GETTY FOUNDATION
KEEPING IT MODERN: PLANNING

FINAL REPORT
July 2016

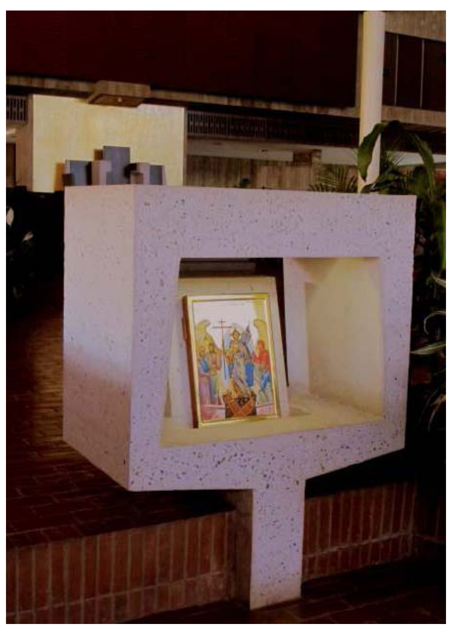
SAINT JOHN'S ABBEY CHURCH

CONSERVATION
RESTORATION
PRESERVATION

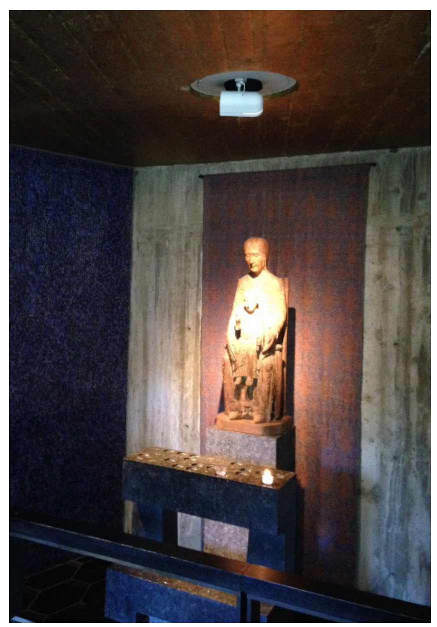
This report is made possible with support from the Getty Foundation as part of its Keeping It Modern initiative.

The Getty Foundation

Keeping It Modern



The Ambo



Mary Chapel

Stair to lower church

Since Fall 2015 much activity has been focused on looking at - and seeing - the Abbey Church and Bell Banner as treasured artifacts in need of conservation.

The Abbey Church is in good condition. Its concrete construction and granite cladding are durable and for the most part in excellent condition. Repairs to the Bell Banner can be made to preserve it.

Forensic work from subsurface geotechnical to above ground structural, glazing, and fenestration investigations have yielded much information about existing conditions. A way forward is coming to view.

Careful review of some project components - lighting, stained glass, plaza paving for example - has yielded options for conservation and restoration activity.

Activity required for the Bell Banner have focused on its restoration. Options for repairing fissures, providing waterproofing, and replacing poor quality repairs have been identified. Structural analyses associated with spiral stair access to the bells provide a strong basis from which to evaluate preservation, restoration, or replacement alternatives.

Three recommendations can be made for immediate action.

Two are associated with conservation of art:

- replace the flourescent lighting in the Ambo where iconographic portraiture is displayed and illuminated 24/7 with LED lighting; and

- replace the current lighting in the Mary Chapel with LED lighting.

The third is a life safety issue:

- install glass balustrade panels at the stair to the lower church, to prevent small children from falling through the widely spaced original balusters and rails.

A list of general recommendations follows: detailed implementation plans will be developed in an effort subsequent to this one, using the findings and recommendations of this Planning document as a guide.

Abbey Church

Recommendations Summary

1 BELL BANNER

Concrete
Remove poor patches and replace with new patch material compatible with original concrete. Provide waterproof solution to top surface of the banner.

Re-alkalinize portions of the banner surface.

Remediate face delaminations using a urethane bonding agent applied through cores by gravity flow installation.

Cross
Continue regular replacement of weathered wood components.

Stairs
Replace existing structure. The extent of corrosion of the reinforcement in the precast concrete treads is very significant.

Drainage
Connect the two dry wells receiving rainwater from the Baptistry roof by 6 inch diameter pipes to the existing storm sewer located in the Abbey's loop road.

Plaza
Replace cracked and broken pavers and stairs. Reset on concrete bed with mortar rather than loose lay.

Geotechnical
Remove and replace existing fill from below pavers and steps to a depth of 7 to 9 feet. Install drain pipes to drain the backfill. Develop a detailed maintenance program to seal or fill cracks and joints developed over the lifetime of the building.

2 ABBEY CHURCH

Exterior
Repair top outer edges of buttresses where needed.

Roof
No modifications required.

Glass
North Facade - Create new custom frames to allow for insulated glass. Apply new heel bead to provide moisture seal.

Replace original sliding track system. Replace existing insulated glass. Repair or replace damaged wood sills, jambs and mullions.

Create a stand off, heavy glass support system around stairs for safety.

Basement Windows - Replace glass with high performing Low-E glass.

Stained Glass
North Facade - Create new custom frames to allow for insulated protective glass. Apply new heel bead to provide moisture seal.

Exterior Doors
Fit existing Baptistry doors with seals. Replace door hardware.

Acoustics
Replace fabric wall membrane behind altar. Provide broadcast video cable routing from lower level church to balcony.

Lighting
Replace fixtures with high-efficiency LEDs. Add additional fixtures as determined by detailed photometric analyses. Restore the original exterior lighting concept using new fixtures.

Systems
Mechanical - Provide a dedicated outdoor air system, install recirculating systems. Replace the in-floor heat. Add fin tube radiation and ventilation at entry and cloister passages.

Electrical - Replace existing electrical distribution systems. Upgrade emergency systems within the Church. Implement local speakers at balcony level.

PROJECT PARTICIPANTS

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stained glass restoration
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aerial drone photography
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BELL BANNER

Examination of the Bell Banner included several methodologies:

- visual ground examination including use of magnification tools;

- aerial examination using vertical lift devices; and

- aerial examination using high resolution photography taken with use of a drone device.

PROGRESS

EXISTING CONDITIONS

The bell banner concrete was cast in multiple construction concrete "lifts" to create the monolithic concrete structure. The concrete surface has developed a colored appearance as it has aged due to a combination of environmental factors. The original surface texture is the result of the form finish of the board forms used in the original casting.

Discolored Areas at Repair Locations

Colored patches occur at the leg intersection to the banner face. Visual observations of the current conditions noted that the off-colored areas occur where the concrete had a higher level of honeycombing. These areas are in a location that would be considerably difficult to cast and the patch was likely placed at the time of original construction to repair the honeycombing. The patch surface color does not match the bulk of the concrete and is likely due to a difference in the material makeup of the patch material. Non-destructive sounding of the patch and edges indicate that the majority of the patches are sound with minor delaminations occurring at the edges.

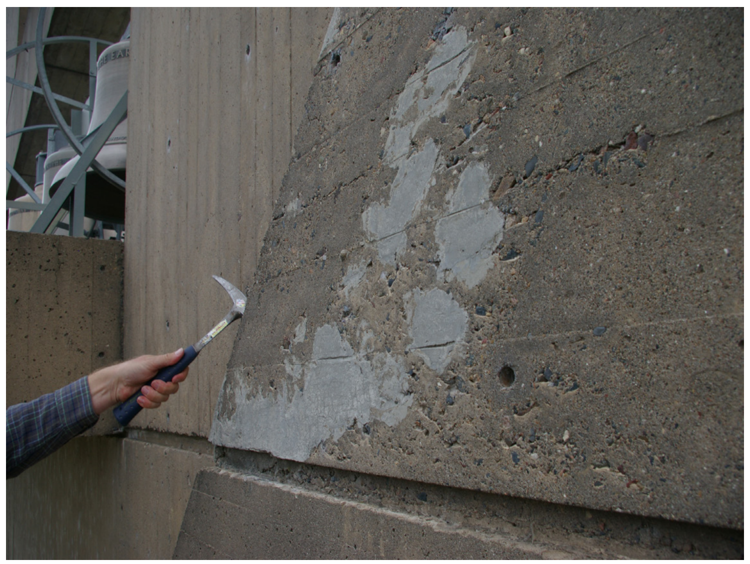
ABOVE Patching near the bell loggia concrete that does not match color and texture of original concrete

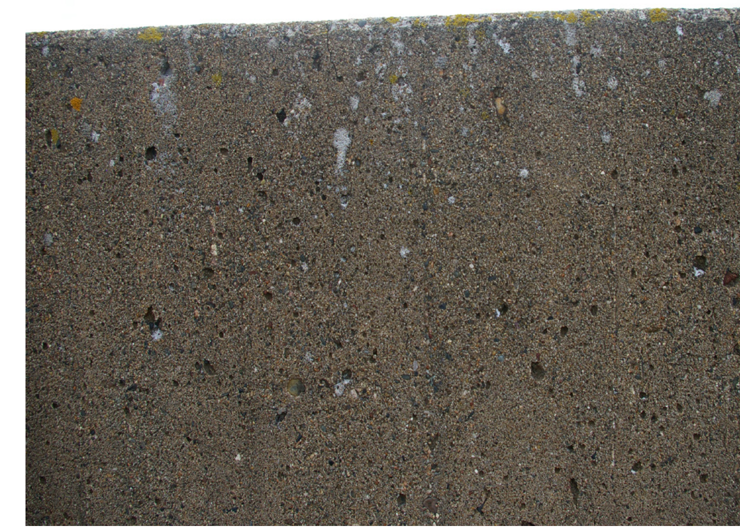
ABOVE Patching near the first reveal between the support arch and bell banner






ABOVE Close ups of various patching efforts






TOP AND LOWER LEFT FOUR Patching , including use of off-the shelf concrete patch mixtures, that does not match color and texture of the original concrete.

TOP RIGHT Rain is much more acidic (pH ~7.5) than the concrete paste. After exposure to rainfall over many years the surficial paste has etched away, revealing the fine aggregate particles present in the concrete.

LOWER RIGHT Raw concrete top of the Banner allows moisture penetration of the upper face. A lighting protection leader rests on top.

UPPER LEFT Detail of Surface texture of Banner with lichen growth.
LOWER LEFT Close-up of lichen growth.

UPPER CENTER Spalling at reveal.
LOWER CENTER Massive patch using off the shelf material incompatible with original concrete.

RIGHT Area at top of Banner where delaminations are detected. Note grey lichen, aggregate popouts and blockouts from form ties. These make the texture unique.






LOWER RIGHT Detail of surface texture of Banner. Exposure to soft water has etched the surface. Combined with the lichen growth the color and texture could not be reproduced with a surficial repair.

Distressed Concrete

The entire top west corner concrete lift region of the banner has a number of intersecting surfaced cracked areas with subsurface delaminated concrete.

Surface efflorescence was observed at a number of locations including the bottom side of the bridge piece over the cross, bottom side of the bell platform in the center, two vertical cracks on the north face east of the cross, and one vertical crack on the north face at the lower east corner of the bell platform. Generally a crack is associated with the location of efflorescence.

One horizontal crack was noted on the bottom of the bell platform, efflorescence was present and there is a possible surface delamination of approximately 1 square foot.

One vertical crack was noted on the south face adjacent to the lower doorway jamb. The crack is approximately 7 feet long with a spalled area and exposed vertical reinforcing bar.

One diagonal hair line crack was noted on the west face on the upper north leg.

Delamination

Delamination was noted on the upper right hand portion of the banner as seen from the south. This delamination was identified by hollow sounding areas when sounded using a hammer. Little or no signs of corrosion were noted on the vertical face, although some cracks and rust stains were noted.

The corrosion of reinforcing steel that has resulted in delamination on the banner is due to carbonation of the concrete. Carbonation, a reaction between carbon dioxide in the air and calcium in the concrete paste, reduces the pH below the point where the steel reinforcement becomes de-passivated. Carbonation will not occur in fully saturated concrete or in concrete that is dry; however carbonic acid, created by the solution of carbon dioxide gas from the atmosphere in water, will result in buildup of calcium carbonate.

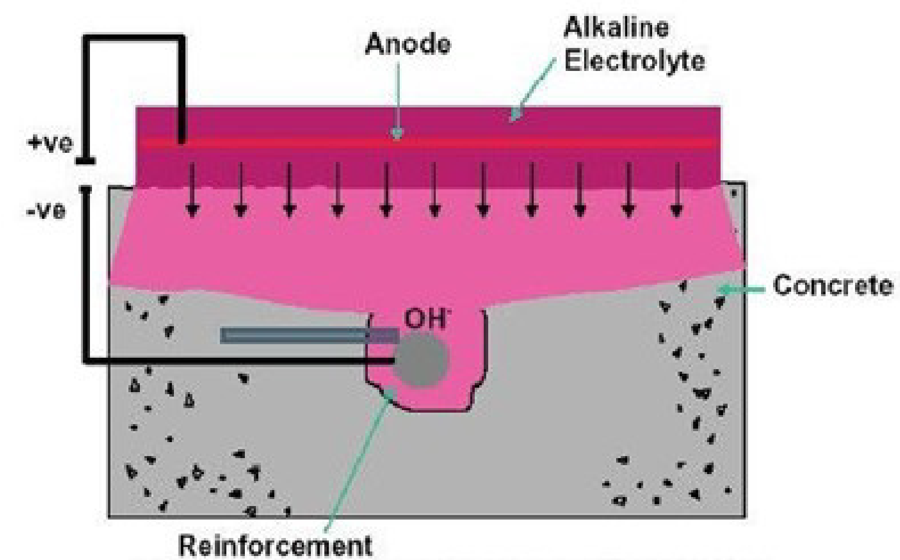
Steel in contact with fresh concrete develops a passivating layer, much as would be seen on aluminum in the environment. This situation prevents the steel from corroding further, resulting in a stable condition known as passivation. Chlorides or acids, which will destroy the passivating layer and / or alter the environment that supported its growth , can cause the steel to corrode, resulting in corrosion of the steel.

The specific volume of the corrosion products is about 7 times larger than the steel. As corrosion occurs the expansive nature of the corrosion products introduces tensile stresses in the concrete which rapidly cause the concrete to crack parallel to the plane of the reinforcement, creating a delamination.

Carbonation is a diffusion control process, and is exacerbated where there is intermittent wet and dry cycles in the concrete, as occurs at the top of the banner. Based on the appearance, and the softwater impact removal of paste at these locations, it is likely that the concrete at the upper surfaces was a higher permeability than in the bulk of the concrete. This may be why delamination was detected only at this location.

One approach to repairing delamination would be to remove the concrete faces down to reinforcing and replacing it with new concrete. As removal and replacement presents significant aesthetic issues (color and texture would be impossible to match), a method of restoring both the integrity of the structure and the passivating conditions is proposed. This process, known as re-alkalinization, involves the perturbative movement of hydroxyl ions into the concrete under an impressed electric field.

The basic process, described by the Nernst-Einstein Equation, causes the negatively charged hydroxyl ions to move through the concrete and towards the steel. This motion is caused by placing a positive charge on the steel, which has been polarized using direct current, and allowing flow in the saturated concrete.



ABOVE Diagram of the concrete re-alkalinization process.

The basic steps of the process are outlined below:

1. The concrete to be re-alkalinized is saturated with water.

2. A poultice of Calcium hydroxide (Builder's Lime) is placed on the surface of the concrete.

3. An external voltage is applied between the steel (the cathode) and the poultice (with embedded anodes) and the hydroxyl ions will move toward the cathode. The rate of movement will depend on the overvoltage magnitude and the permeability of the concrete.

4. The pH of the concrete is monitored using a pH meter. Once the pH has returned to approximately 12 the voltage is removed and the surfaces are cleaned of excess lime.

5. In the localized area where delaminations were noted these are repaired by drilling pilot holes into the delaminated area from the top of the banner and applying a urethane bonding agent by gravity flow. Many such materials are optically clear and can be combined with the swarf from drilling to match the color of the concrete.

Typically the voltage application will be required for less than a week. Exploratory pH measurements at the form tie blockouts, which can readily be hidden, would be used to identify those regions where carbonation presents a risk of corrosion.

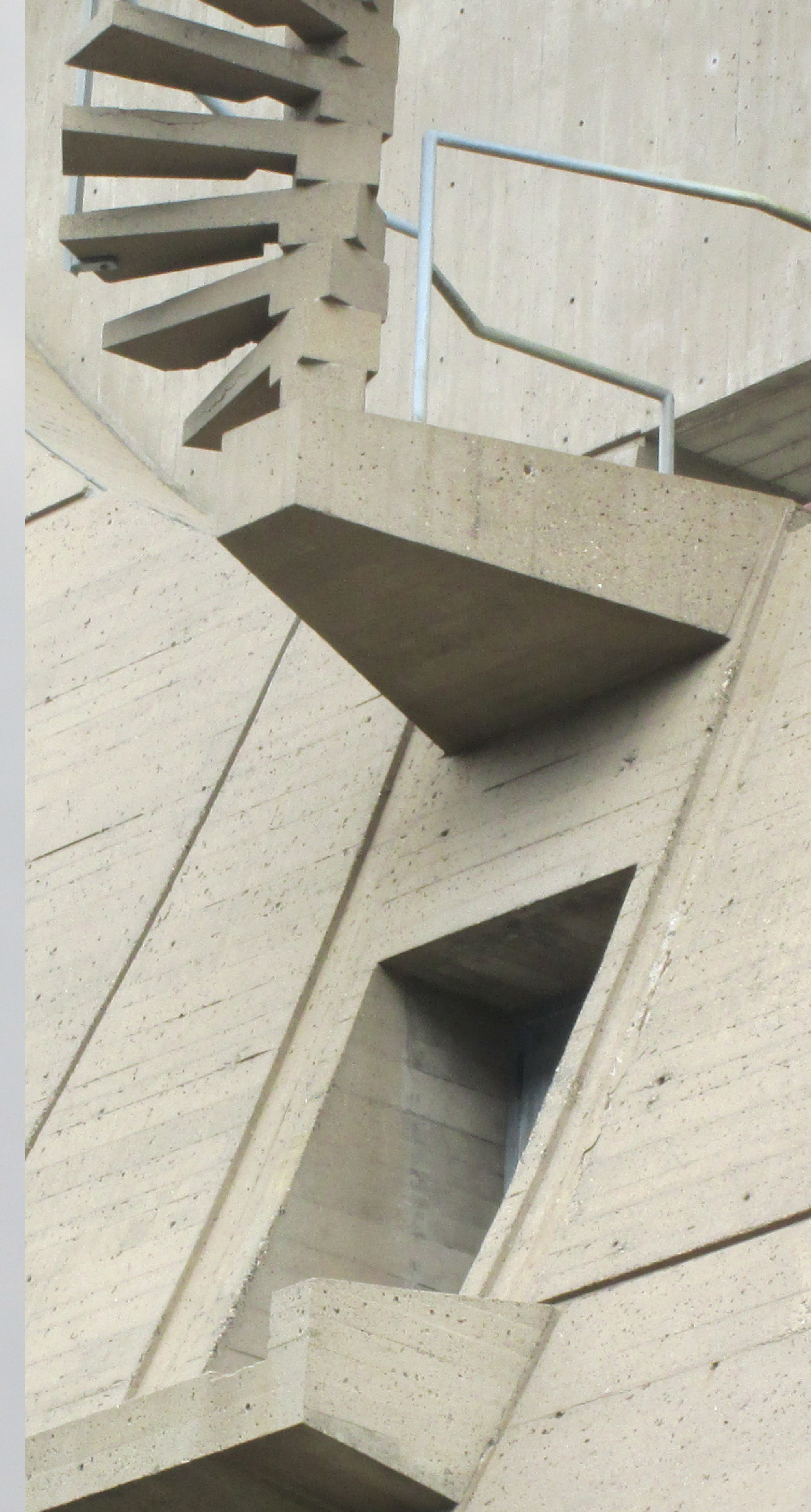
RIGHT Upper right hand corner of banner
where hollow sounding areas (delaminations)
were detected

Iron oxide staining

A multitude of small repetitive rust stains on the underside of the arch intrados are clearly observable. The pattern and spacing is indicative of rebar chairs used to support the internal reinforcing steel. Oxidation of the metal chair legs has occurred resulting in the rust stains.

There are a small number of locations with other rust-colored stains. Each stain is typically in a vertical line emanating from a single spot location or a single spot stain. Stains of this appearance are likely the result of iron particle aggregate in the concrete mix rather than reinforcing steel misplacement. The combination of rust staining, spalling or delamination is more likely an indicator of reinforcing steel oxidation issues. Visual inspection did not indicate any observable spalling or delamination of the concrete at rust stain locations.

Options for removal and repair of the exposed reinforcing chair leg ends include precision drilling with micro-tools and introduction of a sealing product to infill the resulting surface cavity.



Variable Surface Color

In 2000 a concrete sealer was applied to all of the banner surfaces. Areas of a whitish hue or halo were observed across the banner faces in areas where form-tie holes and larger bugholes occur. The sealer was a clear color; however concentration and increased saturation of the sealing material occurring in concrete recesses and small pockets has resulted in some discoloration.

There are whitish areas of lichen near the top of the banner on the west corner. The concrete in this area is distressed with the appearance of surface cracking. Non-destructive hammer tapping of the surface indicated areas of delamination associated with the cracking. The combination of the lichen growth, cracking, and delamination indicates there is something unusual about this area.

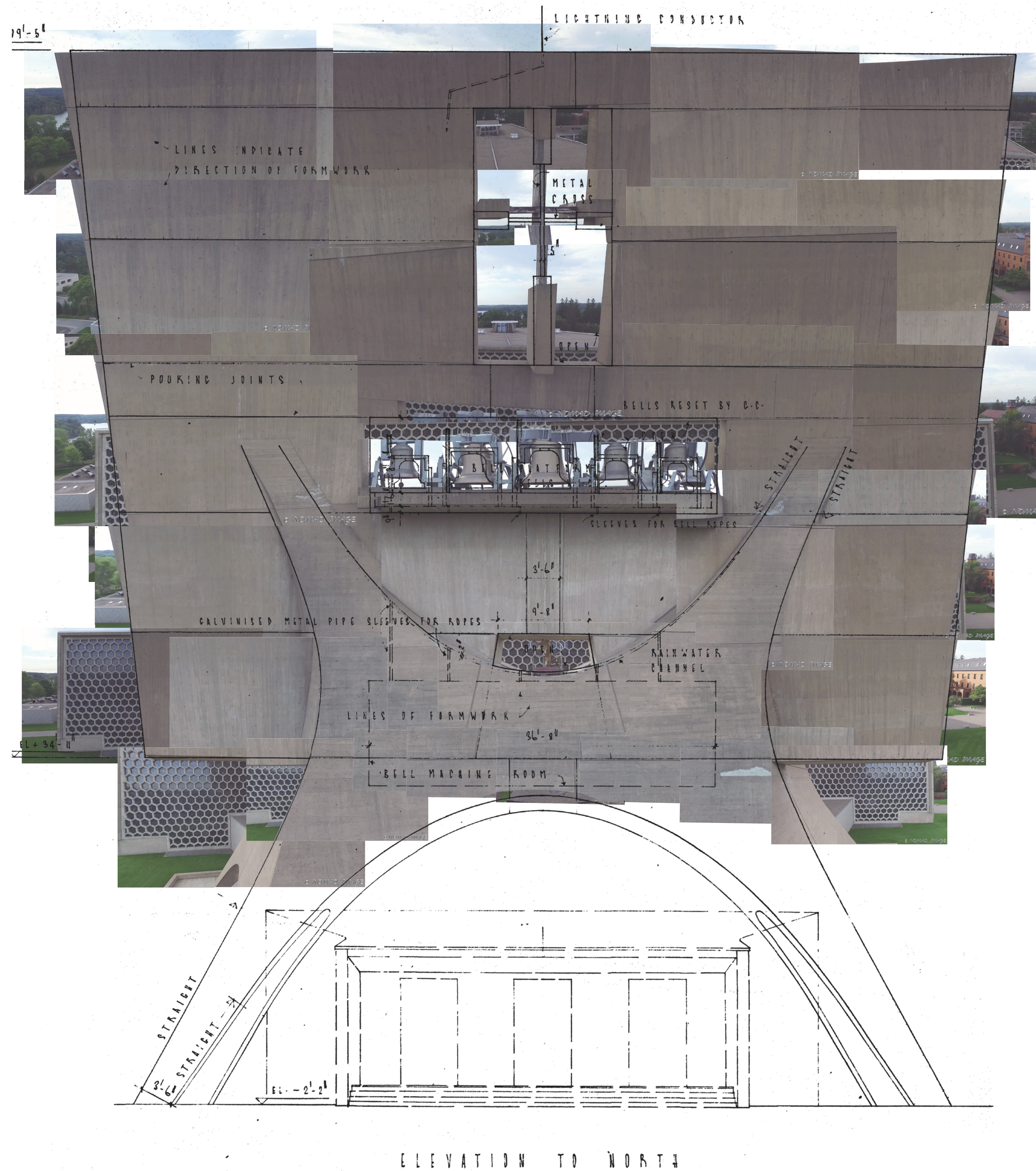
Variable Surface Color

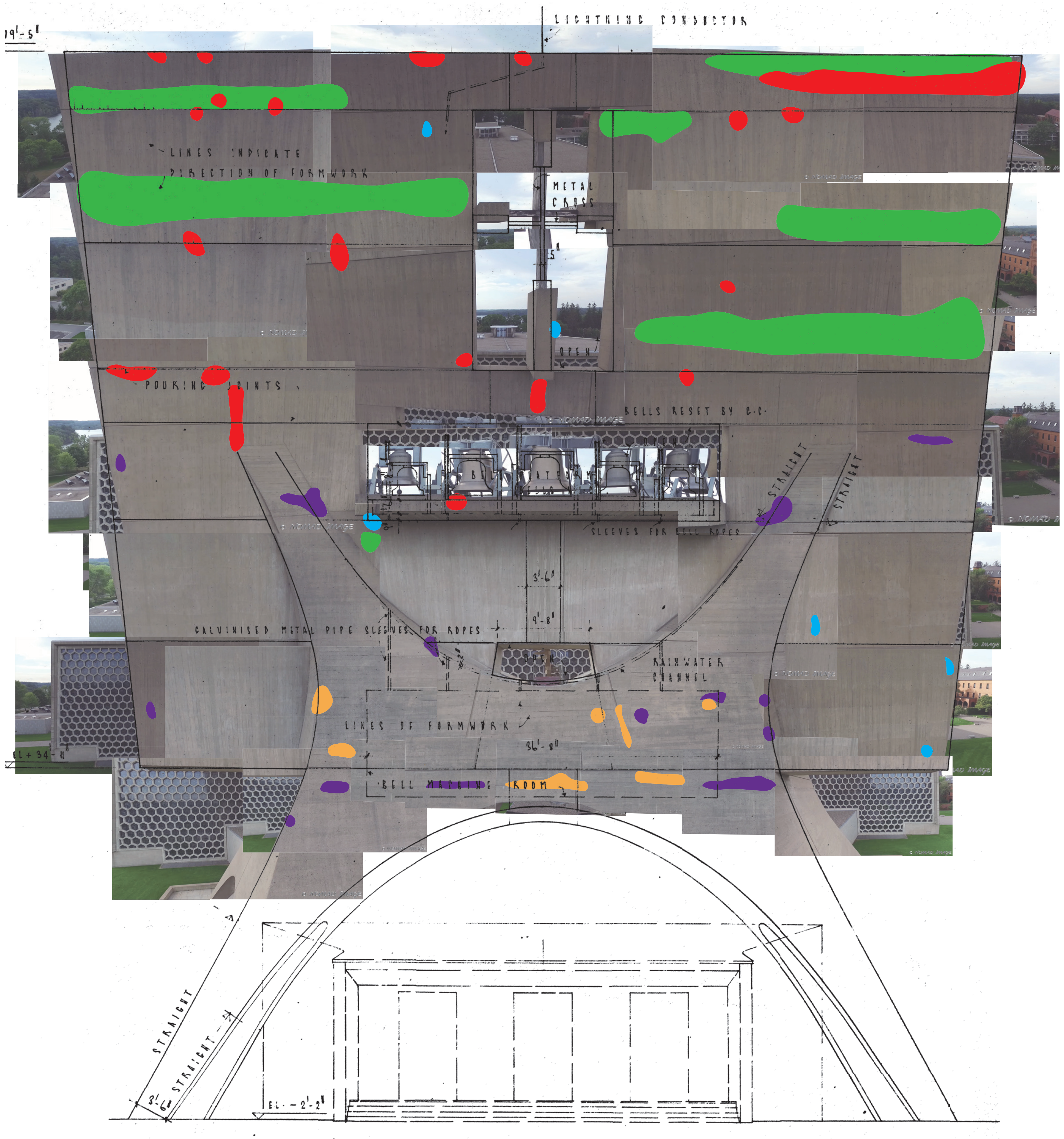
Rainwater washing down the faces of the Bell Banner and supports gives an understanding of how the variable surface coloring of the concrete has developed over the years, and demonstrates the effect of an unprotected top edge of the banner on moisture penetration, saturation and surface wash.

RIGHT Exposed to the elements, the wooden cross is replaced regularly.

Mapping Concrete Conditions

The following images map different surface conditions, ranging from original curing conditions to weathering and degradation that has occurred since completion of construction. Some patches may have occurred during construction subsequent to removal of formwork when faulty concrete was revealed.





