be related to today's social, economic, cultural and in particular creative issues.*"

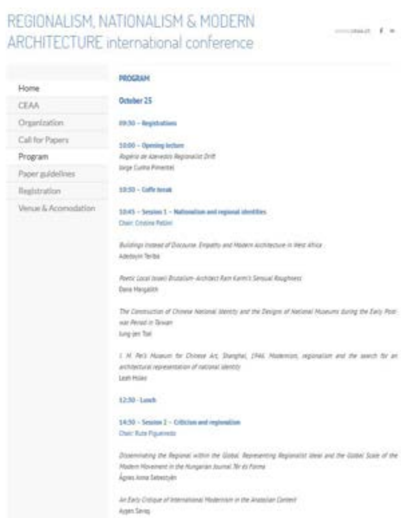
"Modern Heritage Under Pressure", Casablanca - Morocco

Architect Aziza Chaouni, Associate Professor at the University of Toronto, and architect Silvio Oksman, Professor at Escola da Cidade in São Paulo, organized the first "Keeping It Modern: Modern Heritage Under Pressure" (KIMMHUP) workshop in the Sidi Harazem complex. The workshop included in-depth presentations of the Conservation Management Plans of 8 KIM grantees from the Global South, supported by reflections from world leading experts in modern heritage conservation Sheridan Burke, Shikha Jain and Joe Addo.

The workshop took place over 3 days in the hotel of the Sidi Harazem Bath Complex, designed by Jean-Francois Zevaco in 1960. Key members from the Order of Architects of Morocco, leaders, activists, conservation groups and architects working on the conservation of modern heritage from Algeria, Egypt, Iraq, Jordan, Kuwait, Lebanon, Palestine, Tunisia, and Turkey attended.

TUDelft Research Week Conferences- METU Campus: Cultivating Grounds for Modernity

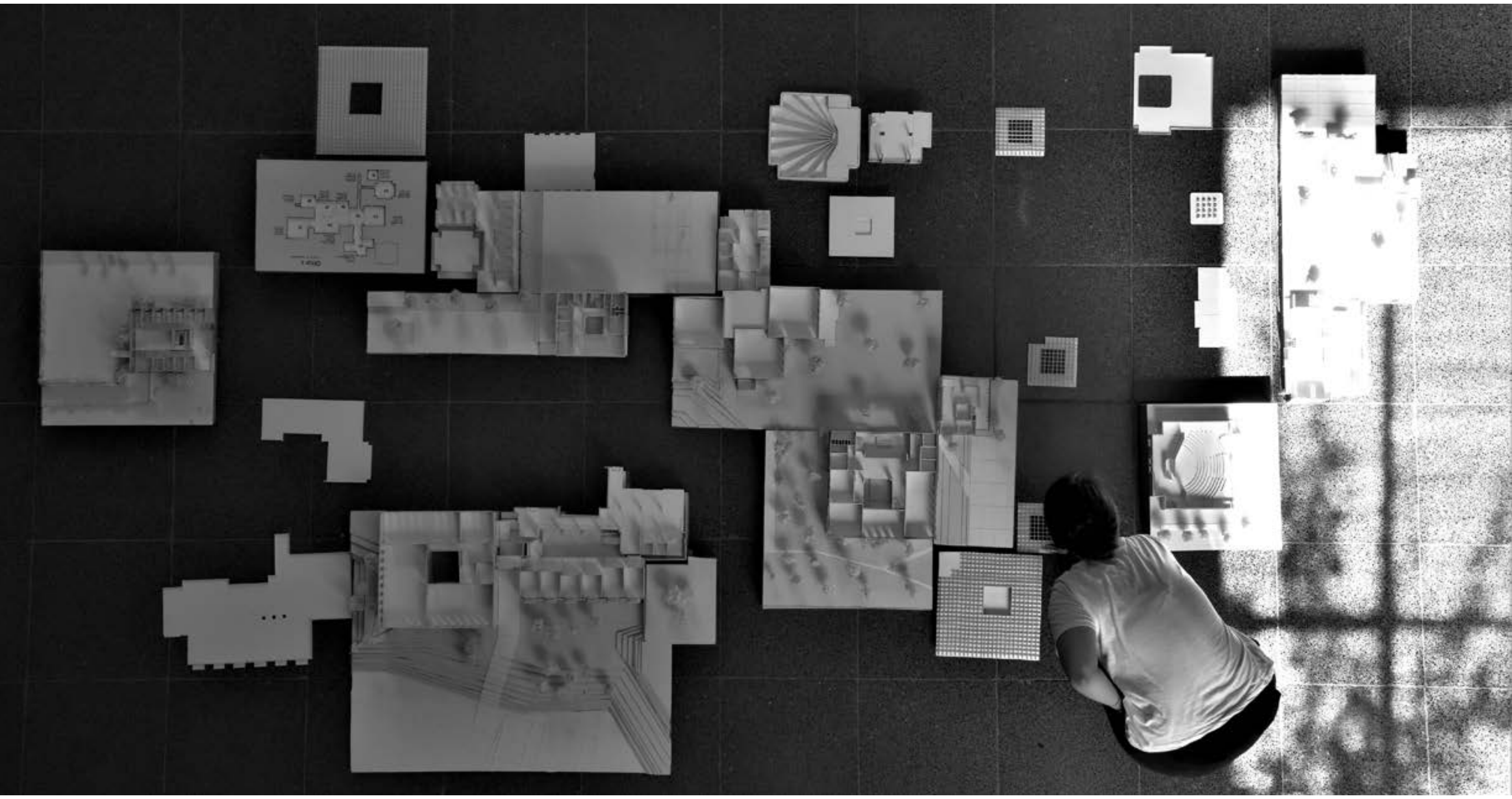




CEAA Conference, Portugal,

Arnaldo Araújo Research Centre (CEAA) is a R&D unit based at Escola Superior Artística do Porto which develops research in the area of Art Studies, specifically in the territories of Theory, Criticism and History.

Originally set up as part of ESAP's internal structure, in 2007 CEAA became a fully recognized research unit, funded by FCT (Portuguese Government Foundation for Science and Technology, uRD 4041). Currently it is organized into three research groups and one common research line. Research groups: (1) Architectural Studies; (2) Film Studies Art; (3) Critical Studies Research line: Common Place. Based on an understanding of theory, criticism, history and practice as differentiated yet interrelated knowledge fields, the Arquitectural Studies group has been developing both fundamental and applied, research in the field of Architecture, understood here in a broad sense.



6.3. Workshops and Social Interactions

- Orientation Workshops
- Oral History Workshop: “Memories”
- Oral History Workshop: “’67 Internship”
- Puzzle-Model Workshop
- Representation Workshops
- Structural Assessment-Loading Test w/First year students
- Questionnaire
- SISER (A Stakeholder-Oriented Intelligent System for Building Energy Retrofitting) for METU Faculty of Architecture Building Complex - Workshops

Orientation Workshops

The most dominant user groups, affecting the physical condition of the building, are educational, administrative staff and students. Although the occupants are conscious about the value of the building, it is highly populated and occupied 7/24h. Therefore, it requires further consideration regarding the specific cases/ issues/ points of the building. Periodical meetings with particular groups are initiated in order to be able to sustain the condition of the building.

Oral History Workshop: "Memories"

The oral history meetings are initiated in 2004. The aim is to collect information regarding the METU History and create a common ground for raising an awareness.

Oral History Workshop: "'67 Internship"

The oral history meeting is focused on the summer internships of METU Faculty of Architecture, since they reflect the social and historical relationshipsof those years. The participants shared their experiences and specify remarkable points of their Internship memories.



Puzzle-Model Workshop

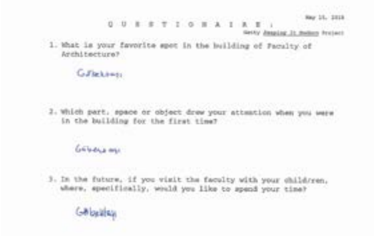
The workshop is organized with graduate students. The physical model of the building is composed of ten parts, which is produced by first year students. In the workshop, the possibilities

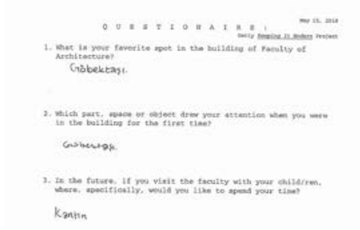
Representation & Documentation Workshops

In the scope of ARCH 524 and Getty KIM Project, a lot of workshops are organized: Photography workshop with professional photographers, Modelling workshop with professional model-making experts and Film-editing workshop with artists.

Loading Test with First Year Students

In the scope of Structural Assessment Procedures, a loading test is organized with students. During the First Year Summer internship, a one-day workshop is organized in order to complete the live load calculations for the focus area of the project.


QUESTIONAIRE:
May 15, 2018
Getty Keeping It Modern Project
1. What is your favorite spot in the building of Faculty of Architecture?
2. Which part, space or object drew your attention when you were in the building for the first time?
3. In the future, if you visit the faculty with your child/ren, where, specifically, would you like to spend your time?


QUESTIONAIRE:
May 15, 2018
Getty Keeping It Modern Project
1. What is your favorite spot in the building of Faculty of Architecture?
Göbektaşı.
2. Which part, space or object drew your attention when you were in the building for the first time?
3. In the future, if you visit the faculty with your child/ren, where, specifically, would you like to spend your time?


QUESTIONAIRE:
May 15, 2018
Getty Keeping It Modern Project
1. What is your favorite spot in the building of Faculty of Architecture?
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QUESTIONAIRE:
May 15, 2018
Getty Keeping It Modern Project
1. What is your favorite spot in the building of Faculty of Architecture?
Göbektaşı
2. Which part, space or object drew your attention when you were in the building for the first time?
Courtyards in general
3. In the future, if you visit the faculty with your child/ren, where, specifically, would you like to spend your time?

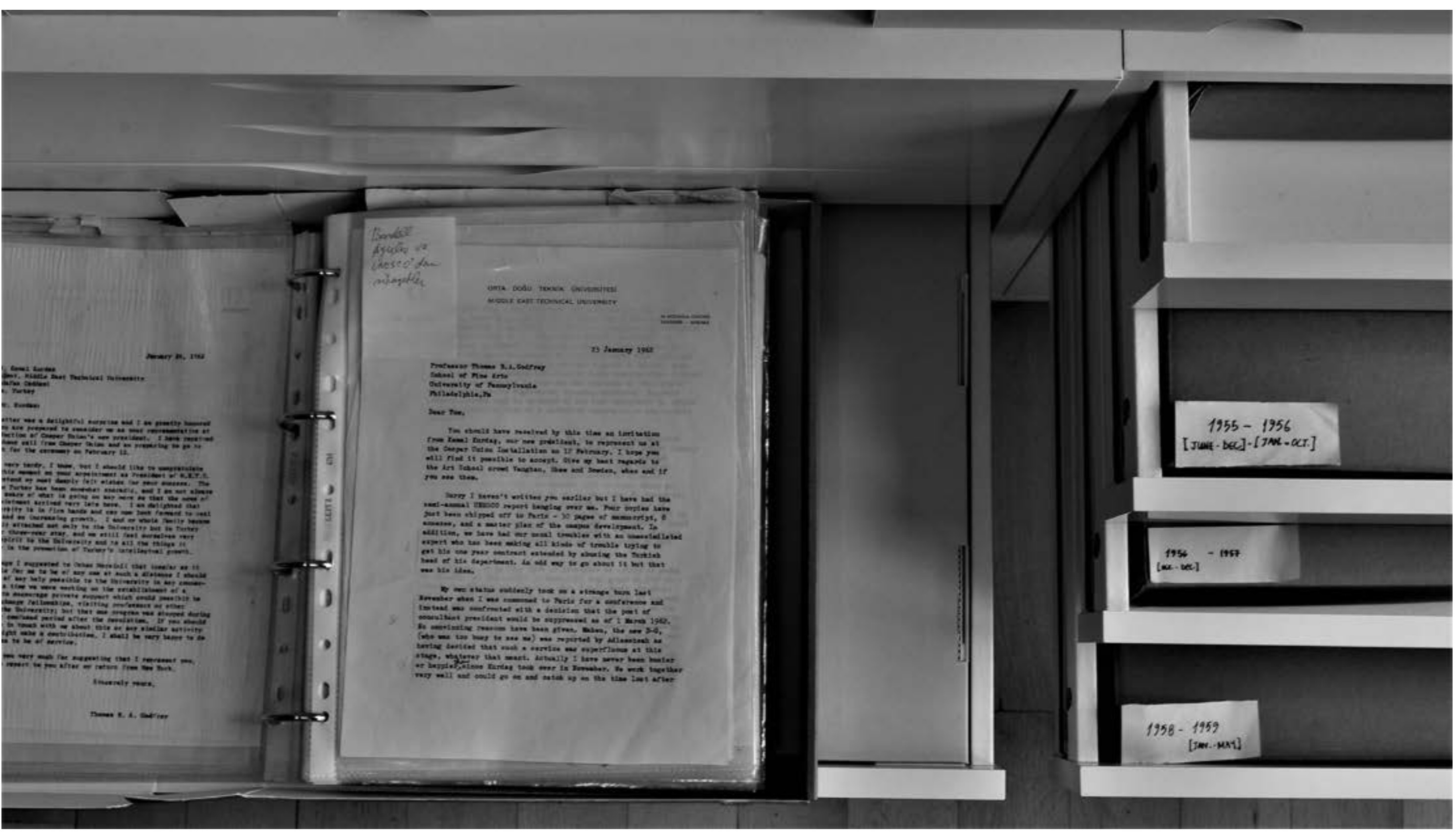
Questionnaire

A Questionnaire is prepared and given to the students in the faculty to locate their favorite spot in the building. This event also help the introduction of the METU-KIM project to a larger group and provided their involvement as stakeholders.

SISER (A Stakeholder-Oriented Intelligent System for Building Energy Retrofitting) for METU Faculty of Architecture Building Complex - Workshops

SISER is aimed at developing an intelligent system and a decision-making process for energy retrofit towards the improvement of energy performance and occupant comfort in existing buildings. SISER is conducted in collaboration between METU and Heriot Watt University in Edinburgh. The project is active between 1 June 2018- 1 June 2020. At METU, the research project is carried out by, Assoc. Prof. Ipek Gursel Dino (Project PI in Turkey), Prof. Aydin Alatan (METU Electrical Engineering) and Assoc. Prof. Sinan Kalkan (METU Computer Engineering), and 4 project researchers. At Heriot Watt, Assoc. Prof. Bilge Erdogan acts as the Project PI in UK. The project is fully funded by the Newton – Katip Çelebi Fund of the Scientific and Technological Research Council of Turkey (TUBITAK) and British Council.

During this phase, a workshop was organized, led by Dr. Bilge Erdogan and Dr. Luke Gooding. The workshop session comprised 11 participants, including key building stakeholder decision makers, along with teaching staff and student building users. With the workshop session, the first stage of investigation is to assess how participants rank the different priorities, which were resultant from initial interviews and questionnaires. Workshop also involves participants analysing the relationships between each requirement or change priority and the building's technical characteristic, in order to assess the extent to which there was a correlation, according to a predefined scale.


ORTA DOĞU TEKNİK ÜNİVERSİTESİ
MIDDLE EAST TECHNICAL UNIVERSITY
1955 - 1956
[JUNE - DEC] - [JAN - OCT.]
1956 - 1957
1958 - 1959
[JAN.-MAY]

6.4. Ongoing Graduate Research

Master & Doctorate Theses

The following theses are supervised and/or conducted by the core team of this project:

- Akın, Şahin. "Immersive Design Environments for Sustainable Architecture: A BIM-based Approach". Supervisor: Assist. Prof. Dr. İpek Gürsel Dino.

- İnan, Fatma Serra. "In-Between Spaces: METU Faculty of Architecture Building Complex". Supervisor: Prof. Dr. Ayşen Savaş.

- Sarıca, Sezin. "Relief-spaces: Trans-positions In Display Environments". Supervisor: Prof. Dr. Ayşen Savaş.