ELEVATION TO NORTH

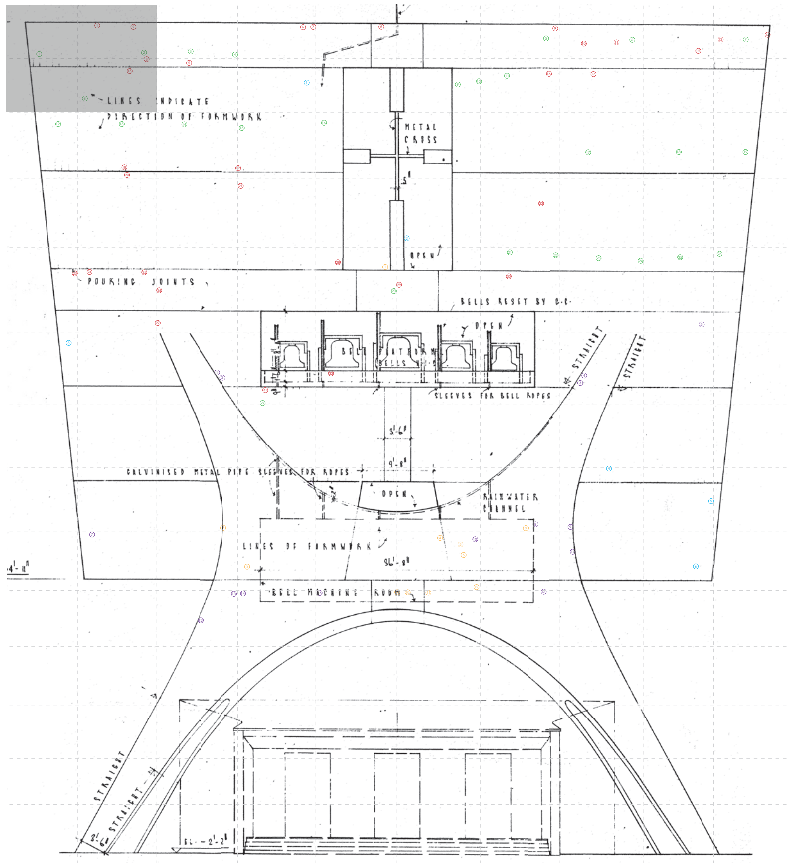
Efflorescence

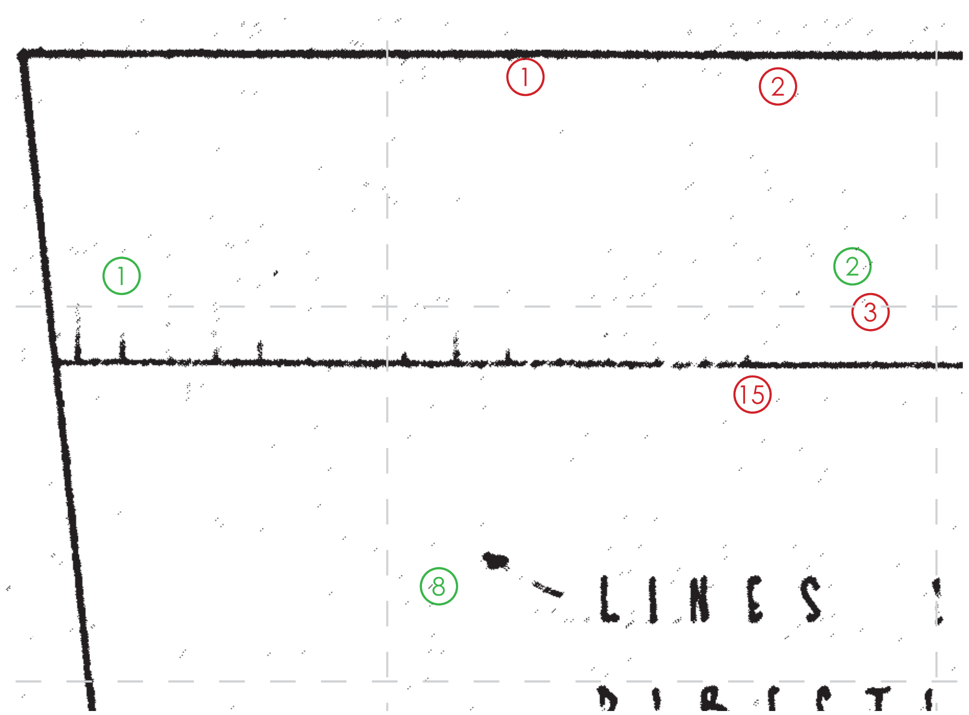
Variable Surface Color

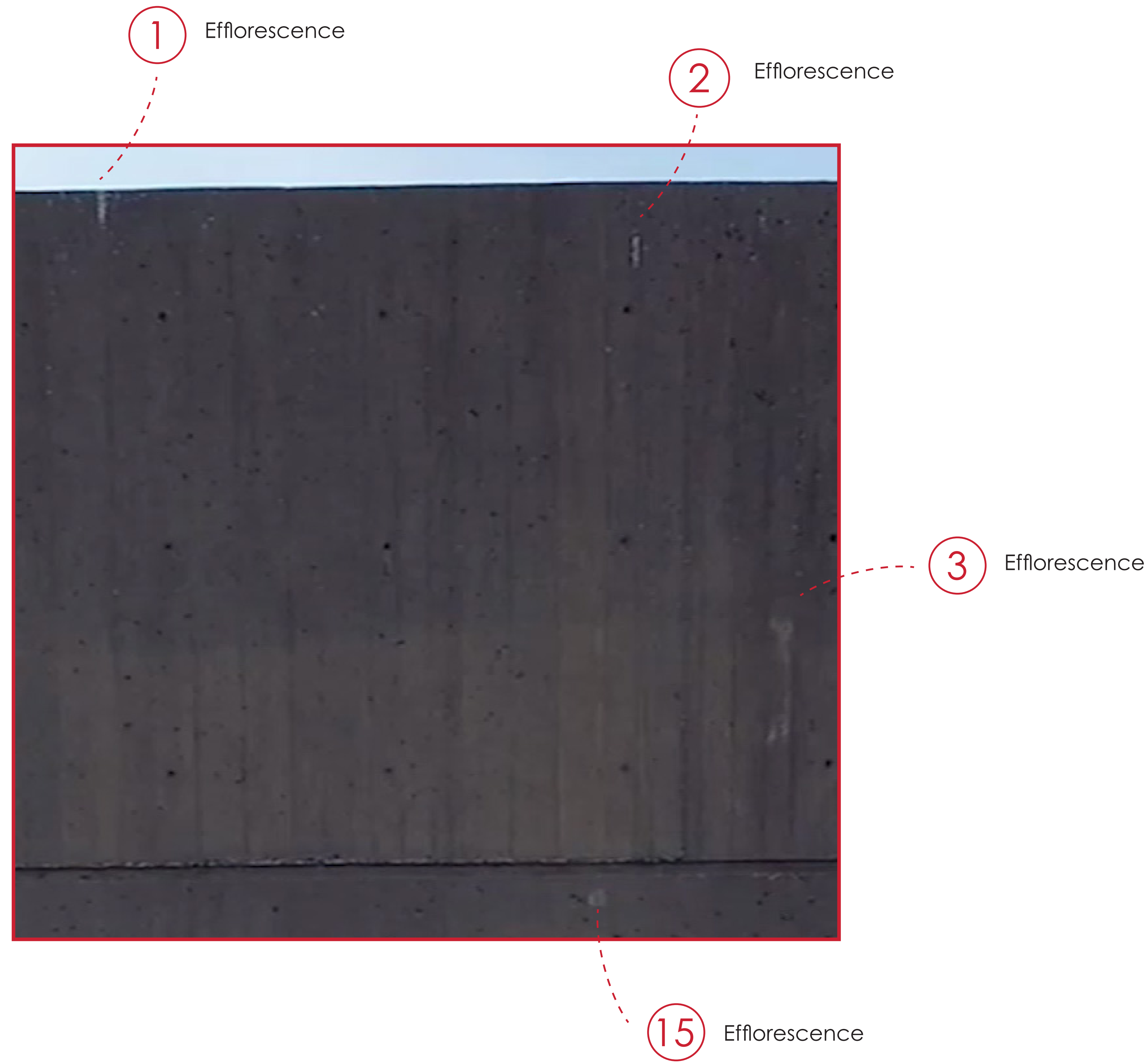
Iron Oxide Staining

Spalling

Chipping



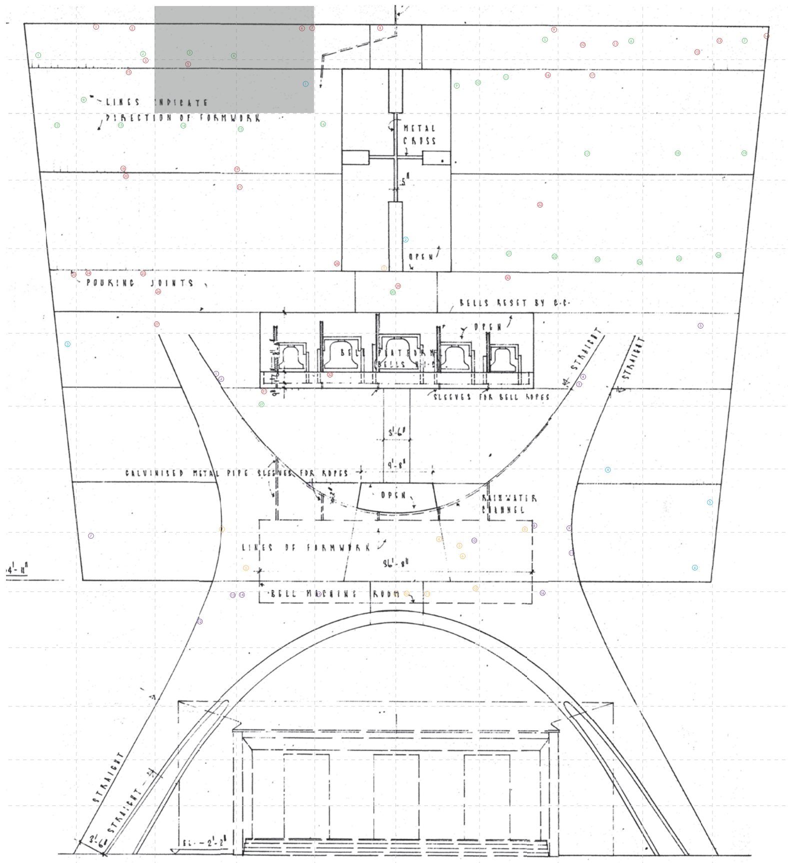




BELL BANNER NORTH ELEVATION

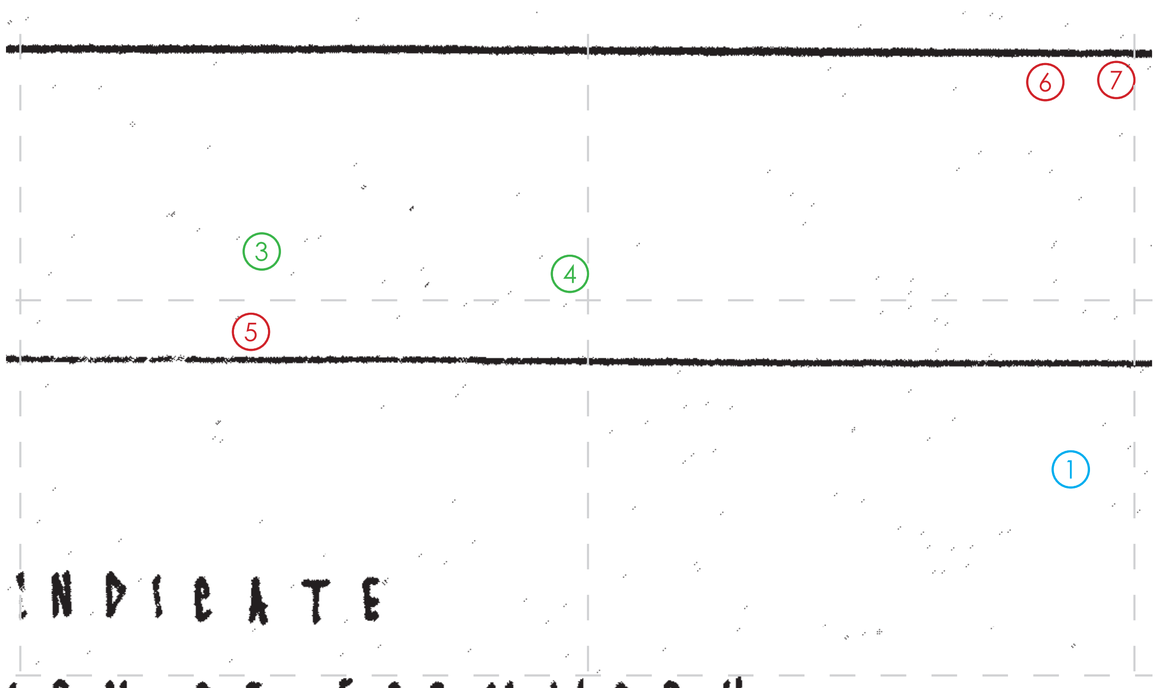
1 Variable Surface Color

2



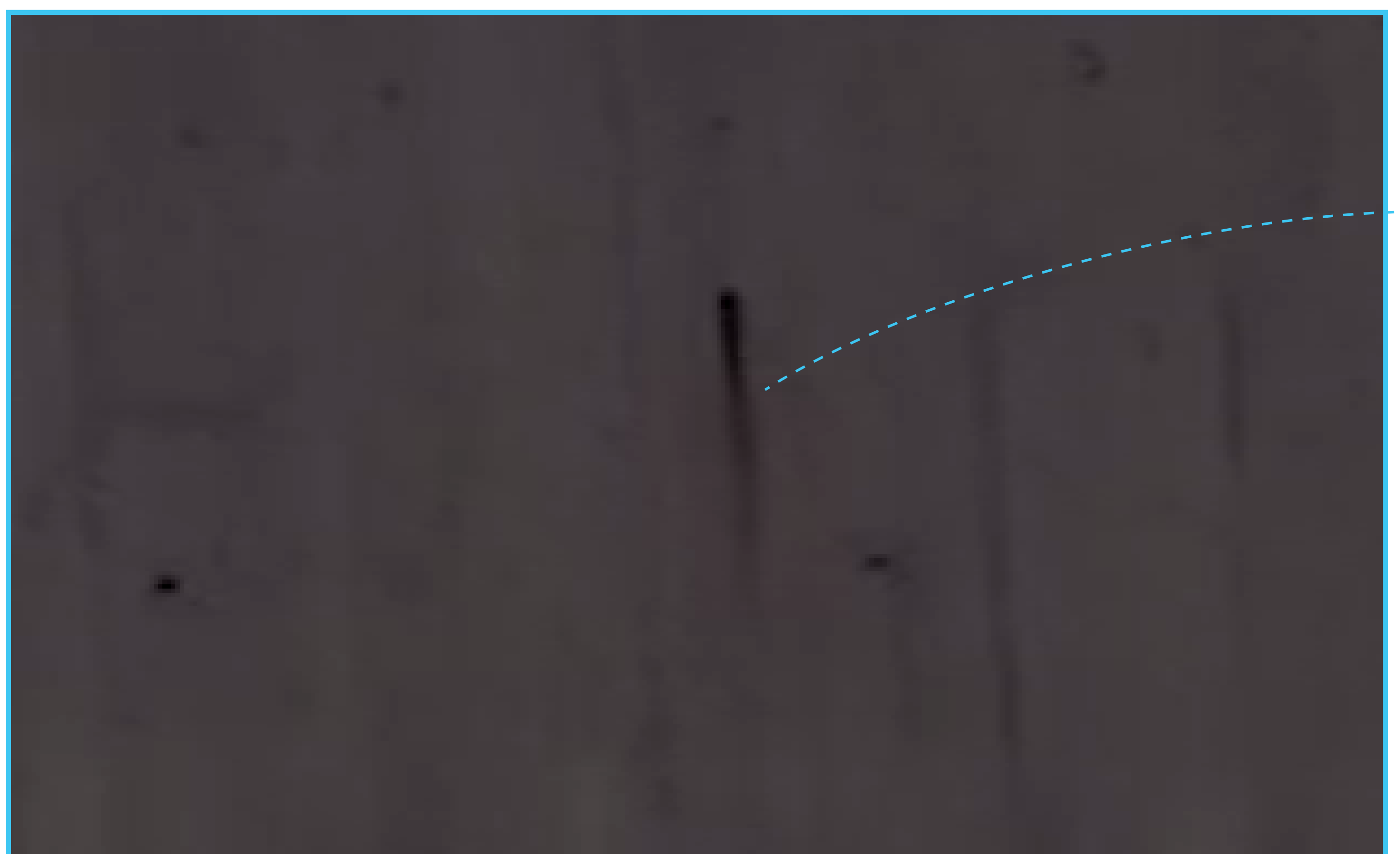
Variable Surface Color 3

Efflorescence 5

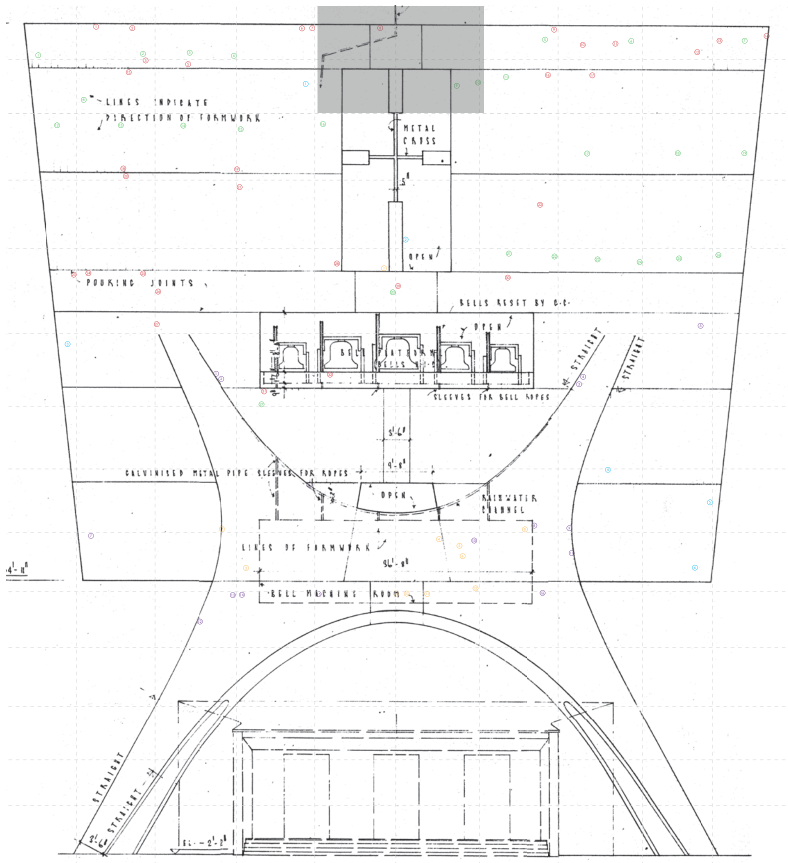


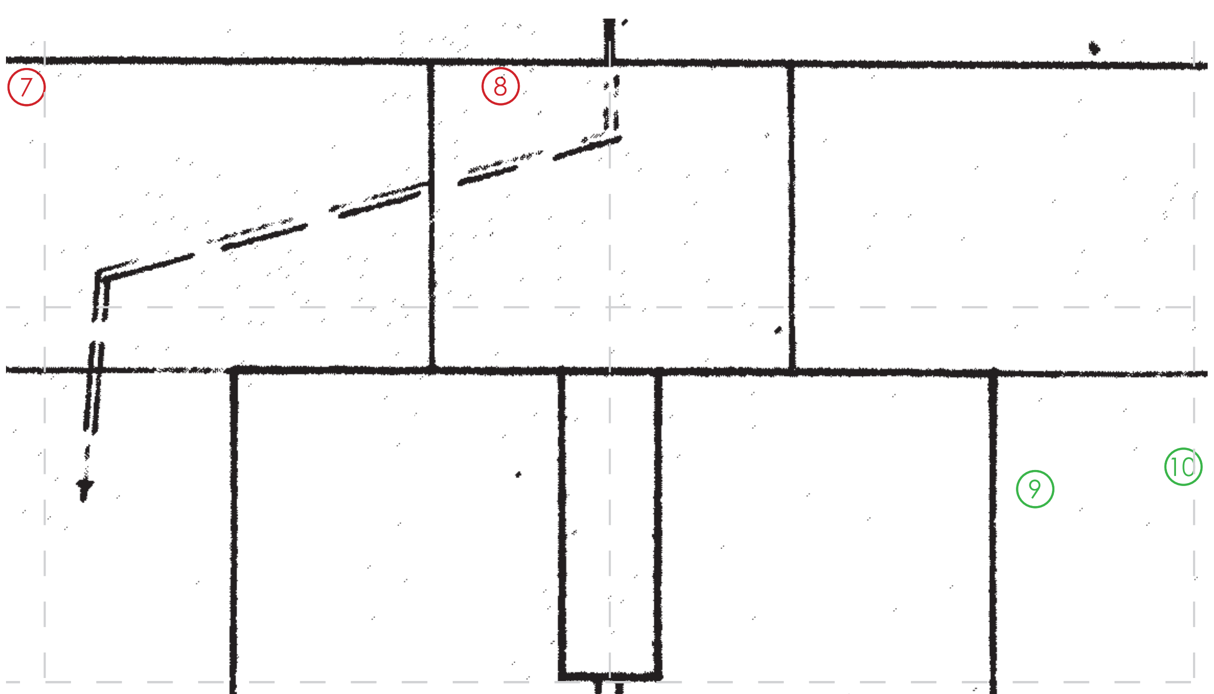
BELL BANNER NORTH ELEVATION

6 7 Efflorescence



1 Iron Oxide Staining



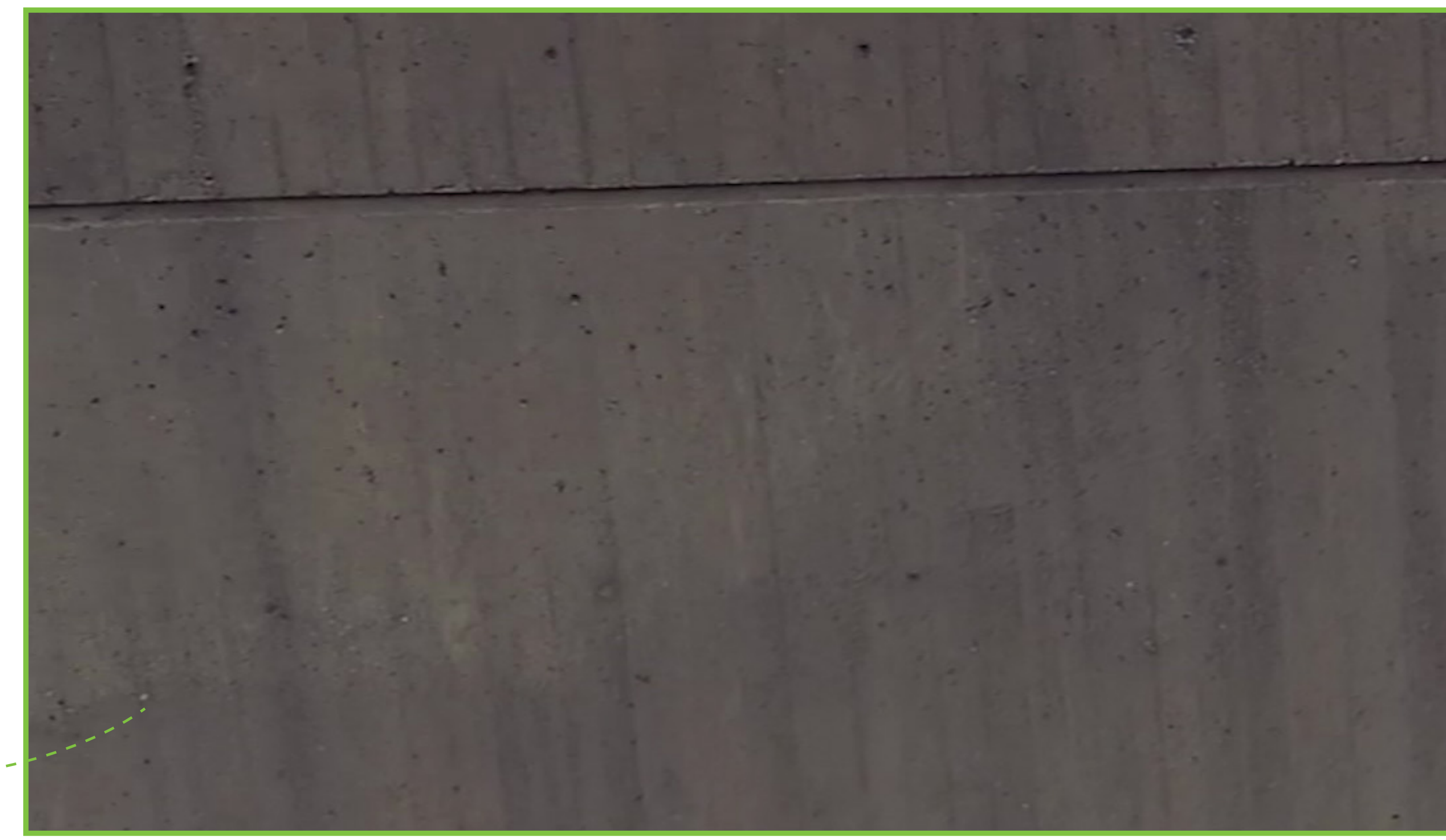


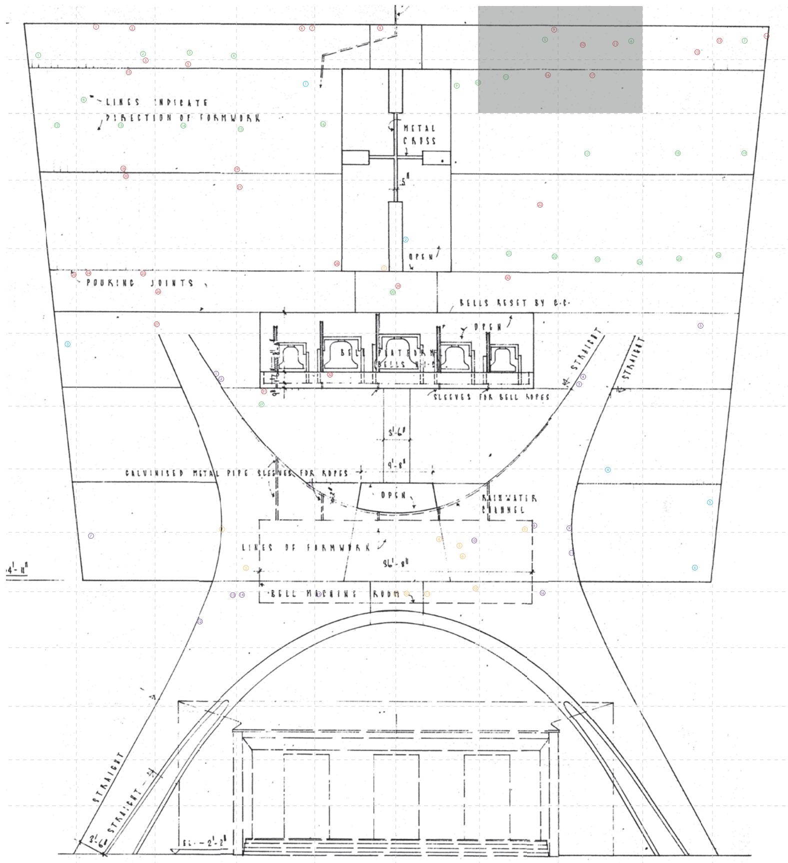
BELL BANNER NORTH ELEVATION

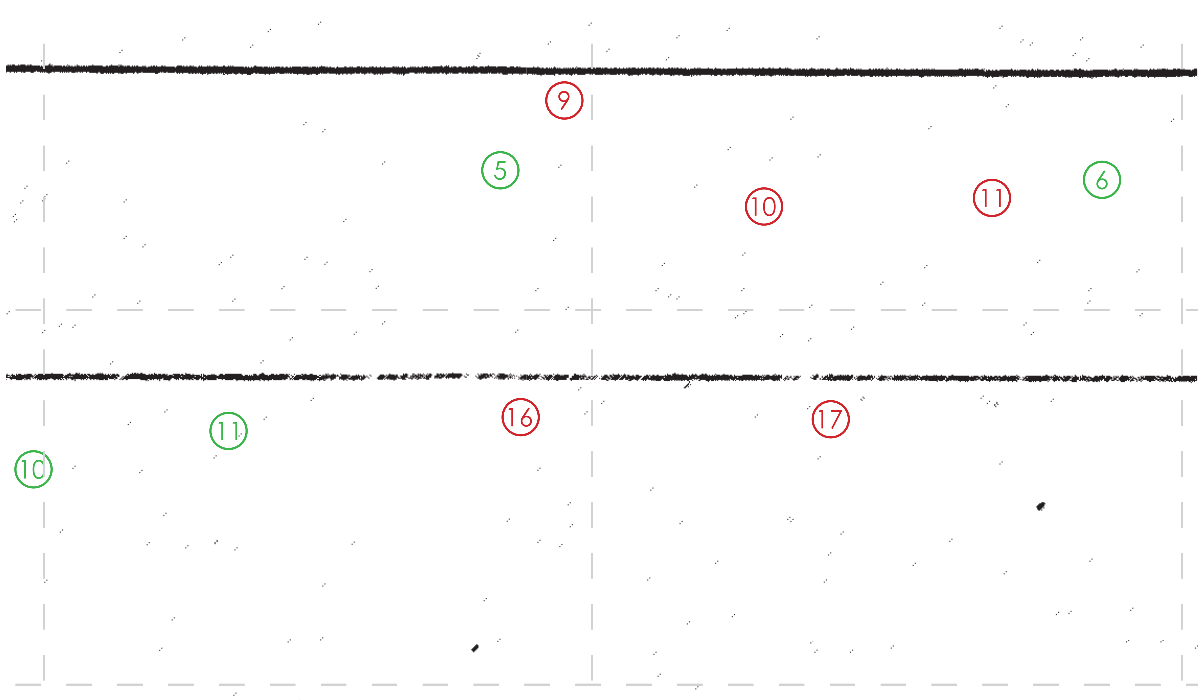
Variable Surface Color

9

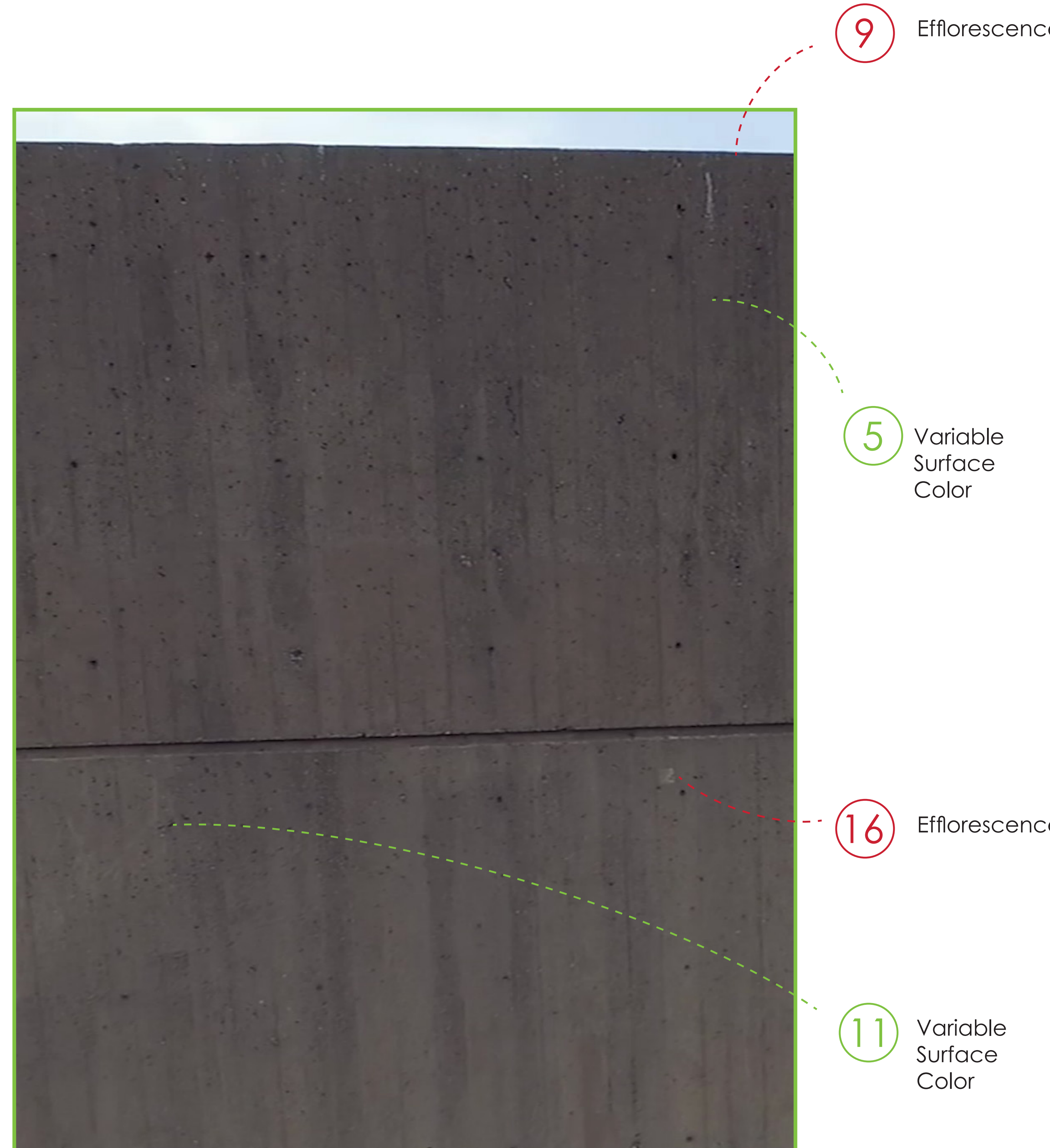
10

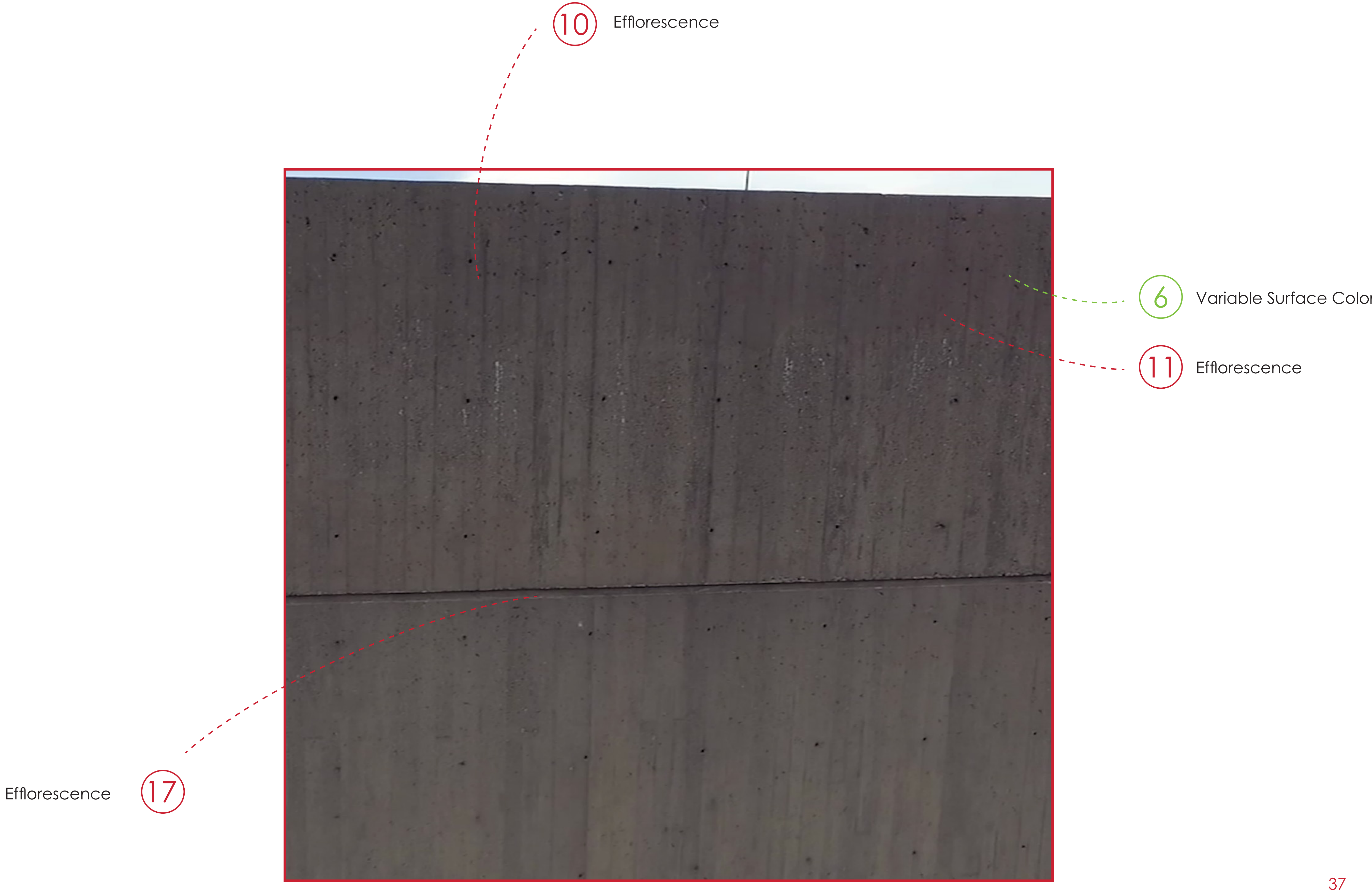


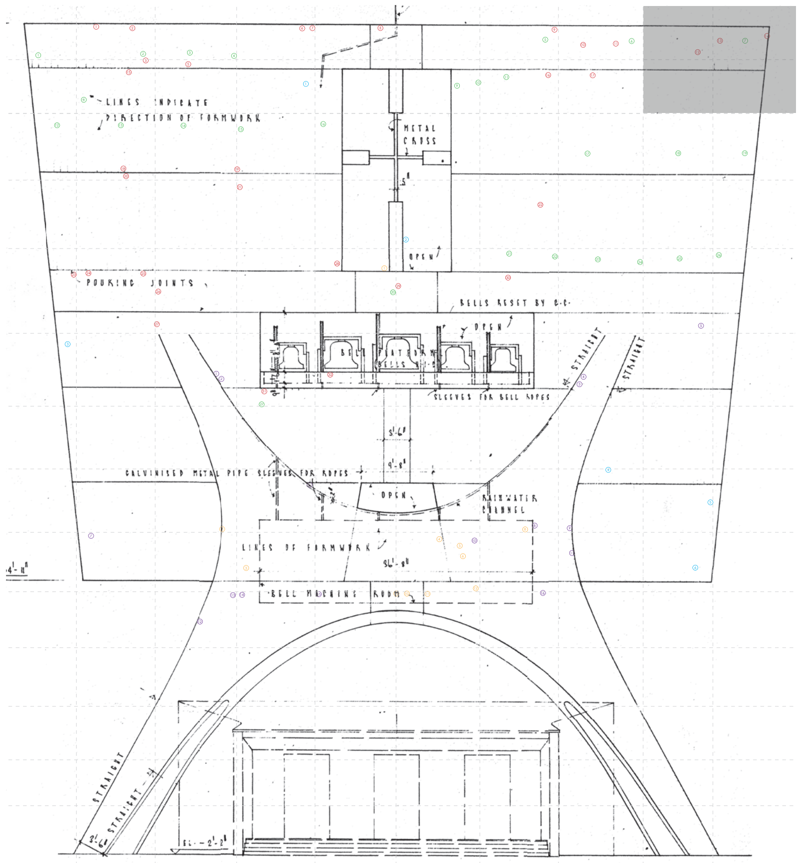


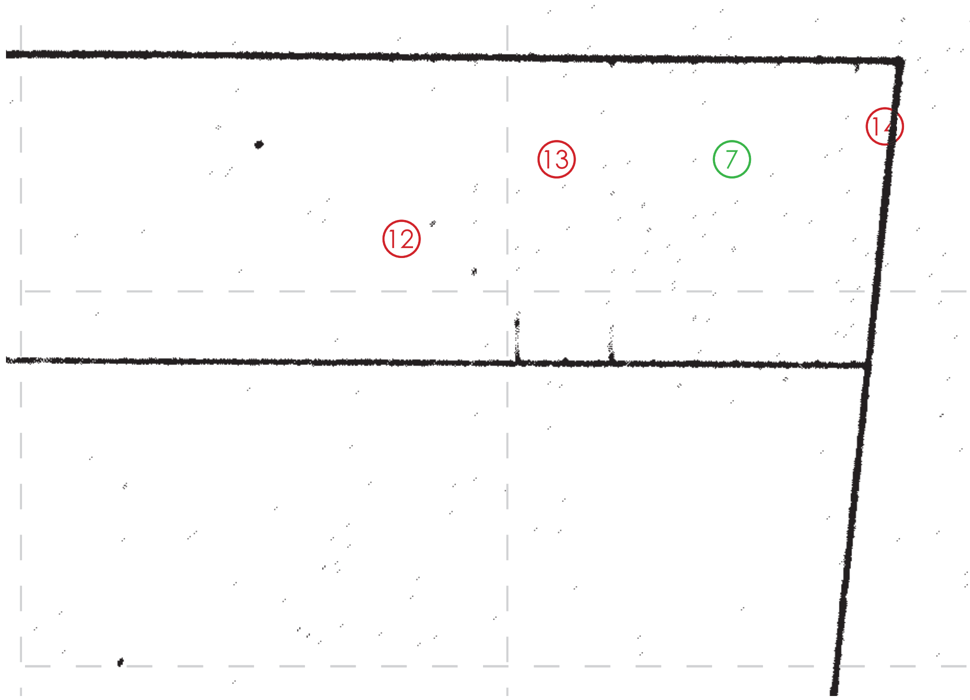


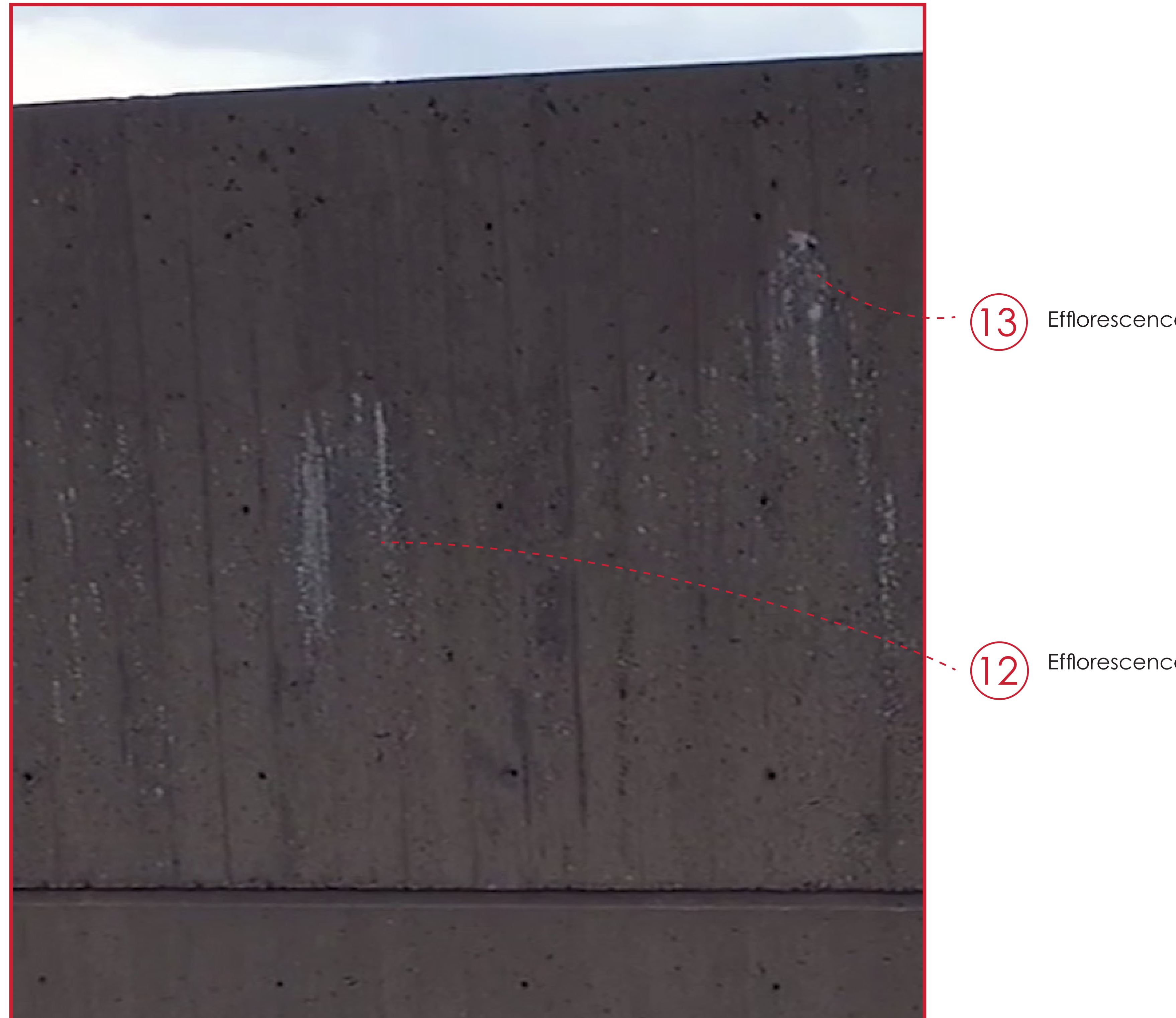
BELL BANNER NORTH ELEVATION




10 Efflorescence
6 Variable Surface Color
11 Efflorescence
Efflorescence 17



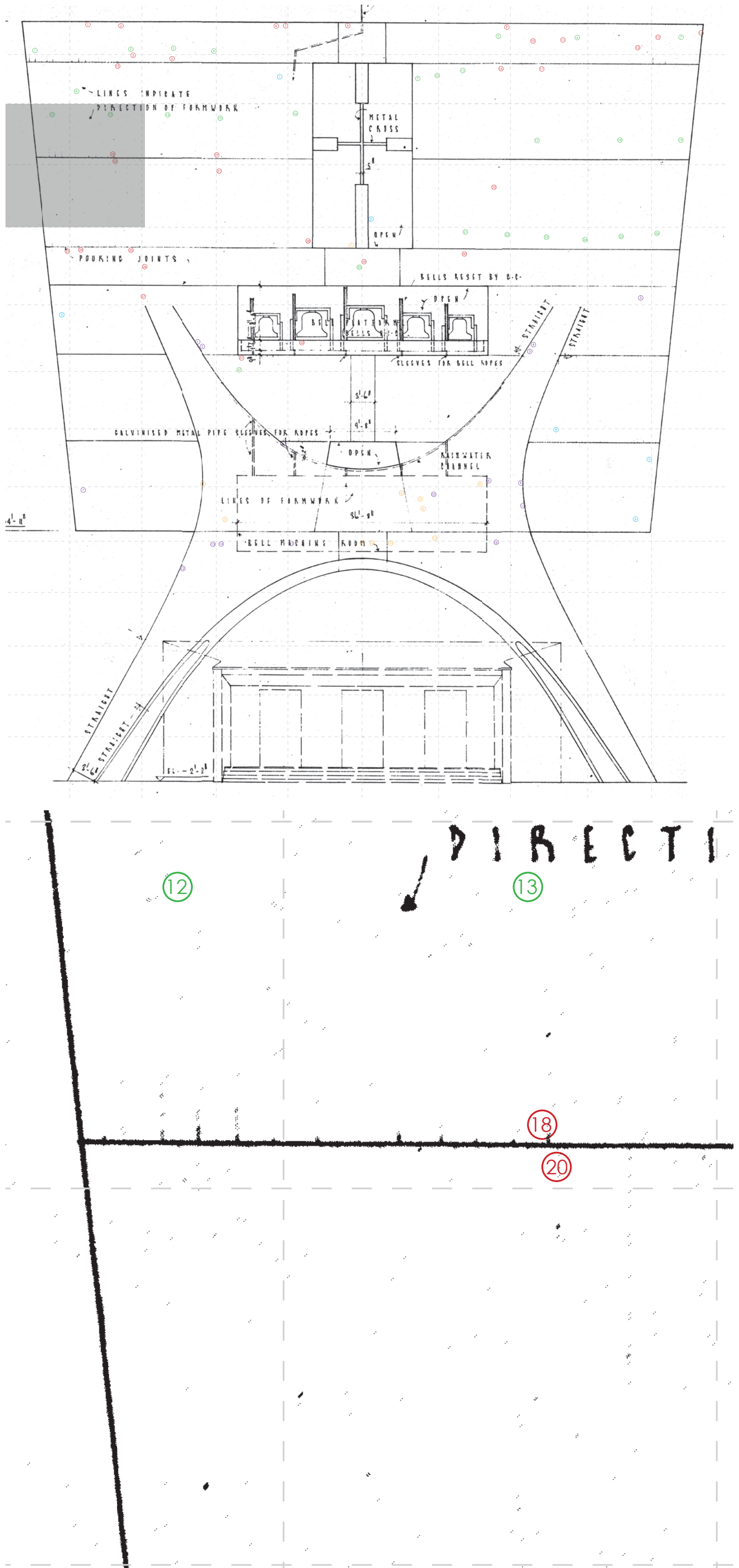


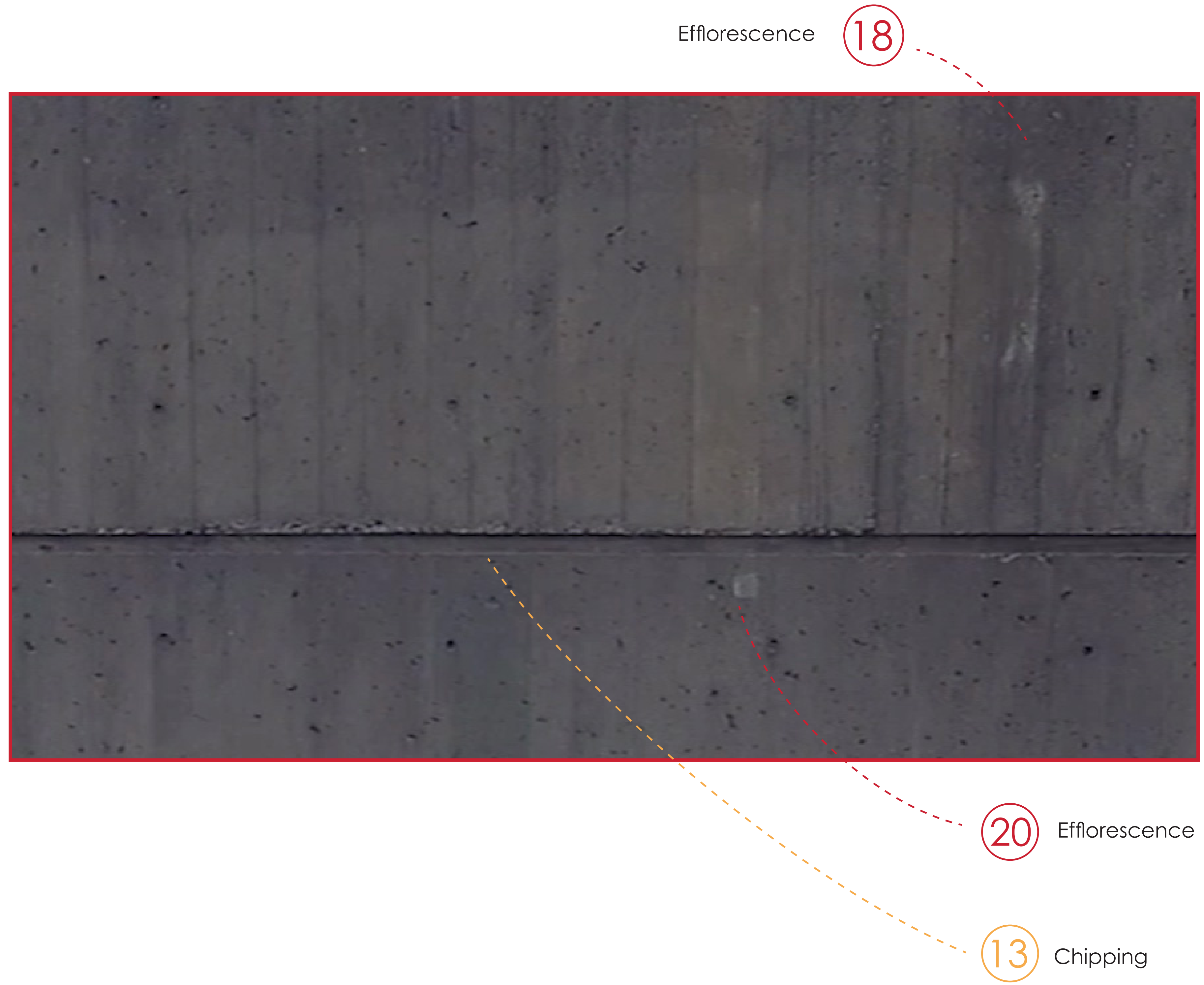


BELL BANNER NORTH ELEVATION

14 Efflorescence

7 Variable Surface Color

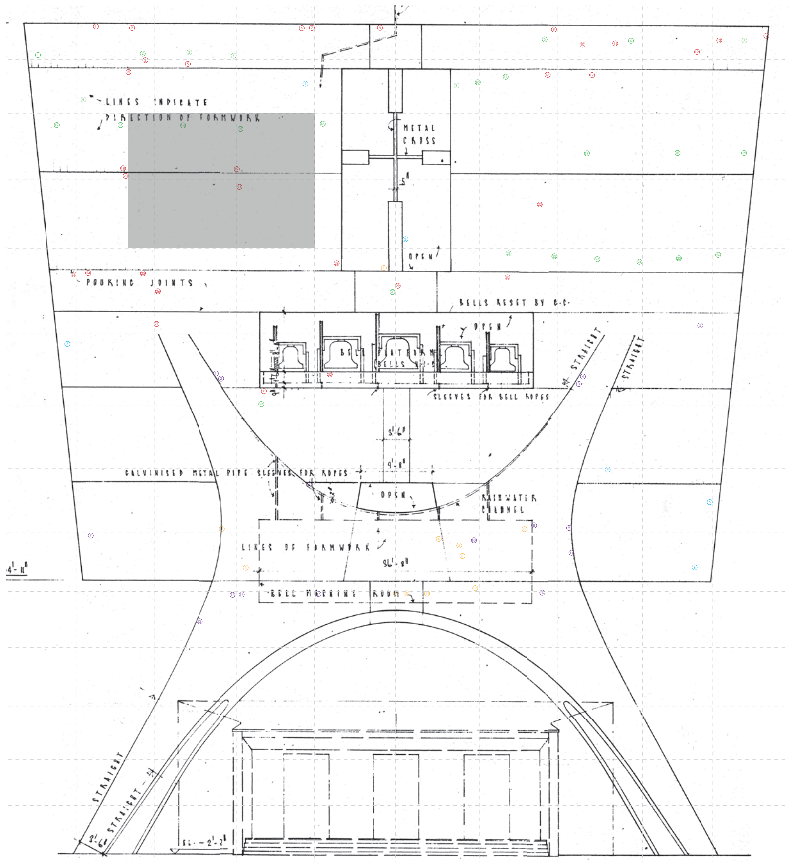


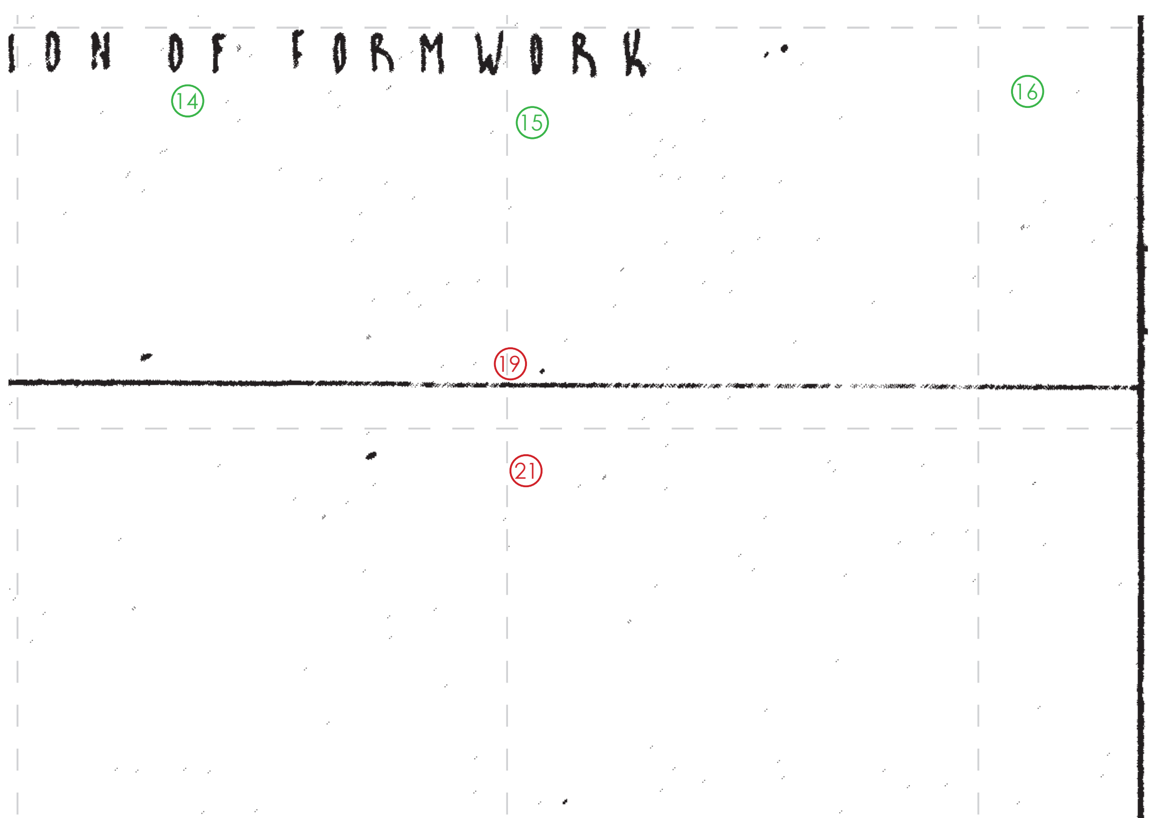


BELL BANNER NORTH ELEVATION

12 Variable Surface Color

13





Variable Surface Color 14

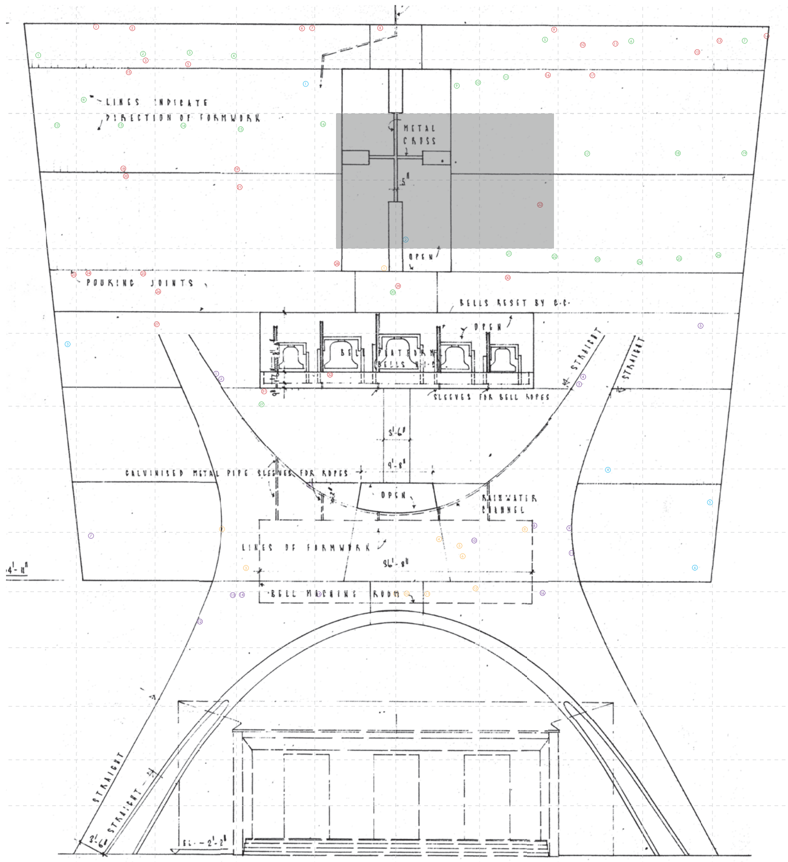
15

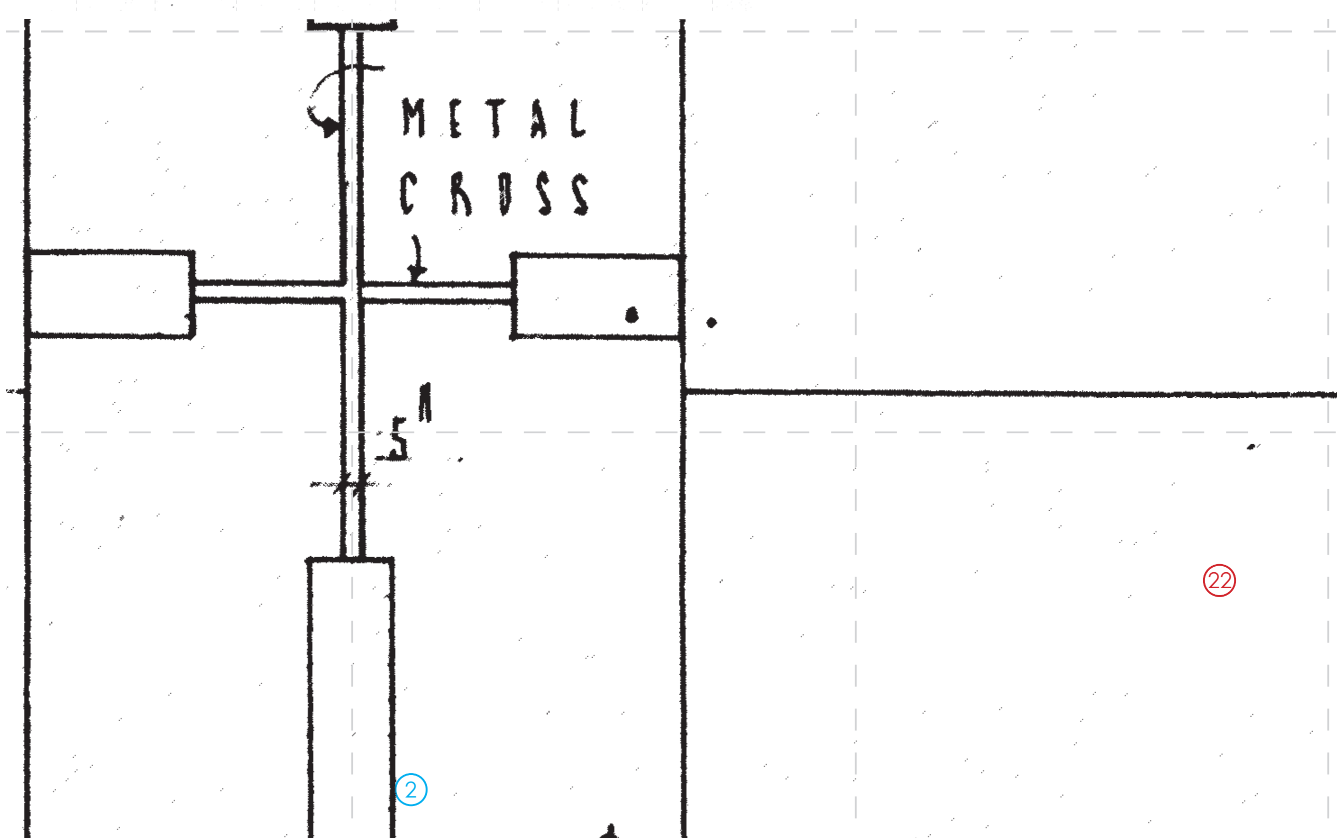
16

Efflorescence 19

21

BELL BANNER NORTH ELEVATION

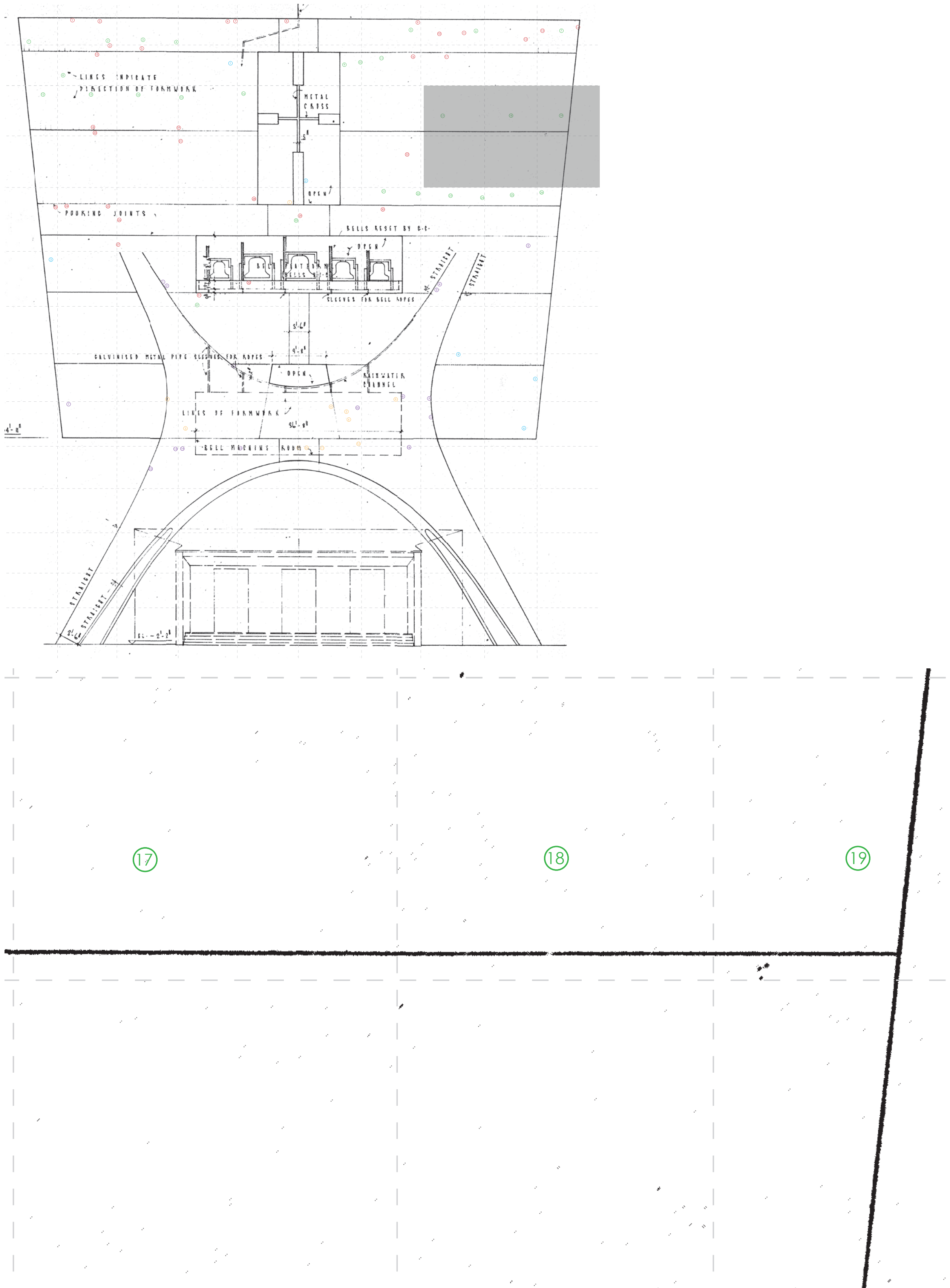




BELL BANNER NORTH ELEVATION

2 Iron Oxide Staining

Efflorescence 22

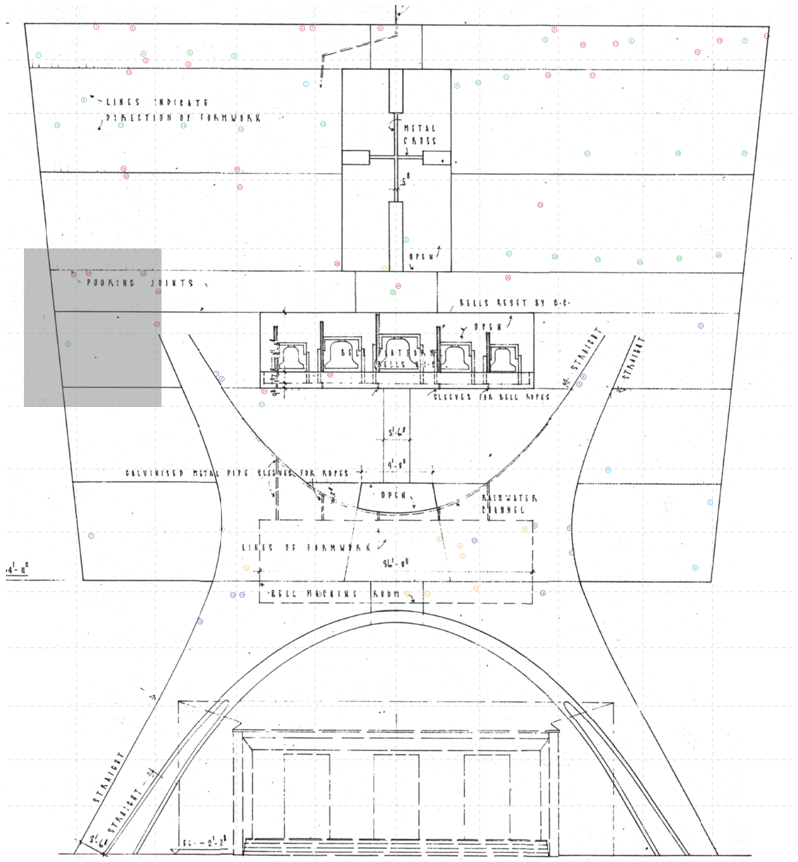


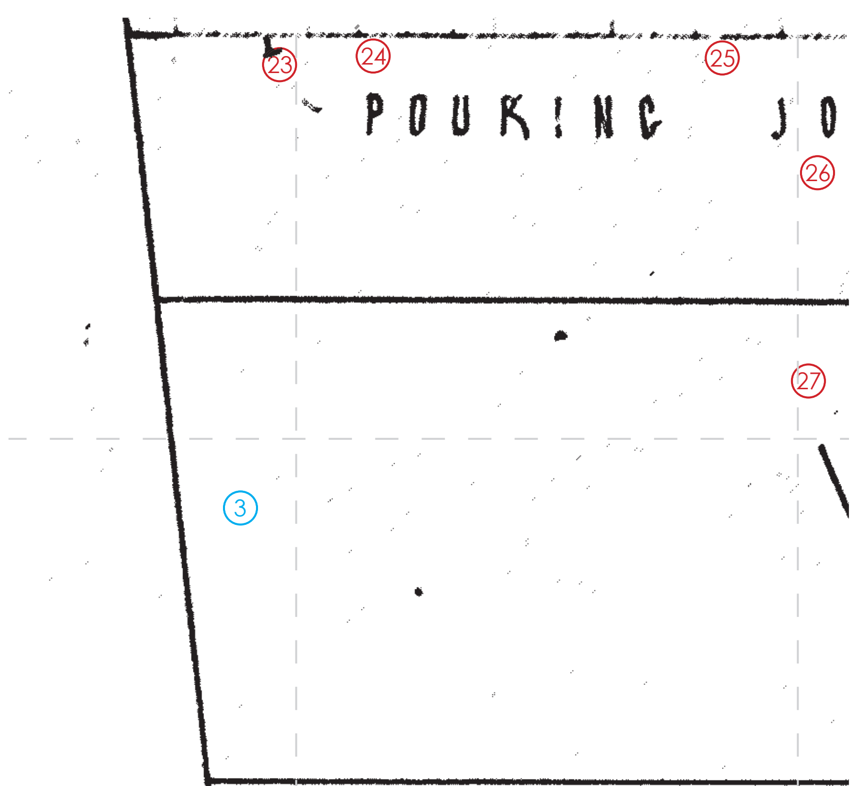
BELL BANNER NORTH ELEVATION

18

19

Variable Surface Color 17





BELL BANNER NORTH ELEVATION

23 Efflorescence

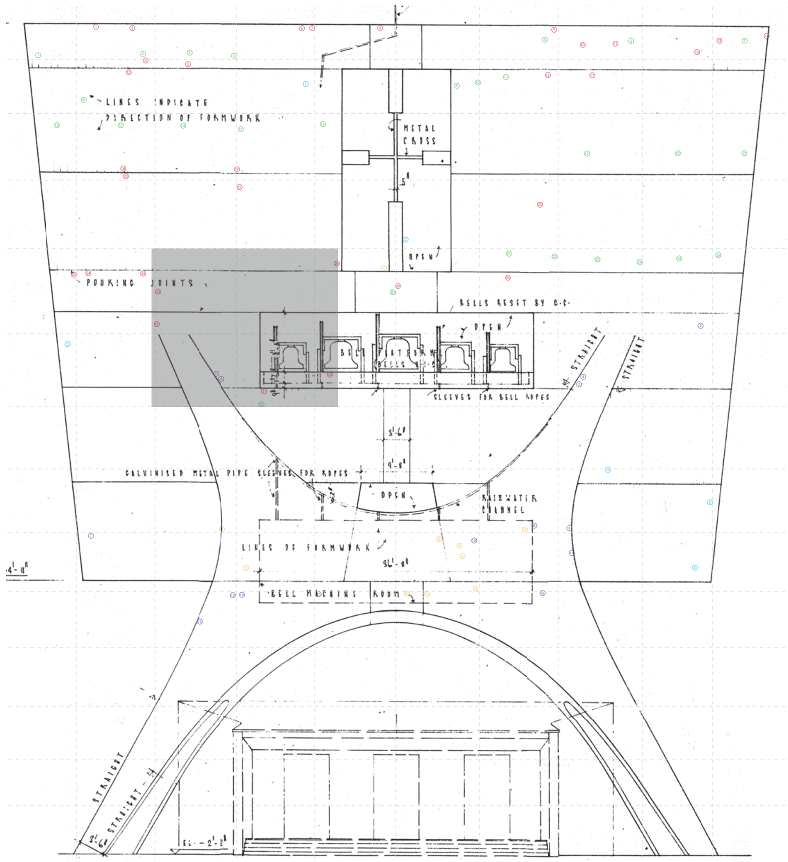
24

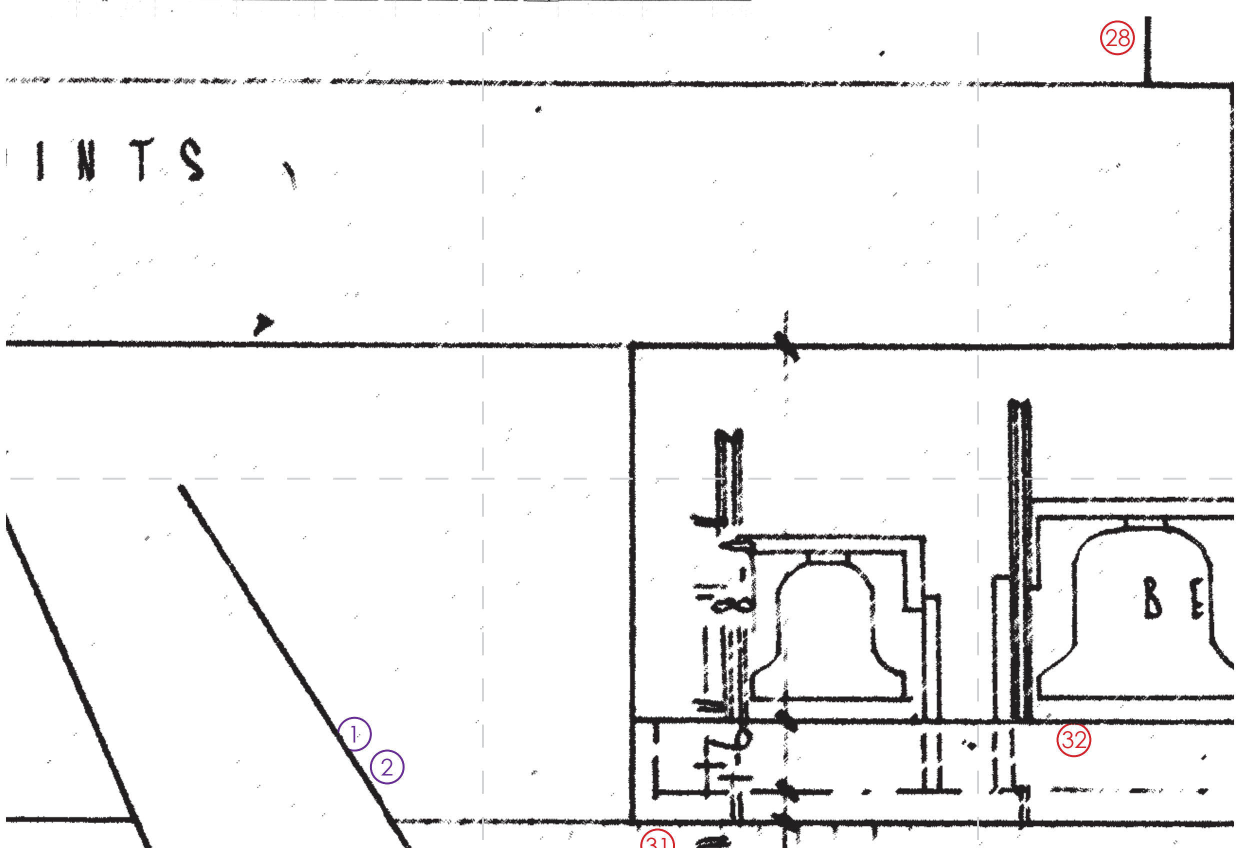
2 Iron Oxide Staining

Efflorescence 25

26 Efflorescence

27 Efflorescence



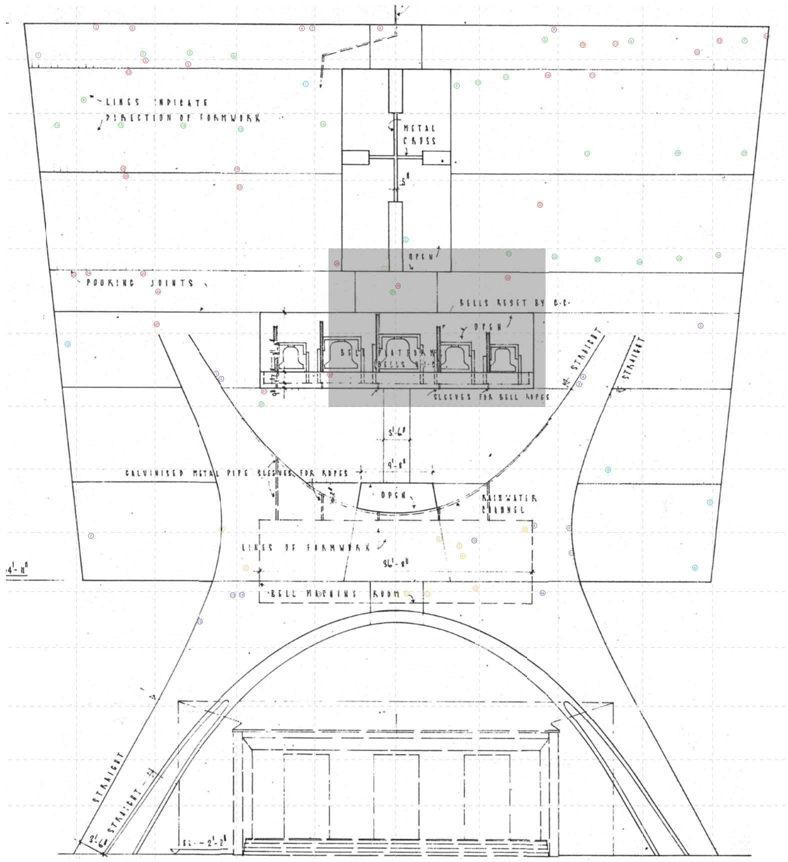


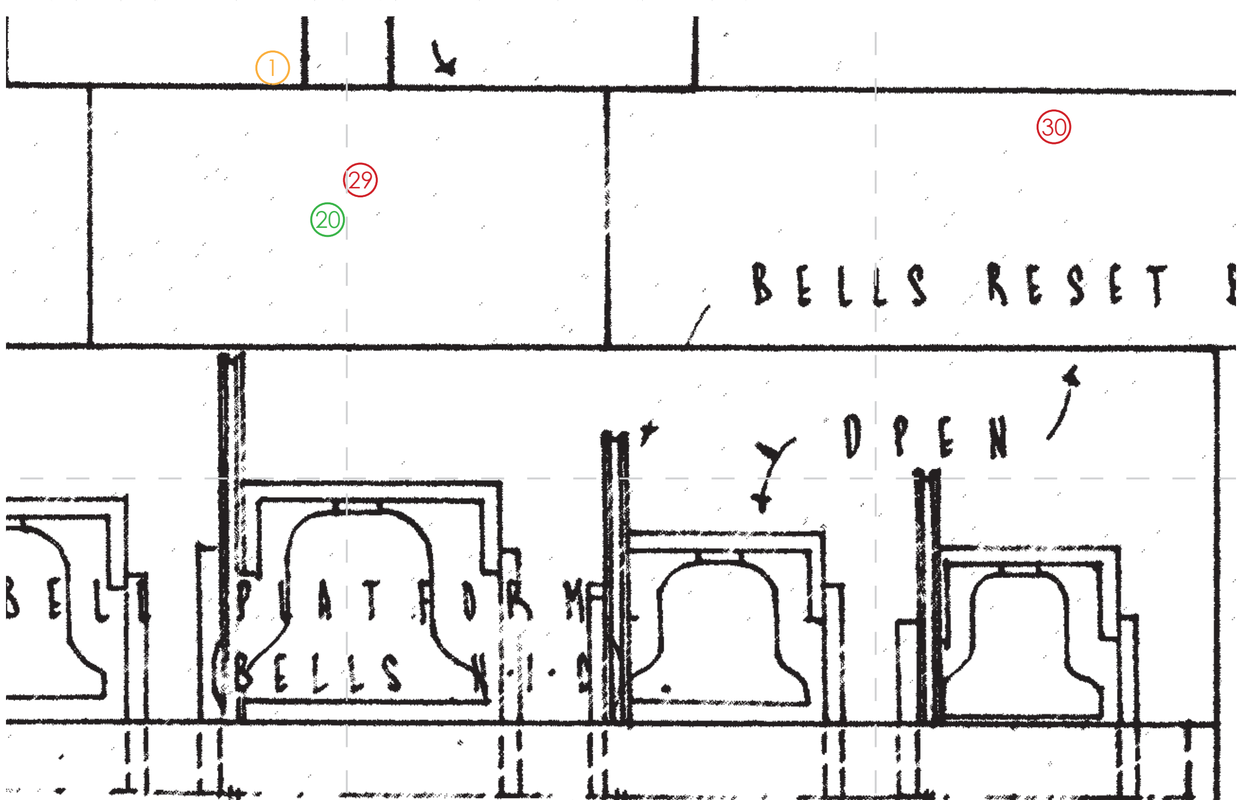
BELL BANNER NORTH ELEVATION

1 Patching

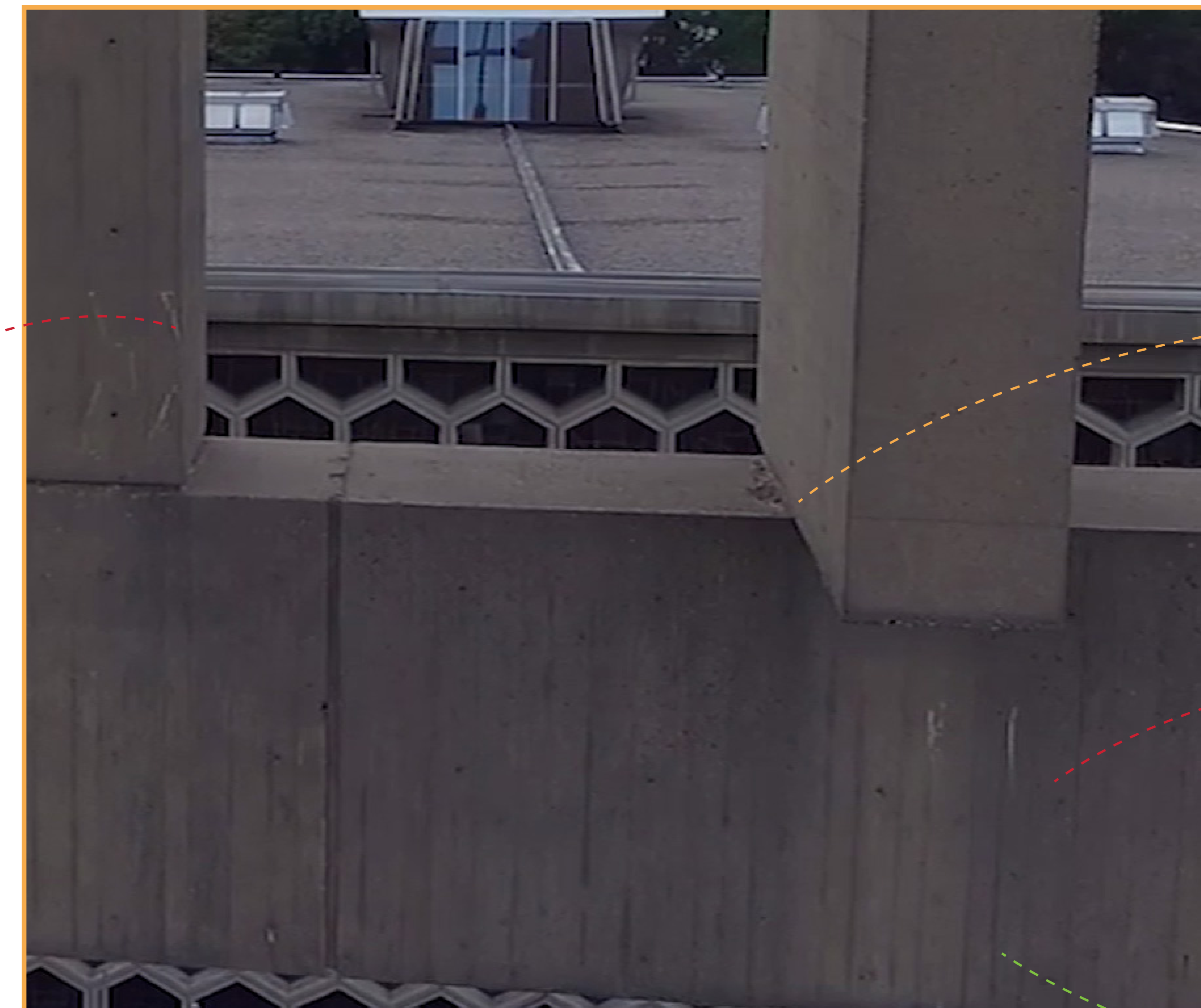
32 Efflorescence

31 Efflorescence





Patching 28

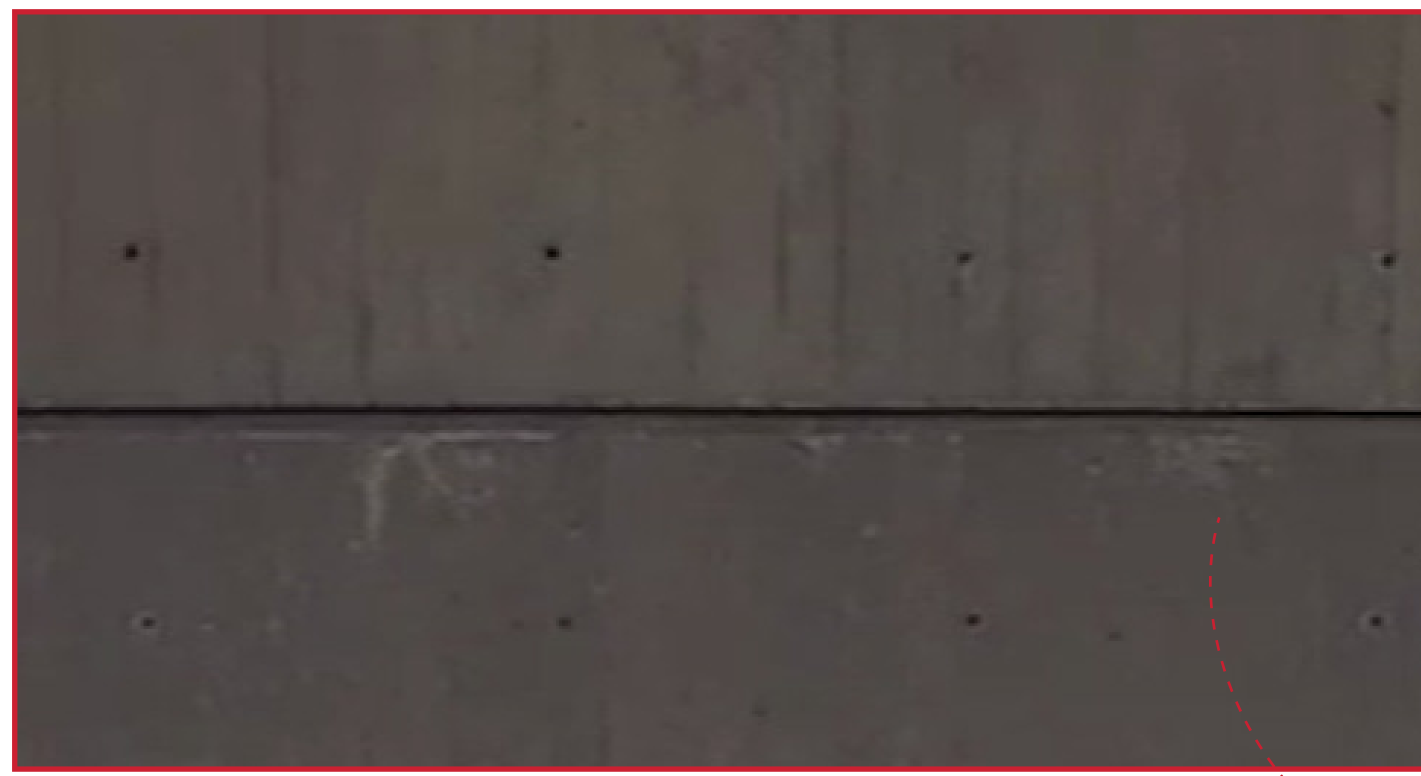


BELL BANNER NORTH ELEVATION

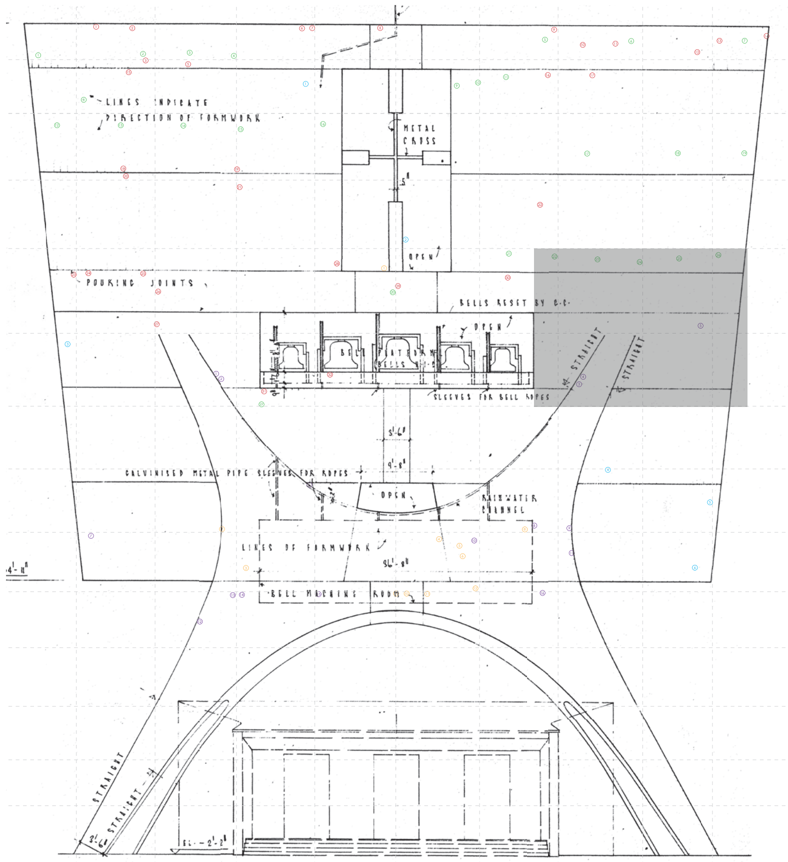
1 Spalling

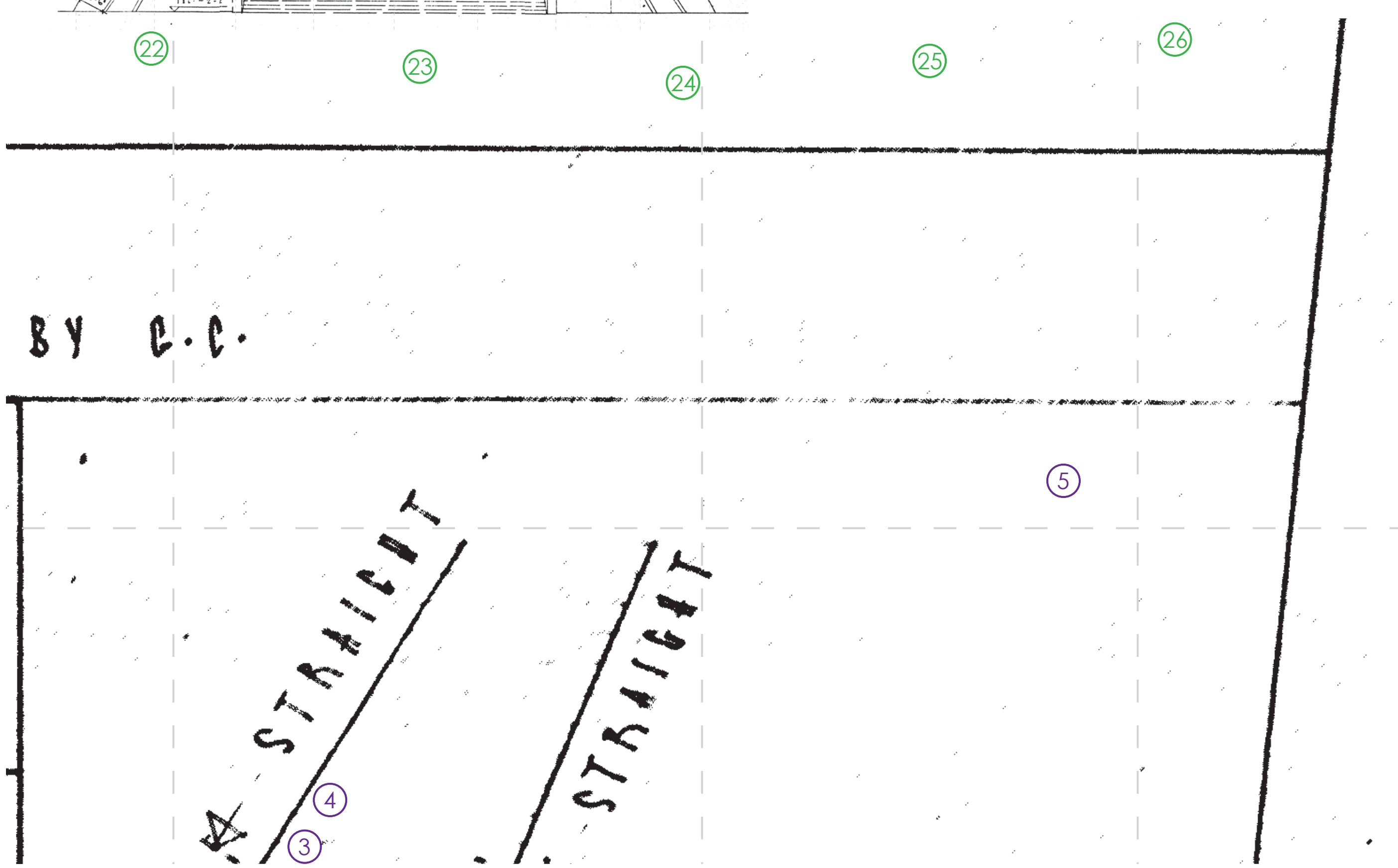
29 Efflorescence

20 Variable Surface Color

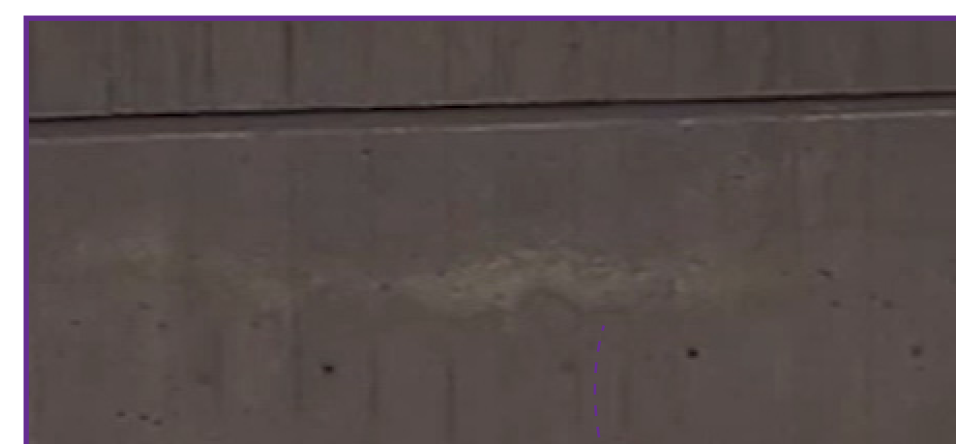


30 Efflorescence





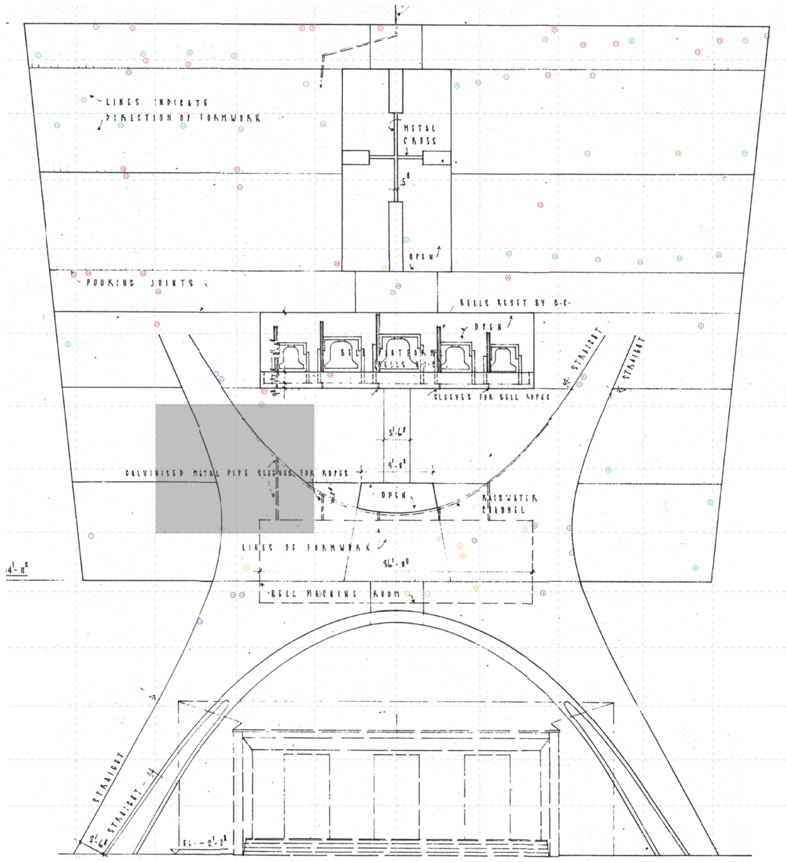
3 Patching

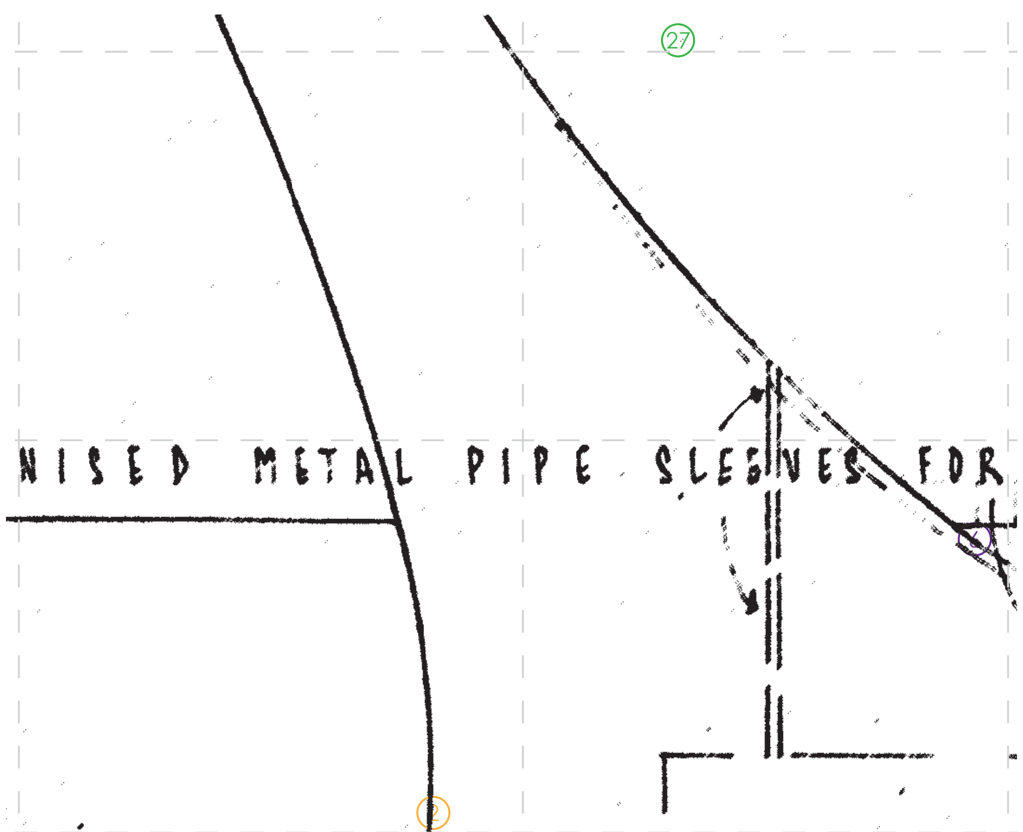


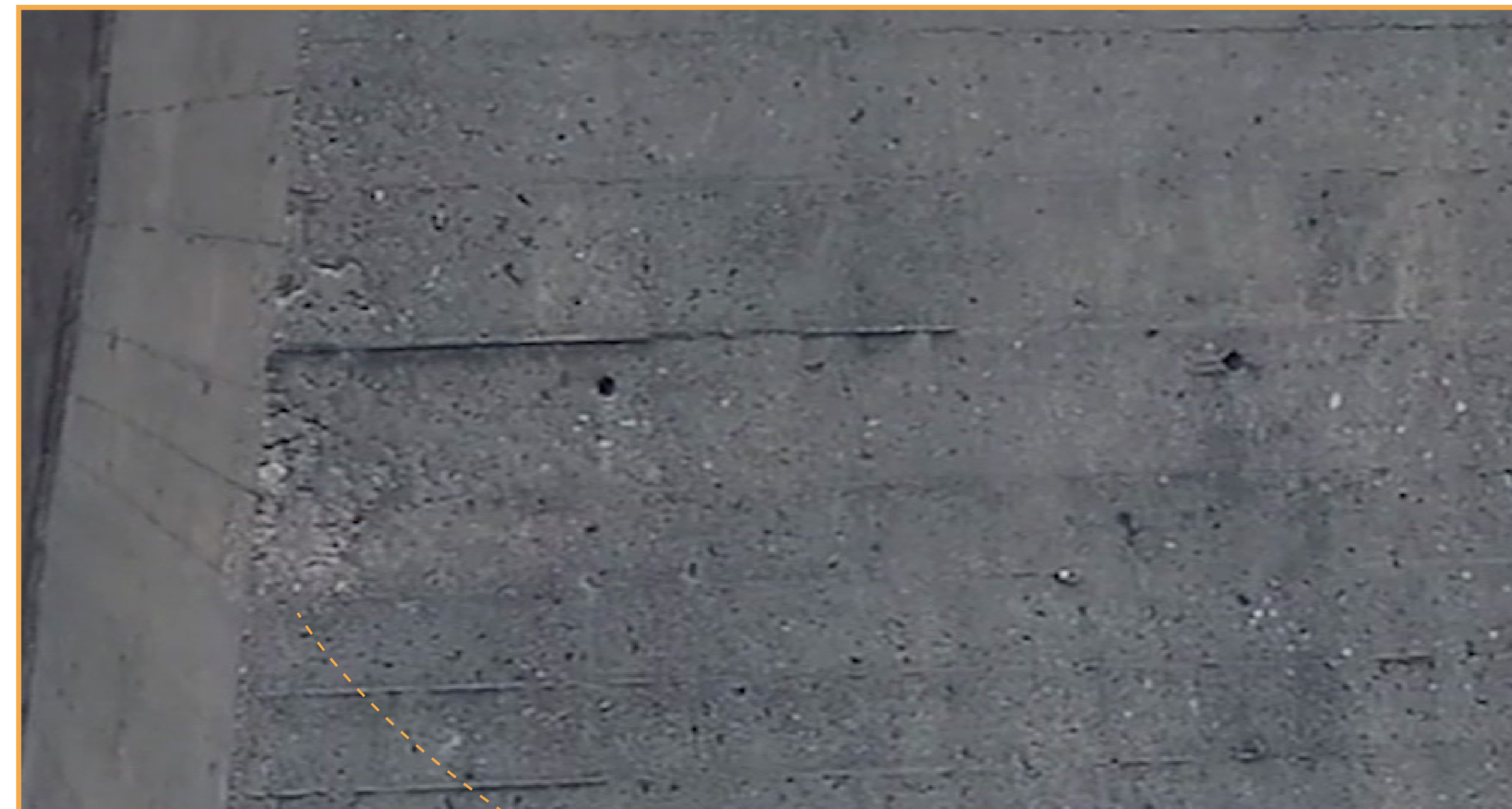
5

BELL BANNER NORTH ELEVATION

22 24 25 Variable Surface Color



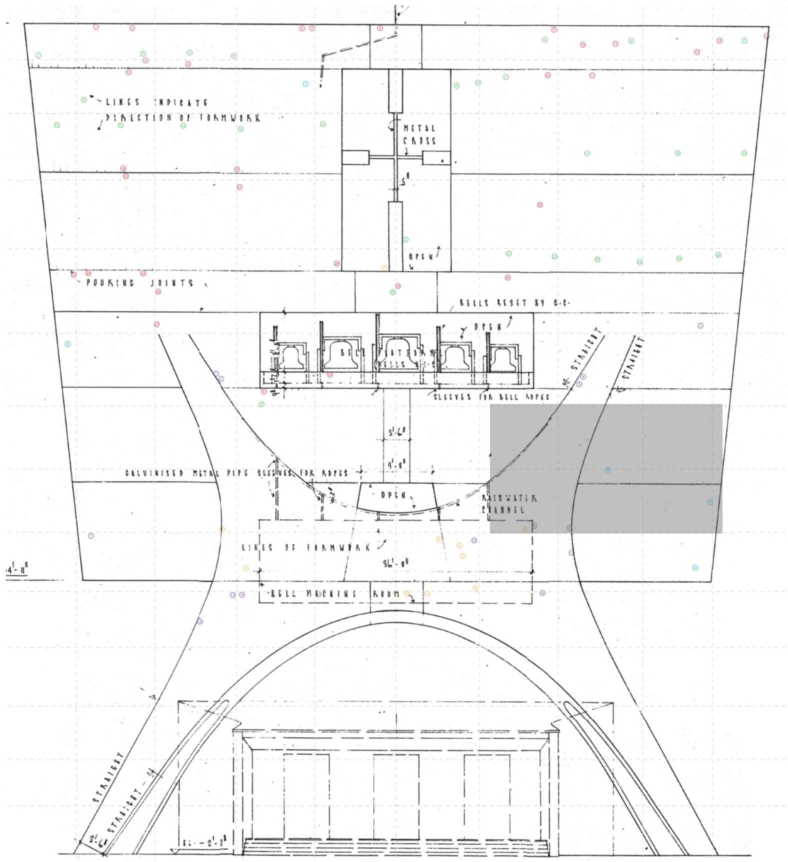


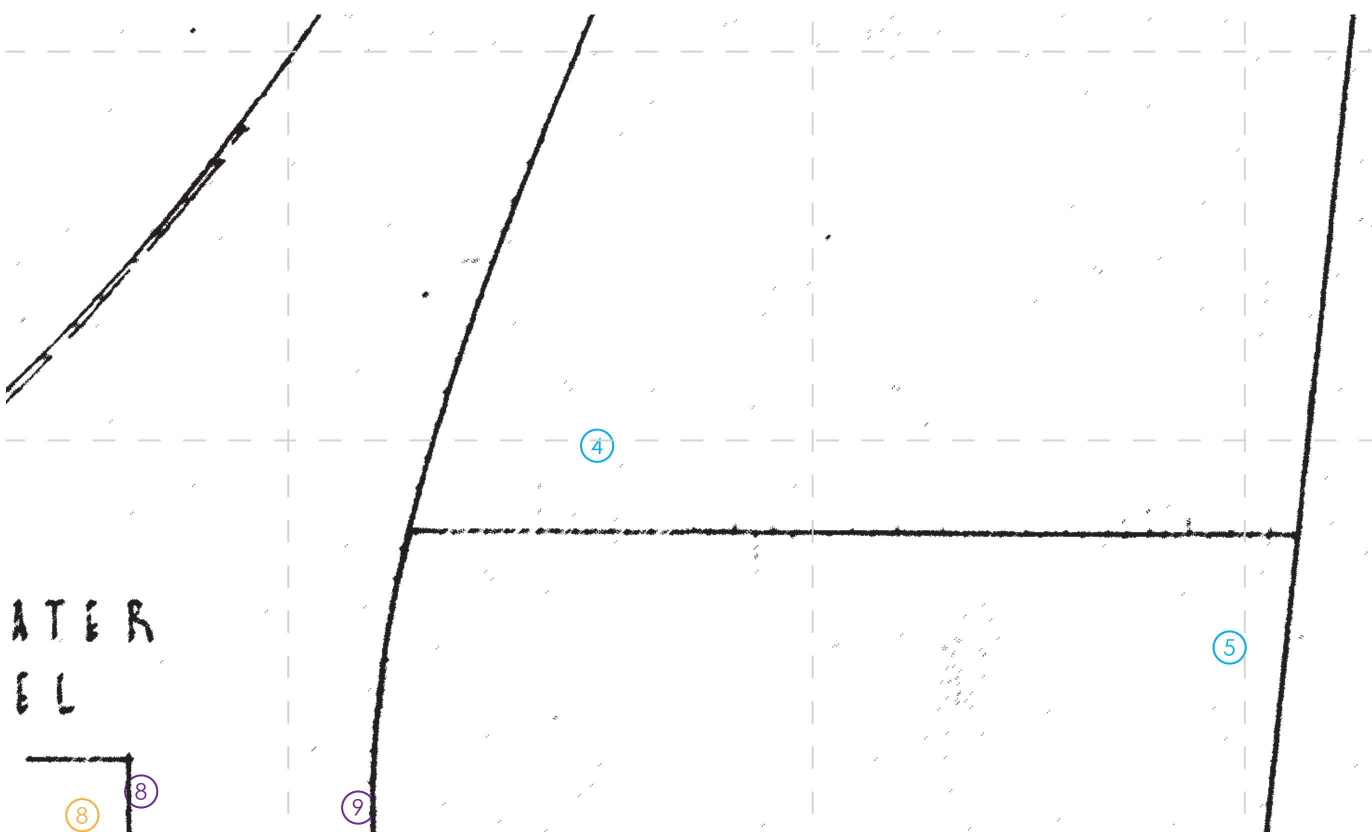


2 Spalling

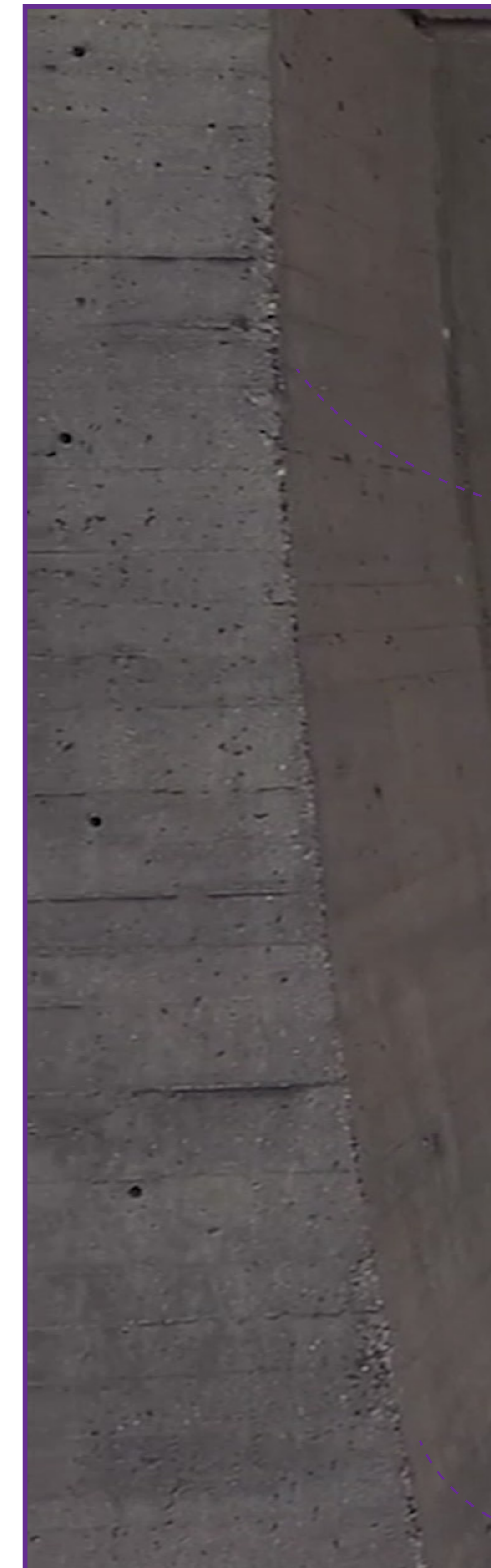
BELL BANNER NORTH ELEVATION

27 Variable Surface Color





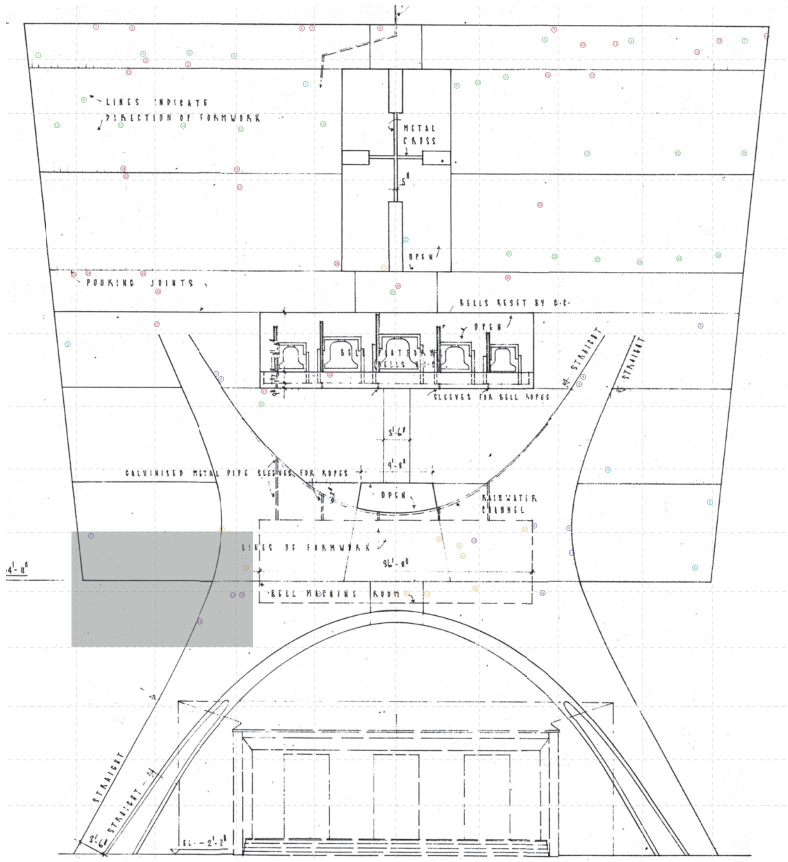
BELL BANNER NORTH ELEVATION

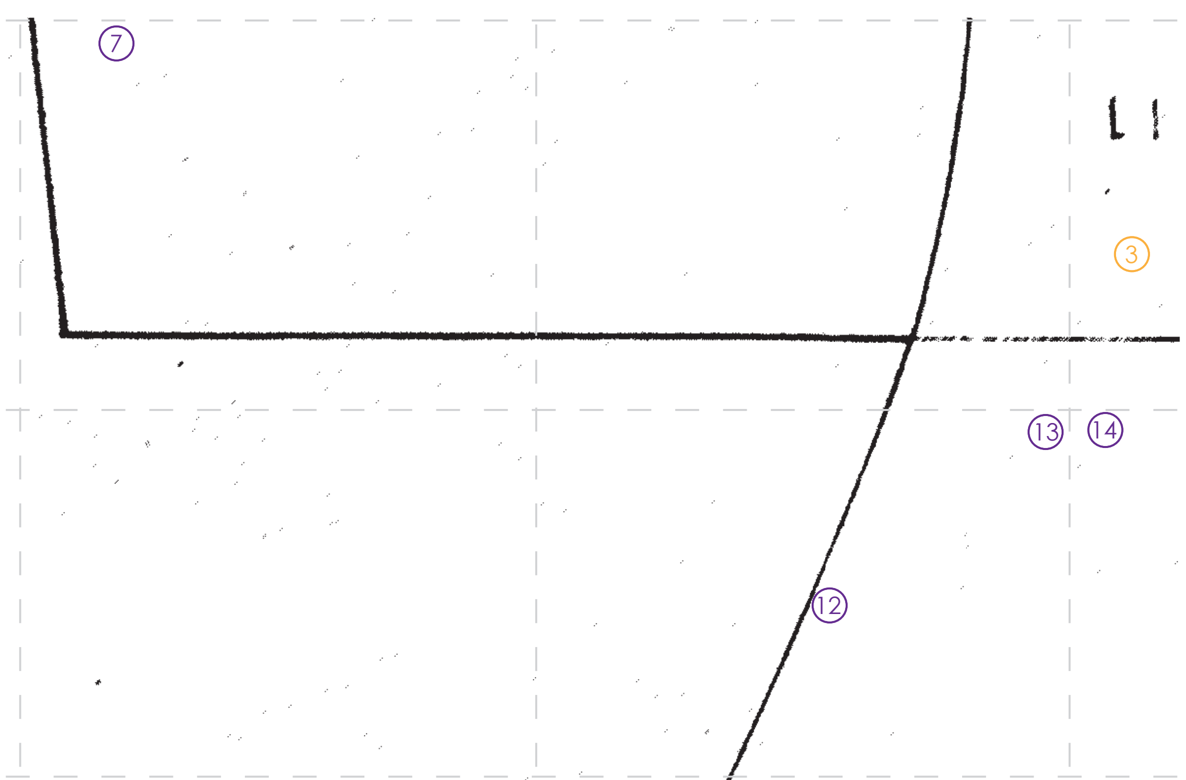


4 Iron Oxide Staining

5 Iron Oxide Staining

8 Spalling

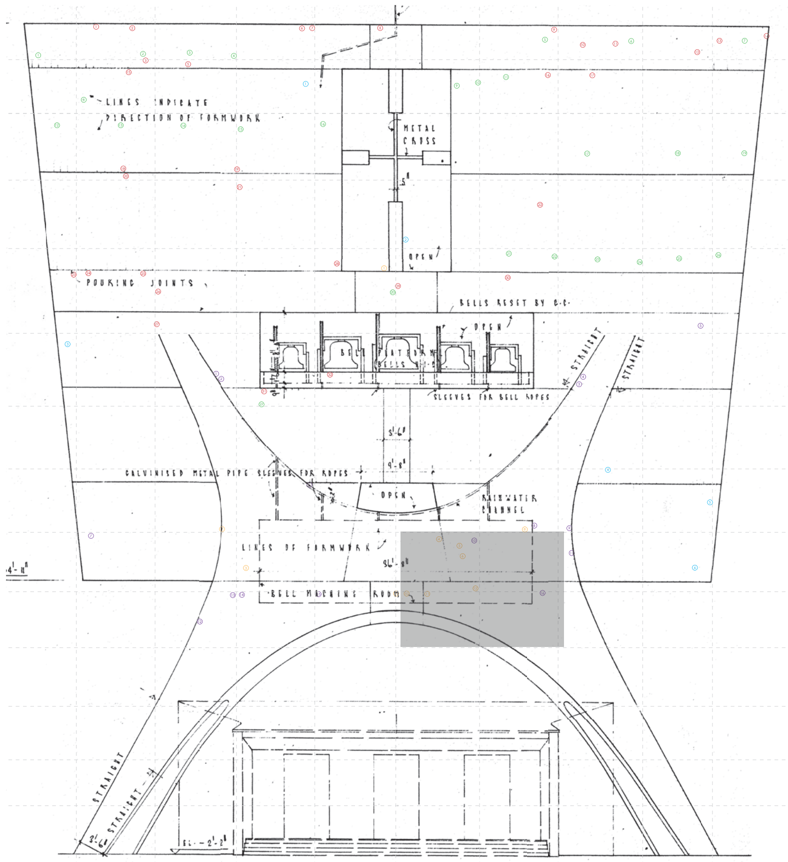


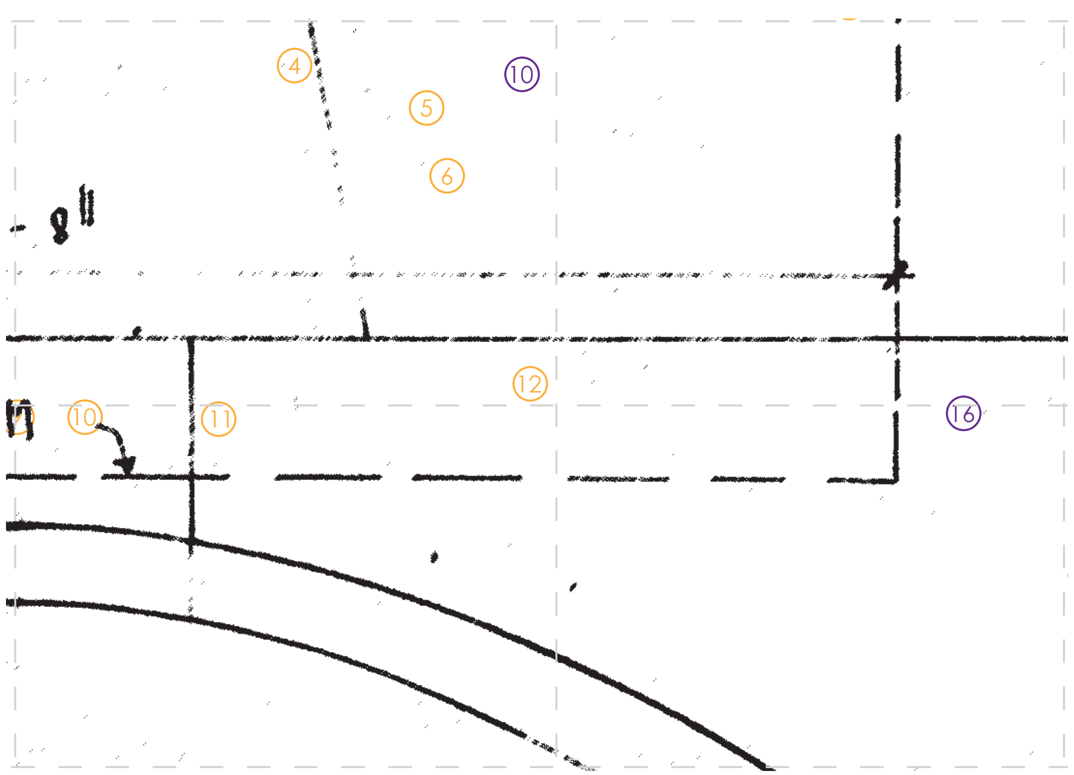


7 Chipping

BELL BANNER NORTH ELEVATION


3
Spalling
13
Chipping
12



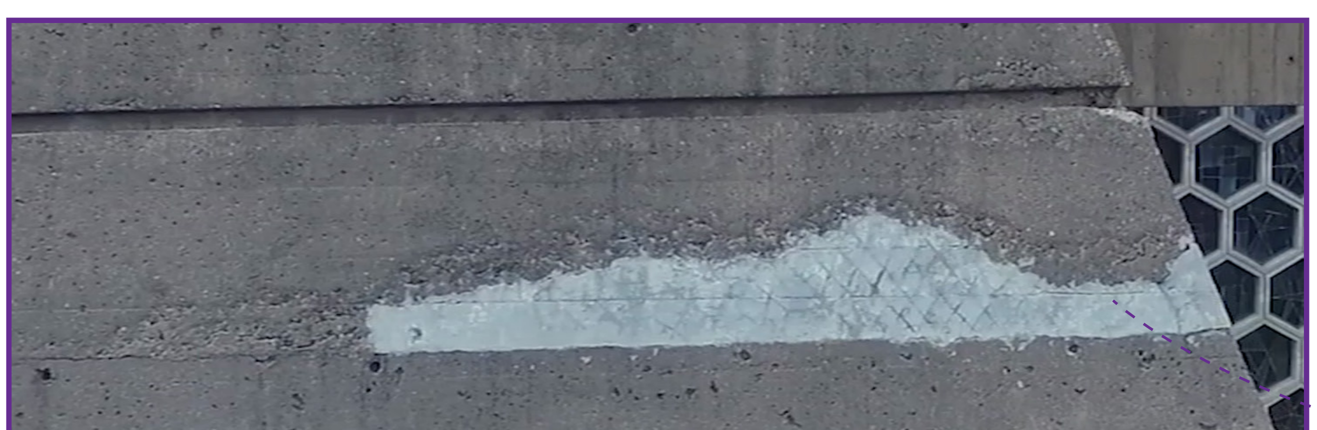


9 Spalling

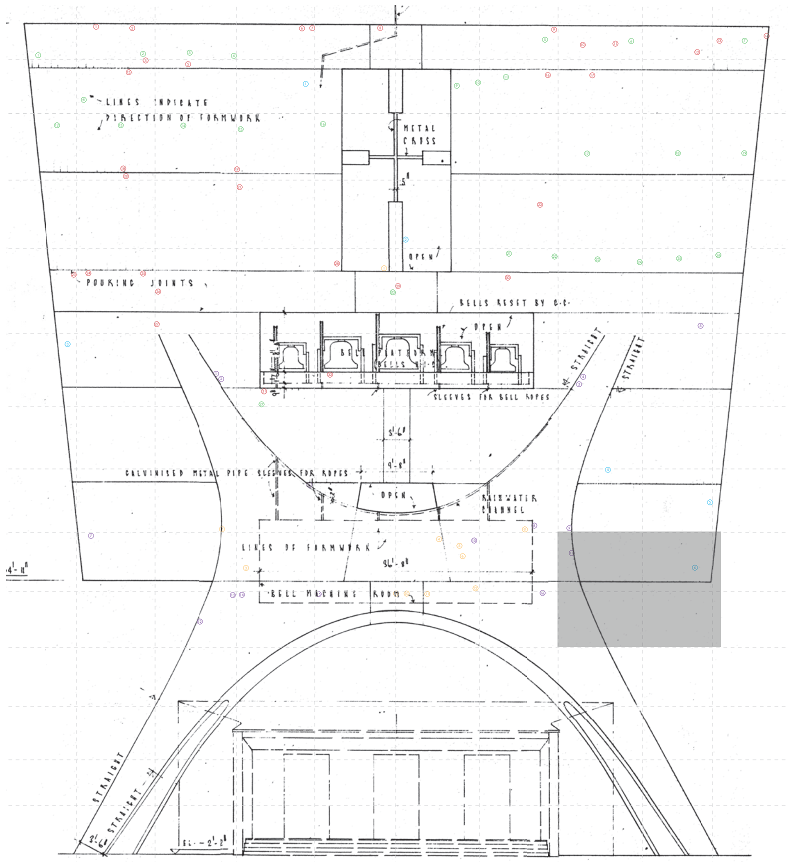
11

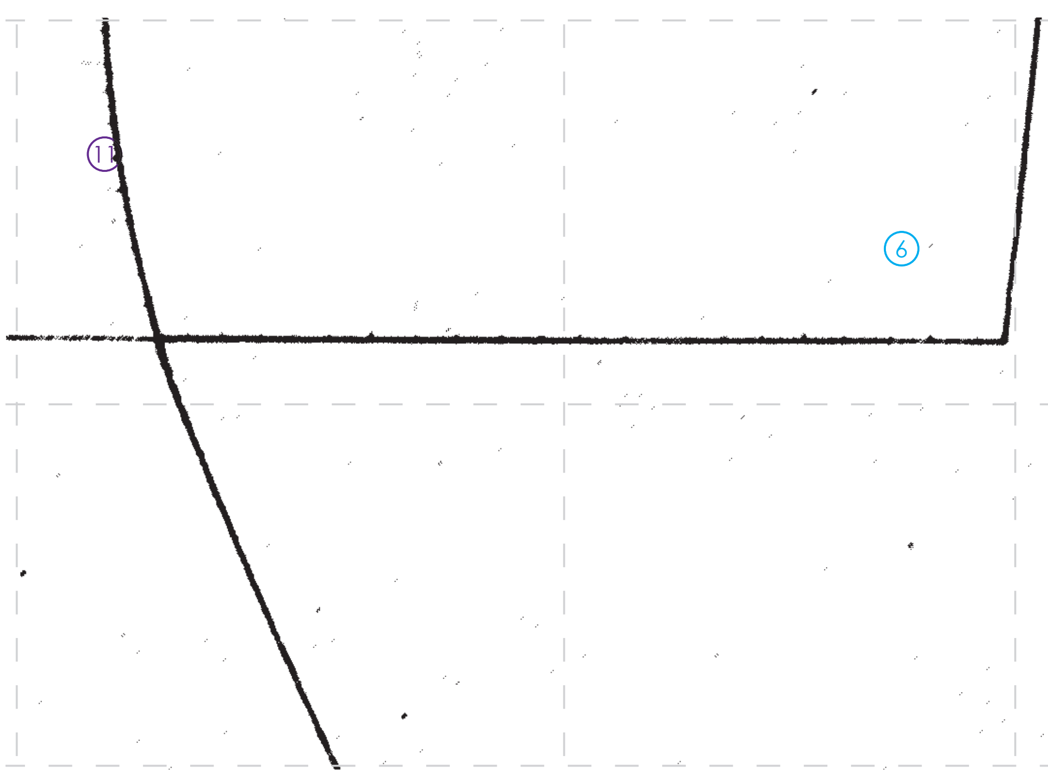
BELL BANNER NORTH ELEVATION

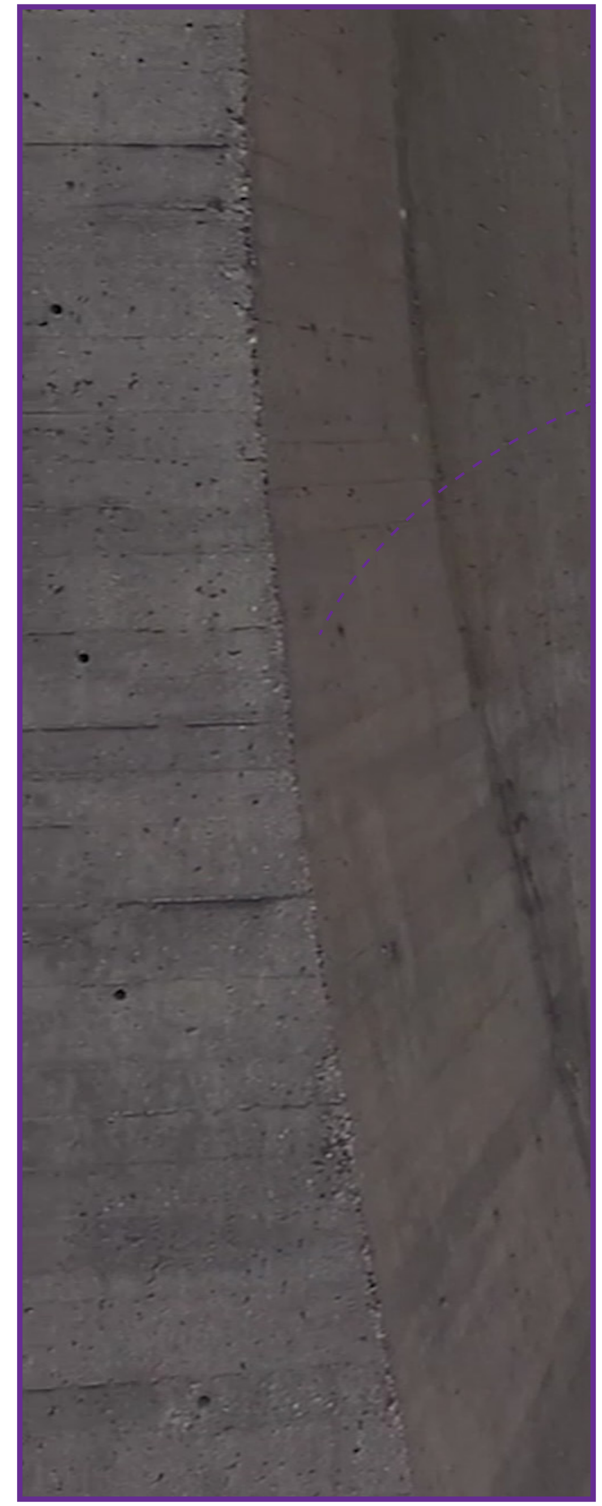

4
Spalling
6
Spalling
10


16


12
Spalling



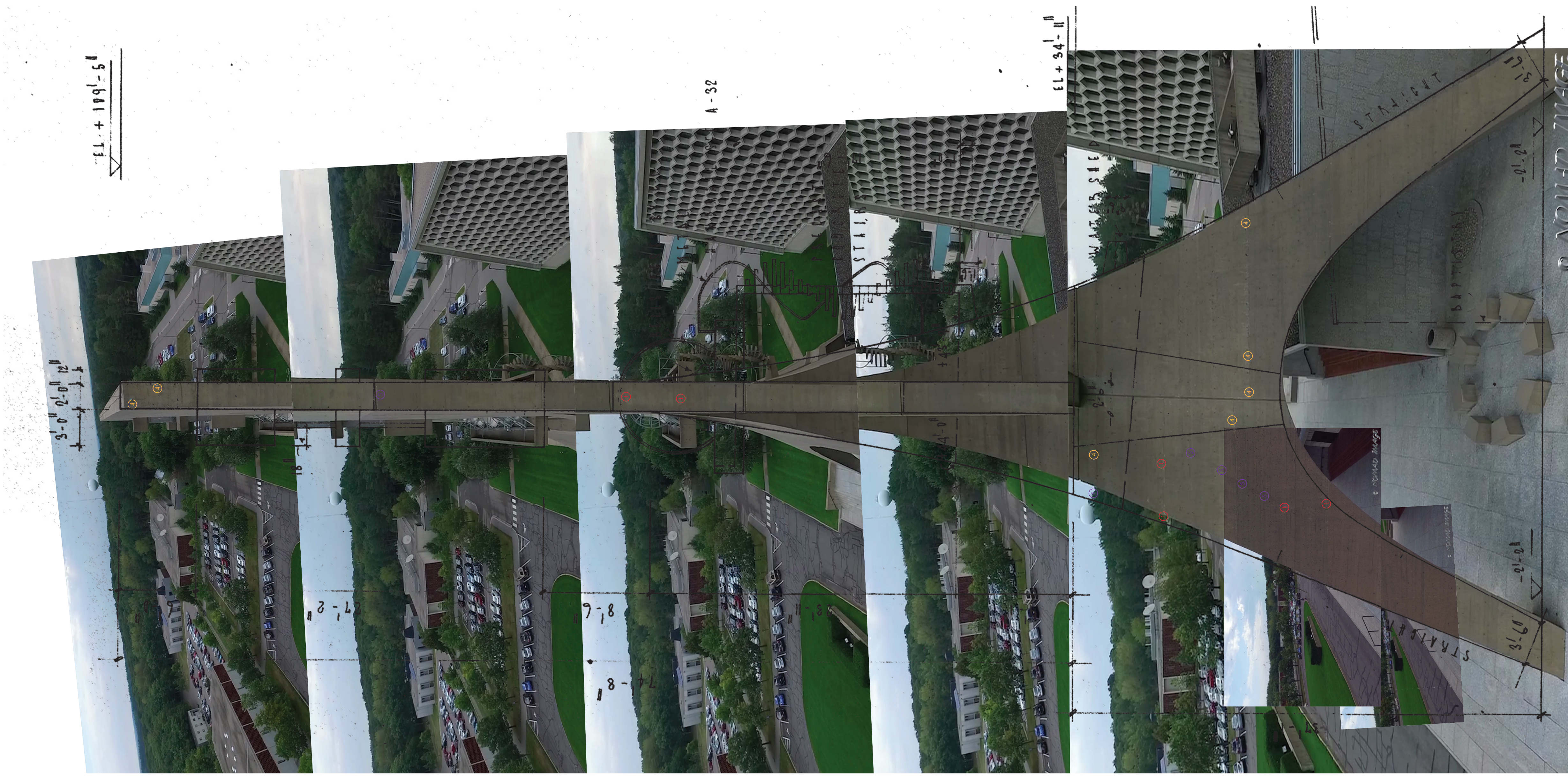




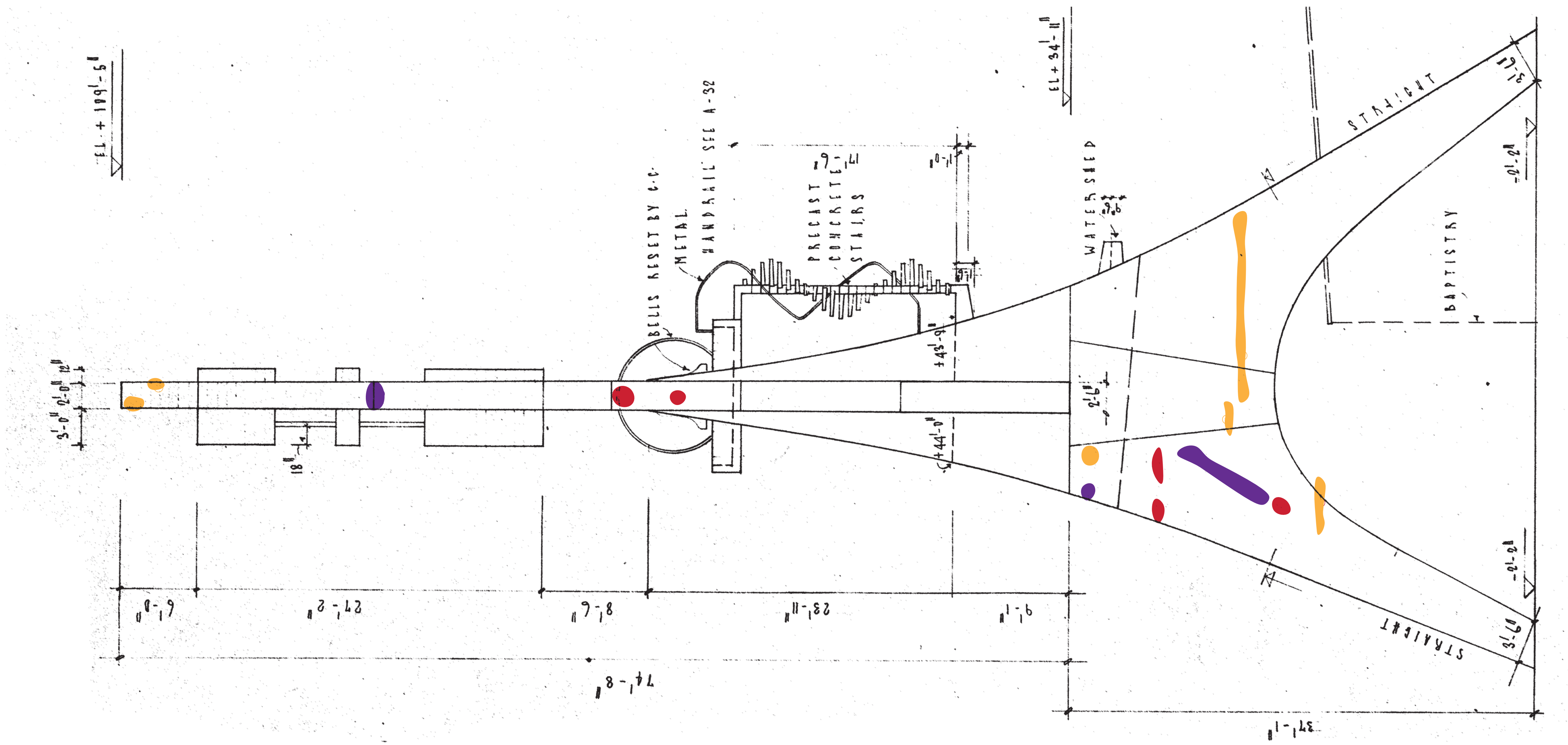
11 Chipping

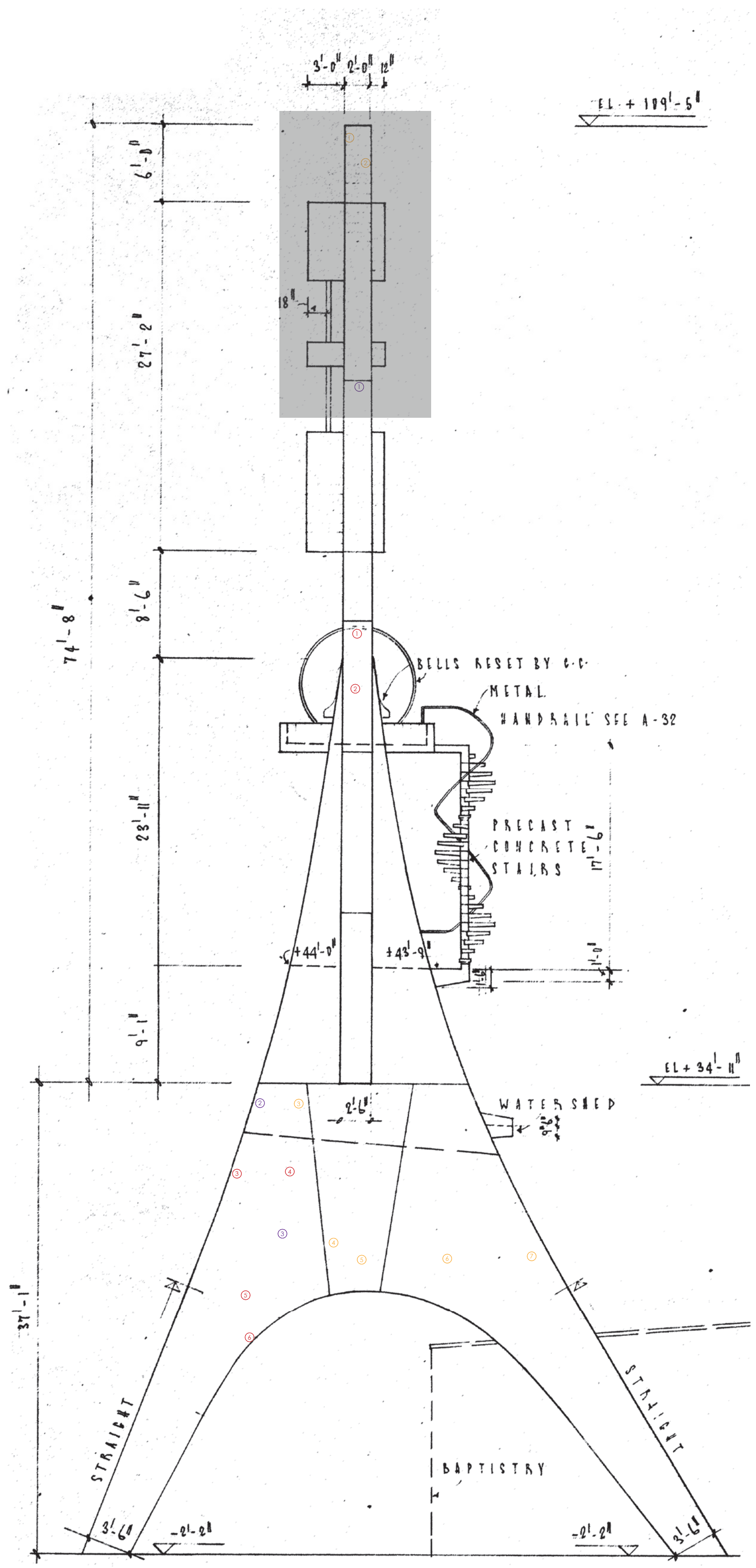
6 Patching

BELL BANNER NORTH ELEVATION



BELL BANNER WEST ELEVATION


EL + 109'-5"
BELLS RESET BY G.C.
METAL HANDRAIL SEE A-32
PRECAST CONCRETE STAIRS
17'-6"
WATERSHED
EL + 34'-11"
STRAIGHT
BAPTISTRY
STRAIGHT
6'-0"
27'-2"
8'-6"
23'-11"
9'-1"
74'-8"
37'-1"

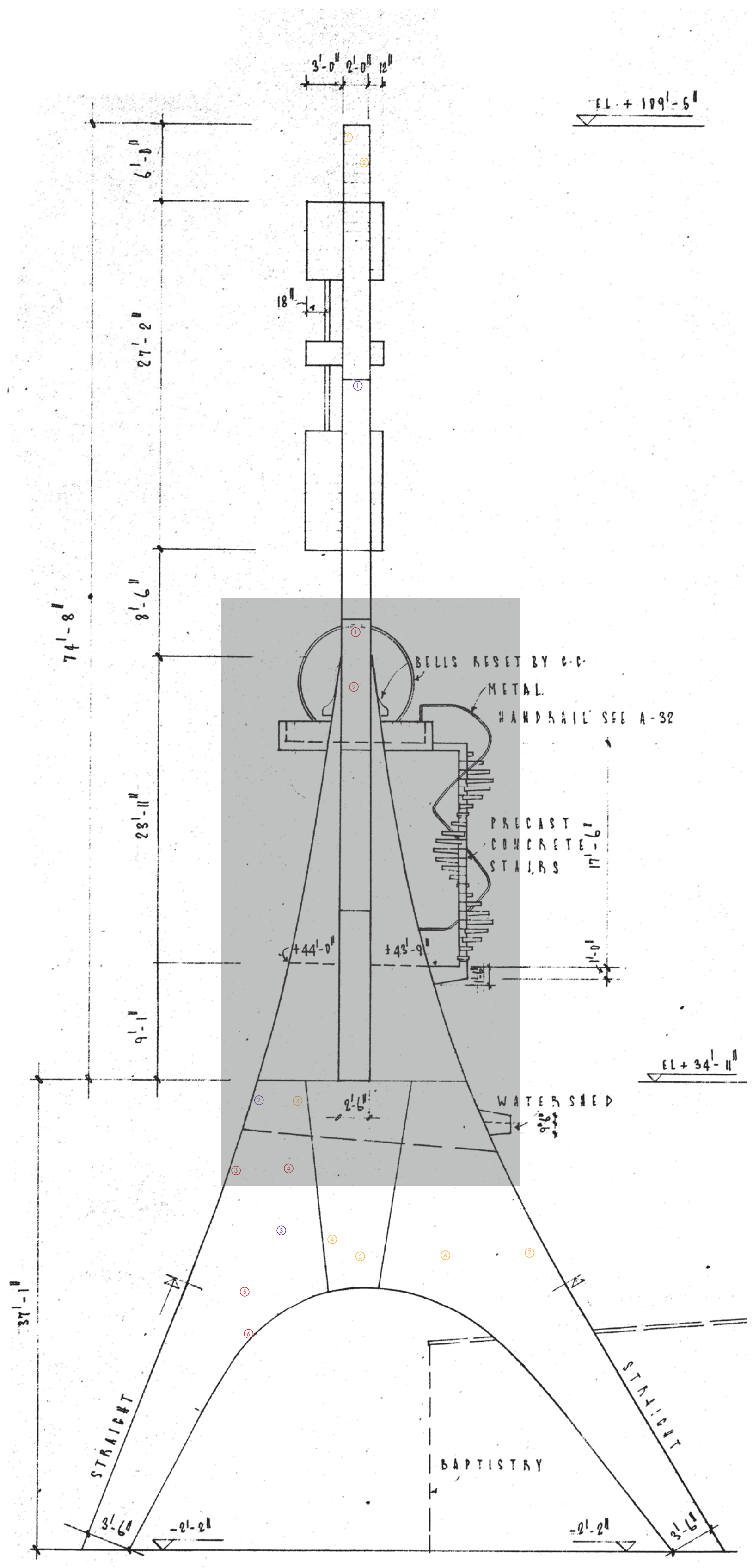


BELL BANNER WEST ELEVATION

1 Spalling

2

1 Chipping



BELL BANNER WEST ELEVATION

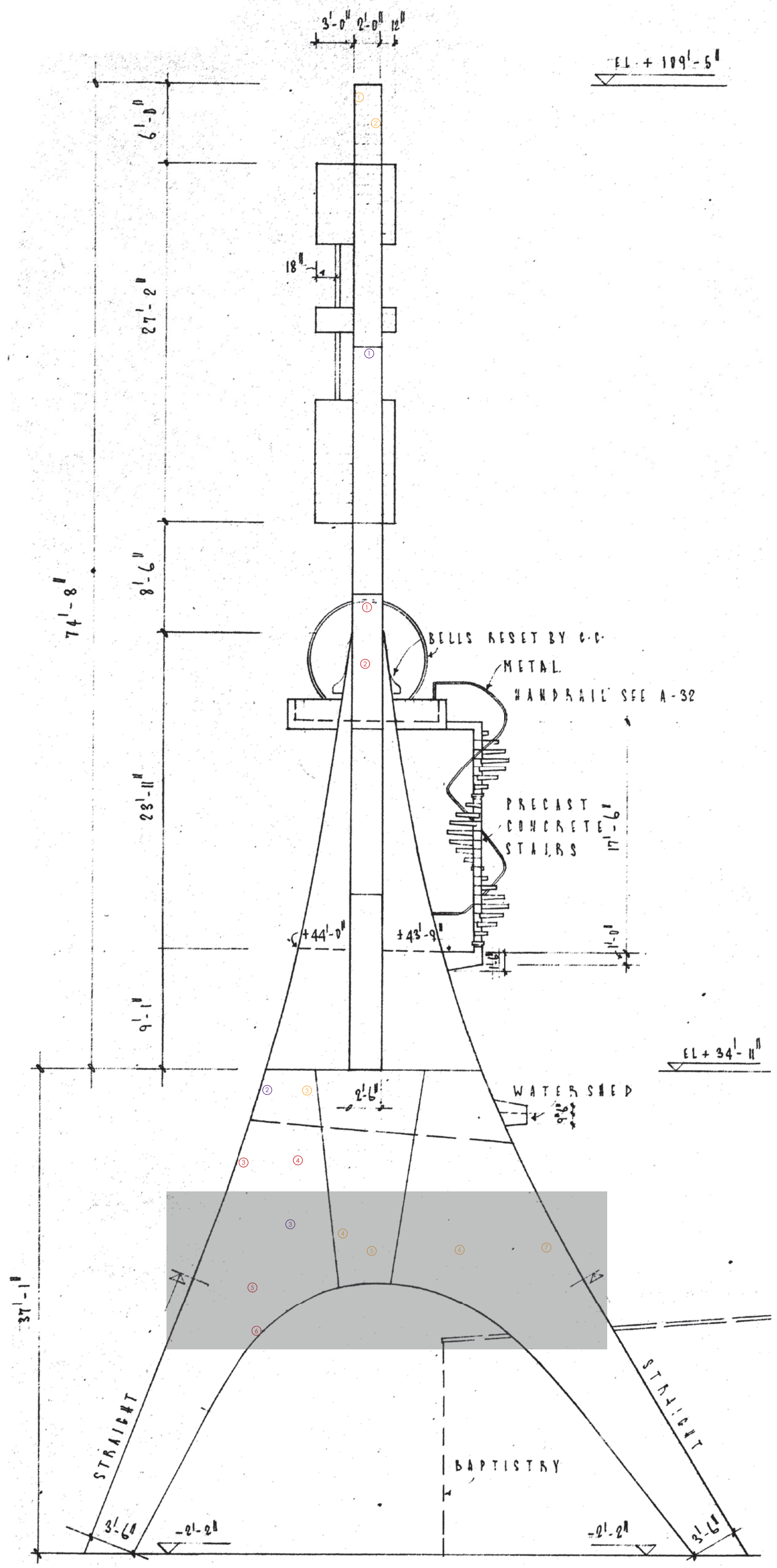
1 Efflorescence

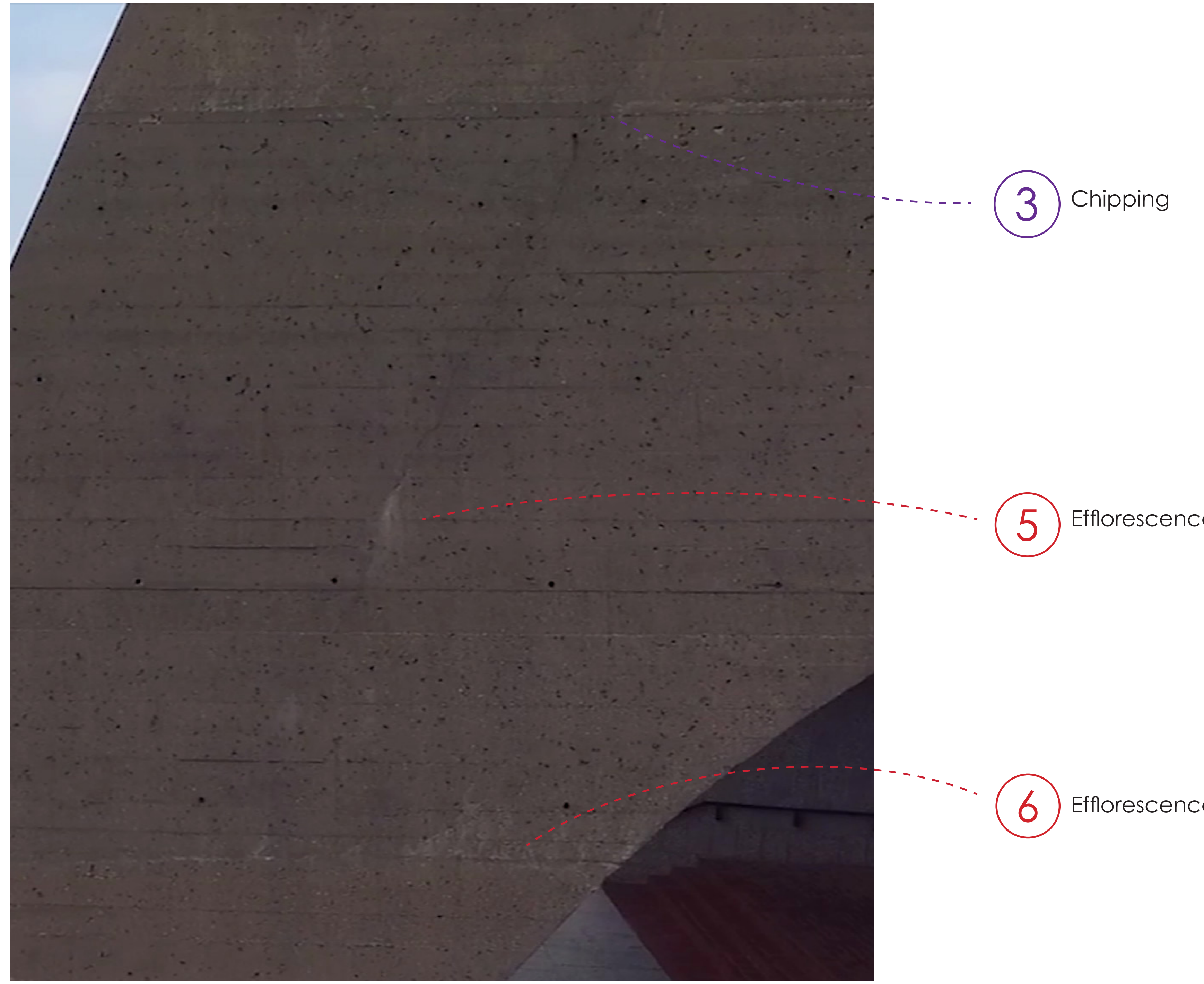
2

3 Spalling

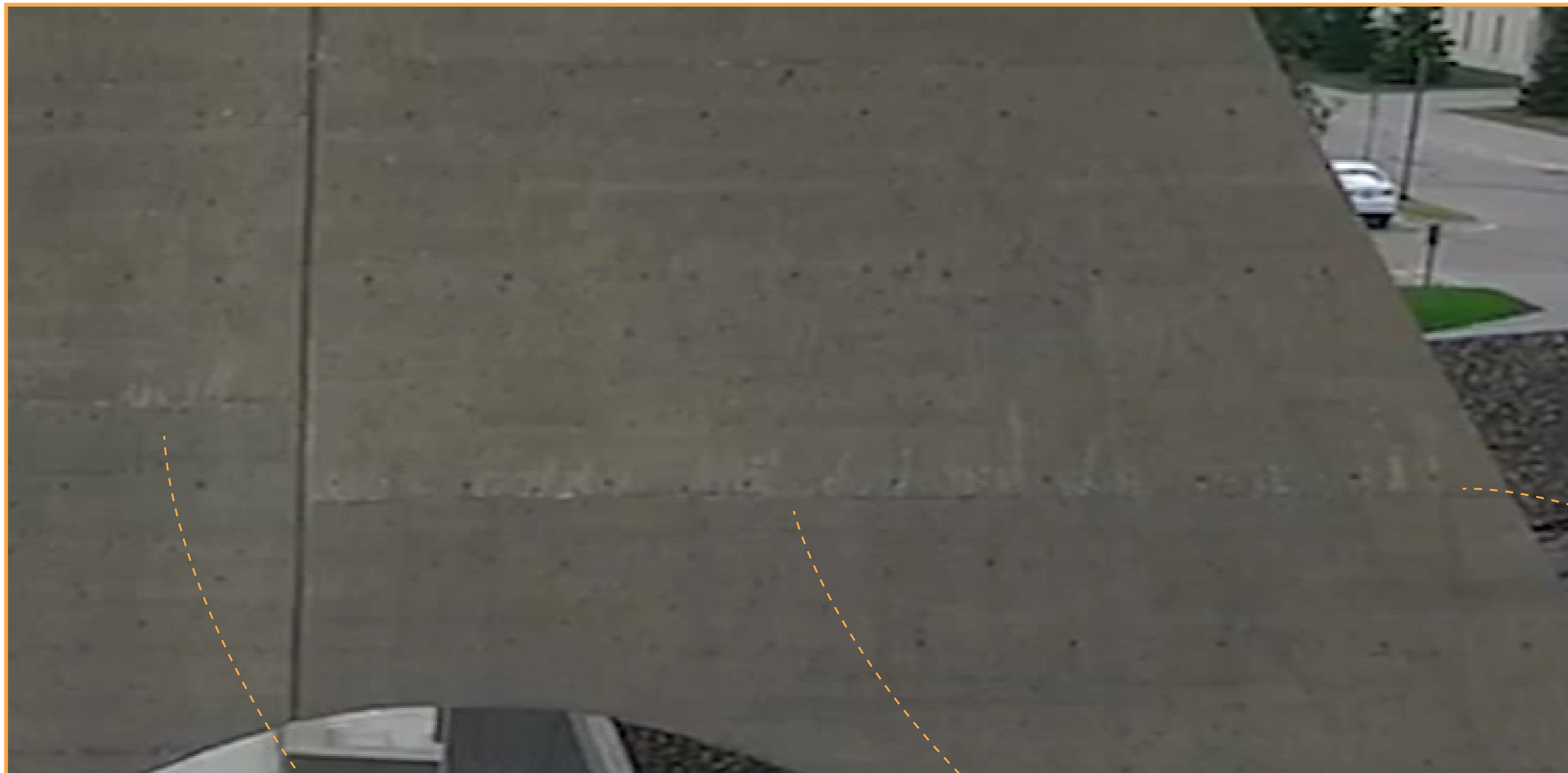
3 Efflorescence

4





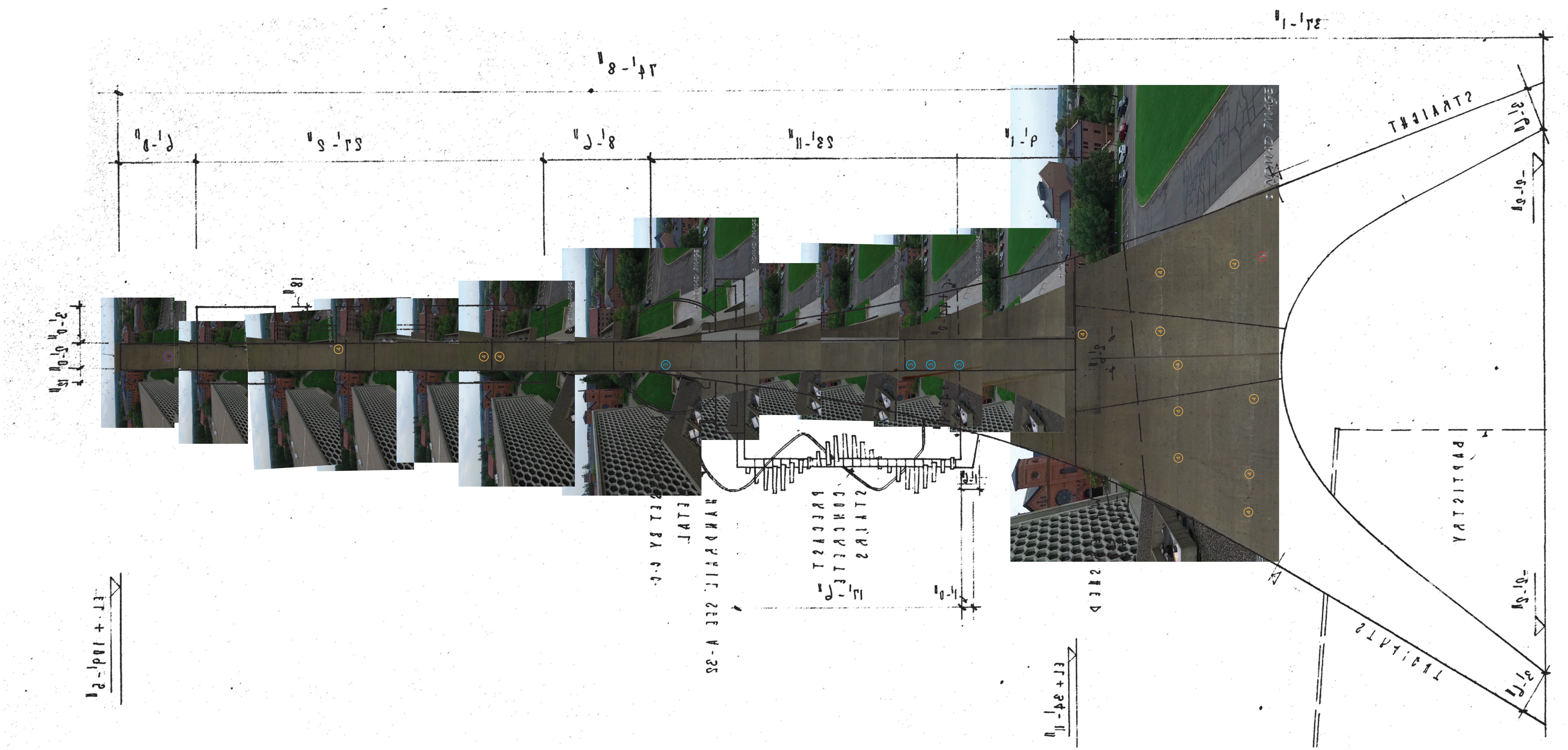
BELL BANNER WEST ELEVATION



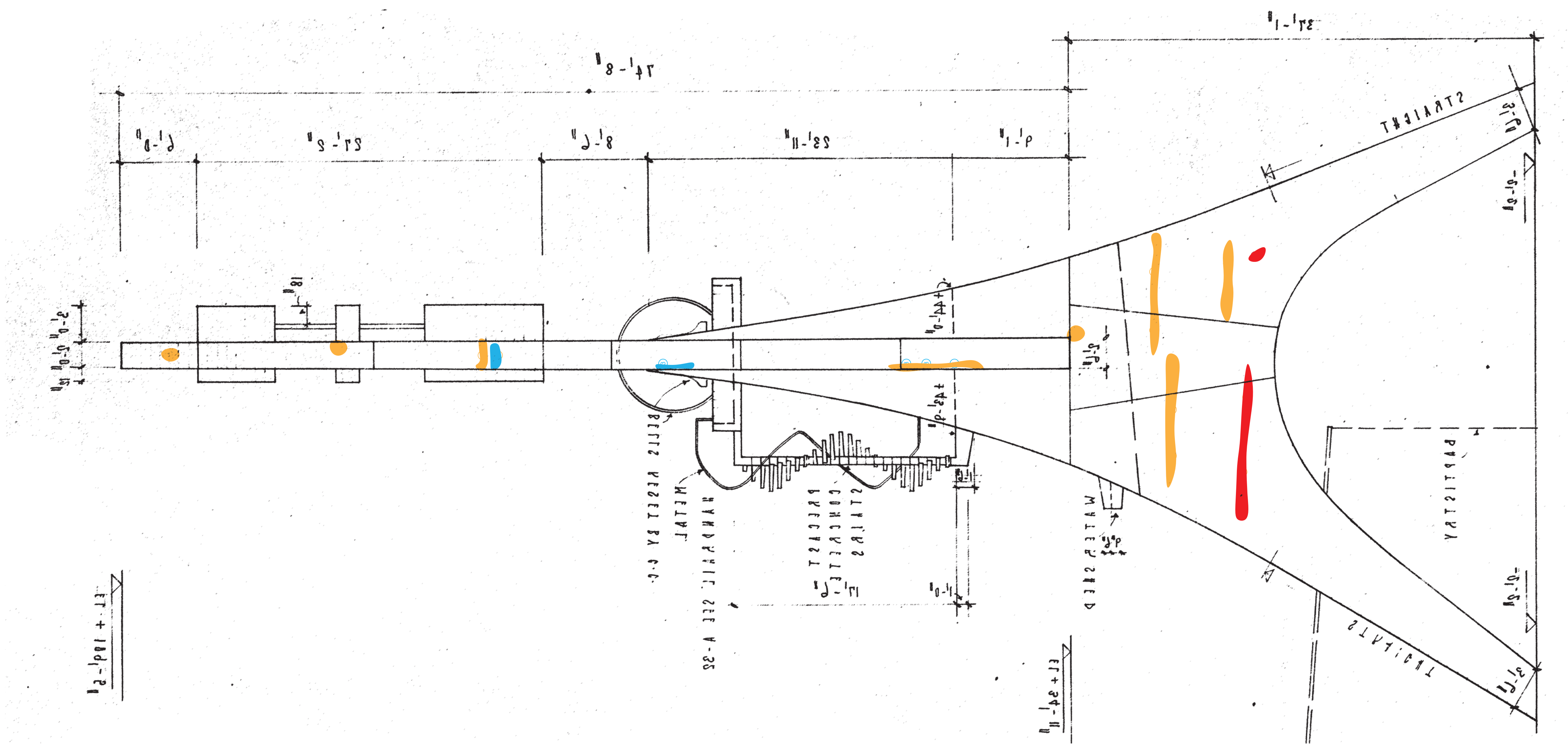
4 Spalling

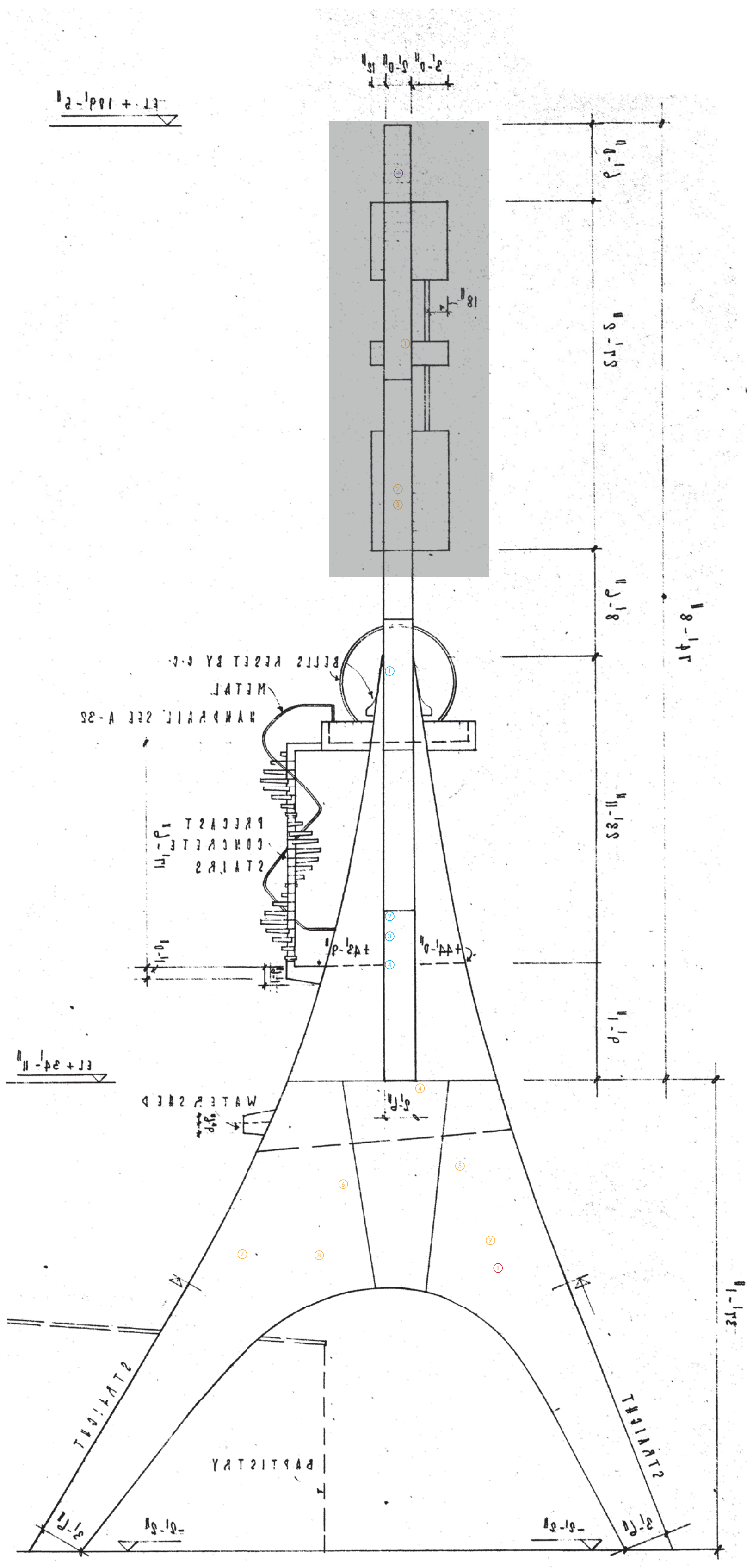
5 6 Spalling

7 Spalling



BELL BANNER EAST ELEVATION

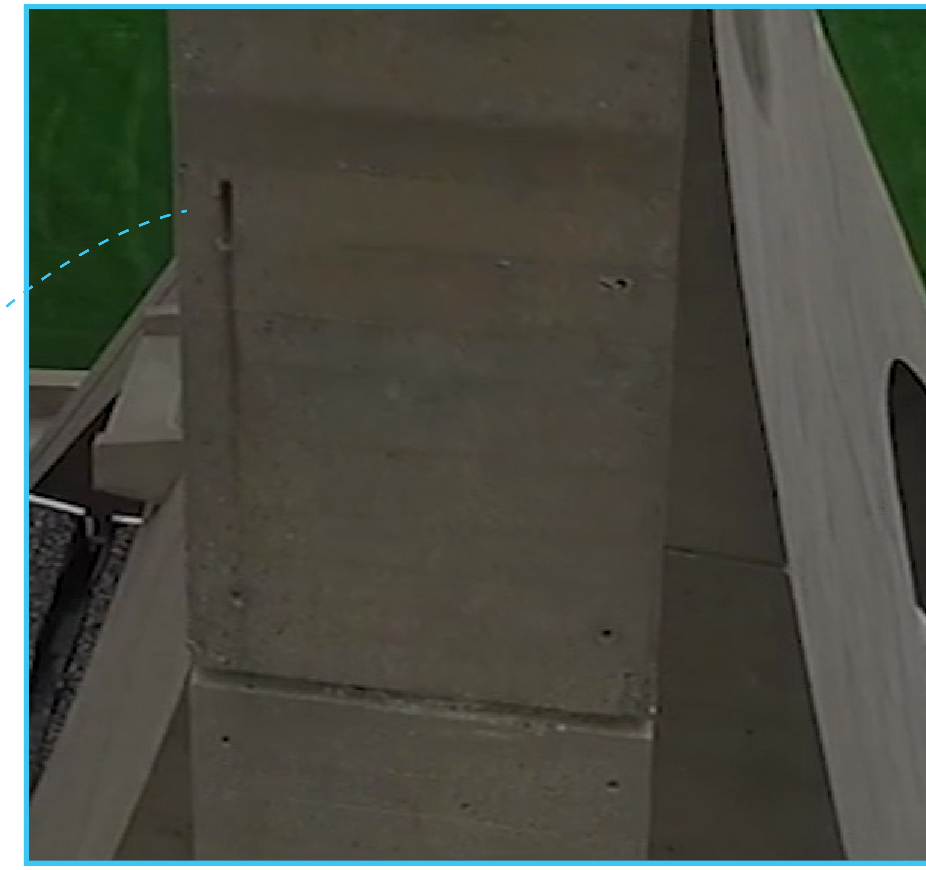




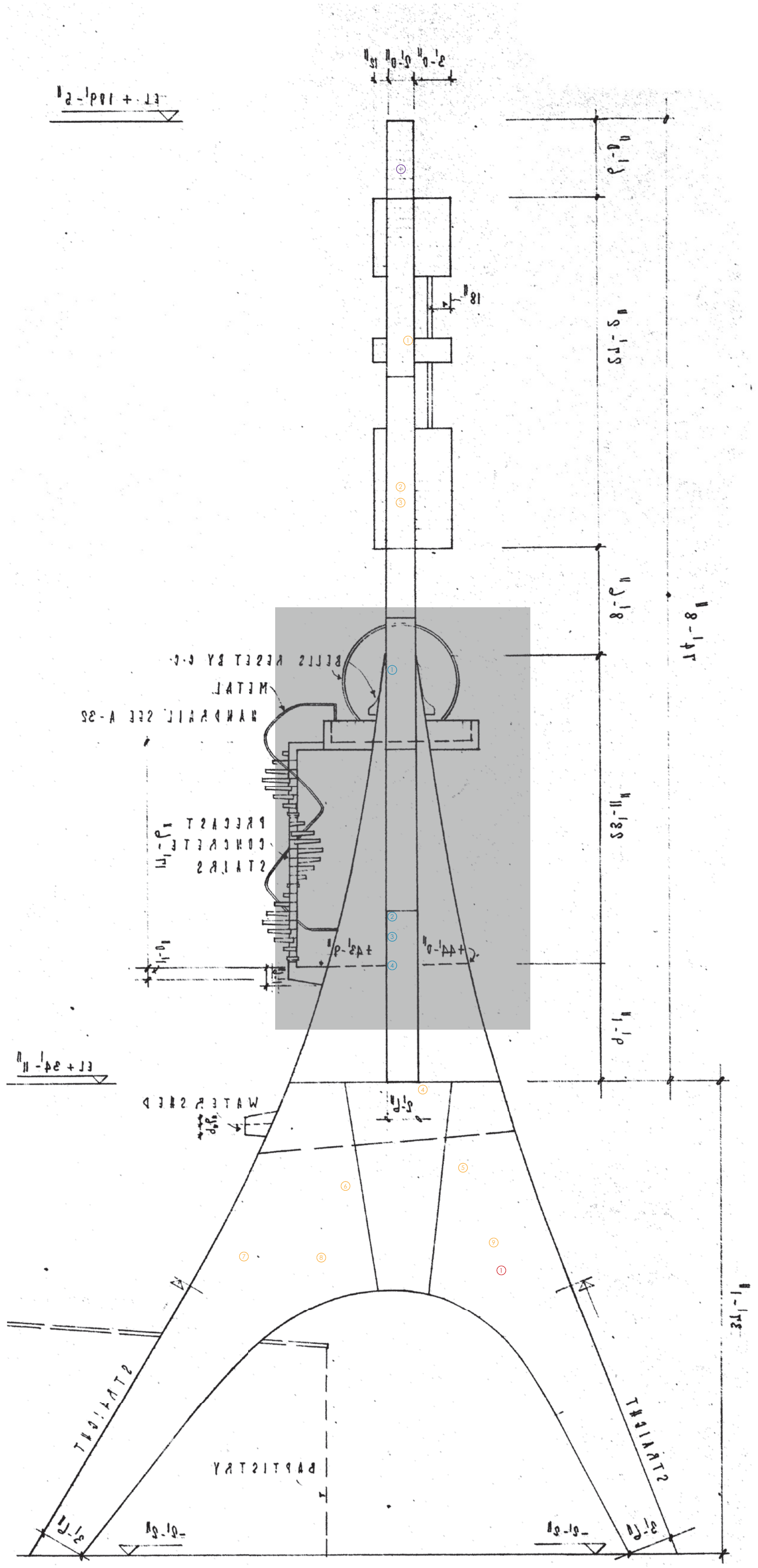
BELL BANNER EAST ELEVATION


1 Spalling


2 Spalling
3 Spalling

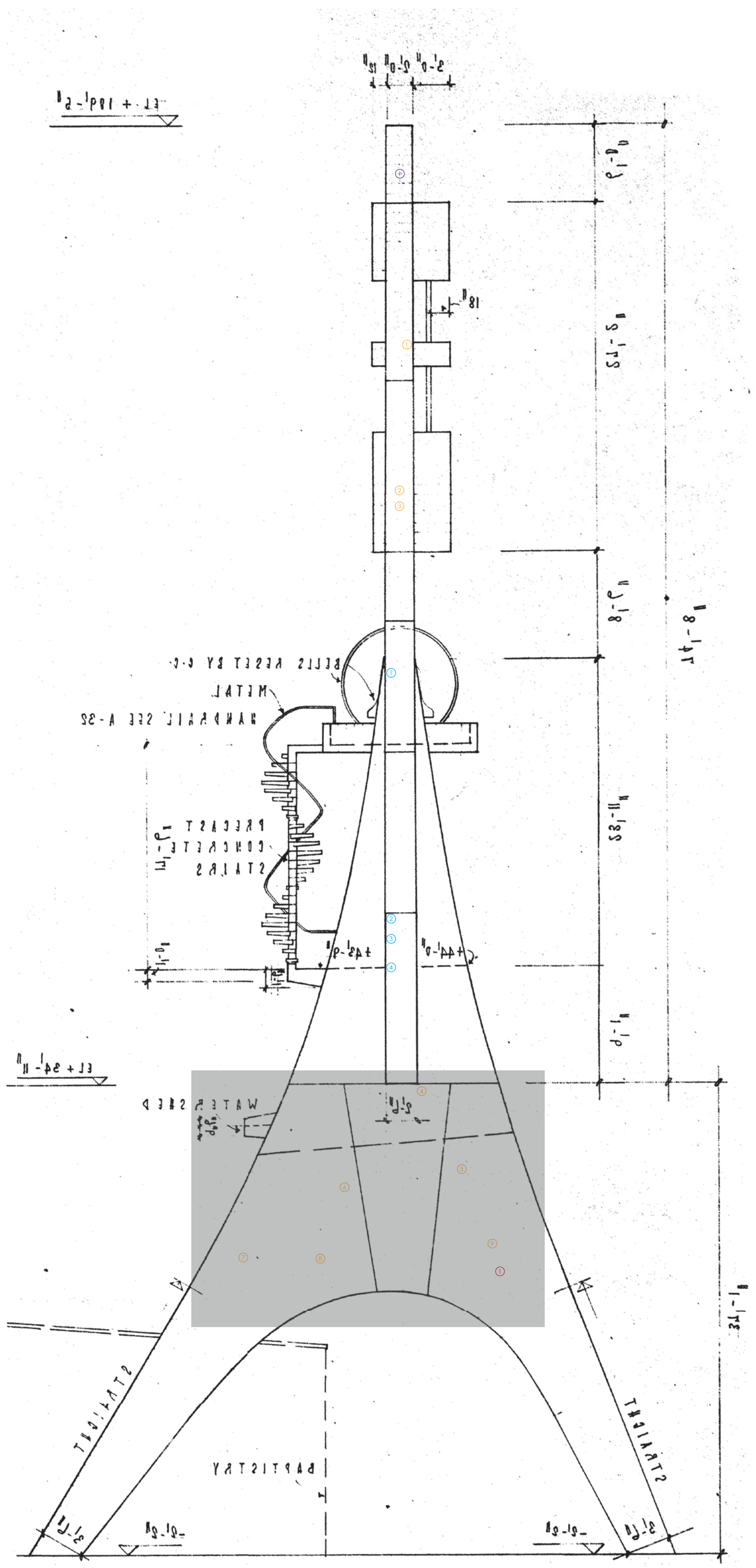


Iron Oxide Staining 1



BELL BANNER EAST ELEVATION

Iron Oxide Staining 2



BELL BANNER EAST ELEVATION

6 Spalling

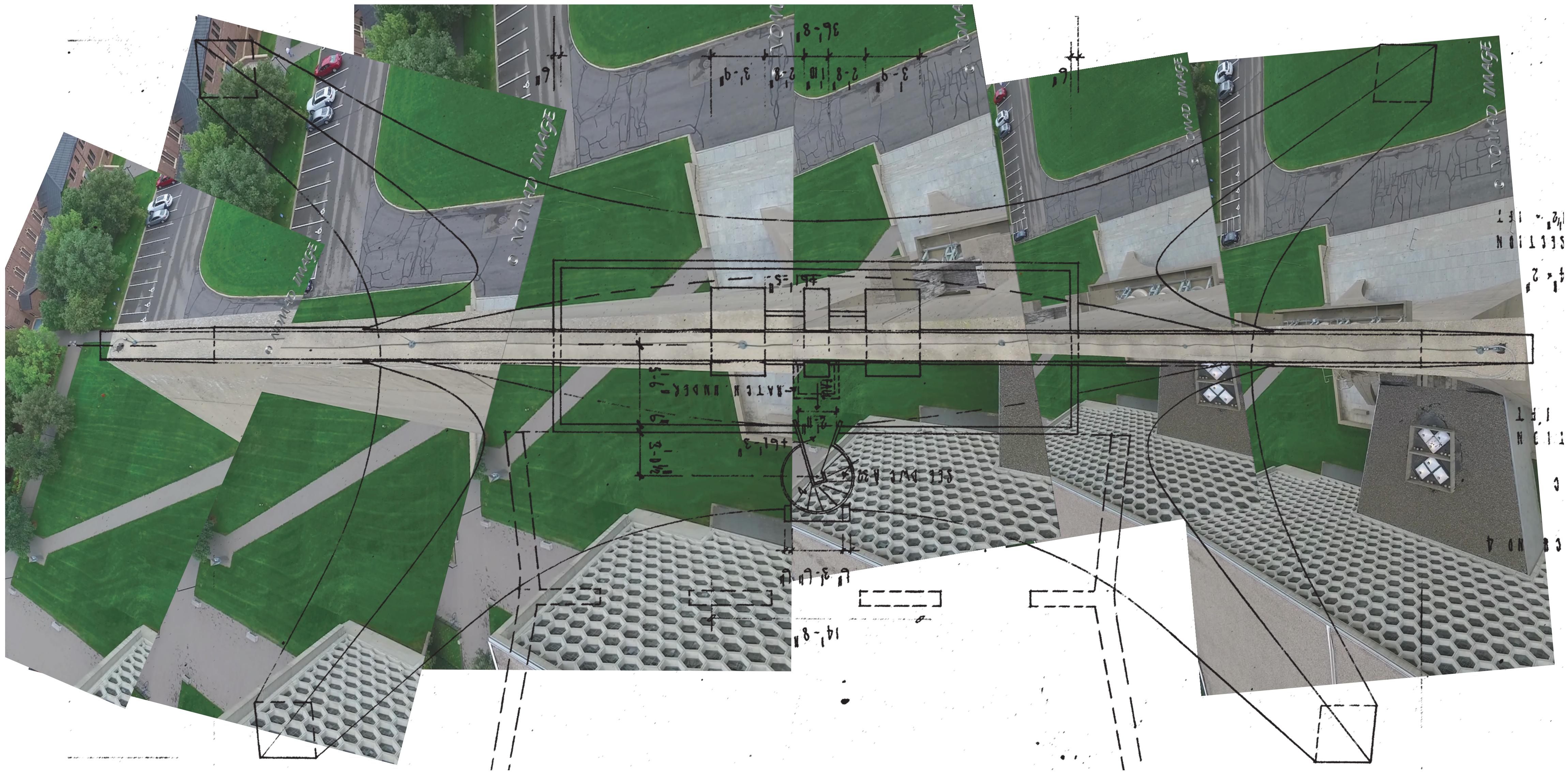
7 Spalling

8

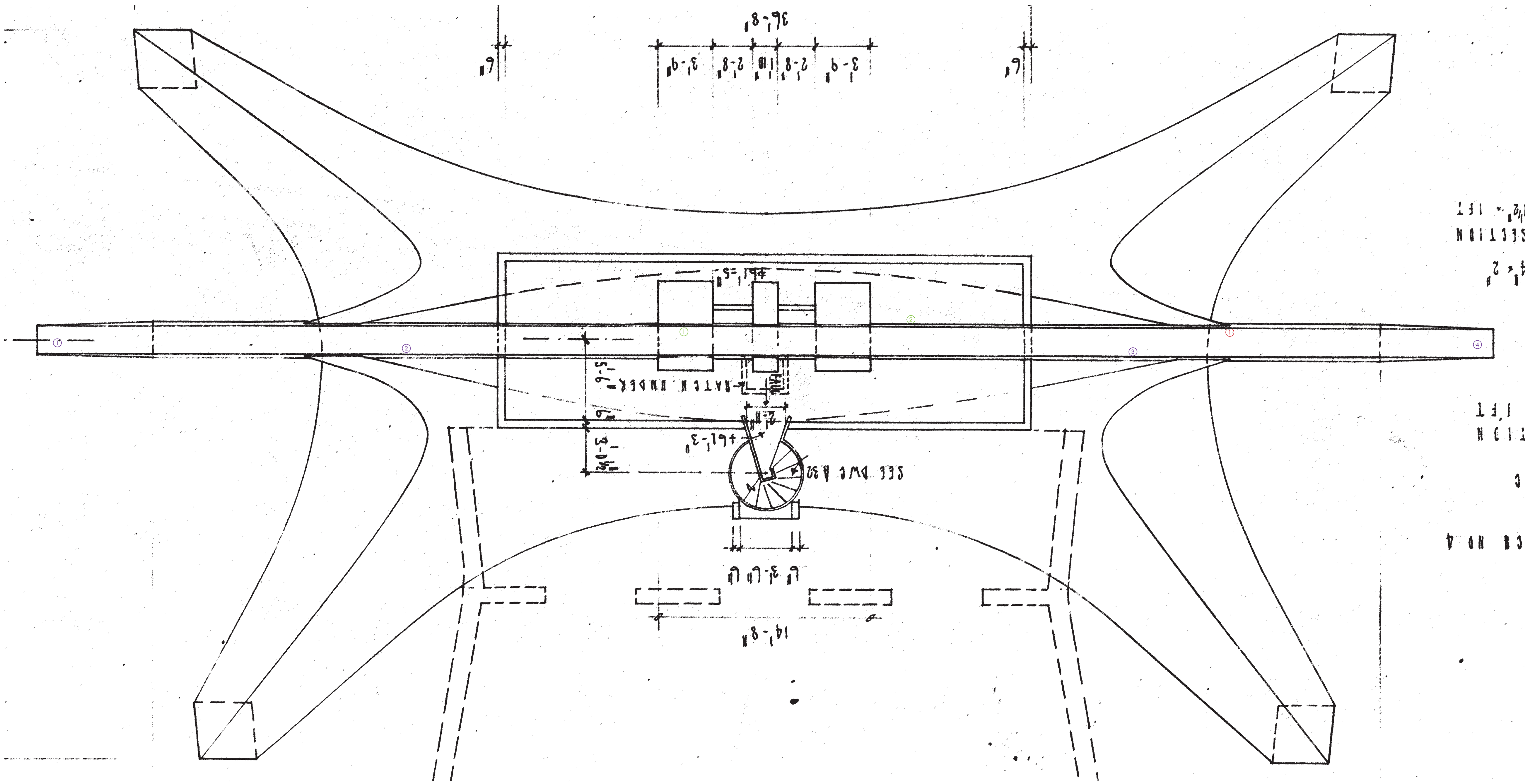
Spalling 5

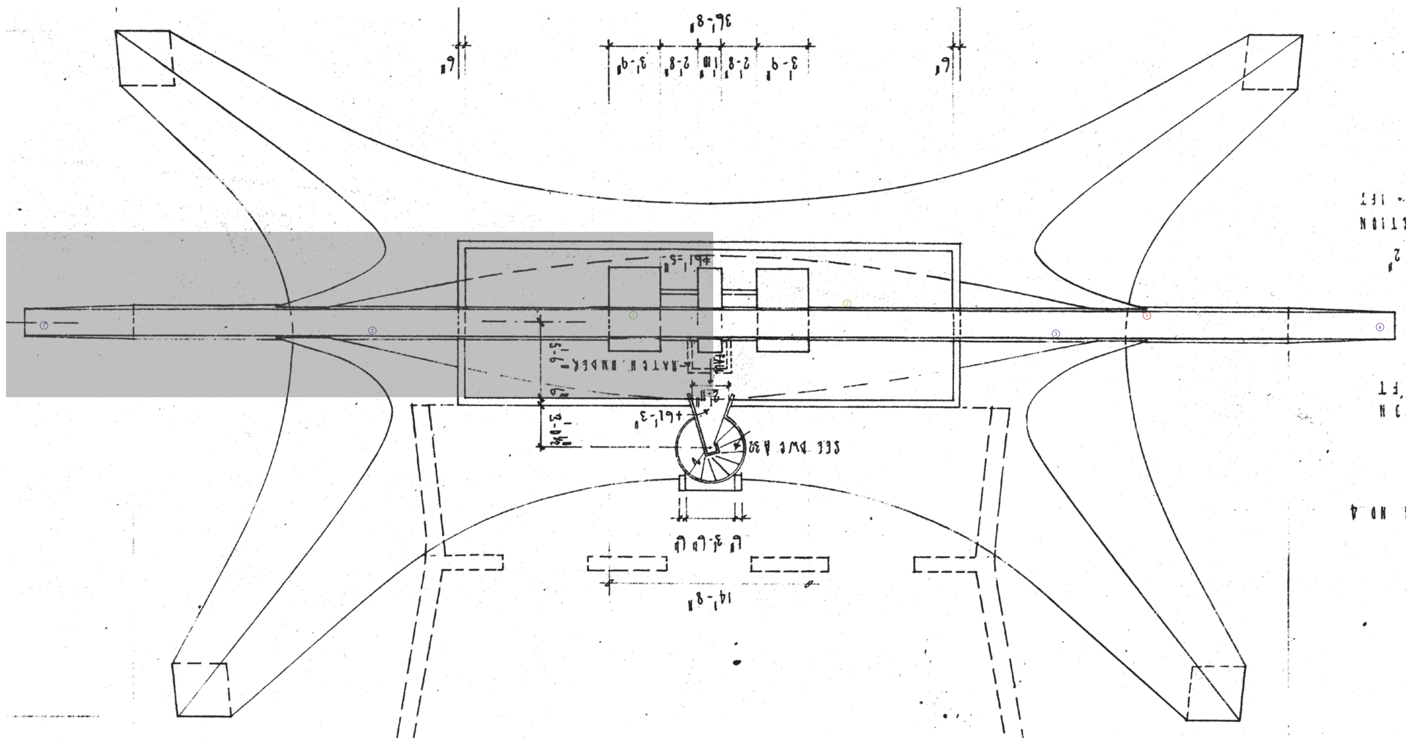
Spalling 9

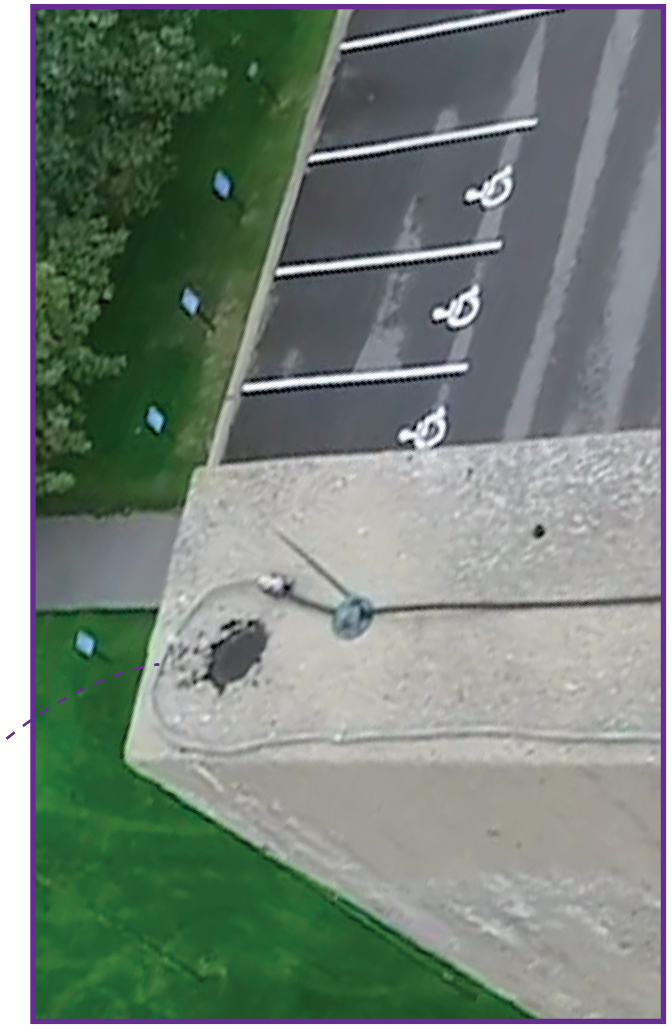
Efflorescence 1



BELL BANNER TOP ELEVATION



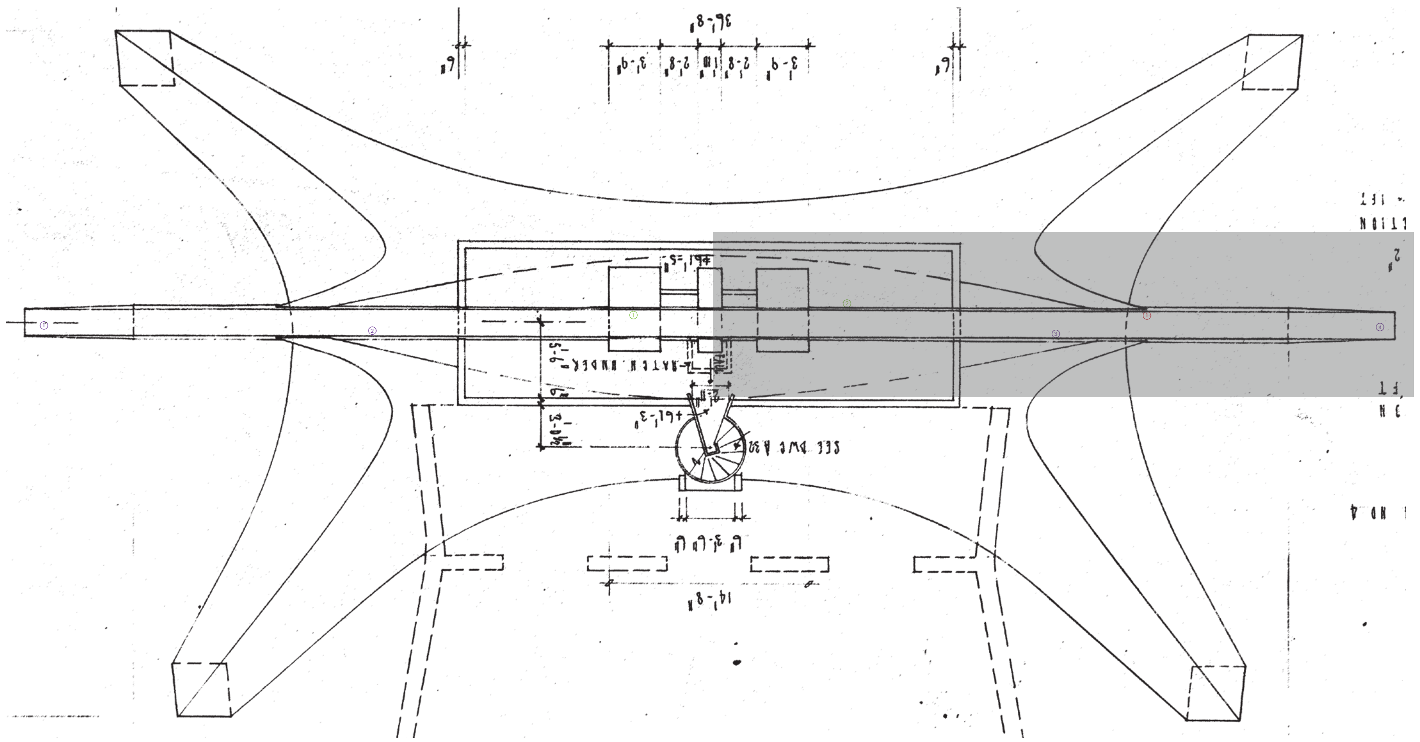




Chipping 1

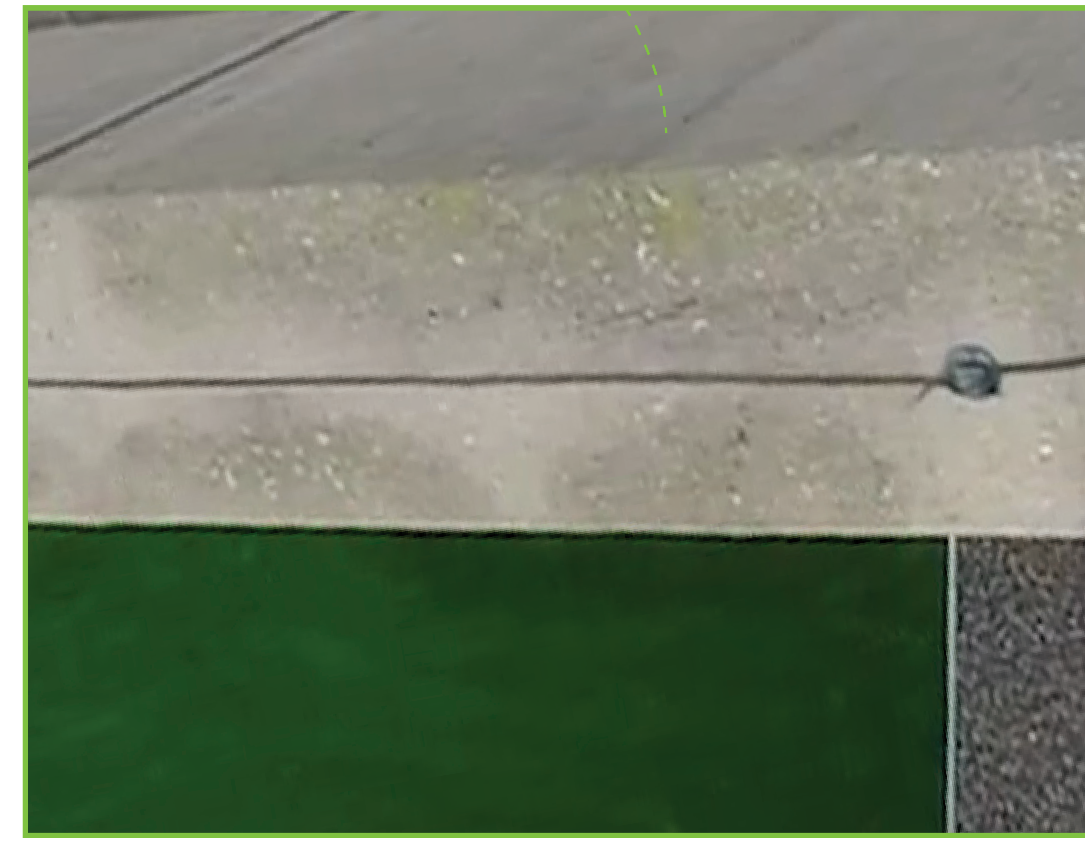
2 Exposed Cabling

1 Variable Surface Color

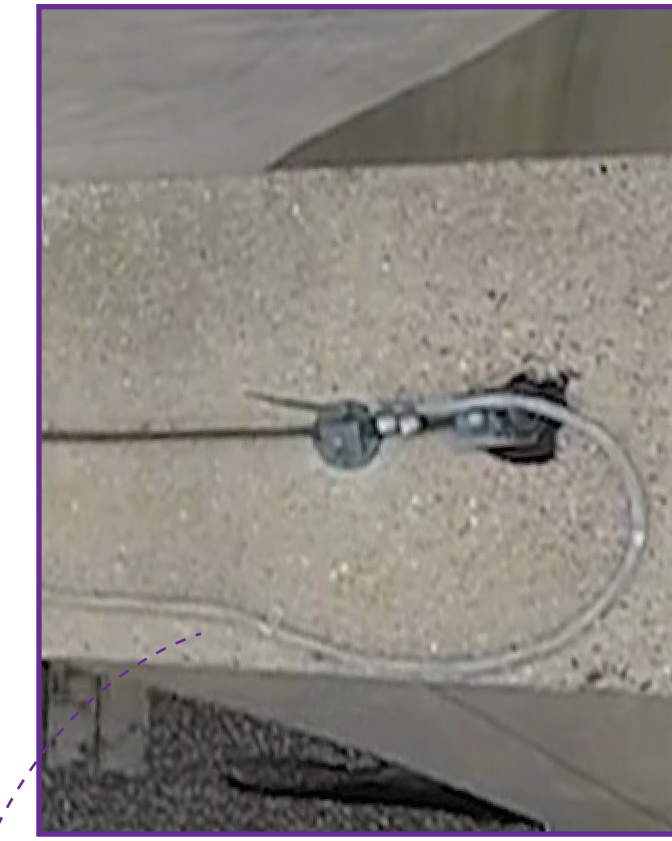


Variable Surface Color

2



1 Efflorescence



3 Exposed Cabling

4 Exposed Cabling

BELL BANNER STAIRS

Introduction

This report describes the extent of structural work for the St. John's University Abbey Church Bell Banner Stair project. It also establishes the structural design criteria to which the replacement project will be completed. The exterior stair climbs the rear (south) of the Bell Banner in front of the Abbey Church and provides maintenance access to the bells. The stair is of a helical configuration and traverses one and a half revolutions (520 degrees) from lower landing to upper landing. The stair and handrail was part of the original construction.

Archive Drawings

We reviewed the St John's University archive architectural drawings from Marcel Breuer and Associates dated 10/4/1957 and structural engineering drawings from Wiesenfeld, Hayward & Leon dated 10/4/1957. The drawings that describe the original construction are A31, A32, S8, S14, S15 (images of the full drawing sheets and detailed extracts of some of the relevant details follow, pp. 94-107). These drawings indicate a concrete cast-in-place bell tower with an access stair on the south to reach the platform with access to the 5 bells located at that level. The drawings are:

A31 BELL TOWER ELEVATIONS, DETAILS (p.94-95; 101-103) – This shows the general elevations of the Bell Tower. The stair landings stair are constructed of cast-in-place (CIP) concrete that support a central steel pipe column that is buried within the upper and lower cantilevered CIP concrete landings.

A32 BELL TOWER STAIR #8 (p.96-100; 103, 106-109) – This shows the upper landing at 61'-3" and the lower landing at 43'-9". The treads consist of sleeved precast concrete elements that are threaded over a central steel pipe column. The galvanized handrails are clamped to certain treads.

S8 BANNER & PIAZZA PLANS & DETAILS (p.101, upper right)– This shows the structural reinforced, cast-in-place (CIP) concrete details of the Bell Tower (Banner) and the lower landing section.

S14 LOW ROOFS & MISCELLANEOUS SECTIONS (pp. 104-105) - This shows the structural reinforced, cast-in-place upper landing section.

S15 STAIR SECTIONS (pp.106-109)- This shows the structural reinforced, precast concrete details of the Bell Tower stair treads.

From our review of our photos (and some 2008 photos from the University) and visually reviewing the stair from ground level, it appears that the original construction documents were followed closely. There are some very minor discrepancies between the architectural and structural drawings and it is not exactly clear which was followed in the construction (this is in regards to drawings A32 and S15 which show a difference in the vertical gap between the precast treads).

Existing Conditions

The stair has suffered extensive freeze/thaw damage over the years to the extent that sections of the original concrete have spalled off from cracks developing from water ingress into the treads. The water has made its way to the internal reinforcing bars, corroded them and they have expanded in volume considerably, spalling away the concrete cover. Several locations show extensive corrosion of the reinforcing bars and concrete is missing on several tread faces. Close access to the stair and landings via a fire-truck ladder was not possible during our trip to the Campus on 9/17/2015 due to a lightning storm. Assessment of the condition of the upper and lower landings will be performed in Spring 2016. The University closed the stair to any maintenance personnel access in the past (date unknown) due to its dangerous and unsafe condition. Photos 8-17 (p. 110-118) taken by the University in April 2008 show these damaged conditions.

Structural Analysis

A three dimensional analysis of the CIP concrete landings, carbon steel pipe column, and precast concrete treads was performed using the structural analysis software program RISA-3D to review the global behavior of the stair and landing assembly. The archive drawing geometry and material strengths were used in this analysis. Refer to Image 1 (p.120) for the geometry model used in our analysis (modeled in REVIT software). We assume the structure was originally designed using the ACI 318 -51 or more probably the ACI 318-56 (1951 or 1956 code respectively). We elected to check the existing structure to the current Minnesota 2015 Building Code as a replacement deign would need to meet this code.

Under static load combinations (and per the Minnesota 2015 code – based on the IBC 2012 code) using a dead load self-weight of the concrete tread (at 145 pcf), a live load of 40psf for maintenance catwalk access (ASCE 7-10 Table 4-1. The live load was applied to the exposed portion of each tread as shown in Image 2, p.120), a snow load of 42psf and a laterally applied wind load of 35 psf, our analysis discovered a lateral maximum deflection of the central steel pipe column of 2", which is within the acceptable stress range of the pipe. This is a conservative analysis as it is unlikely that a full live load will be in place when there is an extreme snow or wind event. Refer to Image 3 (p.123) for the overall stair's deflected shape. The governing loads for stress in the pipe and the results of the code check are shown in Image 4(p.123).

For an access catwalk the applied concentrated live load is 300lbs (ASCE 7-10 Table 4-1). It was assumed that two point loads of this amount would reasonably access the stair at any one time but would be three treads apart at any time (limited by the closest people could be to each other). We ran this dynamic load configuration in conjunction with the dead load self-weight for an ascending or descending moving load on the stair and found the worst case condition shown in Image 5 (p.121). The governing loads for stress, due to concentrated load, in the pipe and the results of the code check are shown in Image 6 (p.122).

The cantilevered upper and lower landings elements have been preliminarily checked with the applied load from the stair itself only bearing on the lower landing, and the upper landing providing lateral restraint. The lower landing has been initially assumed to be 12" tall and 26" wide. This is a reduced width segment that represents the section of the landing at the intersection of the circumference of the stair (as shown on A32 Extract - PLAN OF LOWER PLATFORM p.99, left). The upper landing has been initially assumed to be 7" tall and 26" wide. This is a reduced segment that represents the section of the landing at the intersection with the circumference of the stair (as shown on A32 Extract - PLAN OF UPPER PLATFORM p.99, right). With these assumed sections both landings are structurally acceptable with respect to stress and deflection per load combinations of the Minnesota 2015 (IBC 2012) code. The lower landing is reduced in section at the location of the pipe bearing. More detailed analysis of this will be required, including checking for punching shear of the column through the bearing part of the lower landing (S15 Extract - SECTION OF STAIR p. 106 lower right, p.107).

To analyze each individual tread two methods were employed. First the tread was minimally sized to be 2 3/4" deep by 5 1/4" wide (the narrowest section) by 2'-6" long and analyzed in Enercalc software. Minnesota 2015 (IBC 2012) load combinations were applied to this section to find that it is within code standards for deflection and stress. Please refer to Image 7 (p.122). Next the tread was modeled using Finite Element plate analysis in RISA-3D software. Please refer to Image 8 (p.123,left) for the Finite Element mesh used. This software provides bending stress contours in the tread under dead and live loads that will be used in the design of the replacement stair treads. Please refer to Image 9 for the results (p. 123, right).

Structural elements of the original structure, as designed in the 1957 construction documents, would be structurally sufficient for strength per the load combinations required in the current 2015 Minnesota Building Code. The proposed replacement structure, using the same geometry as Marcel Breuer originally had, and using materials of at least similar if not greater strengths, is possible and would meet this current code.

Analysis of the existing hand rail has not been completed yet. Handrail geometry is as per A32 Extract - SECTION OF HANDRAIL (p.100).

STRUCTURAL DESIGN

DESIGN STANDARDS AND CODES

The following standards have been used in the structural analysis and will be used in the new stair replacement design:

General	2015 Minnesota Building Code (refers to IBC 2012)
Concrete	ACI 318-57 (used in review of the existing conditions) ACI 318-11 (will be used in the stair replacement project)
Steel	AISC 360-10 14th Ed.
Stainless Steel	AISC Design Guide 27 Structural Stainless Steel

MATERIALS

The grades of materials used in this project for main structural elements will be follows:

Concrete	Cast-in-Place Elements (Original)	3,750 psi
	Precast Concrete Elements (Replacement)	5,000 psi
	Ductal Precast Elements (Replacement - TBD)	7,000 psi
Reinforcement	Main Rebar (Original)	40 ksi
	Ties (Original)	40 ksi
Structural Steel	Rolled W-Shapes	A992
	Tubes	A500 Grade B
	Pipes	A53 Grade E
	Channels, Angles, Plates	A36
	High Strength Bolts	A325, A490

Austenitic Stainless Steel	UNS S30400 (304) and UNS S31600 (316)
Austenitic Stainless Steel (weldable)	UNS S30403 (304L) and UNS S31603 (316L)

DESIGN LOADS

Occupancy Type	II
Essential Facility	No

Dead, Live and Snow Loads In accordance with IBC 2012 tables:

Dead Loads	Material weights of structure and finishes	
Live Loads	Maintenance Access	40 psf 200lb concentrated
Snow Loads	Importance Factor	1
Ground Snow Load		50 psf
Roof Snow		42 psf

Wind and Seismic Loads

Wind Load	Importance Factor	1
Basic Wind Speed ($V3_{sec}$)		90 mph
	Exposure	C
Seismic Load	Minimal – does not govern	

DEFLECTIONS

Structural deflections for the steel framed elements will be in accordance with IBC 2012 or the following, whichever is more stringent:

Floor Total dead and live load deflection	span/240
Floor Live load deflection	span/360

TOLERANCES:

Concrete tolerances will be as per ACI 117.
Steel tolerances will be per AISC 360-10 14th Ed.

In order to create a stair that matches the historical precedent set by Marcel Breuer it is recommended that the original stair structure needs to be replaced. The extent of the corrosion of the reinforcement in the precast concrete treads is very significant and does not appear to be able to be halted, such that the structural integrity of the treads are essentially irreversibly damaged, dangerous and unsafe. Further investigation (both non-destructive and destructive) could be done to see if the central steel pipe support column is corroded and could be saved, but in order to replace the treads this column needs to be removed anyway so that the new treads could be sleeved over it. This in turn means that the column needs to be extricated from the upper and lower cantilevered CIP concrete landings, meaning that these elements will need concrete repairs after they are carefully, and minimally removed just enough to release the column.

Stair Treads

The options for replacing the stair treads are either precast concrete (similar to the original) or a precast ultra-high performance concrete (UHPC). The disadvantage of using a traditional precast concrete solution is that over time similar freeze/thaw conditions would affect the treads in a similar manner to the original treads and they would need replacing. This would be approximately a 40-50 year design life. The advantage of using an UHPC solution would be an extended design life as the material is impervious and does not contain tradition reinforcement (it contains either polymer or steel microfibers). Consultation with the specialist UHPC supplier (we recommend LaFarge and their product Ductal) will be needed to get an estimate of design life. Matching the original concrete color of the treads and landings as closely as possible will need careful attention, but initial indications from LaFarge are that if similar aggregates can be found as the original concrete a close color match may be possible within the Ductal product range.

Stair Landings

Similarly, re-building the landings to allow removal and replacement of the column will require careful material selection and could possibly use Ductal (although Ductal is primarily a precast product and possible use on site will need to be discussed with LaFarge). We will send Ductal precedents to discuss during the next phase of this investigation.

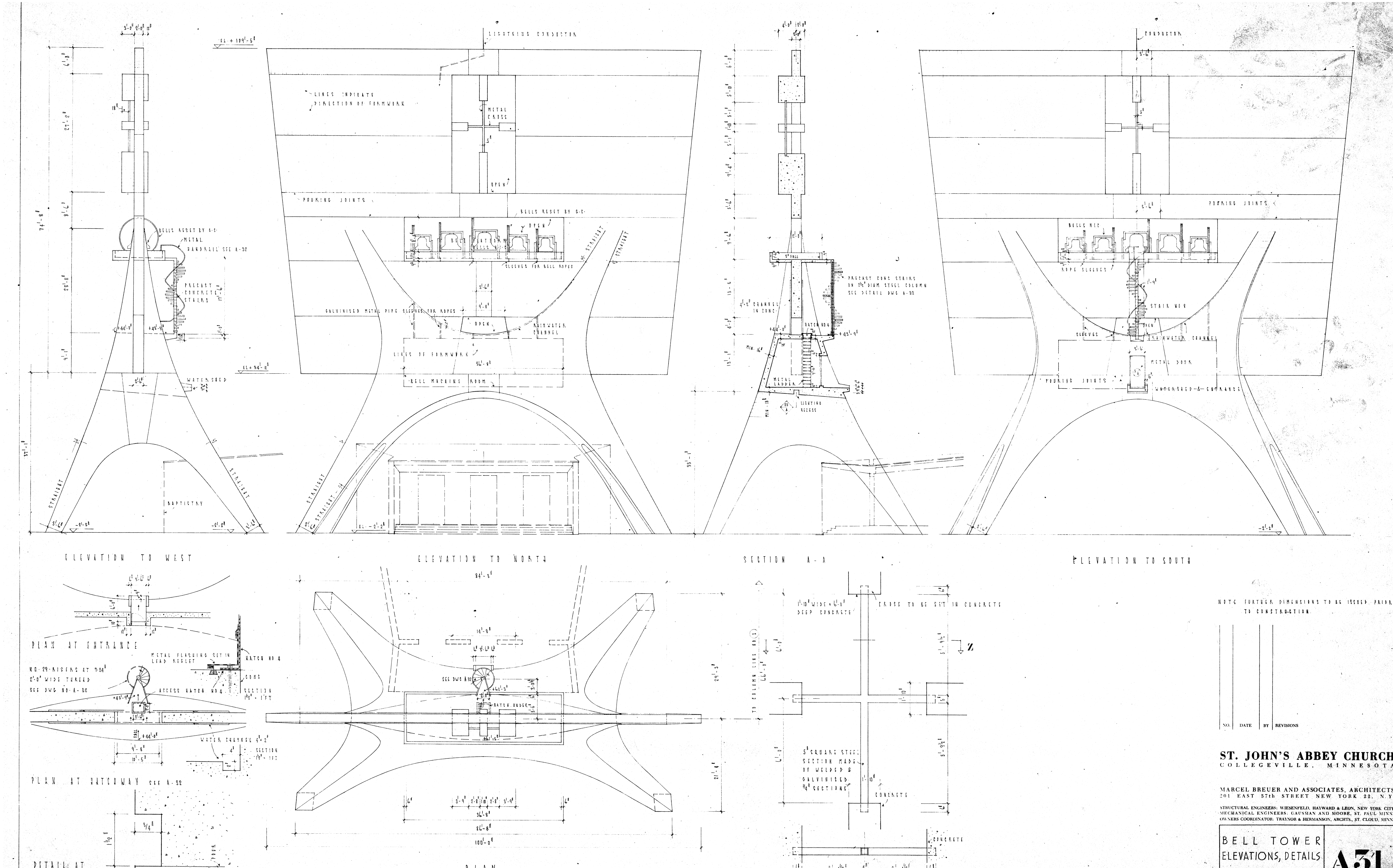
Central Support Column

The options for replacing the central support column are using a carbon steel pipe column as per the original construction, or possibly using a stainless steel pipe column that may have to be internally reinforced to become a composite section to help resist bending loads. The disadvantage of using a traditional carbon steel pipe solution is the potential for corrosion over time, giving this solution an approximate 40-50 year design life. This design life could be extended by hot dip galvanizing the steel section. It is not clear from the original construction drawings whether the pipe column is galvanized. The handrails were. The advantage of using a stainless steel pipe column solution would be an extended design life as the material is essentially corrosion resistant.

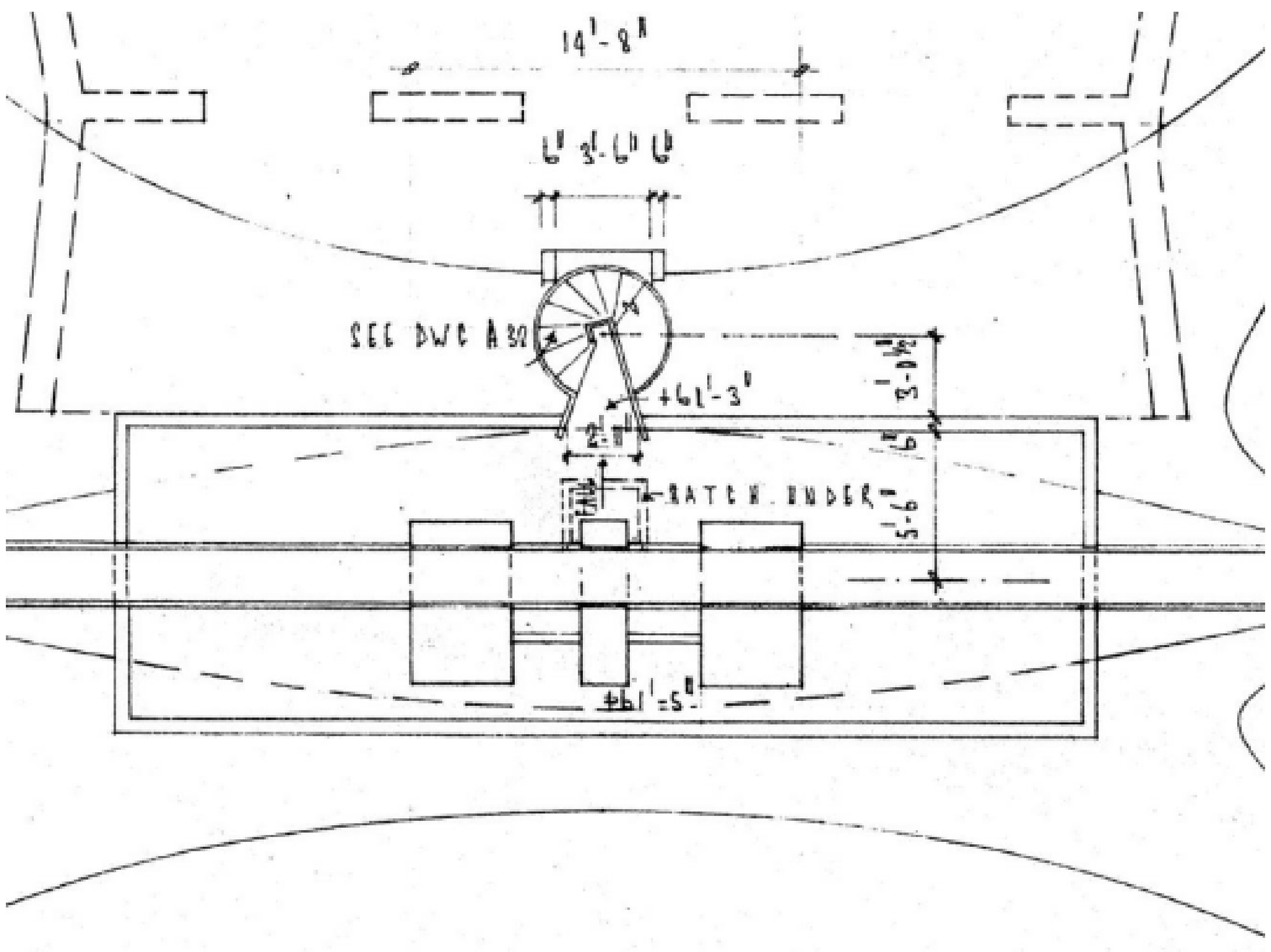
Handrails on Treads and Upper and Lower Landings

The options for replacing the handrails are similar to the central steel pipe column. The solution could use a carbon steel pipe section as per the original construction, or possibly using a stainless steel pipe section that may possibly need strengthening. The disadvantage of using a traditional carbon steel pipe section is the potential for corrosion over time, giving this solution an approximate 40-50 year design life. This design life could be extended by hot dip galvanizing the steel section. The original construction drawings showed the handrails to be galvanized and they are in the field. The advantage of using a stainless steel pipe section solution would be an extended design life as the material is essentially corrosion resistant.

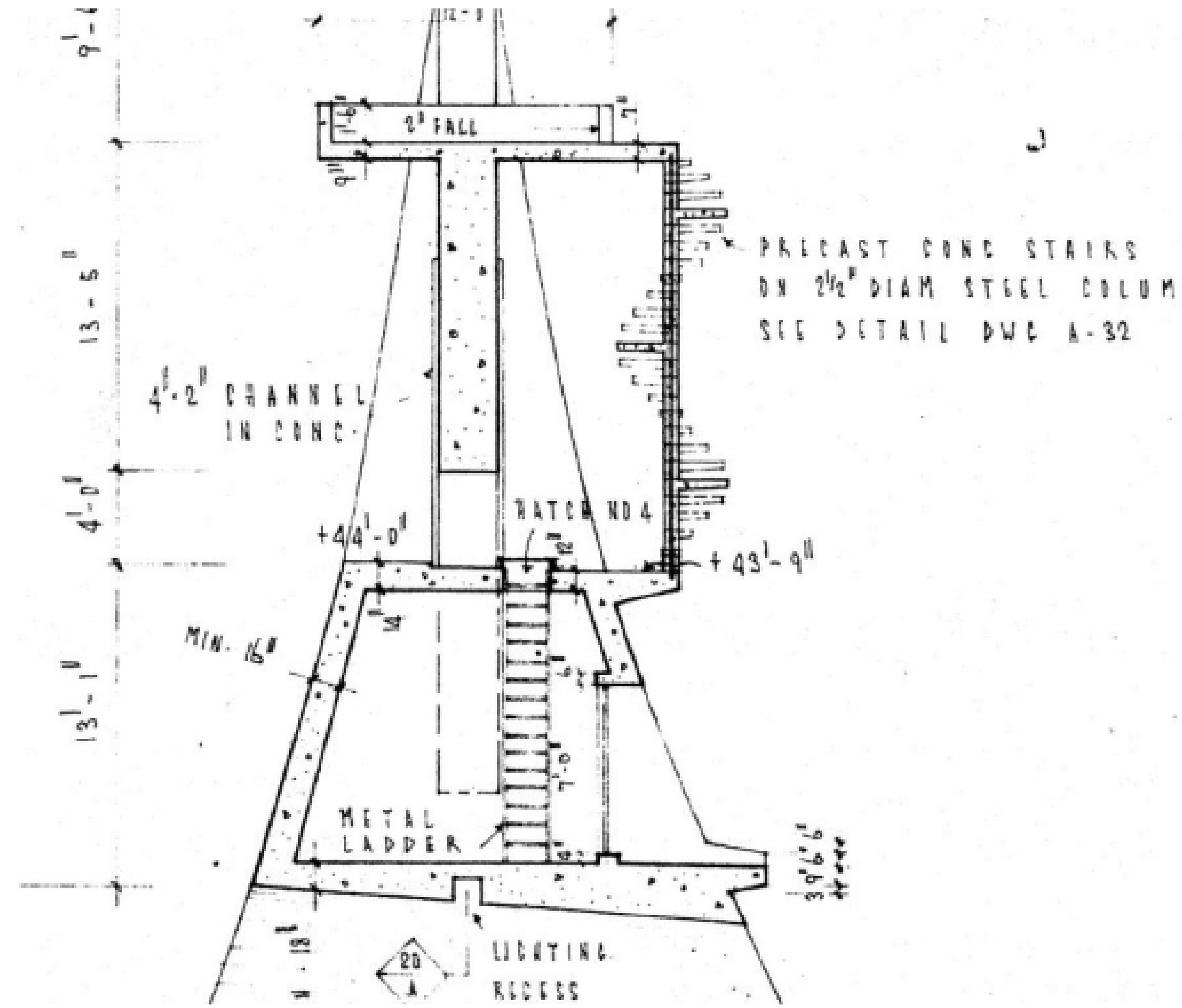
Either option would not meet code structurally for a number of reasons, but primarily because the vertical post sections are not strong enough for the code required lateral loads at the handrail top bar. Also, the handrail is not dense enough to resist the code required panel loads. There are many other architectural code issues with the stair, but we assume these may be able to be grandfathered in under an historic replacement waiver. The loads to be resisted by the handrails will need to be reviewed and agreed with the Building Official.
Discussions with CSNA are needed to determine the correct design options for the handrails.