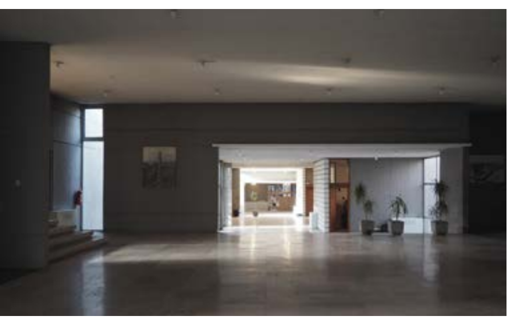
- Derebaşı, Bengisu. "Façade-Wall: An Architecture for Knowledge Representation". Supervisor: Prof. Dr. Ayşen Savaş.

- Akman, Sıla. "Conserving and Managing Modern Campus Heritage: "Alley" as the spine of METU Campus, Ankara". Supervisor: Assoc. Prof. Dr. Güliz Bilgin Altınöz, 2016.

Akın, Şahin. “**Immersive Design Environments for Sustainable Architecture: A BIM-based Approach**”. Supervisor: Assist. Prof. Dr. İpek Gürsel Dino.

The use of shared, simulated, and synchronized virtual environments in design process and increasing the use of computational methods in design are relatively new subjects. Virtual reality immerses the user in a three-dimensional digital environment and has the potential to make the user involve actively in the act of design. Daylighting in architecture is an essential concept in architectural design, but its assessment and integration to the design process can be complicated. The use of Building Information Modelling (BIM) tools is identified as the critical solution for performance-based architectural design with its integrated simulation tools. However, both BIM models and performative simulation data are visualized through non-immersive computer displays. In opposition, immersive environments can create an interactive, multi-sensory, first-person view, three-dimensional computer-generated environment, and can increase designers’ spatial cognition and perception. This research points out the need for interactive design tools in immersive environments (IE) to achieve higher performing architectural solutions that encourage the optimal use of daylighting illumination. The study presents development of a tool called HoloArch, that enables increased certainty and design perception in terms of daylighting performance for BIM users in IE. The tool’s UX studies were conducted in three workshops: DCG Summer School at the University of Lisbon and two Immersive and Responsive Environments workshops at METU. Obtained feedback were analyzed with both quantitative and qualitative analysis methods. The results show that immersive environments have potential to augment designer’s perception and interaction, to enchance designers’ data workflows and to support performative design process.

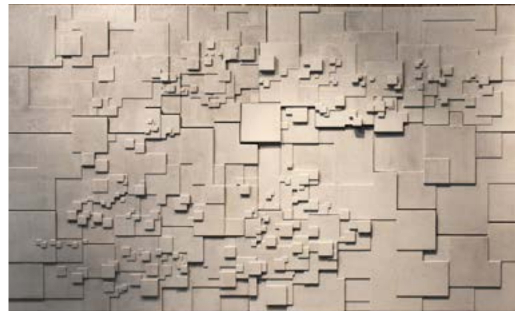
İnan, Fatma Serra. “**In-Between Spaces: METU Faculty of Architecture Building Complex**”. Supervisor: Prof. Dr. Ayşen Savaş.



In-between spaces are interpreted in multiple contexts, scales and considered both as a material and an immaterial space within the scope of this study. The extent of the research is limited to the METU Faculty of Architecture Building Complex; yet, the outputs of the work are beyond this restricted area. The concept of in-between spaces is re-defined with its potential to become a theoretical tool for the analysis of the existing and future architecture in relation to its discourse, object and various subjects. The tryptic method of Peter Eisenman, which aims to “blur” the architectural object and to carry it beyond the limits of traditional architecture, is adopted for the classification and the re-interpretation of in-between spaces. The representation medium is photography which has a further role as an analytical research tool. Through the effort of a concrete visualization of a rather abstract concept of in-between spaces, with the “realistic” tool of photography, the thesis itself also stands between materiality and immateriality.

Sarıca, Sezin. “**Relief-Spaces: Trans-Positions In Display Environments**”.
Supervisor: Prof. Dr. Ayşen Savaş.

The aim of this study is to redefine the relationship between the exhibition space and the object on display. With the recognition that architecture of exhibition space has been a renowned problematic in the architectural discourse, this study specifically focuses on the spatial integrity of both the container, the exhibition space, and the content, the object on display. The inquiry is into the possibility of using the visual field of artistic production, “relief”, as a decoder, in order to be able to define a new way of seeing the visual field of exhibition space. Relief is reintroduced as a scaleless surface and space formation. Therefore, it becomes a seeing/reading tool that can magnify the environments superimposed in one immersive medium. Space and the surface are read together as a display environment. The aim is to look into the term and condition “expansion” that surface defines while creating a relief-space as a display space. Relief-space is defined as an architectural condition, which is conceptualized through a collocated textual ground of both architecture and art. The discussion questions both the conventional singularity of museum and galleries as “the” exhibition space and the conventional stability of architecture, which has been accepted only as the “container”.



Derebaşı, Bengisu. “**Façade-Wall: An Architecture for Knowledge Representation**”.
Supervisor: Prof. Dr. Ayşen Savaş.

This study aims to track the traces of knowledge in architecture. Architecture, here, refers to the materiality of the knowledge; knowledge, on the other hand, is considered as an abstract concept. In order to reveal the intricate relation between knowledge and architecture, surfaces of certain libraries are inquired. By liberating knowledge representation from the books, this inquiry perceives the wall and the library as the architectural interfaces where knowledge could be represented. Through certain cases: The Temple of Edfu, Fang Shan Archive and the Sainte Genevieve Library, the reflection of knowledge in architecture is quested. The walls of the mentioned cases are transformed into a surface, a wall-niche or a façade-wall to accommodate knowledge. Thus, the wall, the renowned architectural element, is reconceptualized with the presence of knowledge. As the utmost condition of this convergence, the term façade-wall is introduced. It is generated depending on the Sainte Genevieve Library and this term is reinterpreted by revisiting the Foucauldian concept of *table*.

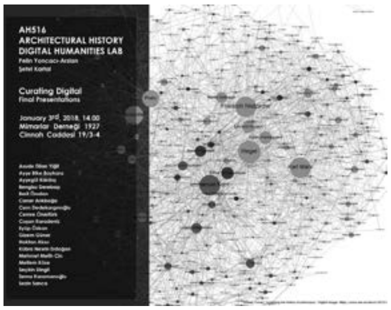
Akman, Sıla. “**Conserving and Managing Modern Campus Heritage: "Alley" as the spine of METU Campus, Ankara**”.
Supervisor: Assoc. Prof. Dr. Güliz Bilgin Altınöz, 2016.

University Campuses are significant cultural heritage places with their generated social and physical environment. The way for the conserving the university campuses, which intrinsically need continuous changing and enlargement, only is conservation and management plan defining and directing the change and development of the campus. Middle East Technical University (METU) Campus is a representative of our modern heritage and one of the first Republican Period university campuses in Turkey. METU Campus as a cultural heritage site needs to be conserved because it is very important cultural landscape area with its educational, social and cultural values, the place of social memory, well qualified natural and built-up environment and its archaeological areas, not only for Ankara but also for Turkey.

The main subject of the thesis is conservation of the METU Campus, under the concept of the conservation of the modern campus heritage. "Alley" shaping social and physical environment is the spine of the METU Campus; therefore, this study focuses on "Alley" of the campus as the first step in the conservation of the METU Campus.

Related courses

AH 516: Architectural History Digital Humanities Lab



The aim in this course is to introduce students the current topics and critical issues that underlie digital humanities scholarship - in particular, as they relate to Architectural History. The course is organized around three modules, each extending over a period of roughly three weeks. The first set explores concerns and techniques related to geospatial studies, namely mapping and spatial visualizations; the second will concern techniques for network6 visualizations and textual analysis; and the third will address the creation of digital exhibitions and archives. Some part of the course is intersected with the archival work, and some experiments on "visualizing" both the archival material and its information is made.

ARCH 723: Advanced Architectural Design Research&
ARCH 524: Architecture and Different Modes of Representation

For last 2 years, the scope of these courses included the annual METU Faculty of Architecture archive exhibitions in order to be able to make the collections visible to the faculty and disseminate its information to a larger audience to create a public awareness. In the courses, the theoretical framework on "archive" and "representation" help the spatial organization of the display environments. The exhibition theme of the last two years was entitled as "Representing Itself". Using different modes, media and techniques of representation, students are asked to design a space and a display for the reading, understanding and interpretation of the Building and its archive. These courses are about different modes and techniques of representation in architecture: directed to master students. Focusing on conventional representation techniques, its objective is to study the transformations in the definition of the works of architects from "tool of communication" to "archival objects". Instead of suggesting continuity in this transformation process, however, these courses are organized to show the possible coexistence of these characteristics. The courses can be considered as experiments on the formation of textual base for the spatialization of ontology-based data integration for METU Faculty of Architecture Archive as an extension of "Keeping It Modern" Project run by Getty Foundation.

ARCH 524: Architecture and Different Modes of Representation, 2019-2020 Fall

A series of exhibitions entitled "ARCHIVE: METU DOCUMENTED" had been held since January 2017, as part of the Getty Foundation "Keeping It Modern" project activities. The major goal behind these exhibitions is the collection of the archival material that is focusing on the establishment years of the university and the formation of its physical environment.
Preparation of a living archive is a "critical operation", using the Tafurian terminology. It is a continuous interpretation process, effective even after the completion of the institutional procedures. Thus, the ultimate objective of this archive is to protect the campus and its outstanding architectural elements. As Derrida states "the archivization produces as much as it records the event", the structuring of the archive, in other words the process of archivization, amplifies both the concept and the future productions. Therefore, this semester, the course ARCH 524: Architecture and Different Modes of Representation dwells on the concept of 'archive'. It invites students of different academic background to collectively imagine the novel ways of representi ng/exhibiting/constructing the METU Faculty of Architecture Archive.

ARCH 524: Architecture and Different Modes of Representation, 2018-2019 Fall

The course, ARCH524 Architecture and Different Modes of Representation, invites students of different academic background to collectively imagine the novel ways of representing/exhibiting METU Faculty of Architecture building. The reader is intended for informative purposes only and the attendees are encouraged to intervene and progress the trajectory of the course.

ARCH 524: Architecture and Different Modes of Representation, 2017-2018 Fall

This course is about different modes and techniques of representation in architecture; directed to master students.
Focusing on conventional representation techniques, its objective is to study the transformations in the definition of the works of architects from `tool of communication` to `aesthetic objects`. Instead of suggesting a continuity in this transformation process however, this course is organized to show the possible coexistence of these characteristics.

The course is also an experiment on the formation of textual base for the spatialization of ontology-based data integration for METU Faculty of Architecture Archive as an extention of "Keeping It Modern" Project run by Getty Foundation.

ARCH 723: Advanced Architectural Design Research, 2016-2017 Spring

ARCH 723 is a project base studio course introduces students to advanced topics in the design research with a strong link to architectural representation. This studio course takes on the challenge of designing a traveling exhibition. Using different modes, media and techniques of representation, students are asked to design a space and a display for the reading, understanding, interpreting and finally documenting METU Lodging.

The goal of this exhibition is to promote the production of "new documents" by means of the active involvement of architects, architectural students, historians, theorists and critics. Here we will benefit from the definition of the term "curator" as it is used in art world. "The words etymological roots attest that it "treats", "cures" art, with its intricate ways". So does this exhibition as it not only makes architectural documents visible and understandable and treats them as museological objects identified, collected and preserved, but also creates and completes them to construct an archive for the promotion of architectural knowledge. In other words, architectural knowledge will be obtained by the actual making of documents and documentation. This critical act is conceived as a process, rather than an end product.

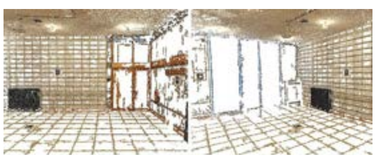
Thus we conceive exhibition as "an instrumental tool" for architectural research. This exhibition should be evaluated as a research initiative and the material collected should be seen as the seed of a "new archive" for emerging research fields. The way we study history and theoretical interpretations of architectural objects and their documentation, contributed to the "expansion" of its disciplinary boundaries.

METU Lodging exhibition, on the contrary, particularly focusing on a very specific object of study, "the house", aims at puling architecture back to its basics. In other words, our documentation does not expand the borders of the architectural production to a necessary social, political and historical context; it rather forms the ground and provides the tools for further contextualization.

Research Project Initiation: SISER (A Stakeholder-Oriented Intelligent System for Building Energy Retrofitting) for METU Faculty of Architecture Building Complex

SISER is aimed at developing an intelligent system and a decision-making process for energy retrofit towards the improvement of energy performance and occupant comfort in existing buildings. SISER is conducted in collaboration between METU and Heriot Watt University in Edinburgh. The project is active between 1 June 2018- 1 June 2020. At METU, the research project is carried out by, Assoc. Prof. Ipek Gursel Dino (Project PI in Turkey), Prof. Aydin Alatan (METU Electrical Engineering) and Assoc. Prof. Sinan Kalkan (METU Computer Engineering), and 4 project researchers. At Heriot Watt, Assoc. Prof. Bilge Erdogan acts as the Project PI in UK. The project is fully funded by the Newton – Katip Çelebi Fund of the Scientific and Technological Research Council of Turkey (TUBITAK) and British Council.

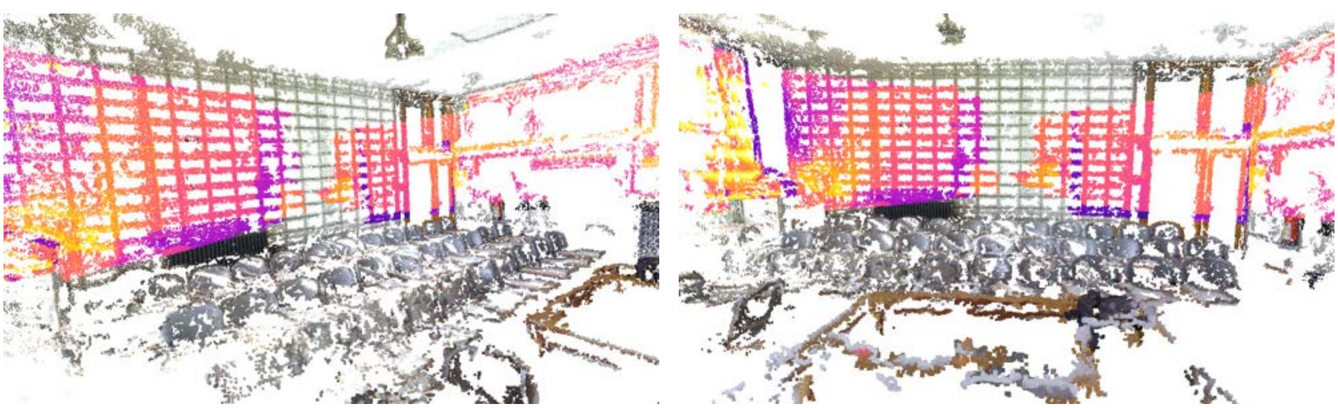
As part of its main research objectives, SISER address two key activities: 1) developing computer vision-based methods for the easy and precise energy modelling and simulation of existing buildings and retrofit scenarios, 2) collaborative decision-making for improvement of energy and comfort. For both activities, novel methods and tools will be developed for the aim of improving the performance and quality of the existing buildings and realising environmental and economic impact. METU Faculty of Architecture building is selected as the case study building for the research activities regarding tool development, testing and validation.



3d point-cloud generated using the pipeline

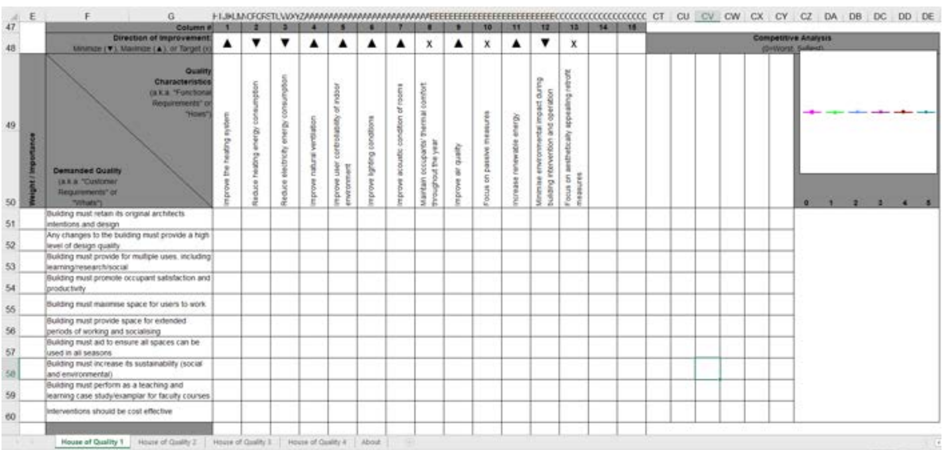
As part of the first research activity, an automated pipeline for 3D modelling of the building was developed.

Two 3D reconstruction methods for the robust estimation of the building planes from a 3D point cloud that (i) independently estimates each plane and (ii) imposes a perpendicularity constraint to plane estimation were developed. As part of this pipeline, external walls' thermal resistance was estimated using the surface temperatures measured by a thermal camera, following an existing method. Our approach is validated (i) by testing the pipeline's ability in constructing accurate surface models subject to different image sets with varying sizes and levels of image quality, and (ii) through a comparative analysis between the calculated energy performance metrics of a ground truth and calculated energy simulation model. For the benchmaring of the calculated model with the actual building model, we used the 3D point cloud model that was captured during the Getty project.



Thermal data registered point cloud

As part of the second research activity, methods to capture building stakeholders' preferences and priority rankings through field studies through surveys and interviews are developed. The developed framework provides a step by step guidance on all stages of the collaborative stakeholder decision making process for simultaneous achievement of comfort and energy performance as well as addressing occupant energy use behaviour. Initially, semi-structured individual end user interviews were carried out along with group interviews, to qualitatively assess the priorities for a retrofit scheme of works. Utilising qualitative textual analysis software, specific elements to consider in the retrofit design process are defined, along with particular areas in need of focus, to best enhance user experience and energy efficiency gains.



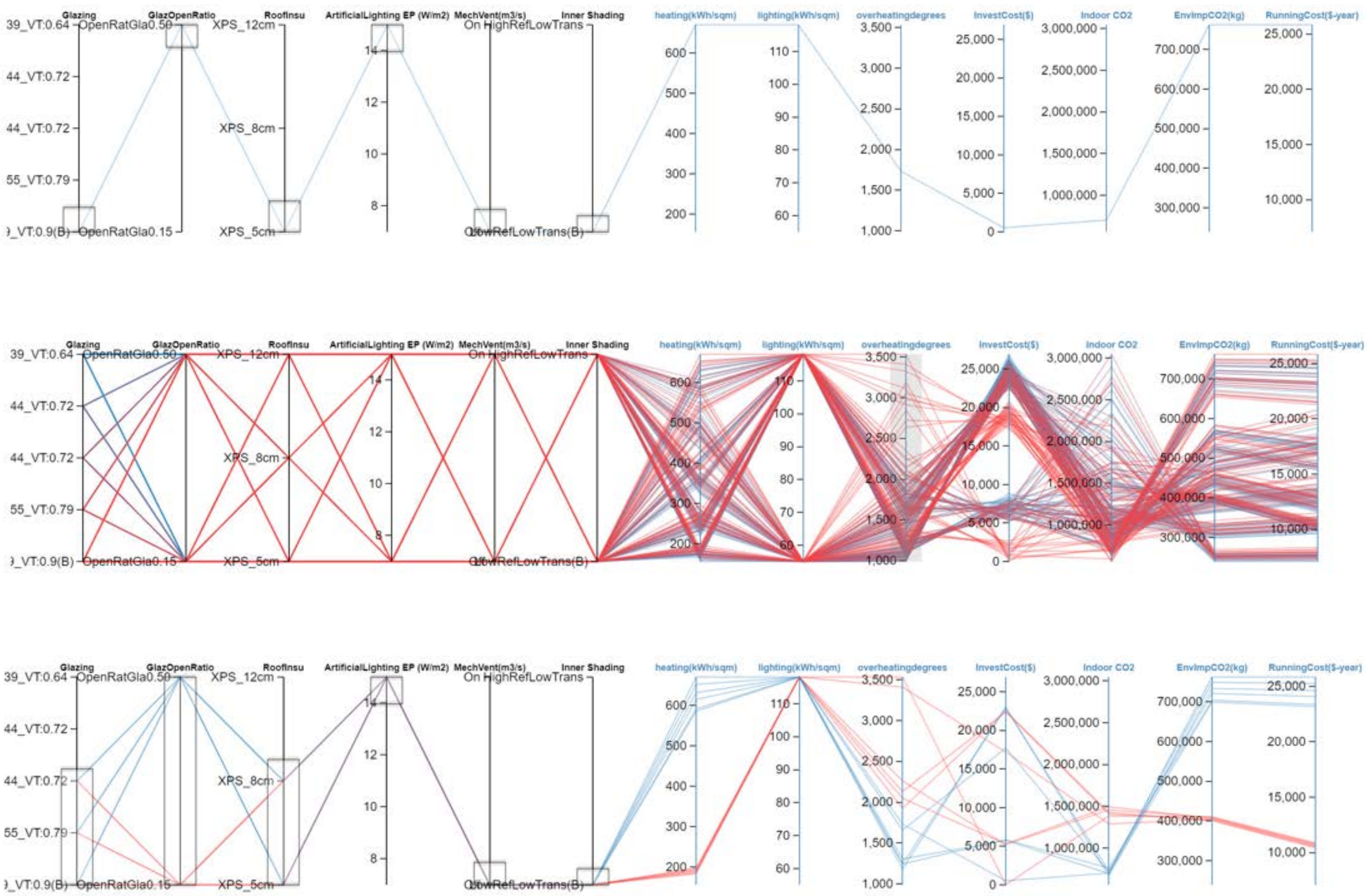
Using a case study approach, this research looks to highlight key elements of successful early design end user engagement, utilised to promote successful project completion. Following the interviews, a more structured approach of an environmental comfort questionnaire was followed with increased numbers of responses to questions regarding how they rate the building, and the key elements which were successful or in need of amendment. This primarily assists in triangulating the findings from the interviews, and to ensure that any key priorities detected at interview stage, are also shared by the wider user and occupant groups. The most reoccurring building priorities are recorded and taken to the second stage of stakeholder interaction. During this phase, a workshop was organized, led by Dr. Bilge Erdogan and Dr. Luke Gooding.

The workshop session comprised of eleven participants, including key building stakeholder decision makers, along with teaching staff and student building users. With the workshop session, the first stage of investigation is to assess how participants rank the different priorities which were resultant from initial interviews and questionnaires. Workshop also involves participants analysing the relationships between each requirement or change priority and the building's technical characteristic, in order to assess the extent to which there was a correlation, according to a predefined scale.

A final workshop was organized in December 2019 with a smaller yet more focused group of participants that represent different stakeholder groups. This workshop aimed at the collaborative decesion-making towards the determination of < set of retrofit intervention actions that all stakeholders agree on. To guide decision-making, a quantitative analytical process is triggered, wherein the building energy simulation results are presented to the users. The energy models that were semi-automatically built using the computer vision methods previously developed during the project were used for simulations. A different energy model is built for each interventiona scenario, and its simulations were run.

A total number of six intervention scenarios were selected as a result of the previous workshop, and seven performance metrics were calculated with the simulation tools: total heating energy use, lighting energy use, overheating hours, indoor CO2 concentration, investment cost, running cost, and envirenmental impact. The results were presented to the decision-makers using Design Explorer, an open-source, web-based interface that allows the exploration of multi-dimensional parametric studies. During the workshop, it was concluded that the indoor air quality is the most pressing issue that needs to resolved for occupant comfort. The installation of new fan coil units and the modification of the existing window frames so to allow indoors a larger volume of outdoor air were two selected interventions.

As such, the decision-making framework developed during the project was concluded by its complete implementation on the Faculty of Architecture building and its representative stakeholders.



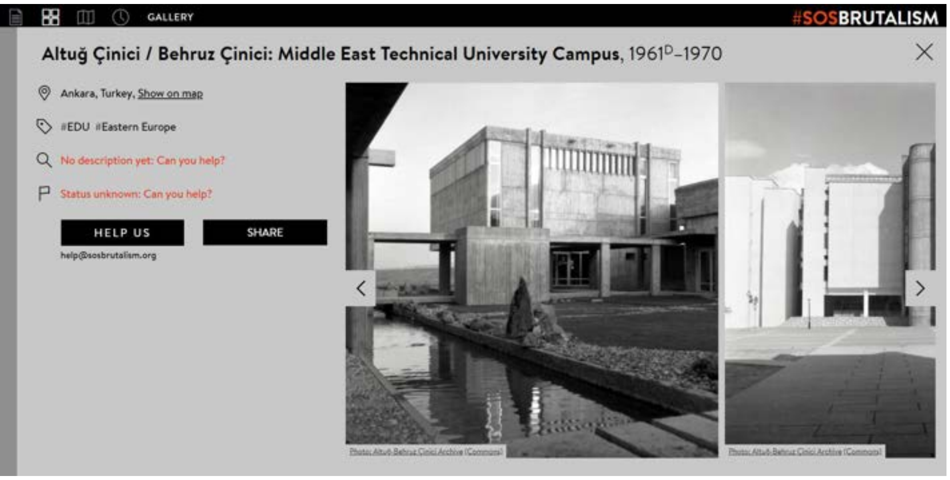
6.5. Media Coverage

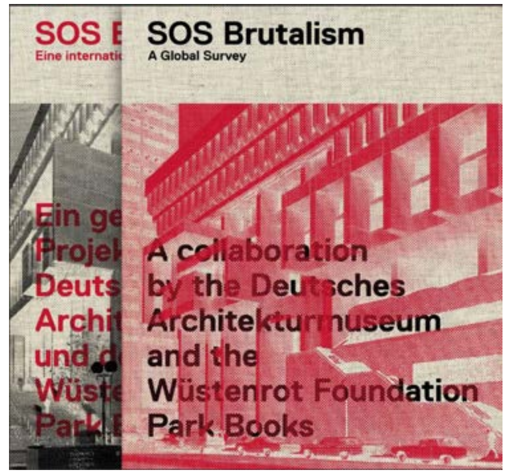
The grant supplied by Getty Foundation for METU Faculty of Architecture is reported in the news and in various platforms both international:

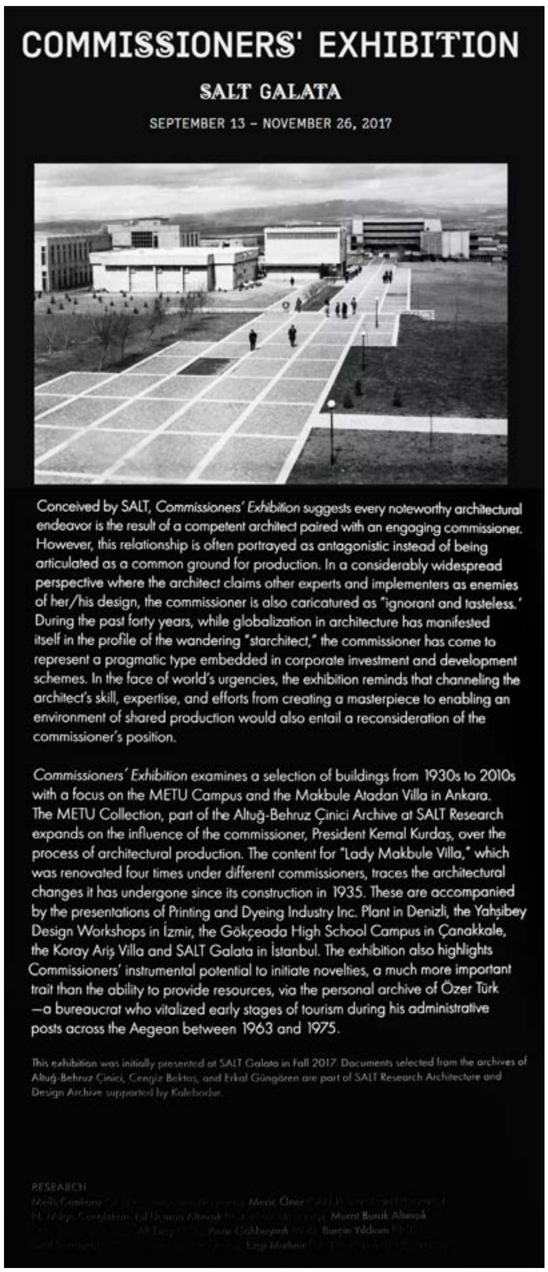
- Archdaily (worldwide architecture website)

and national:

- Hürriyet Gazetesi (nationwide newspaper)
- CNNTürk, (TV, News Channel)
- Mimarlık Dergisi (Chamber of Architects' Journal of Architecture)
- Arkitera (a web-based national architectural portal)
- Mimarizm (architecture and design media platform)
- T24 (an independent internet newspaper)
- Vbenzeri (web portal for creative disciplines)
- mimdap (architecture portal)







COMMISSIONERS' EXHIBITION

SALT GALATA

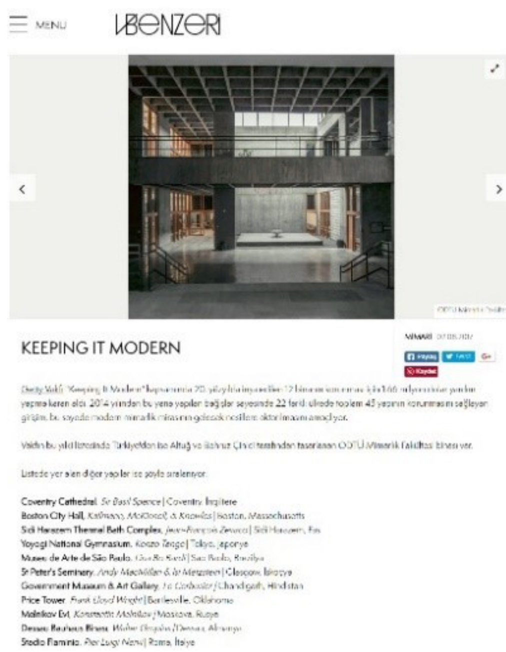
SEPTEMBER 13 – NOVEMBER 26, 2017

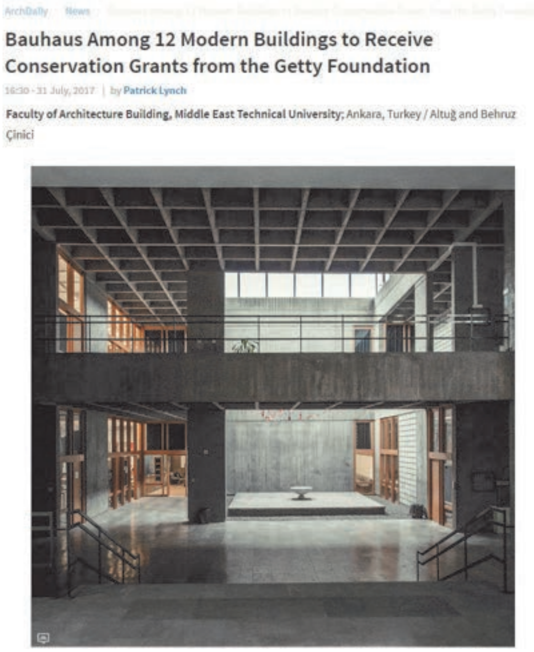
Conceived by SALT, *Commissioners' Exhibition* suggests every noteworthy architectural endeavor is the result of a competent architect paired with an engaging commissioner. However, this relationship is often portrayed as antagonistic instead of being articulated as a common ground for production. In a considerably widespread perspective where the architect claims other experts and implementers as enemies of her/his design, the commissioner is also caricatured as "ignorant and tasteless." During the past forty years, while globalization in architecture has manifested itself in the profile of the wandering "starchitect," the commissioner has come to represent a pragmatic type embedded in corporate investment and development schemes. In the face of world's urgencies, the exhibition reminds that channeling the architect's skill, expertise, and efforts from creating a masterpiece to enabling an environment of shared production would also entail a reconsideration of the commissioner's position.