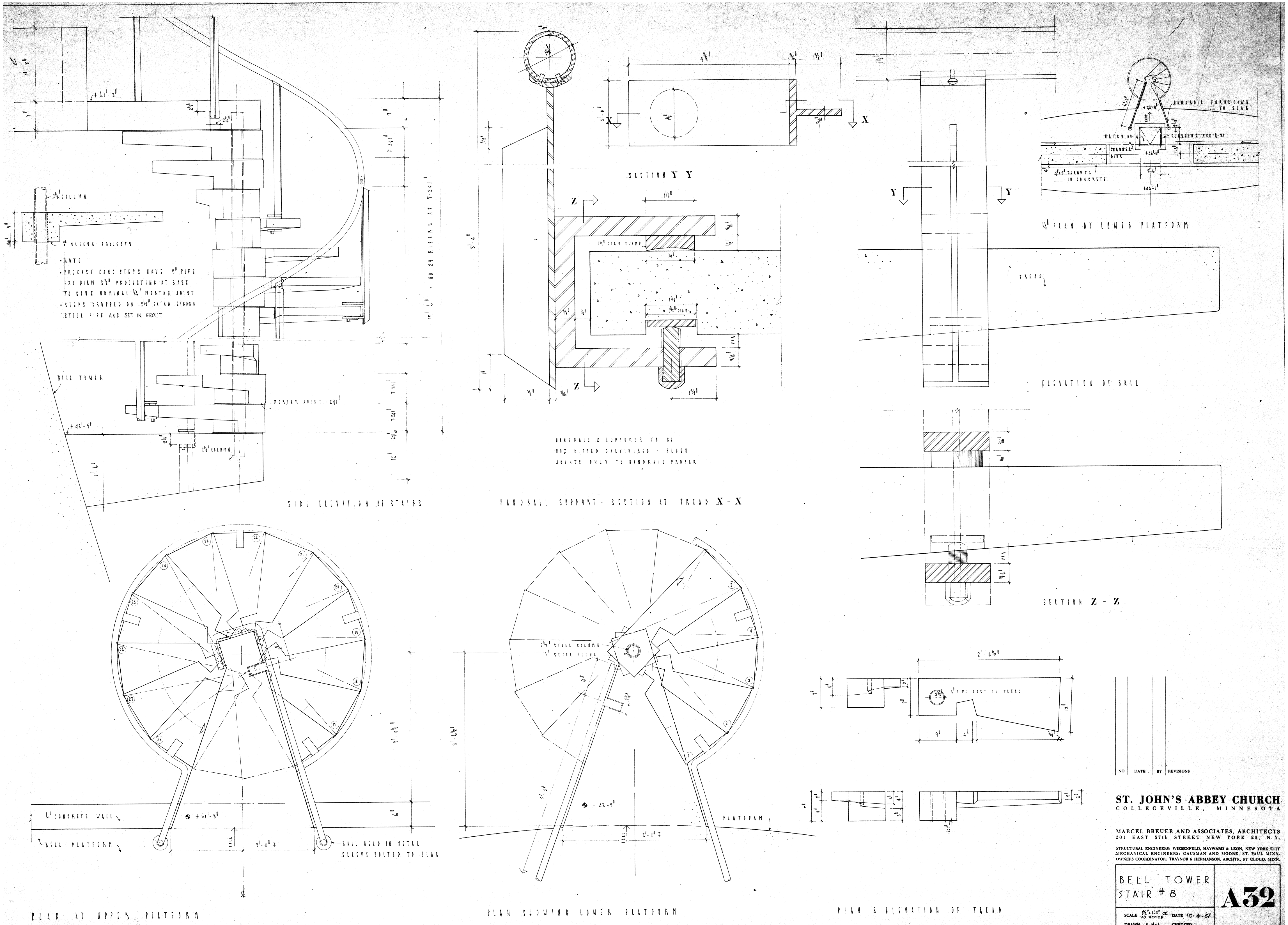
Drawing A31 – Bell Tower Elevations & Details



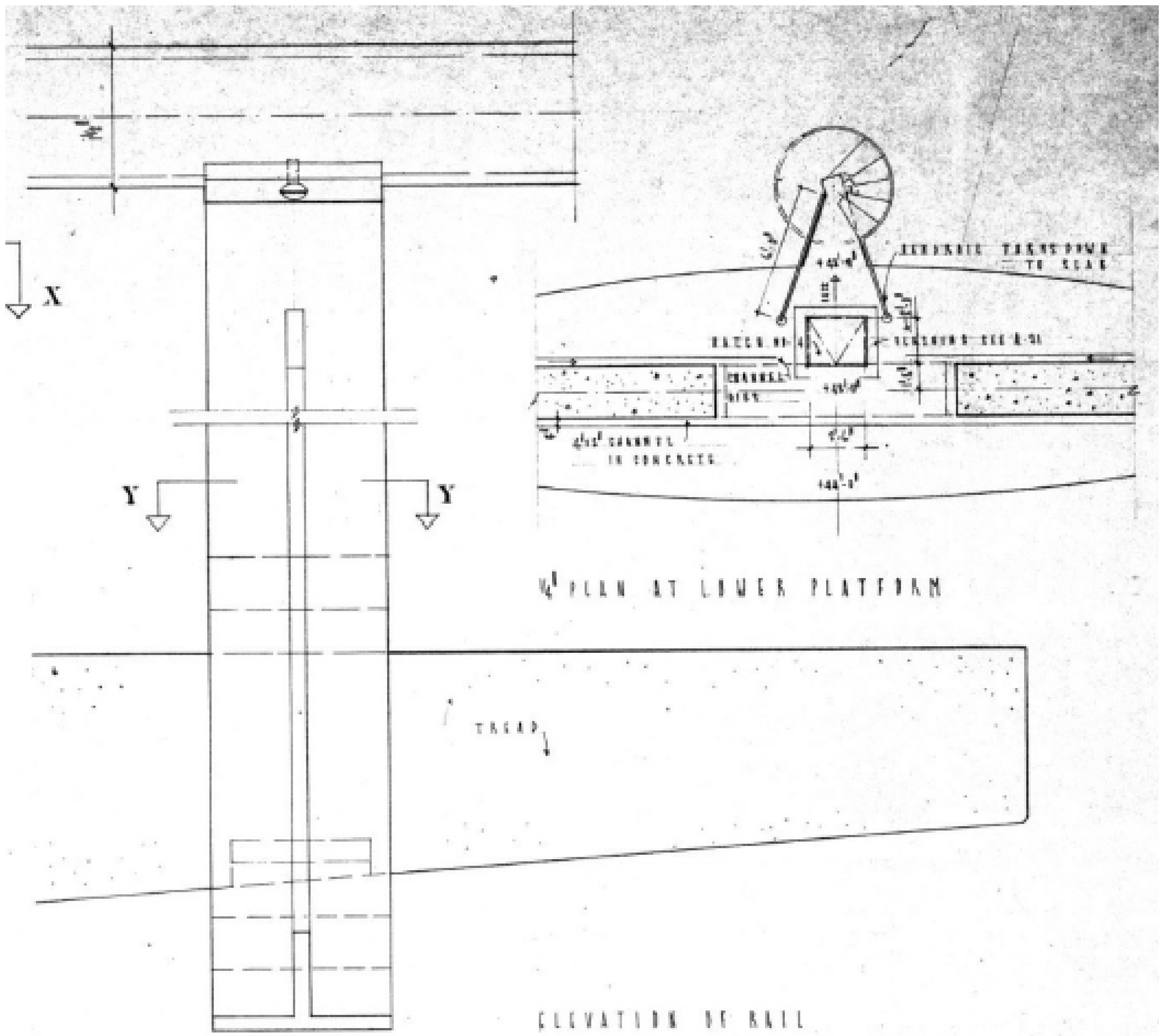
Drawing A31 Extract – Plan of Bell Platform



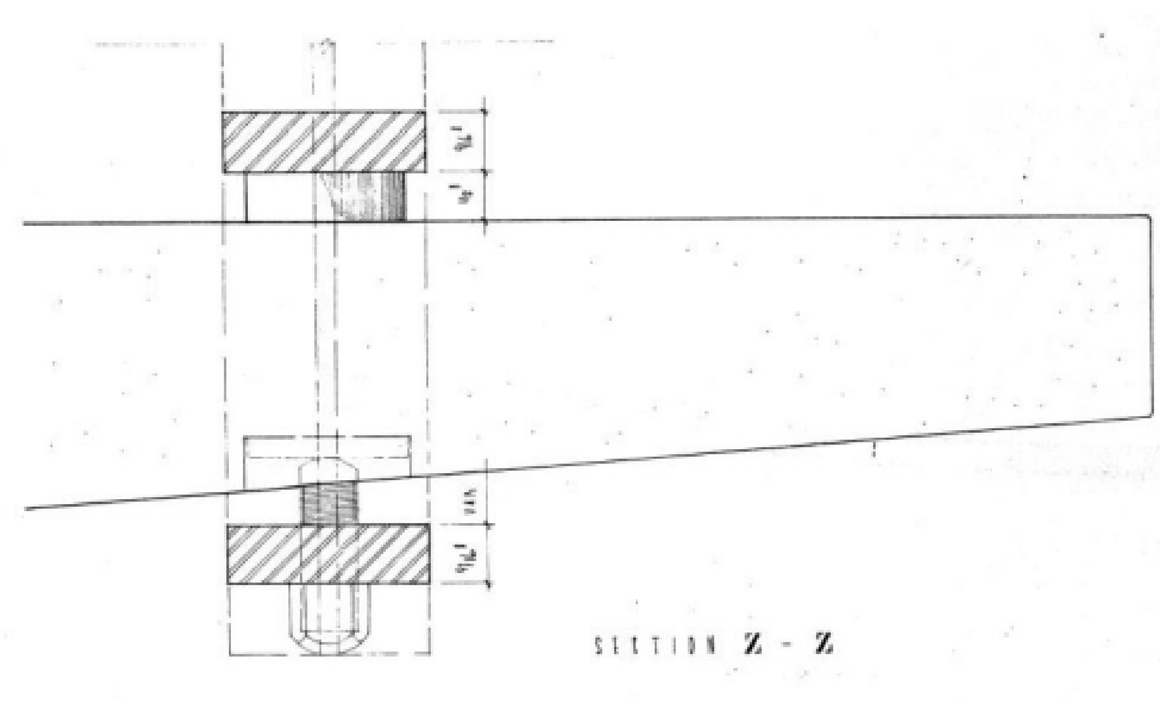
Drawing A31 Extract – Section of Banner



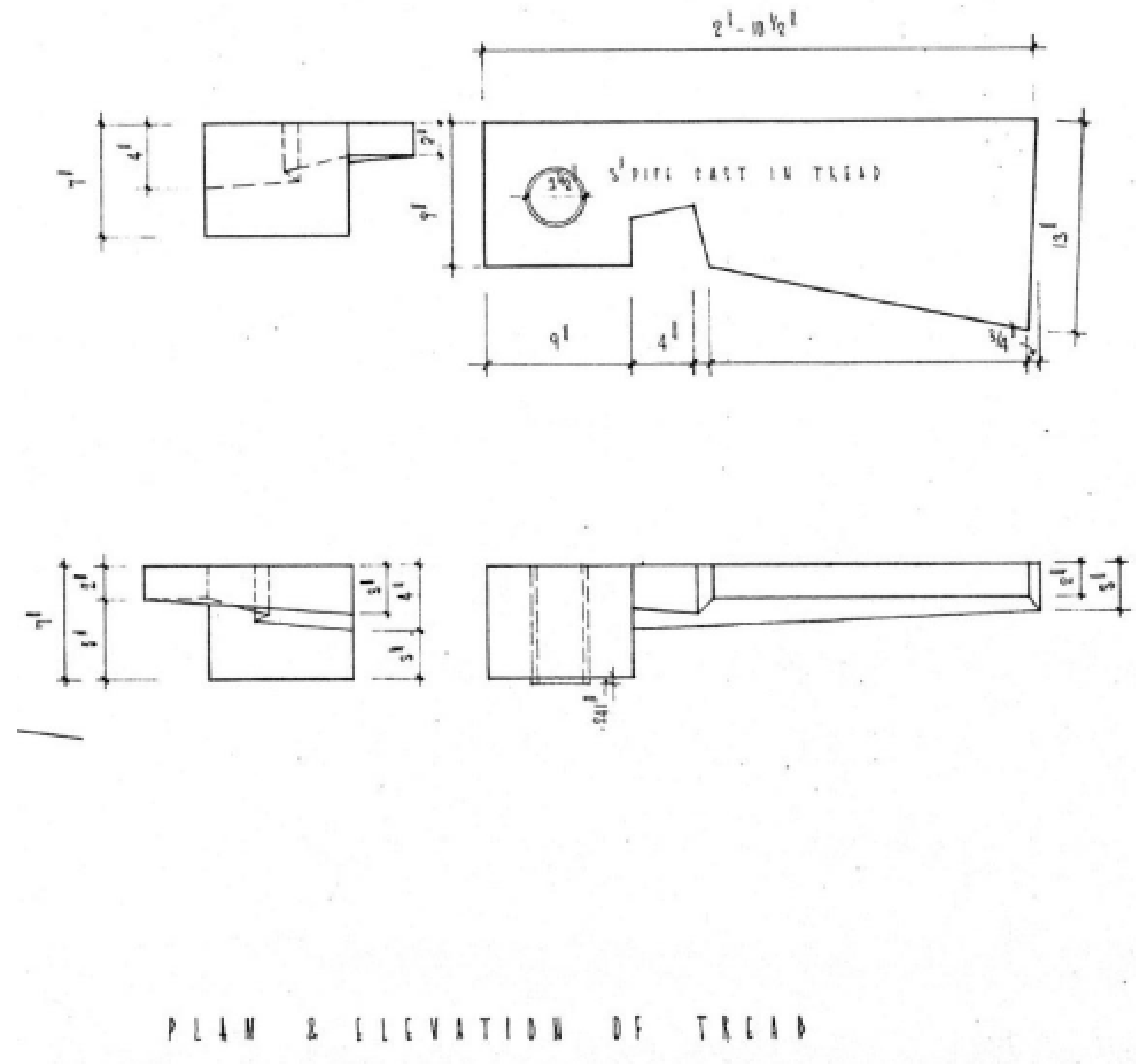
Drawing A32 – Bell Tower Stair #8



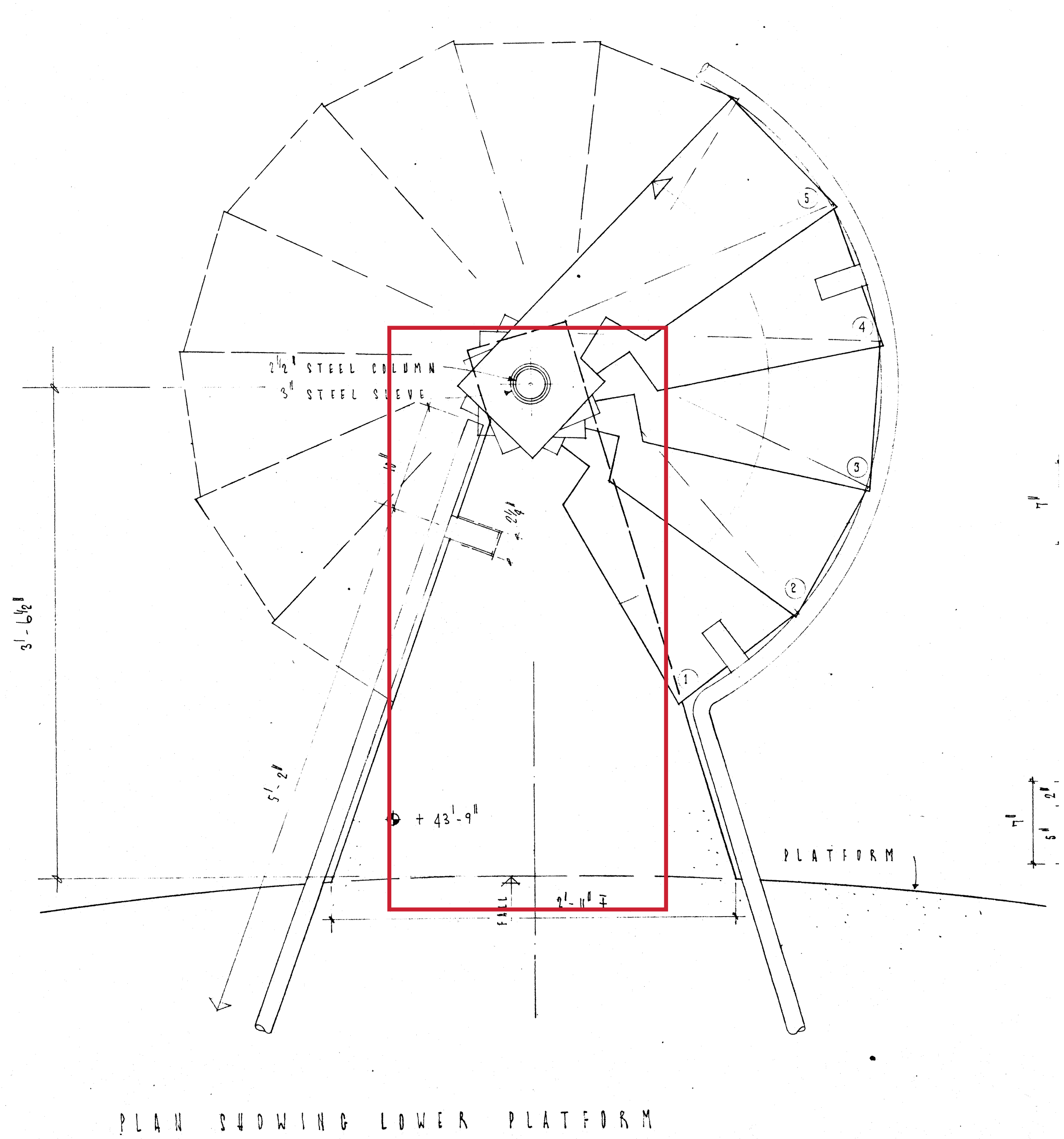
Drawing A32 Extract – Elevation of Handrail



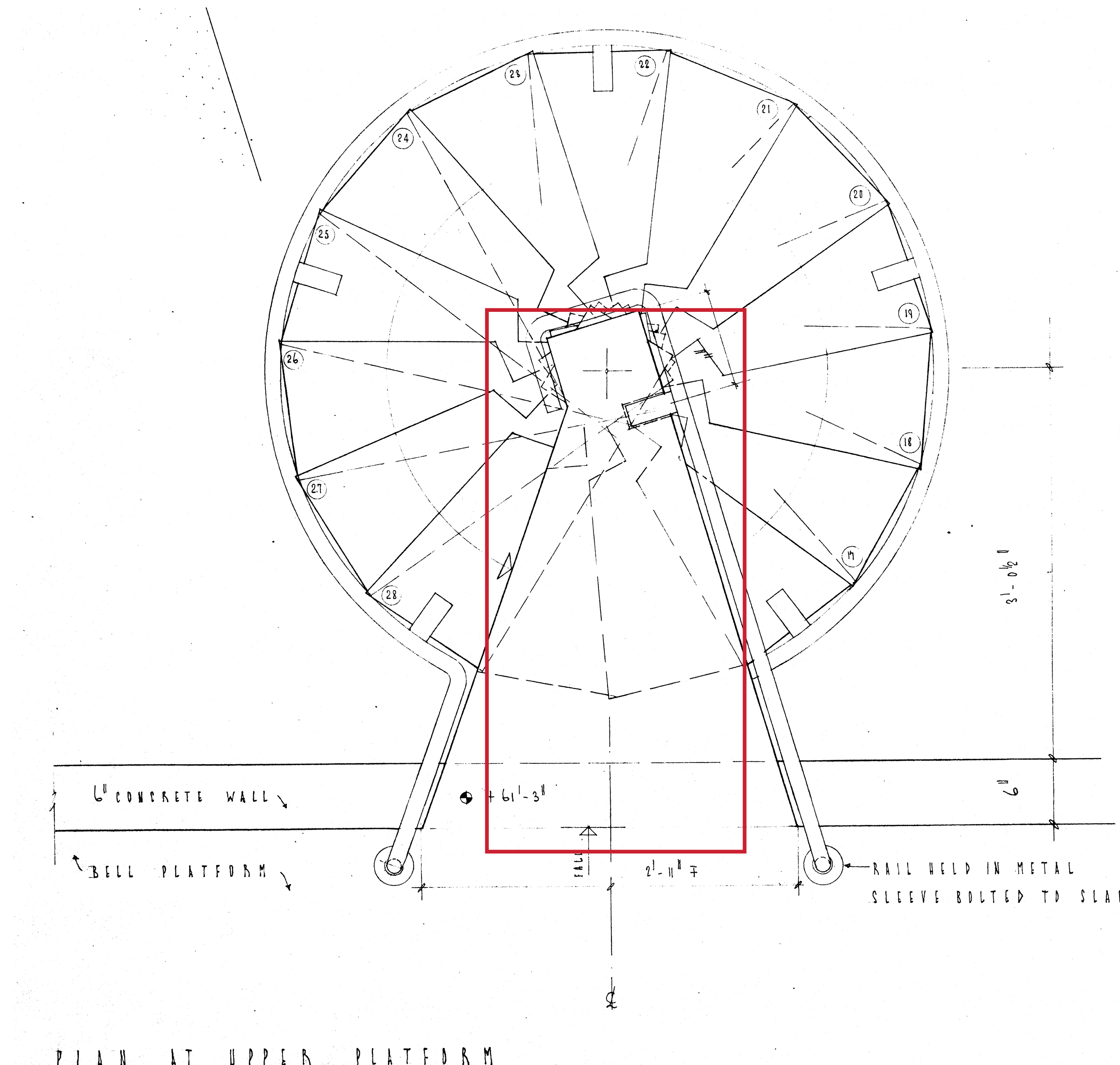
Drawing A32 Extract – Handrail Attachment



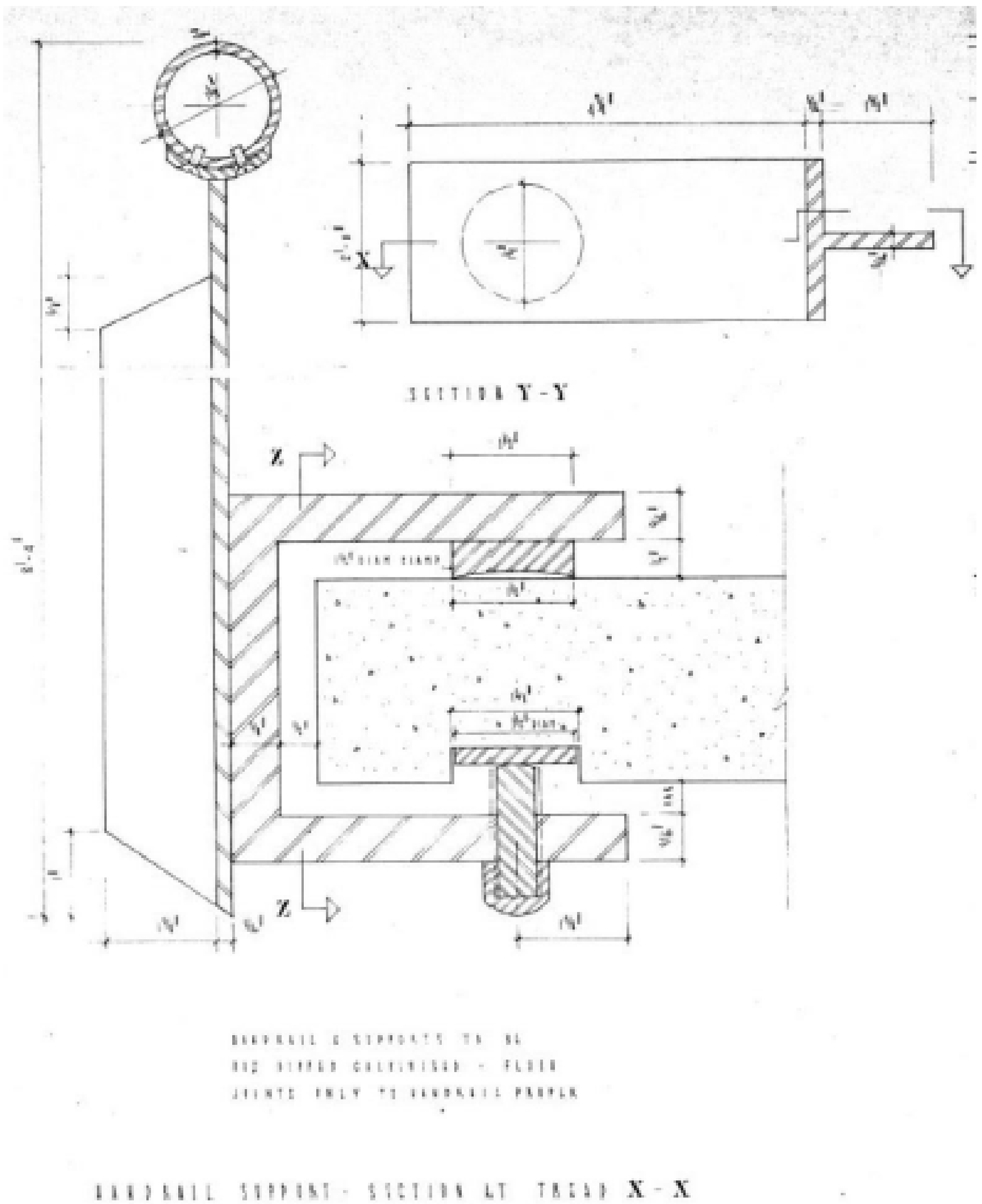
Drawing A32 Extract – Orthographic Projection of Tread



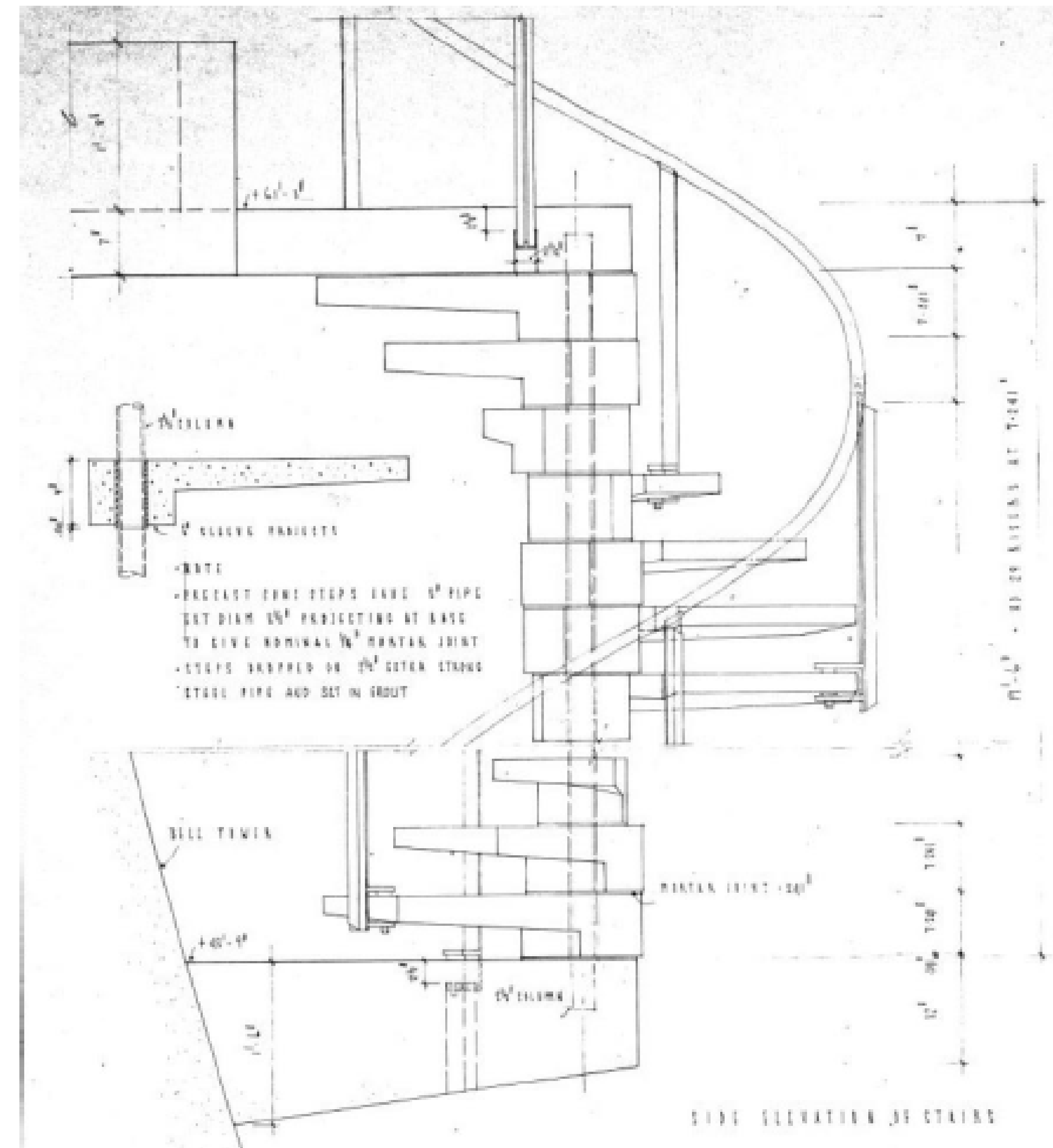
Drawing A32 Extract – Plan of Lower Platform – red line indicates preliminary landing size for structural analysis



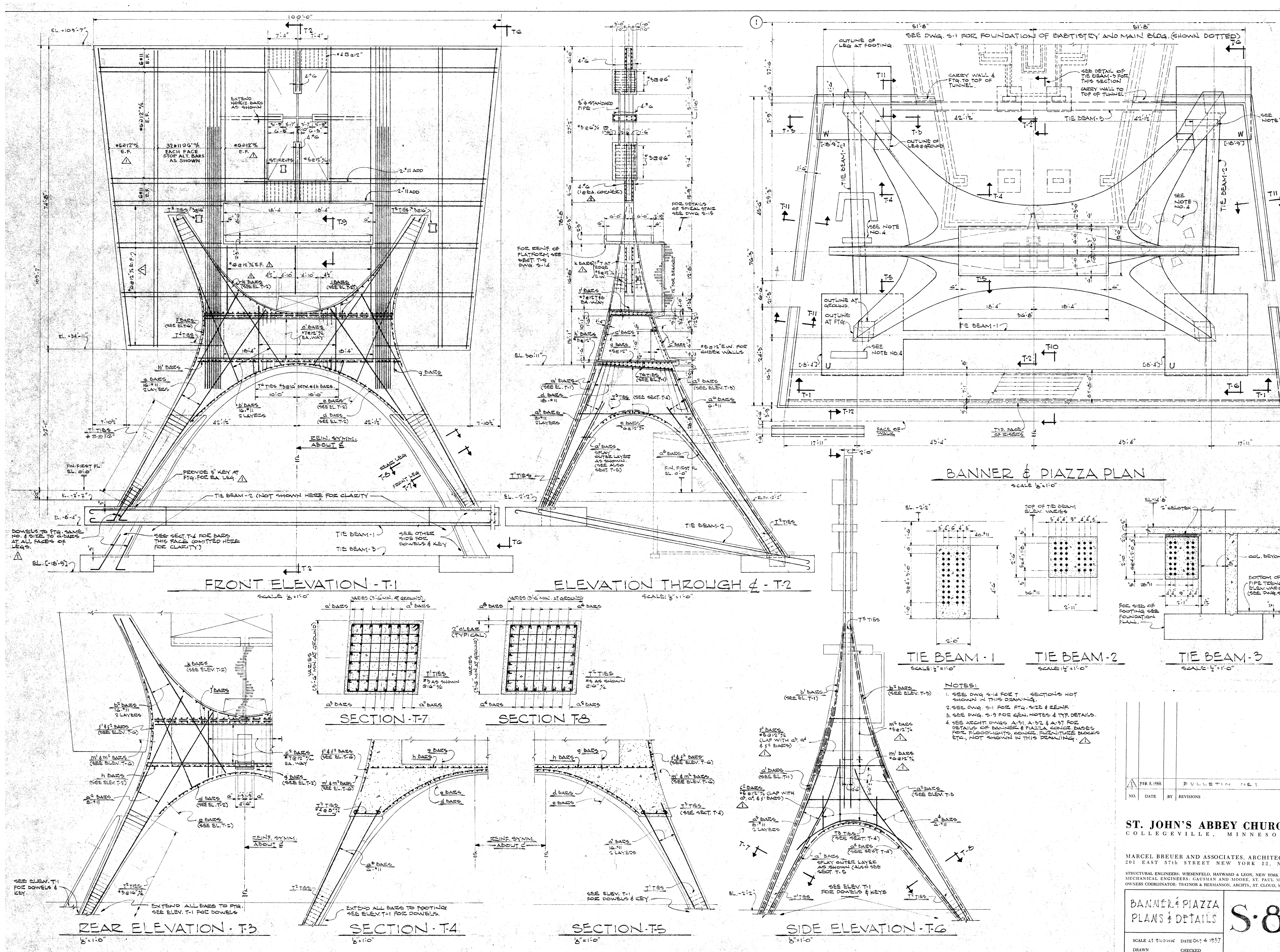
Drawing A32 Extract – Plan of Upper Platform – red line indicates preliminary landing size for structural analysis



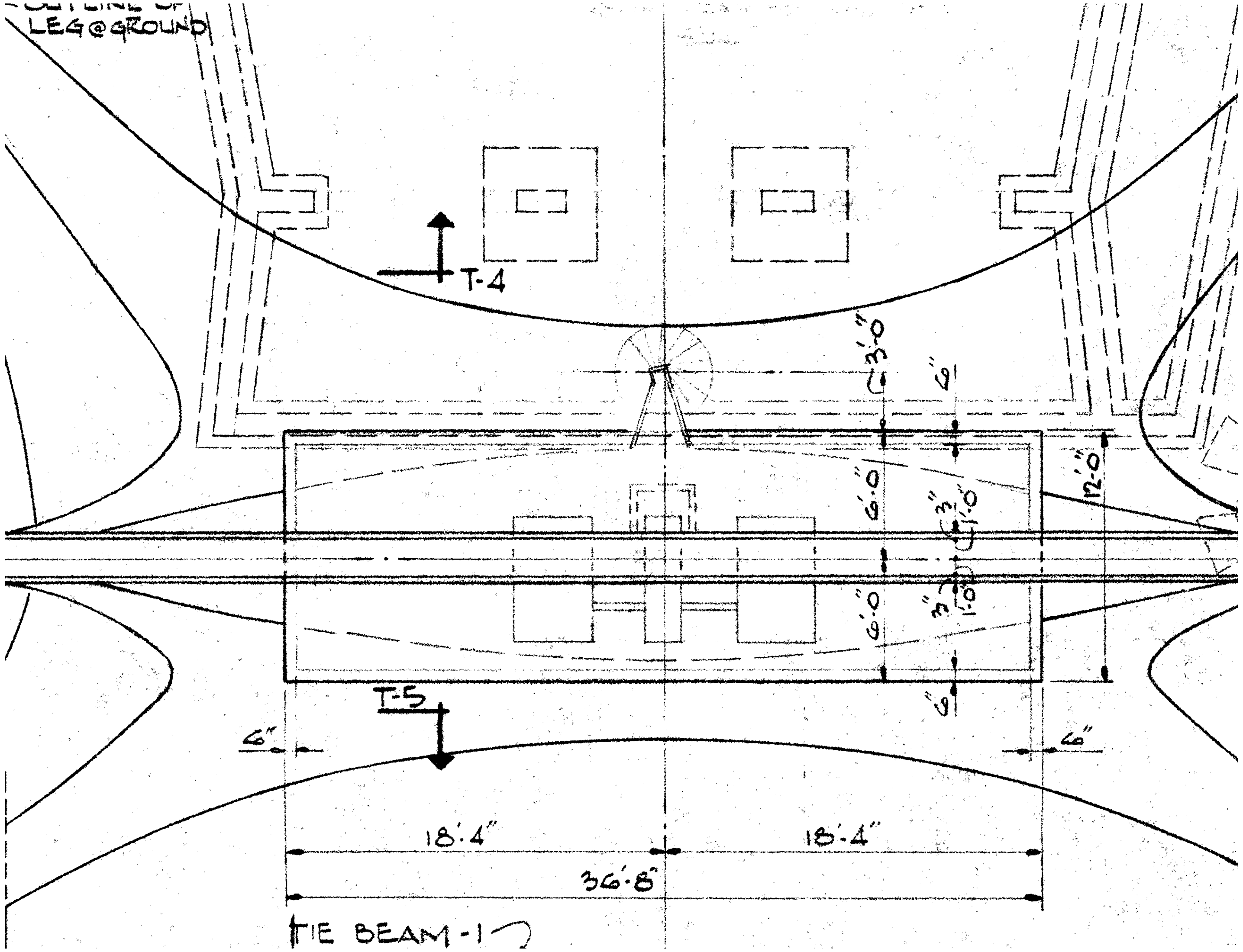
Drawing A32 Extract – Handrail Support Detail



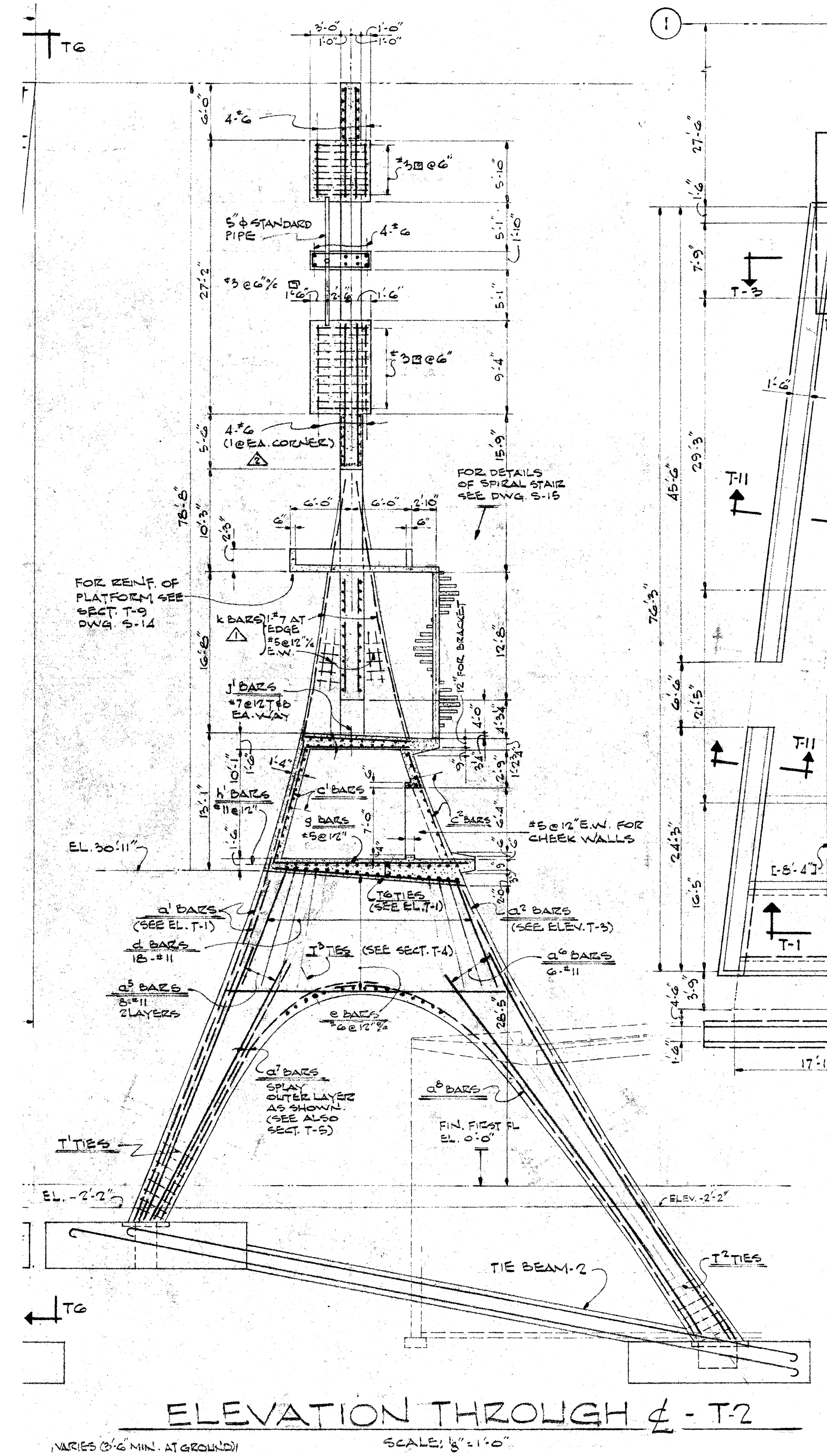
Drawing A32 Extract – Side Elevation of Stairs



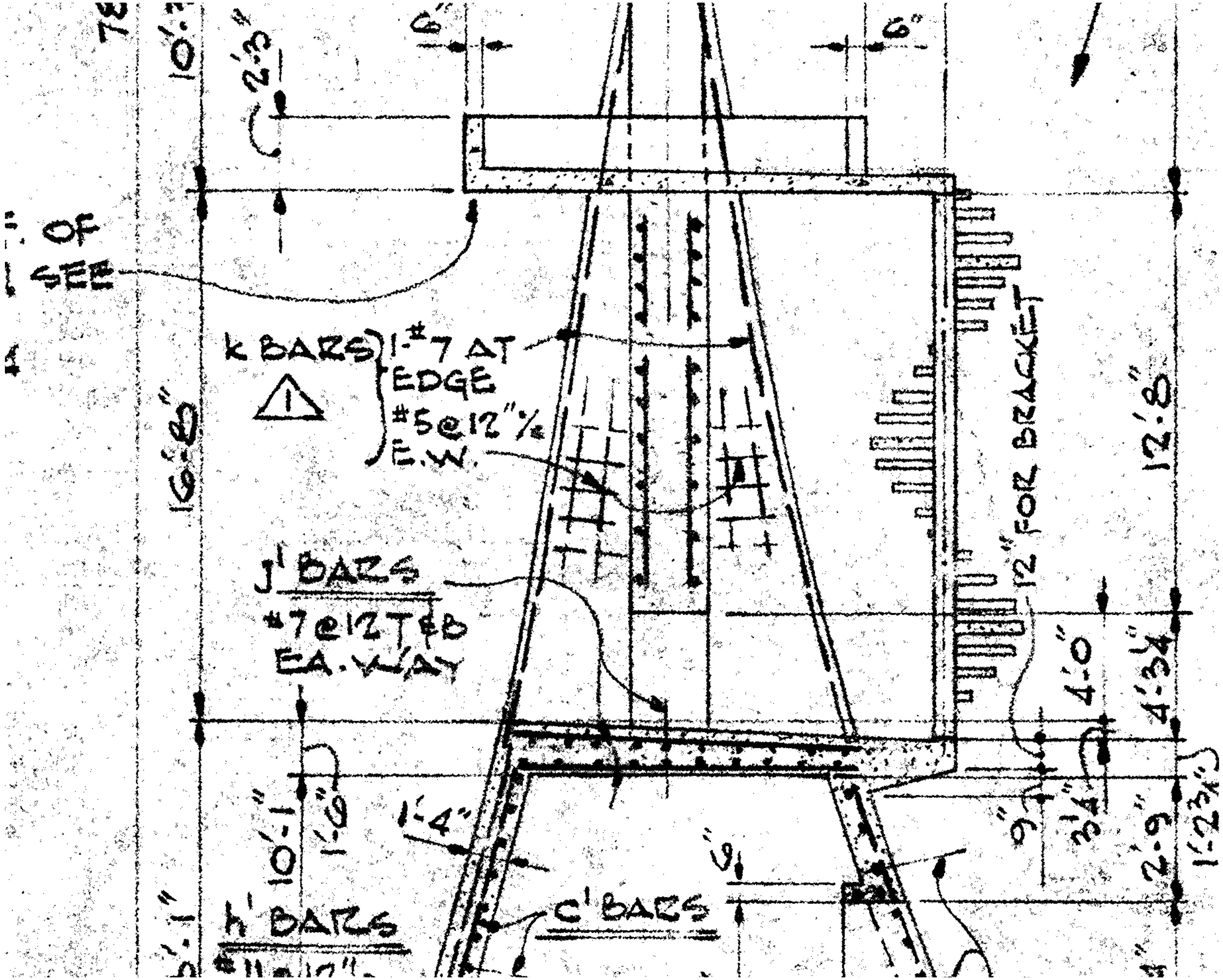
Drawing S8 – Banner & Piazza Plans & Details



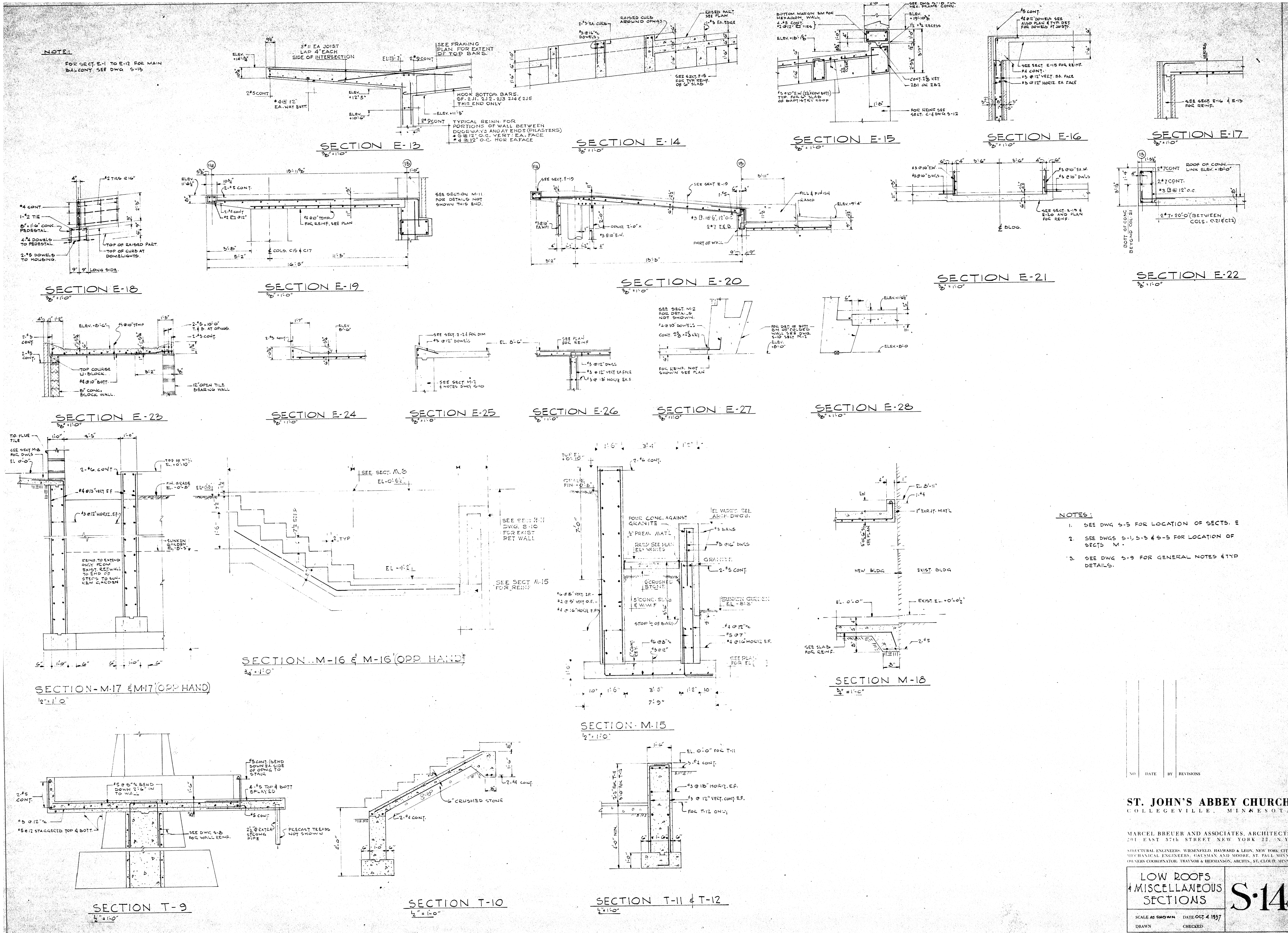
Drawing S8 Extract – Plan of Bell Platform



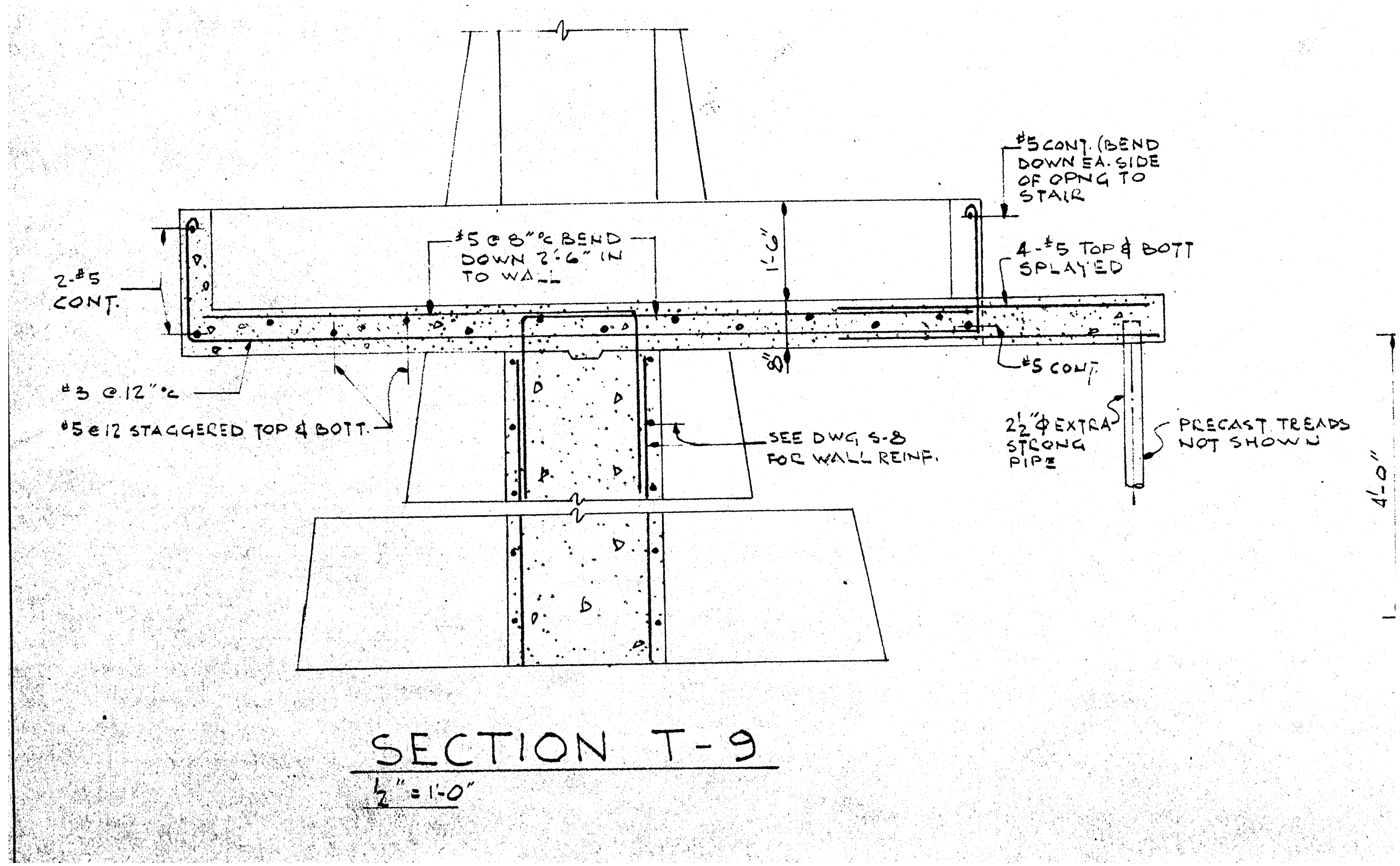
Drawing S8 Extract – Section through Centerline T2



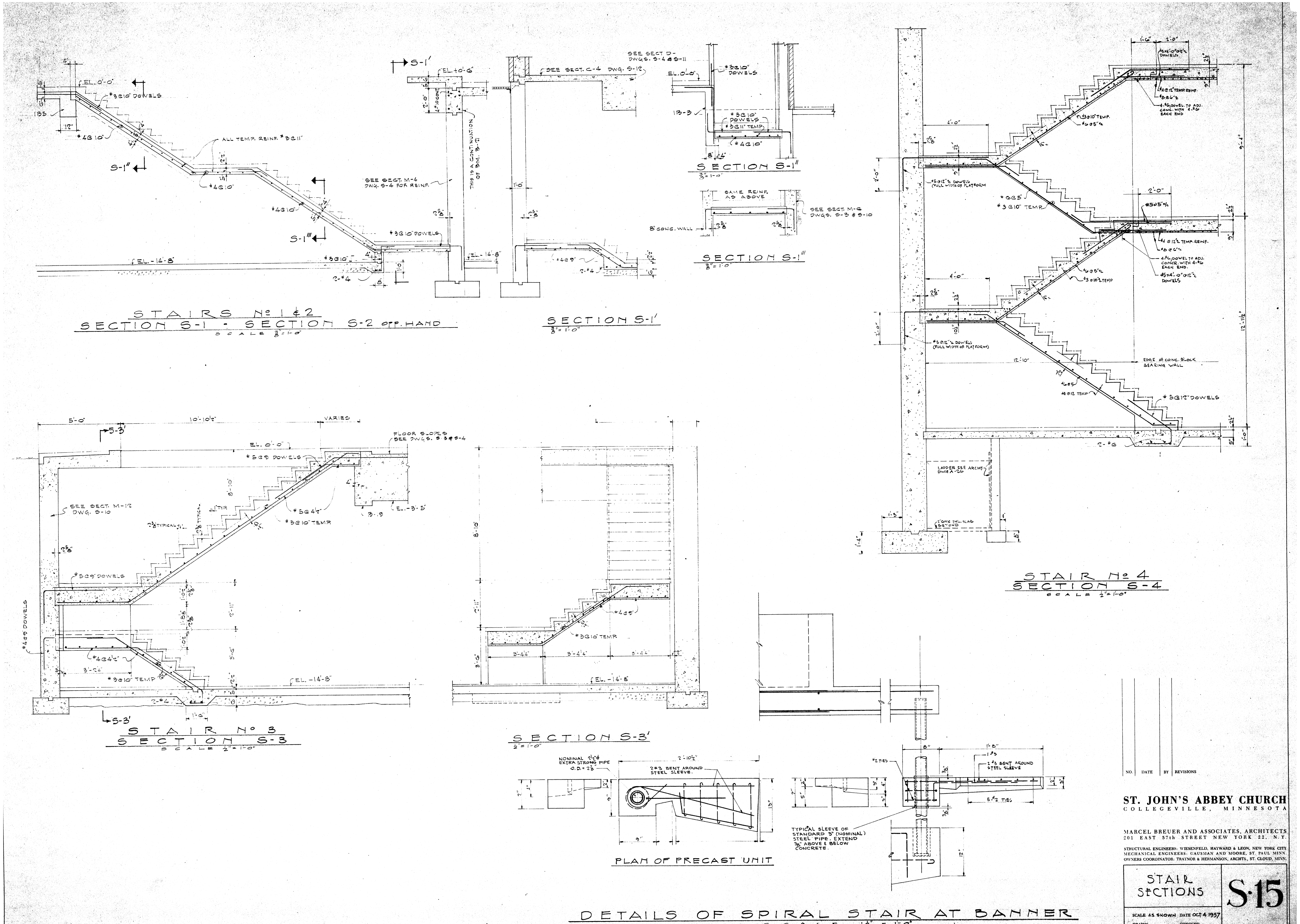
Drawing S8 Extract – Section through
Centerline T2 enlarged



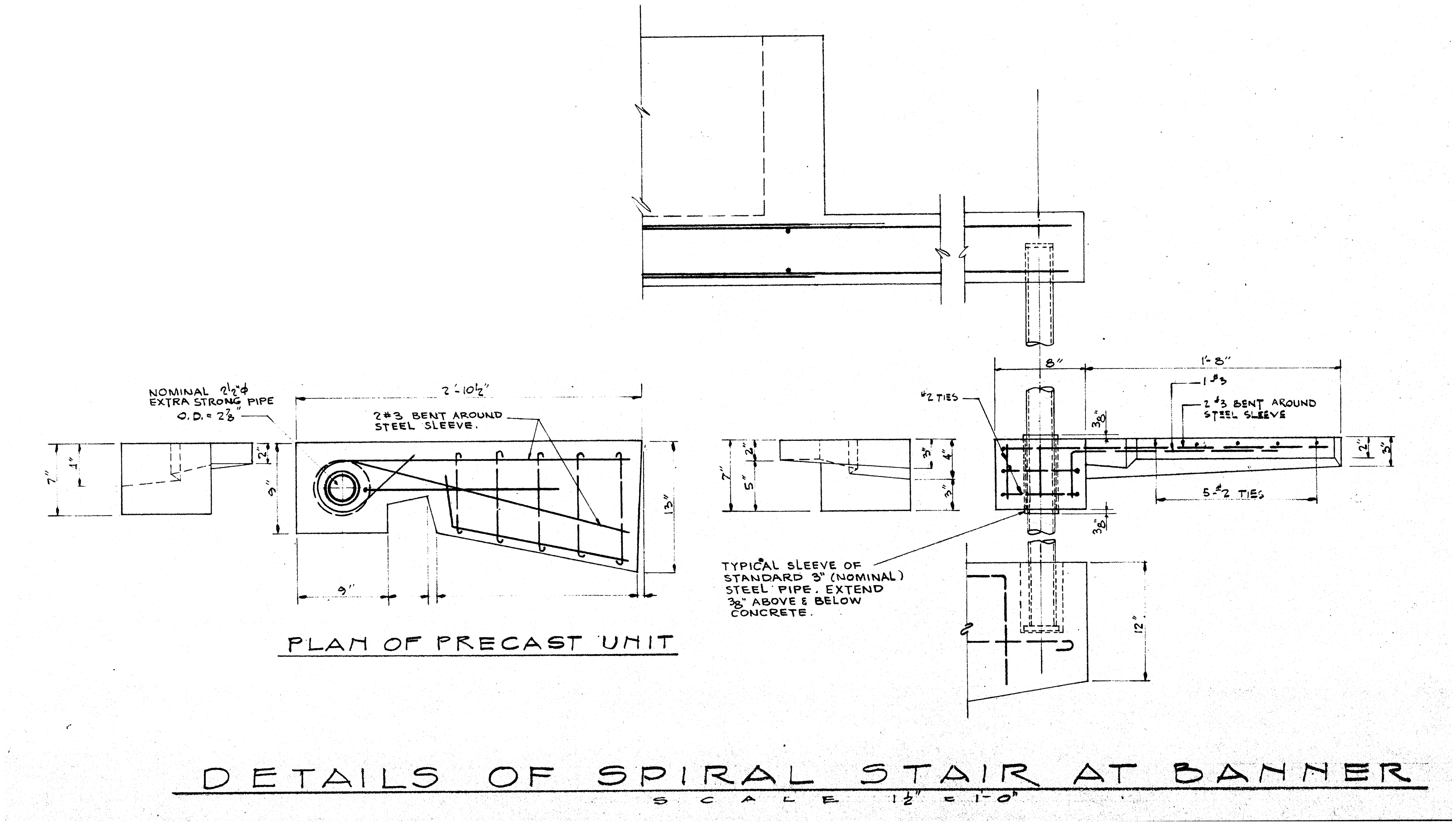
Drawing S14 – Low Roofs & Miscellaneous Sections



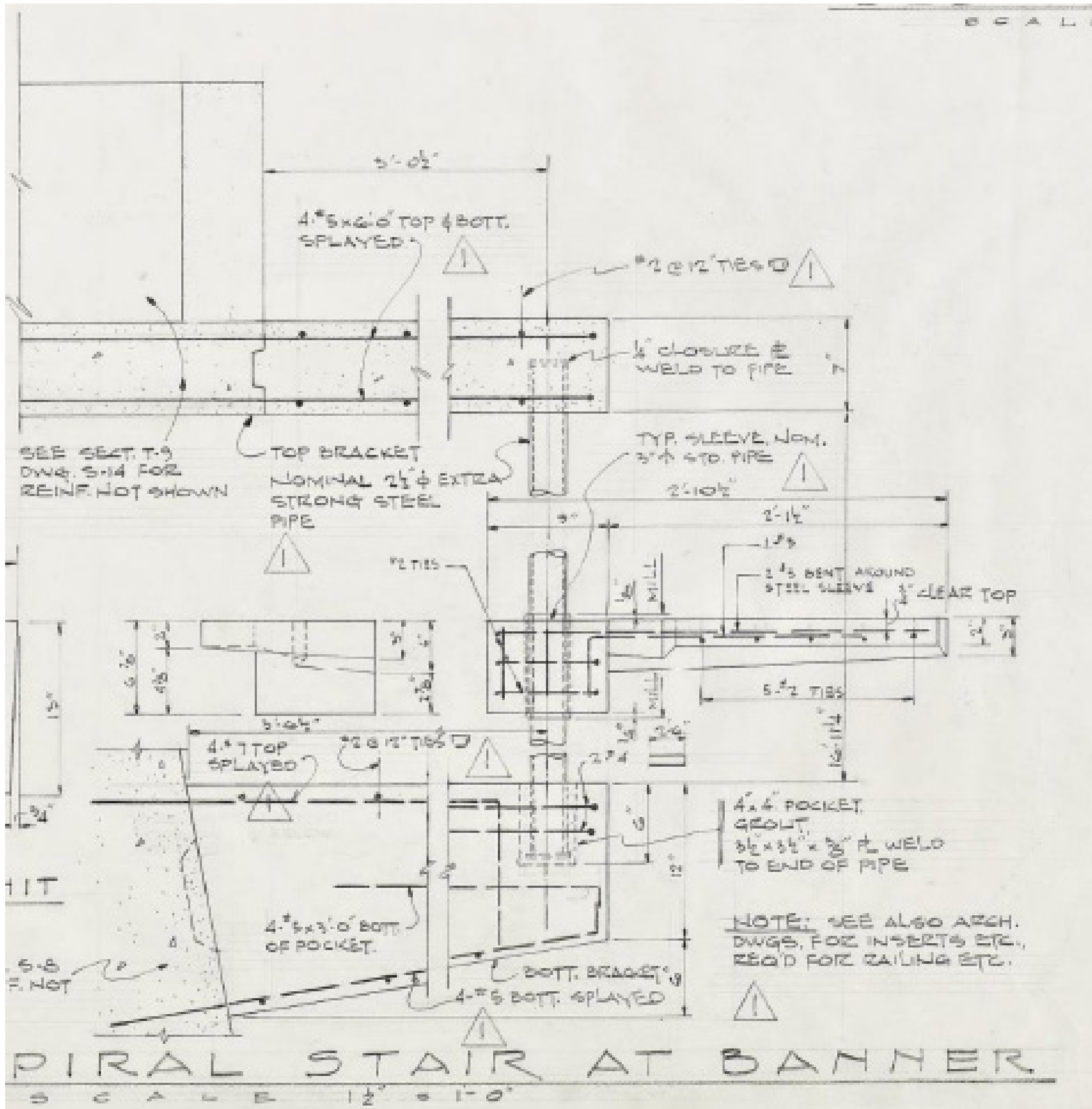
Drawing S14 Extract – Section T9



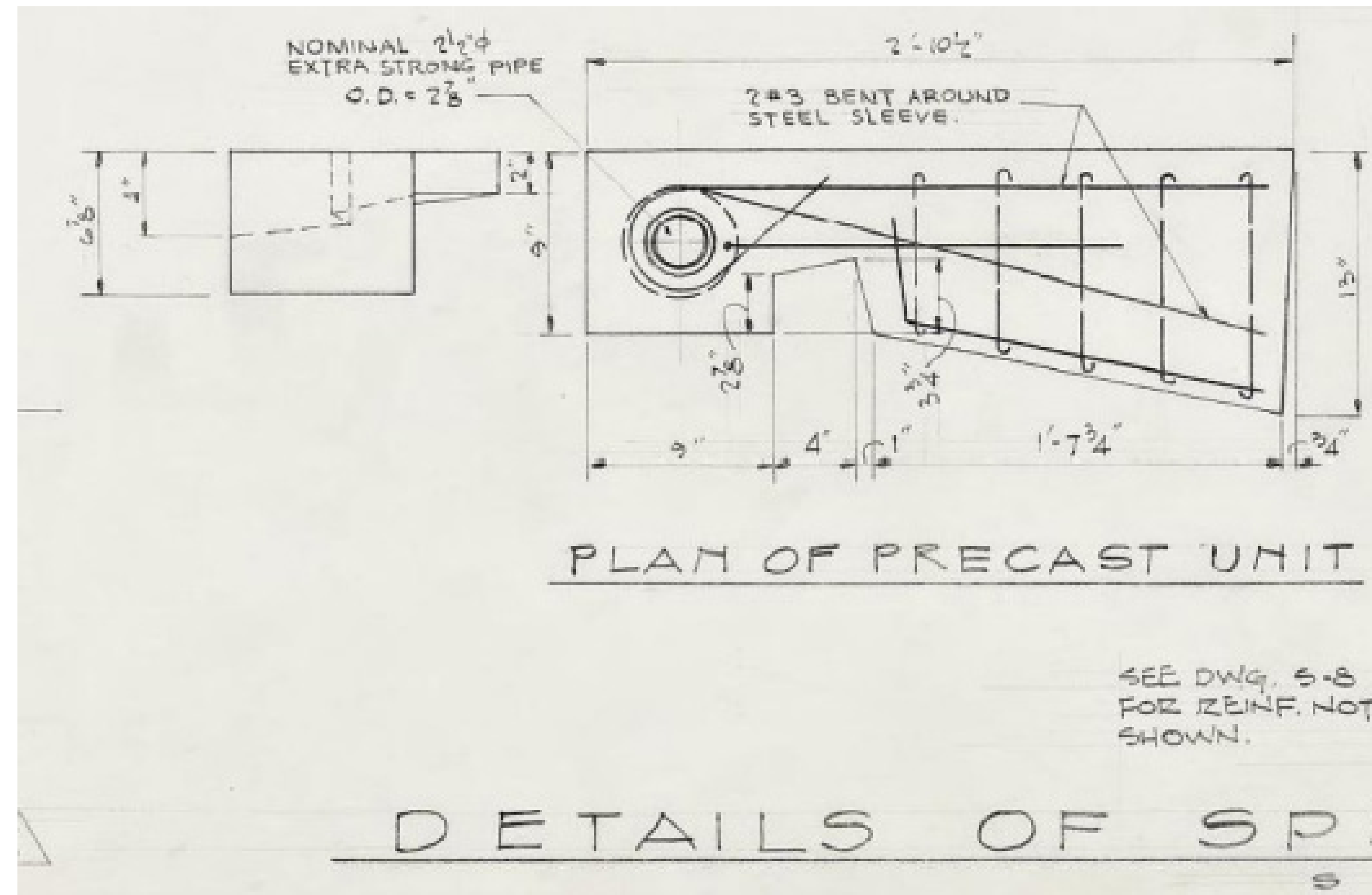
Drawing S15 – Stair Sections



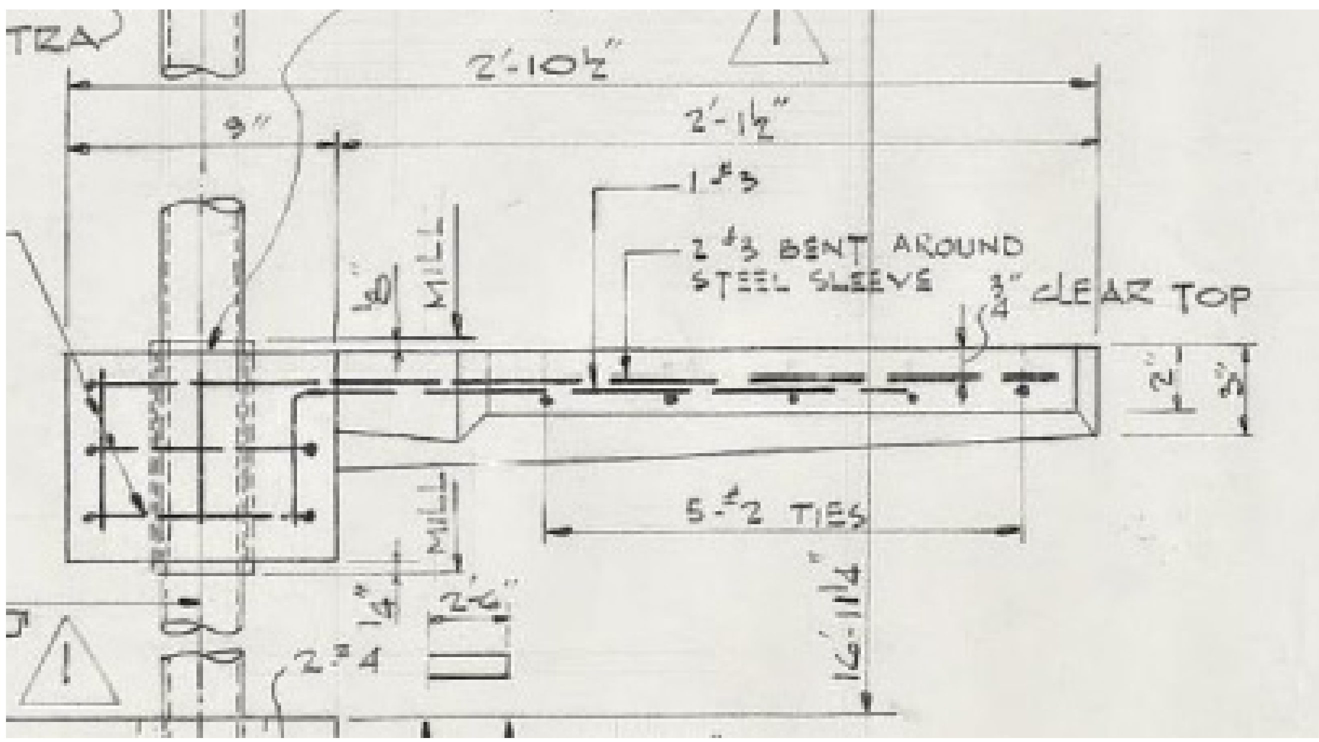
Drawing S15 Extract – Stair Details



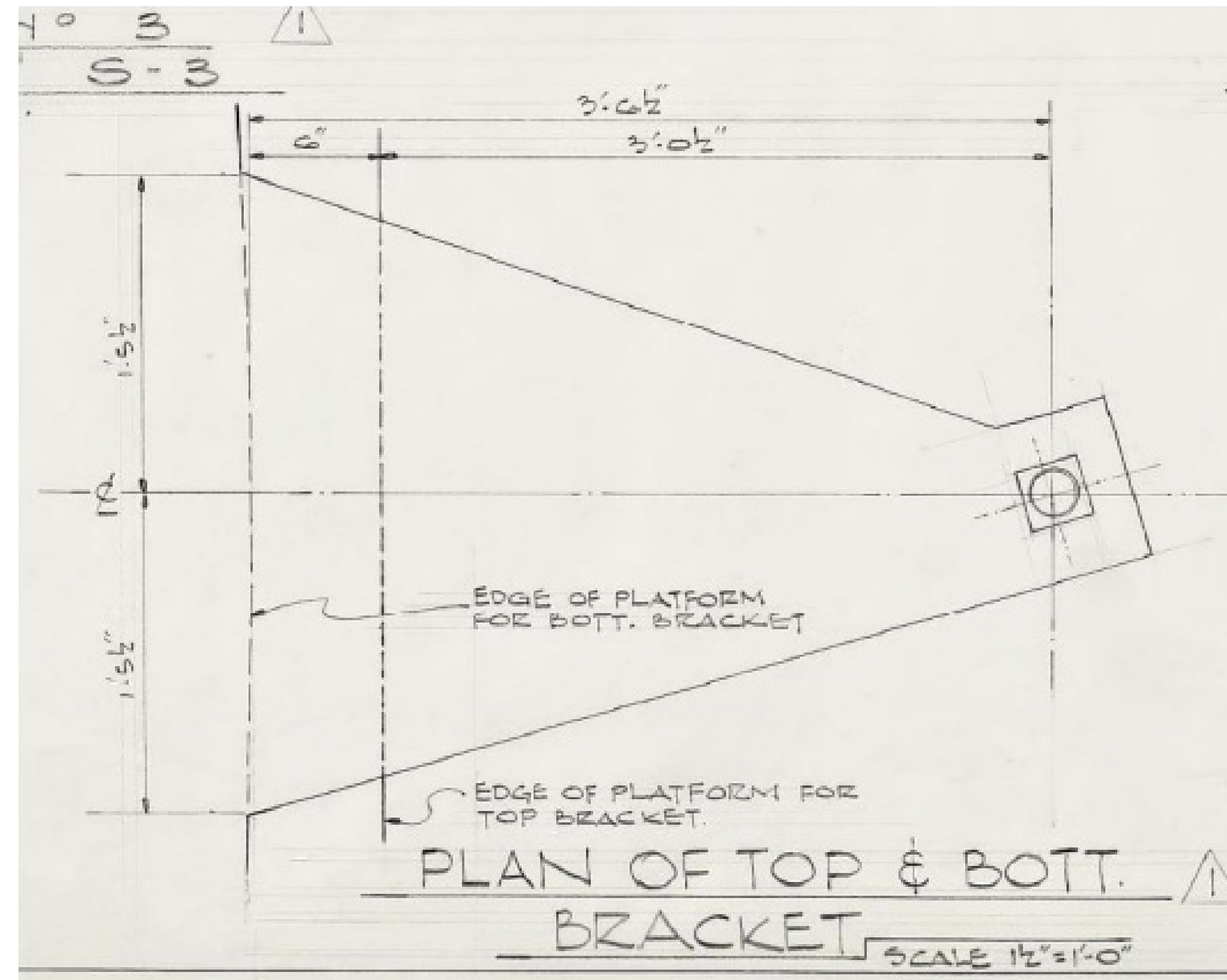
Drawing S15 Extract – Stair Details



Drawing S15 Extract – Plan of Tread



Drawing S15 Extract – Section of Tread



Drawing S15 Extract – Plan of Top and Bottom Bracket

Photo 1 – The Bell Banner from the Quad in front of St, John's Abbey Church

Photo 2 – The Bell Banner from the side showing the spiral stair

Photo 3 – The Bell Banner from behind showing the spiral stair
and upper and lower landings.

Photo 4 – The Bell Banner from behind showing a close up
of the spiral stair and upper and lower landings.

Photo 5 – The Bell Banner from behind showing the other side view of the spiral stair and upper and lower landings.

Photo 6 – The Bell Banner from behind showing the other side: close up view of the lower portion of the spiral stair and lower landing.

Photo 7 – The Bell Banner from behind showing the other side: close up view of the upper portion of the spiral stair and upper landing.

Photo 8 – April 2008 photo - The stair from the Bell Banner lower landing showing major cracking and spalling of the front face of tread.

Photo 9 – April 2008 photo - The stair from the Bell Banner lower landing showing major cracking and spalling of the front face of tread.

Photo 10 – April 2008 photo - The stair from the Bell Banner lower landing looking up at the upper landing - showing major cracking and spalling of the front face of tread.

Photo 11 – April 2008 photo - The stair from the Bell Banner lower landing looking up - showing major cracking and spalling of the front face of tread.

Photo 12 – April 2008 photo - The stair from the Bell Banner lower landing looking up - showing major cracking and spalling of the front face of tread.

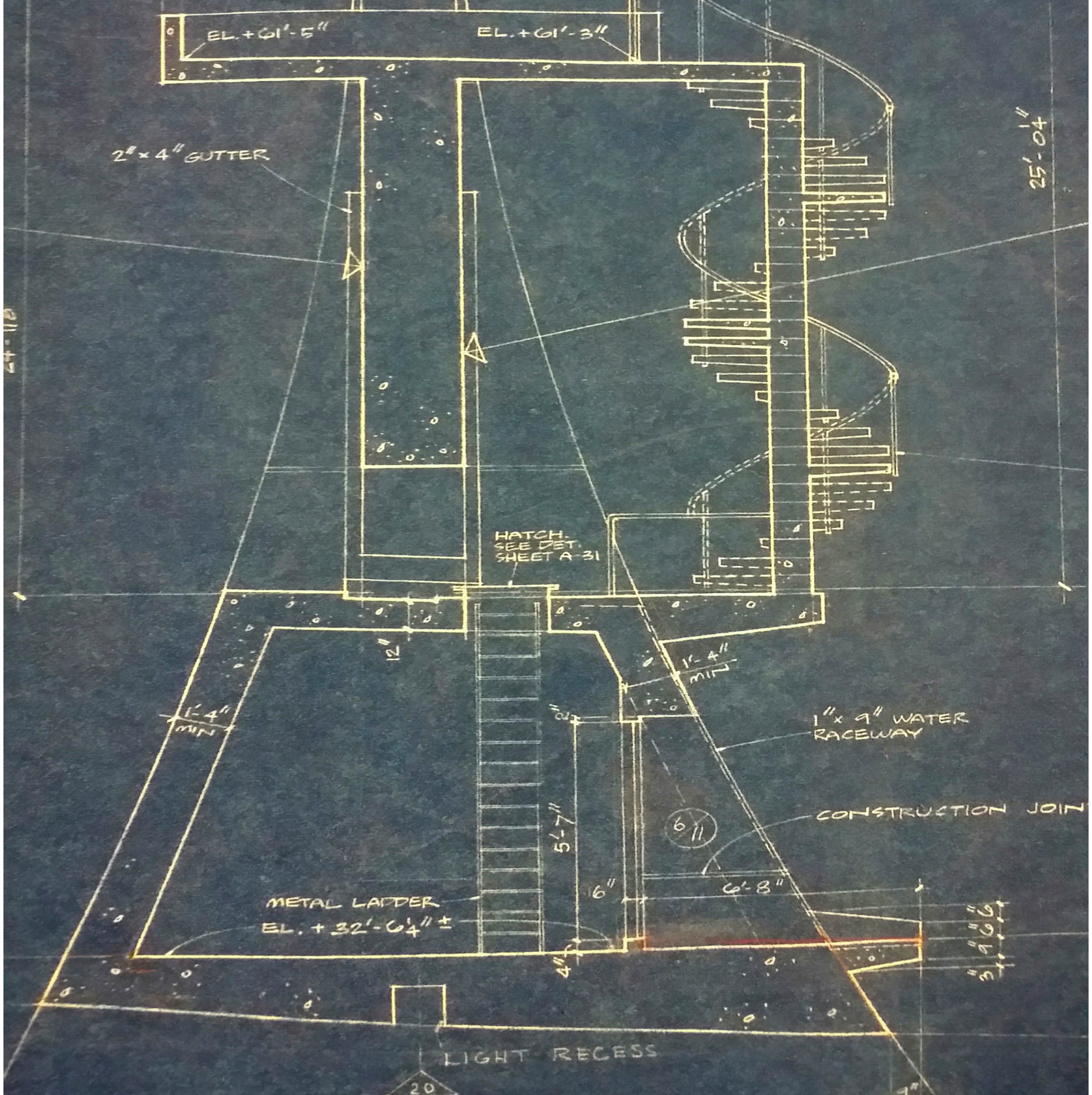
Photo 13 – April 2008 photo - The stair from the Bell Banner lower landing looking up - showing major cracking on rear of tread.

Photo 14 – April 2008 photo - The stair from the Bell Banner lower landing - showing concrete repair on front face of tread. Also showing there is a mortar joint between each tread as assumed from our review of the archive drawings.

Photo 15 – April 2008 photo - The stair from the Bell Banner lower landing - showing concrete spalling on the front face of a tread and extensive reinforcement corrosion.

Photo 16 – April 2008 photo - The stair from the Bell Banner lower landing looking up - showing cracking on the front face of a tread.

Photo 17 – April 2008 photo - The stair from the Bell Banner lower landing looking up - showing cracking on the front face of a tread and rear face of a lower tread.



Extract from original Bethlehem Steel shop drawings.

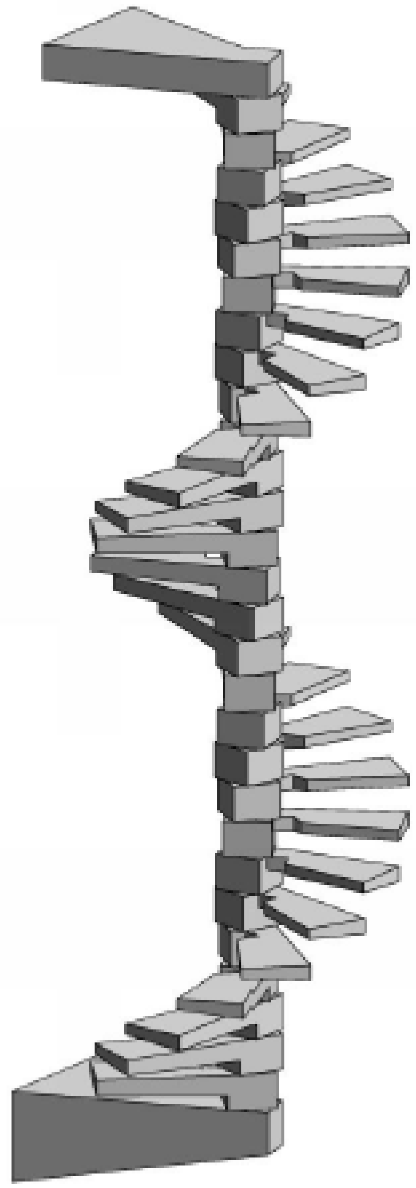


Image 1 - The 3D modeled geometry of the stair in REVIT.

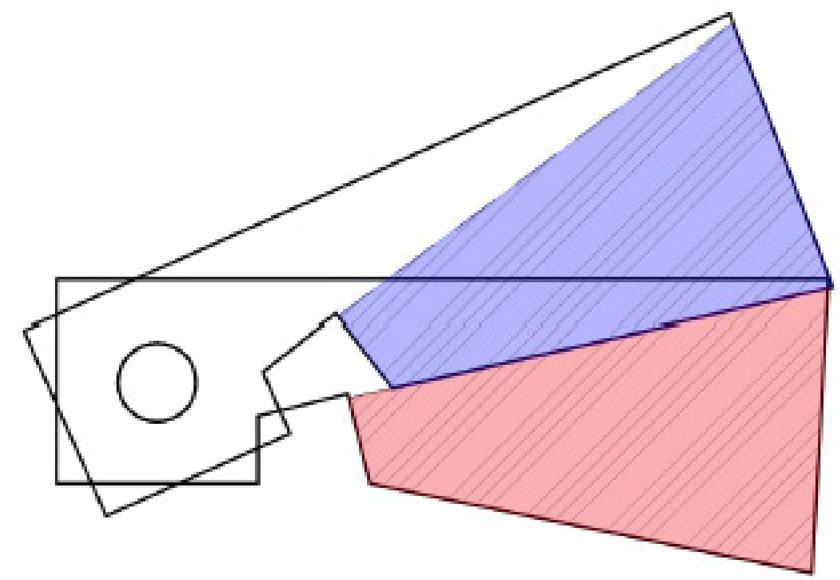
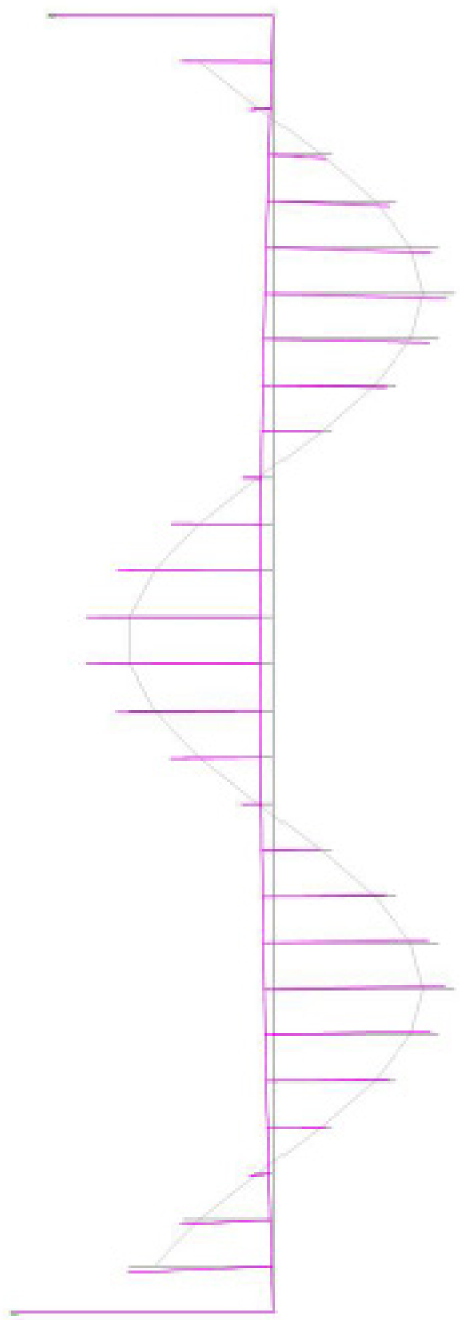
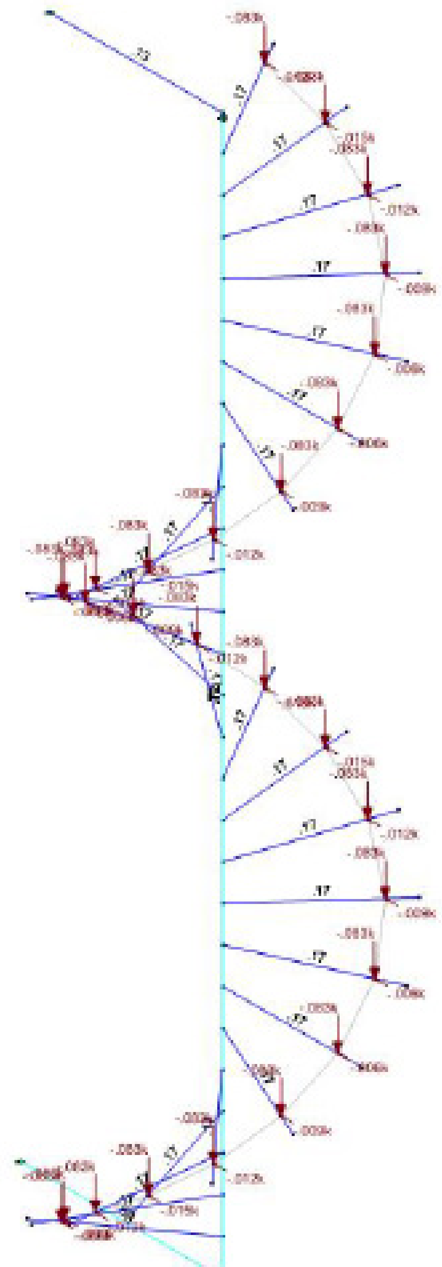


Image 2 - The stair tread plan – showing the area of the tread that can receive live load of people walking up it – one tread area is red, another blue.





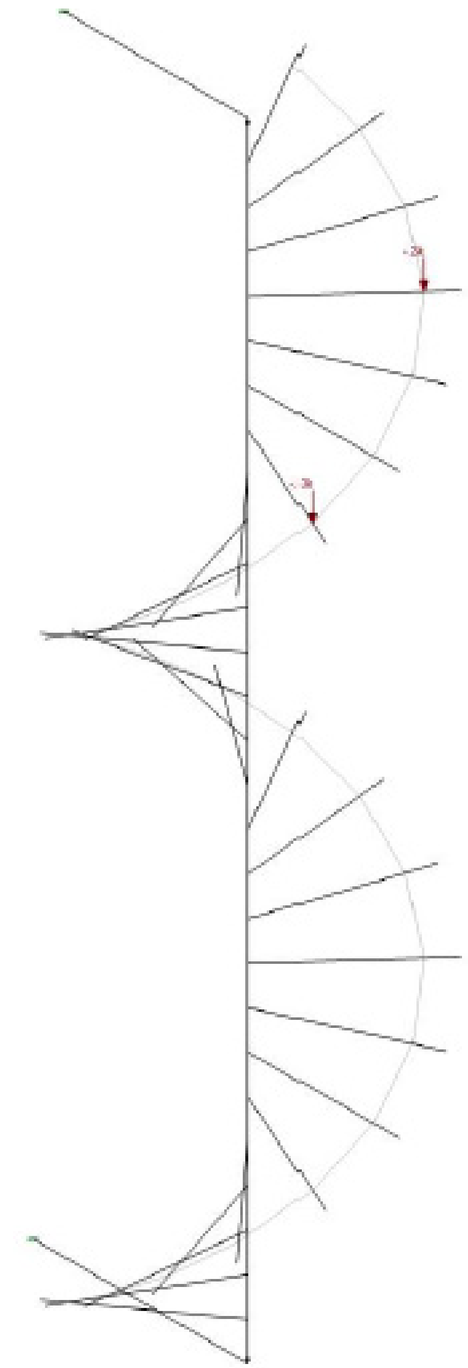


Image 3 – Side Elevation with upper and lower landing supports on the left of the image. The original location's un-deflected shape with no load is in blue, the deflected shape is in pink.

Image 4 – Isometric view with upper and lower landing supports on the left of the image. This shows the maximum live loads on each tread. The numbers represent the stress in the members on a scale of Zero to One (with One being maximum allowed stress).

Image 5 – Isometric view with upper and lower landing supports on the left of the image. This shows the maximum concentrated dynamic moving live load combination on the stair.

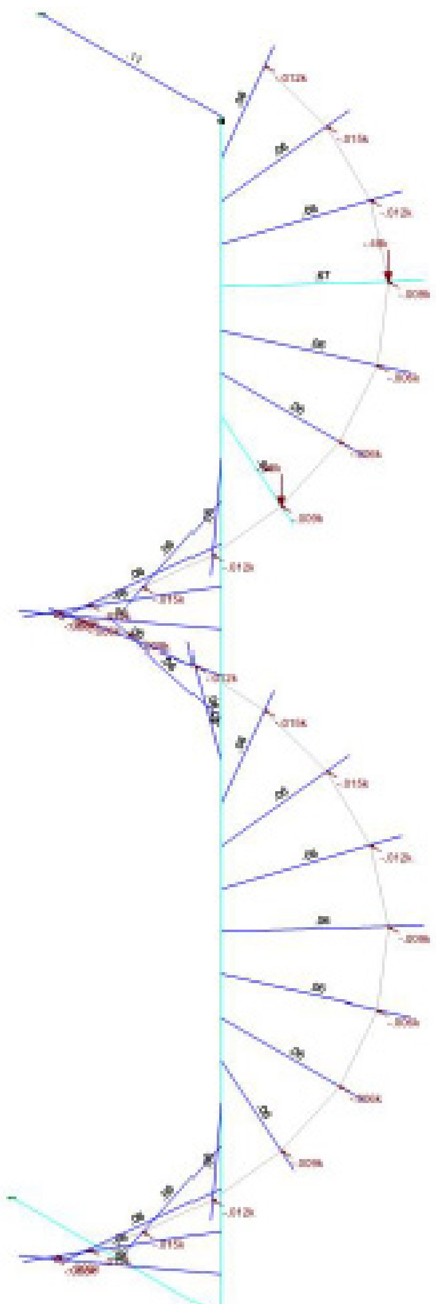


Image 6 – Isometric view with upper and lower landing supports on the left of the image. This shows the maximum concentrated dynamic moving live load combination on the stair. The numbers represent the stress in the members on a scale of Zero to One (with One being maximum allowed stress).

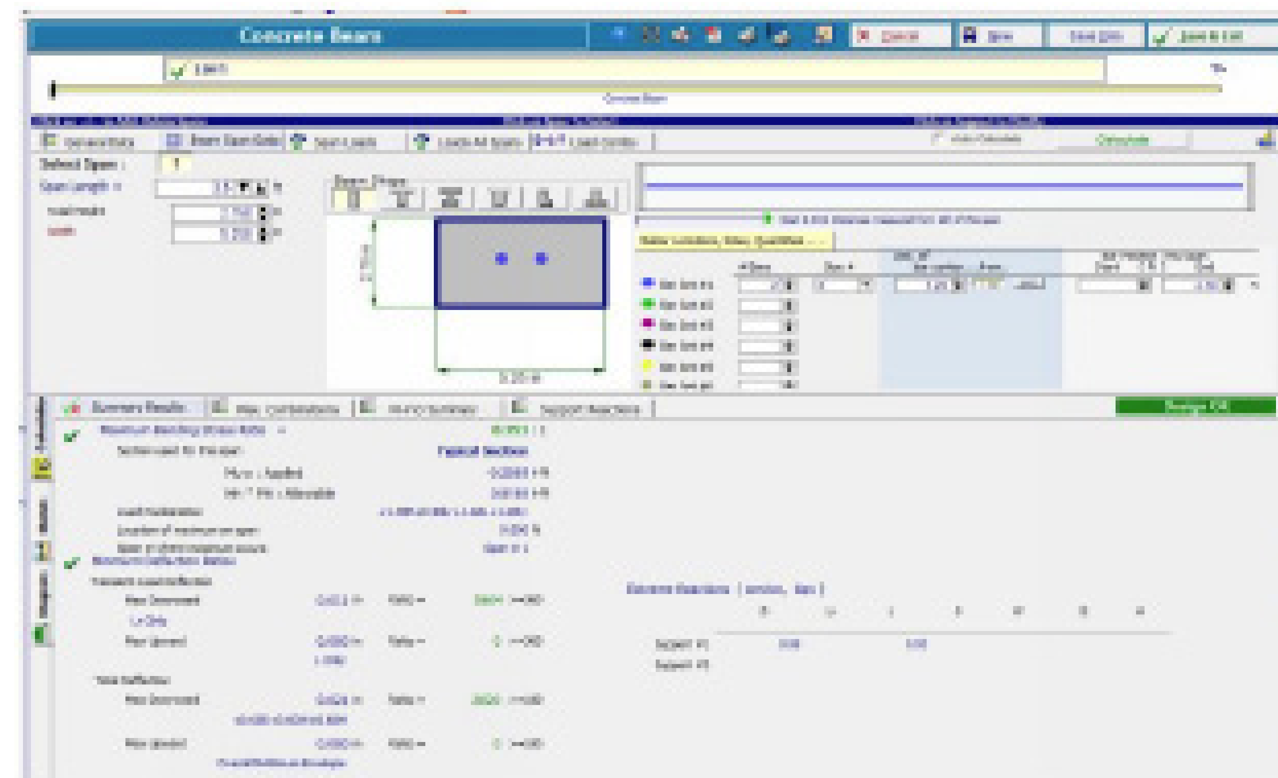


Image 7 – Enercalc software check of minimum section of the precast concrete stair tread.

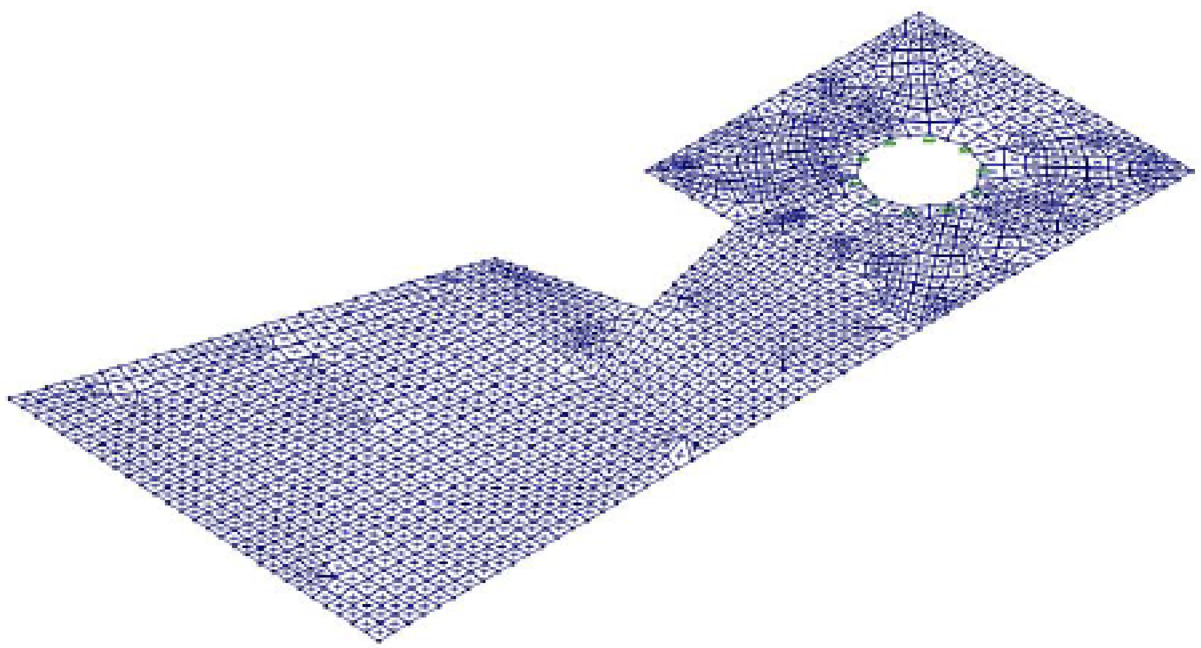


Image 8 – Isometric view of stair tread modeled as a Finite Element plate element. This shows the Finite Element mesh used to model the intricate tread geometry.

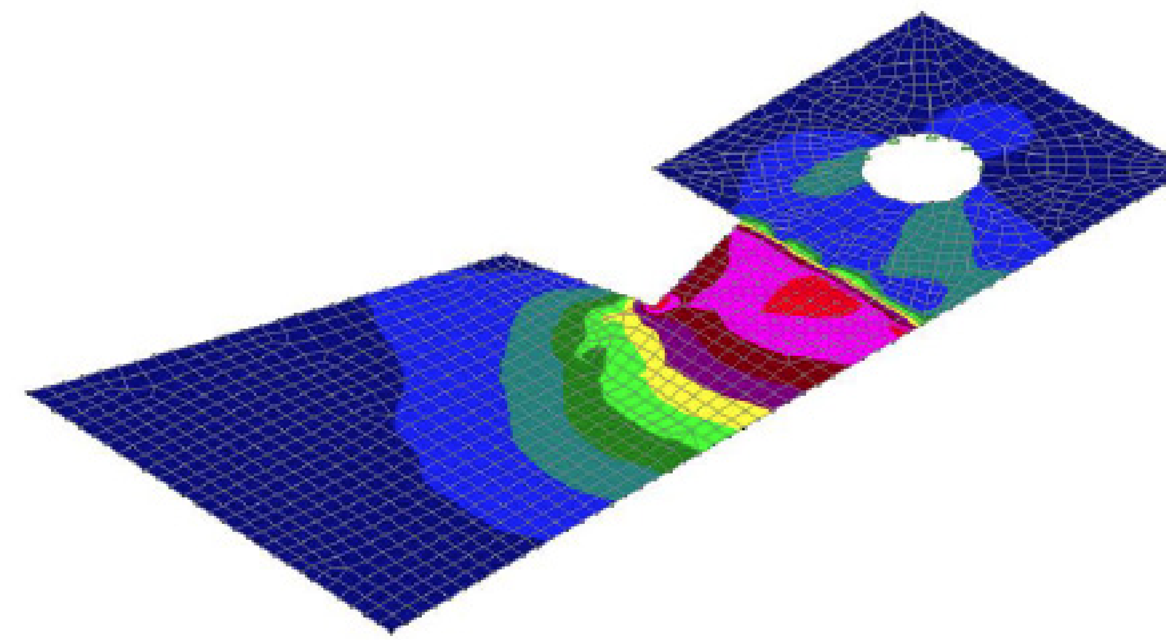


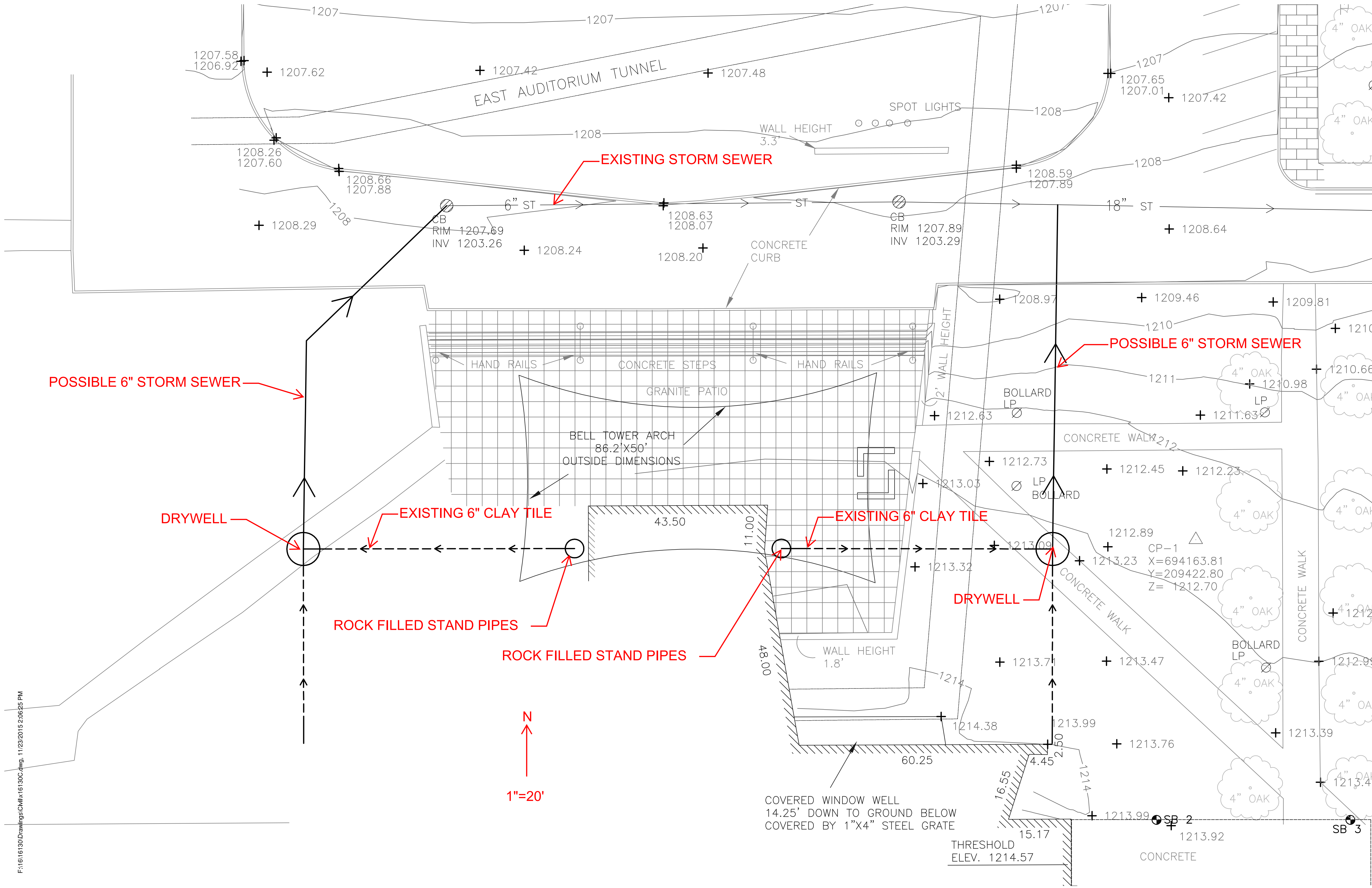
Image 9 – Isometric view of stair tread modeled as a Finite Element plate element. This shows the bending stress contours under dead and live load for the intricate tread geometry.

Bell Banner

Drywells and Drains

The roof scuppers of the bell tower drain into 5-foot diameter rock filled standpipes located directly below the scuppers. Each of the two standpipes is connected by clay tile to drywell structures located both east and west of the granite stairs. The drywells currently appear to be located under existing sidewalks that run diagonally through the landscape.

The two drywells could be connected by 6-inch diameter pipes to the existing storm sewer located in the Abbey's loop road, directly north of the granite plaza and stairs. The existing storm sewer drains east and then southwest around the Guesthouse into the Guesthouse pond/rain garden. Sidewalks, concrete curbs, asphalt paving and landscaped lawns would be disturbed due to the proposed sewer trenching.



EAST AUDITORIUM TUNNEL
EXISTING STORM SEWER
POSSIBLE 6" STORM SEWER
POSSIBLE 6" STORM SEWER
DRYWELL
DRYWELL
EXISTING 6" CLAY TILE
EXISTING 6" CLAY TILE
ROCK FILLED STAND PIPES
ROCK FILLED STAND PIPES
6" ST
18" ST
CB RIM 1207.69 INV 1203.26
CB RIM 1207.89 INV 1203.29
CONCRETE CURB
SPOT LIGHTS
WALL HEIGHT 3.3'
HAND RAILS
CONCRETE STEPS
HAND RAILS
GRANITE PATIO
BELL TOWER ARCH 86.2'X50' OUTSIDE DIMENSIONS
2' WALL HEIGHT
BOLLARD LP
CONCRETE WALK
LP BOLLARD
CP-1 X=694163.81 Y=209422.80 Z= 1212.70
CONCRETE WALK
CONCRETE WALK
BOLLARD LP
WALL HEIGHT 1.8'
43.50
11.00
48.00
60.25
4.45
2.50
16.55
15.17
COVERED WINDOW WELL 14.25' DOWN TO GROUND BELOW COVERED BY 1"X4" STEEL GRATE
THRESHOLD ELEV. 1214.57
CONCRETE
SB 2
SB 3
4" OAK
N
1"=20'
F:\16\16130\Drawings\Civil\x16130C.dwg, 11/23/2015 2:06:25 PM

Bell Banner

PLAZA

Artistic Stone

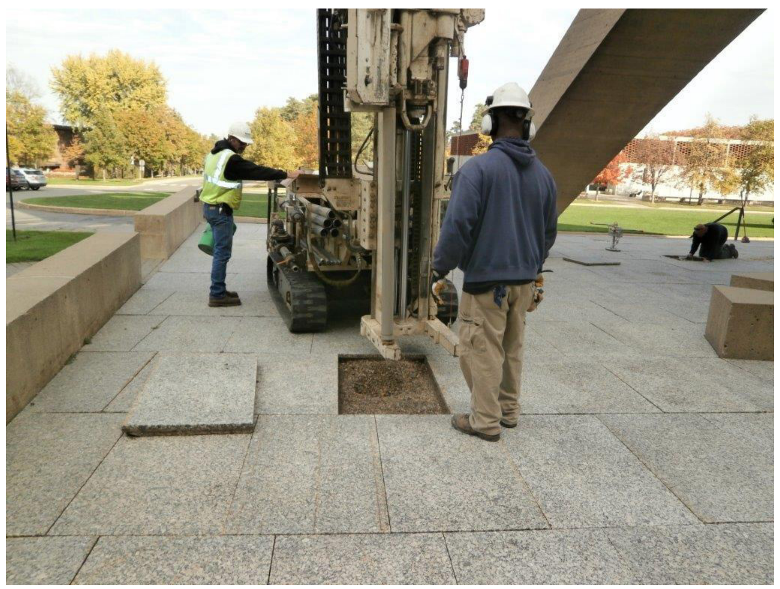
The following information is our recommendations of the steps and procedures for the restoration of the St. John's Abbey stairs and plaza area. This is based on best industry practices, Braun Engineering geotechnical evaluation report, visual analysis, and our expertise. Investigative work to date involved removing pavers for soil testing drill rig. A total of eight pavers were moved and due to unknown concrete obstructions only two test holes were completed successfully.

The third hole and other attempts met refusal from the auger. Drawings that show the location and extent of the concrete have not been found to date. It is recommended that a contingency be included for some subsurface obstructions. In addition to the current investigation, Mike Guggengerger has performed corrective work six times on the plaza re-leveling tipped pavers and performing patching work on the stair treads.

Step One:
Remove all pavers, tag and label custom pieces, and palletize for storage on site. Identify cracked and broken pieces, so replacements that match color and texture can be ordered.

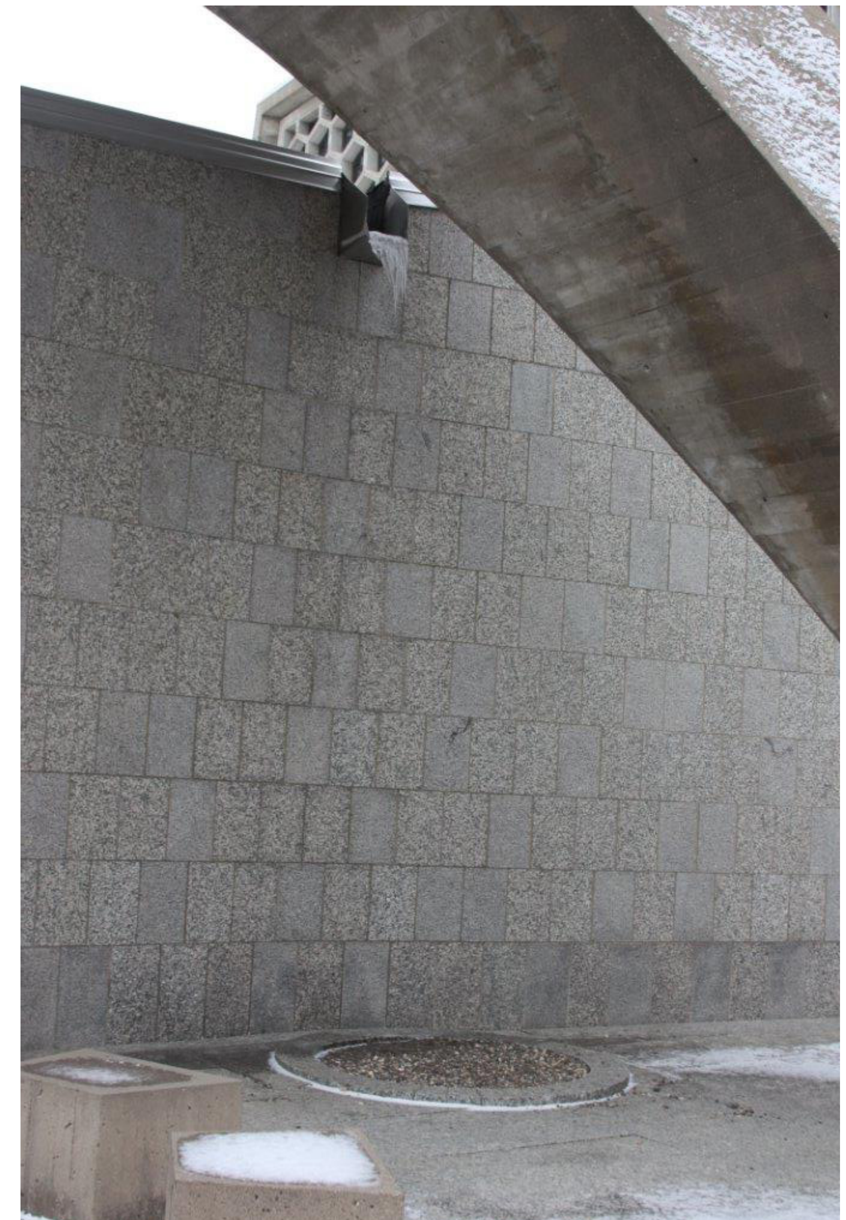
Step Two:
Label stairs for exact location prior to removal. Remove stairs and properly store for future installation. Identify and order replacement stairs for broken treads. If existing stair treads have rough-back quarried finish then sawing or milling may be necessary to create a flat surface for re-installation.






Step Three:
Excavate soil per Braun Intertec recommendations. This will involve removing 7–9 feet of soil. Verification of existing foundation and drainage piping elevations will have to be monitored during this work. Actual depth of excavation to be verified by testing company to ensure proper soils are reached. Verify existing concrete foundation work for stairs and determine what needs to be replaced or modified.

Step Four:
Install new storm water drainage system and connect to storm water system in street. This will replace the existing dry wells and collect the roof water from existing scuppers. Collection of water and prevention of soils from being saturated is critical to minimize long-term maintenance and failures.

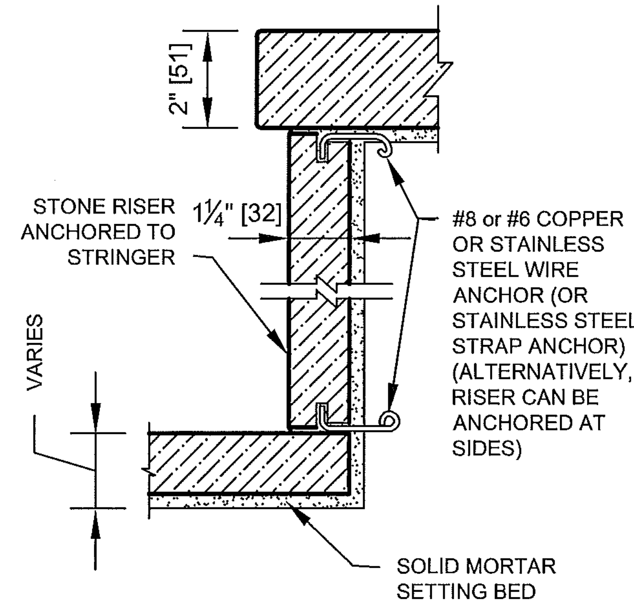


Step Five:
Backfill with structural fill in lifts and test for compaction.

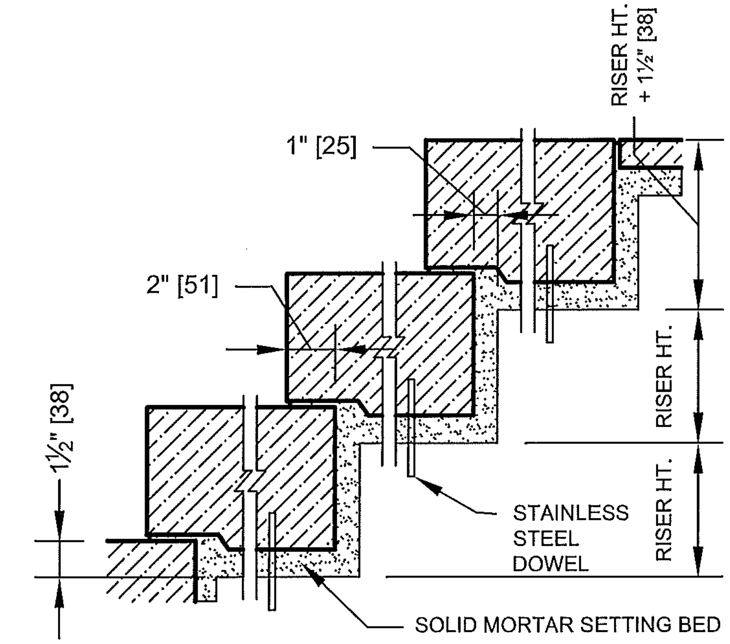
Step Six:
Place concrete stair and paving sub – slabs at proper elevation for finished granite elevations. Coordinate expansion and contraction joints in sub – slab with layout for granite dimensions.

Step Seven:
Reset steps on full mortar bed with stainless steel pins.

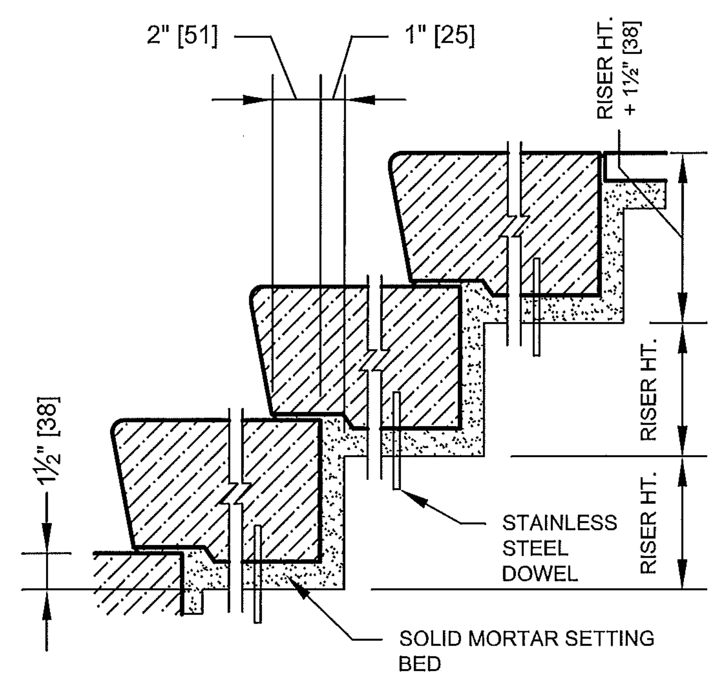
Step Eight:
Reset pavers on full mortar bed with membrane and grouted expansion joints.



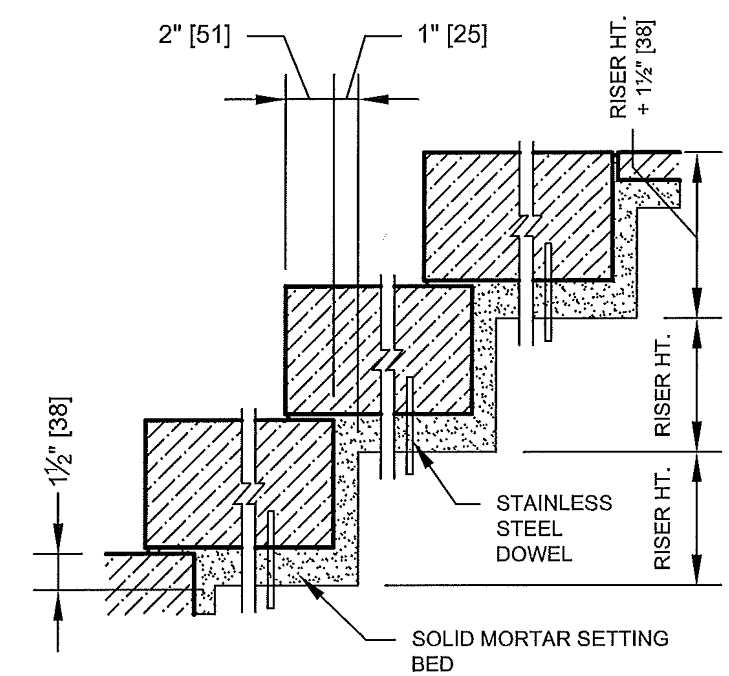
1 VENEERED STEP DETAIL
SCALE: 3" = 1'-0" (1:4)



2 CUBIC STEP DETAIL
SCALE: 1½" = 1'-0" (1:8)

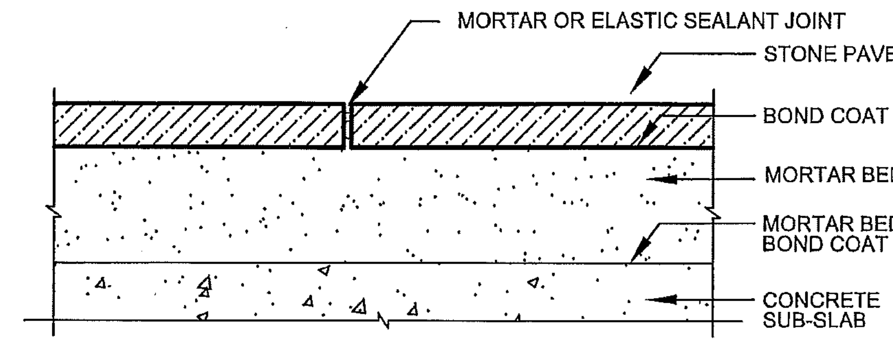


3 CUBIC STEP DETAIL
SCALE: 1½" = 1'-0" (1:8)

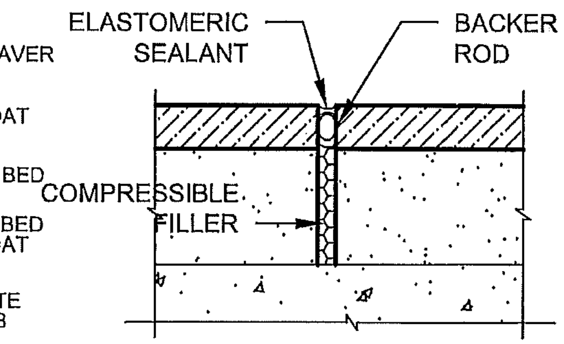


4 CUBIC STEP DETAIL
SCALE: 1½" = 1'-0" (1:8)

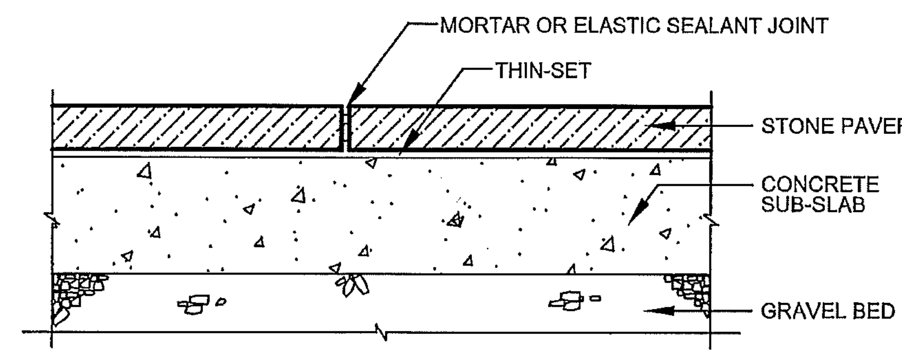
NOTES:
1. *A ROUGH OR TEXTURED FINISH IS RECOMMENDED FOR EXTERIOR USAGE.*
2. *MINIMUM ABRASION RESISTANCE OF 12.0 (TESTED PER ASTM C 241) IS RECOMMENDED FOR STONE TREADS.*



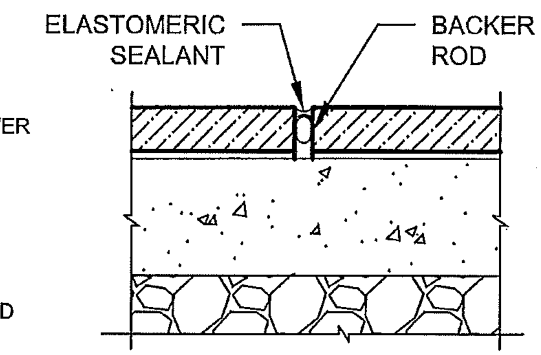
(1) MORTAR BED WITH BOND COAT



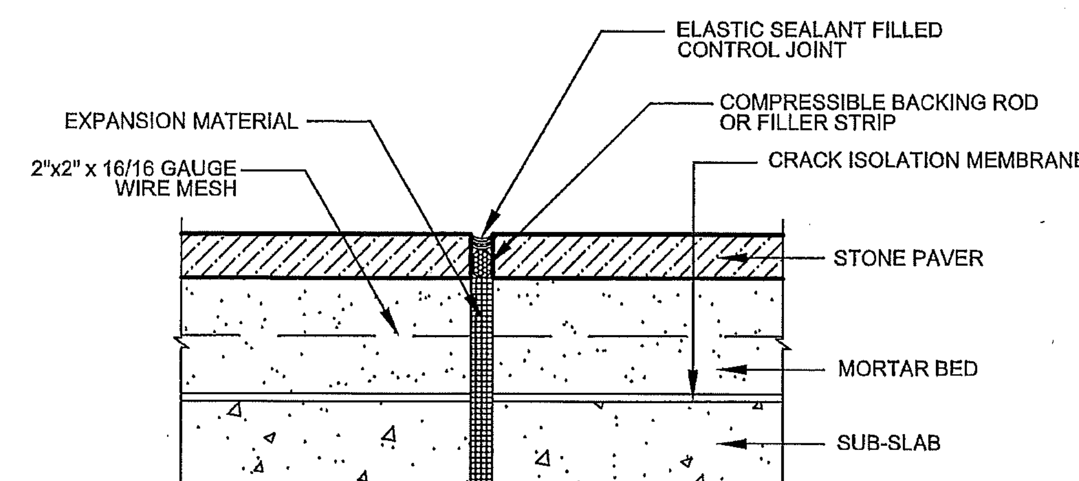
(1A) MOVEMENT JOINT



(2) MORTAR BED WITH THINSET

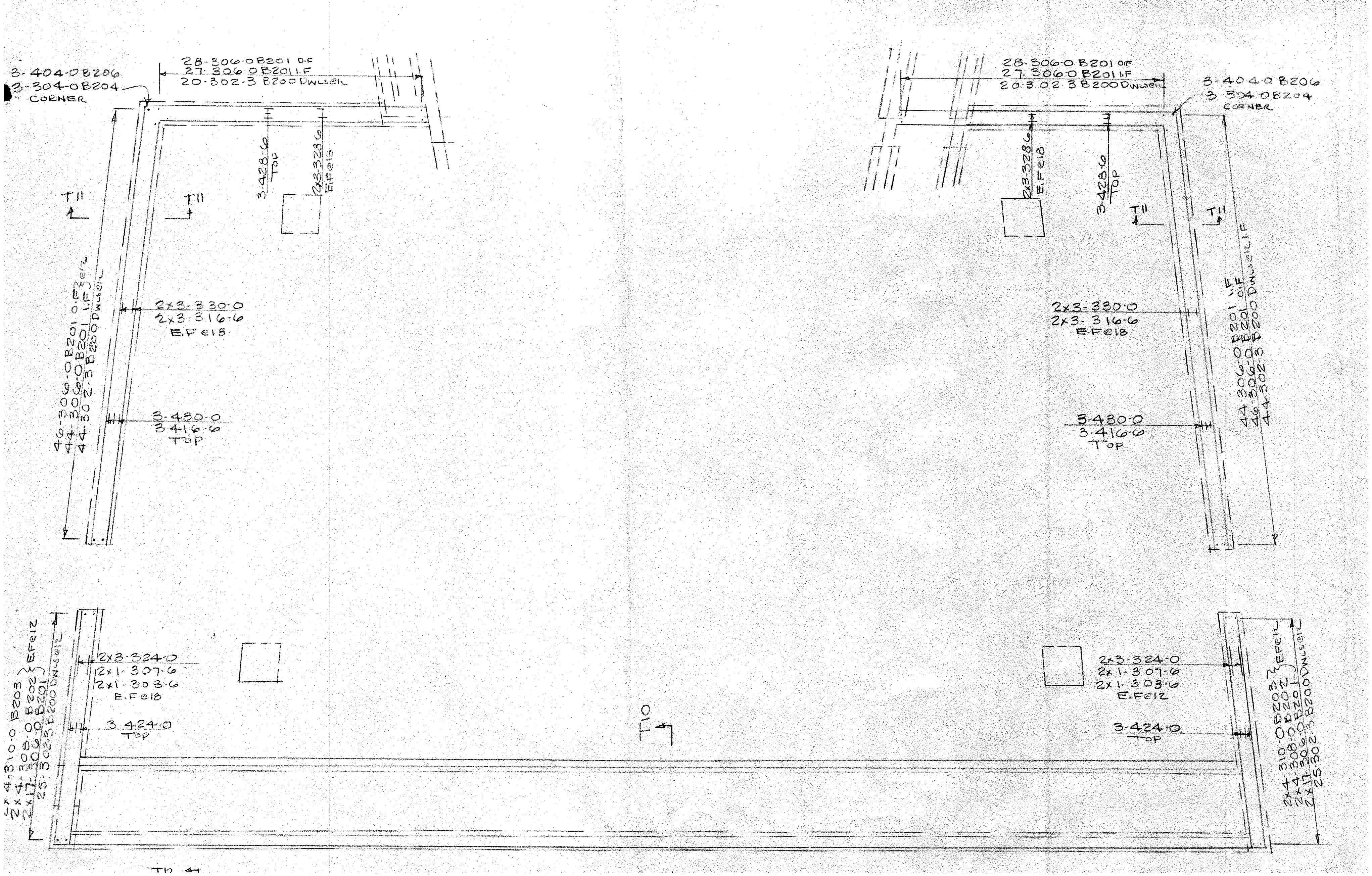


(2A) MOVEMENT JOINT

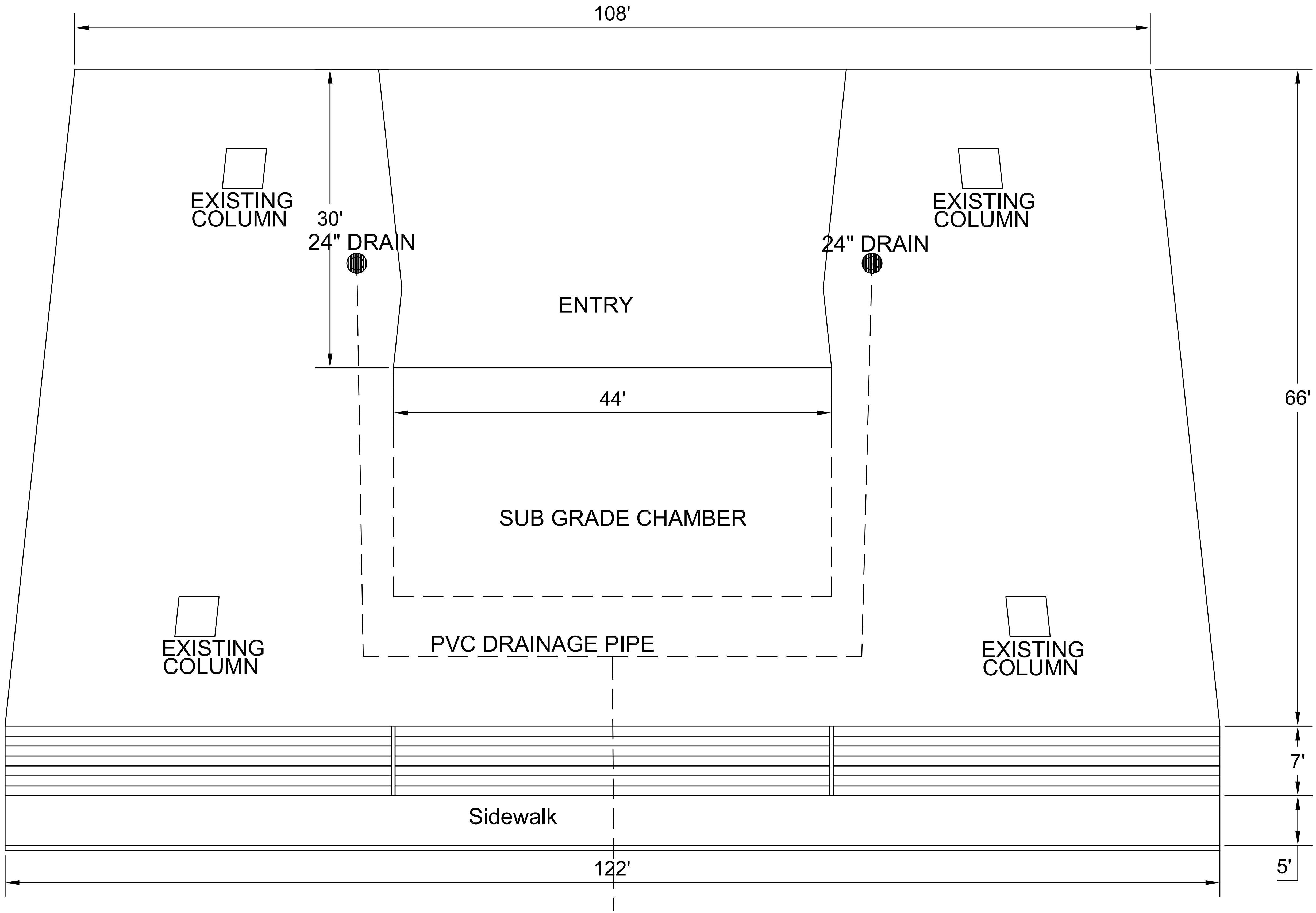


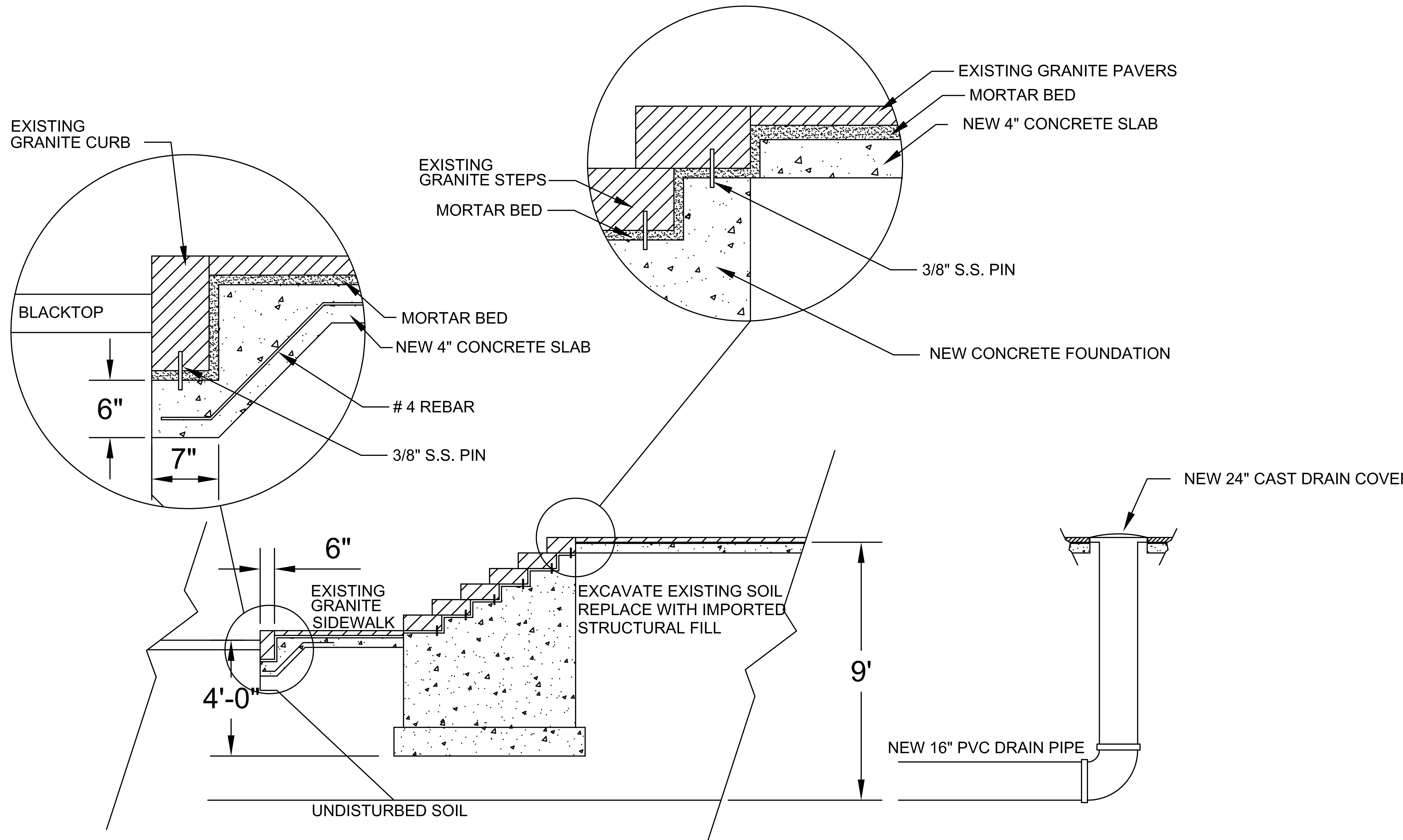
(3) FULL MORTAR BED WITH MEMBRANE AND EXPANSION JOINT

***NOTE:** IT IS NOT THE INTENT OF THIS MANUAL TO MAKE EXPANSION, CONTROL, OR MOVEMENT JOINT RECOMMENDATIONS FOR A SPECIFIC PROJECT. THE SPECIFYING AUTHORITY MUST DESIGN AND LOCATE EXPANSION, CONTROL, AND MOVEMENT JOINTS ON THE CONSTRUCTION DOCUMENTS.*



Extract from original Bethlehem Steel shop drawings.


108'
30'
EXISTING COLUMN
24" DRAIN
EXISTING COLUMN
24" DRAIN
ENTRY
44'
66'
SUB GRADE CHAMBER
EXISTING COLUMN
PVC DRAINAGE PIPE
EXISTING COLUMN
7'
Sidewalk
122'
5'


EXISTING GRANITE PAVERS
MORTAR BED
NEW 4" CONCRETE SLAB
EXISTING GRANITE STEPS
MORTAR BED
3/8" S.S. PIN
NEW CONCRETE FOUNDATION
EXISTING GRANITE CURB
BLACKTOP
MORTAR BED
NEW 4" CONCRETE SLAB
4 REBAR
3/8" S.S. PIN
6"
7"
NEW 24" CAST DRAIN COVER
6"
EXISTING GRANITE SIDEWALK
EXCAVATE EXISTING SOIL REPLACE WITH IMPORTED STRUCTURAL FILL
4'-0"
9'
NEW 16" PVC DRAIN PIPE
UNDISTURBED SOIL

Introduction

This Geotechnical Evaluation Report addresses reconstruction of the stone plaza at the St. John's Abbey. The project consists of reconstructing the existing paver plaza in front of the church. The purpose of our geotechnical evaluation will be to characterize subsurface geologic conditions at selected exploration locations and evaluate their impact on the design and reconstruction of the plaza.

Site Conditions

The existing plaza is paved with granite stone pavers. Each paver has dimensions of about 2-feet by 3- feet. Mr. Mike Guggenberger, Artistic Stone and Concrete, indicated the pavers experience continual movement, tipping, and occasionally crack. They all cause tripping hazards. The plaza is elevated about 3 feet above the drive and parking areas to the west, and is accessed with granite stairs.

Scope of Services

Tasks performed in accordance with our authorized scope of services included:

- Performing a reconnaissance of the site to evaluate equipment access to exploration locations.
- Coordinating the locating of underground utilities near the borings.
- Performing 3 penetration test borings to a depth of 15 feet each.
- Performing laboratory percent-passing-200-sieve tests on selected penetration test samples.
- Preparing this report containing a sketch, exploration logs, a summary of the geologic materials encountered, results of laboratory tests, and recommendations for supporting the pavers and reducing the frost heave.

Boring Locations

Exploration locations were chosen in the field by Mr. Guggenberger and the drill crew. Approximate locations are shown on the sketch in the appendix of this report.
Log of Boring sheets for our penetration test borings are included in the Appendix. The logs identify and describe the geologic materials that were penetrated, and present the results of penetration resistance tests performed within them and groundwater measurements.

Strata boundaries were inferred from changes in the penetration test samples and the auger cuttings. Because sampling was not performed continuously, the strata boundary depths are only approximate. The boundary depths likely vary away from the boring locations, and the boundaries themselves may also occur as gradual rather than abrupt transitions.

Geologic Origins

Geologic origins assigned to the materials shown on the logs and referenced within this report were based on: (1) a review of the background information and reference documents cited above, (2) visual classification of the various geologic material samples retrieved during the course of our subsurface exploration, (3) penetration resistance testing performed for the project, (4) laboratory test results, and(5) available common knowledge of the geologic processes and environments that have impacted thesite and surrounding area in the past.

Geologic Profile

Geologic Materials

The general geologic profile at the site consists of 7 to 9 feet of existing fill soils underlain by silty sand and poorly graded sand. The existing fill soils generally consisted of clayey sand. Penetration resistances in the fills ranged from 1 to 8 blows per foot (BPF), indicating they were very soft to medium consistency and generally not very well compacted. Penetration resistances in the silty sand and sands ranged from 5 to 19 BPF, indicating they ranged from loose to medium dense.

Groundwater

Groundwater was not observed as our borings were advanced. Based on the moisture contents of the geologic materials encountered, it appears that groundwater was below the depths explored.

Seasonal and annual fluctuations of groundwater, however, should be anticipated.

Laboratory Test Results

We selected several penetration test samples and determined the percent-passing-200-sieve of the samples. Our mechanical analyses indicated that the fill soils contained 21 to 30 percent silt and clay byweight.

Basis for Recommendations

Design Details

Proposed Construction

Mr. Guggenberger indicated the project will consist of removing the pavers, placing a concrete slab and setting the pavers in a mortar. Elevations of the pavers will not change. Subgrade corrections will be completed as necessary to limit movement of the slab.

Precautions Regarding Changed Information

We have attempted to describe our understanding of the proposed construction to the extent it was reported to us by others. Depending on the extent of available information, assumptions may have beenmade based on our experience with similar projects. If we have not correctly recorded or interpreted the project details, we should be notified. New or changed information could require additional evaluation, analyses and/or recommendations.

Design and Construction Considerations

Based on the penetration resistances, the existing fill soils appear to be poorly compacted. Based on the laboratory test results, they are also frost-susceptible.

Uncompacted fill soils can consolidate under loads or when they become saturated. The consolidation is typically not uniform. Frost-susceptible soils will heave when they become saturated and freeze.

To reduce the potential for settlement and frost heave, we recommend removing the existing fill soils and replacing them with nonfrost-susceptible sands. Recommendations are presented below in Section D.

Recommendations

Subgrade Preparation

Excavations

We recommend removing the existing fill from below the pavers and steps. Based on the borings, excavation depths are expected to range from approximately 7 to 9 feet.

Excavation depths will vary between the borings. Portions of the excavations may also be deeper than indicated by the borings. Contractors should also be prepared to extend excavations in wet or fine- grained soils to remove disturbed bottom soils.

To provide lateral support to replacement backfill, additional required fill and the structural loads they will support, we recommend oversizing (widening) the excavations 1 foot horizontally beyond the outer edges of the building perimeter footings, or pavement limits, for each foot the excavations extend below bottom-of-footing or pavement subgrade elevations.

Selecting Excavation Backfill and Additional Required Fill

We recommend backfilling with coarse sand having less than 50 percent of the particles by weight passing a #40 sieve, and less than 5 percent of the particles passing a #200 sieve. We anticipate that this material will need to be imported.

Placement and Compaction of Backfill and Fill

We recommend spreading backfill and fill in loose lifts of approximately 12 inches. We recommend compacting backfill and fill to a minimum of 95 percent of its standard Proctor determined in accordance with ASTM International Test Method D698.

Drainage

The bottom of the excavation should be sloped toward one or more collection points so that any water entering the backfill can be collected and removed. A series of perforated drainpipes will need to be installed to collect and dispose of the infiltrating water and/or groundwater that could accumulate within the backfill. The piping should be connected to a storm sewer or a sump to remove any accumulated water, or "day lighted" if grades permit. If the water is not removed, it is our opinion this option will not
be effective in controlling heave.
An important geometric aspect of the excavation and replacement approach described above is sloping the banks of the excavations to create a more gradual transition between the unexcavated soils considered to be frost-susceptible and the excavation backfill which is not, to attenuate differential movement that may occur along the excavation boundary. We recommend 3:1 (horizontal:vertical) banks along transitions between frost-susceptible and non-frost-susceptible soils.

Crack Maintenance

Regardless of what is done to the walkway or pavement area subgrade, it will be critical the end-user develop a detailed maintenance program to seal and/or fill any cracks and joints that may develop during the useful life of the various surface features. Concrete and bituminous will experience episodes of normal thermo-expansion and thermo-contraction during its useful life. During this time, cracks may develop and joints may open up, which will expose the subgrade and allow any water flowing overland to enter the subgrade and either saturate the subgrade soils or to become perched atop it. This occurrence increases the potential for heave due to freezing conditions in the general vicinity of the crack or joint. This type of heave has the potential to become excessive if not addressed as part of a maintenance program. Special attention should be paid to areas where dissimilar materials abut one another, where construction joints occur and where shrinkage cracks develop.

Construction Quality Control

Excavation Observations
We recommend having a geotechnical engineer observe all excavations related to subgrade preparation. The purpose of the observations is to evaluate the competence of the geologic materials exposed in the excavations, and the adequacy of required excavation oversizing.

Materials Testing
We recommend density tests be taken in excavation backfill and additional required fill placed below slabs. We also recommend slump, air content and strength tests of Portland cement concrete.

Cold Weather Precautions
If site grading and construction is anticipated during cold weather, all snow and ice should be removed from cut and fill areas prior to additional grading. No fill should be placed on frozen subgrades. No frozen soils should be used as fill.

Concrete delivered to the site should meet the temperature requirements of ASTM C 94. Concrete should not be placed on frozen subgrades. Concrete should be protected from freezing until the necessary strength is attained. Frost should not be permitted to penetrate below footings.

Procedures

Penetration Test Borings
The penetration test borings were drilled with a geoprobe-mounted core and auger drill. Penetration test samples were taken at 2 1/2-foot intervals. Actual sample intervals and corresponding depths are shown on the boring logs.

Material Classification and Testing

Visual and Manual Classification
The geologic materials encountered were visually and manually classified in accordance with ASTM Standard Practice D 2488. A chart explaining the classification system is attached. Samples were placed in jars or bags and returned to our facility for review and storage.

Laboratory Testing
The results of the laboratory tests performed on geologic material samples are noted on or follow the appropriate attached exploration logs. The tests were performed in accordance with ASTM or AASHTOprocedures.

Groundwater Measurements
The drillers checked for groundwater as the penetration test borings were advanced. The boreholes were then backfilled as noted on the boring logs.

Qualifications

Variations in Subsurface Conditions

Material Strata
Our evaluation, analyses and recommendations were developed from a limited amount of site and subsurface information. It is not standard engineering practice to retrieve material samples from exploration locations continuously with depth, and therefore strata boundaries and thicknesses must be inferred to some extent. Strata boundaries may also be gradual transitions, and can be expected to vary in depth, elevation and thickness away from the exploration locations.

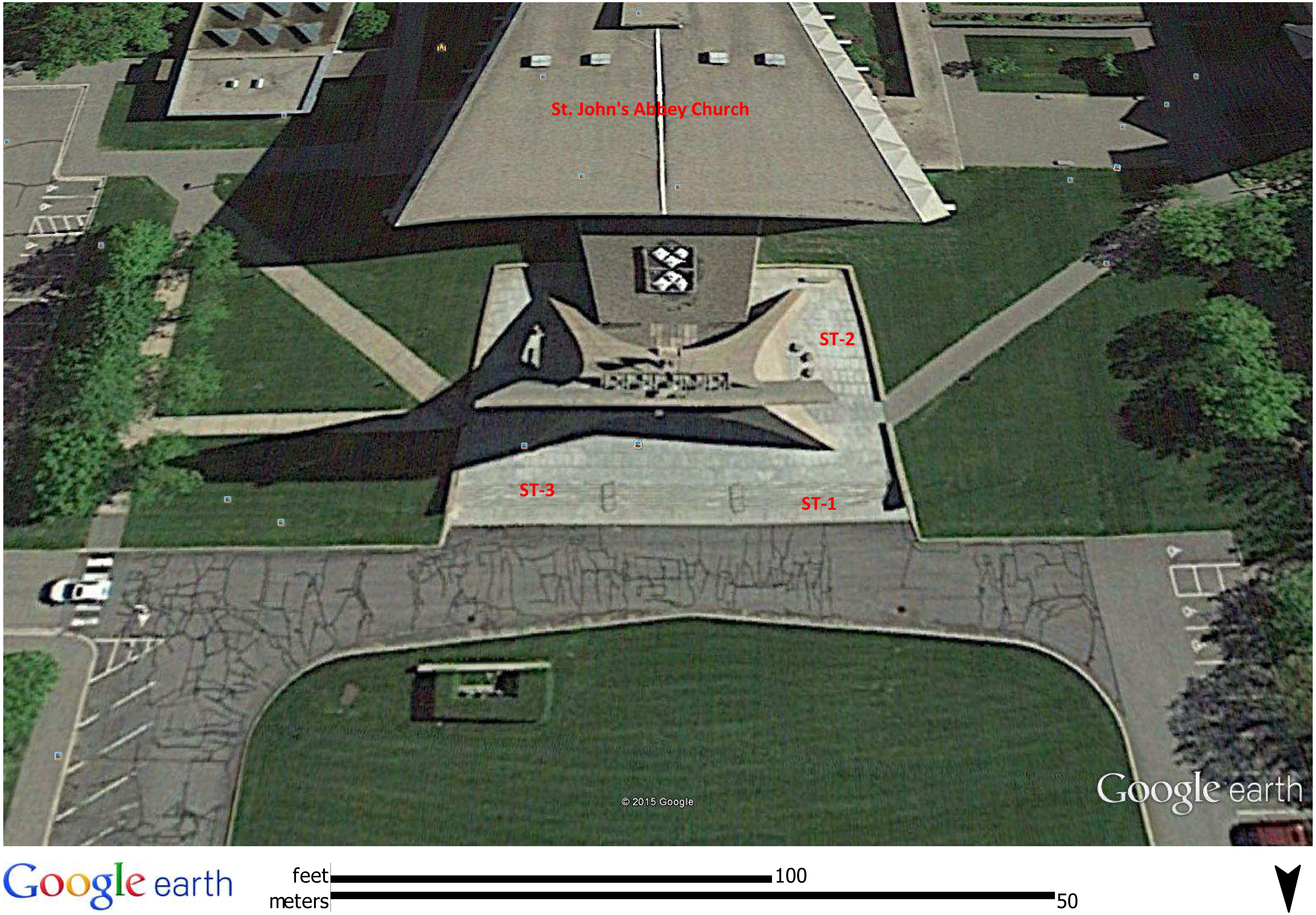
Variations in subsurface conditions present between exploration locations may not be revealed until additional exploration work is completed, or construction commences. If any such variations are revealed, our recommendations should be re-evaluated. Such variations could increase construction costs, and a contingency should be provided to accommodate them.

Groundwater Levels
Groundwater measurements were made under the conditions reported herein and shown on the exploration logs, and interpreted in the text of this report. It should be noted that the observation periods were relatively short, and groundwater can be expected to fluctuate in response to rainfall, flooding, irrigation, seasonal freezing and thawing, surface drainage modifications and other seasonal and annual factors.

Continuity of Professional Responsibility

Plan Review
This report is based on a limited amount of information, and a number of assumptions were necessary to help us develop our recommendations. It is recommended that our firm review the geotechnical aspects of the designs and specifications, and evaluate whether the design is as expected, if any
design changes have affected the validity of our recommendations, and if our recommendations have been correctly interpreted and implemented in the designs and specifications.

Construction Observations and Testing
It is recommended that we be retained to perform observations and tests during construction. This will allow correlation of the subsurface conditions encountered during construction with those encountered by the borings, and provide continuity of professional responsibility.



- Denotes approximate soil boring location

BRAUN INTERTEC

LOG OF BORING

Braun Project B1509390
Geotechnical Evaluation
St. Johns Abbey Stone Plaza
Fruit Farm Road
Collegeville, Minnesota

BORING: **ST-1**

LOCATION: See sketch.

DRILLER: M. Barber	METHOD: 3 1/4" HSA, Autohammer	DATE: 10/19/15	SCALE: 1" = 4'

Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	P200	Tests or Notes
1.0	FILL	FILL: Poorly Graded Sand, with Gravel, brown, moist.			1.7	
7.0	FILL	FILL: Clayey Sand, with Gravel, brown, moist, soft to rather soft.	5		21.4	
			3			
14.0	SM	SILTY SAND, fine-grained, with Gravel, brown, moist, loose to medium dense. (Glacial Till)	5			
			14			
			13			
15.0	SP	POORLY GRADED SAND, fine- to medium-grained, with Silt lenses, brown, moist, medium dense. (Glacial Outwash)	19			
		END OF BORING. Water not observed while drilling. Boring then backfilled.				

(See Descriptive Terminology sheet for explanation of abbreviations)

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BRAUN INTERTEC

LOG OF BORING

Braun Project B1509390
Geotechnical Evaluation
St. Johns Abbey Stone Plaza
Fruit Farm Road
Collegeville, Minnesota

BORING: **ST-2**

LOCATION: See sketch.

DRILLER: M. Barber	METHOD: 3 1/4" HSA, Autohammer	DATE: 10/19/15	SCALE: 1" = 4'

Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	P200	Tests or Notes
1.0	GP	Gravel.				
9.0	FILL	FILL: Clayey Sand, with Gravel, brown, moist, medium to very soft. (Glacial Till)	8		29.6	
			7		23.0	
			1			No recovery.
15.0	SM	SILTY SAND, fine- to medium-grained, with Gravel, brown, moist, medium dense. (Glacial Till)	17			
			11			
			16			
		END OF BORING. Water not observed while drilling. Boring then backfilled.				

(See Descriptive Terminology sheet for explanation of abbreviations)

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BRAUN INTERTEC

LOG OF BORING

Braun Project B1509390 Geotechnical Evaluation St. Johns Abbey Stone Plaza Fruit Farm Road Collegeville, Minnesota	BORING: **ST-3** LOCATION: See sketch.	
DRILLER: M. Barber	METHOD: 3 1/4" HSA, Autohammer	DATE: 10/19/15 SCALE: 1" = 4'

Depth feet 0.0	Symbol	Description of Materials (Soil-ASTM D2488 or D2487, Rock-USACE EM1110-1-2908)	BPF	WL	Tests or Notes
1.0	FILL	FILL: Poorly Graded Sand, fine- to medium-grained, with Gravel, brown, moist.			
2.5	FILL	FILL: Silty Sand, fine- to medium-grained, brown, moist.			
		Boring terminated upon refusal.			

(See Descriptive Terminology sheet for explanation of abbreviations)

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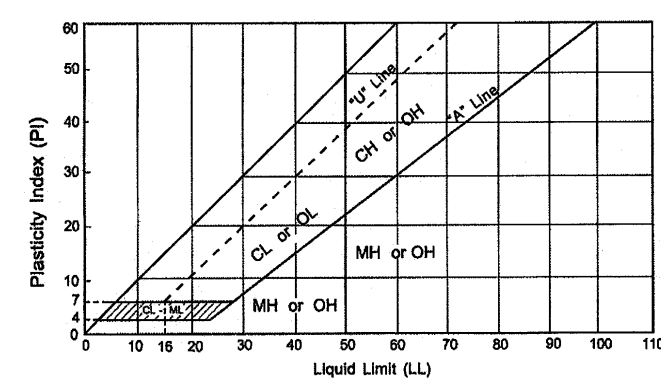
BRAUN INTERTEC

Descriptive Terminology of Soil

Standard D 2487
Classification of Soils for Engineering Purposes
(Unified Soil Classification System)

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [a]				Soils Classification: Group Symbol	Group Name [b]
Coarse-grained Soils more than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines [e]	$C_u \geq 4$ and $1 \leq C_c \leq 3$ [c]	GW	Well-graded gravel [d]
			$C_u < 4$ and/or $1 > C_c > 3$ [c]	GP	Poorly graded gravel [d]
		Gravels with Fines More than 12% fines [e]	Fines classify as ML or MH	GM	Silty gravel [d f g]
			Fines classify as CL or CH	GC	Clayey gravel [d f g]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines [i]	$C_u \geq 6$ and $1 \leq C_c \leq 3$ [c]	SW	Well-graded sand [h]
			$C_u < 6$ and/or $1 > C_c > 3$ [c]	SP	Poorly graded sand [h]
		Sands with Fines More than 12% [i]	Fines classify as ML or MH	SM	Silty sand [f g h]
			Fines classify as CL or CH	SC	Clayey sand [f g h]
Fine-grained Soils 50% or more passed the No. 200 sieve	Silts and Clays Liquid limit less than 50	Inorganic	PI > 7 and plots on or above "A" line [j]	CL	Lean clay [k l m]
			PI < 4 or plots below "A" line [j]	ML	Silt [k l m]
		Organic	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OL	Organic clay [k l m n]
				OL	Organic silt [k l m o]
	Silts and clays Liquid limit 50 or more	Inorganic	PI plots on or above "A" line	CH	Fat clay [k l m]
			PI plots below "A" line	MH	Elastic silt [k l m]
		Organic	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OH	Organic clay [k l m p]
				OH	Organic silt [k l m q]
Highly Organic Soils	Primarily organic matter, dark in color and organic odor			PT	Peat

a. Based on the material passing the 3-inch (75mm) sieve.
b. If field sample contained cobbles or boulders, or both, add "with cobbles or boulders or both" to group name.
c. $C_u = D_{60}/D_{10}$ $C_c = \frac{(D30)^2}{D_{10} \times D_{60}}$
d. If soil contains ≥15% sand, add "with sand" to group name.
e. Gravels with 5 to 12% fines require dual symbols:
GW-GM well-graded gravel with silt
GW-GC well-graded gravel with clay
GP-GM poorly graded gravel with silt
GP-GC poorly graded gravel with clay
f. If fines classify as CL-ML, use dual symbol GC-GM or SC-SM.
g. If fines are organic, add "with organic fines: to group name.
h. If soil contains ≥15% gravel, add "with gravel" to group name.
i. Sand with 5 to 12% fines require dual symbols:
SW-SM well-graded sand with silt
SW-SC well-graded sand with clay
SP-SM poorly graded sand with silt
SP-SC poorly graded sand with clay
j. If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.
k. If soil contains 10 to 29% plus No. 200, add "with sand" or "with gravel" whichever is predominant.
l. If soil contains ≥ 30% plus No. 200, predominantly sand, add "sandy" to group name.
m. If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.
n. PI ≥ 4 and plots on or above "A" line.
o. PI < 4 or plots below "A" line.
p. PI plots on or above "A" lines.
q. PI plots below "A" line.



Laboratory Tests

DD	Dry density, pcf	OC	Organic content, %
WD	Wet density, pcg	S	Percent of saturation, %
MC	Natural moisture content, %	SG	Specific gravity
LL	Liquid limit, %	C	Cohesion, psf
PL	Plastic limits, %	Ø	Angle of internal friction
PI	Plasticity index, %	qu	Unconfined compressive strength, psf
P200	% passing 200 sieve	qp	Pocket penetrometer strength, tsf

Particle Size Identification

Boulders................ over 12"
Cobbles .... 3" to 12"
Gravel
Coarse .... 3/4" to 3"
Fine................ No. 4 to 3/4"
Sand
Coarse .... No. 4 to No. 10
Medium.......... No. 10 to No. 40
Fine................ No. 40 to No. 200
Silt .... <No. 200, PI< 4 or below "A" line
Clay .... <No. 200, PI ≥ 4 and on or about "A" line

Relative Density of Cohesionless Soils

Very Loose............ 0 to 4 BPF
Loose..................... 5 to 10 BPF
Medium dense .... 11 to 30 PPF
Dense .... 31 to 50 BPF
Very dense............ over 50 BPF

Consistency of Cohesive Soils

Very soft................ 0 to 1 BPF
Soft .... 2 to 3 BPF
Rather soft .... 4 to 5 BPF
Medium .... 6 to 8 BPF
Rather stiff .... 9 to 12 BPF
Stiff .... 13 to 16 BPF
Very stiff................ 17 to 30 BPF
Hard....................... over 30 BPF

Drilling Notes

Standard penetration test borings were advanced by 3 1/4" or 6 1/4" ID hollow-stem augers, unless noted otherwise. Jetting water was used to clean out auger prior to sampling only where indicated on logs. All samples were taken with the standard 2" OD split-tube samples, except where noted.

Power auger borings were advanced by 4" or 6" diameter continuous flight, solid-stern augers. Soil classifications and strata depths were inferred from disturbed samples augered to the surface, and are therefore, somewhat approximate.

Hand auger borings were advanced manually with a 1 1/2" or 3 1/4" diameter auger and were limited to the depth from which the auger could be manually withdrawn.

BPF: Numbers indicate blows per foot recorded in standard penetration test, also known as "N" value. The sampler was set 6" into undisturbed soil below the hollow-stem auger. Driving resistances were then counted for second and third 6" increments, and added to get BPF. Where they differed significantly, they are reported in the following form: 2/12 for the second and third 6" increments, respectively.

WH: WH indicates the sampler penetrated soil under weight of hammer and rods alone; driving not required.

WR: WR indicates the sampler penetrated soil under weight of rods alone; hammer weight, and driving not required.

TW: TW indicates thin-walled (undisturbed) tube sample.

Note: All tests were run in general accordance with applicable ASTM standards.

Rev. 9/15

Abbey Church

EXTERIOR

ABBEY CHURCH EXTERIOR

Exterior Wall Cladding

The exterior granite façade cladding mortar joints were tuckpointed in 2000. Vertical control joint sealants were replaced and additional vertical control joints were installed along the corners of the folded plate points during that same time. Visual observation of the current conditions noted no distress in the mortar joints or sealant control joints.

ABBEY CHURCH EXTERIOR

North Wall

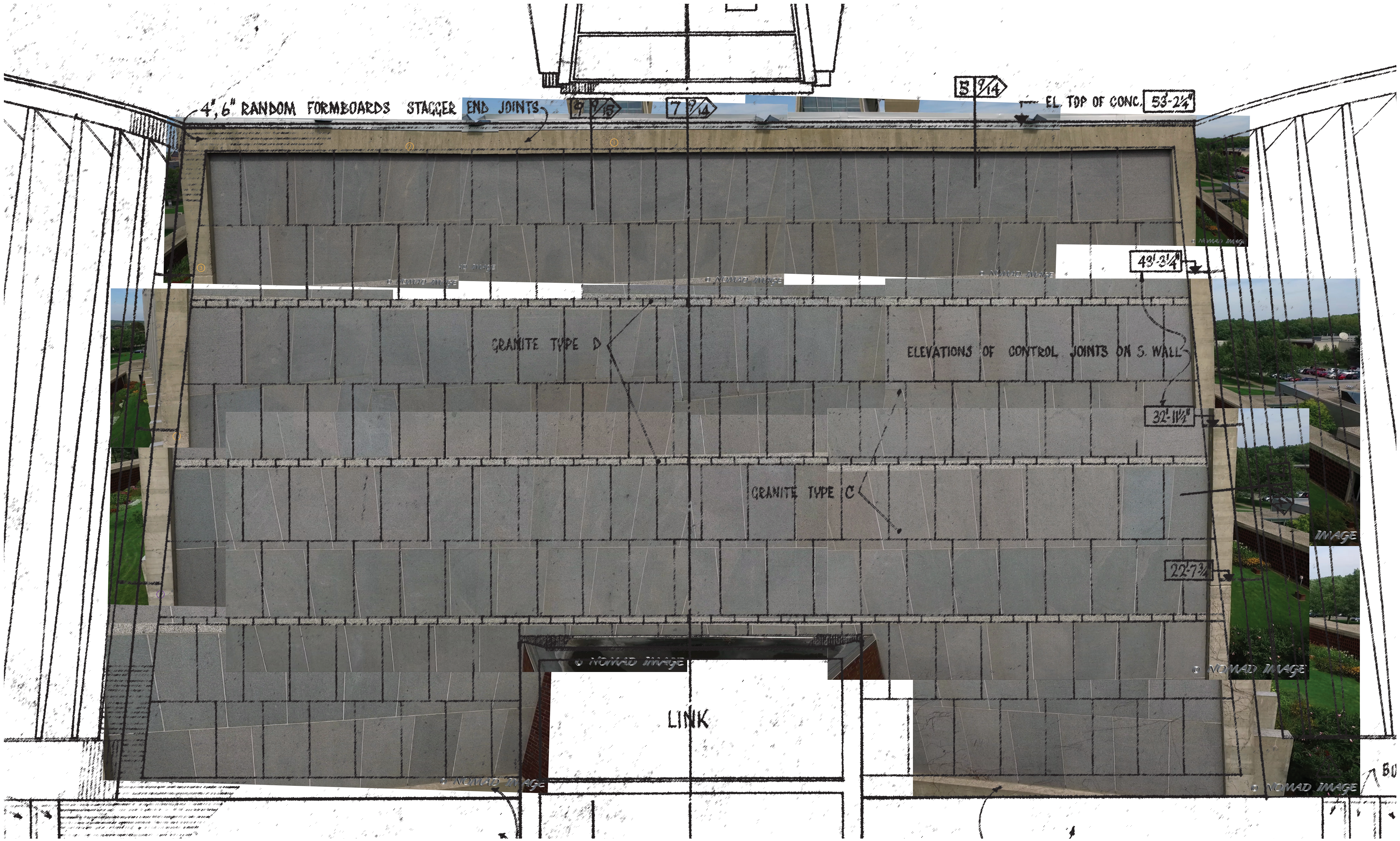
The north wall concrete frames vertical control joint sealants were replaced in 2000. The polygonal concrete frames initial construction casting pattern resulted in a high number of horizontal construction joints. The flat surfaces of the frames appear to have a concrete rubbed finish.

Visual observation of the current conditions noted cracking at the frames intersections and micro-crazing of the horizontal surfaces. The cracking pattern is predictable due the stress concentrations at the frame joint intersections. The micro cracking is likely the result of plastic shrinkage at the time of construction.

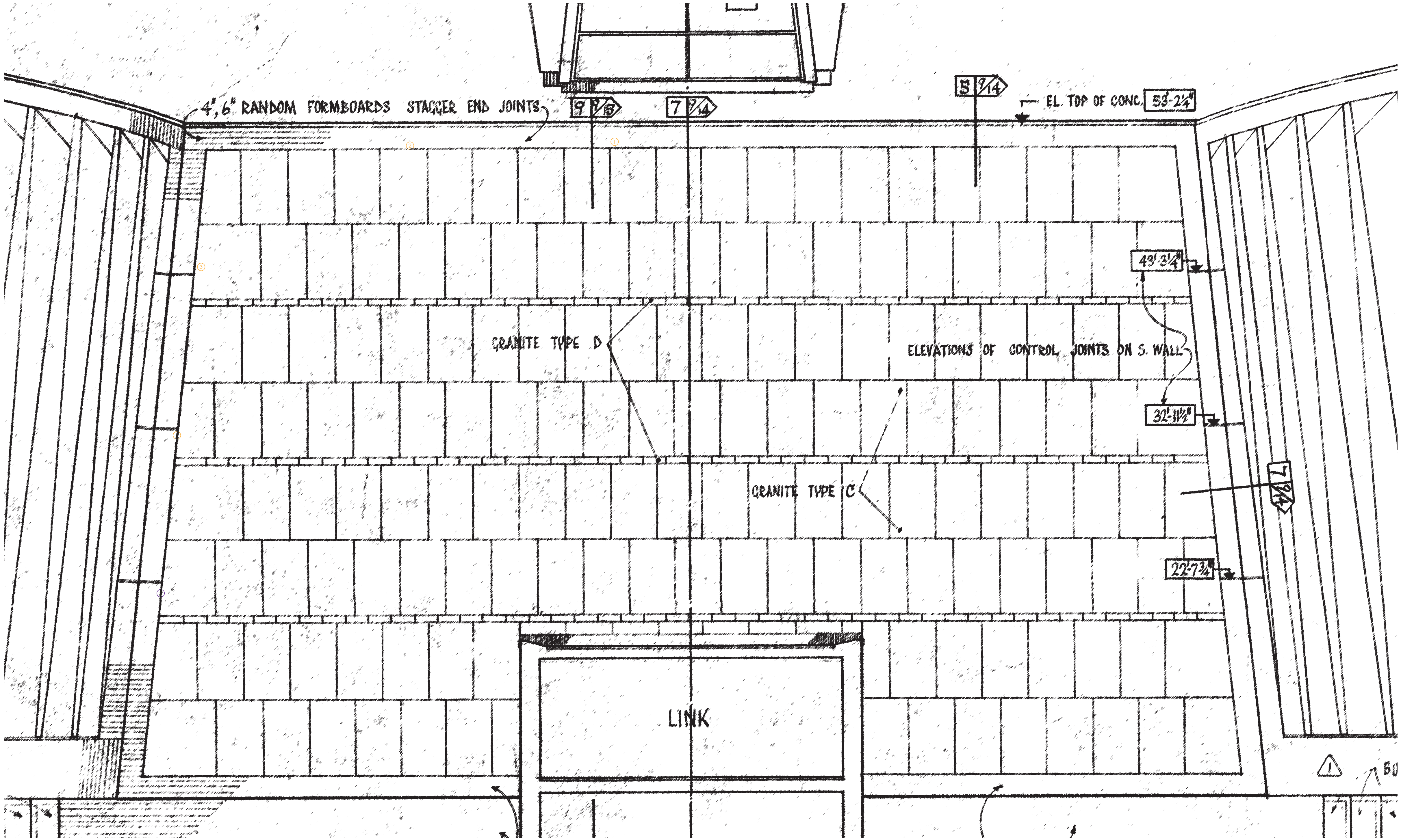
Buttresses

The buttress tops were repaired and the light fixture recesses capped and waterproofed. Visual observation of the current conditions noted micro cracking of the surface. Non-destructive sounding results of the areas indicate the concrete is sound.


BETON



ABBEY CHURCH SOUTH ELEVATION



4",6" RANDOM FORMBOARDS STAGGER END JOINTS
9 9/13
7 9/14
13 9/14
EL. TOP OF CONC. 53'-2¼"
43'-3¼"
GRANITE TYPE D
ELEVATIONS OF CONTROL JOINTS ON S. WALL
32'-11½"
7 9/14
GRANITE TYPE C
22'-7¾"
LINK

1 Spalling

2 Spalling

Patching 1

3 Spalling

Abbey Church

ROOF

Atrium and Baptistry Roof Survey

The atrium roof structure consists of concrete pan and joist waffle ribs spanning the space. Minor hairline cracking was observed at a very small number of pan locations. Efflorescence or water staining was evident at a majority of the observed cracks. The assistant building and facility manager was not aware of any present roof leaks. The surfaces were dry at the time of observation. The cracking is not judged a structural concern.



ABBEY CHURCH ROOF

Sanctuary Folded Roof Plate Survey

The sanctuary roof structure consists of concrete folded plate “V” form ribs clear spanning the sanctuary space. The vertical sides of the plates have numerous lighting and ventilation openings. There is a concrete walkway bridge running north-south across the center with doorway openings for access to the ribs.

Minor hairline cracking was observed at a majority of the doorway openings over the bridge in the top corners. The majority of these cracks were tracked with a plaster medallion placed shortly after original construction. In a number of cases the plaster has not cracked but that is not true of all conditions. The location is a typical case for cracking due to the reentrant corner condition. The cracking observed was hairline and is not judged a structural concern.

Minor hairline cracking was observed at a small number of the formed openings in the vertical sides. The majority of these cracks were tracked with a plaster medallion placed shortly after original construction. The cracking is not judged a structural concern.

Minor hairline vertical or slightly diagonal cracking was observed at the vertical sides at a majority of the rib plates south of grid 7. The majority of these cracks have plaster medallions over the crack. The cracks have advanced through and cracked the plaster in all cases. The cracking is not judged a structural concern.

Moderate sized cracks were observed at the exterior ends where the horizontal plate meets the vertical exterior wall plate at a number of ribs at the area south of gridline 6. The cracking is not judged a structural concern.

Abbey Church

GLASS

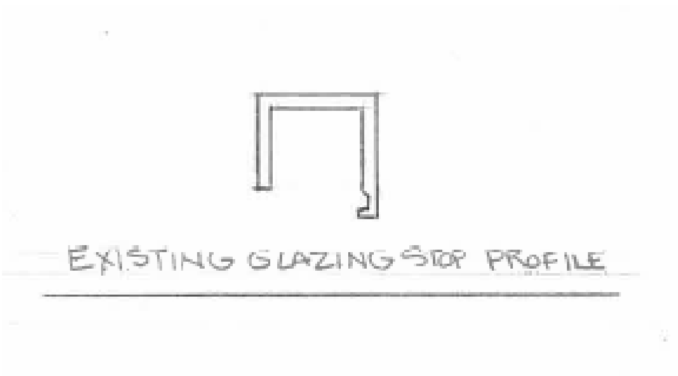
North Wall Glass Analysis

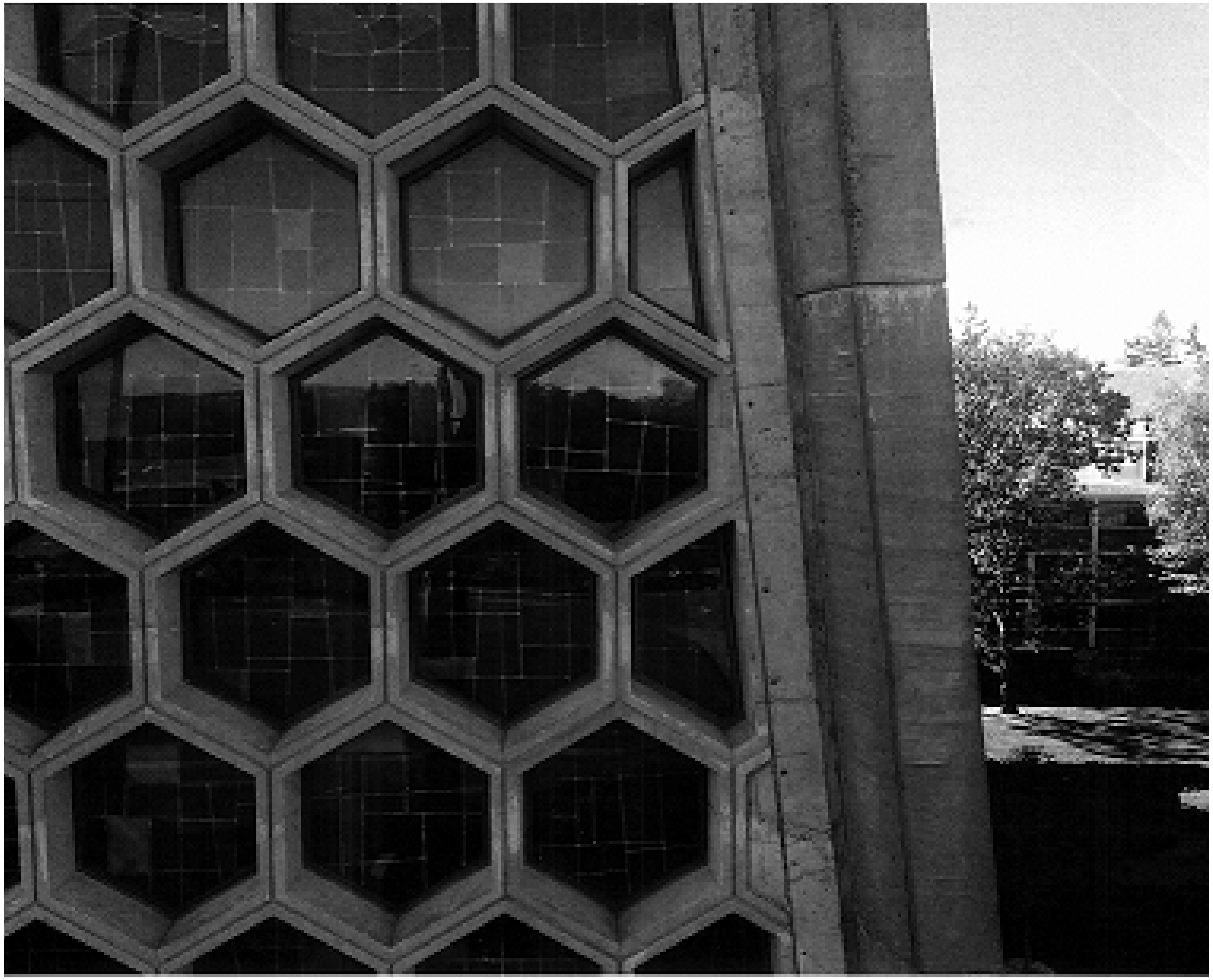
Investigating conditions of the existing polygonal aluminum windows the following observations were noted.

The 1/2" x 5/8" glazing stops retaining the existing protective 1/8 annealed glass has an offset leg (see sketch) for a friction fit into the main frame and against the 1/8" glass.

Numerous windows where the glass has been replaced, the stops have been reinstalled using screws to fasten the stop securely; the reason being the stops are difficult to remove do to the amount sealants originally used causing some distortion to the original profile. Forcing the stop back into the proper location is also difficult to maintain the needed pressure for the stop to stay in the correct position.

The window polygonal shape has complimented the preservation of the windows by not having any part of the window installation retaining moisture that cascades off the surfaces.







The original protective glazing was heel beaded, taped and cap beaded. The cap bead is deteriorating allowing moisture penetration. (See Photo # 104, 105). Photo (#123) shows the Heel Bead and the recess in the main frame for the leg of the offset glazing stops.

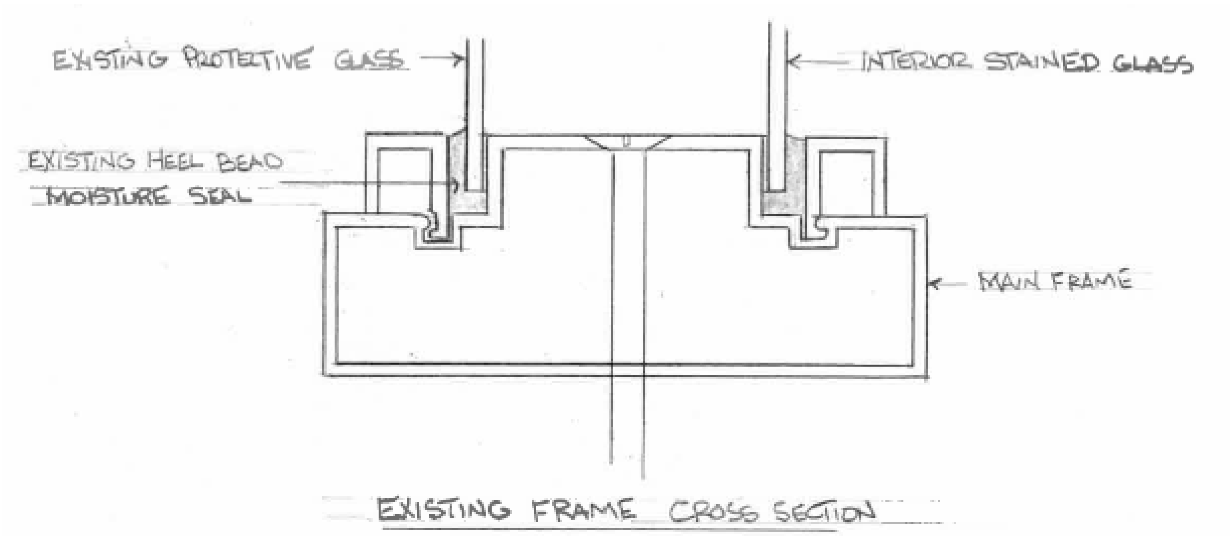
In multiple locations the main frame anchor screws are backing out. (See Photo 111)

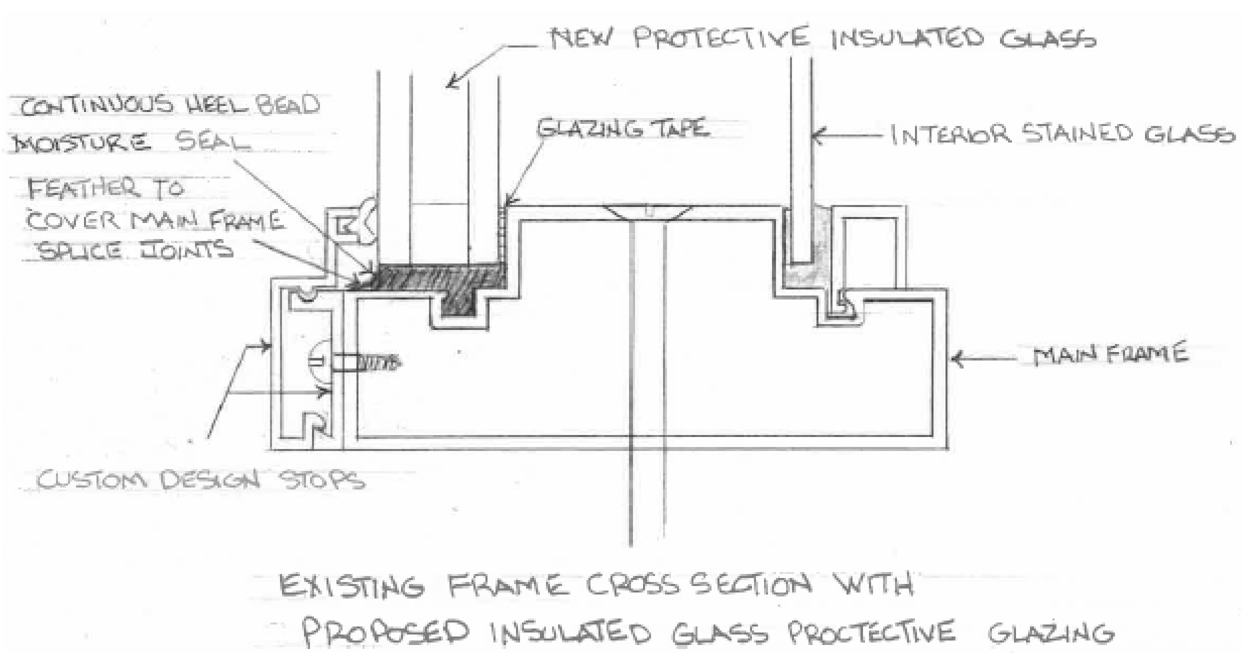
The main frame perimeter sealant is losing its integrity and is showing signs of failure. (See Photo #98,99,107) A certified sealant manufacturer and applicator should be consulted to analyze the existing sealant between the main frame and concrete.

The main frame appears structurally sound and in good condition. The joints at the intersections of the jambs have not separated and look to be tight.

Improving the Protective Glazing

The existing glazing stops and recess location will not be able to be utilized with the implementation of high performance insulated glass do to the increase in the glazing thickness. Project specific custom extrusions will need to be created allowing the use of 7/8" (+-) thick insulated glass.





The new protective glass is to be heel beaded around the entire perimeter of the glass creating the critical moisture seal. Feathering of the heel bead sealant over the remaining exposed connection splice joint of the main frame members will be necessary to prevent moisture penetrating into the main frame cavity.

When existing glazing is removed for replacement, the exterior side of the existing stained glass should be cleaned and checked for lead and putty fatigue and corrected as required by a certified stained glass contractor. All main frame anchor screws should be reset insuring adequate attachment.

Any moisture penetrating the new stop system will weep through seams of the stops at the sills. All moisture will be stopped from penetrating past the protective glazing at the continuous heel bead.

The heel bead sealant specified should be tested and applied according to manufacturer's recommendations.

The following performance data for the existing 1/8" protective glazing is based on current manufactures product. Actual characteristics of the existing protective glass may vary slightly.

Date:	December 2, 2015
Customer:	East Side Glass Company
Project:	
Location:	
Glass Type:	

MONOLITHIC GLASS PERFORMANCE DATA

	ID #		Notes
Lite:	3011	1/8" Guardian Clear Float Glass	a

Nominal Thickness: **0.129 Inches** f

Performance Properties	COG Results*	Units
Transmittance		
Visible Light	90	%
Solar Energy	85	%
Ultraviolet	72	%
Reflectance		
Visible Light (Exterior)	8	%
Visible Light (Interior)	8	%
Solar Energy (Exterior)	8	%
Thermal		
Winter Nighttime:		
U-factor/U-Value	1.04	Btu/hr-ft^2-^{o}F
Summer Daytime:		
U-factor/U-Value	0.94	Btu/hr-ft^2-^{o}F
Shading Coefficient (SC)	1.00	-
Solar Heat Gain Coefficient (SHGC)	0.87	-
Relative Heat Gain	213	Btu/hr-ft^2
Light to Solar Gain	1.03	-

***Vertically Glazed Center Of Glass (COG) Results Calculated Using LBNL Window 6.3 Software.**

Notes: a) NFRC certified spectral data file
b) Data generated by Oldcastle BuildingEnvelope®
c) Average solar data
d) Simulated with LBNL Optics 6.0
e) Vendor supplied spectral data file
f) Please reference ASTM C1036 and C1172 for allowable glass thickness variations

The finsulating glass performance data (next page) is based on 7/8" insulating glass, utilizing Pilkington Energy Advantage Low-E on the No. 2 surface. The improvement of the insulated protective glazing from a U value of 1.04 for the existing glass to a U value of .33 for the new glass will have a substantial impact on the HVAC systems being proposed. The visible light transmittance of 90% for the existing glass to 75% for the insulated protective glazing would be difficult to notice and be worth the improved performance.

The aluminum finish on the new stop system should be a painted finish to best match the original color and hue of the existing main frame. Painting applicators specializing in aluminum finishing should be consulted to best determine the proper product to achieve the desired result.