Commissioners' Exhibition examines a selection of buildings from 1930s to 2010s with a focus on the METU Campus and the Makbule Atadan Villa in Ankara. The METU Collection, part of the Altuğ-Behruz Çinici Archive at SALT Research expands on the influence of the commissioner, President Kemal Kurdaş, over the process of architectural production. The content for "Lady Makbule Villa," which was renovated four times under different commissioners, traces the architectural changes it has undergone since its construction in 1935. These are accompanied by the presentations of Printing and Dyeing Industry Inc. Plant in Denizli, the Yahşibey Design Workshops in İzmir, the Gökçeada High School Campus in Çanakkale, the Koray Ariş Villa and SALT Galata in İstanbul. The exhibition also highlights Commissioners' instrumental potential to initiate novelties, a much more important trait than the ability to provide resources, via the personal archive of Özer Türk—a bureaucrat who vitalized early stages of tourism during his administrative posts across the Aegean between 1963 and 1975.

This exhibition was initially presented at SALT Galata in Fall 2017. Documents selected from the archives of Altuğ-Behruz Çinici, Cengiz Bektaş, and Erkal Güngören are part of SALT Research Architecture and Design Archive supported by Kalebodur.

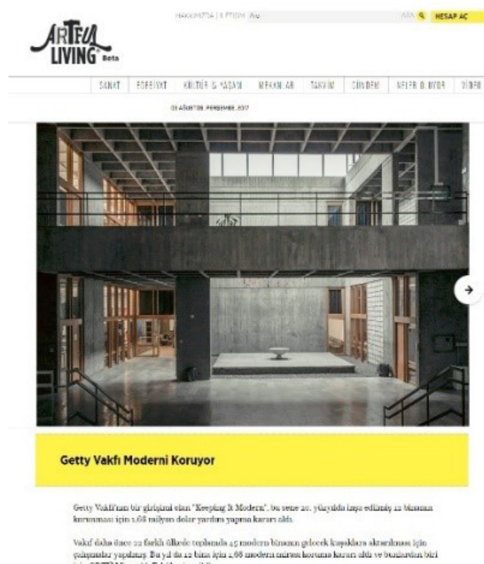
RESEARCH

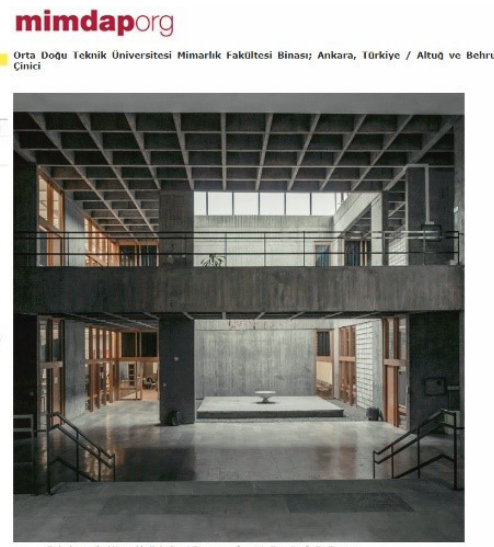



Bauhaus Among 12 Modern Buildings to Receive
Conservation Grants from the Getty Foundation
by Patrick Lynch
Faculty of Architecture Building, Middle East Technical University; Ankara, Turkey / Altuğ and Behruz Çinici

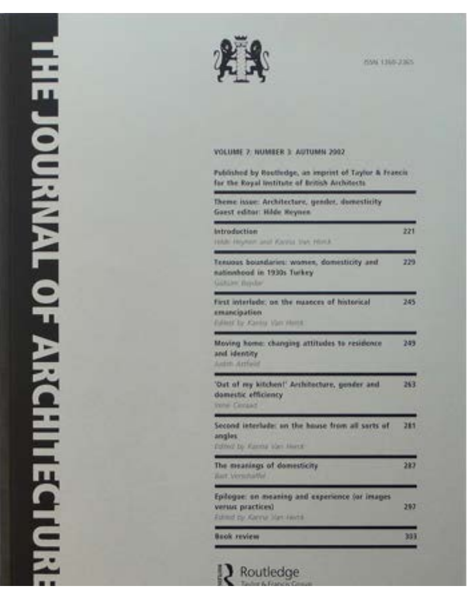

ARKITERA
Getty Vakfı'ndan ODTÜ Mimarlık Fakültesi'nin Korunması İçin Destek
Getty Vakfı'nın bir girişimi olan "Keeping It Modern", bu sene 20. yüzyılda inşa edilmiş 12 binanın korunması için 1,66 milyon dolar yardım yapma kararı kaldı.


mimarizm
MİMARLIK VE TASARIM
YAYIN PLATFORMU
ODTÜ Mimarlık'a Yurtdışından Koruma Hibesi
Tuba Tellioğlu Şeren / 01 Ağustos 2017
Getty Foundation, "Keeping It Modern" girişimi kapsamında 12 önemli 20. yüzyıl yapısına koruma projesi hibesi sağlıyor. Bunlar arasında Türkiye'den ODTÜ Mimarlık Fakültesi Binası da bulunuyor.
Ortadoğu Teknik Üniversitesi Mimarlık Fakültesi Binası; Ankara, Türkiye / Altuğ ve Behruz Çinici
"Keeping It Modern" girişimi, konservasyon planlaması ve araştırmasını odağına alarak modern mimarinin korunmasını ve daha iyi anlaşılmasını sağlamayı amaçlıyor. 2014 yılında faaliyete geçen program kurulduğu günden bu yana dünya çapında 45 koruma projesine destek sağlamış.


Arttful LIVING
Getty Vakfı Moderni Koruyor


mimdap.org
Orta Doğu Teknik Üniversitesi Mimarlık Fakültesi Binası; Ankara, Türkiye / Altuğ ve Behruz Çinici
Göbektaşı ile Mimarlık Fakültesi Binasının İçerisi. Fotoğraf: D. Tuncas.


Students
Staff
Alumni
Researchers
Visitors
Media
Search
Türkçe
ORTA DOĞU TEKNİK ÜNİVERSİTESİ
MIDDLE EAST TECHNICAL UNIVERSITY
"WE CAN CHANGE THE WORLD"
METU NORTHERN CYPRUS CAMPUS
About ODTÜ
Academic
Services
Campus Life
Research
Prospective Students
Giving to METU
Search


THE JOURNAL OF ARCHITECTURE
ISSN 1360-2365
VOLUME 7: NUMBER 3: AUTUMN 2002
Published by Routledge, an imprint of Taylor & Francis for the Royal Institute of British Architects
Theme issue: Architecture, gender, domesticity
Guest editor: Hilde Heynen
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Tenuous boundaries: women, domesticity and nationhood in 1930s Turkey 229
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Routledge


DIAMONDSINSAHARA
METULODGINGSDOCUMENTED
Ayşen Savaş | Agnes van der Meij


METU DOCUMENTED
BELGELERLE ODTÜ
AYŞEN SAVAŞ


1956'dan 2006'ya ODTÜ Mimarlık Fakültesi'nin 50 Yılı
ANILAR
Bir Sözlü Tarih Çalışması
derleyenler Sevgi Aktüre Sevin Osmay Ayşen Savaş

6.6. Publications

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• Savaş, Ayşen. ed. *Middle East Technical University: 50th Anniversary*, Ankara: METU Press, 2006.

• Aktüre, Sevgi, Sevin Osmay and Ayşen Savaş eds., *Memories. An Oral History. (Anılar. Bir Sözlü Tarih Çalışması. 1956'dan 2006'ya ODTÜ Mimarlık Fakültesi-nin 50 Yılı)*, Ankara: METU Press, 2007.

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http://www.bauhaus-imaginista.org/articles/5600/for-the-faculty-of-architecture-at-metu

• Savaş, Ayşen. and Agnes van Der Meij eds. *Diamonds in Sahara: METU Lodgings Documented,* Ankara: Middle East Technical University, Faculty of Architecture, 2018.

• Savaş, Ayşen. "An Early Critique of International Modernism in the Anatolian Context", Regionalism, Nationalism and Modern Architecture" CEAA Conference Proceedings, Portugal, October 25-27, 2018: 359-370.

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7. APPENDICES

Appendix A. Faculty Facilities and the Existing Infrastructure

Faculty of Architecture has an extensive infrastructure that will facilitate the archival, research and analysis activities. These laboratories, libraries and the equipment they contain will be used while conducting the research activities detailed above.

- bs.lab | Building Simulation Laboratory
- bm.lib | Building Materials Library
- Computer Lab
- DDS | Digital Design Lab
- Model Making Workshops
- MCL | Materials Conservation Laboratory
- Photogrammetry Laboratory
- Photography Laboratory

bs.lab | Building Simulation Laboratory

The Building Simulations Lab was established in December 2009 by Building Science Graduate Program, through funding provided by the Faculty of Architecture. The lab became fully operative in March 2010 with the installation of licensed building simulation software on ten state-of-the-art computers; thus, making it possible for the first time, to offer a course on building performance simulations. Since then BPS courses have focused on different software each term, such as Ecotect, EnergyPlus or Design Builder; in conjunction with Climate Consultant. During these courses graduate students learn to simulate buildings for their thermal performance; natural and artificial lighting design, natural and mixed mode ventilation; mechanical heating and cooling loads; as well as energy consumption and carbon emissions.

bm.lib | Building Materials Library

The Building Materials Library was established in 2011 as an archive where catalogues and samples of building material and components are stored and displayed; and where system-detail models prepared by architecture students are also exhibited. The library provides an on-line access to browse electronic catalogues and CDs related to various building products. The Library has located in Architecture Annex.

Computer Lab

Established in 1980 and being upgraded since then on a regular basis in order to comply with the needs and the expectations of the members of the faculty, students and the academic staff respectively, The Computer Lab aims at providing a cutting-edge environment for education and research. Today equipped with advanced tools of digital technology and now being under a comprehensive upgrading once again the Lab has long been regarded as an info-locus for METU students throughout courses, workshops, seminars and even in personal and/or group studies as it is centrally located within the main building and thus open to public use accessible to all.

DDS | Digital Design Lab

Digital Design Studio (DDS) was initially established as a part of a Scientific Research Project (BAP) in 2003 (by Arzu Goneng Sorgug and §ebnem Yalinay) aiming to provide necessary hardware and software to explore state of art computational design and fabrication technologies. Following the very first years of the establishment, DDS has become the foundation of computational design education at METU Department of Architecture. Today DDS is still the core of computational design education and not only the number of courses, staff and the students using DDS is increasing but also the number of workshops, seminars open to public is becoming an international venue.

Photography Laboratory

As an active part of DOME [Faculty Archive | Documentation Center] the Lab has a two-fold purpose that of documentation of faculty works and of service space for courses in photography and digital media. The Lab has a primary function that is to document and then archive educational materials; the archival material is extremely original in nature, having a historical value for METU, Faculty of Architecture. Along with those of listed qualities, the Lab also offers an educational infrastructure for courses by which analog/digital photography is being thought/trained for the students.

Model Making Workshops

Fully supporting architectural/planning/design education and research, the Faculty of Architecture provides the students and the academic staff with a Model Making Workshop accessible to all since its establishment in 1956. Model making facility with its experienced and specialized staff has long been an active milieu of hands-on production as well as computer-based fabrication as it offers an extensive space in Annex where students and staff could carry out their physical model making and prototypes as part of their research and education programs. In addition to tools and equipment for hands-on production techniques, such as woodwork, metalwork and ceramics, high-tech CAM systems, such as 3d printers, laser cutters and3d router (milling machine) are also available under the supervision of faculty technician and specialists. The Model Making Facility, which has been regularly updated, is now under a comprehensive remodeling/refurbishing and thus upgrading in hardware to be able to offer a well-established, cutting-edge environment for undergraduate education that includes the Faculty's half-a-century-long tradition of extensive summer practices.

mcl materials conservation laboratory

MCL | Materials Conservation Laboratory

The Materials Conservation Laboratory (MCL), which is an academic extension of the Conservation of the Cultural Heritage Graduate Program, Department of Architecture, Middle East Technical University, was established in the early 1960s, as an educational and research laboratory for the said program. Once an independent academic unit, "Department of Restoration" is now a a center for excellence in research and education for the preservation of the built environment as MCL has become an internationally acclaimed research center in time for the development of scientific conservation studies and the improvement of conservation practices. MCL aims at diagnostic analyses of historic structures and materials for the active decay factors and sources, development of conservation treatments, selection and preparation of compatible repair materials, and the establishment of maintenance and monitoring programs for historic structures. MCL has more than thirty years of experience on site and laboratory investigations of historic structures in Turkey. It has been the task of the laboratory to study technological properties of historical building materials and their problems for the purpose of their conservation. In 2003, the Graduate Program restructured itself in complying with the contemporary paradigms of higher education and the cutting-edge research as it begun to recruit non-architect graduates from different disciplines and fields; starting from 2007-2008 Fall Semester, the graduates of four-year-degree programs are also eligible.

Photogrammetry Laboratory

Photogrammetry Laboratory

The Photogrammetry Laboratory (PL) of METU Department of Architecture was established in 1967. Being a pioneer in the field of architectural photogrammetry in Turkey, PL is one of the few educational and research centers developed by Restoration and Preservation Program of METU Department of Architecture.

The main purposes of PL are providing training for undergraduate and postgraduate students in architectural documentation and photogrammetry; providing theoretical, practical, and technical support to all researchers of METU in documentation of the physical environment, especially the historic environment; following the developments, and conducting researches on new ways of documenting and analyzing architectural heritage in different scales.