Oldcastle BuildingEnvelope®

Date: December 2, 2015
Customer: East Side Glass Company
Project:
Location:
Glass Type:

INSULATING GLASS UNIT PERFORMANCE DATA

	ID #		Notes
Outboard:	9923	3/16" Pilkington Energy Advantage™ Low-E #2	a
Air Space:	1	1/2" Spacer, (Air Filled)	
Inboard:	3015	3/16" Guardian Clear Float Glass	a

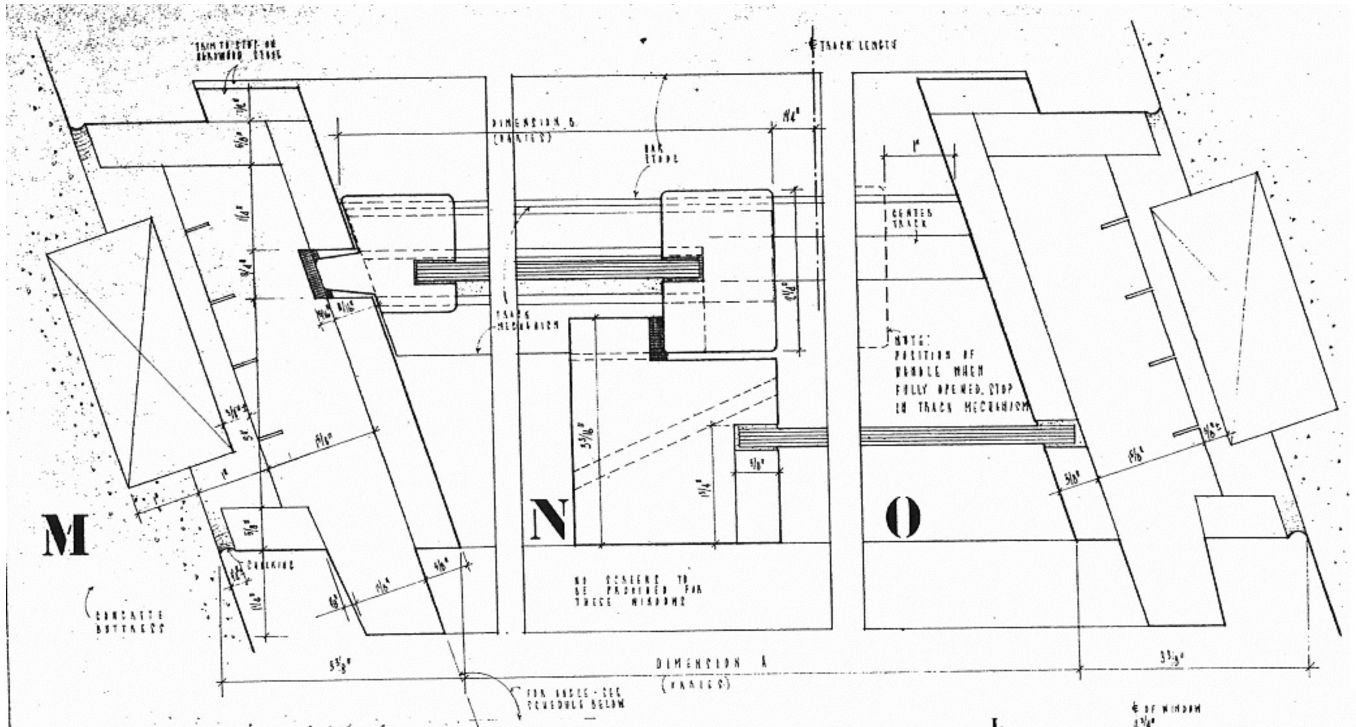
Nominal Thickness: **0.867 Inches** f

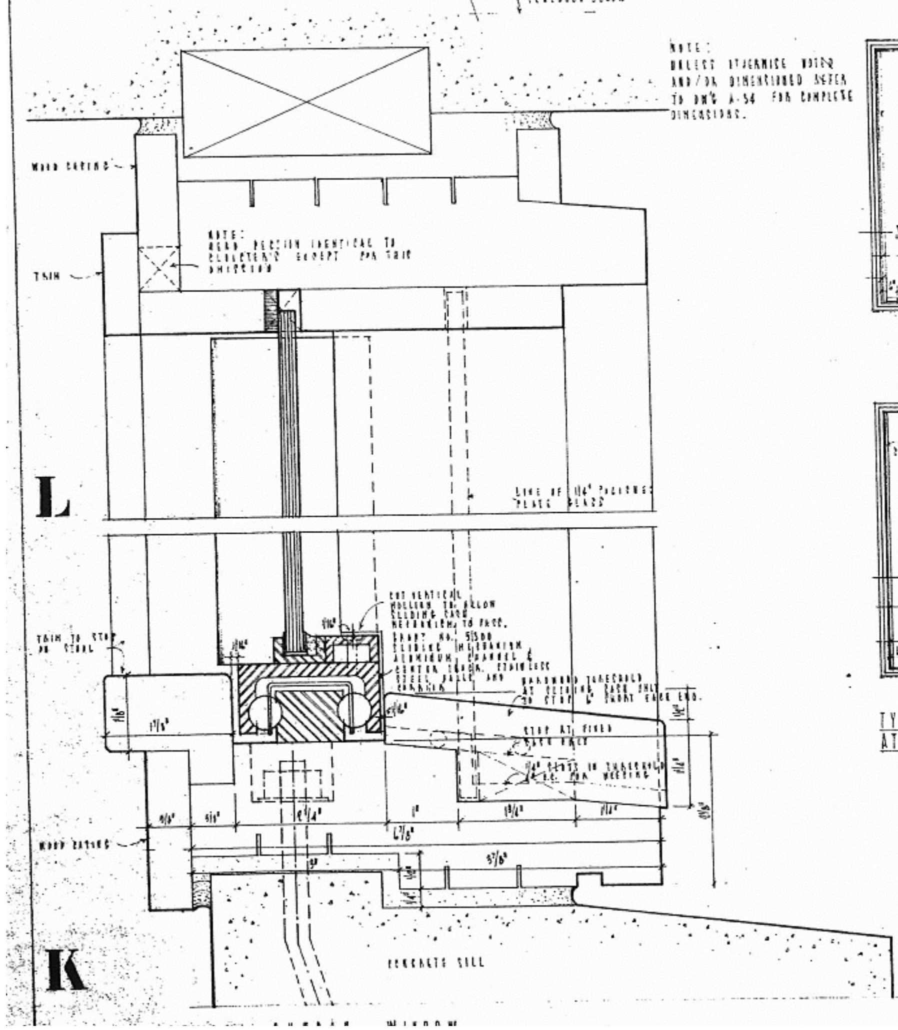
Performance Properties	COG Results*	Units
Transmittance		
Visible Light	75	%
Solar Energy	38	%
Ultraviolet	42	%
Reflectance		
Visible Light (Exterior)	17	%
Visible Light (Interior)	18	%
Solar Energy (Exterior)	8	%
Thermal		
Winter Nighttime		
U-factor/U-Value	0.33	Btu/hr-ft^2-°F
Summer Daytime		
U-factor/U-Value	0.33	Btu/hr-ft^2-°F
Shading Coefficient	0.46	-
Solar Heat Gain Coefficient	0.40	-
Relative Heat Gain	96	Btu/hr-ft^2
Light to Solar Gain	1.88	-

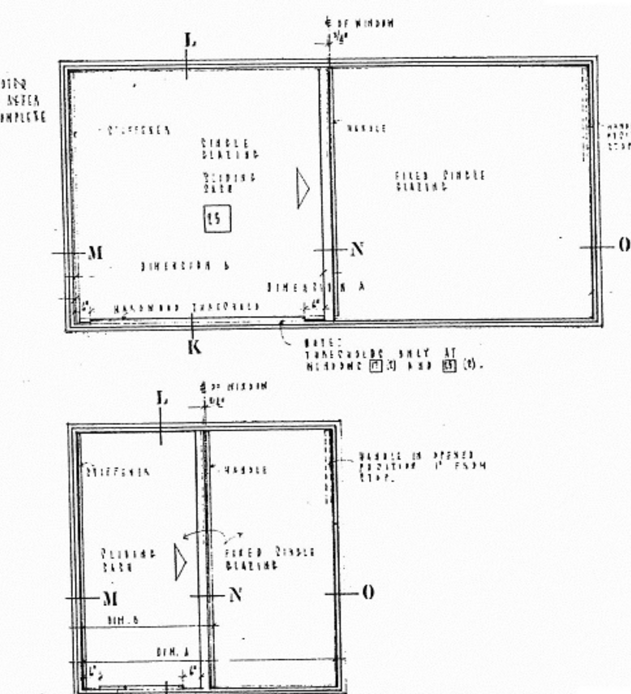
***Vertically Glazed Center Of Glass (COG) Results Calculated Using LBNL Window 6.3 Software.**

Notes: a) NFRC certified spectral data file
b) Data generated by Oldcastle BuildingEnvelope®
c) Average solar data
d) Simulated with LBNL Optics 6.0
e) Vendor supplied spectral data file
f) Please reference ASTM C1036 and C1172 for allowable glass thickness variations

ABBEY CHURCH GLASS







TYPICAL WINDOW WALL AT CHURCH

MILLWORK AND HARDWARE NOTES

- HANDLE AND STIFFENER TO BE FINISHED BEFORE BEING APPLIED TO GLASS. NO FINISH IN GROOVED SURFACES THAT ARE TO RECEIVE ADHESIVE.
- WHEN SLIDING GLASS IS IN CLOSED POSITION, BACK OF HANDLE IS TO BE FLUSH WITH MULLION. HANDLE AND STIFFENER SHOULD COMPRESS RUBBER WEATHERSTRIPPING.
- SPONGE RUBBER TO CONFORM TO A.S.T.M. SPECIFICATION D-1056-57T GRADE R-12-CF.
- MINNESOTA ADHESIVE #[illegible] TO BE USED IN GLUING STIFFENERS AND HANDLES.
- ALL WOOD FOR FRAMES TO BE THOROUGHLY KILN DRIED CLEAR WHITE PINE. OAK MUST BE THOROUGHLY KILN DRIED AND SEASONED.
- ALL FRAME JOINTS TO BE SET IN WATERPROOF GLUE. NO MITRED JOINTS.
- CASING OVER 5" WIDE TO BE MADE OF PLYWOOD.
- PROVIDE NECESSARY TRIMMING AND BLOCKING AT HEAD AND JAMBS TO INSURE PROPER NAILING OF CASING AND TRIM.
- ALL ROUNDS 1/8" RADIUS.
- TRACK HARDWARE AND SLIDING GLASS TO BE INSTALLED AT END OF JOB JUST PRIOR TO FINAL PAINTING.
- WHERE HARDWOOD IS CALLED FOR ON DRAWINGS FOR WINDOW STIFFENERS, HANDLES, STOOLS AND THRESHOLDS SUCH HARDWOOD SHALL BE OF OAK.
- ALL CHURCH WINDOWS DETAILED ON THIS SHEET ARE TO BE SINGLE GLAZED.

WINDOW SCHEDULE - CHURCH					
MARK	DIM. A	DIM. B	GLASS	ANGLE	REMARKS
16	8'-6"	4'-1 9/16"	POLISHED PLATE 1/4" THRU.-[illegible]	70°00'	TWO UNITS OF OPPOSITE HAND REQUIRED OF THESE WINDOWS
17	9'-1"	4'-5 [illegible]"		70°00'	
18	9'-7 3/4"	4'-8 [illegible]"		72°30'	
19	10'-[illegible]"	4'-10 [illegible]"		70°00'	
20	10'-9 [illegible]"	5'-5 [illegible]"		70°40'	
21	[illegible]	5'-7 [illegible]"		75°30'	
22	[illegible]	5'-11 [illegible]"		74°30'	
23	[illegible]	6'-5 [illegible]"		76°15'	
24	15'-5 [illegible]"	6'-7 [illegible]"		78°00'	
25	15'-11 [illegible]"	7'-0 [illegible]"		80°00'	

NO	DATE	BY	REVISIONS

ST. JOHN'S ABBEY CHURCH
COLLEGEVILLE, MINNESOTA

MARCEL BREUER AND ASSOCIATES, ARCHITECTS
201 EAST 57th STREET NEW YORK 22, N.Y.

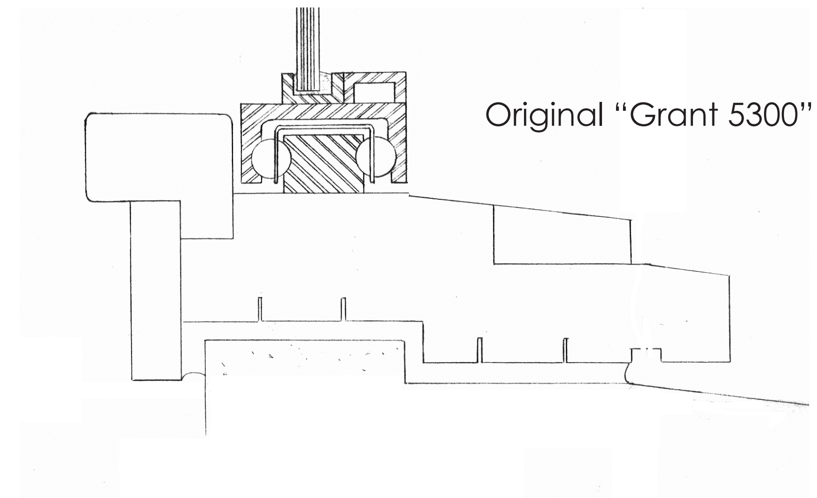
STRUCTURAL ENGINEERS: WIESENFELD, HAYWARD & LEON, NEW YORK CITY
MECHANICAL ENGINEERS: GAUSMAN AND MOORE, ST. PAUL, MINN.
OWNERS COORDINATOR: TRAYNOR & HERMANSON, ARCHTS., ST. CLOUD, MINN.

WOOD WINDOWS CHURCH

A53

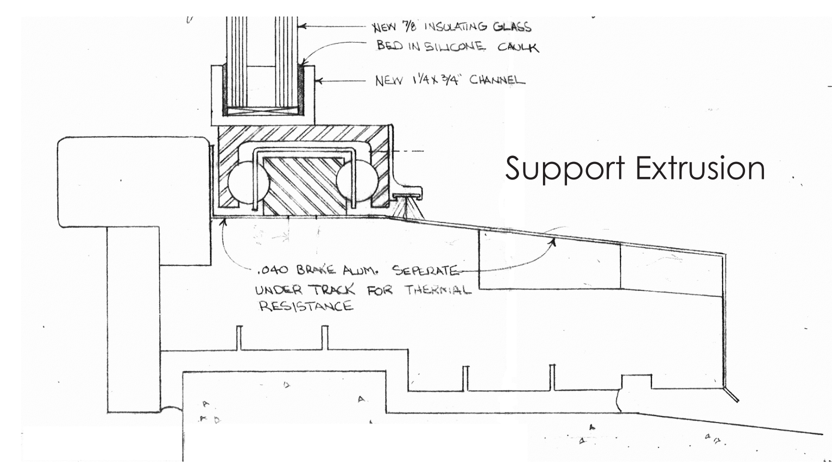
Sanctuary Windows

There are 20 operable windows, 10 on the east side and 10 on the west side of the Sanctuary. The openings vary in size from 8’4” to 16’0 wide x7’10” tall. The openings are all OX with one fixed glass panel and one sliding panel. The windows are constructed of custom wood designed specifically for the Abby Church. The sliding panel is set on an aluminum and stainless steel rolling track system by “Grant / Hetich”. The original glass panels were ¼” annealed (non tempered) clear polished plate glass.



Original “Grant 5300” assembly modified to fit the window application

In 1984 the ¼” glass was replaced with 7/8” insulated glass consisting of (2) sheets of ¼”glass separated by a 3/8” sealed air space. The weather stripping at the head, interlocks and jambs was improved. A brush sweep was added at the sill. Aluminum cladding was added at the sill to protect the wood and minimize maintenance.



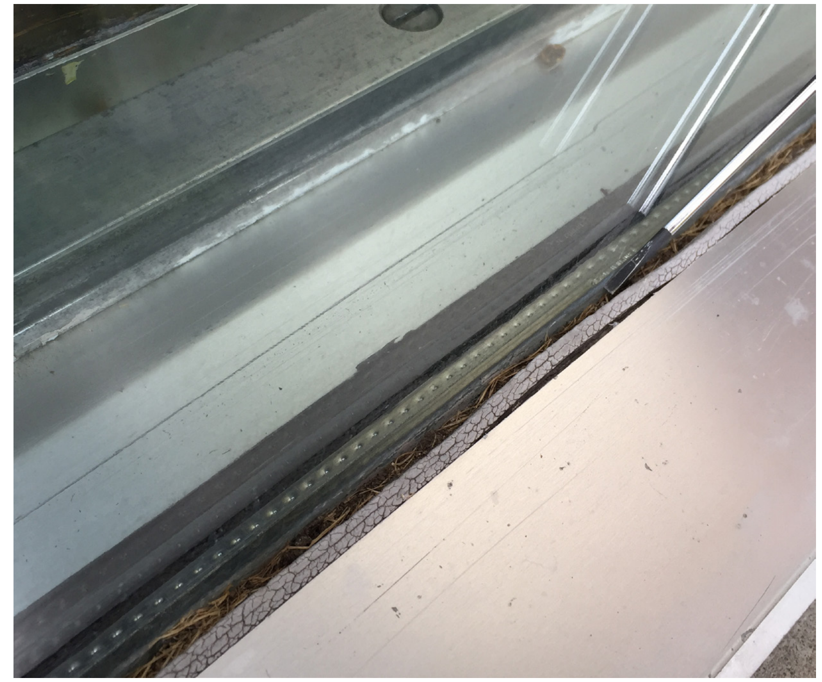
Support Extrusion

In 2015 not all the doors are functioning properly. Some are not opening, and the openings show signs of deterioration and need repair or replacement. The rolling systems extrusion supporting the sliding glass panels is the major cause of the sliding windows failure; it is collapsing and braking down, losing its structural integrity.

The stainless steel roller channel and the fixed bottom aluminum guide are in good condition and show minimal signs of deterioration.

Wood Frame Deterioration

Sealant from the 1984 conversion has completely failed and in most locations is gone. Paint at the sill areas is in very poor condition. The critical seal area at the intersection of the vertical jambs and center mullions has failed and the wood in these areas is severely compromised.



The sealant at the perimeter of the fixed glass has failed and allowing moisture penetration.

The wood under the sliding panels shows minimal signs of compression from the weight of the glass; most are level indicating a solid base at that location.

Preservation challenges in sequence of restoration:

We are quite certain the original “Grant 5300” sliding track system is available and should be replaced.

The existing insulated glass should be replaced if restoration is undertaken because of the age (31 years) and the stress to the perimeter insulated glass seal from handling.

See the product comparison chart below for some performance improvement options available for the glass.

Oldcastle BuildingEnvelope®

Product Comparison Chart

Customer: East Side Glass
Project: Comparison

Existing Insulated Glass

Color	Product Description - Performance Characteristics	Thickness (inches)	Visible Trans. (%)	Visible Refl. Out (%)	Visible Refl. In (%)	UV Trans. (%)	Solar Trans. (%)	Solar Refl. Out (%)	Winter U-factor	Summer U-factor	Shading Coeff.	Solar Heat Gain Coeff.	Relative Heat Gain	Light to Solar Gain
	OB: 1/4" Clear AS: 1/2 inch (Air Fill) IB: 1/4" Clear	0.946	79	15	15	50	61	12	0.47	0.50	0.81	0.70	169	1.13
	OB: 1/4" Clear AS: 1/2 inch (Air Fill) IB: 1/4" Pilkington Energy Advantage™ Low-E #3	0.945	73	17	16	38	52	14	0.33	0.33	0.77	0.67	158	1.09
	OB: 1/4" Clear AS: 1/2 inch (Air Fill) IB: 1/4" PPG Solarban® 60 on Clear Low-E #3	0.946	70	12	11	18	34	30	0.29	0.27	0.53	0.46	110	1.52
	OB: 1/4" Clear AS: 1/2 inch (Air Fill) IB: 1/4" PPG Solarban® 70XL Low-E #3	0.946	64	13	12	6	25	36	0.28	0.26	0.43	0.37	89	1.73

NOTES:

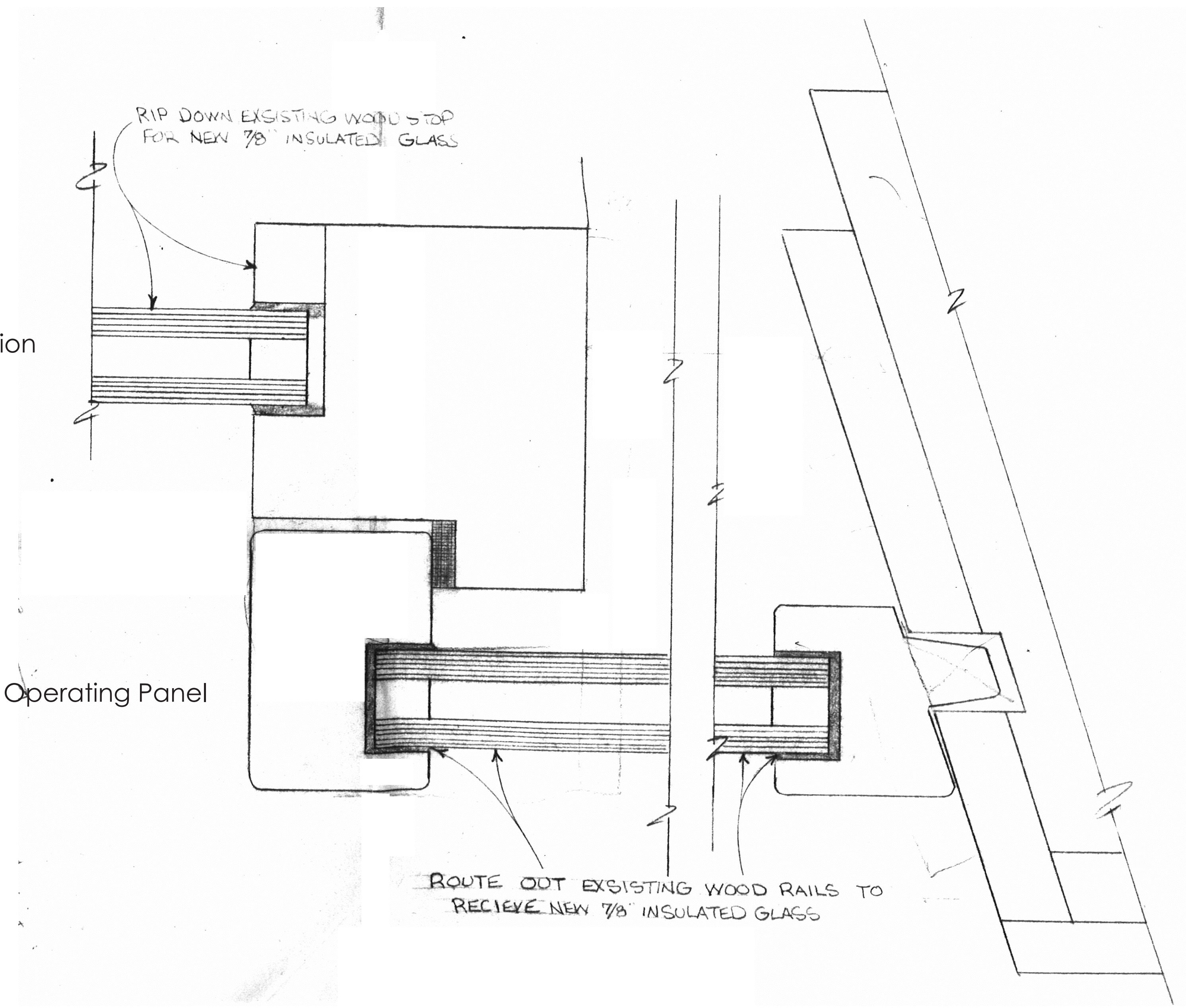
GlasSelect® calculates center of glass performance data using the Lawrence Berkeley National Laboratory (LBNL) Window 6.3 program (version 6.3.74.0) with Environmental Conditions set at NFRC 100-2001. Gas Library ID#1 (Air) is used for Insulating Glass units with air. Gas Library ID#9 (10% Air/90% Argon) is used for insulating Glass units with argon. Monolithic glass data is from the following sources: 1. LBNL International Glazing Database (IGDB) version 38.0; 2. Vendor supplied spectral data files. Laminated glass data is from the following sources: 1. LBNL International Glazing Database (IGDB) version 38.0; 2. LBNL Optics 6 (version 6.0 Maintenance Pack 1); 3. Vendor supplied spectral data files; 4. Vendor supplied data.5. Based on vendor testing, clear acid-etched glass performance data is estimated using regular clear glass of equivalent thickness.

Glass colors represented herein are included only for the general purpose of glass selection. Accurate representation of optical properties, including color and reflectivity, can only be achieved by viewing glass mock-ups in conditions that are similar to the actual job. User assumes all responsibility and liability for glass color selection. Thermal values are in Imperial units.

Remove the vertical wood rails on the operable panels and refurbish as required.

Fixed Panel Vertical Mullion

Operating Panel



Rail Conditions after 1984 Glass Conversion

Remove the fixed non operable glass by removing the wood stops that are securing the glazing. Remove the roller system and aluminum cladding. After all the glass, track, and cladding have been removed all the original wood will be exposed.

Repair or replace the original damaged wood sills, jambs, and vertical mullions by a qualified craftsman.

Original wood should be stripped and refinished along with all repaired and replaced wood, restoring the frame to its original condition.
Install the fixed performance improved insulated glass panels.

Reassemble the sliding door panels with new “Grant 5300” stainless steel rolling track system. Apply refurbished vertical wood rails with adhesives as required.
Apply quality sealants per manufacturer’s specifications insuring a water tight installation.

Create a maintenance schedule for continued preservation of the window assemblies.

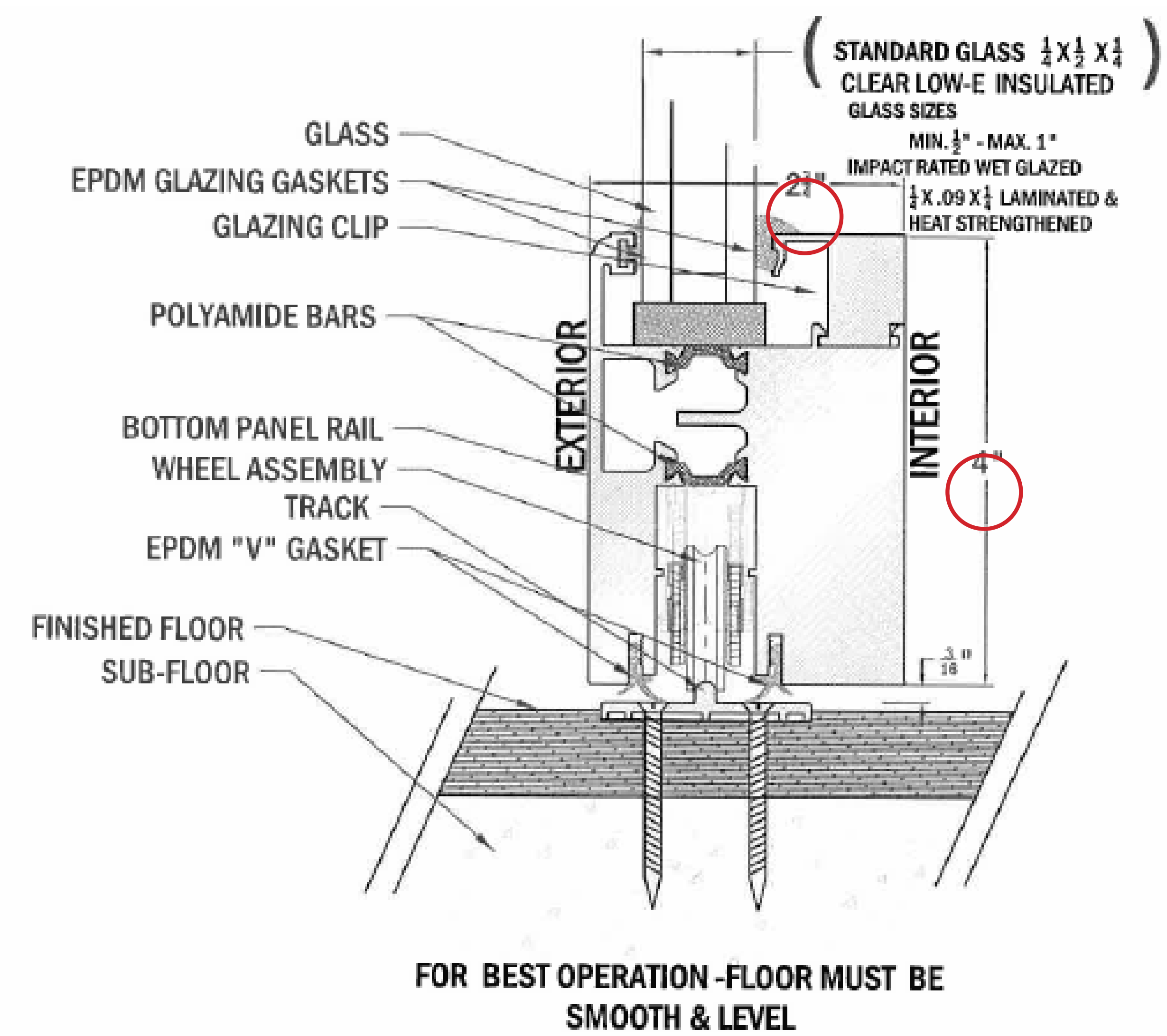
Re-evaluate the “Green” space at the exterior of the windows insuring the watering systems do not impact the openings.

Replacement Challenges

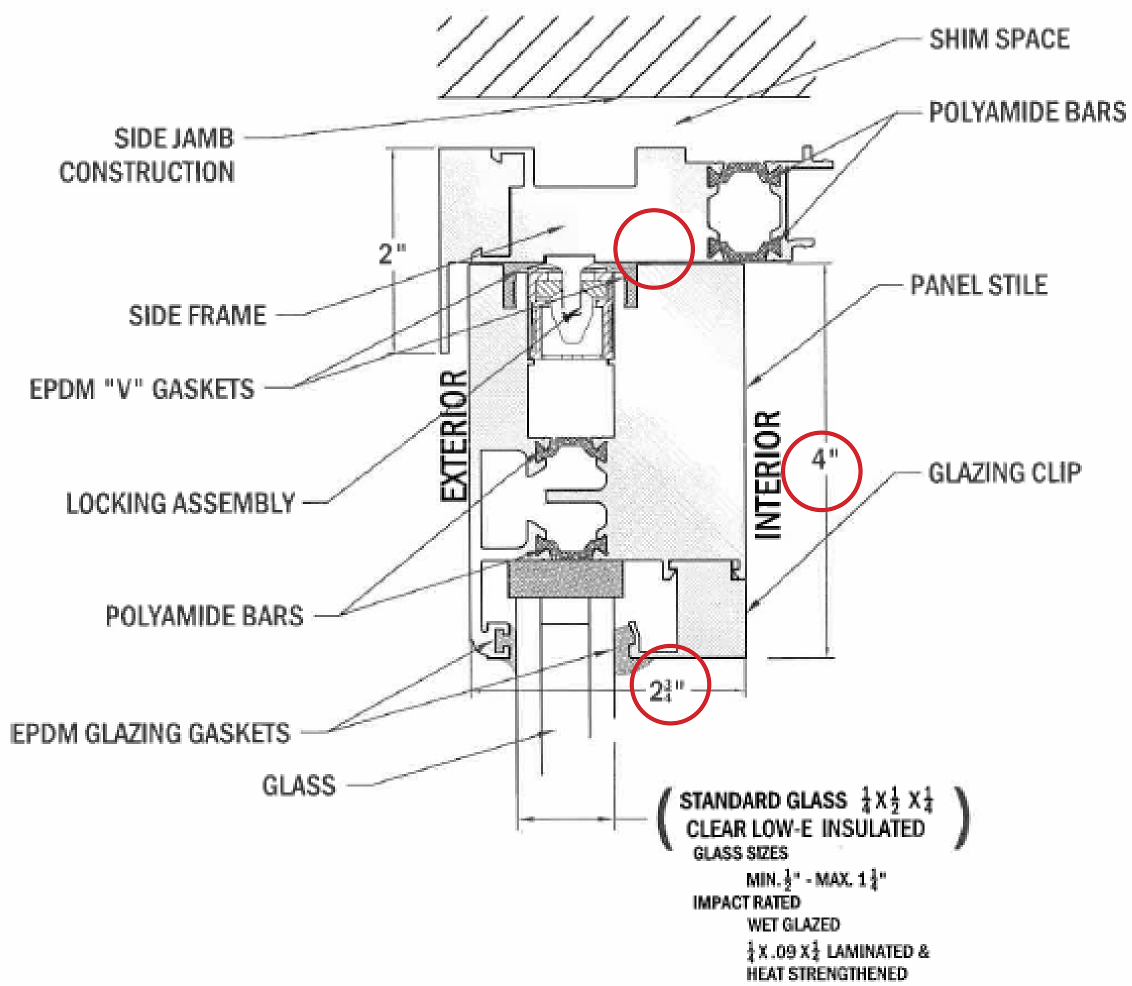
Product and manufacturers capabilities to produce a sliding door assembly with the characteristics to match the existing from available systems would be extremely difficult, if not impossible. Do to the performance codes required by today’s standards a increase in rail sizes and mass would have to be expected.

Below are details for discussion from a 2013 product and budget analysis requested by St. Johns. These details are from the only manufacturer discovered capable of making some of the larger OX panels to the sizes required, they were unable to make the two largest sized windows.

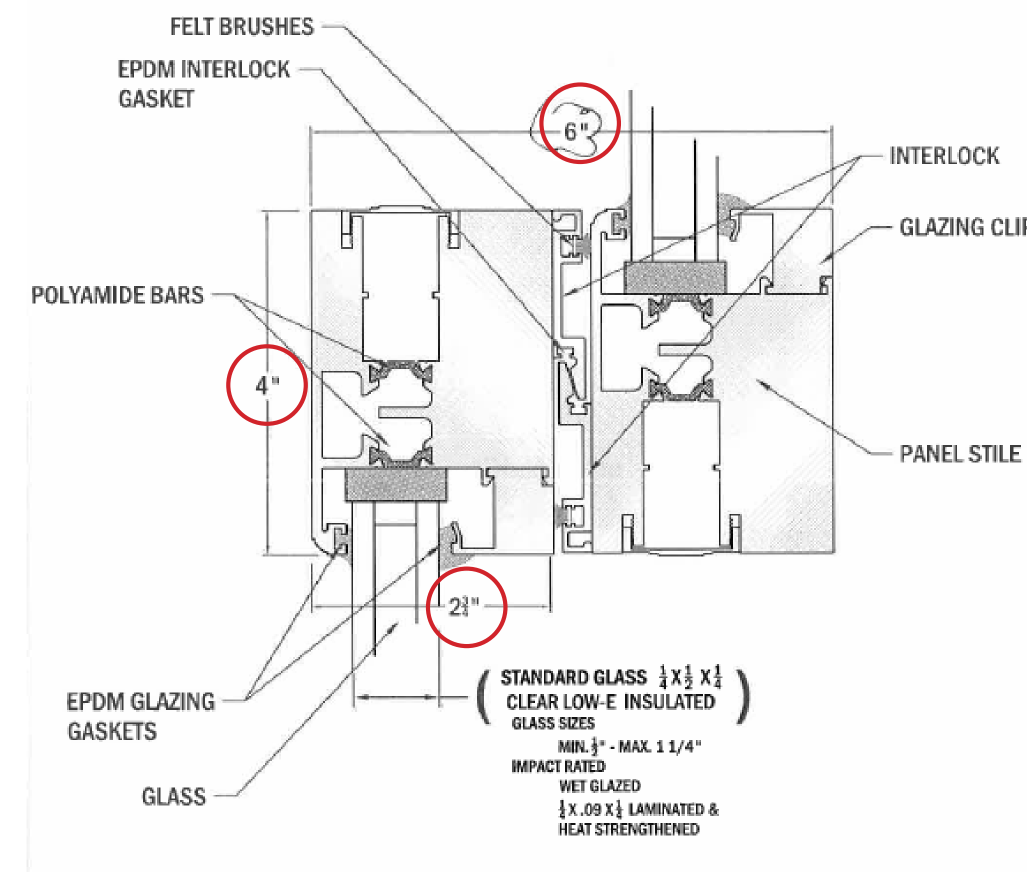
Our opinion is the only way to preserve the original architectural design of the sanctuary window is to restore the original.



Sill



Head



Meeting Rail

East and West Cloister Walk

The windows on the walk ways are generally in good condition. The large fixed glass panels have been converted to insulated glass and this existing glass could easily be replaced with better performance glass. (See insulated glass product comparison chart) Stripping and refinishing of the wood frames should be undertaken to preserve their original condition.

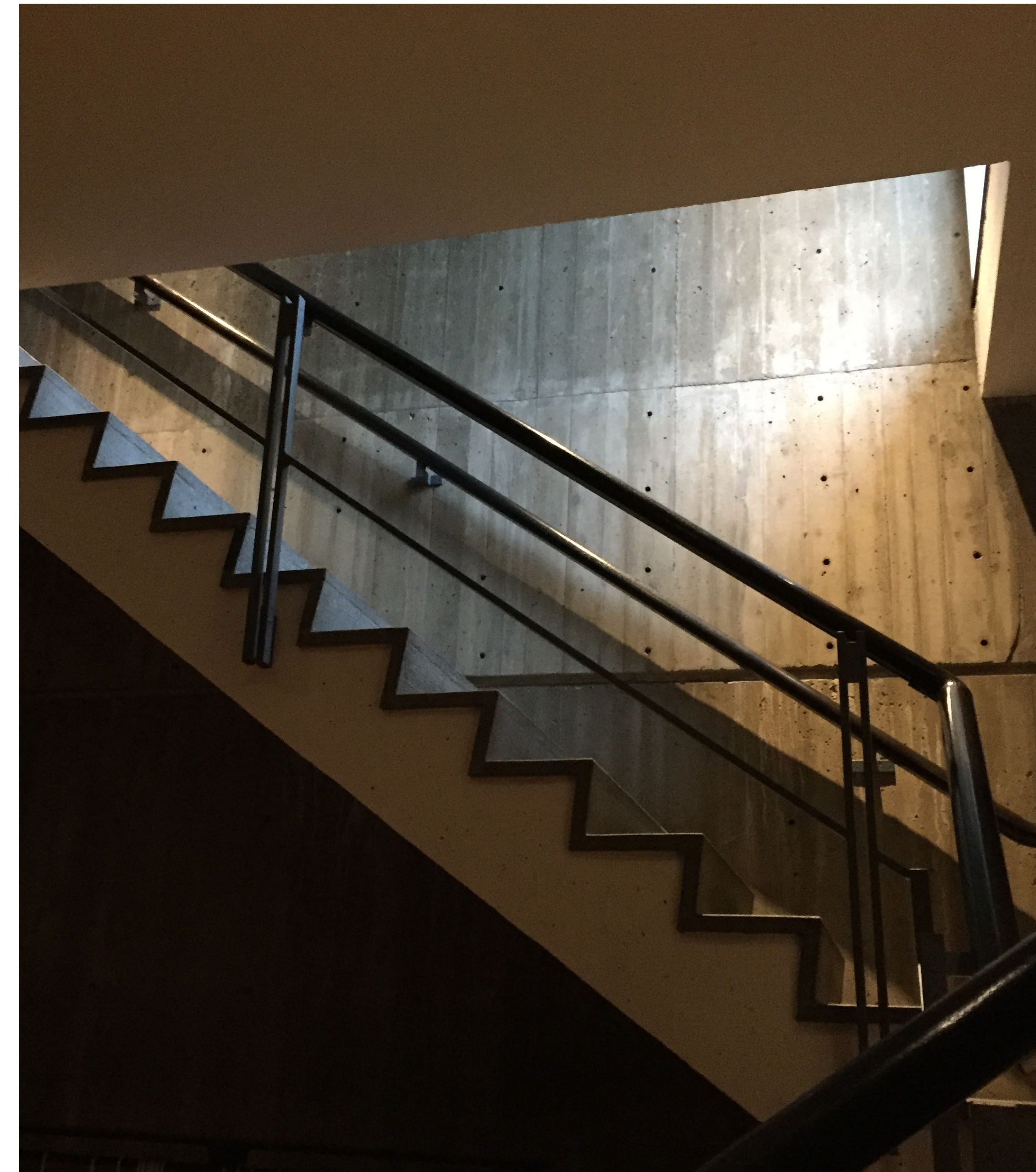
There are four original sliding door assemblies in each walkway similar to the twenty original panels in the Sanctuary that are glazed with single ¼" non insulated glass. These doors could be modified to receive high performance glass (see performance chart) utilizing the methods used to convert the sanctuary windows. There is one door showing signs of metal deterioration.

There are two hinged doors that are glazed with single non insulated glass that could be converted to insulated glass.

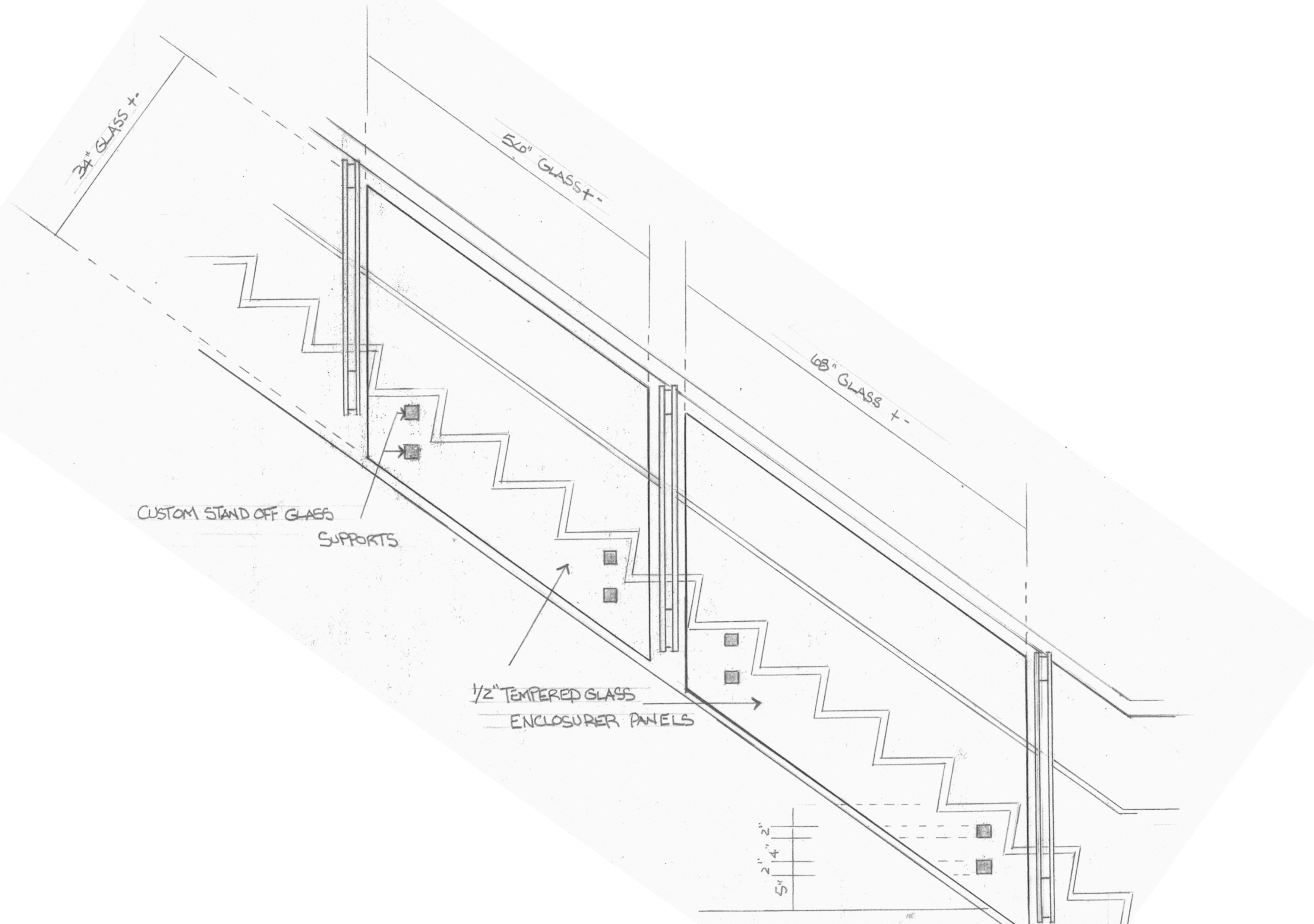
There are twelve steel hinged operable windows, five at the east walkway and seven at the west walkway

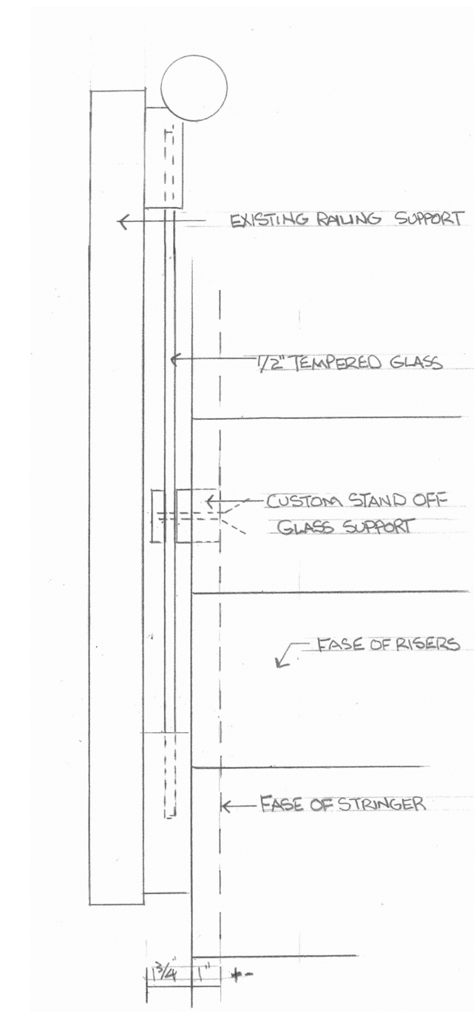
The glass in these windows are single pane (non-insulated) and glazed with putty and wire clips

There is ample room for converting this glass to insulated glass. The weather stripping at these windows should be evaluated and improved as conditions allow



East Stairway to the Lower Restrooms





The enclosure of these stairs for safety concerns can be accomplished by developing a "Stand Off" heavy glass support system attached to the concrete stringers. The following elevation and cross section are for illustration and discussion.

There is + or - a 1 ¾" clearance between the existing treads and risers and railing system allowing the placement of enclosure safety tempered glass. Custom standoff glass supports can be made and finished to compliment the original architectural design. A possible concern is the anchoring used to attach the stand offs to the concrete formed stringer. The original concrete stringer drawings should be reviewed for location of steel reinforcing.

Basement Windows

These windows are quite unique; they are constructed of brass/ bronze and glazed with 1/8" monolithic single pane non- insulated glass

There are both fixed and center pivoted operable windows with latching handles. The screw applied glazing stops and the latching handles will prevent replacing the single glass with thicker insulated glass.

The glass can be replaced with higher performing Low- E #2 monolithic glass by removing the existing glass and re-glazing into the existing stop system. See below data sheets for improved performance. The windows performance can also be enhanced by the application of compatible weather-stripping.

Handle is pressed against the glass allowing no room for thicker glass

Oldcastle BuildingEnvelope®

Date: December 14, 2015
Customer:
Project:
Location:
Glass Type:

MONOLITHIC GLASS PERFORMANCE DATA

	ID #		Notes
Lite:	3011	1/8" Guardian Clear Float Glass	a

Nominal Thickness: **0.129 Inches** f

Performance Properties	COG Results*	Units
Transmittance		
Visible Light	90	%
Solar Energy	85	%
Ultraviolet	72	%
Reflectance		
Visible Light (Exterior)	8	%
Visible Light (Interior)	8	%
Solar Energy (Exterior)	8	%
Thermal		
Winter Nighttime:		
U-factor/U-Value	1.04	$Btu/hr\text{-}ft^2\text{-}^\circ F$
Summer Daytime:		
U-factor/U-Value	0.94	$Btu/hr\text{-}ft^2\text{-}^\circ F$
Shading Coefficient (SC)	1.00	-
Solar Heat Gain Coefficient (SHGC)	0.87	-
Relative Heat Gain	213	$Btu/hr\text{-}ft^2$
Light to Solar Gain	1.03	-

***Vertically Glazed Center Of Glass (COG) Results Calculated Using LBNL Window 6.3 Software.**

Notes: a) NFRC certified spectral data file
b) Data generated by Oldcastle BuildingEnvelope®
c) Average solar data
d) Simulated with LBNL Optics 6.0
e) Vendor supplied spectral data file
f) Please reference ASTM C1036 and C1172 for allowable glass thickness variations

original glass

Oldcastle BuildingEnvelope®

Date: December 14, 2015
Customer:
Project:
Location:
Glass Type:

MONOLITHIC GLASS PERFORMANCE DATA

	ID #		Notes
Lite:	9921	1/8" Pilkington Energy Advantage™ Low-E #2	a

Nominal Thickness: **0.118 Inches** f

Performance Properties	COG Results*	Units
Transmittance		
Visible Light	82	%
Solar Energy	43	%
Ultraviolet	57	%
Reflectance		
Visible Light (Exterior)	11	%
Visible Light (Interior)	12	%
Solar Energy (Exterior)	6	%
Thermal		
Winter Nighttime:		
U-factor/U-Value	0.65	$Btu/hr\text{-}ft^2\text{-}^\circ F$
Summer Daytime:		
U-factor/U-Value	0.50	$Btu/hr\text{-}ft^2\text{-}^\circ F$
Shading Coefficient (SC)	0.51	-
Solar Heat Gain Coefficient (SHGC)	0.44	-
Relative Heat Gain	109	$Btu/hr\text{-}ft^2$
Light to Solar Gain	1.86	-

***Vertically Glazed Center Of Glass (COG) Results Calculated Using LBNL Window 6.3 Software.**

Notes: a) NFRC certified spectral data file
b) Data generated by Oldcastle BuildingEnvelope®
c) Average solar data
d) Simulated with LBNL Optics 6.0
e) Vendor supplied spectral data file
f) Please reference ASTM C1036 and C1172 for allowable glass thickness variations

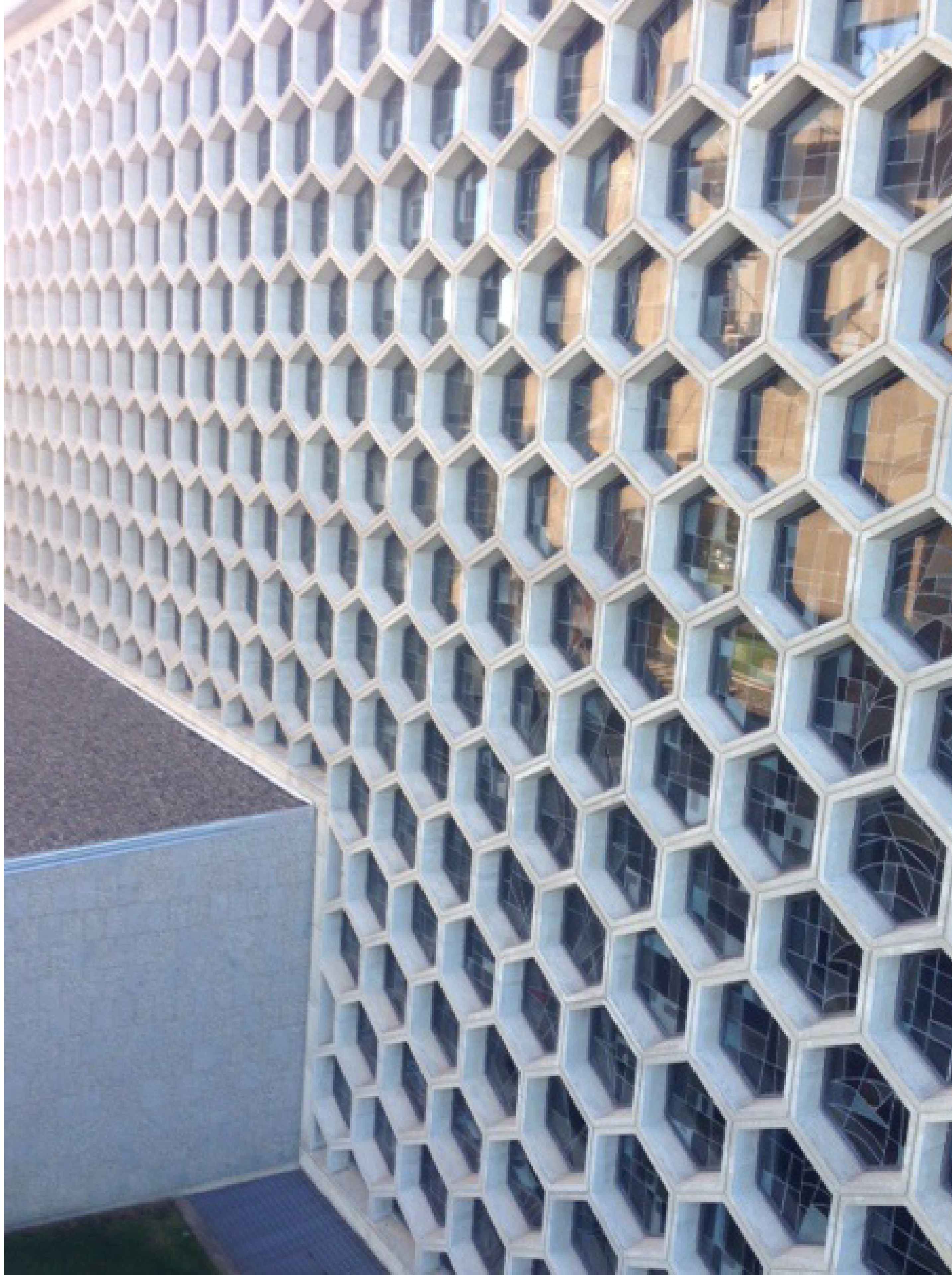
high performance glass

Abbey Church

STAINED GLASS

TerHaar Stained Glass Studio has completed an extensive and detailed inspection of the conditions of the stained glass windows at the Marcel Breuer-designed Saint John's Abbey Church, Collegeville, Minnesota. This included close inspection of the north facing wall of stained glass from top to bottom interior and exterior with the aid of scaffolding inside and sky lift on the outside. See photos.

We also closely inspected the north-facing skylight above the church altar. We were able to ascend to the roof skylight through the circular stairs behind the church organ to get a close view from both inside and outside. See photos. Please note: TerHaar Stained Glass Studio replaced the south-facing stained glass skylight in 1988. This also included an outside protective glass system that allows air flow between the stained glass panels and the protective glass, to relieve heat buildup. Upon recent inspection, the new stained glass panels and protective glass remain in excellent condition.



PROGRESS

EXISTING CONDITIONS

North facing stained glass wall of windows

On inspection of the interior and exterior, we found the integrity of the lead and solder joints in good condition. There are no noticeable cracks or breaks detected in either lead or solder joints. The reinforcing bars, with a few exceptions, are intact, still soldered to the lead and performing very well. No bowing or bulging of the panels was seen.

Upon removal of several panels of stained glass, both the stained glass and leading showed strength and remained intact with the lead, solder and reinforcing bars showing strong performance. The vapor barrier space between the stained glass and outside protective glass seems to be intact, showing no signs of moisture buildup or water penetration (although somewhat dusty.)

The stained glass window panels have dust and dirt and some spider webs on both the interior and exterior stained glass panels. The interior and exterior concrete portions of the windows openings are also quite dirty and dusty.

There are a few pieces of cracked stained glass on the north facing wall.

We inspected the outside protective glass top to bottom with East Side Glass Company. Again what we found was a single glazed glass panel outside, which seemed to be intact in a frame system that is attached to the concrete and puttied around perimeter.

We saw no evidence of water penetration or heat buildup between the stained glass and protective glass, so the air flow seems adequate. This may be partly the result of north facing windows (no direct sun). It is highly possible that a thermo glass on the exterior would provide better insulation for both heat and cooling. East Side Glass Company will be addressing this aspect of the window inspection.

North facing stained glass skylight above the Abbey Church altar

We went on the roof and interior roof to inspect this skylight from both the interior and exterior. We replaced the south stained glass skylight in 1988. We found these north facing panels of stained glass showing the same condition that the south panels showed in 1988.

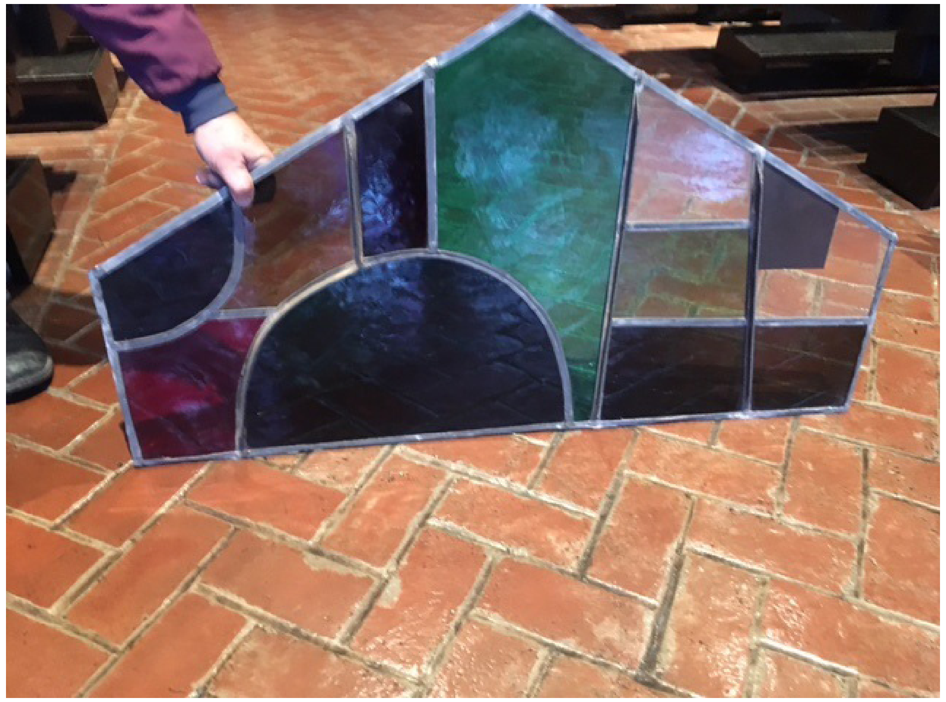
These 8 stained glass panels comprising the skylight are European glass pieces, which are laminated to a ¼" piece of clear glass and held with epoxy. Marcel Breuer did not want a leaded panel fabrication process as in the regular stained glass windows. He preferred just the stained glass look without the visible lines of lead.

1. Some stained glass pieces are missing and cracked.

2. The epoxy is starting to discolor and is losing its adhesive quality.

3. Dirt is getting between the stained glass and ¼" clear glass.










Abbey Church

VESTIBULES & EXTERIOR DOORS

The main Abbey Church entry is north-facing, through the Baptistry. There is no air lock. Solid wood pairs of doors do not provide a weather seal. Light - and cold air in the winter - leaks through where the door leafs should join. Options for restoration and repair include fitting the existing door edges and bases with seals to provide a tight fit; or reconstruction of new, thicker doors with faces that are identical to the existing ones but which clad thermally-broken insulating cores.

Door hardware has exceeded its useful life. Parts are no longer available for closer mechanisms, which are cast and recessed into the floor. Options for closer repair include custom milling of new parts to replaced the ones that have failed, with adequate spares; providing all new hardware, which will require some intervention to the paving surfaces either side of the recessed mechanisms and subsequent careful repair; or all new, heavier replacement hardware if the existing doors are replaced with thermally broken leafs with similar appearance to the existing ones. Repair of the existing doors is preferred.

The Baptistry does not provide an air lock, like do the side cloister vestibules providing entry to the Abbey Church, because the entry from it to the main sanctuary is open above the sanctuary doors, storage closets, and confessionals. One option to allow for the Baptistry to serve as an airlock is to infill the openings with clear glass, preserving the original design appearance. Doors at the bottom of the stairs on both sides of the Baptistry, separating it from the lower church, already contribute to an air lock.

ABOVE A pair of entry doors from beneath the Bell Banner porch into the Baptistry. Light leak is a simile for air infiltration in the winter, which at times creates a whistle.

ABOVE The Baptistry could provide an air lock for the Abbey Church sanctuary, through infill with clear glass of the openings above the sanctuary doors, storage closets, and confessionals.

Abbey Church

ACOUSTICS

The interior Abbey Church is primarily enclosed by hard, reflective surfaces and is quite reverberant.

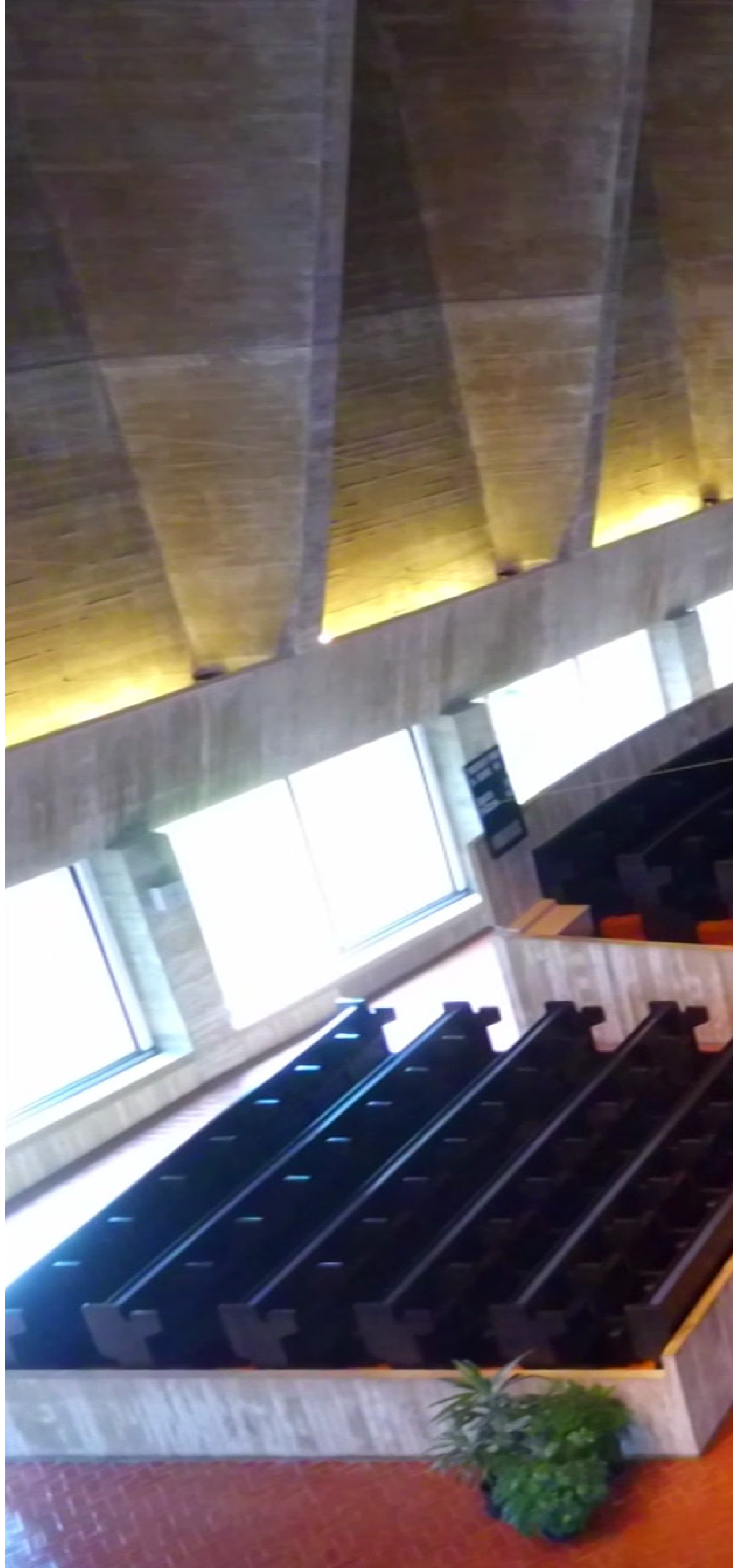
Some attenuation is provided by the red fabric infill of the metal screen above dais. It is recommended that this fabric be replaced. It has exceeded its useful life, and has had numerous small repairs made with patches to tears and perforations. The patches are visible through close inspection from the balcony behind the screen but not visible from the Sanctuary.

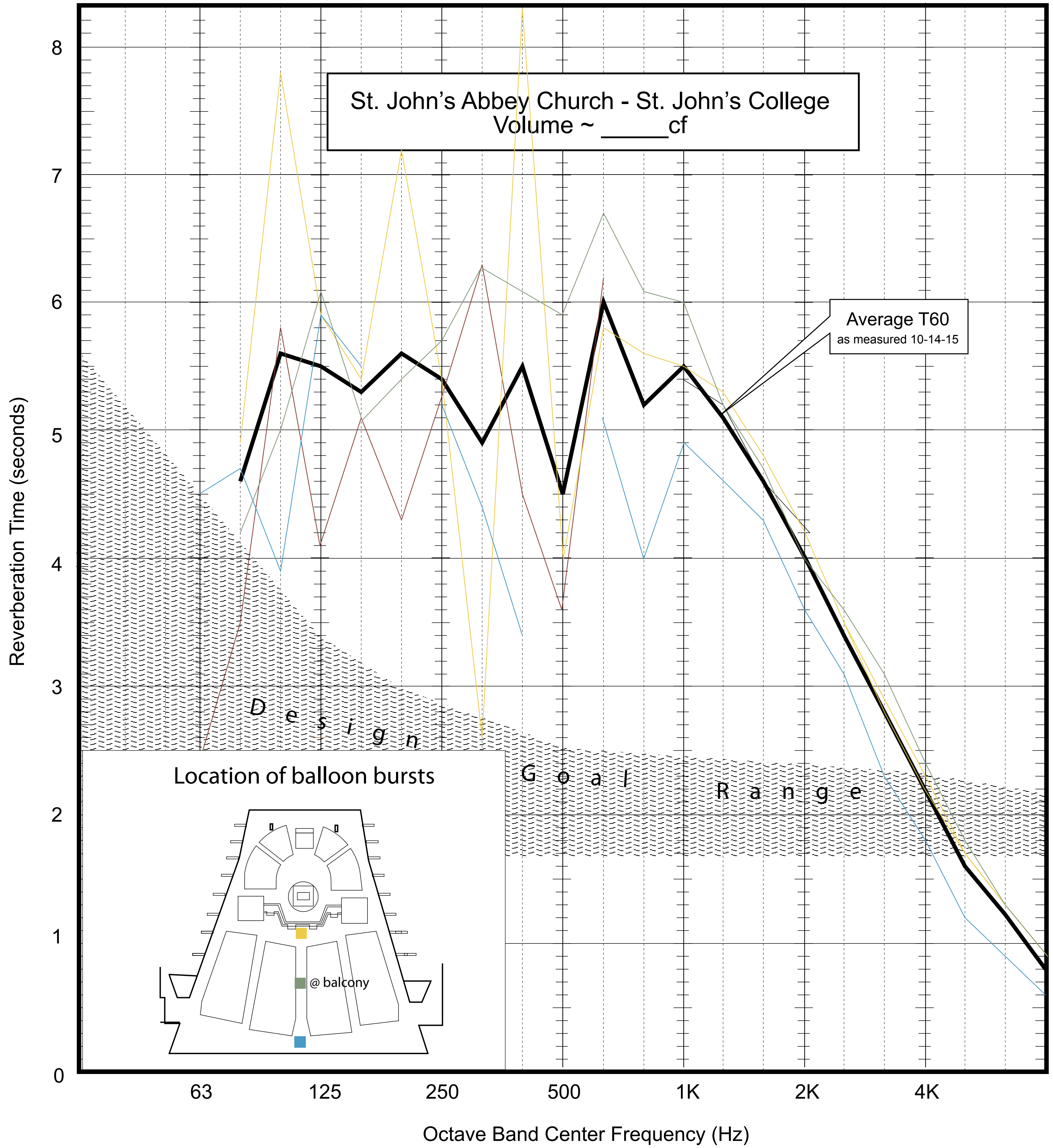
Additional attenuation is provided by occupants.

Reverberation was established by measuring base reverberation in a silent and unoccupied Sanctuary, followed by a measurement of reverberation after a balloon burst.

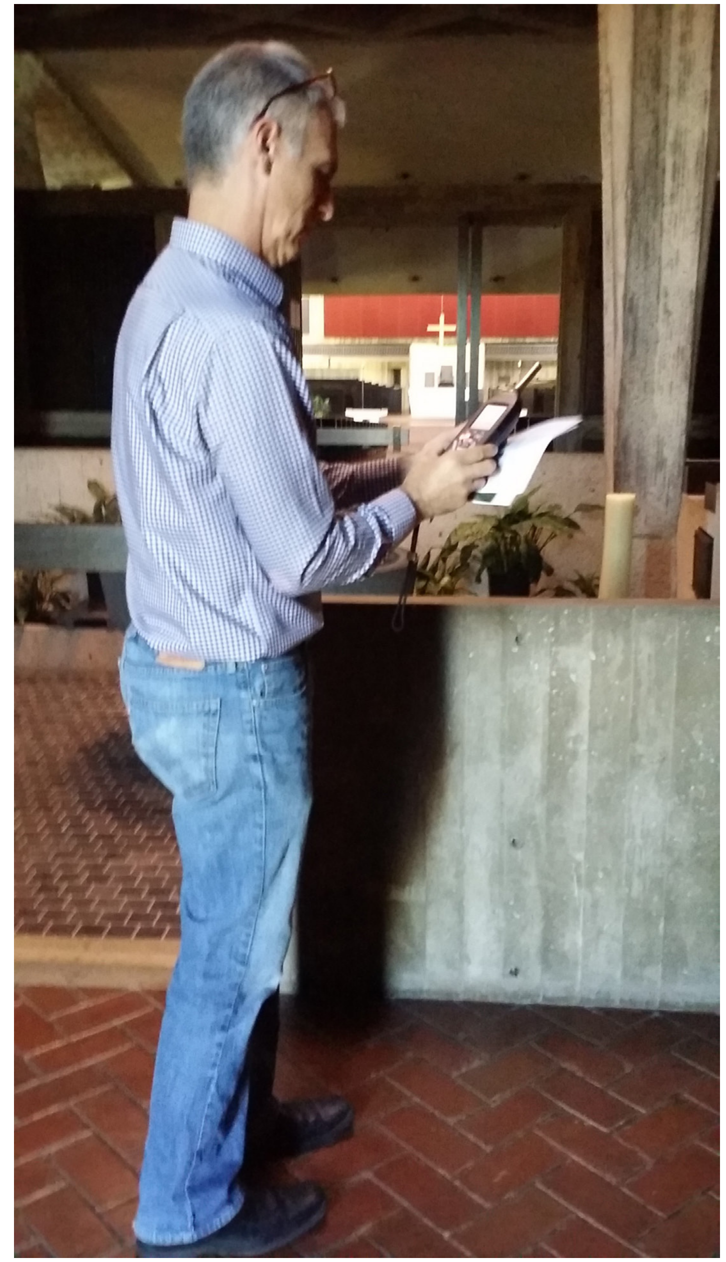
The reverberation is both acceptable and desired for daily chant. Electro-acoustic enhancement has been installed and is used for large gatherings.

Reverberation has not been measured in a fully occupied condition: this would need to occur during a service at Easter or Christmas and for this study such a measurement has been determined to be inappropriate.





Reverberation Time Graph



Abbey Church

INTERIOR SURFACES

Sanctuary Interior Surface Survey

The sanctuary interior surfaces consist of the original exposed concrete folded plate structure. Minor cracking was observed near the base of the east and west elevation walls near the north end. The cracking was not judged a structural concern.
Additional cracking was observed on the interior wall adjacent to each side of the doorway to the Blessed Sacrament Chapel on the east side of the sanctuary. The cracking was not judged a structural concern.

One location at the third roof rib from the north on the west wall elevation a short length of cold joint/crack was observed that exhibit a leached whitish material. The material is unknown but appears consistent with form oil or efflorescence. The location is at the bottom of the folded roof plate rib location. The cracking is not judged a structural concern.

ABBEY CHURCH INTERIOR


MASS
PSALM

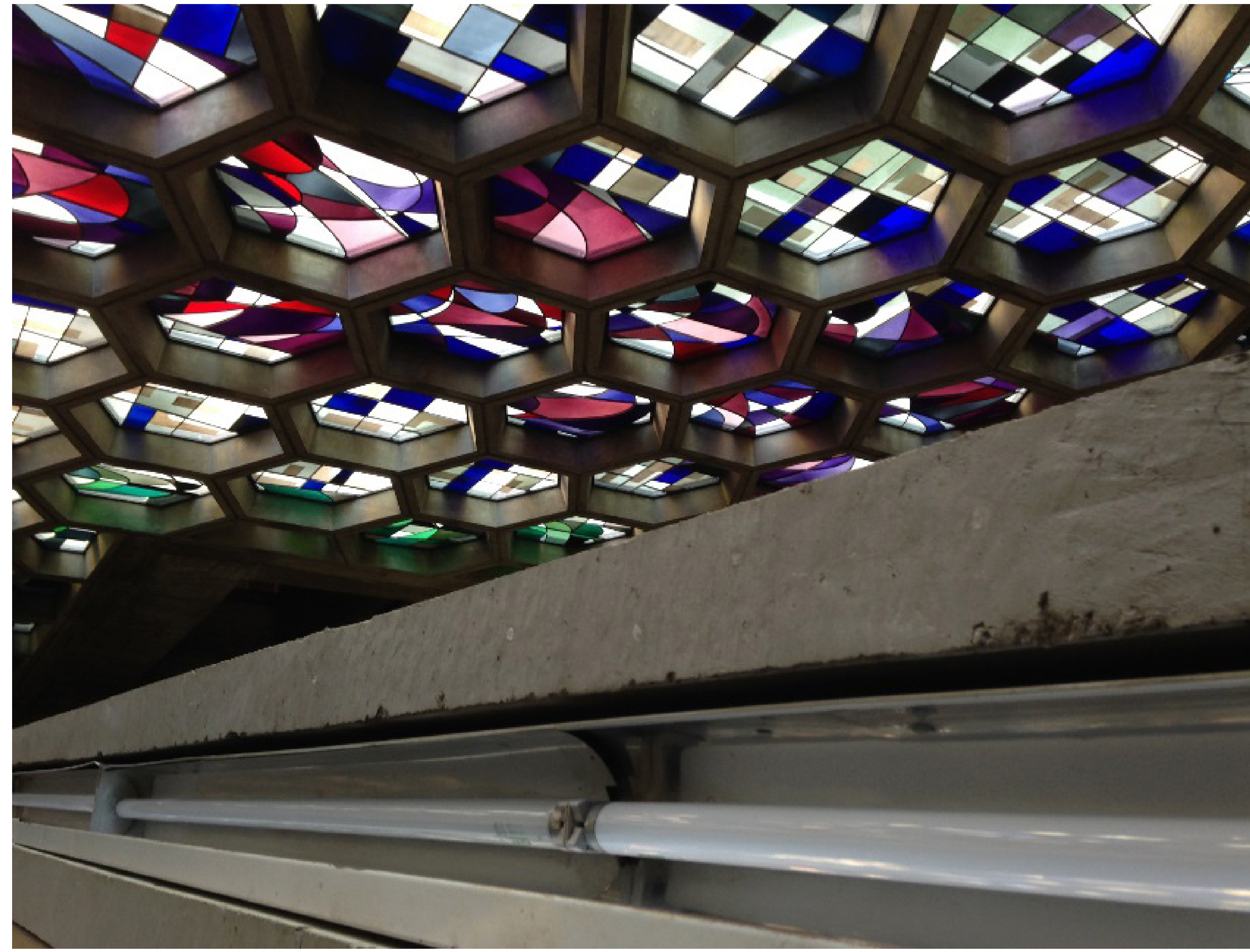
Abbey Church

LIGHTING

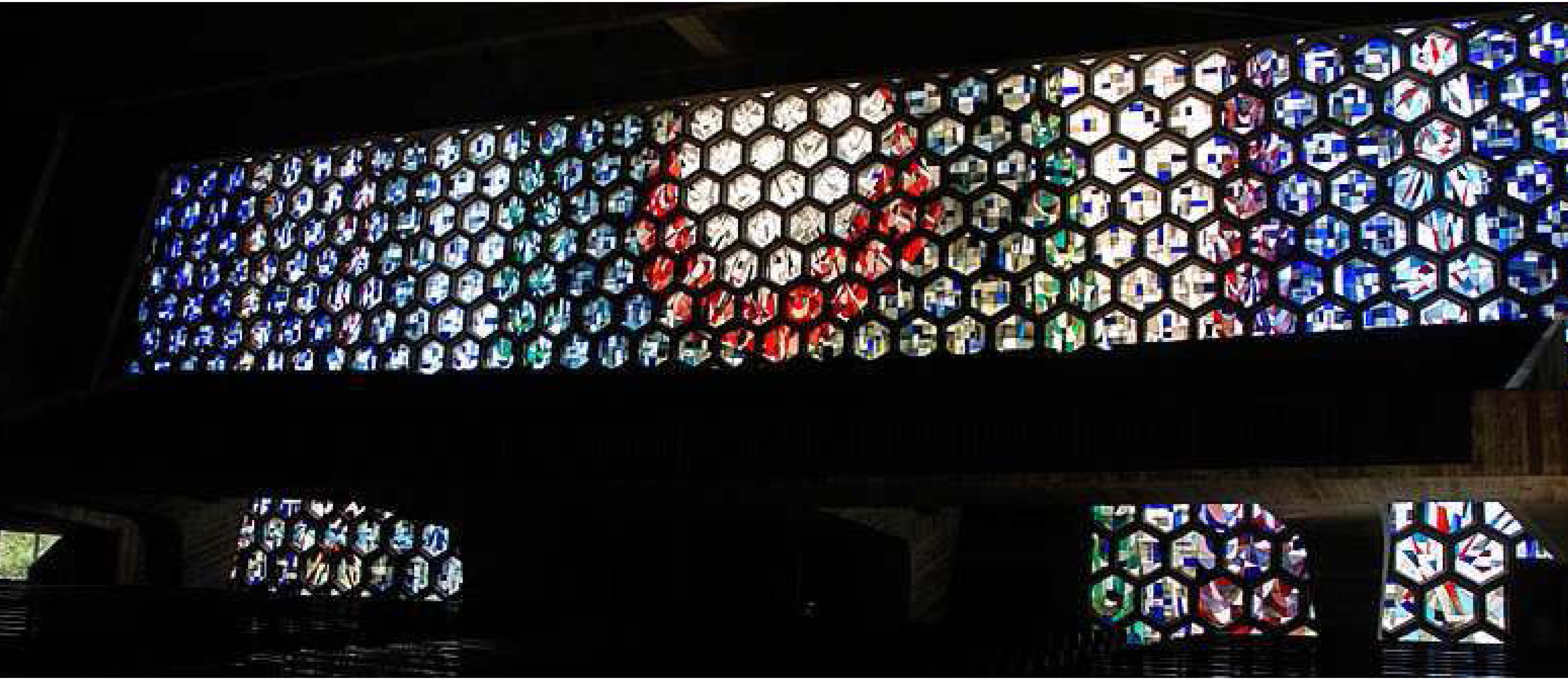
North Wall

The wall is a monolithic stained-glass window that encompasses most the north façade. Hexagonal concrete frames are stacked on each other to form the structure. Each honeycomb unit is filled with stained-glass in a symmetrical pattern that corresponds to the colors of the liturgical year. Daylight through the window adds to the illumination inside the church and provides a dramatic background when the service is conducted facing the monastic choir.

The interior face of the wall is illuminated on select feast days using a row of fluorescent wallwashers at the back of the balcony. These fixtures will be replaced using high-efficiency LED wall wash fixtures.



Type	Existing Description	Proposed Solution
	Interior up-lighting of North Wall	Replace the existing fluorescent units with linear LED striplights



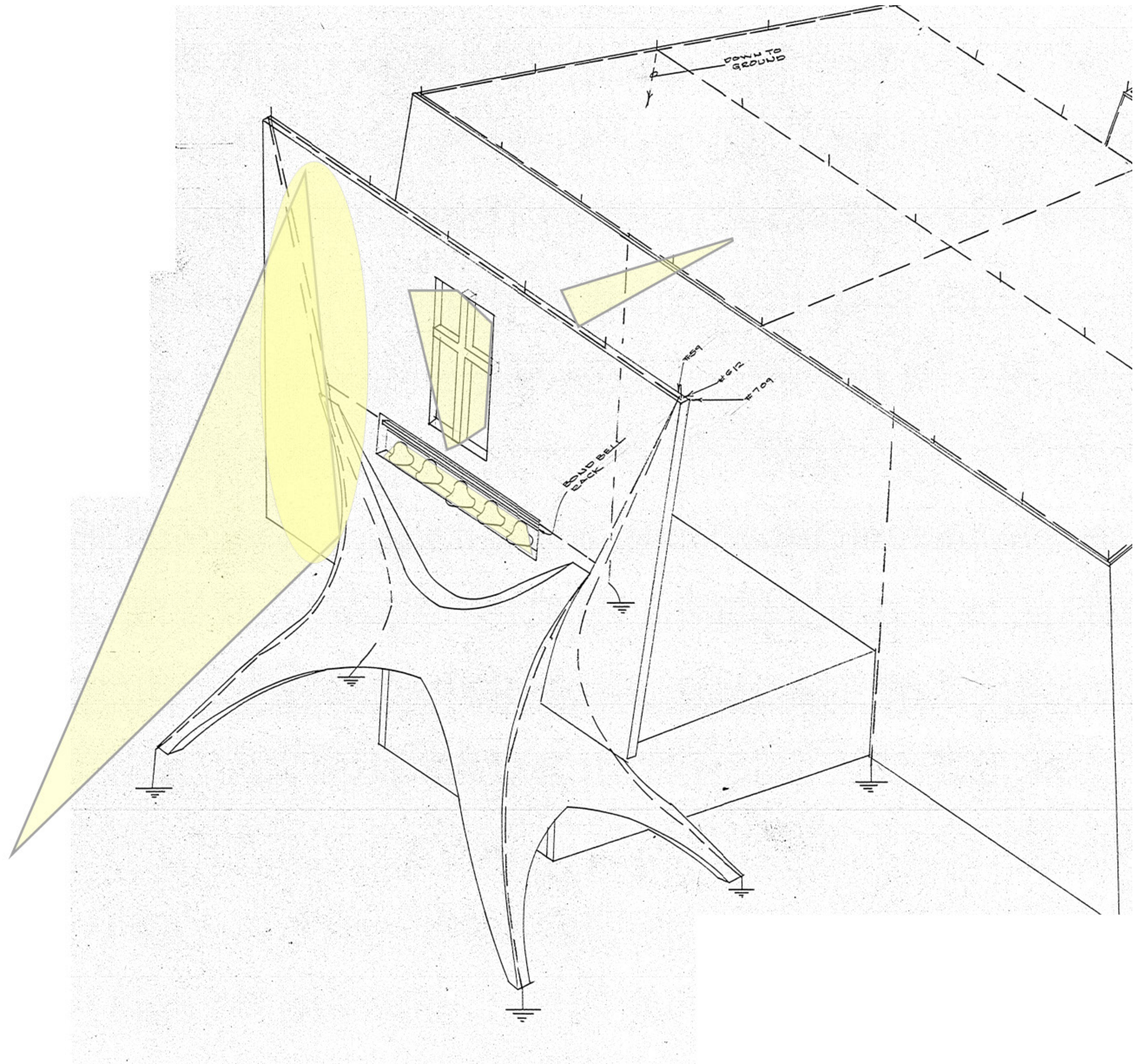
Lighting will play an important role in the restoration and upgrade of the church. In general the existing lighting locations will be re-used with careful attention to the architects design intent. However, in some areas of the church the original solutions are not adequate to support the needs of the monastic community and the congregation. To support the ongoing mission of the building, light levels will be increased in many areas, which will include supplemental lighting. Added lighting will be hidden from view wherever possible.

Bell Banner

The Bell Banner is illuminated with fixtures mounted at grade level and concealed in a hedge at the Abbey Plaza. The lighting follows the liturgical calendar and varies according to the celebration.

The fixtures will be replaced with new floodlights with LED sources. Color-changing fixtures will be considered to allow the color of light at the Banner to follow the liturgical year. The color-changing fixture will be coordinated with similar fixtures at the side walls of the church.
Recessed into the arch of the Banner are a series of downlights fitted with Fresnel lenses. New components will be fitted into the existing fixture housing, and a new lens door and lens will be fabricated. The light source will be LED.
Lighting emphasis will be added to enhance the banner cross using spotlights at the roof of the church. The bells within the banner with sources concealed on the shelf below them.

Type	Existing description	Proposed Solution
SA	Stanchion mounted HPS floodlights at the Abbey Plaza	Replace with New 3000k LED floodlights
SB1	Recessed Fresnel lens downlights at the Banner arch	Retrofit kit
SB2	Recessed Fresnel lens downlights at the church entry doors	Retrofit kit
SC	None Add backlight to the cross and bells within the Banner.	
Fixtures at Bell level to light Cross:		
	Are Dedication stones lighted; do they need to be? TBD	TBD

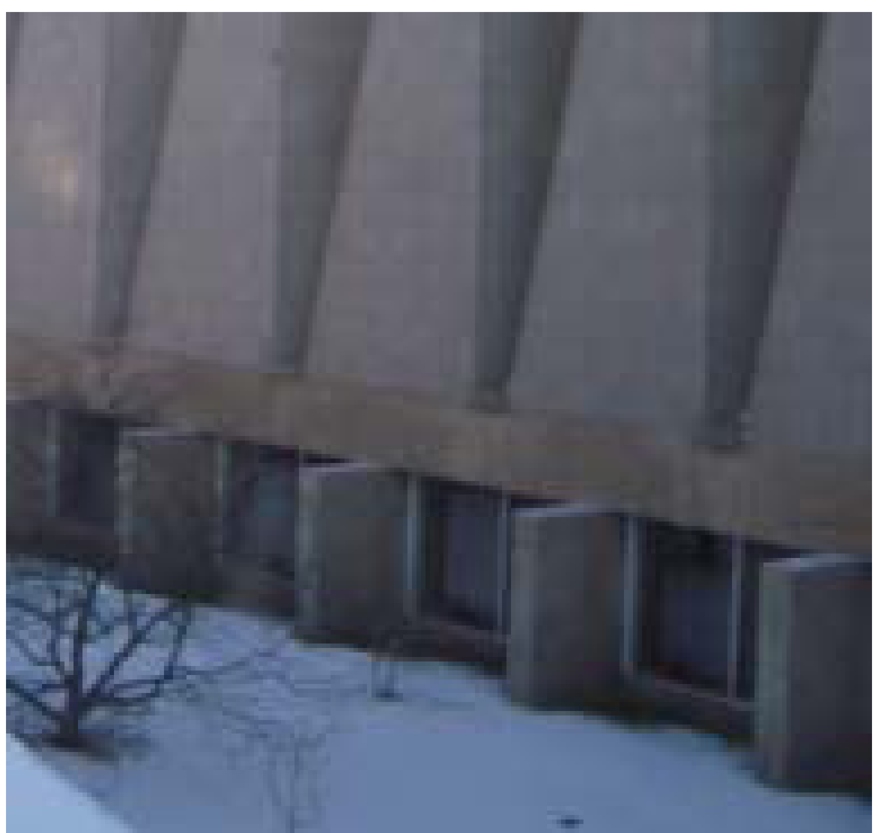

DOWN TO
GROUND
#59
#612
#709
BOND BELL
RACK

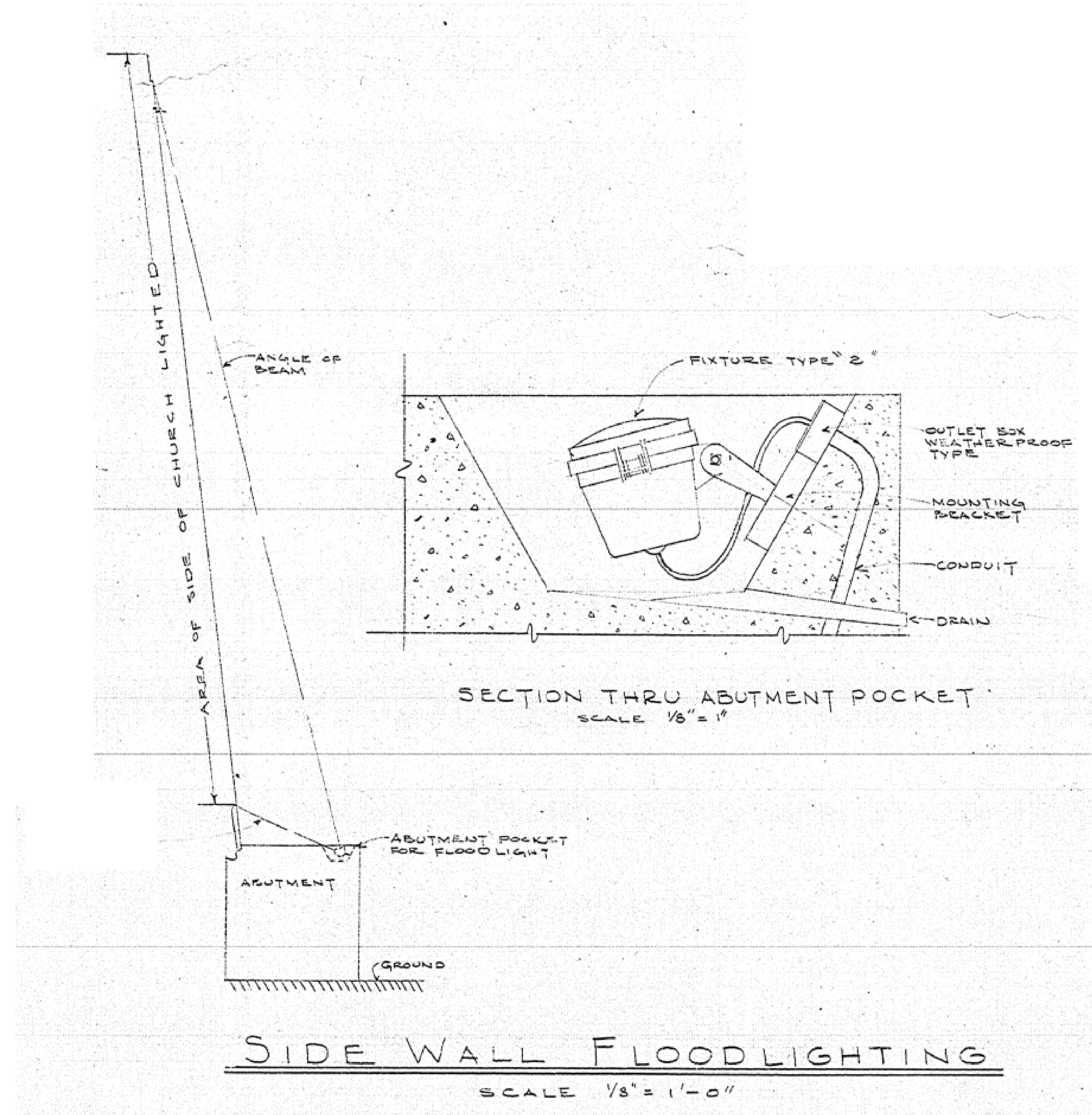
Side Walls and Buttress

The original lighting design included uplighting on the exterior side walls that engaged the folded concrete plates in a dramatic way. The fixtures were recessed into the tops of the buttresses that are centered between the massive V-shaped 'columns'. Water intrusion occurred at the fixtures, which resulted in some spalling of the concrete due to freeze-thaw action. It is the strong desire of the community that the lighting effect be restored. As part of the study, determine if original locations can be restored, or if an alternate solution can be effective.