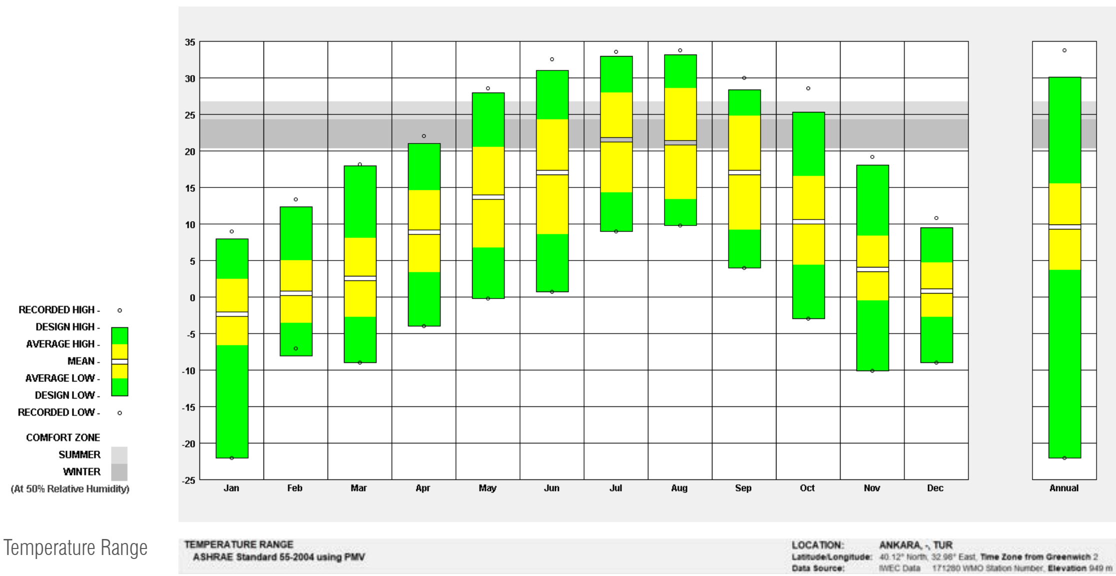

Figure 1: Temperature Range

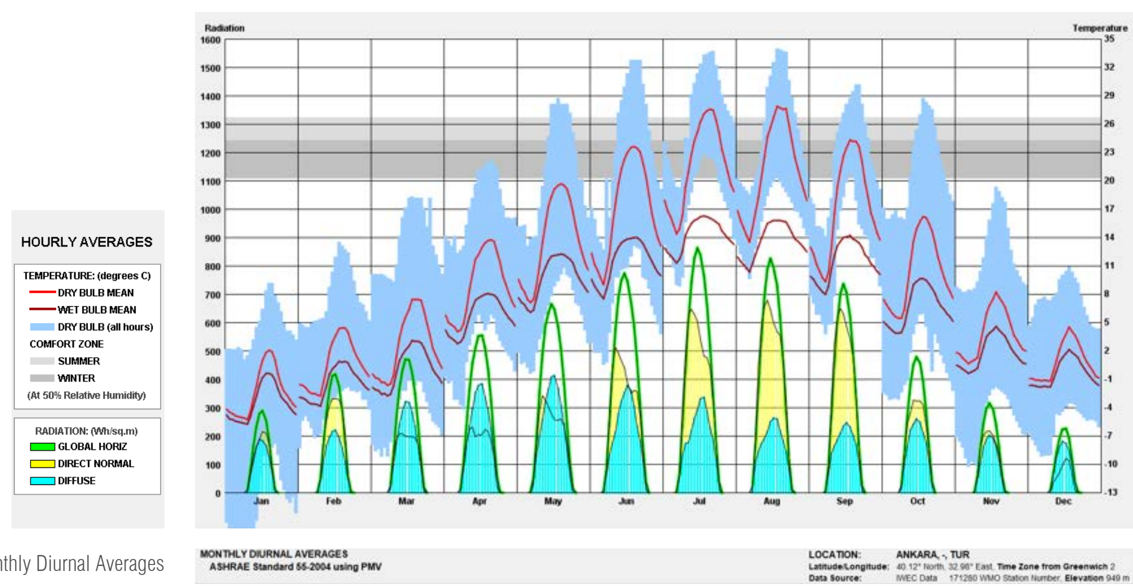

Figure 2: Monthly Diurnal Averages

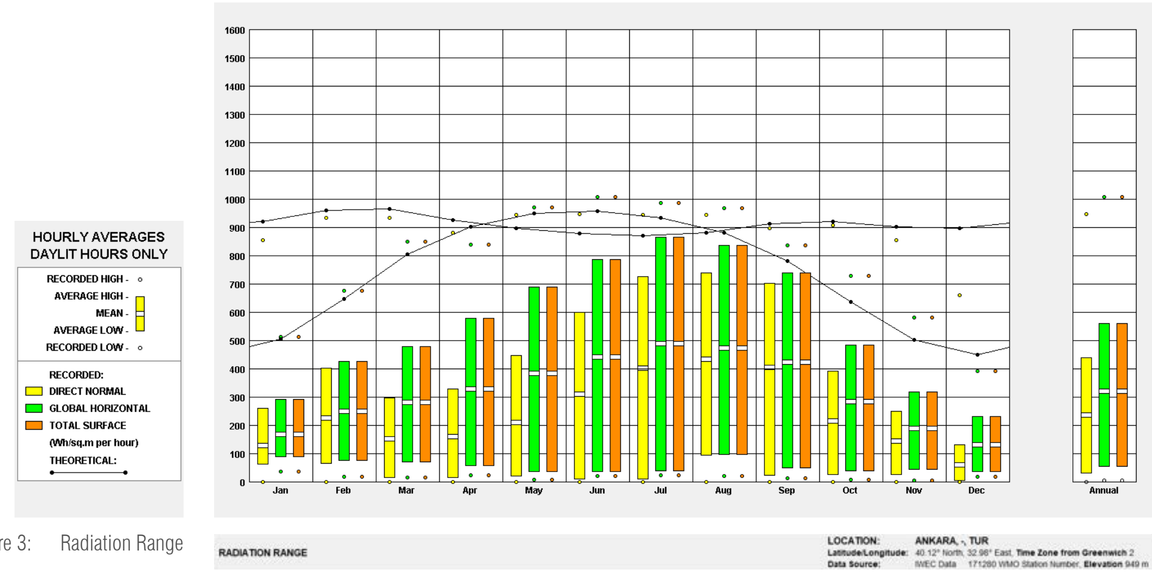

Figure 3: Radiation Range

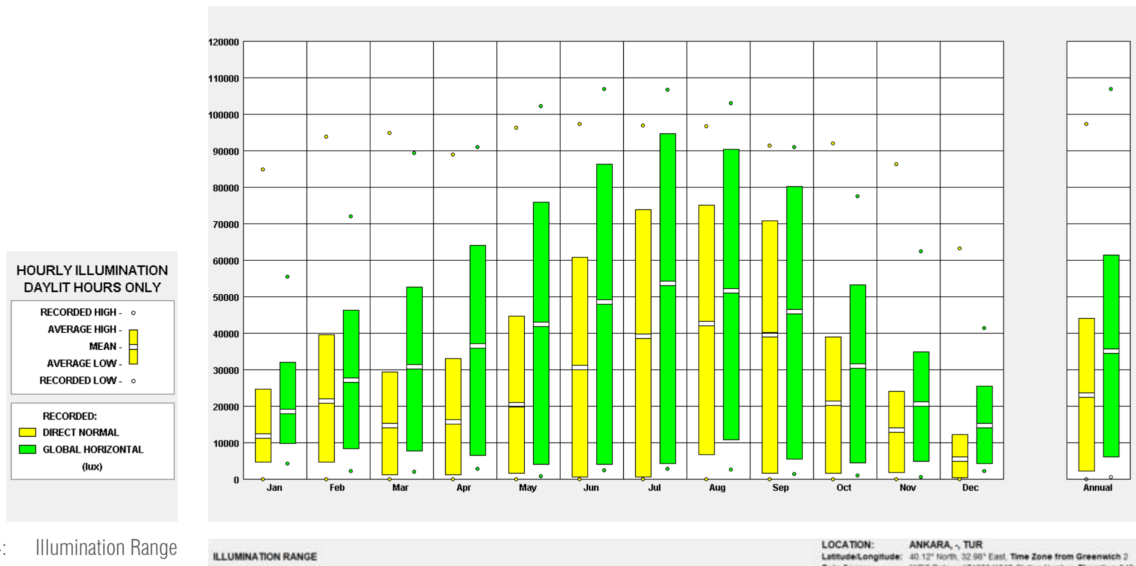

Figure 4: Illumination Range

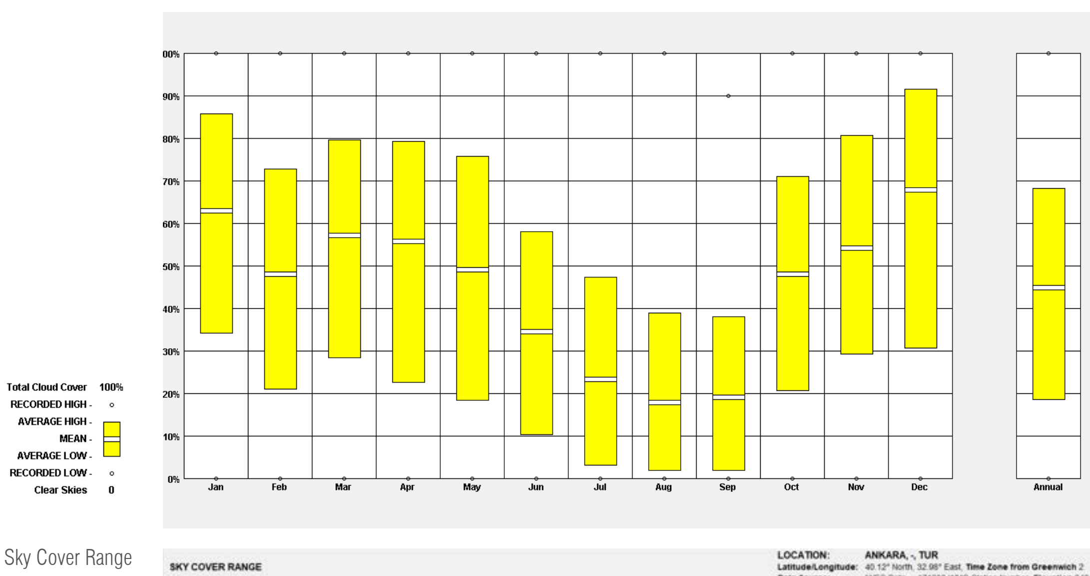

Figure 5: Sky Cover Range

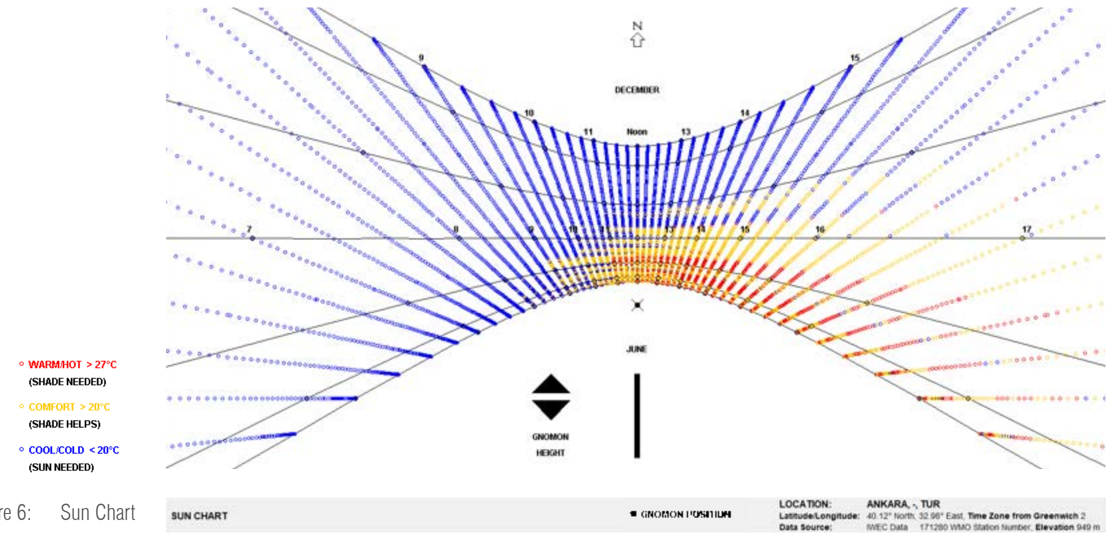

Figure 6: Sun Chart

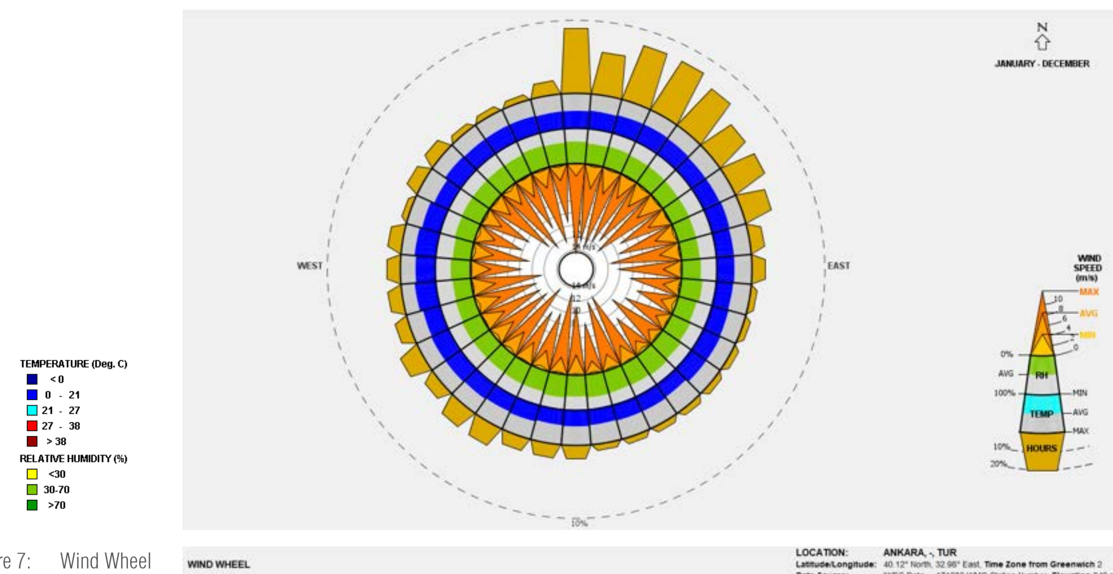

Figure 7: Wind Wheel

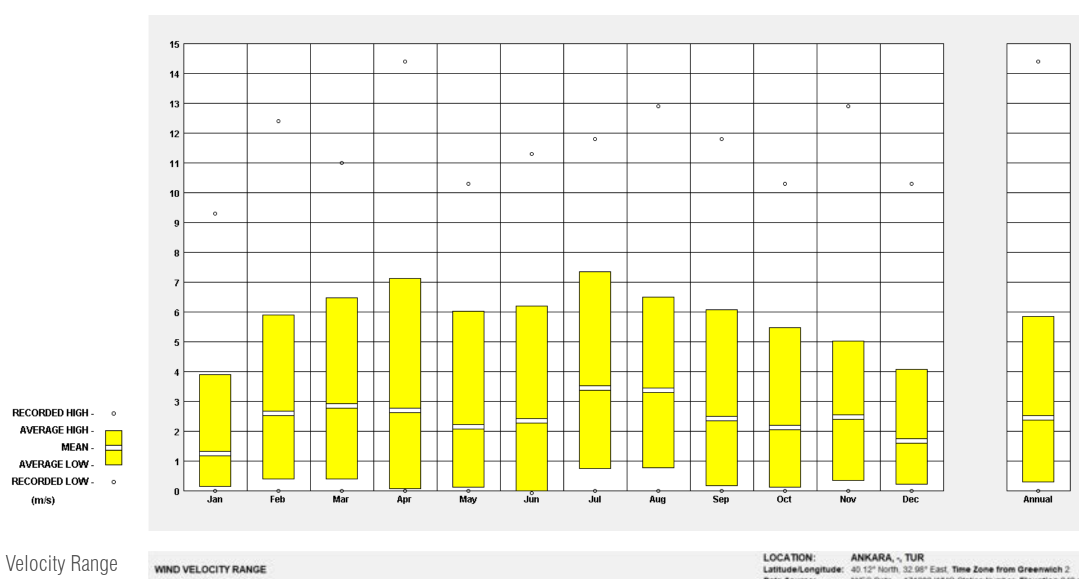

Figure 8: Wind Velocity Range

Appendix C. Heat Balance Charts for Proposed Energy Scenarios

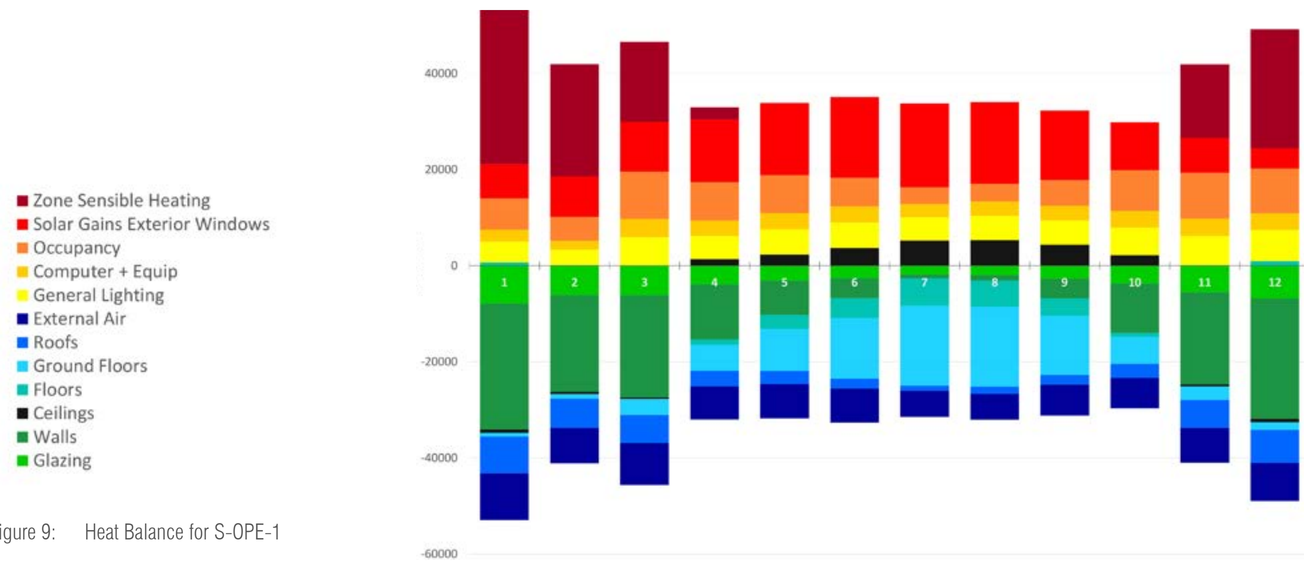

Figure 9: Heat Balance for S-OPE-1

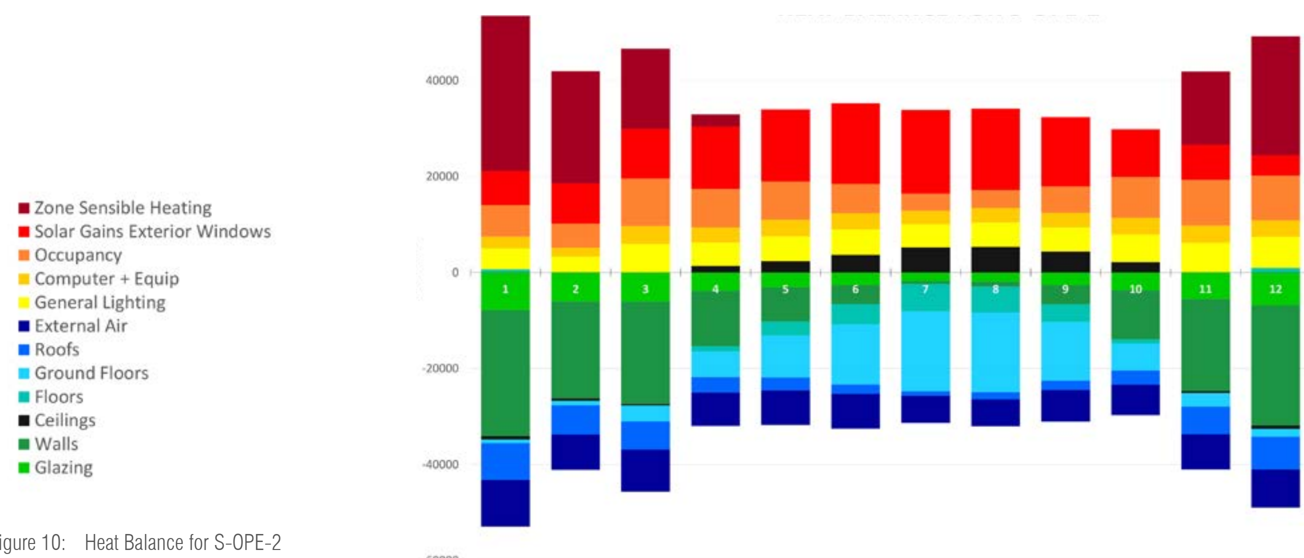

Figure 10: Heat Balance for S-OPE-2

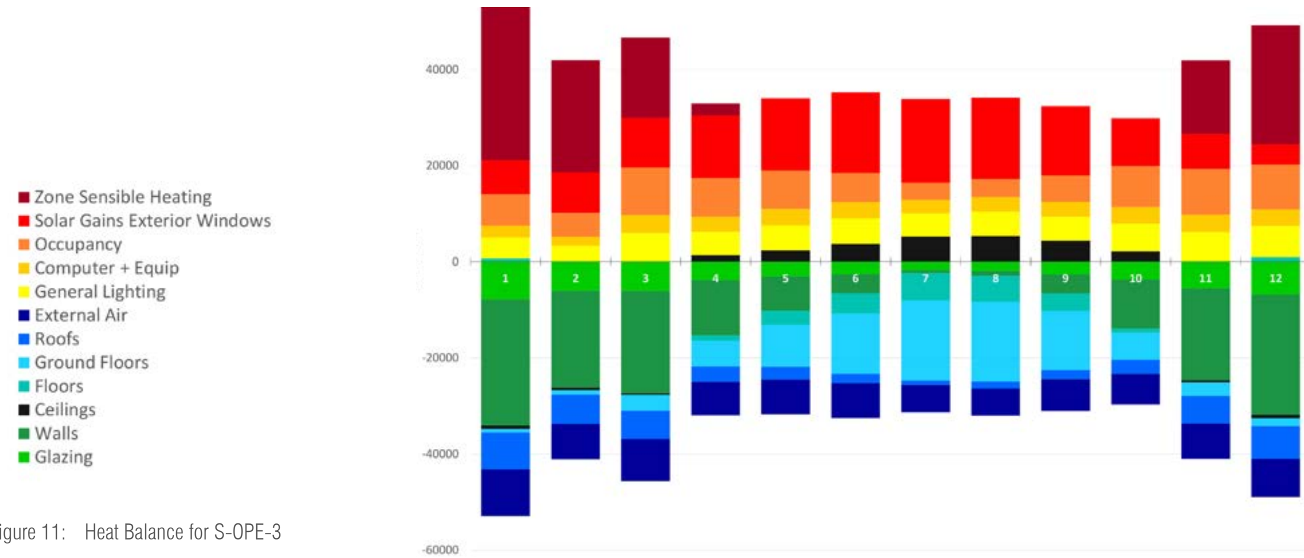

Figure 11: Heat Balance for S-OPE-3

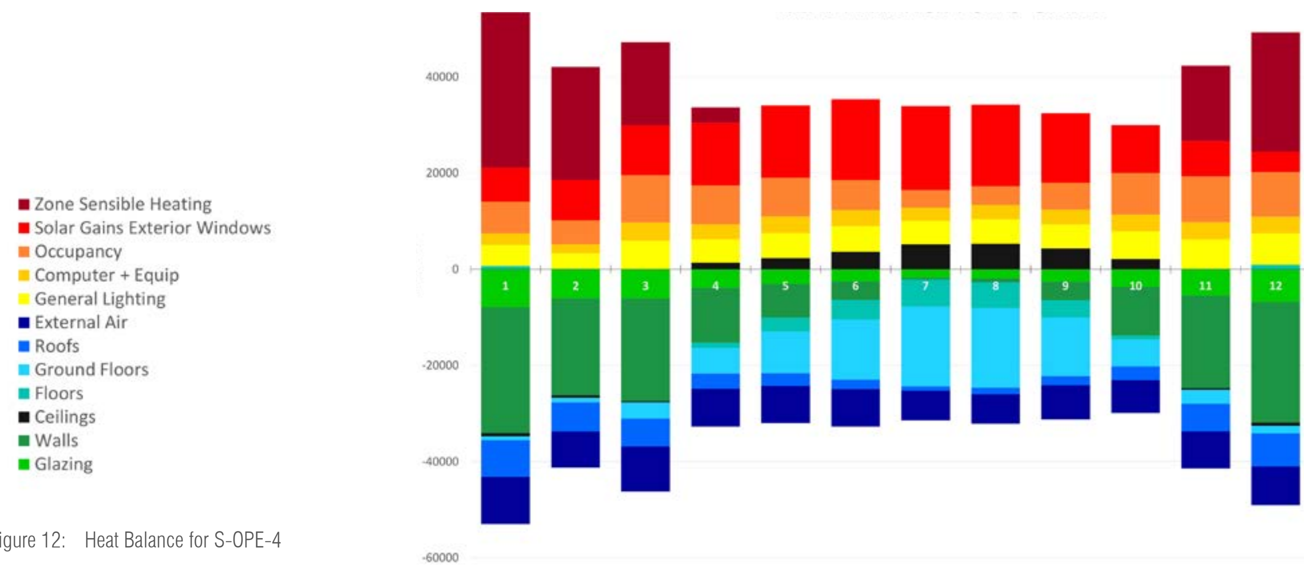

Figure 12: Heat Balance for S-OPE-4

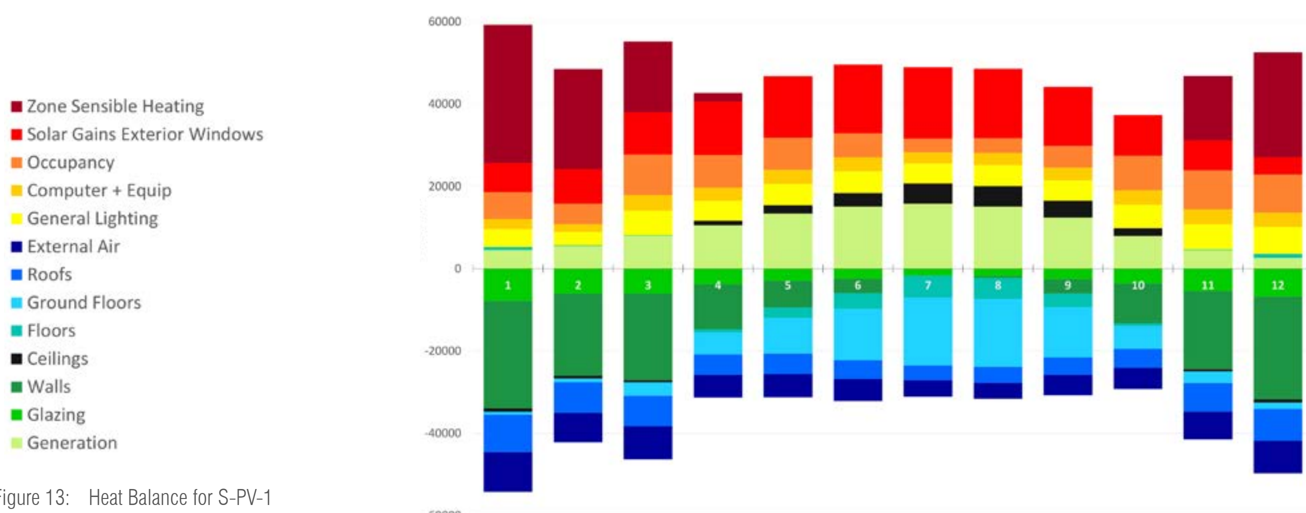

Figure 13: Heat Balance for S-PV-1

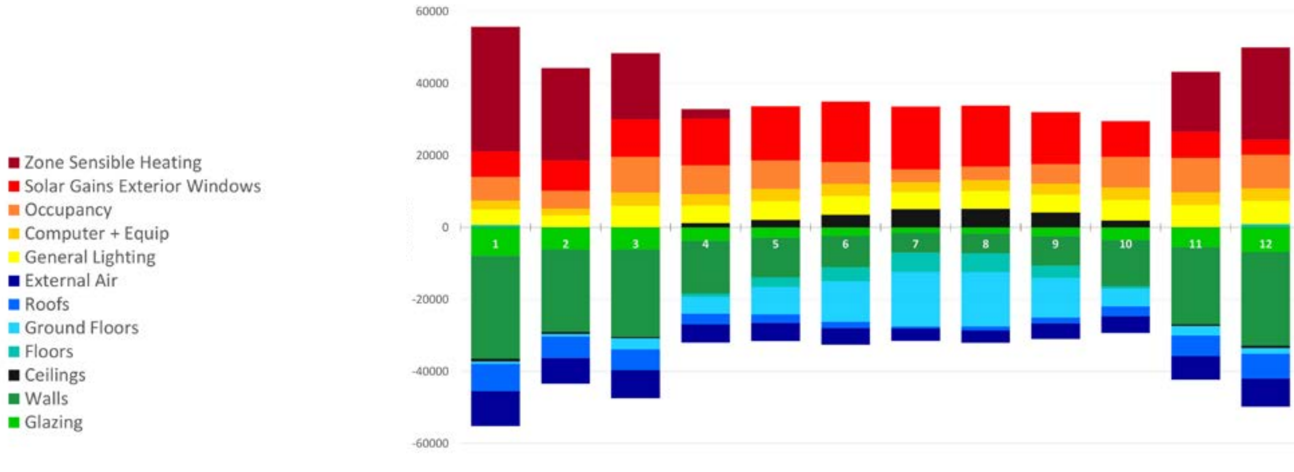

Figure 14: Heat Balance for S-OPE-3

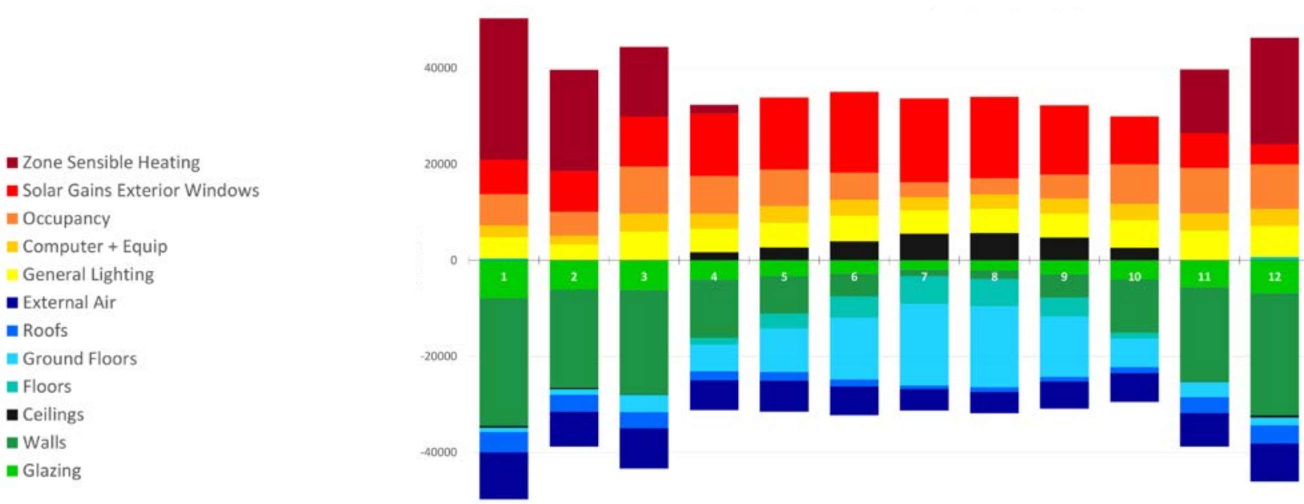

Figure 15: Heat Balance for S-RISO-1

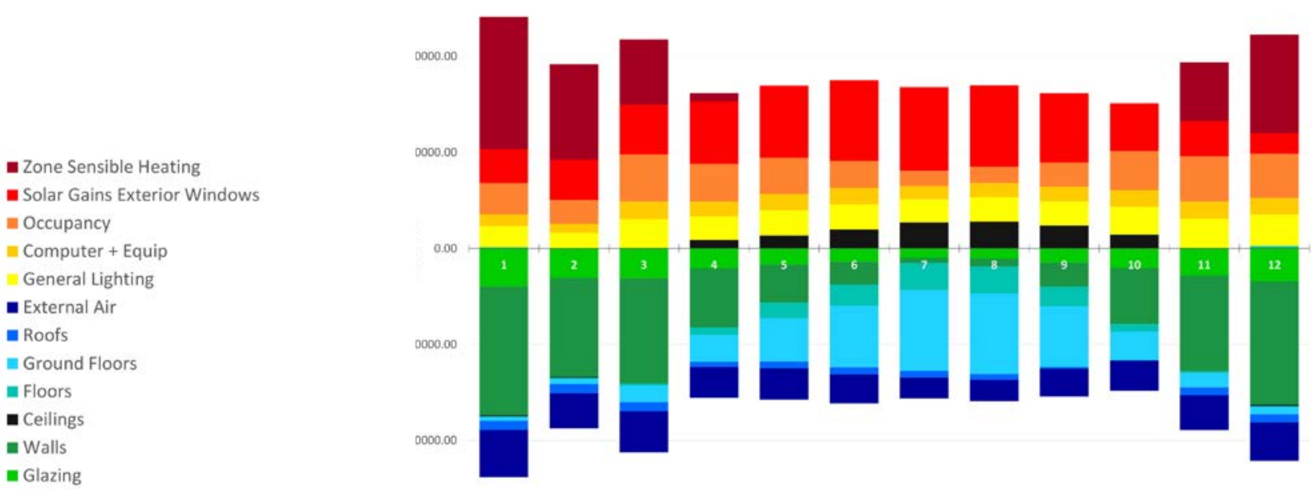