Type	Existing description	Proposed Solution
	Uplights for side walls from buttresses.	
		Alt. A. Determine feasibility of restoration of original idea: -Core-drill new recess into the buttress to permit installation of new LED fixture. -pour new formed corner to accommodate new fixtures. Alt. B. Develop alternate lighting approach-surface mount to buttresses or mount to roof of cloisters.
	Courtyard lighting	Supplementary light of landscaping within the courtyards will be evaluated.

Alternates will be explored ranging from the viability of restoring the original lighting fixtures recessed into the upper surface of the concrete support buttresses and evaluation of further possible impact of freeze thaw cycles on spalling.

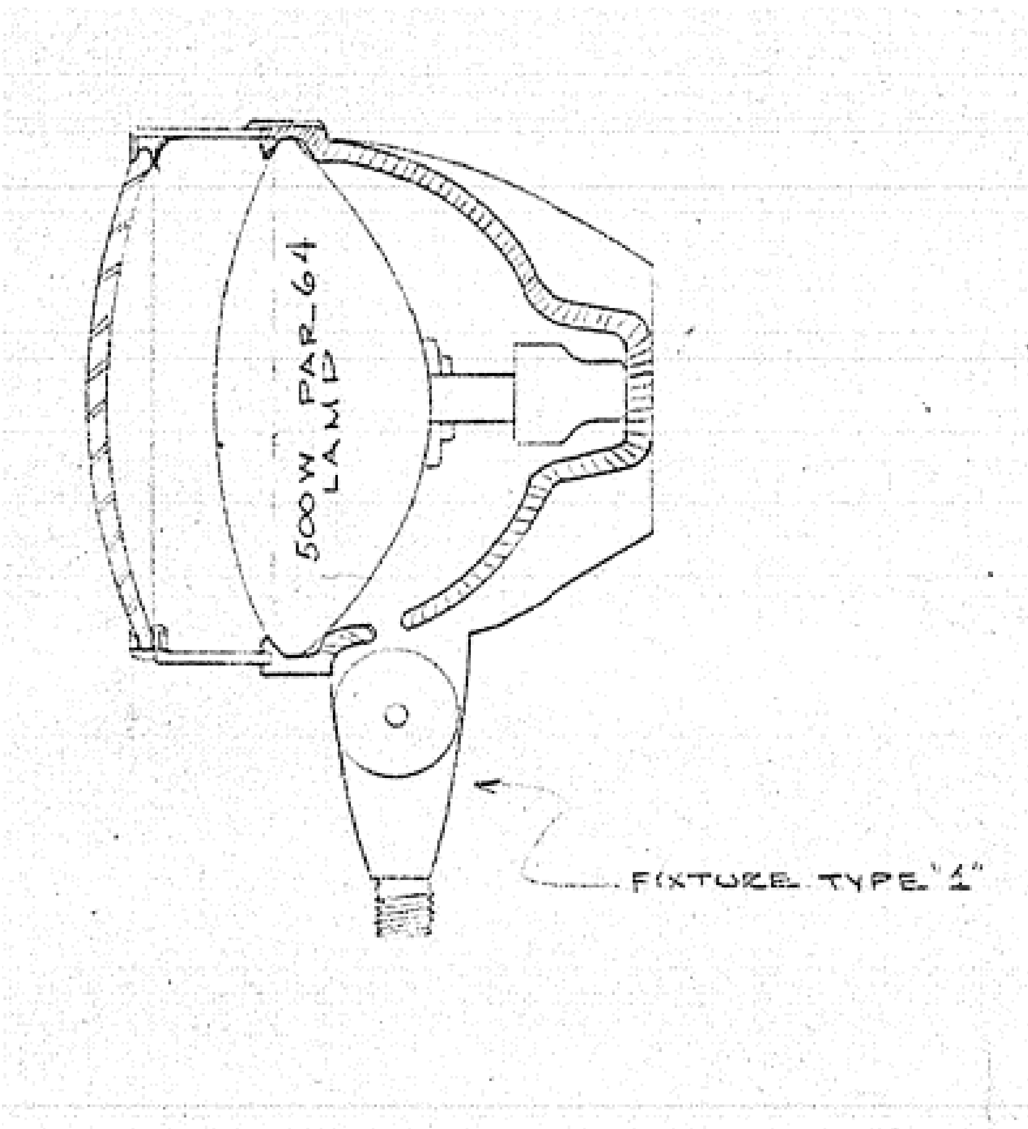


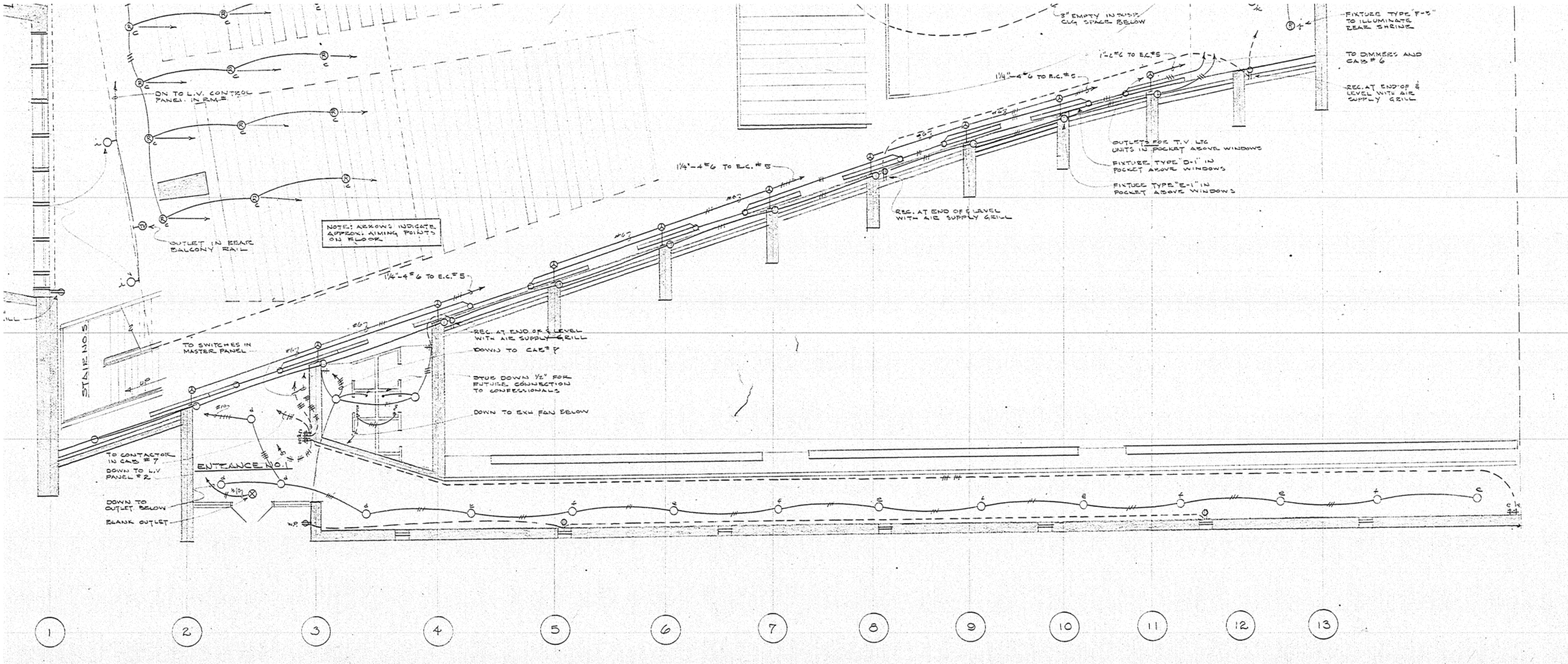

ANGLE OF BEAM
FIXTURE TYPE "2"
OUTLET BOX WEATHERPROOF TYPE
MOUNTING BRACKET
CONDUIT
DRAIN
SECTION THRU ABUTMENT POCKET
SCALE 1/8"=1"
ABUTMENT POCKET FOR FLOOD LIGHT
ABUTMENT
GROUND
SIDE WALL FLOODLIGHTING
SCALE 1/8" = 1'-0"

Cloisters

The original lighting design included a wash of light that illuminated the flue walls of the cloisters. Visible and quite prominent from the nave, the lighted cloisters were used during select services to add visual interest. The existing fixtures were hidden from view with a shield made from a flue tile cut in half. The light reflected from the flue pipe onto the wall behind it.

The original design concept will be re-created using a high-efficiency light source.


500W PAR-64
LAMP
FIXTURE TYPE "1"



Typical location of cloister wall wash lights.

Typical location of façade lighting at buttresses.

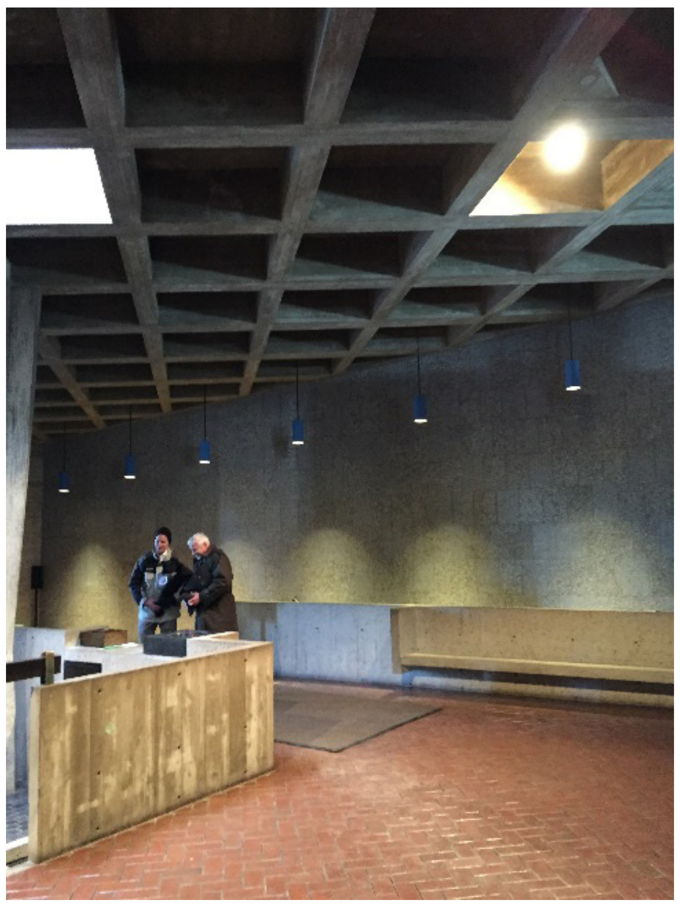
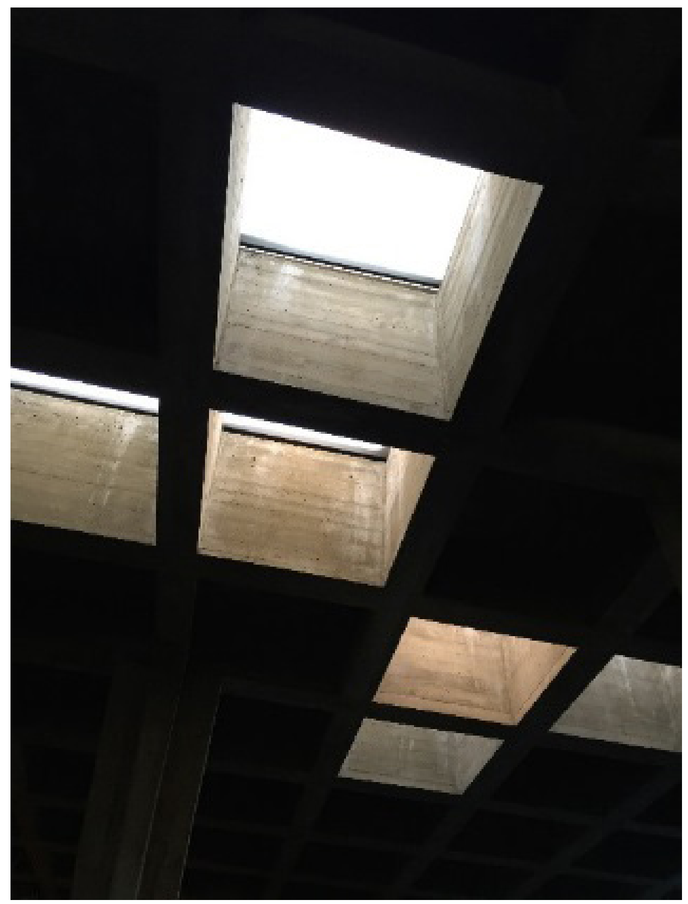
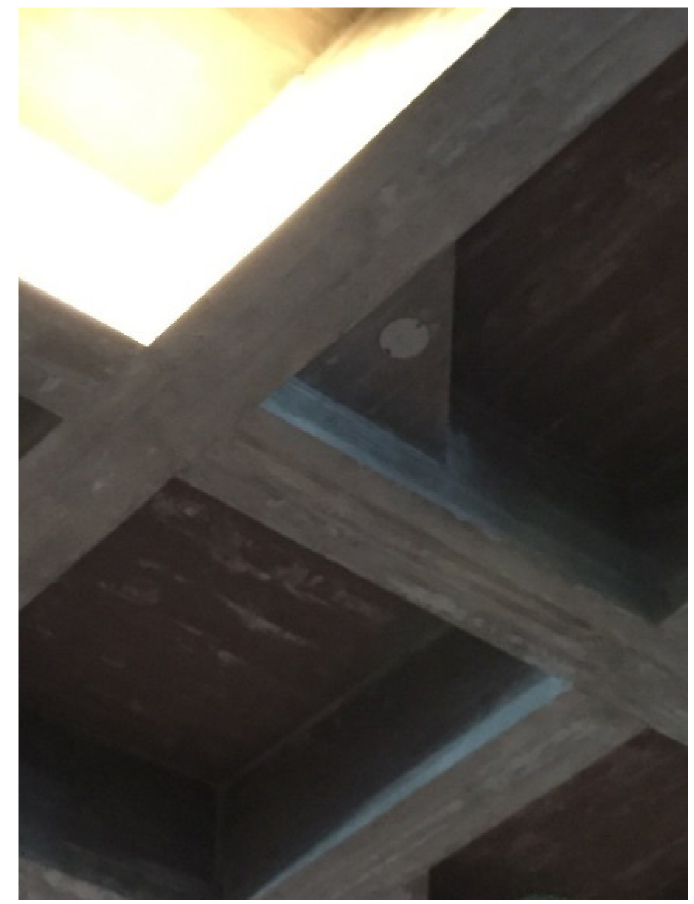
Baptistry

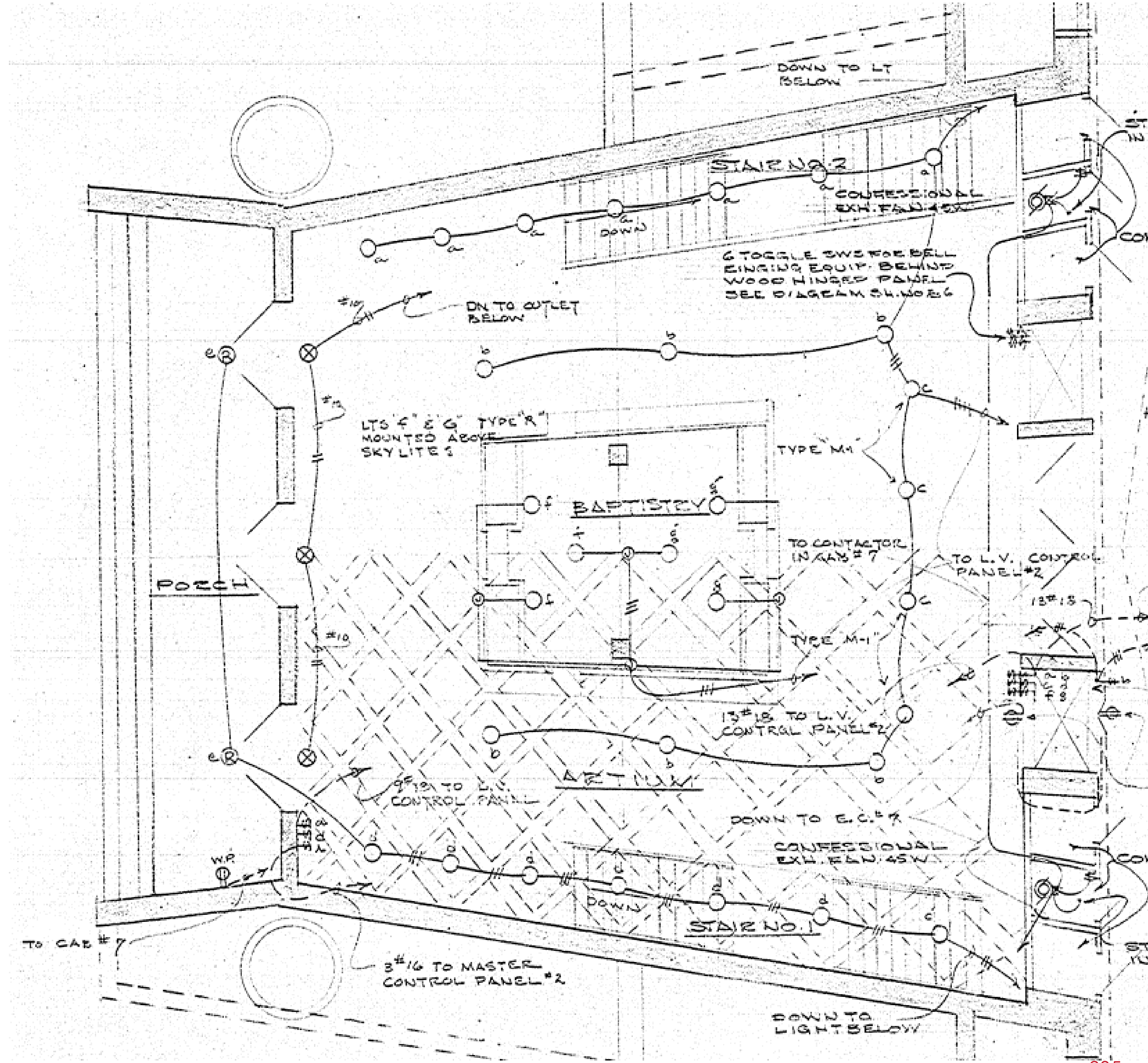
The baptistry is the beginning of the spiritual axis that leads through the nave to the altar with the baldachin above, and continuing to the abbot's throne and the apse screen that concludes at the southern wall of the choir. The Baptistry is primarily lit by skylights through its poured concrete roof structure. The original design included artificial lights which were mounted above the skylights and would shine through them when needed to augment or replace natural sunlight. The original lamps were of such intensity that heat generated by them deteriorated the skylight domes to the point of failure - they basically melted and have been replaced several times.

Alternates for replacement skylights that are in conformance with original design intent and profiles will be identified. Alternates for artificial lighting will be identified, including low-heat high-lumen-output LED lamps, to restore the lighting of the Baptistry to original design intent.

Two rows of pendant mounted cylinders at the perimeter of the baptistry light the walkways and stairs down to the crypt. In their current form, the fixtures light only the bottom third of the wall. To reduce the extreme contrast of daylight through the skylights against the dark interior, several lighting ideas will be explored including adding a linear wall wash fixture at the side walls to provide supplementary light while preserving the quality of the space. Another option is to investigate existing electrical boxes that were installed as part of the original construction. On the plans, fixtures had been specified, but evidently were not installed. The boxes may allow us to add supplementary ambient illumination, and accent light at statuary, using the original electrical layout.

Type	Existing description	Proposed Solution
	Pendant Cylinder	The existing fixtures will be fitted with screw-in LED lamps.
	None – to be added	Wall wash at side walls to reduce contrast. 80 feet
	None – to be added	Spotlights to highlight statue, and the font. Re-use exsitng power boxes at the ceiling.
	None – to be added	
	Investigate hand rails at stairs to the crypt below for possible integral lighting.	



DOWN TO LT BELOW
STAIR NO. 2
CONFESSIONAL EXH. FAN 45W
DOWN
6 TOGGLE SWS FOR BELL RINGING EQUIP. BEHIND WOOD HINGED PANEL SEE DIAGRAM SH. NO E6
DN TO OUTLET BELOW
LTS "F" & "G" TYPE "R" MOUNTED ABOVE SKY LITES
TYPE "M-1"
BAPTISTRY
TO CONTACTOR IN CAB #7
TO L.V. CONTROL PANEL #2
PORCH
TYPE "M-1"
13#18 TO L.V. CONTROL PANEL #2
9#18 TO L.V. CONTROL PANEL
ATRIUM
DOWN TO E.C. #7
CONFESSIONAL EXH. FAN 45W
W.P.
DOWN
STAIR NO. 1
TO CAB #7
3#16 TO MASTER CONTROL PANEL #2
DOWN TO LIGHT BELOW

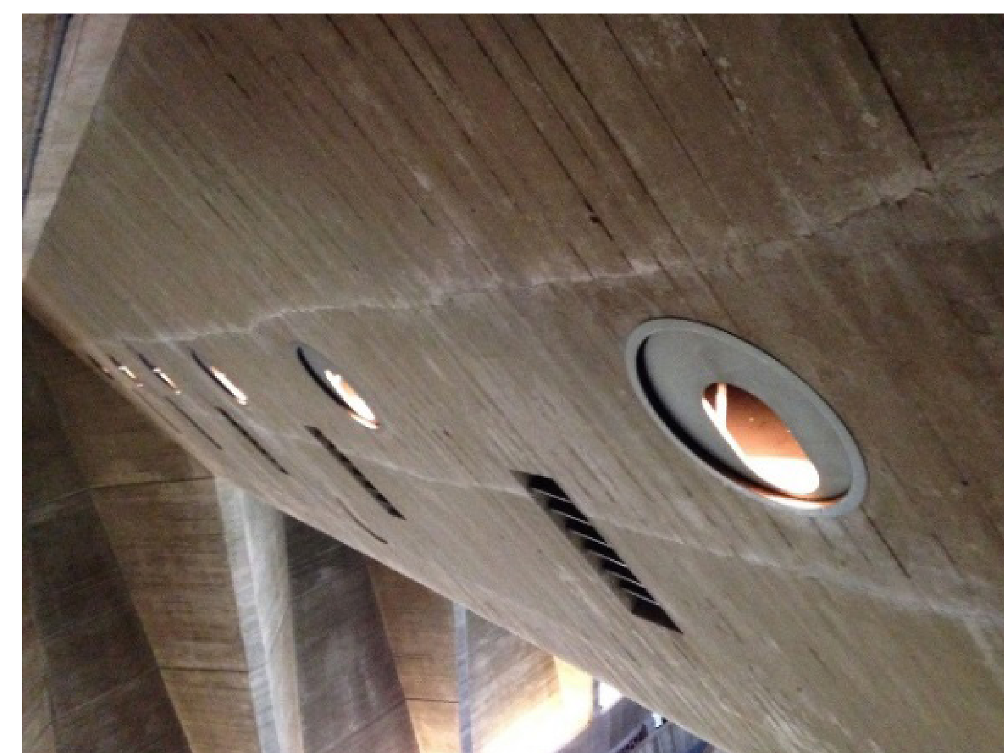
Nave

Daylight enters the nave from windows set between the buttresses at the base of the side walls, a massive skylight above the Baldachin, and from the north wall.

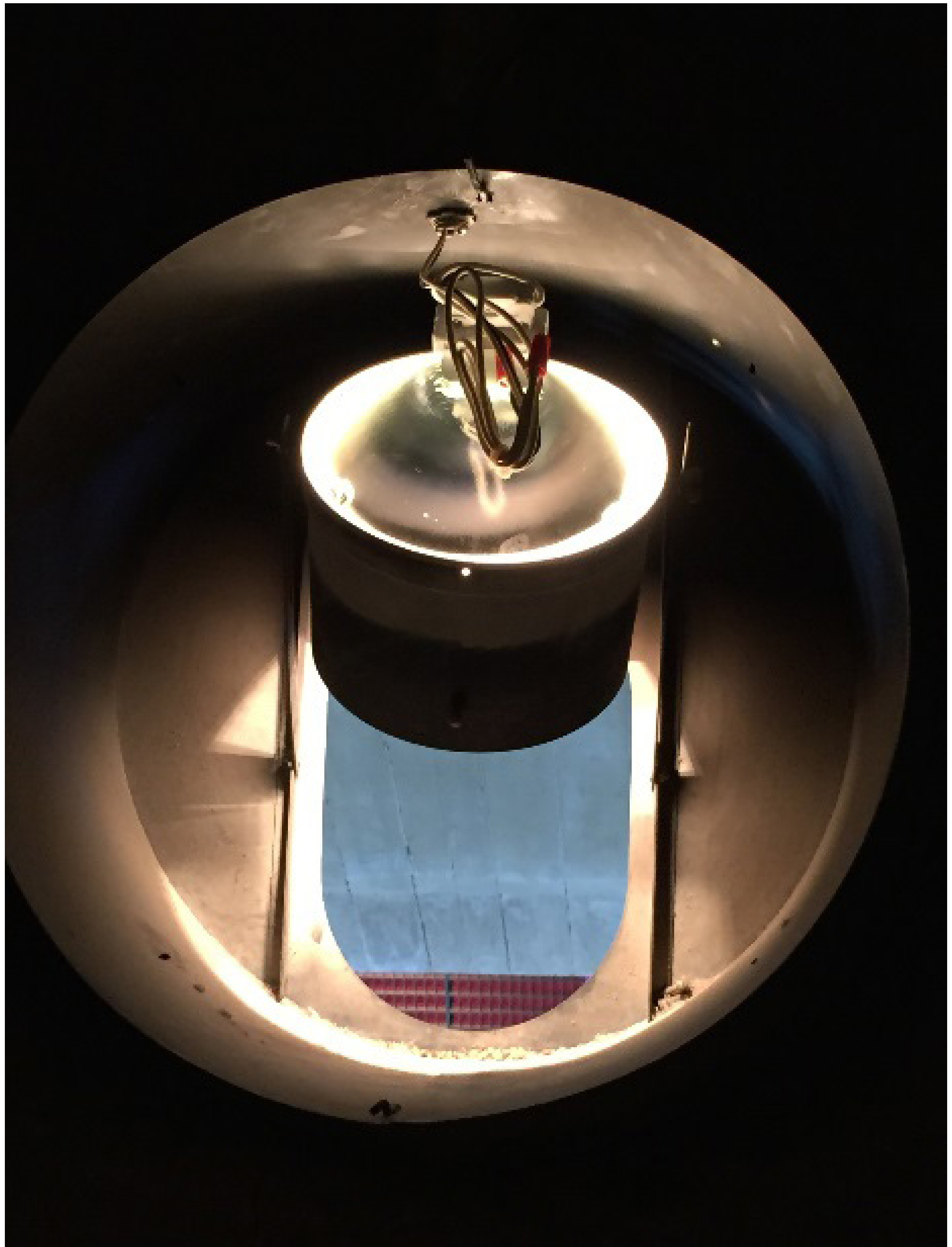
The ceiling of the church is a series of thin folded concrete plates, with the folds creating twelve massive hollow V-shaped beams that span between the side walls. A flat roof caps the beams thus creating vaults for lighting and mechanical equipment in the interstitial space. Artificial illumination in the nave and balcony is provided by fixtures mounted into openings punched through the concrete beams. Custom metal housings fitted into the openings hold large incandescent floodlights (PAR64). Light levels are adequate for circulation, but do not provide sufficient light to read worship materials.

New LED floodlights will be retrofitted into the existing fixtures to provide a smooth wash of light at every pew. Based on review of exiting conditions, new housings may be required. The quantity of light will be increased to meet current recommended practice for worship spaces.

Alternate/supplementary ideas include locating two LED light sources at select ports to allow downlight and accent light from a single port. Initial review suggests that this is feasible, and this idea will be explored fully. Control zones will be revised as needed to allow light levels to be adjusted to support current liturgical requirements.

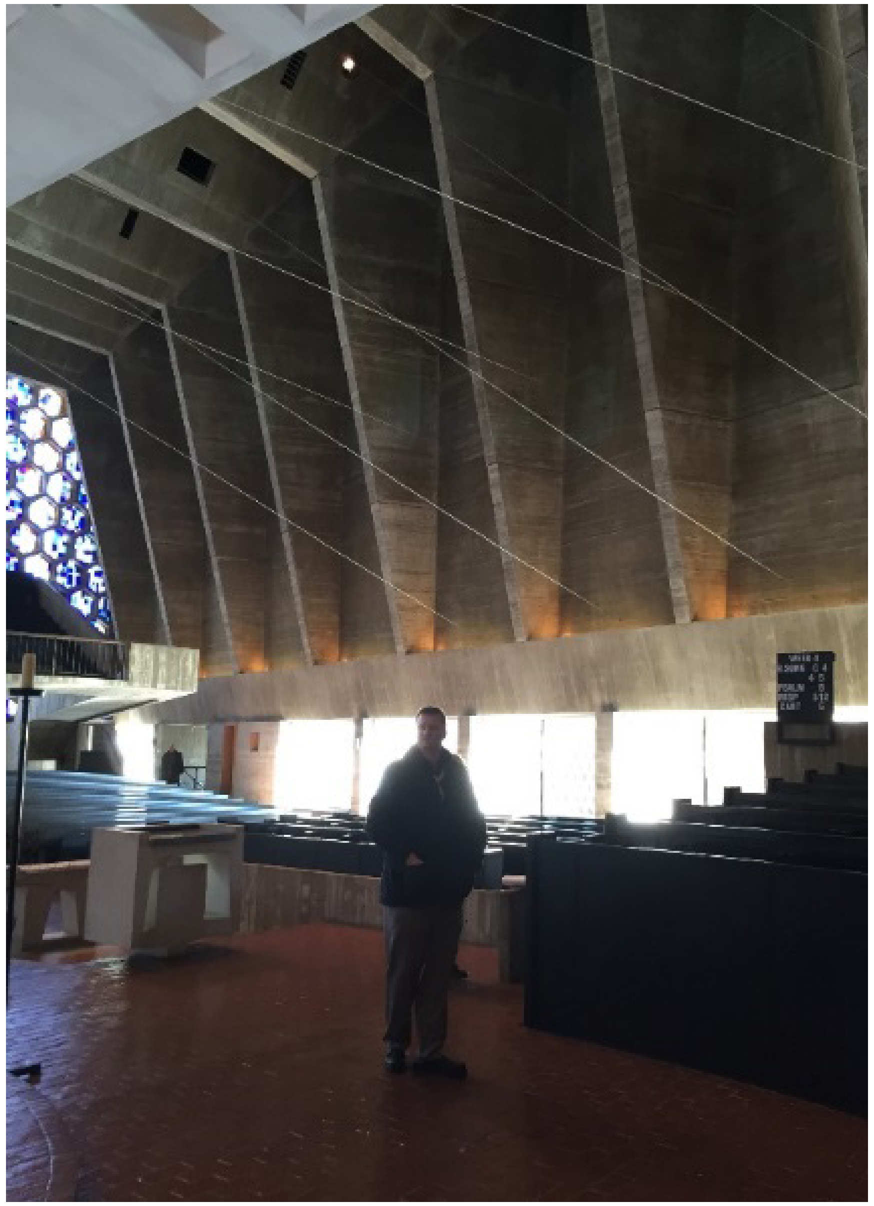


Type	**Existing description**	**Proposed Solution**
Gimbal-mounted	PAR64 Incandescent in circular housing recessed into concrete beam	-retrofit existing housing with LED head -new housing -multiple heads within one housing. Verify UL requirements.



The side walls of the church are folded concrete plates in the same style as the ceiling, and the folds meet the ceiling to form a series of massive arches. At the base of the columns is a deep valence that conceals three types of uplight fixtures at each bay. Incandescent floodlights directed out into the volume of the church illuminate the ceiling. Spotlights add dramatic shafts of light to provide definition to the columns. Linear fluorescent strip lights add a glow at the base of the walls, and add ambient light to the nave.

Proposed solutions include color-changing spotlights on either side of each concrete column, to provide strong highlights that will add visual interest. It is anticipated that colored light will used to compliment the use of color across the liturgical calendar. A row of LED strip lights will graze the the walls between columns which will create strong highlight to the texture of the board-formed concrete. A second row of linear LED strip lights will provide ambient uplight that will light the ceiling.



Under Balcony

The balcony is a concrete plate supported by massive columns. The last few rows of pews extend under the balcony, and are illuminated by downlights recessed into a cement plaster ceiling below the concrete structure. Light levels are low, making it difficult to read worship material.
These fixtures will be retrofitted with new LED downlights to increase illumination levels.

Entry Doors

Additional recessed and surface mounted downlights provide illumination at the entry doors, and will retrofitted in a similar way.

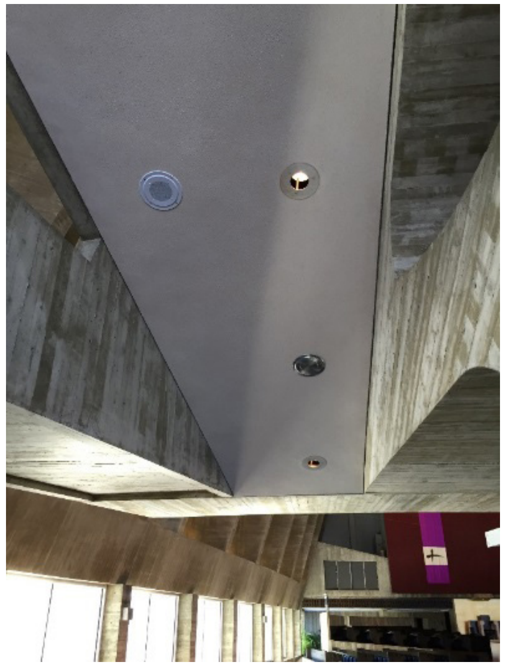
Type	Existing description	Proposed Solution
	Recessed downlight	Explore retrofit kit
	Recessed Adjustable?	Explore added fixtures at entry doors
	Surface Downlights	Locate and determine condition

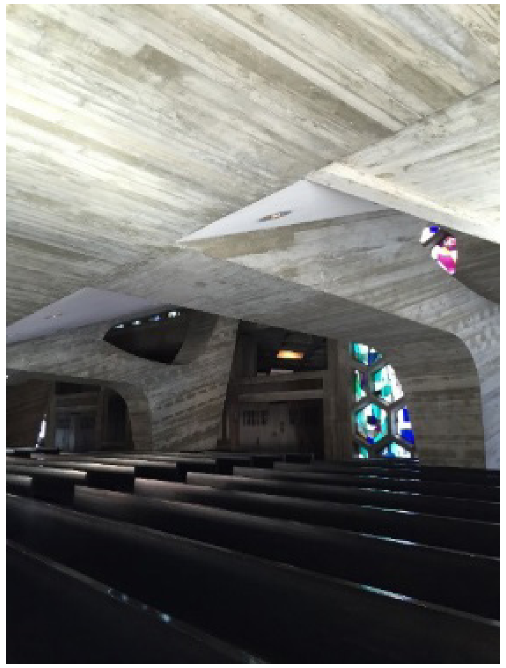
Blessed Sacrament Chapel

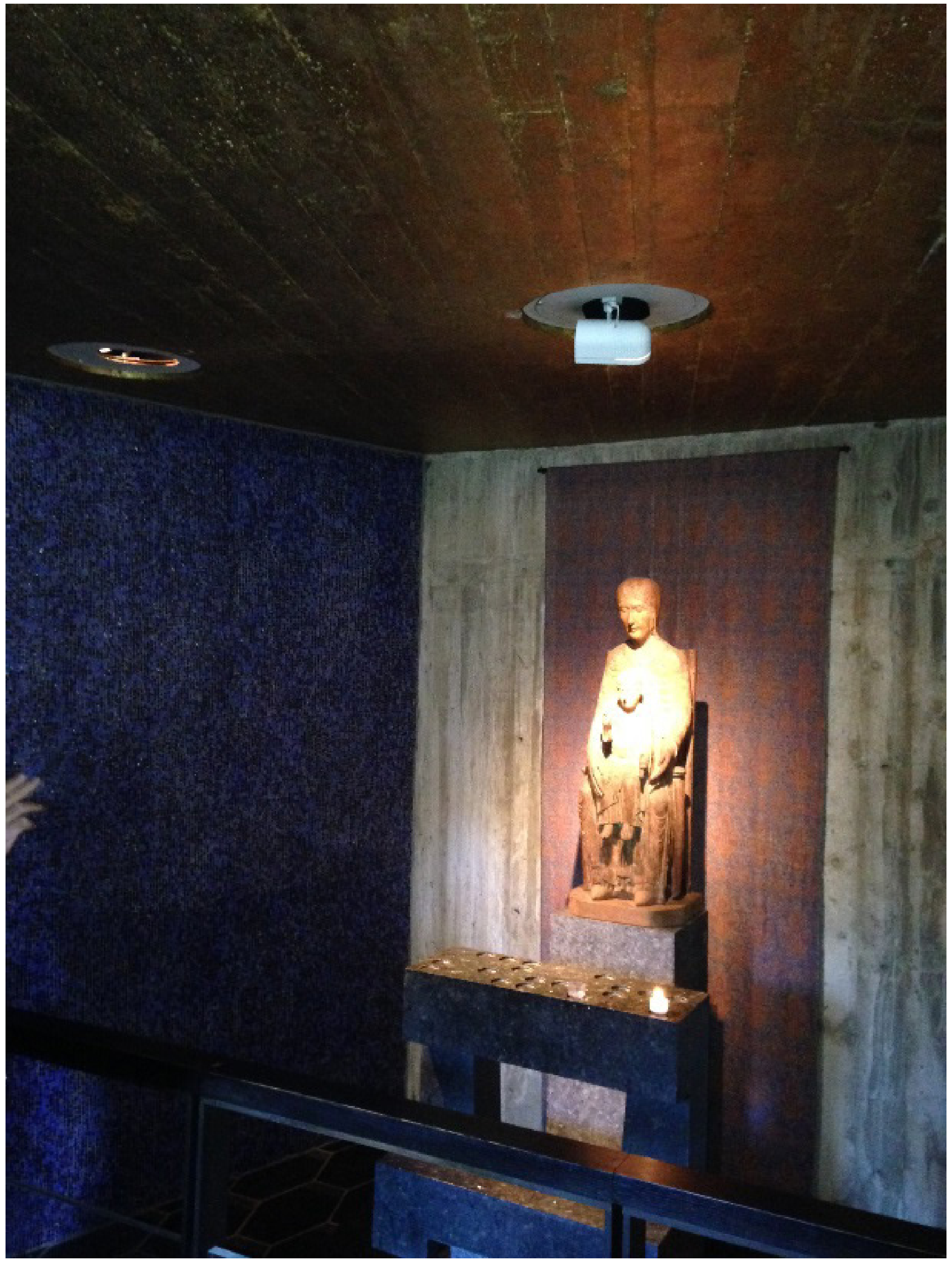
The Blessed Sacrament Chapel was recently renovated and will not be part of this project.

Chapel of Mary

The existing lighting includes halogen accent lights that have been grafted into a recessed downlight fixture. The heat and UV produced by the fixture may be a concern for an historic statue.
The proposed solution includes an LED track lighting that will use the existing power source.








Sanctuary

Daylight enters the sanctuary from a massive skylight fitted with stained glass. Additional illumination is provided by downlights and accent lights at the ceiling. Openings punched through the folded concrete ceiling beams provide mounting locations for theatrical style lighting fixtures that highlight the altar, the ambo and four communion tables.

Baldachin

Above the altar is suspended a large ceremonial canopy called a baldachin, which includes downlights and uplights recessed into its white wooden structure. Existing fixtures will be replaced will high-efficiency sources.

Skylight

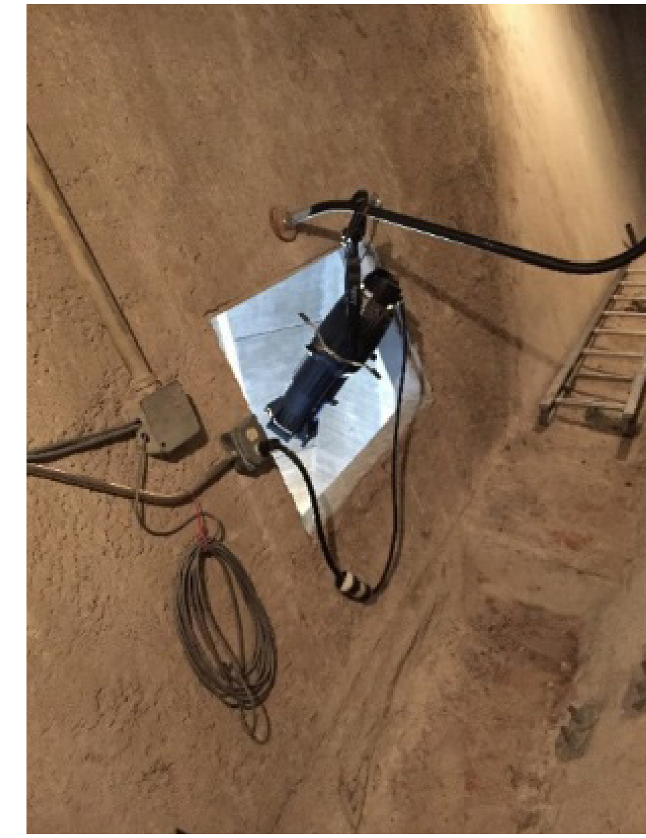
Linear fluorescent lamps in the skylight vault provide a glow to the glass at night. The fixtures will be replaced with LED striplights to reduce energy use and provide the high level of illumination required. We will explore the use of white material at the walls of the vault to improve reflection.

Altar

The altar is lighted from existing fixtures recessed in the baldachin. Proposed new fixtures will allow improved illumination, and more flexible control of the lighting.

Flemish Crucifix

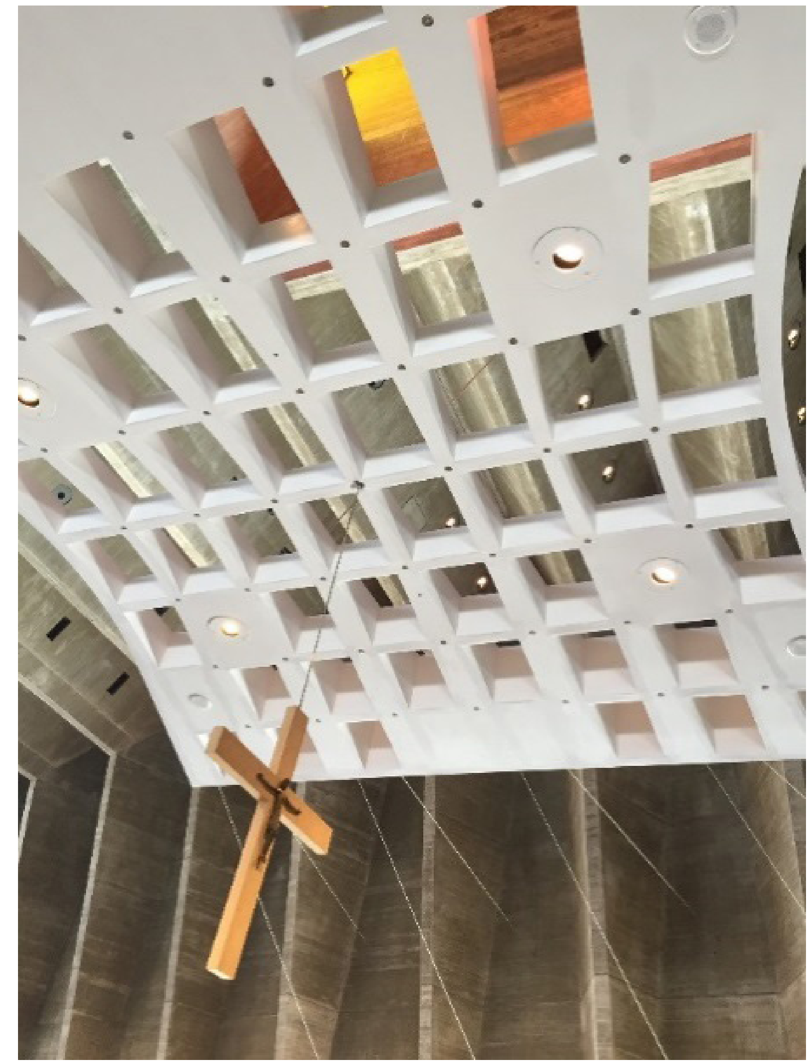
On the wall behind the abbots throne is a crucifix of historic and spiritual significance. The cross is located so that the brothers can see it as they exit the monastery and enter the church. A new fixture at the ceiling will for the first time provide much need illumination of the cross.



Upgrade Lighting for Broadcasting

For distance worship, approaches to augmenting lighting at the Altar adequate for television and streaming, web-based broadcasting will be explored. Impacts of preserving original conditions compared with conserving worship purpose will be evaluated when considering alternate solutions.

Type	Existing description	Proposed Solution
	Fluorescent strips at skylight vault	LED Strips – add white reflectors?
	Downlights recessed into Baldachin	Replace with recessed multiples
	Uplights recessed into Baldachin	Replace with LED washlights
	Altar spots for front and back from within Baldachin	
	Ellipsoidal spotlights at concrete beams with halogen light source.	Replace with LED spotlights to enhance illumination
	Flemish Crucifix	Add new fixture


Sanctuary

Ambo

This is the Eucharistic center of the church. The existing light within the ambo is a short fluorescent tube. The proposed solution is a small LED striplight that will provide a warm glow.

Abbot's Throne

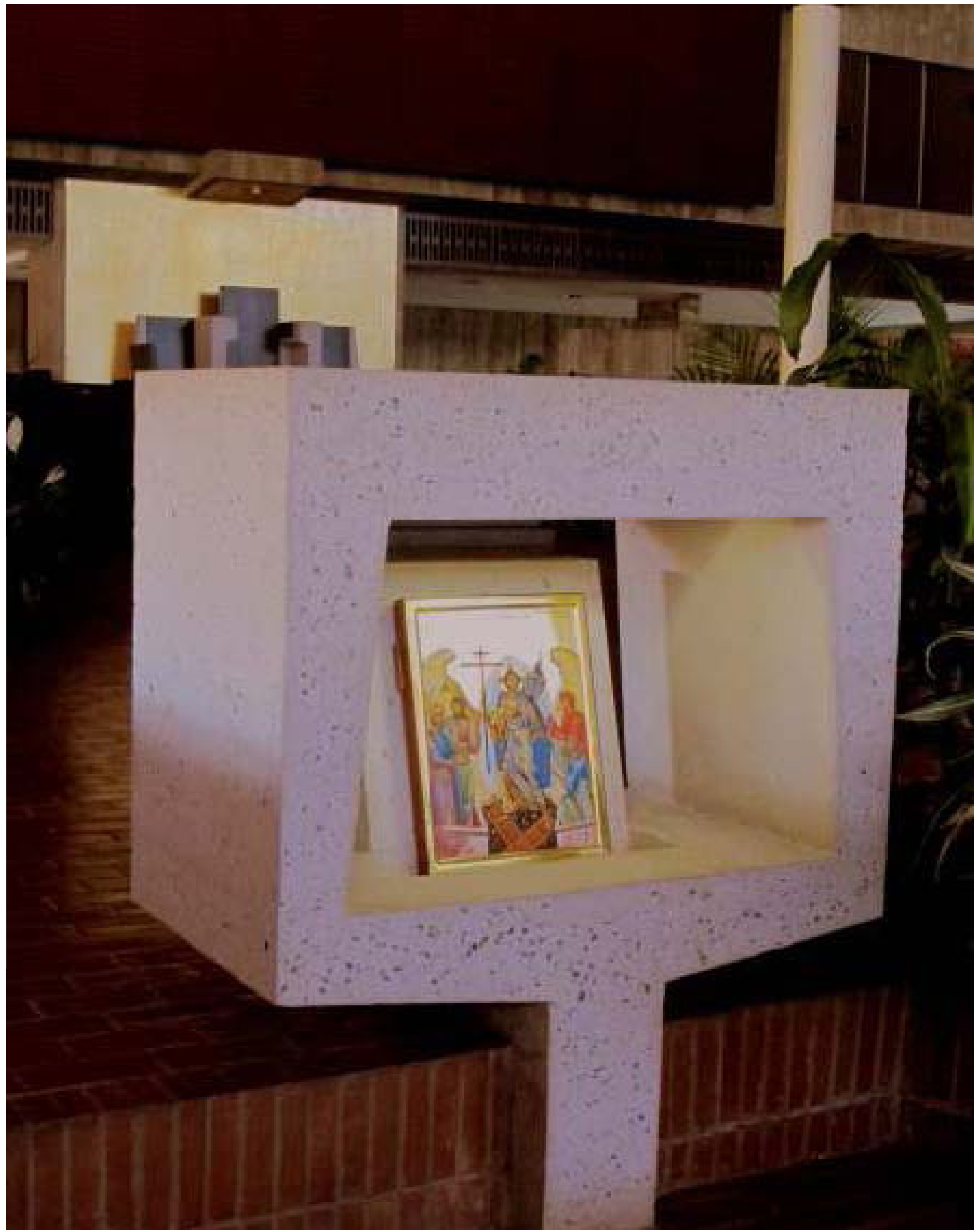
This element completes the sacred arc that begins at the baptistry, and passes through the nave to the altar to the throne of the abbot. The throne includes three chairs, a back wall with a gold mosaic pattern and a small canopy that includes a downlight over the center chair to provide a glow of light to the abbot for special occasions when the throne is occupied. The downlight will be retrofitted, and supplementary illumination will be provide from the ceiling ports above.

Monastic Choir

Four sections of pews arranged on either side of altar provide seating for monks and lay brethren. The priest can celebrate mass from both sides of the altar, facing the nave or facing the choir when the monks alone are congregated. The monastic community gathers daily for early morning and late night services, and during this time they have great difficulty reading worship material due to low and uneven light levels.

The lighting levels will be increased as a results of new LED fixtures that will replace the existing halogen fixtures. The new fixtures will be zoned to allow selective illumination of the sanctuary and the nave to suit the needs of the service.

Type	**Existing description**	**Proposed Solution**
	Fluorescent mini-strip at Ambo LED strip	
	Downlight at Abbots Throne	Evaluate retrofit options
	Supplementary lighting	Add front light from ceiling vaults
	Downlights at choir	Zone for separate use from nave downlights
	Accent light for all liturgical furniture	Multiple accent lights to illuminate the worship space



Apse Screen

The fabric has deteriorated over time and is quite fragile. Replacement options will be evaluated. Existing lighting at the ceiling vault immediately in front of the screen will be replaced with LED floodlighting.

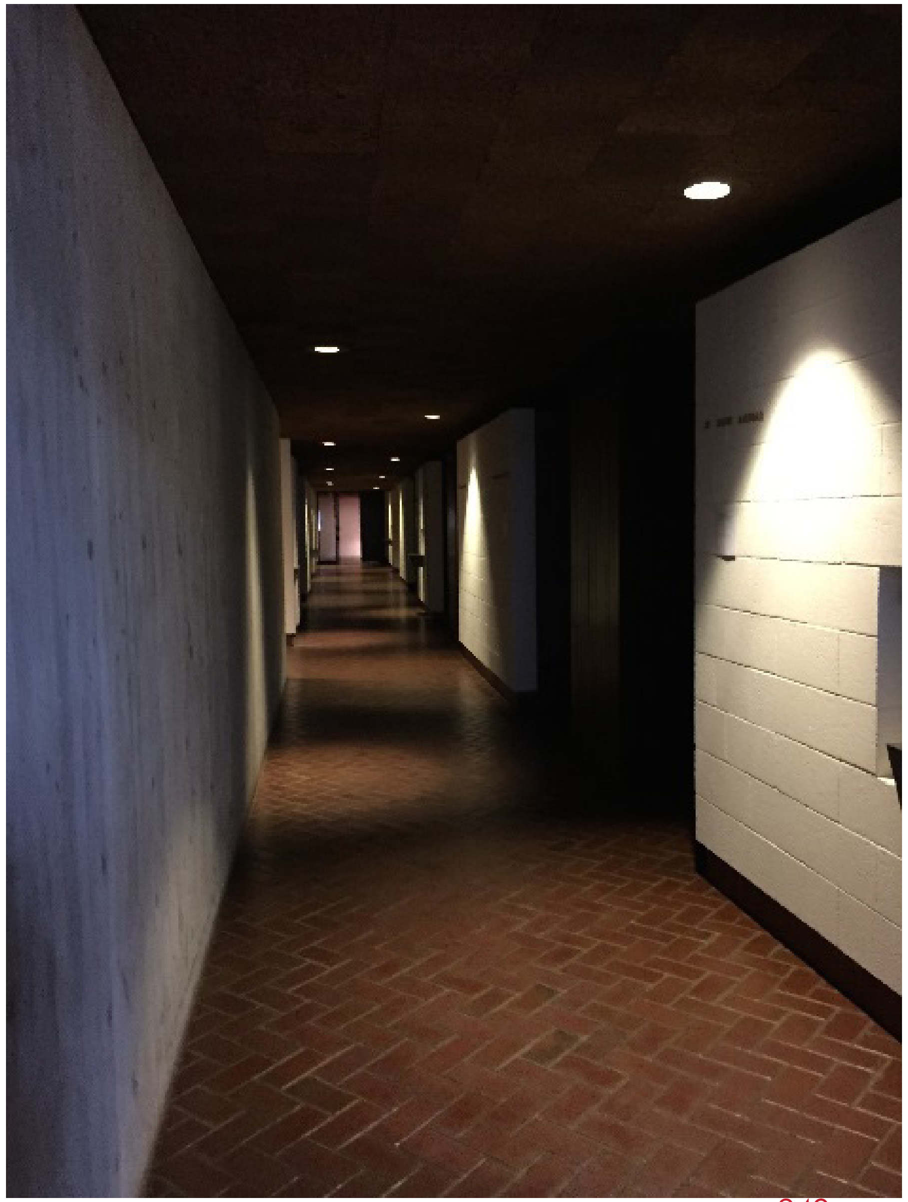
Type	Existing description	Proposed Solution
	Verify frontlight	Add/replace illumination

Lower Church

Narthex at Lower Church and Brother's Chapel
Illumination levels in the Lower Church Narthex are very low. The original design includes windows to an exterior area well covered by a metal grate at ground surface, which modulate Ronchamp-style in size and wall location. Artificial lighting from recessed can fixtures adds some illumination, but does not provide adequate levels or uniformity. A new layout of lighting fixtures will improve the quantity and quality of the lighting.

The original design for the Brother's Chapel Narthex includes ceiling fixtures augmented with windows located high in the wall and above the exterior grade. Alternates that preserve the original fixtures will be considered while options for improving the illumination are developed.

Reliquary Chapel
Artifacts preserved within the treasury, including holy relics, will be reviewed and alternates for improving lighting quality with high-lumen output LED lamps explored.

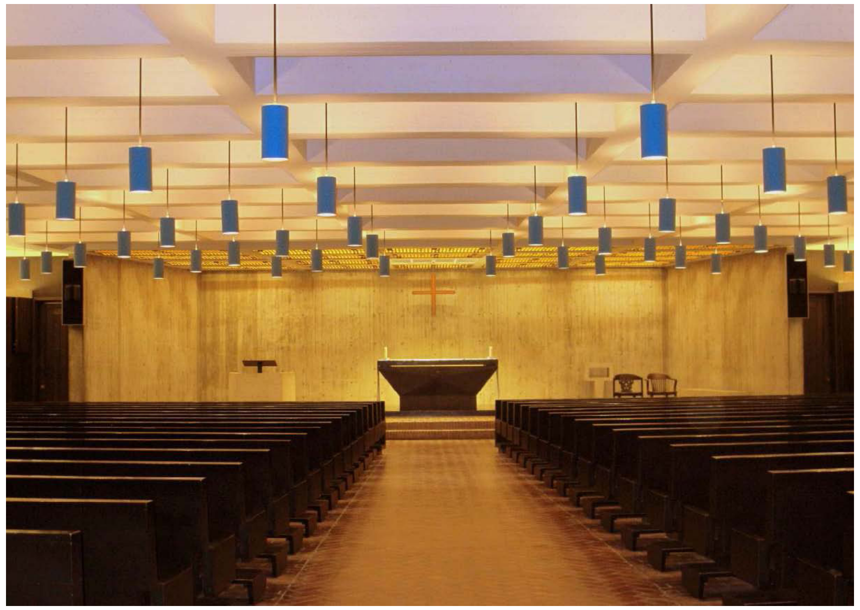


Assumption Chapel

The illumination at the sanctuary is provided by fluorescent strip lights at the ceiling, which are concealed above a wooden framework. The strip lights will be replaced with LED strip lights. LED spotlights will be added to provide illumination at the altar and ambo.

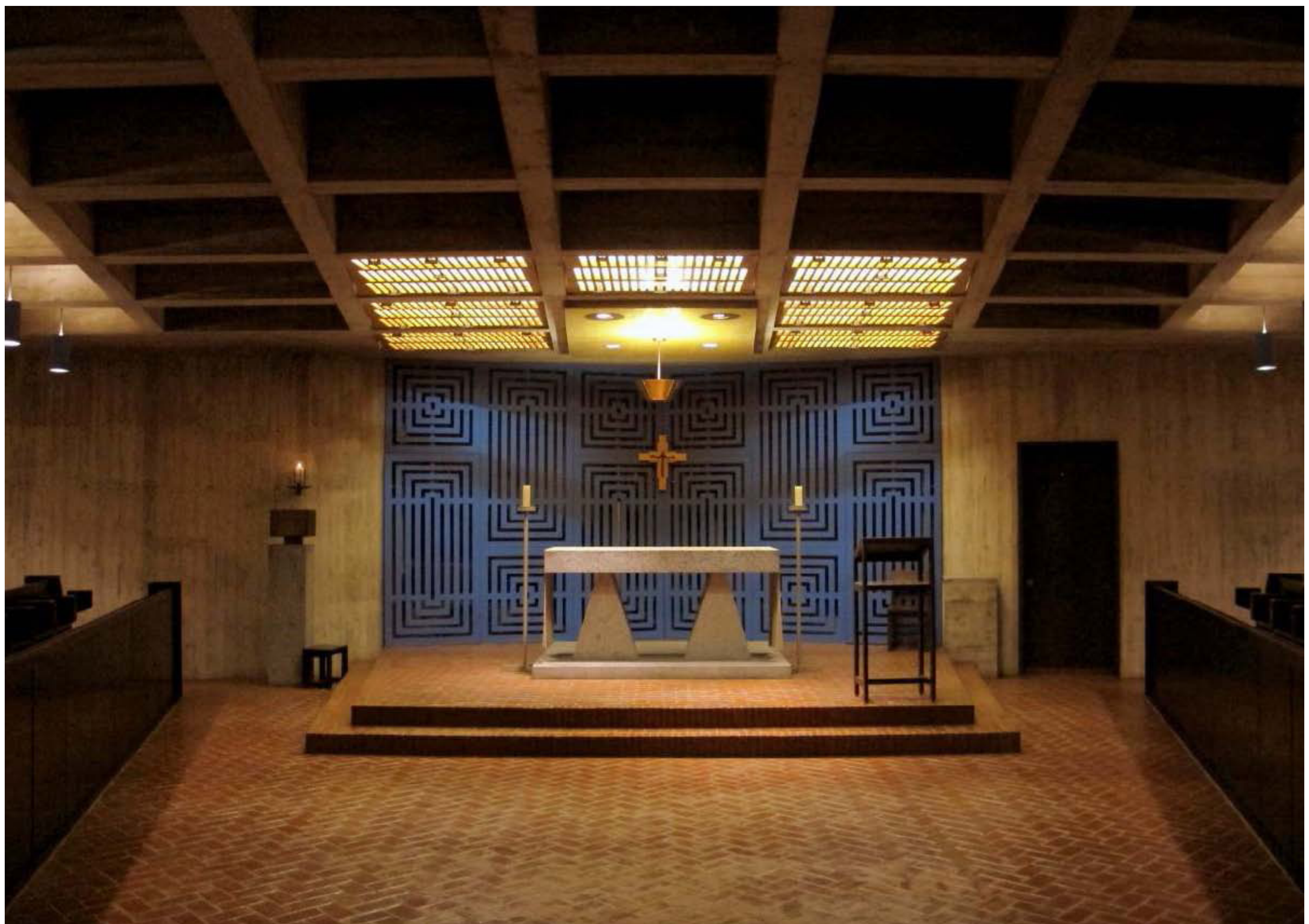
The existing pendant fixtures will be retrofitted with replacement LED lamps. Fluorescent strip lights will be replaced with LED strip lights.

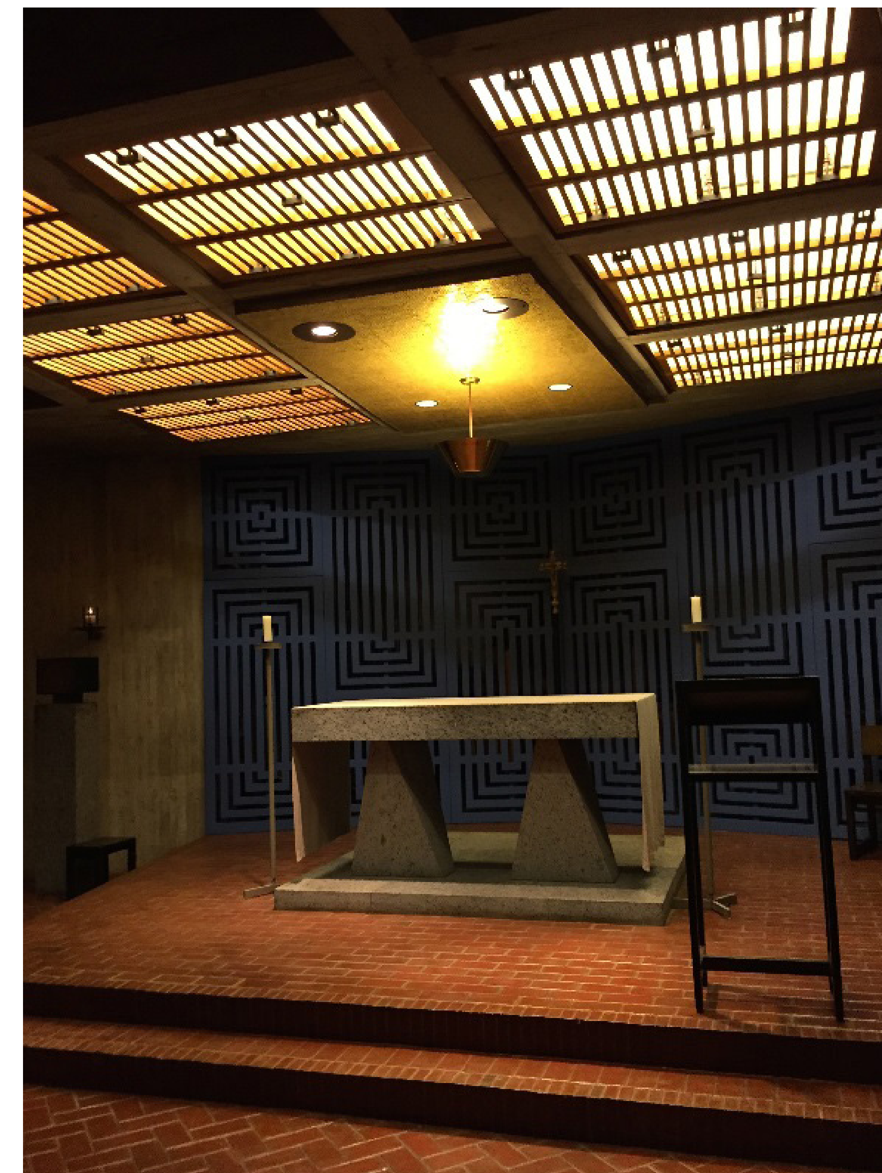
Type	Existing description	Proposed Solution
	Cylinders	Retrofit cylinders with up/down LED
	Back wall and Cross	New fixtures
	Altar	New fixtures
	Ambo	New fixtures
	Lectern	New fixtures
	Uplight over confessionals	New fixtures

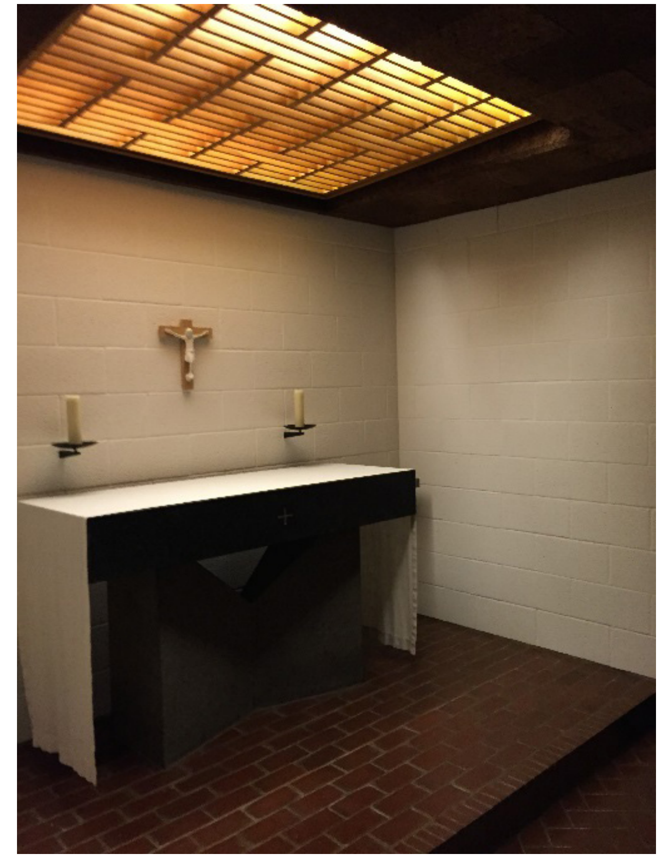


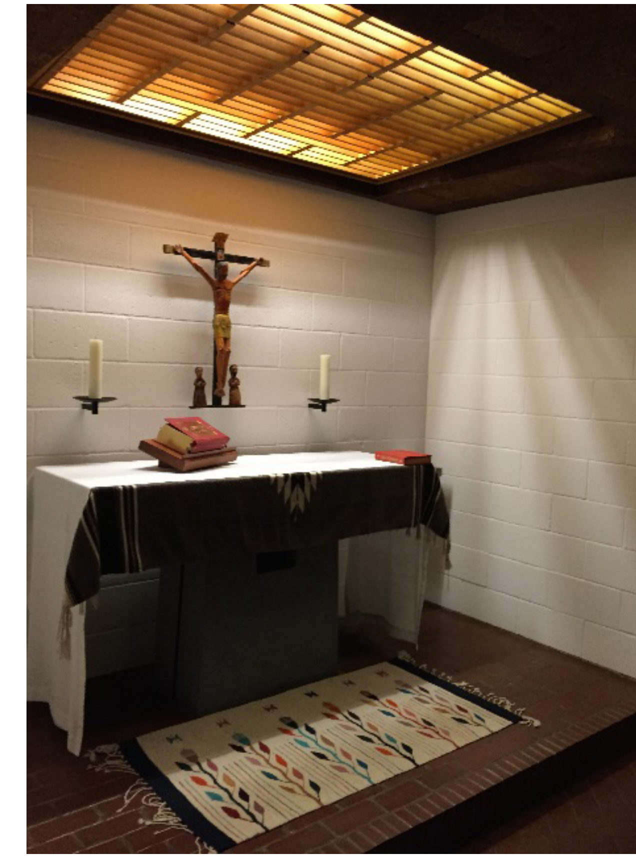
Chapel of Saint Benedict
(also called Brothers Chapel)

As with the Upper and Lower Balcony, Sanctuary, Altar, and Chancel or Monk's Choir, both the Lower Church and Brother's Chapel have inadequate illumination. Approaches to providing augmentive lighting will be explored.



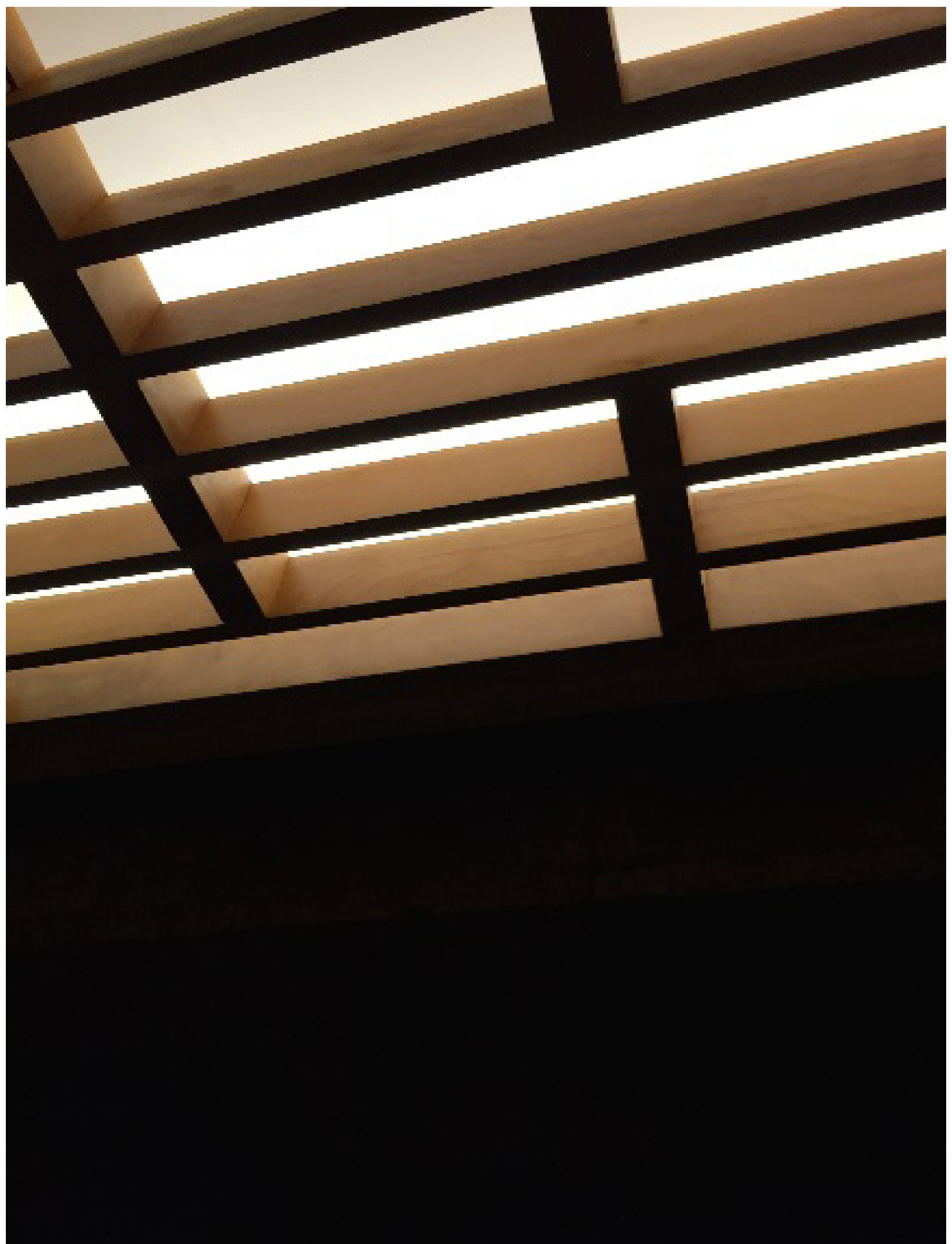


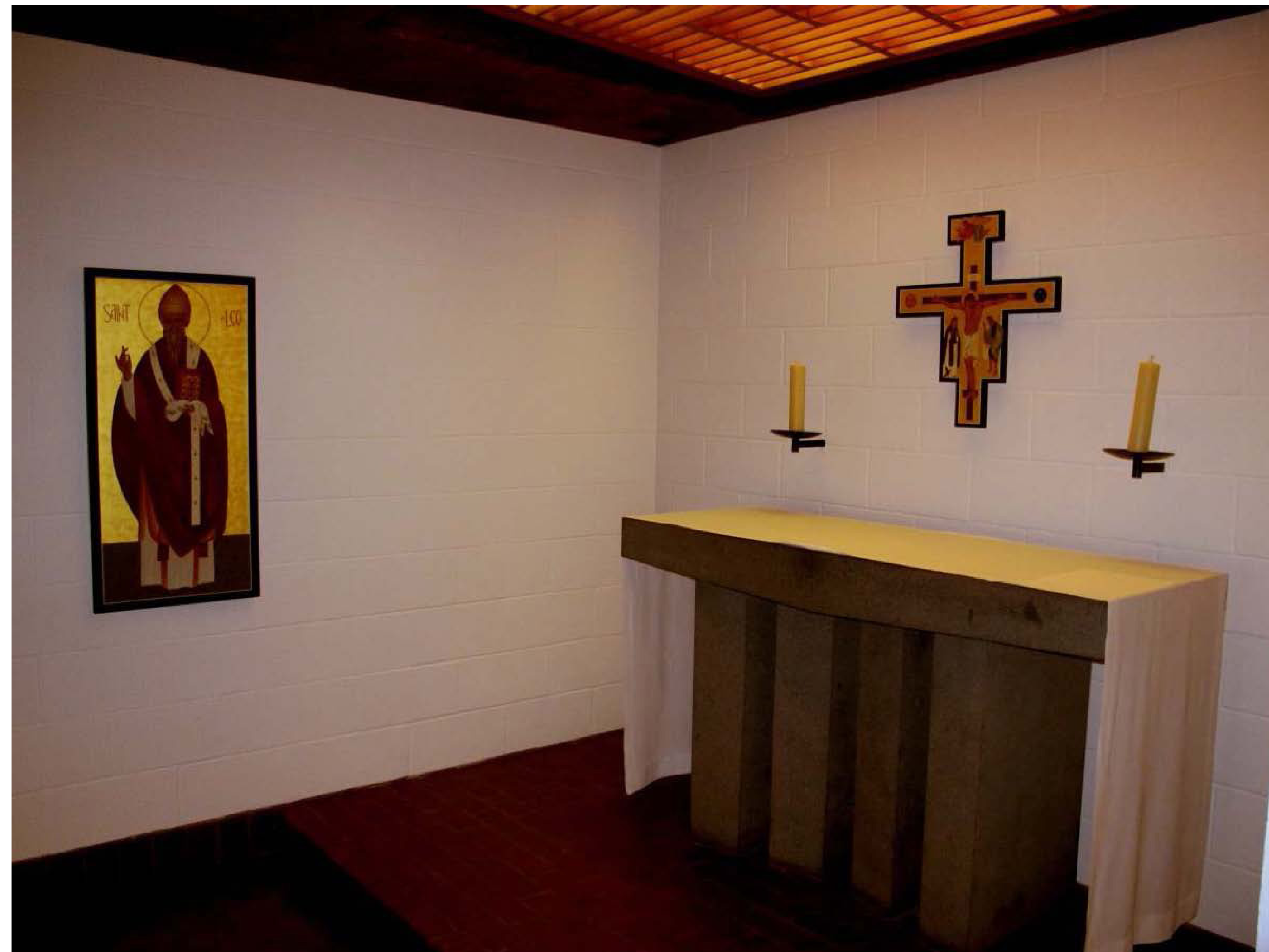




Private Chapels

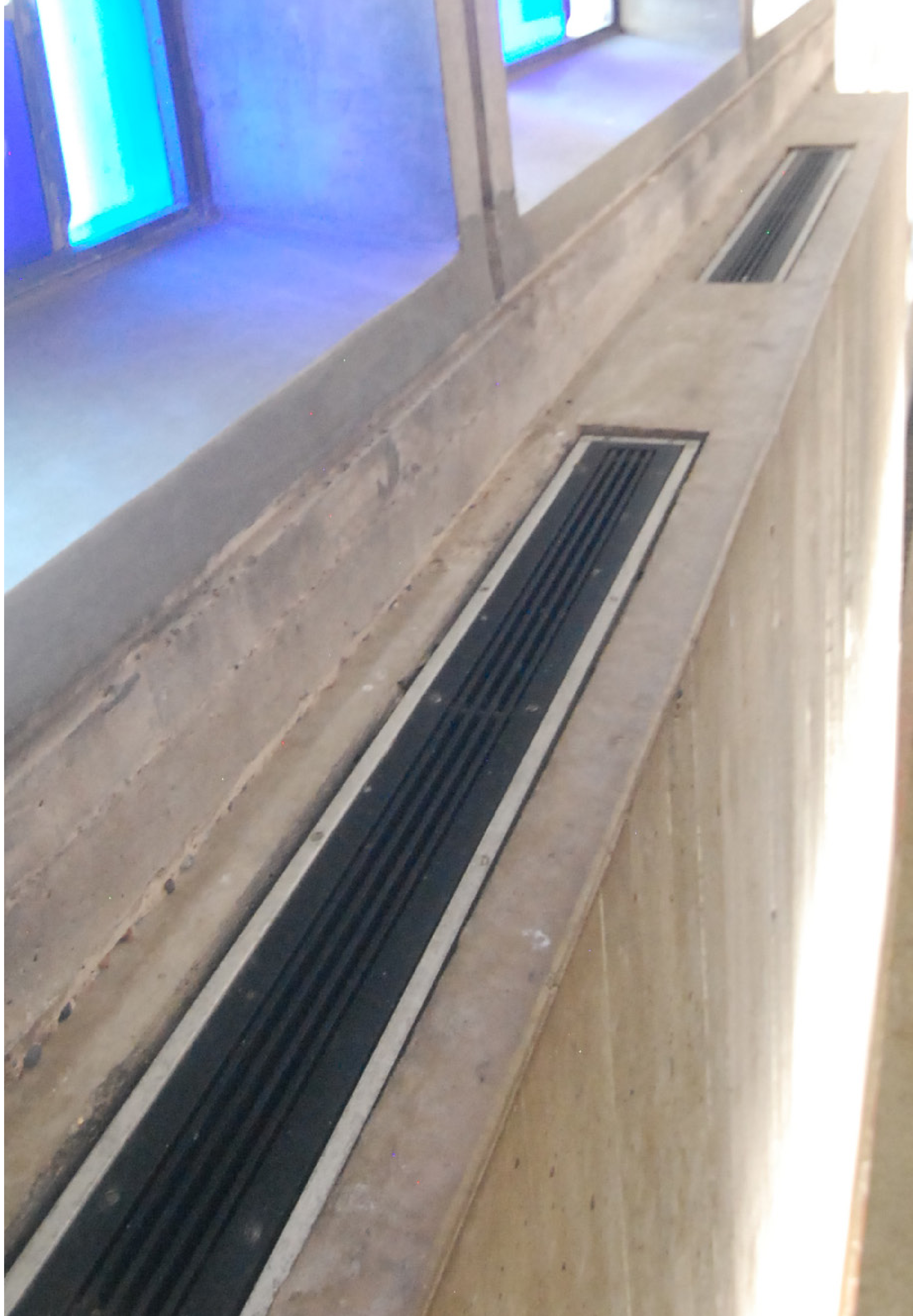
The thirty-four Private Chapels beneath the Abbey Church Sanctuary and located between the Lower Church and Brother's Chapel are each unique in liturgical, art and artifact furnishings. They share indirect lighting solutions which use concealed fluorescent fixtures illuminating curved luminous surfaces above the ceiling and discreet spotlighting. Alternates to improving the quality of light using LED lamps will be explored.




SAINT
LEO

Abbey Church

SYSTEMS

Introduction

St. Johns University commissioned Dunham Associates, Inc (Dunham) to provide a facility analysis of the major mechanical and electrical equipment serving the Abbey Church. The goal is to provide St. John's University with information identifying systems that may require modification or replacement as part of the Abbey Church conservation as well as identify potential challenges to replacing the mechanical and electrical system with limiting the impact on other conservation activates. The University's goal is to have mechanical and electrical systems that will last for an additional 50 years at the completion of the conservation effort.

The focus of this analysis is on the major mechanical and electrical systems to include the following:

- Air Handling Units and associated components
- Hydronic Heating and Steam System
- Plumbing Distribution System
- Control System (Temperature and Humidity)
- Electrical Distribution
- Lighting
- Electrical Power
- Communications and Security Systems

Determining the remaining life expectancy of mechanical and electrical equipment is both an art and a science. There are several factors to consider, namely age of the equipment, condition of the equipment, and maintenance procedures in place. There are two main benchmarks used as a basis for determining "average" life expectancies of mechanical equipment. The first is the estimate of service life published by the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE). The second is a study performed by Whitestone Research for the National Nuclear Security Administration (NNSA) that developed survivor curves based on NNSA historical data. Both benchmarks will be sued to review the condition and expected service life of the equipment and systems. The ASHRAE tables have been included for reference.

The benchmarks used as a basis for determining "average" life expectancies of electrical equipment is published by the US Department of Energy and US Department of Interior Bureau of Reclamation. A condensed table from the US Department of Energy and US Department of Interior Bureau of Reclamation (2006) has been included for reference.

End of service life may occur for many reasons, including: obsolescence, reduced reliability, excessive maintenance costs, changed system requirements, energy prices, environmental considerations, or failure. Since several of these variables are totally independent of the equipment or system design, they are nearly impossible to forecast to a specific year of failure.

A large number of the Abbey Church mechanical systems have exceeded their ASHRAE, NNSA or US Department of Energy tabulated life expectancy. The fact that the air handling systems have been operational for more than 58 years indicates that the maintenance procedures in place have been effective. The drawback is that this equipment is on "borrowed time" and increased maintenance or failure could occur without significant warning.

This report is not intended to be all-encompassing nor is it supposed to provide the design of the proposed modifications. Rather, it is to provide information on the major systems combined with recommendations for further action. In addition, it can be used as a reference for the condition and operation of the equipment which will be an extremely helpful tool during remodeling projects.

Table 3 Estimates of Service Lives of Various System Components[a]

Equipment Item	Median Years	Equipment Item	Median Years	Equipment Item	Median Years
Air conditioners		Air terminals		Air-cooled condensers	20
Window unit	10	Diffusers, grilles, and registers	27	Evaporative condensers	20
Residential single or split package	15	Induction and fan-coil units	20	Insulation	
Commercial through-the-wall	15	VAV and double-duct boxes	20	Molded	20
Water-cooled package	15	Air washers	17	Blanket	24
Heat pumps		Ductwork	30	Pumps	
Residential air-to-air	15[b]	Dampers	20	Base-mounted	20
Commercial air-to-air	15	Fans		Pipe-mounted	10
Commercial water-to-air	19	Centrifugal	25	Sump and well	10
Roof-top air conditioners		Axial	20	Condensate	15
Single-zone	15	Propeller	15	Reciprocating engines	20
Multizone	15	Ventilating roof-mounted	20	Steam turbines	30
Boilers, hot water (steam)		Coils		Electric motors	18
Steel water-tube	24 (30)	DX, water, or steam	20	Motor starters	17
Steel fire-tube	25 (25)	Electric	15	Electric transformers	30
Cast iron	35 (30)	Heat exchangers		Controls	
Electric	15	Shell-and-tube	24	Pneumatic	20
Burners	21	Reciprocating compressors	20	Electric	16
Furnaces		Package chillers		Electronic	15
Gas- or oil-fired	18	Reciprocating	20	Valve actuators	
Unit heaters		Centrifugal	23	Hydraulic	15
Gas or electric	13	Absorption	23	Pneumatic	20
Hot water or steam	20	Cooling towers		Self-contained	10
Radiant heaters		Galvanized metal	20		
Electric	10	Wood	20		
Hot water or steam	25	Ceramic	34		

Notes: 1. ASHRAE makes no claims as to the *statistical* validity of any of the data presented in this table.
2. Table lists base values that should be adjusted for local conditions (see the section on Service Life).

Source: Data obtained from a survey of the United States by ASHRAE Technical Committee TC 1.8 (Akalin 1978).
[a] See Lovvorn and Hiller (1985) and Easton Consultants (1986) for further information.
[b] Data updated by TC 1.8 in 1986.