Figure 16: Heat Balance for S-RISO-2

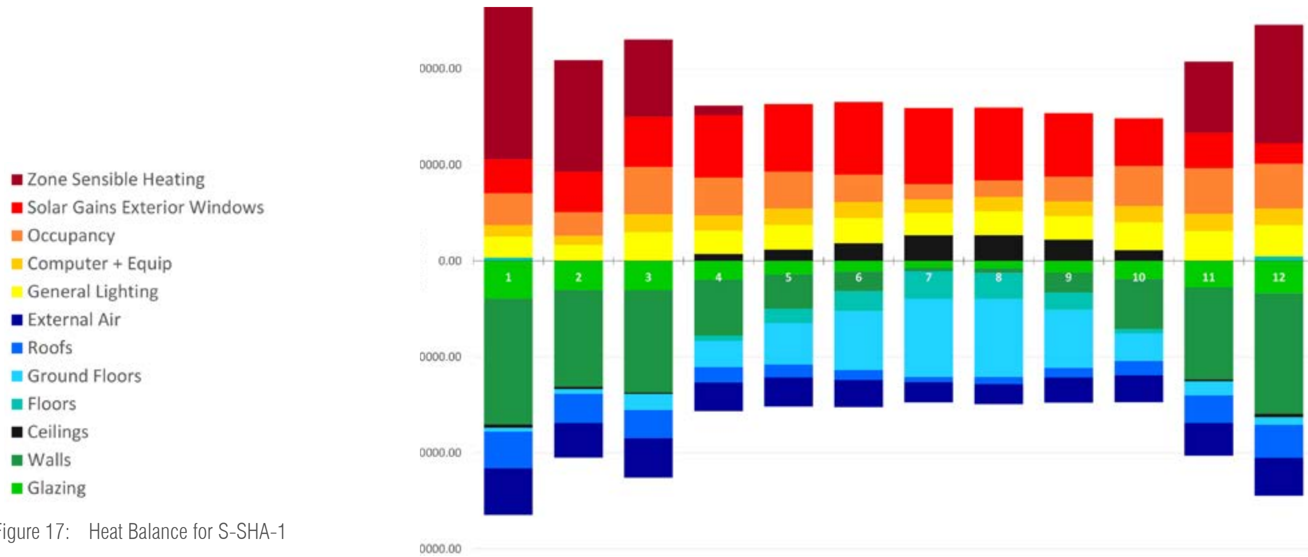

Figure 17: Heat Balance for S-SHA-1

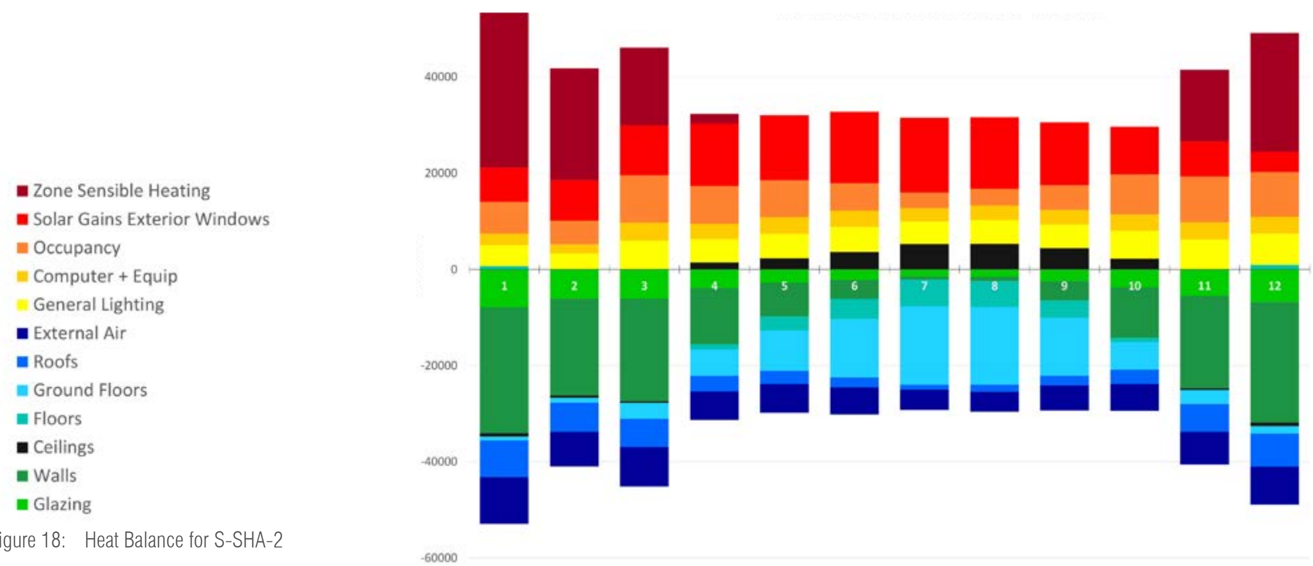

Figure 18: Heat Balance for S-SHA-2

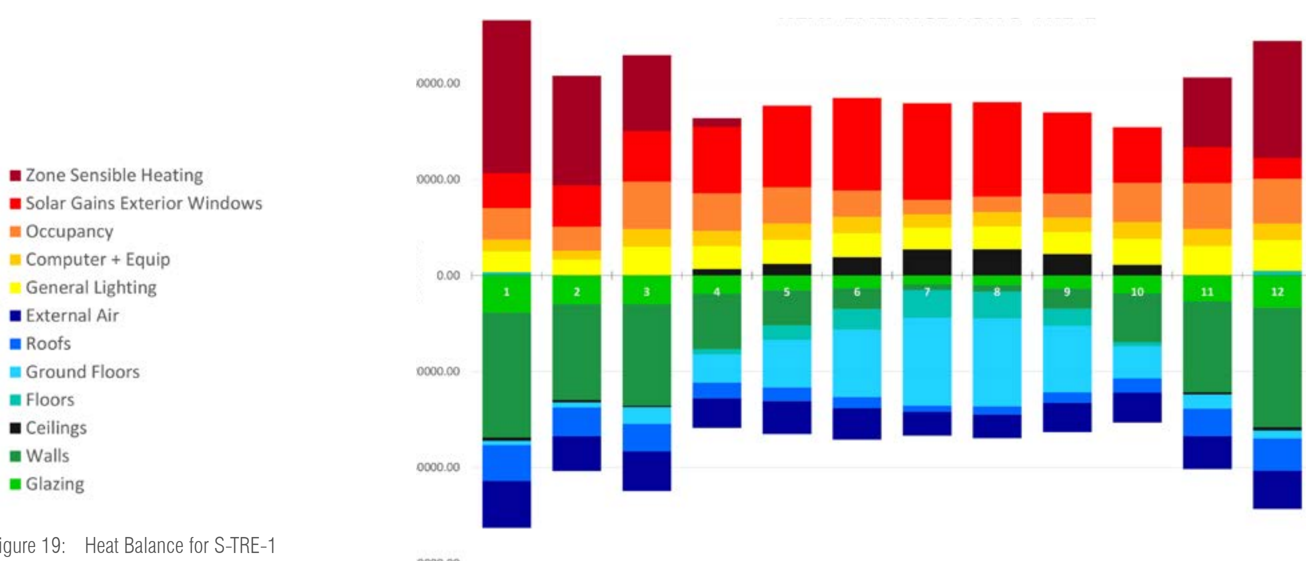

Figure 19: Heat Balance for S-TRE-1

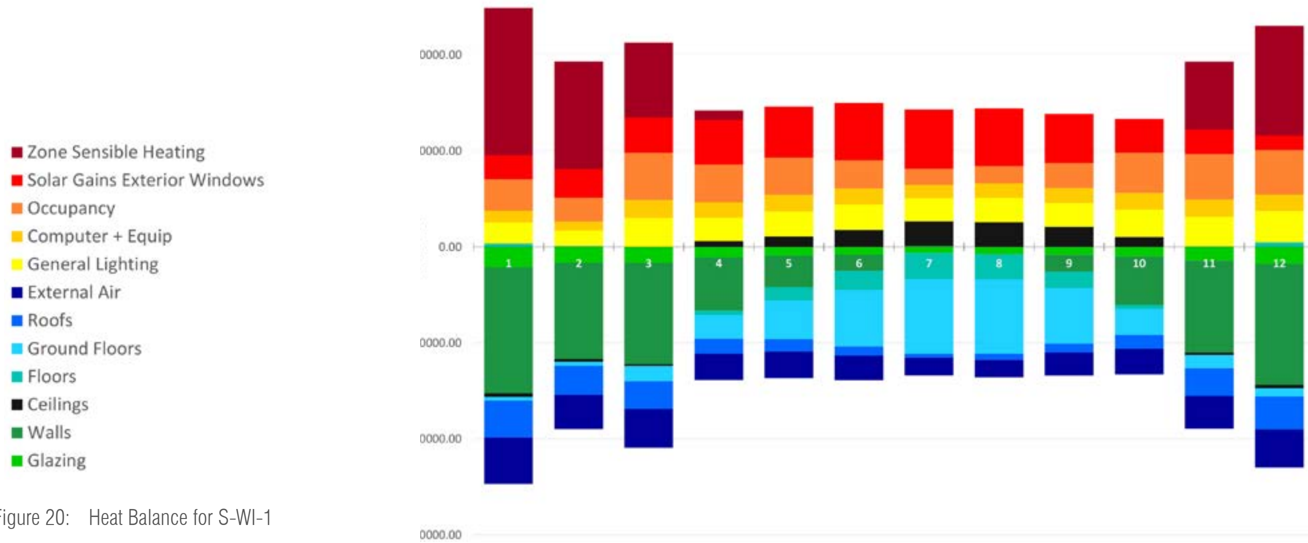

Figure 20: Heat Balance for S-WI-1

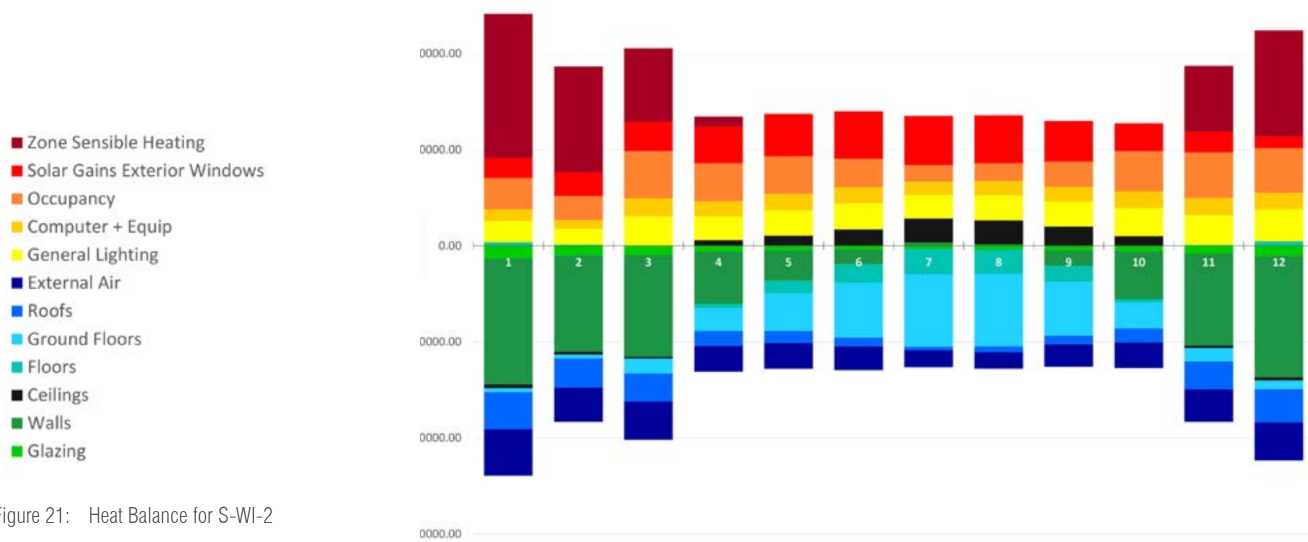

Figure 21: Heat Balance for S-WI-2

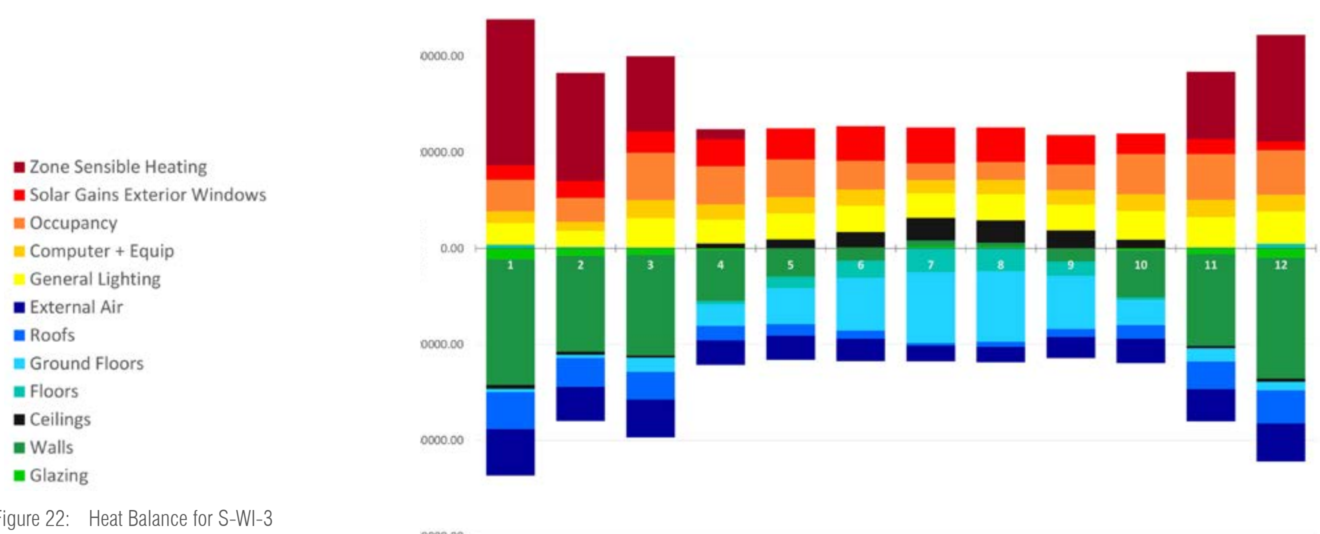

Figure 22: Heat Balance for S-WI-3

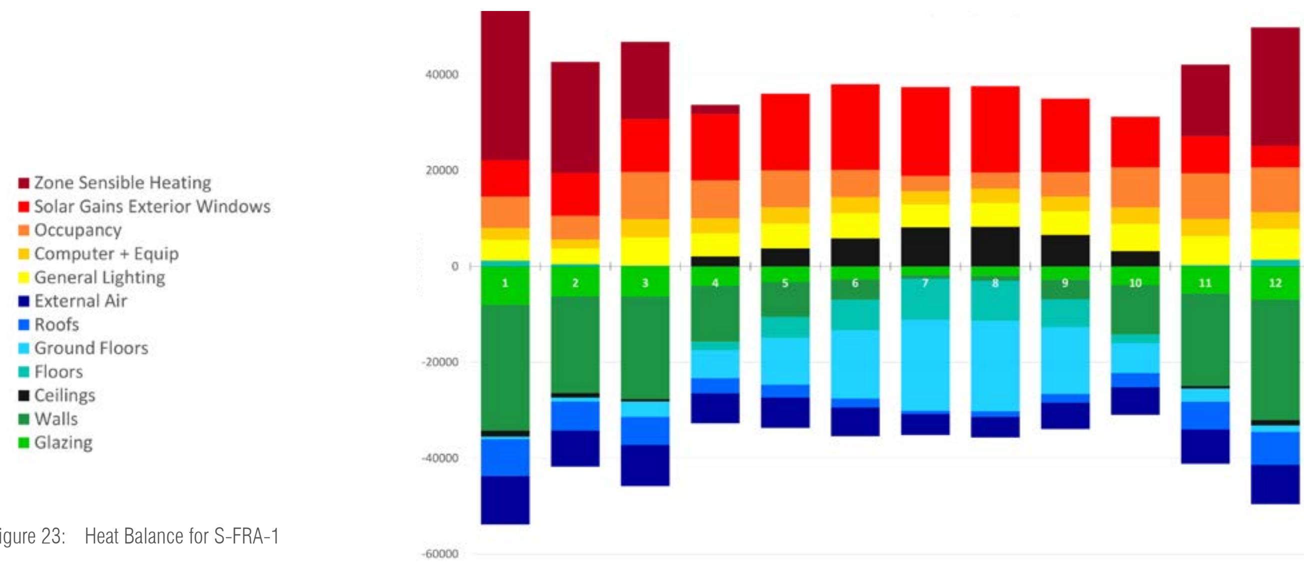

Figure 23: Heat Balance for S-FRA-1

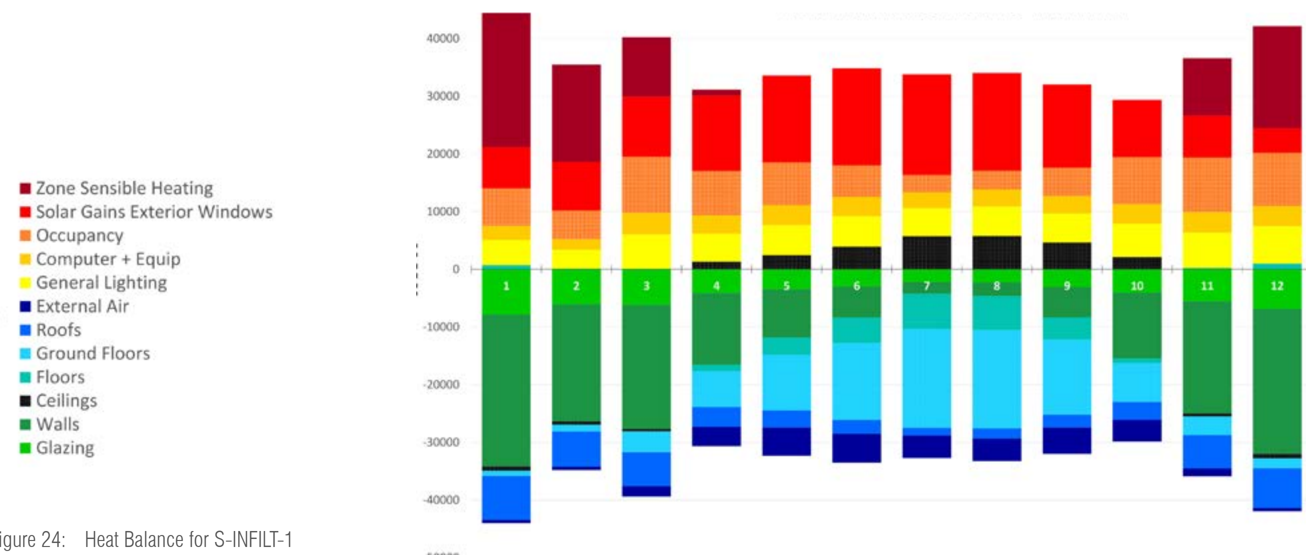

Figure 24: Heat Balance for S-INFILT-1

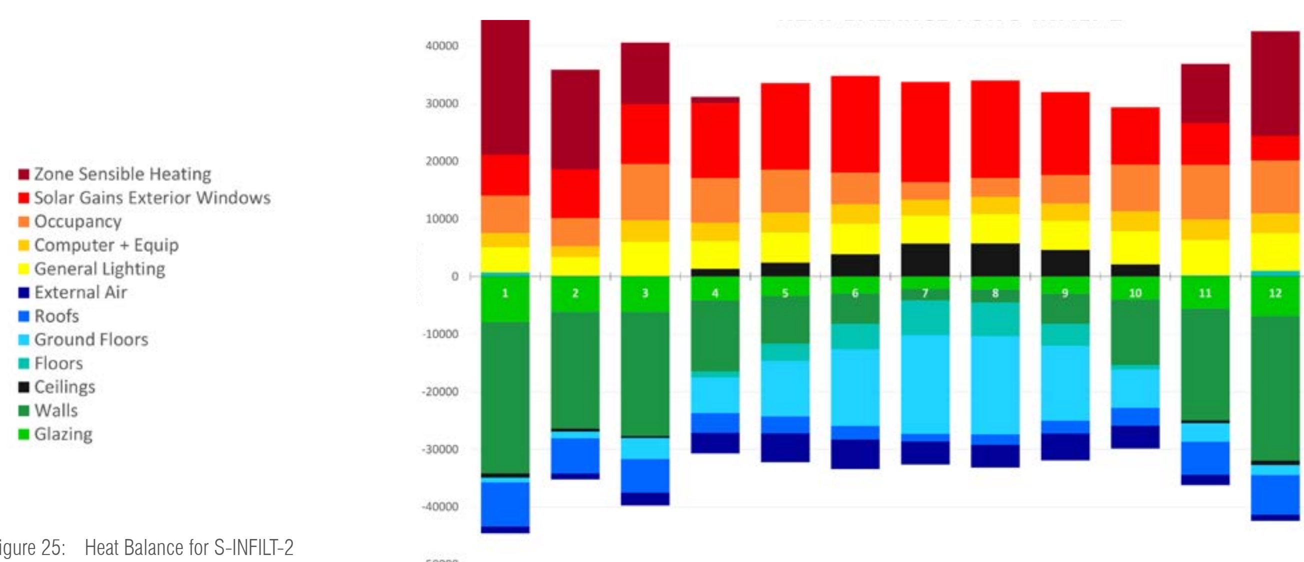

Figure 25: Heat Balance for S-INFILT-2

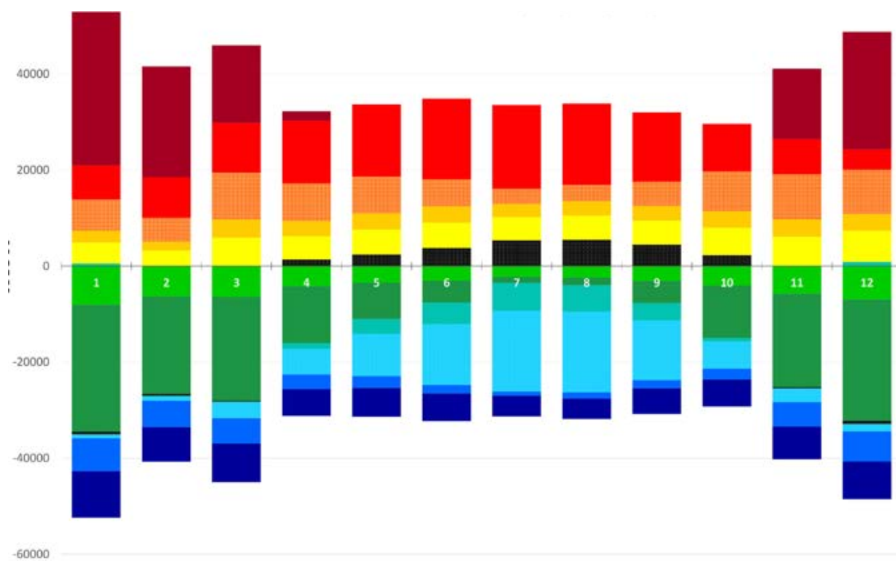

Figure 26: Heat Balance for S-PCM-1

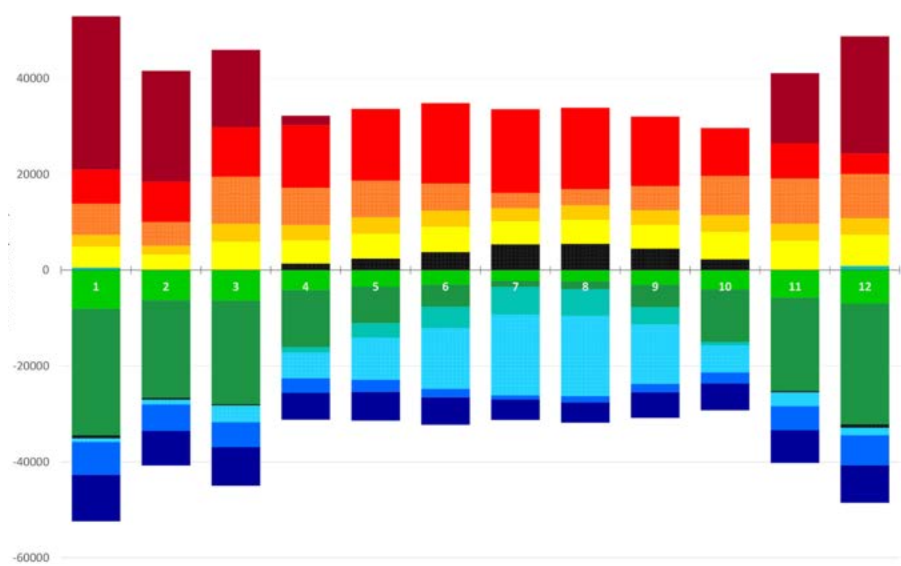

Figure 27: Heat Balance for S-PCM-2

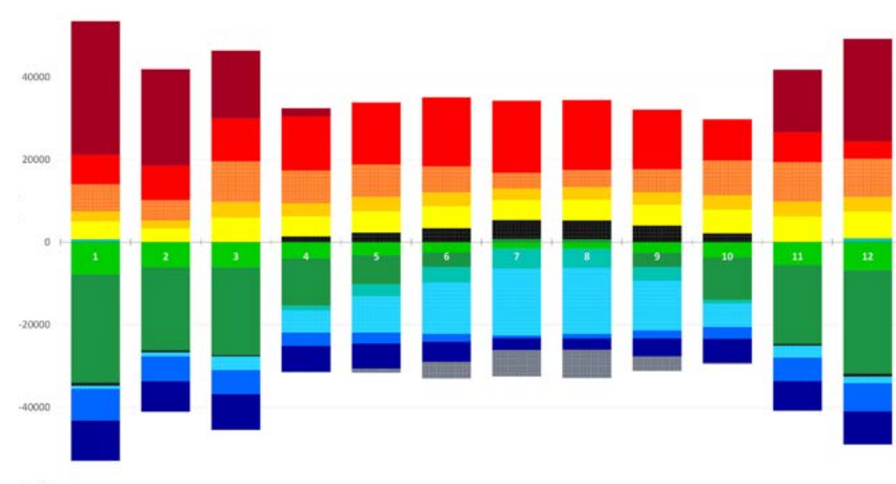

Figure 28: Heat Balance for S-COOL-1

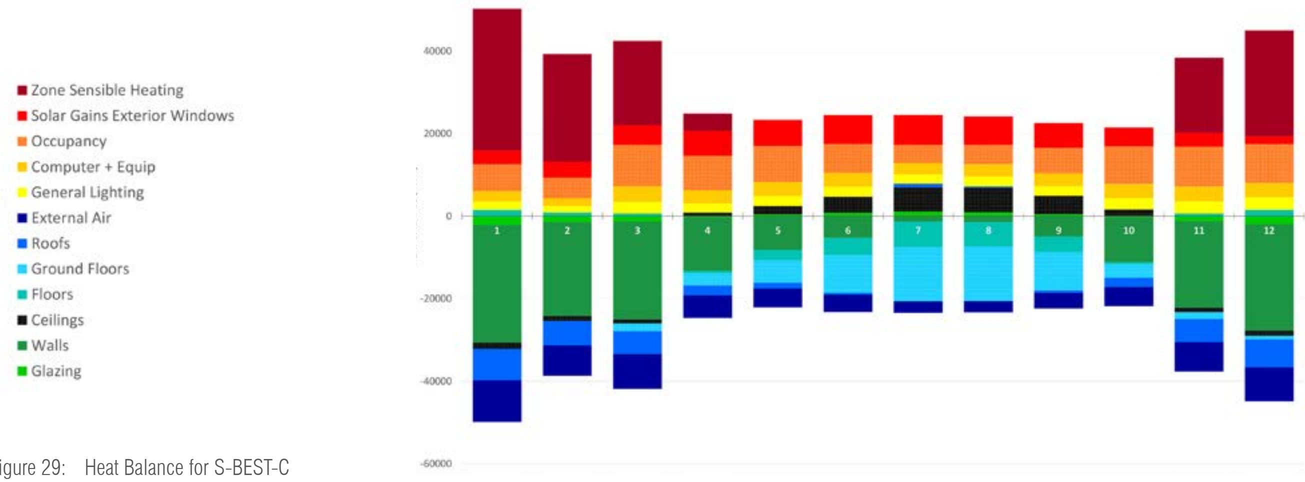

Figure 29: Heat Balance for S-BEST-C

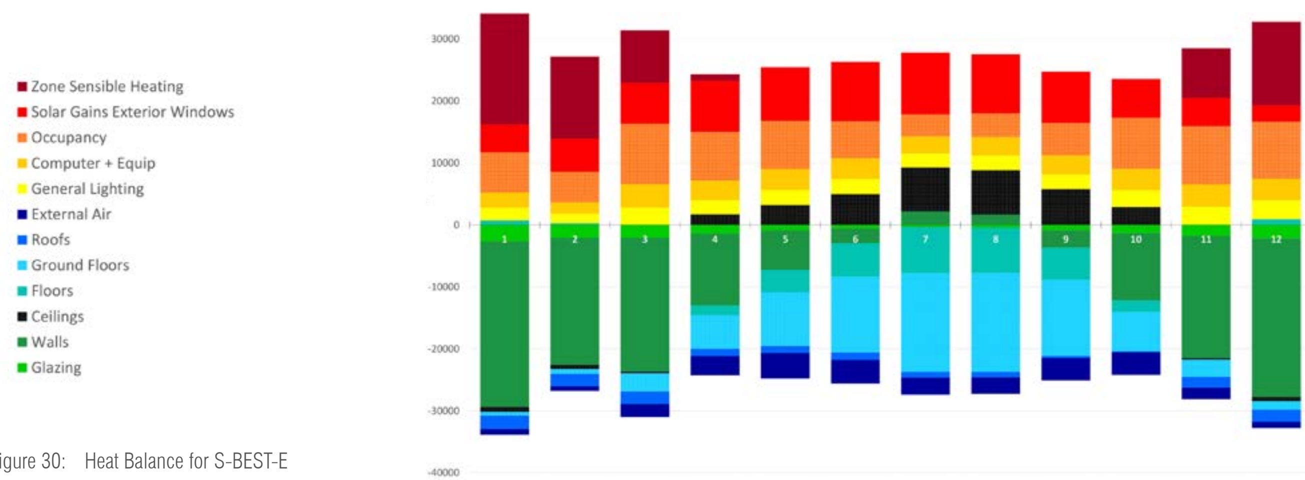

Figure 30: Heat Balance for S-BEST-E

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