Table 4 Comparison of Service Life Estimates

Equipment Item	Median Service Life, Years		Equipment Item	Median Service Life, Years		Equipment Item	Median Service Life, Years	
	Abramson et al. (2005)	Akalin (1978)		Abramson et al. (2005)	Akalin (1978)		Abramson et al. (2005)	Akalin (1978)
Air Conditioners			**Air Terminals**			**Condensers**		
Window unit	N/A*	10	Diffusers, grilles, and registers	N/A*	27	Air-cooled	N/A	20
Residential single or split package	N/A*	15	Induction and fan-coil units	N/A*	20	Evaporative	N/A*	20
Commercial through-the-wall	N/A*	15	VAV and double-duct boxes	N/A*	20	**Insulation**		
Water-cooled package	>24	15	**Air washers**	N/A*	17	Molded	N/A*	20
Heat pumps			**Ductwork**	N/A*	30	Blanket	N/A*	24
Residential air-to-air	N/A*	15[b]	**Dampers**	N/A*	20	**Pumps**		
Commercial air-to-air	N/A*	15	**Fans**	N/A*		Base-mounted	N/A*	20
Commercial water-to-air	>24	19	Centrifugal	N/A*	25	Pipe-mounted	N/A*	10
Roof-top air conditioners			Axial	N/A*	20	Sump and well	N/A*	10
Single-zone	N/A*	15	Propeller	N/A*	15	Condensate	N/A*	15
Multizone	N/A*	15	Ventilating roof-mounted	N/A*	20	**Reciprocating engines**	N/A*	20
Boilers, Hot-Water (Steam)			**Coils**			**Steam turbines**	N/A*	30
Steel water-tube	>22	24 (30)	DX, water, or steam	N/A*	20	**Electric motors**	N/A*	18
Steel fire-tube		25 (25)	Electric	N/A*	15	**Motor starters**	N/A*	17
Cast iron	N/A*	35 (30)	**Heat Exchangers**			**Electric transformers**	N/A*	30
Electric	N/A*	15	Shell-and-tube	N/A*	24	**Controls**		
Burners	N/A*	21	**Reciprocating compressors**	N/A*	20	Pneumatic	N/A*	20
Furnaces			**Packaged Chillers**			Electric	N/A*	16
Gas- or oil-fired	N/A*	18	Reciprocating	N/A*	20	Electronic	N/A*	15
Unit heaters			Centrifugal	>25	23	**Valve actuators**		
Gas or electric	N/A*	13	Absorption	N/A*	23	Hydraulic	N/A*	15
Hot-water or steam	N/A*	20	**Cooling Towers**			Pneumatic	N/A*	20
Radiant heaters			Galvanized metal	>22	20	Self-contained		10
Electric	N/A*	10	Wood	N/A*	20			
Hot-water or steam	N/A*	25	Ceramic	N/A*	34			

*N/A: Not enough data yet in Abramson et al. (2005). Note that data from Akalin (1978) for these categories may be outdated and not statistically relevant. Use these data with caution until enough updated data are accumulated in Abramson et al.

Table 1: Average Expected Service Life of Major Mechanical Equipment

Equipment	**Median Years**
Switchboards	40
Distribution Bus	50
Distribution Gear	35
Panelboards	30
Power Feeders	35
Transformers	30
Emergency Generator	35
Transfer Switches	30
Controls - Electric	18
Controls - Electronic	15
Motors	18
UPS Systems	10
Batteries	5
Branch Circuit Wiring	50
Light Fixtures	20
Smoke Detectors	10
Fire Alarm	15
Emergency Lights	10
Low Voltage Cables	15
CATV Systems	15
CCTV Systems	10
Exit Signs	15-25

Condensed from US Department of Energy and US Department of Interior Bureau of Reclamation (2006)

Table 2: Average Expected Service Life of Major Electrical Equipment

Conservation Challenges

Mechanical Challenges

A majority of the existing mechanical system shave failed or are at the end of their life. The replacement of the systems may require impacting the existing architecture of the building.

New central systems typically require additional space to implement current energy efficiency requirements or improved operation. Implementing new ventilation systems within the existing mechanical space and gaining access to the space for replacement will be a challenge.

Implementing updated HVAC systems without adversely impacting the existing architecture. Reuse of the exiting distribution system may be necessary.

Additional, inspection of the interior ductwork is recommended with a remote camera to determine that the existing insulation is well adhered and functional.

Reuse of the existing piping distribution system in not recommended. This piping is currently located above gypsum ceiling in the lower level. Access to replace the piping will impact the ability to keep the original ceilings as-is.

The Baptistry functions as a vestibule for the church. This area is served from a separate zone coil from AHU-1 and from in floor heating. The air is supplied to the Baptistry from the interior low velocity diffusers approximately 40 feet from the doors. Due to the location of the grilles and the failure of the in floor heating system, the current function of the system is not able to provide sufficient heat for the space.

The Cloister walks will require new radiation to provide sufficient heat to the space. This radiation will affect the architecture of the space.

The in floor heating system for the church has failed. A new system will be required. Options to be reviewed may impact the existing finished in the space.

The space is currently not cooled. Routing chilled water to the building may be possible.

Electrical Challenges

Maintaining the architectural master piece that the Abbey Church is today after 50 year of use, while implementing required electrical upgrades to the building.

Maintaining the building usage while upgrades occur.

Implementing current code requirements within the constraints of the existing building.

Additional receptacle locations to accommodate the current functions that occur in the Church while concealing conduits without affecting the integrity of the building.

Addressing the sound system deficiency in the balcony of the main church and the Parish Church due to the amount of hard surfaces in the building.

Recommendation for System Modifications

Preliminary Mechanical Options

Utilize the existing Unit locations above the church and in the basement. Provide a dedicated outdoor air system. Install recirculating systems to provide space conditioning and air movement.

Benefit the DOAS can be modulated to control OSA based on the occupancy.

Adds Cooling to the space.

Replace the in-floor heat. This provide heat low and at the space served. Will required reworking of the existing floor. (in addition to option a)

Add FTR and ventilation at entry and cloister passages.

Lower Level: Replace existing with VAV AHU with CO2 Control

Preliminary Electrical Options

Replace the existing electrical distribution system due to the age of the equipment and conductors. This would include feeder and branch circuit conductor replacement along with panelboard replacement.

Upgrade emergency systems within the Church to ensure safe evacuation in the event of an emergency. This will be accomplished by providing an emergency feed from the emergency generator system that feeds into the Lower Level of Alcuin Library. The generator will serve egress lighting and exit signs.

Implement local speakers at balcony level similar to the main level of the Church to improve the sound quality on the balcony level of the Church. The challenge with this solution is getting cabling to the balcony level without infringing on the architectural integrity of the entry to the Main Church.

Overview

The Abbey Church is serviced by five central air handling units. Four of the air handling units are located in the lower level mechanical room to the North and one is located in the lower level mechanical room to the south. The air handling unit locations are noted with in each section discussed here in. The air handling units are comprised of a remote utility set return/relief fan, mixing box, filter steam heating coil, and utility set supply fan. The outside air for each unit is drawn in from an air tunnel which is connected to an area well. The relief air for each unit is drawn in from an air tunnel which is connected to an area well. Refer to the following for specific information on each air handling unit.

Air Handling Unit #1- Main Church and Baptistry Unit

System Overview: The ventilation system that services the Main Church and Baptistry consists of a constant volume air handling unit that provides ventilation and heating air to the occupied areas. There are approximately 2 individual temperature control zones with the building. One serves the East side of the building and one zone serves the West side of the building.

The air handling unit (AHU) is original to the 1957 building placing the unit and the components over 55 years old. This unit consists of a single inlet utility set backward inclined supply fan, pneumatic operated return, relief and outdoor air dampers, fiber media filters, and a steam preheat coil. This unit does not have a return fan, cooling coil for dehumidification or a humidifier. This AHU is a built-up air handling with single wall construction and exposed fibrous insulation exposed in the air stream. The unit is located in the basement mechanical room as highlighted in Figure 1: Mechanical Plan Excerpt

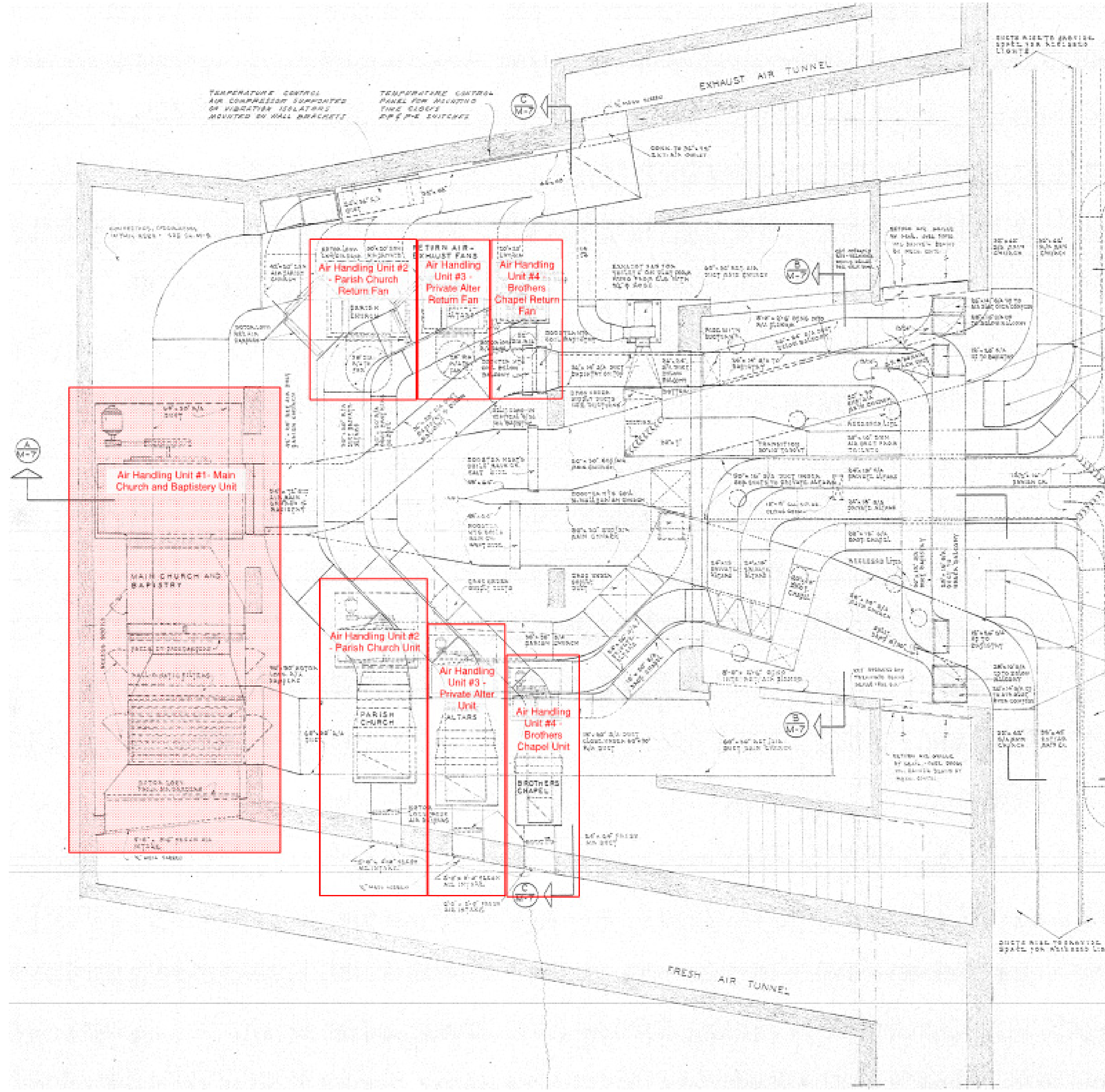


Figure 1: Mechanical Plan Excerpt

The unit has a variable frequency drive on the supply fan but operates as a constant air volume system that does not meet the current energy code. Energy code requires that a fan system over 5,000 CFM of this size to be able to vary the flow to meet space demand, thereby limiting reheat operation.

The AHU serves two individual temperature control zones within the building. Zone temperature control is accomplished using a steam coil. The steam coils are fed from the Campus central systems.

The supply air distribution system consists of ductwork with internal lining. All supply zones are fully ducted to the diffuser outlet. The supply air ductwork is routed to the main church through ductwork located in the basement ceiling. Supply air is then fed to the main church through floor diffusers located at the perimeter windows. This method of supply has allowed for the heated and conditioned air to be supplied at the source of major heat loss and condensation. This method has allowed for the windows to remain condensation free. There are no observable signs of condensation at the windows. Refer to Figure 2 for the typical window condition with supply grille.

Figure 2: Supply Grille at Perimeter Window

The Baptistry functions as a vestibule for the church. This area is served from a separate zone coil from AHU-1. The air is supplied to the Baptistry from the interior low velocity diffusers approximately 40 feet from the doors. Due to the location and low flow the air system is not able to provide sufficient heating and recovery for the space. An additional method of heating the Baptistry is recommended.

The return air ductwork consists of a combination of ducted and plenum return. The return air ductwork is routed to the main church through ductwork located in the basement ceiling. Return air is then returned from the main church through wall grilles at the West side from the confessionals and at the back of the church, adjacent to the baptistry, as indicated in Figure 3: Return Grille at back of Church. Air is also returned from the choir areas from below seat grilles and plenums as shown in Figure 4: Return Grille under Seat at Choir. This method of returning air is efficient with the design of the church as there is limited return ductwork. One concern though is that the heated air can stratify in the large volume space and result in significant temperature differences at the balcony

Figure 3: Return Grille at back of Church

Figure 4: Return Grille under Seat at Choir

Return air / Relief Air / Outdoor Air Damper Condition

The dampers are original to the building construction and are therefore over 55 years old. The outside air dampers are worn and do not actuate and seal properly, refer to Figure 5: Outdoor Air Dampers (next page). On the day of the field review, the dampers were 100% closed, but significant cold air was observed penetrating the dampers. This has led to the steam coil freezing and resulting in significant repairs to the steam coil. The maintenance personnel have attempted to mitigate the infiltration by partially blocking off the intake located in the tunnel as indicated in Figure 6: AHU-1 Outside Air Inlet (next page). Consideration should be given to replacing the dampers in conjunction with an overall air handling unit replacement.

Figure 5: Outdoor Air Dampers

Figure 6: AHU-1 Outside Air Inlet

Figure 7: AHU-1 Filter Section

Air Handling Unit Casing Condition
The air handling unit casing consists of a single wall sheet metal with internal fibrous insulation exposed in the air stream. The insulation has held-up well for its age, but is showing signs of wear and beginning to separate from the sheet metal. Fibrous particles in the air stream can pose risk to both health of occupants and finishes in the building as these particles can be abrasive to adjacent air vents and be breathed in by individuals. The separation of the insulation from the casing is degrading the performance of the insulation. Consideration should be given to replacing the casing and insulation junction with an overall air handling unit replacement plan.

Filter Section Condition
The original filtration system installed in the AHU was a roll filter. That filter has been removed and replaced with filters that consist of a fabric media filters, shown in Figure 7: AHU-1 Filter Section. The filters are located immediately downstream of the mixing plenum. Facilities personnel indicate that the filters are changed regularly and do not report any issues with the filters. The existing filtration level of the filter bank was reported to be MERV 8. Consideration should be given to replacing the filters in conjunction with an overall air handling unit replacement plan.

Steam Preheat Coil Condition
The preheat coil is original to the building construction. The stream preheat coil consists of multiple individual coils to make-up the larger complete coil. An integral face and bypass damper is installed on the coil. The dampers are controlled with pneumatic actuators. Operation of these dampers could not be verified. Facilities personnel noted that the coil has frozen due to the outside air damper issues and repairs have occurred to the coil. There was no access to the downstream coil section to perform a visual inspection. The condensate traps appear to be original to the coils. Due to their age, replacement parts are no longer available and are required to be completely replaced when they fail. Due to the repairs performed to the coil, the coil is operating on borrowed time and should be replaced. Refer to Figure 8: AHU-1 Steam Preheat Coil (next page) for the damper and coil.

Figure 8: AHU-1 Steam Preheat Coil

Supply Fan Condition

The fan is original to the building construction and is over 55 years old. The existing supply fan was retrofitted with a VFD.

Fan condition is as follows:

- The motor has been replaced and appears to be in good operating condition.
- The fan casing appears to be sound.
- The flexible connector is showing signs of wear.
- Facilities personnel indicated that the bearings were replaced sometime within the last 20 years.
- Fan shaft and blade soundness (due to stress fatigue) is not attainable by visual observation.

Zone Coils Condition

The zone coils and associated steam valves and dampers are original to the building construction and are therefore over 55 years old. Each temperature control zone consists of, steam coil and control valve. These zone coils are located in the lower level mechanical room.

Facilities personnel indicated that the coils have not been serviced and that the condition is unknown. Field observations indicated that there are no access panels in the ductwork to perform visual observations of the coils. The associated piping and steam traps are original, but there is no visual evidence of pipe leaks. Consideration should be given to replacing the coils in conjunction with an overall air handling unit replacement plan.

Recommendation/Comments

The condition the each air handling unit as a whole is near the end of its serviceable life. The casing, dampers, and steam coil are suspect. This is due to the conditions of the individual AHU components as well as and the age of the air handling unit. The air handling unit and components are over 55 years old and beyond its expected life by utilizing the approaches described below. Due to its age, components could fail without notice. There are individual components of the air handling unit that may last longer than others, but consideration should be given to replacing the entire air handling unit as it will likely not last an additional 50 years. Therefore, it is recommended to replace the air handling unit with a unit designed with both energy efficiency upgrades and performance enhancements to increase occupant comfort.

There are three approaches used to quantify the expected remaining life of the air handling units and its components.

- Approach #1 is to compare the existing equipment life against the published ASHRAE Estimates of Service Life table, Table 1 (p. 257). Per this table, the air handling unit individual components are is past their expected useful life of 20 to 30 years.
- Approach #2 is to compare the existing equipment life against actual data being collected by ASHRAE as indicated in Table 3 (next page). This table indicates that the mean age that constant volume air handling units have been required to be replaced have been in the range of 35 years of age. The standard deviation is 20 years. Meaning that the upper life expectancy for this unit is 55 years.
- Approach #3 is to compare the existing equipment life against the survivor curves from the NNSA benchmark data (Figure 9, next page). This graph indicates that the maximum probable life of the air handling unit is 64 years, with a mean life of 38 years.

	Total Units	Currently in Service							Replaced						
		No.of Units	Equipment Age (years)						No.of Units	Age at Removal (years)					
			Mean	Median	Std Dev	95% C.I.	Max	Min		Mean	Median	Std Dev	95% C.I.	Max	Min
Air handling unit, constant volume	206	184	25.9	27.0	11.9	4.8	46.0	6.0	22	34.7	40.0	20.5	23.2	52.0	12.0
Air handling unit, dual duct	20	20	36.5	37.0	6.6	5.3	45.0	25.0	0	n/a	n/a	n/a	n/a	n/a	n/a
Air handling unit, multizone	229	229	30.4	24.5	18.4	8.5	76.0	6.0	0	n/a	n/a	n/a	n/a	n/a	n/a
Air handling unit, single zone	87	87	21.7	18.5	12.5	7.7	44.0	10.0	0	n/a	n/a	n/a	n/a	n/a	n/a
Air handling unit, variable air volume	962	893	18.6	20.0	8.8	1.8	47.0	-20.0	69	28.2	26.0	12.4	6.3	64.0	12.0
Air handling unit, variable volume, variable temperature	196	61	20.1	21.5	9.2	5.2	34.0	4.0	135	12.0	12.0	n/a	n/a	12.0	12.0

Table 3: Table of AHU life against ASHRAE

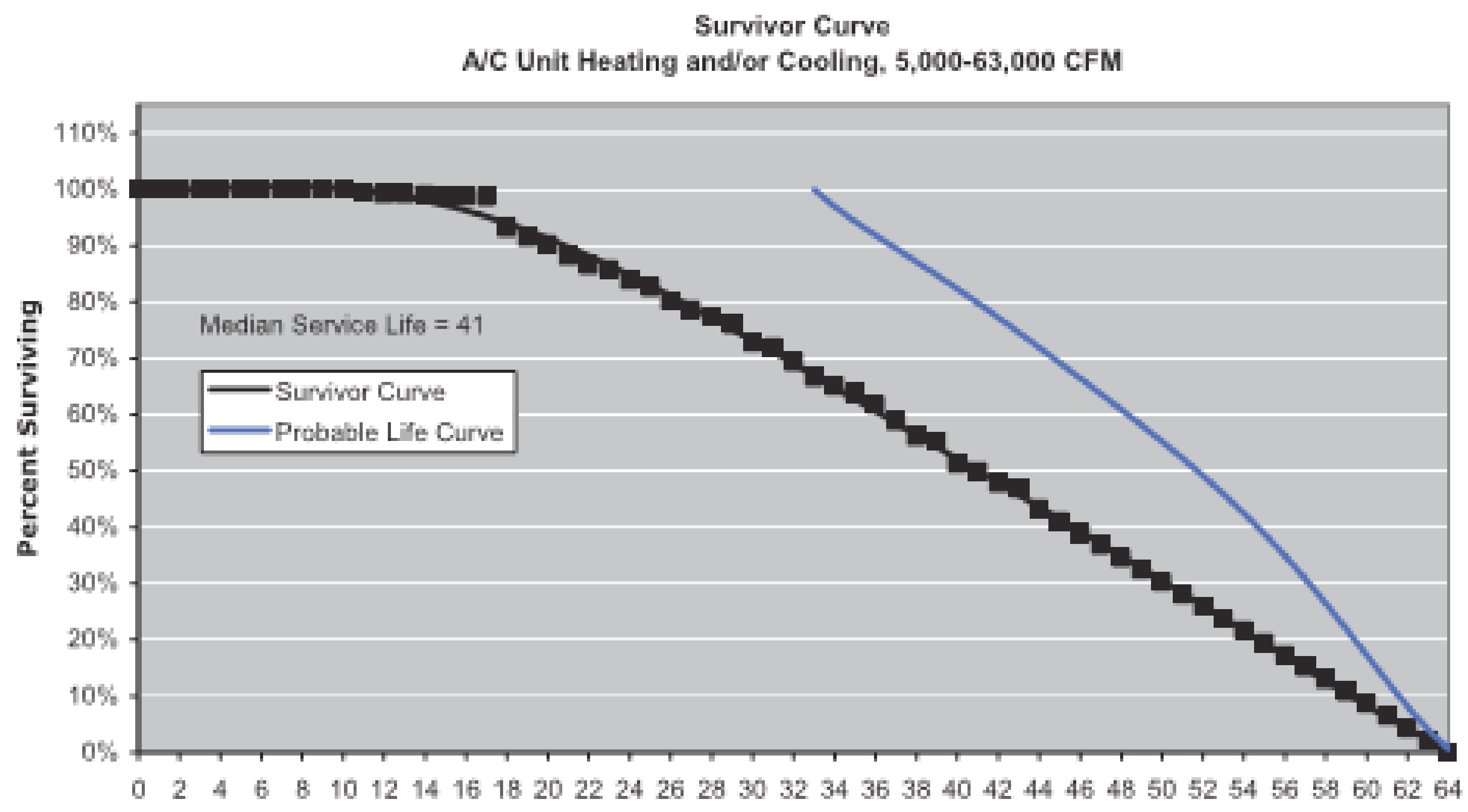


Figure 9: AHU Survivor Curve

Figure 10: Recirculation Fan Installation

Main Church Recirculation and Exhaust System

System Overview
The main Church has a recirculation and exhaust system to remove ventilation air and reduce the stratification of the heated air in the space. This system consists of four recirculation unit s and four roof mounted exhaust fans.

Condition
The recirculation fans are located in the upper saw tooth structure as shown in Figure 10: Recirculation Fan Installation. These fans draw in air from one side of the saw tooth and then blows it out the other side. Figure 11: Recirculation Fan Diffusers (next page) shows the supply diffuser locations. The system was reported to be noisy and therefore is not operated when the church is in use. The fans are in poor condition excessive bearing issue was observed and general unit casing was poor. The diffusers did not appear to have sufficient velocity to achieve a high vertical flow.

Figure 11: Recirculation Fan Diffusers

The four exhaust fans are located on the roof. These fans exhaust air from the church via the unducted grilles in the saw tooth. Two of the fans have failed and are no longer serviceable. This limits the ability for the HVAC system to operate in a condition to adequately cool the building.

Recommendation/Comments

The recirculation fans and exhaust fans are in poor and failing condition and are recommended to be replaced. Consideration should be given to implement the replacement of this system along with the air handling g unit replacement to incorporate a holistic approach to the upgrade of the mechanical system.

Air Handling Unit #2 – Parish Church Unit:

System Overview

The ventilation system that services the Parish Church Nave located in the basement consists of a constant volume air handling unit that provides ventilation and heating air to the occupied areas. This is a single zone unit with no additional reheat coils.

The air handling unit (AHU) is original to the 1957 building placing the unit and the components over 55 years old. This unit consists of a single inlet backward inclined utility set return fan, pneumatic operated return, relief and outdoor air dampers, fiber media filters, steam preheat coil, and single inlet backward inclined utility set supply fan. This unit does not have a cooling coil for dehumidification or a humidifier. This AHU is a built-up air handling with single wall construction and exposed fibrous insulation exposed in the air stream. The unit and associated return fan is located in the basement mechanical room as highlighted in Figure 12: Mechanical Plan Excerpt.

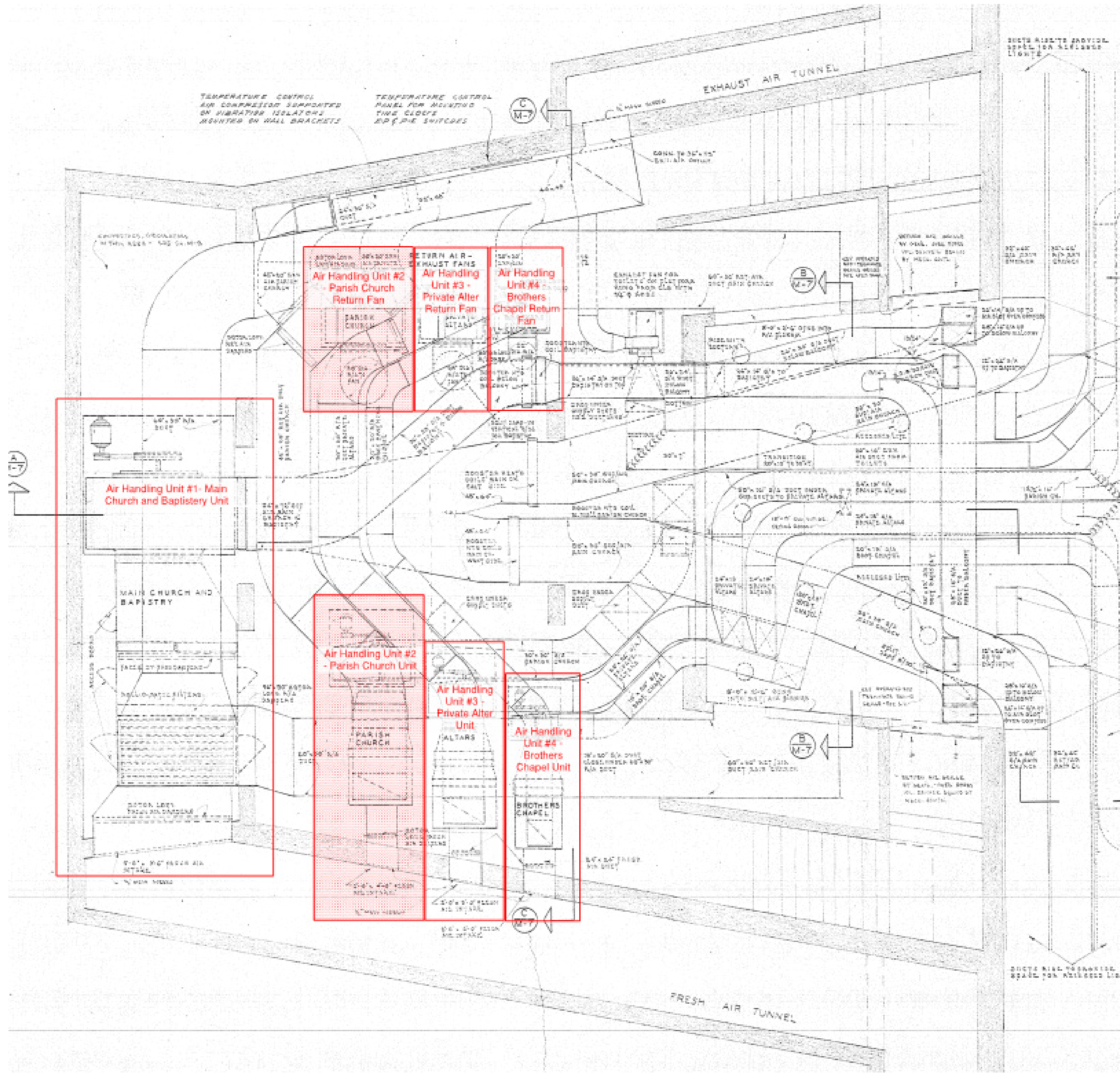


Figure 12: Mechanical Plan Excerpt

The unit is a constant air volume system that does not meet the current energy code. Energy code requires that a fan system over 5,000 CFM of this size to be able to vary the flow to meet space demand, thereby limiting reheat operation.

The supply air distribution system consists of ductwork with internal lining. All supply zones are fully ducted to the diffuser outlet. The supply air ductwork is routed to the Parish Church through ductwork located in the basement ceiling to overhead side wall grilles in the rear of the church. Refer to Figure 13: Parish Church Supply for the supply grille installation.

Figure 13: Parish Church Supply

Figure 14: Underground Return Conduit

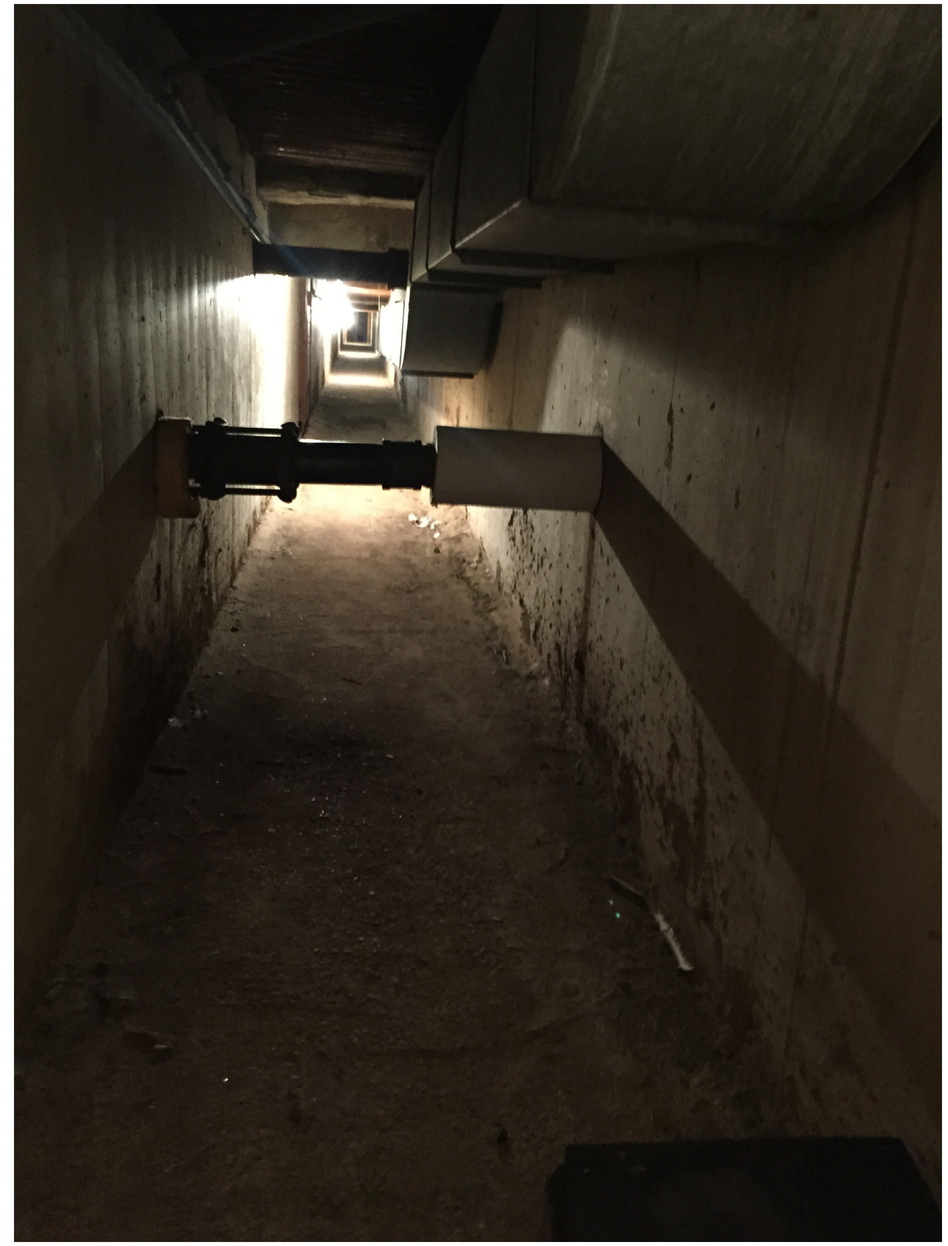


Figure 15: Underground Return Tunnel

The return air ductwork consists of ducted and underground concrete tunnels for return. The underground return air tunnels are common to AHU-2, AHU-3 and AHU-4. The underground tunnels are comprised of concrete enclosures. Aside from being dirty, the enclosures appear to be in good condition. No moisture penetration was observed. Refer to Figure 14: Underground Return Conduit and Figure 15: Underground Return Tunnel for the representative photos. The underground return ducts are connected to return duct work and grilles located at the floor level of the parish church.

Return Fan Condition

The return fan is original to the building construction and is therefore over 55 years old- Figure 16: AHU-2 Return Fan. The existing fan does not have inlet vanes or VFD to control fan speed.

Fan condition is as follows:

- The motor has been replaced and appears to be in good operating condition.
- The fan casing appears to be sound.
- The flexible connector is showing signs of wear.
- Bearings appear to be original. Due to the age, the bearing life is suspect.
- Fan shaft and blade soundness (due to stress fatigue) is not attainable by visual observation.

Return air / Relief Air / Outdoor Air Damper Condition

The dampers are original to the building construction and are therefore over 55 years old. The outside air dampers are worn and do not actuate and seal properly. On the day of the field review, the dampers were 100% closed, but significant cold air was observed penetrating the dampers. This has the potential to damage the steam coil. The maintenance personnel have attempted to mitigate the infiltration by partially blocking off the intake as indicated in Figure 17: AHU-2 Blocked Outside Air (next page). Consideration should be given to replacing the dampers in conjunction with

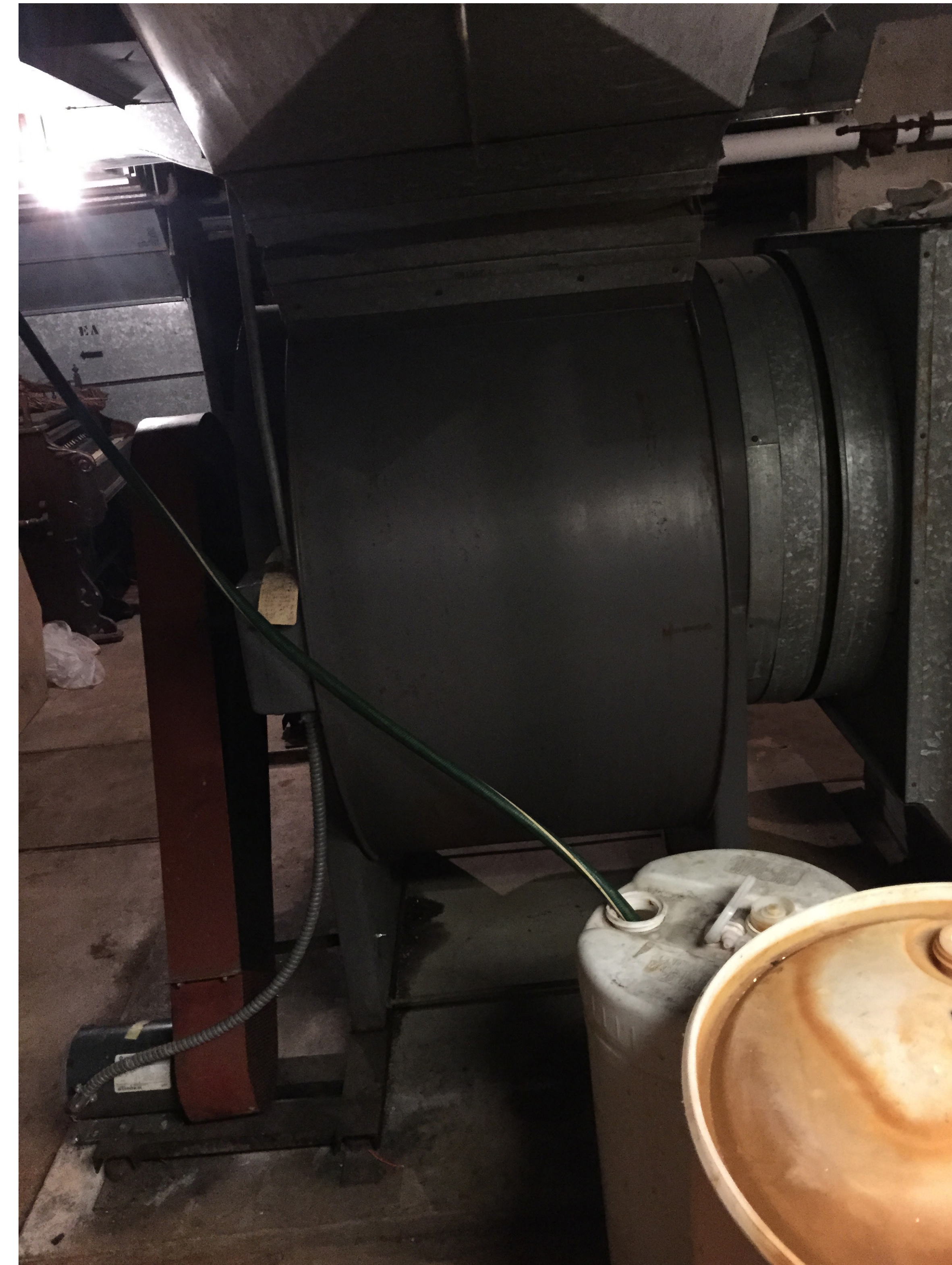


Figure 16: AHU-2 Return Fan

Figure 17: AHU-2 Blocked Outside Air

Figure 18: AHU-2 Outside Air Inlet

Air Handling Unit Casing Condition
The air handling unit casing consists of a single wall sheet metal with internal fibrous insulation exposed in the air stream. The insulation has is soiled, deteriorating, failing, and beginning to separate from the sheet metal and be drawn into the air stream. Fibrous particles in the air stream can pose risk to both health of occupants and finishes in the building as these particles can be abrasive to adjacent air vents and be breathed in by individuals. The separation of the insulation from the casing is degrading the performance of the insulation. Refer to Figure 19: AHU-2 Insulation Condition (next page) for an example of the casing insulation condition. Consideration should be given to replacing the casing and insulation junction with an overall air handling unit replacement plan.

Filter Section Condition
The filter bank consist of a fabric media filters. They are located immediately downstream of the mixing plenum. Facilities personnel indicate that the filters are changed regularly and do not report any issues with the filters. Facilities personnel indicate that the filters are changed regularly and do not report any issues with the filters. The existing filtration level of the filter bank was reported to be MERV 8. Consideration should be given to replacing the filters in conjunction with an overall air handling unit replacement plan.

Steam Heating Coil Condition
The heating coil is original to the building construction. The coils is controlled with a pneumatic operated control valve. The access door to inspect this coils was glued shut. It is possible that this coil has not been accessed and inspected since its install. The condensate traps appear to be original to the coils. Due to their age, replacement parts are no longer available and are required to be completely replaced when they fail.

Supply Fan Condition
The fan is original to the building construction and is over 55 years old. The existing supply fan is a constant flow fan with a starter. The fan is a single inlet backward inclined utility set return fan.
Fan condition is as follows:

- The appears to be original.
- The fan casing appears to be sound.
- The flexible connector is showing signs of wear.
- There is a significant amount of oil / grease under the fan. The fan bearing condition may be suspect.
- Fan shaft and blade soundness (due to stress fatigue) is not attainable by visual observation.

Recommendation/Comments

The condition the each air handling unit as a whole is near the end of its serviceable life. The casing, dampers and fan bearings are suspect. This is due to the conditions of the individual AHU components as well and the age of the air handling unit. The air handling unit and components are over 55 years old and beyond its expected life by utilizing the approaches described in the discussion of AHU-1. Due to its age, components could fail without notice. There are individual components of the air handling unit that may last longer than others, but consideration should be given to replacing the entire air handling unit as it will likely

Figure 19: AHU-2 Insulation Condition

not last an additional 50 years. Therefore, it is recommended to replace the air handling unit with a unit designed with both energy efficiency upgrades and performance enhancements to increase occupant comfort.

Air Handling Unit #3 – Private Altar Unit

System Overview
The ventilation system that services the Private Altars located in the basement consists of a constant volume air handling unit that provides ventilation and heating air to the occupied areas (Figure 22 p. 277). This is a single zone unit with no additional reheat coils and is sized at approximately 4,000 CFM.

The air handling unit (AHU) is original to the 1957 building placing the unit and the components over 55 years old. This unit consists of a single inlet backward inclined utility set return fan, pneumatic operated return, relief and outdoor air dampers, fiber media filters, steam preheat coil, and single inlet backward inclined utility set supply fan. This unit does not have a cooling coil for dehumidification or a humidifier. This AHU is a built-up air handling with single wall construction and exposed fibrous insulation exposed in the air stream. The unit and associated return fan is located in the basement mechanical room as highlighted in Figure 20: Mechanical Plan Excerpt (next page). The unit is a constant air volume system. Although the capacity of this unit does not require that it be variable flow by code, the owner can see significant energy savings were it operated as a variable flow system.

The supply air distribution system consists of ductwork with internal lining. All supply zones are fully ducted to the diffuser outlet. The supply air ductwork is routed to the alter area through ductwork located in the basement ceiling to floor level grilles in the toe kick of the cabinetry. Refer to Figure 21: Private Altars Supply (p.276 right) for the supply grille installation.

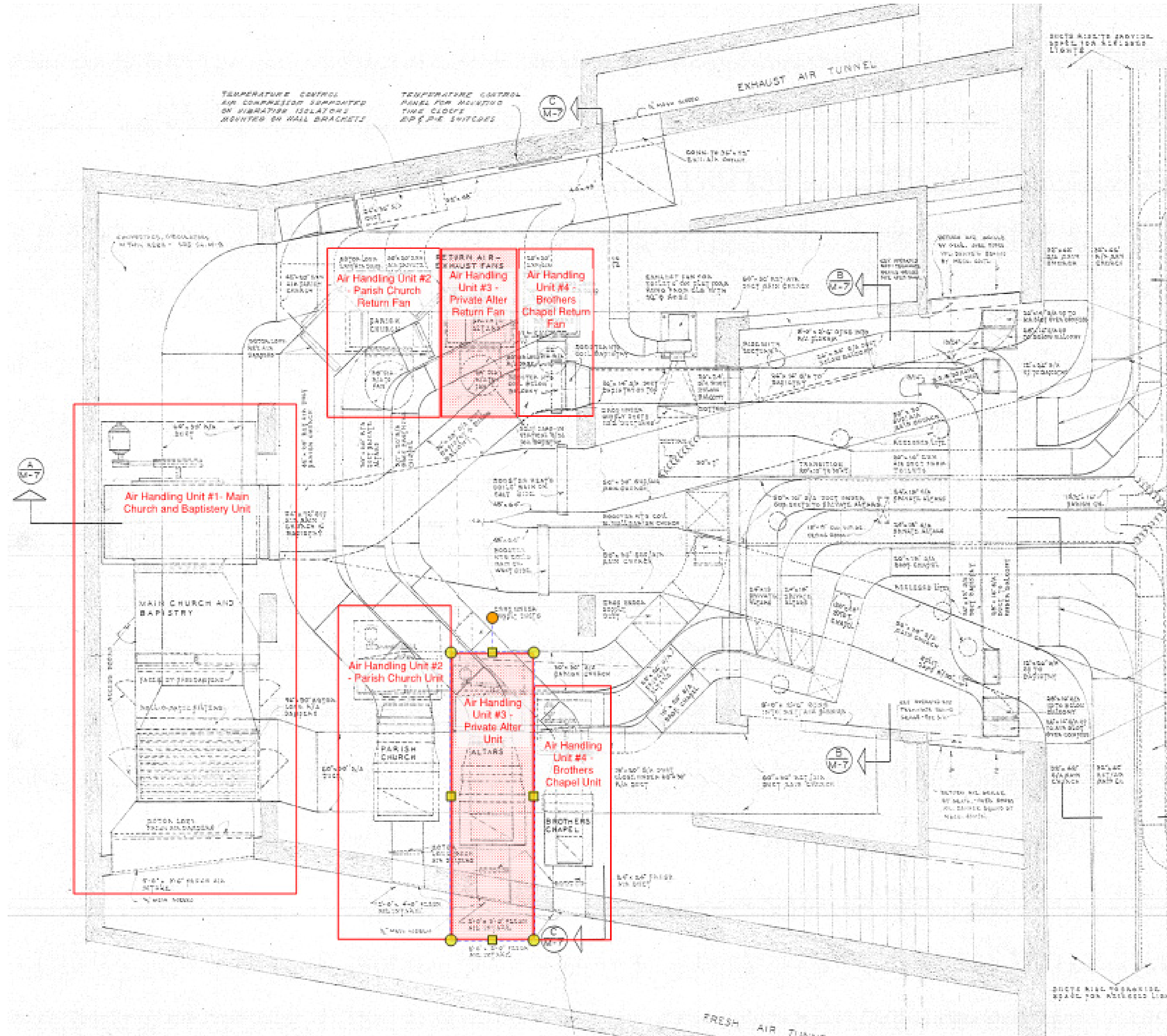


Figure 20: Mechanical Plan Excerpt

Figure 21: Private Altars Supply

Figure 22: AHU-3 Return Fan

The return air ductwork consists of ducted and underground concrete tunnels for return. The underground return air tunnels are common to AHU-2, AHU-3 and AHU-4. Refer to discussion on AHU-2 for description of condition. The underground return ducts are connected to return duct work and grilles located at the floor level of the in each side of the Private Altar area.

Return Fan Condition
The return fan is original to the building construction and is therefore over 55 years old. The existing fan does not have inlet vanes or VFD to control fan speed.
Fan condition is as follows:

- The motor appears to be original.
- The fan casing appears to be sound.
- The flexible connector is showing signs of wear.
- There is a significant amount of oil / grease under the fan. The fan bearing condition may be suspect.
- Fan shaft and blade soundness (due to stress fatigue) is not attainable by visual observation.

Return Air / Relief Air / Outdoor Air Damper Condition
The dampers are original to the building construction and are therefore over 55 years old. The outside air dampers are worn and do not actuate and seal properly. Some of the linkages on the damper were disconnected or failed. The unit has as freeze sensor installed to prevent adverse effects of freezing air. The outside air is taken in from the air tunnel via a grille as indicated in Figure 23: AHU-3 Outside Air Inlet (next page). Consideration should be given to replacing the dampers in conjunction with an overall air handling unit replacement.


Figure 23: AHU-3 Outside Air Inlet


Figure 24: AHU-3 Insulation Condition

Air Handling Unit Casing Condition
The air handling unit casing consists of a single wall sheet metal with internal fibrous insulation exposed in the air stream. The insulation has is soiled, deteriorating, failing, and beginning to separate from the sheet metal and be drawn into the air stream. Fibrous particles in the air stream can pose risk to both health of occupants and finishes in the building as these particles can be abrasive to adjacent air vents and be breathed in by individuals. The separation of the insulation from the casing is degrading the performance of the insulation. Refer to Figure 24: AHU-3 Insulation Condition for an example of the casing insulation condition. Consideration should be given to replacing the casing and insulation junction with an overall air handling unit replacement plan.

Filter Section Condition
The filter bank consist of a fabric media filters. They are located immediately downstream of the mixing plenum. Facilities personnel indicate that the filters are changed regularly and do not report any issues with the filters. Facilities personnel indicate that the filters are changed regularly and do not report any issues with the filters. The existing filtration level of the filter bank was reported to be MERV 8. Consideration should be given to replacing the filters in conjunction with an overall air handling unit replacement plan.

Steam Heating Coil Condition
The heating coil is original to the building construction. The coil is controlled with a pneumatic operated control valve. Observation of the coil indicated not visible signs of wear. Although due to its age the coil tube ends are suspect. The condensate traps appear to be original to the coils, refer to Figure 25: AHU-3 Steam Trap (next page). Due to their age, replacement parts are no longer available and are required to be completely replaced when they fail.

Supply Fan Condition
The fan is original to the building construction and is over 55 years old. Refer to Figure 26: AHU-3 Supply Fan and Enclosure. The existing supply fan is a constant flow fan with a starter. The fan is a single inlet backward inclined utility set return fan.
Fan condition is as follows:

- The appears to be original.
- The fan casing appears to be sound.
- The flexible connector is showing signs of wear.
- There is a significant amount of oil / grease under the fan. The fan bearing condition may be suspect.
- Fan shaft and blade soundness (due to stress fatigue) is not attainable by visual observation.

Figure 25: AHU-3 Steam Trap

Figure 26: AHU-3 Supply Fan and Enclosure.

Recommendation/Comments

The condition the each air handling unit as a whole is near the end of its serviceable life. The casing, dampers, steam coil and traps, and fan bearings are suspect. This is due to the conditions of the individual AHU components as well and the age of the air handling unit. The air handling unit and components are over 55 years old and beyond its expected life by utilizing the approaches described in the discussion of AHU-1. Due to its age, components could fail without notice. There are individual components of the air handling unit that may last longer than others, but consideration should be given to replacing the entire air handling unit as it will likely not last an additional 50 years. Therefore, it is recommended to replace the air handling unit with a unit designed with both energy efficiency upgrades and performance enhancements to increase occupant comfort.

Air Handling Unit #4 – Brothers Chapel Unit

System Overview: The ventilation system that services the Brothers Chapel located in the basement consists of a constant volume air handling unit that provides ventilation and heating air to the occupied areas. This is a single zone unit with no additional reheat coils. Refer to Figure 30:AHU-4 Return Fan, p.282.

The air handling unit (AHU) is original to the 1957 building placing the unit and the components over 55 years old. This unit consists of a single inlet backward inclined utility set return fan, pneumatic operated return, relief and outdoor air dampers, fiber media filters, steam preheat coil, and single inlet backward inclined utility set supply fan. This unit does not have a cooling coil for dehumidification or a humidifier. This AHU is a built-up air handling with single wall construction and exposed fibrous insulation exposed in the air stream. The unit and associated return fan is located in the basement mechanical room as highlighted in Figure 27: Mechanical Plan Excerpt(next page).

The unit is a constant air volume system. Although the capacity of this unit does not require that it be variable flow by code, the owner can see significant energy savings were it operated as a variable flow system.

The supply air distribution system consists of ductwork with internal lining. All supply zones are fully ducted to the diffuser outlet. The supply air ductwork is routed to the Brothers Chapel through ductwork located in the basement ceiling to overhead side wall grilles on the East and west sides of the chapel. Refer to Figure 28: Brothers Chapel Supply (page 281 upper left) and Figure 29: Brothers Chapel Return Grille (page 281 lower left) or the supply and return grille installation.

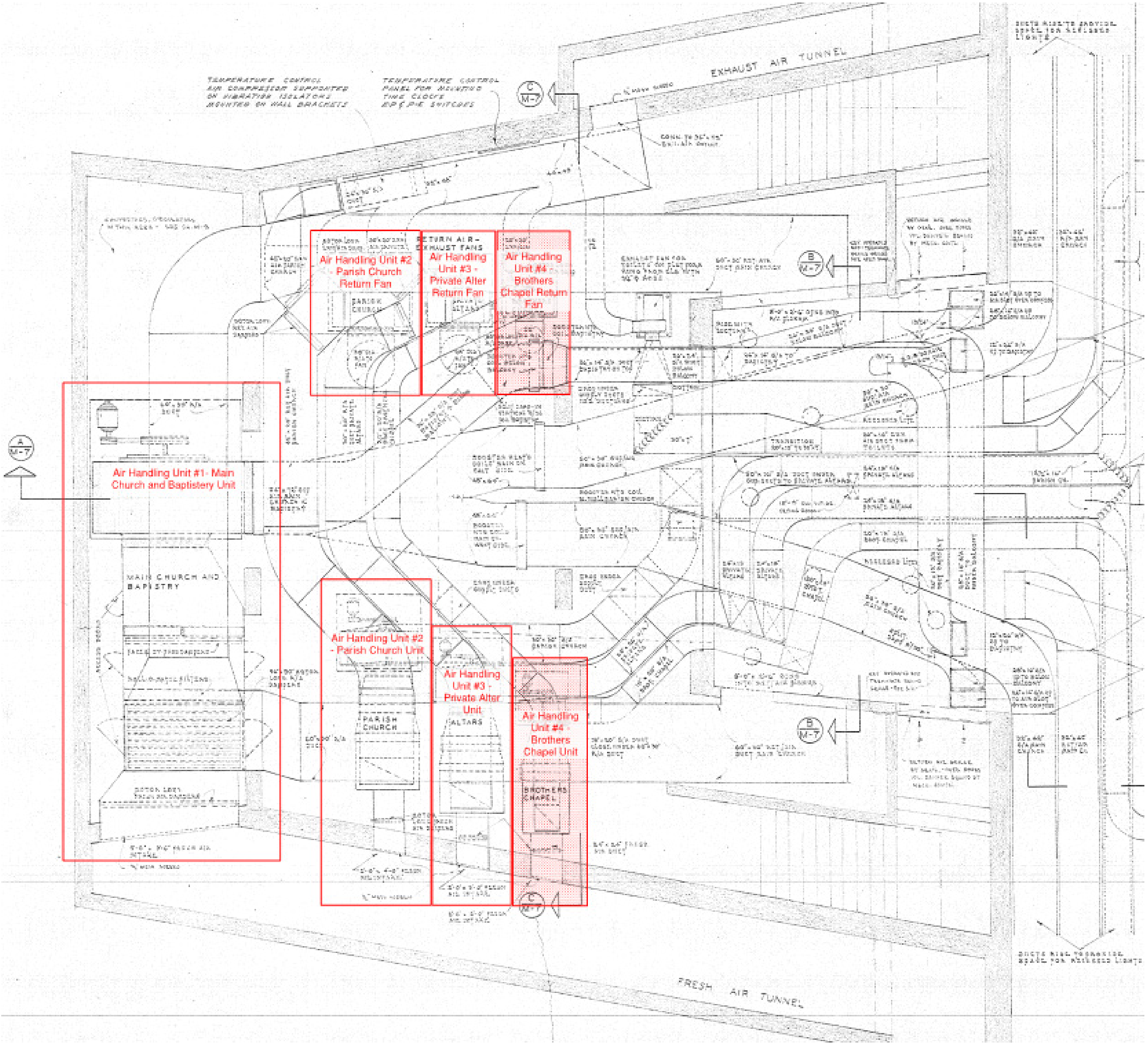


Figure 27: Mechanical Plan Excerpt

Figure 28: Brothers' Chapel Supply

Figure 29: Brothers Chapel Return Grille

The return air ductwork consists of plenum and underground concrete tunnels for return. The underground return air tunnels are common to AHU-2, AHU-3 and AHU-4. Refer to discussion on AHU-2 for description of condition. The underground return ducts are connected to the plenums that are under the seating area of the chapel.

Return Fan Condition

The return fan is original to the building construction and is therefore over 55 years old. The existing fan does not have inlet vanes or VFD to control fan speed. Fan condition is as follows:

- The appears to be original.
- The fan casing appears to be sound.
- The flexible connector is showing signs of wear.
- There is a significant amount of oil / grease under the fan. The bearing block appears to have been repaired. The fan bearing condition may be suspect.
- Fan shaft and blade soundness (due to stress fatigue) is not attainable by visual observation.

Return air / Relief Air / Outdoor Air Damper Condition

The dampers are original to the building construction and are therefore over 55 years old. The outside air dampers are worn and do not actuate and seal properly. On the day of the field review, the dampers were 100% closed, but significant cold air was observed penetrating the dampers. This has led to damage at the steam coil. The maintenance personnel have attempted to mitigate the infiltration by partially blocking off the intake as indicated in Figure 31: AHU-4 Outside Dampers (next page, middle). The outside air is taken in from the air tunnel via a grille as indicated in Figure 32: AHU-4 Outside Air Inlet (next page, right). Consideration should be given to replacing the dampers in conjunction with an overall air handling unit replacement.

Figure 30: AHU-4 Return Fan

Figure 31: AHU-4 Outside Dampers

Figure 32: AHU-4 Outside Air Inlet

Figure 33: AHU-4 Insulation Condition

Air Handling Unit Casing Condition
The air handling unit casing consists of a single wall sheet metal with internal fibrous insulation exposed in the air stream. The insulation has is soiled, deteriorating, failing, and beginning to separate from the sheet metal and be drawn into the air stream. Fibrous particles in the air stream can pose risk to both health of occupants and finishes in the building as these particles can be abrasive to adjacent air vents and be breathed in by individuals. The separation of the insulation from the casing is degrading the performance of the insulation. Refer to Figure 33: AHU-4 Insulation Condition (left) for an example of the casing insulation condition. Consideration should be given to replacing the casing and insulation junction with an overall air handling unit replacement plan. Refer to Figure 35:AHU-4 Supply Fan and Casing (next page).

Filter Section Condition
The filter bank consist of a fabric media filters. They are located immediately downstream of the mixing plenum. Facilities personnel indicate that the filters are changed regularly and do not report any issues with the filters. Facilities personnel indicate that the filters are changed regularly and do not report any issues with the filters. The existing filtration level of the filter bank was reported to be MERV 8. Consideration should be given to replacing the filters in conjunction with an overall air handling unit replacement plan.

Steam Heating Coil Condition
The heating coil is original to the building construction. The coil is controlled with a pneumatic operated control valve. The coil shows signs of damage as indicated in Figure 34: AHU-4 Steam Coil (next page, upper left). It is unknown if this coil is functioning or has been repaired. The condensate traps appear to be original to the coils. Due to their age, replacement parts are no longer available and are required to be completely replaced when they fail.

Figure 34: AHU-4 Steam Coil

Supply Fan Condition

The fan is original to the building construction and is over 55 years old. The existing supply fan is a constant flow fan with a starter. The fan is a single inlet backward inclined utility set return fan.

Fan condition is as follows:

- The motor appears to be original.
- The fan casing appears to be sound.
- The flexible connector is showing signs of wear.
- There is a significant amount of oil / grease under the fan. The fan bearing condition may be suspect.
- Fan shaft and blade soundness (due to stress fatigue) is not attainable by visual observation.

Figure 35: AHU-4 Supply Fan and Casing

Recommendation/Comments

The condition the each air handling unit as a whole is near the end of its serviceable life. The casing, dampers, steam coil, steam traps and fan bearings are suspect. This is due to the conditions of the individual AHU components as well and the age of the air handling unit. The air handling unit and components are over 55 years old and beyond its expected life by utilizing the approaches described in the discussion of AHU-1. Due to its age, components could fail without notice. There are individual components of the air handling unit that may last longer than others, but consideration should be given to replacing the entire air handling unit as it will likely not last an additional 50 years. Therefore, it is recommended to replace the air handling unit with a unit designed with both energy efficiency upgrades and performance enhancements to increase occupant comfort.

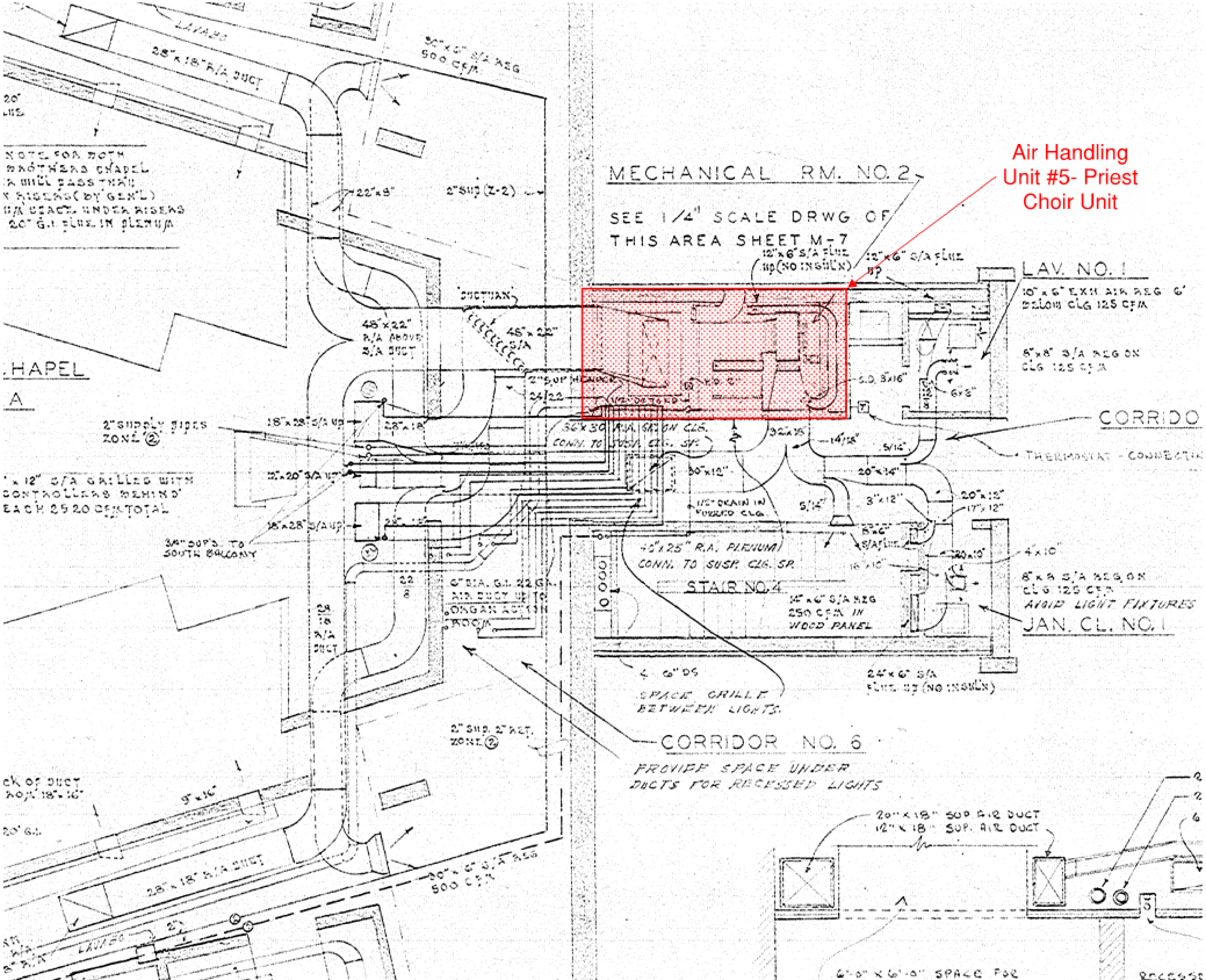


Figure 36: Mechanical Plan Excerpt

Air Handling Unit #5 – Priests Choir Unit

System Overview

The ventilation system that services the Priests Choir area located in the main level consists of a constant volume air handling unit that provides ventilation and heating air to the space. This is a single zone unit with no additional reheat coils. and is sized at approximately 9,000 CFM.

The air handling unit (AHU) is original to the 1957 building placing the unit and the components over 55 years old. This unit consists of a single inlet backward inclined utility set return fan, pneumatic operated return, relief and outdoor air dampers, fiber media filters, steam preheat coil, and single inlet backward inclined utility set supply fan. This unit does not have a cooling coil for dehumidification or a humidifier. This AHU is a built-up air handling with single wall construction and exposed fibrous insulation exposed in the air stream. The unit and associated return fan is located in the basement mechanical room as highlighted in Figure 36: Mechanical Plan Excerpt (previous page) and Figure 37: Mechanical Plan Excerpt (right). The fan and coil are located within a small mechanical room with no direct access to the fan, fan motor, or coils. This location of the equipment presents difficulty's for the maintenance personnel to service and repair the equipment. Due to the location, the fan and motor were not able to be observed for review.

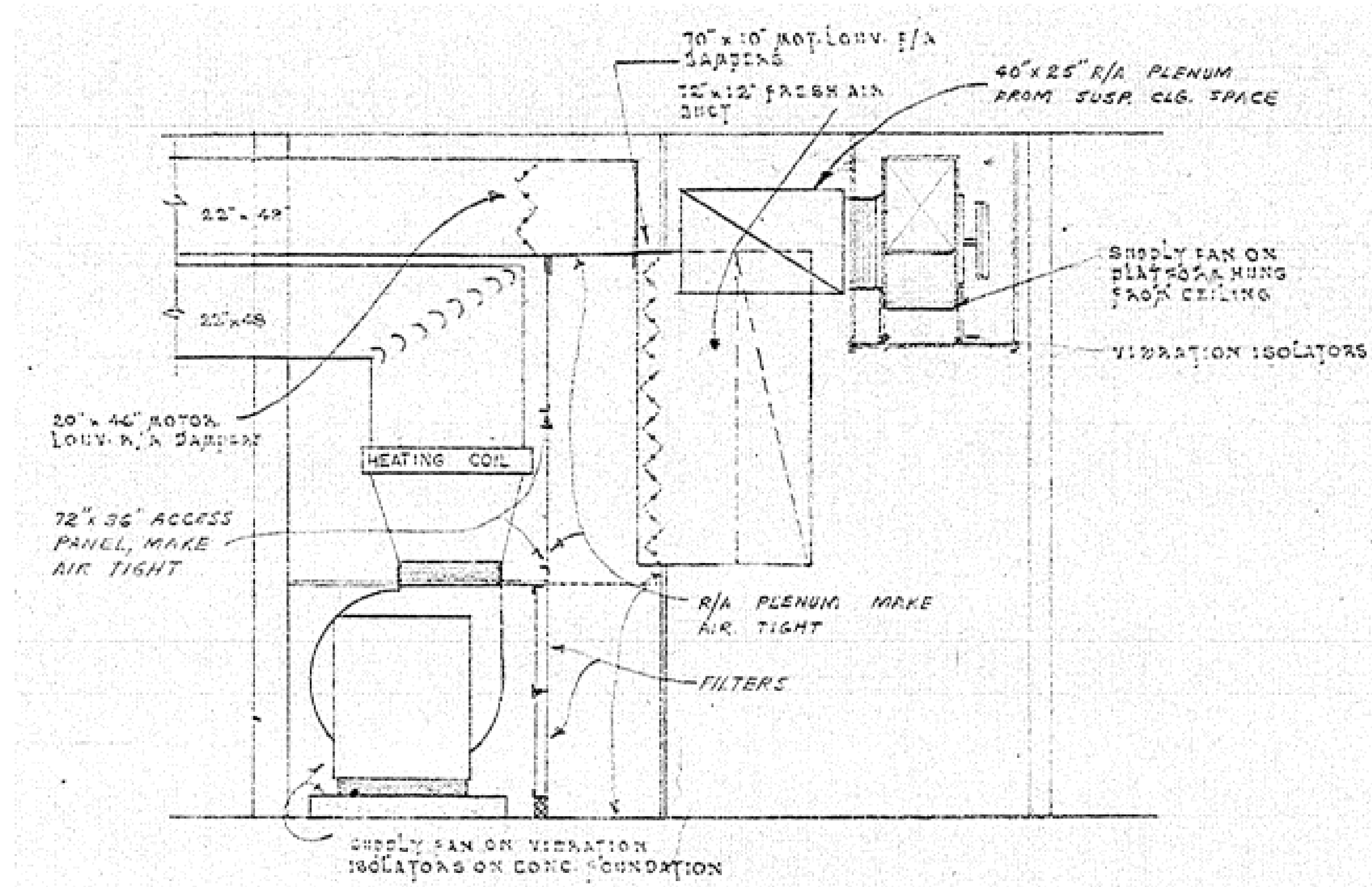


Figure 37: Mechanical Plan Excerpt

The unit is a constant air volume system that does not meet the current energy code. Energy code requires that a fan system over 5,000 CFM of this size to be able to vary the flow to meet space demand, thereby limiting reheat operation.

The supply air distribution system consists of ductwork with internal lining. All supply zones are fully ducted to the diffuser outlet. The supply air ductwork is routed to the Priests Choir area through ductwork located in the basement ceiling and then routed to overhead side wall grilles under the front balcony of the church. Refer to Figure 38: Priest Choir Supply (next page) for the supply grille installation. The supply grille is at a elevation that directly blows air into the occupants. This results in significant draftiness and discomfort for the occupants. Maintenance personnel indicated that they can alleviate some of the discomfort by elevating the supply air temperature and providing it at near room temperature. The trade-off is that the cooling effect is reduced.

Figure 38: Priest Choir Supply

Figure 39: Under Seat Return

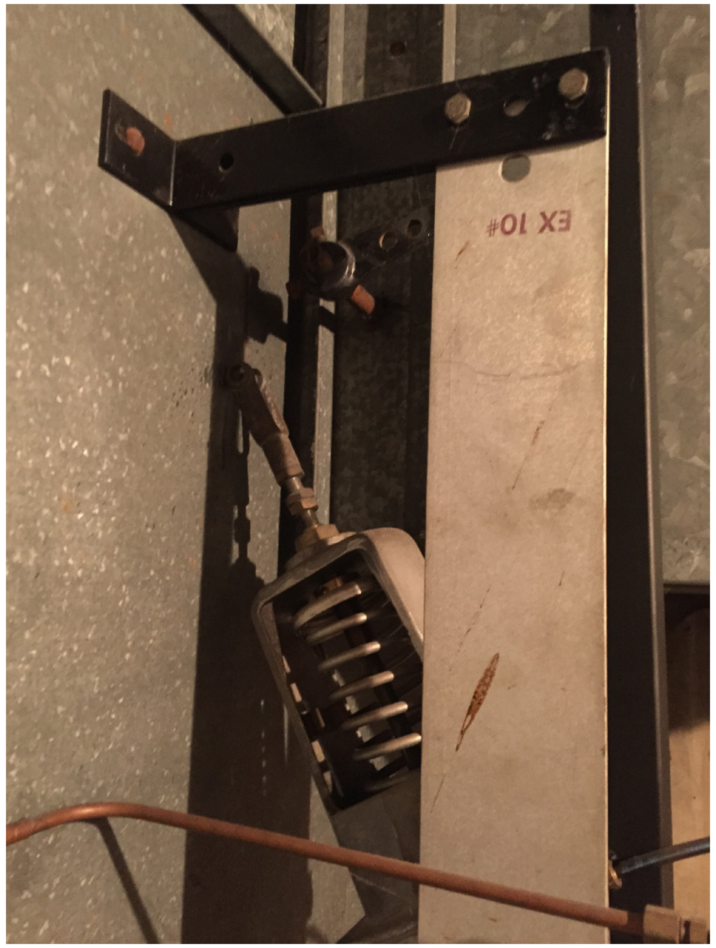


Figure 40: AHU-5 Disconnected Outside Air Damper

The return air ductwork consists of a combination of ducted and plenum return. The return air ductwork is routed to the Priest Choir area in the main church through ductwork located in the basement ceiling. Return air is then returned from the Priest Choir Area via plenums that are under the seating area, as indicated in Figure 39: Under Seat Return (above, center).

Figure 41: AHU-5 Insulation Condition

Figure 42: AHU-5 Insulation Condition

Return Air / Relief Air / Outdoor Air Damper Condition
The dampers are original to the building construction and are therefore over 55 years old. The outside air dampers have failed and are disconnected, as indicated in Figure 40: AHU-5 Disconnected Outside Air Damper (previous page, right). The seals and dampers were observed to be in poor condition.

Air Handling Unit Casing Condition
The air handling unit casing consists of a single wall sheet metal with internal fibrous insulation exposed in the air stream. The insulation has is soiled, deteriorating, failing, and beginning to separate from the sheet metal and be drawn into the air stream. Fibrous particles in the air stream can pose risk to both health of occupants and finishes in the building as these particles can be abrasive to adjacent air vents and be breathed in by individuals. The separation of the insulation from the casing is degrading the performance of the insulation. Refer to Figure 41: AHU-5 Insulation Condition (above, left) and Figure 42: AHU-5 Insulation Condition (above) for an example of the casing insulation condition. Consideration should be given to replacing the casing and insulation junction with an overall air handling unit replacement plan.

Filter Section Condition
The filter bank consist of a fabric media filters. They are located immediately downstream of the mixing plenum. Facilities personnel indicate that the filters are changed regularly and do not report any issues with the filters. Facilities personnel indicate that the filters are changed regularly and do not report any issues with the filters. The existing filtration level of the filter bank was reported to be MERV 8. Consideration should be given to replacing the filters in conjunction with an overall air handling unit replacement plan.

Steam Heating Coil Condition
The heating coil is original to the building construction. The coils is controlled with a pneumatic operated control valve. Due to the coil location, there is no access door to inspect this coil. The condensate traps appear to be original to the coils. Due to their age, replacement parts are no longer available and are required to be completely replaced when they fail.

Supply Fan Condition
The fan is original to the building construction and is over 55 years old. The existing supply fan is a constant flow fan with a starter. Due to the fan location, there is no access to inspect this fan. The condition was therefore, not observable.

Recommendation/Comments

The condition the each air handling unit as a whole is near the end of its serviceable life. The casing, dampers are suspect or have already failed. This is due to the conditions of the individual AHU components as well and the age of the air handling unit. The air handling unit and components are over 55 years old and beyond its expected life by utilizing the approaches described in the discussion of AHU-1. Due to its age, additional components could fail without notice. There are individual components of the air handling unit that may last longer than others, but consideration should be given to replacing the entire air handling unit as it will likely not last an additional 50 years. Therefore, it is recommended to replace the air handling unit with a unit designed with both energy efficiency upgrades and performance enhancements to increase occupant comfort.

Mechanical Ventilation Ductwork

Condition
The supply and return duct distribution system is original to the building construction and is over 55 years old. The exterior observation of the exposed ductwork in the basement level yielded limited physical wear or issues. The interior of the ductwork in inaccessible due to the lack of access panels. There are a few of concerns with the duct distribution system:

Lined Ductwork
The supply duct system consists of internally lined (insulated) ductwork. This internal lining helps with the attenuation of fan and airflow generated noise and condensation on the ductwork when in cooling. The duct liner typically degrades over time from air erosion or by failure of the mechanical bond from the ductwork. When this happens, the liner may be block portions of the ductwork and restrict airflow. It also will result in locations where the duct is not insulated and allow for condensation to form on the exterior ductwork, should cooling be added to the building air handling unit. Over time this condensation can lead to mold and moisture issues on the surrounding structure. Additional, inspection of the interior ductwork is recommended with a remote camera to determined that the existing insulation is well adhered and functional.

Underground Ductwork
here is underground l return ductwork the runs from the Brothers Chapel to the mechanical room. This ductwork was constructed of concrete. There was limited amounts of dirt and debris in the ductwork and no visible moisture penetration. This return ductwork appeared to be in satisfactory condition. Refer to Figure 14: Underground Return Conduit (p. 270) and Figure 15: Underground Return Tunnel (p.270) for the representative photos.

Duct Construction Class
Due to the age and operation of the ductwork, it is likely construction as a low pressure class duct system. Should modifications occur that will require a higher pressure class, then the duct system may experience increased leaks and a wear or fail due to pressure.

Recommendation/Comments

The ductwork is recommended to be further reviewed to determine the condition of the internal liner. External insulation may be required if cooling is added to the system.

System Overview
The building is served from the central steam plant. The steam is piped to the air handling unit heating coils, zone heating coils, and heat exchangers. There is a system of heat exchangers to make hydronic heating water that serves various in floor heat.

Steam and Condensate Piping and Insulation

Condition
The steam and condensate piping is original to the building. The steam piping appears to be constructed of welded and flanged steel piping. The main piping does not have visible signs of wear.

The condensate piping appears to be constructed of welded and screwed steel piping. Facilities personnel do not report any issues with the condensate piping. However, the condensate piping is showing signs of wear at the connections to the coils and steam traps. This is to be expected for the age of the piping as the smaller pipe has a thinner wall than the larger pipe sizes and the process of threading the piping reduces the wall thickness further. Carbonic acid in the condensate tends to corrode the condensate return piping quicker than the steam piping.

There are various lengths of condensate piping located underground. The plans indicate that the condensate piping is sleeved in a secondary pipe. The penetration into the floor has been sealed and the condition of this piping is unknown. There is a concern that the underground piping is compromised due to corrosion.

The steam traps are original to the building construction. Refer to Figure 43: Steam Trap Assembly at Zone Coil, above right). Facilities personnel have been maintaining these traps as they fail. Due to the age, the steam traps service parts are no longer available.

The Steam and condensate isolation valves appear original to the building construction. There are visible signs of wear, corrosion and leaks at the valves. The function and ability to operate as designed is in question. Refer to Figure 44: Steam Condensate Piping (right).

This steam piping appears to be covered with insulation containing ACM's (asbestos containing materials). This insulation is in average shape for its age. There are some locations that insulation has been removed. This poses a safety concern for any maintenance personnel working in the vicinity of the exposed steam piping.

Recommendation/Comments

Due to the age the condensate piping smaller than 3 inch in size and all underground condensate piping is recommended to be replaced as it is near the end of its useful life. The steam traps should be replaced with new traps to allow for continued serviceability. Recommend that the owner survey and remove all ACM insulation.

Figure 43: Steam Trap Assembly at Zone Coil

Figure 44: Steam Condensate Piping

Condensate Receiver

Condition
Condensate receiver pumps the building steam condensate to the central condensate receiver located in an adjacent building. This condensate receiver and pump is original to the building construction. The system appears to be average condition for its age. The tank condition and lining is unknown due to it being buried. Facilities personnel did not note any performance issues or leaks with this pump or tank. Refer to Figure 45:Building Condensate Receiver (below).

Recommendation/Comments: The condensate pump unit is past its estimated service life of 15 years per ASHRAE guidelines. Consideration should be given to establishing a scheduled replacement plan for this condensate pump.

Figure 45: Building Condensate Receiver

Figure 46: Steam to Water Heat Exchangers

Steam to Water Heat Exchangers

Condition
The steam to water heating system consists of three steam to water heat exchangers. Refer to Figure 46: Steam to Water Heat Exchanger (above). The original plans show 5 heat exchangers, but due to failures 2 have been removed. Of the remaining heat exchangers, only one functions. This heat exchanger serves low temperature heating water to the remaining cloister passage in floor and finned tube radiation. The pump on the new zone was recently replaced.

Recommendation/Comments

The condensate receiver are in poor condition and should be replaced.

In-floor Radiation:

Condition

The main level of the Church utilizes in floor radiation. Refer to Figure 47: In-floor Heating Zones (right). This radiation is served from the heat exchangers and is divided into three zones. The piping from the heat exchangers is supplied through the lower level ceiling space to serve the in floor heating. The in floor heating piping has failed in all zones except for the East Cloister Passage. The piping has a leak, but due to the piping being contained within the concrete floor it is not possible to identify the location. The maintenance personnel have turned off all in floor radiation piping. Currently, all heating is via the air handling systems. This presents space conditioning issues as follows:

The Baptistry does not have sufficient air volume or distribution to properly heat this space without the in floor heat.

The South Cloister Passage has had finned tube radiation installed to attempt to heat the space. Since the pipe servicing this space is connected to a low temperature heat exchanger, the radiation does not provide enough heat to properly heat the space. This area was observed to attain temperature s in the 50 degree range during winter.

Recommendation/Comments

The in floor heating system has failed. Only one of the remaining zones is still active, but due to the condition and history of the remaining system the longevity for the system is suspect. The entire system should be replaced.

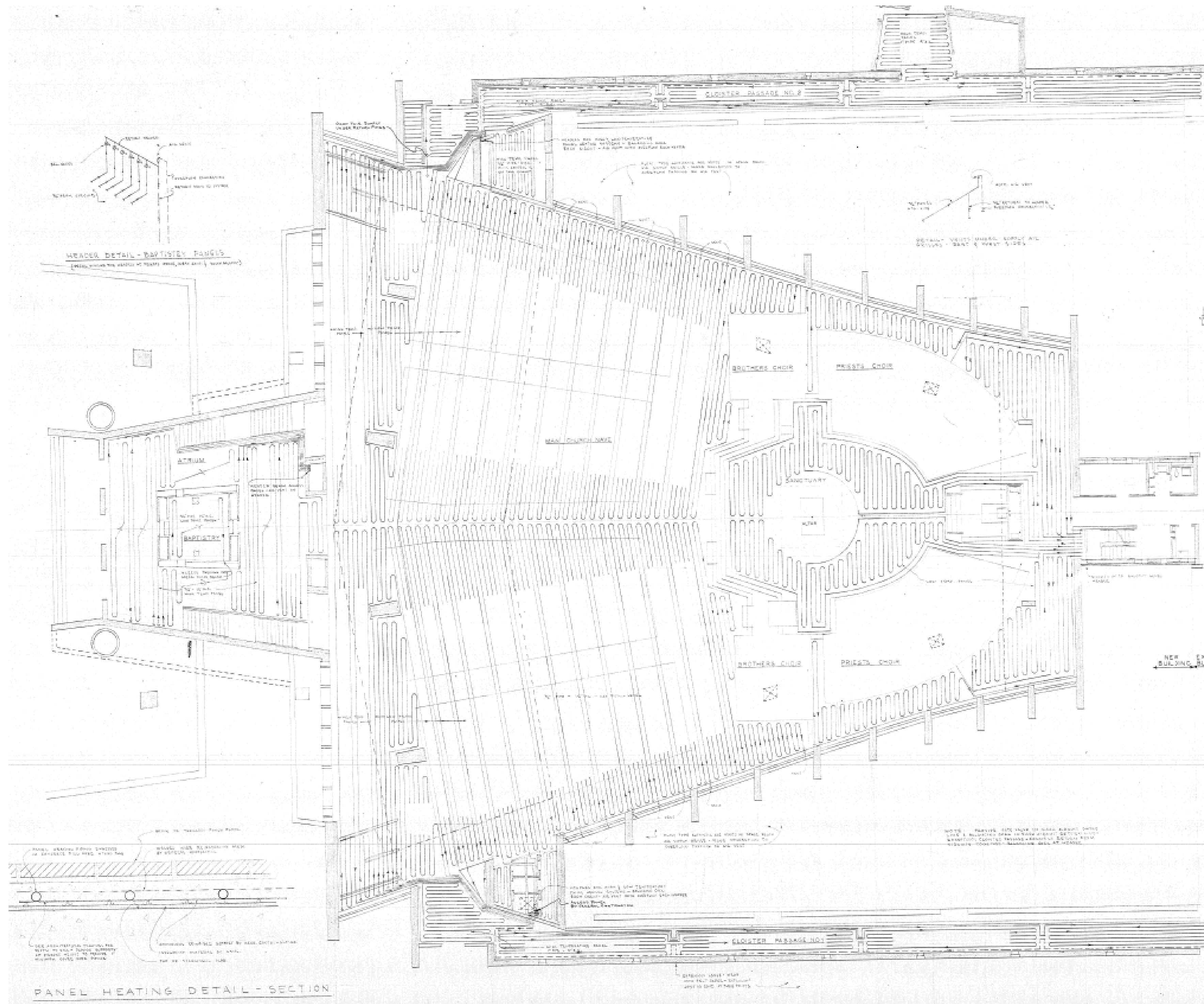


Figure 47: In-floor Heating Zones

BUILDING CONTROL SYSTEM

System Overview

The building utilizes pneumatic controls with an overlay of DDC/electric to allow connectivity to the campus main building automation system. The pneumatic controls are original to the building, installed in 1958.

Condition

A majority of the valve and operators are original to the building construction and are therefore over 50 years old. The damper operators are pneumatic.

Recommendation/Comments

There are two approaches used to quantify the expected remaining life of the pneumatic control system:

Approach #1 is to compare the existing equipment life against the published ASHRAE Estimates of Service Life table (Table 4, right).. This table is indicated on the preceding pages. Per this table, the control system unit is past its expected useful life.

Approach #2 is to compare the existing equipment life against actual data being collected by ASHRAE as indicated in Table #4. This chart indicates that the max age of other pneumatic control systems is over 55 years. Coincidently, that is the current age of this system.

With either approach, the control system is beyond its expected life. Consideration should be given to replacing the entire air handling unit as it will likely not last an additional 50 years. Pneumatic controls original to the building are recommended for replacement with direct digital controls and electric operators. To enhance occupant comfort, increase energy efficiency, and to better control, monitor, and trend each component, it is recommended to install a complete direct digital control building automation system which can connect seamlessly with the existing campus wide DDC building automation system.

		Currently in Service								Replaced						
	Total Units	No.of Units	Equipment Age (years)						No.of Units	Age at Removal (years)					
			Mean	Median	Std Dev	95% C.I.	Max	Min		Mean	Median	Std Dev	95% C.I.	Max	Min
Energy mgmt. system, all electronic components	101	77	12.5	11.0	7.0	1.6	37.0	5.0	24	22.1	18.0	16.3	6.5	69.0	8.0
Energy mgmt. system, all pneumatic components	20	19	16.2	17.0	7.2	3.2	28.0	6.0	1	11.0	11.0	n/a	n/a	11.0	11.0
Energy mgmt. system, direct digital controls	146	115	10.9	10.0	5.2	1.0	26.0	-6.0	31	24.7	25.0	13.4	4.7	52.0	4.0
Energy mgmt. system, hybrid system with elec./pneumatic components	133	101	13.6	13.0	5.3	1.0	26.0	3.0	32	16.7	14.0	11.7	4.1	48.0	1.0
Manual control	7	6	14.3	11.5	11.3	9.0	37.0	7.0	1	76.0	76.0	n/a	n/a	76.0	76.0
Pneumatic controls	19	19	35.0	37.0	7.7	3.8	51.0	17.0	0	n/a	n/a	n/a	n/a	n/a	n/a
Thermostats, electric	1	1	22.0	22.0	n/a	n/a	22.0	22.0	0	n/a	n/a	n/a	n/a	n/a	n/a
Time clock	18	16	9.3	4.0	10.5	10.3	25.0	4.0	2	20.0	20.0	n/a	n/a	20.0	20.0
Other control system	38	30	15.0	13.0	7.7	2.8	42.0	6.0	8	32.6	25.0	24.9	17.3	88.0	11.0

Table 4: Table of Controls life against ASHRAE

PLUMBING SYSTEMS

System Overview: The plumbing system consists of domestic distribution, storm sewer and sanitary sewer original to the building construction. There are limited plumbing fixtures located in the building. All water is served to this building from adjacent buildings. Existing plumbing piping located in the mechanical tunnels were observed to be capped. Further review is necessary to verify if any domestic water piping currently exists in this building.

Sanitary Sewer System Condition
The sanitary system piping appears original to the building construction. Facilities personnel have noted limited issues with the system. This system appear to constructed of cast iron with hub and spigot joints. This system does not receive high levels of acidic waste and there are no visible signs of wear. The waste branches that serve the janitor sinks may have experienced higher levels of exposure to chemicals and therefore may have been corroded over the years and are suspect.

Recommendation/Comments

Properly sized cast iron waste piping systems in a non-corrosive environment can have an expected service life in excess of 100 years. It is recommended that only the branch piping servicing janitor sinks or other potential chemical waste locations be replaced in the near future.

Storm Sewer Water System Condition
The storm sewer system consists of primary drains with scuppered overflow. The storm sewer piping system piping appears original to the building construction. Facilities personnel have not noted and issues with the system.

Recommendation/Comments

Properly sized cast iron waste piping systems in a non-corrosive environment can have an expected service life in excess of 100 years. Dunham recommends no modifications to the storm sewer system unless necessary for the forthcoming renovation.

FIRE PROTECTION SYSTEM

System Overview
The building does not have a fire protection system.

Figure 48 - Typical Panelboard Nameplate

4160 V Distribution System

System Overview
The campus is served by a university owned 4160V medium voltage distribution system. No 4160V distribution was observed in the Abbey Church; refer to the following section for building electrical feeder information.

Electrical Distribution Equipment

System Overview
The Church is fed via a 300A feeder rated at 208/120V from the Monastery. The main distribution cabinet for the building is located on the north side of the building on the first floor. From this location feeders are routed to adjacent panelboards, dimming panels, down to panelboards on the Crypt Level, up to panels on the second floor link level, and up to panelboards and dimming panels located in the truss space.

The vast majority of electrical equipment including panelboards, contactor cabinets, and distribution panels installed in Abbey Church are original to the 1957 construction. The majority of panelboards were manufactured by GE as shown in the nameplate shown in Figure 48 - Typical Panelboard Nameplate (preceding page, left).

Condition
The equipment is showing age after 50+ years, and there are some items that could make for unsafe conditions for people access spaces with electrical equipment. These unsafe conditions are as follows:

Main distribution panel has exposed live part and lugs of circuit breaker are exposed were conductors are landed on the circuit breakers. This is accessible by simply opening the panelboard cover. The room that this equipment is located in is accessible to many of the building users, because the camera equipment is located in this space; refer to Figure 49 - Distribution Cabinet (right).

Figure 49 - Distribution Cabinet

As shown in the photo, there are covers missing from the panelboard enclosure. This panelboard was not locked at the time of our site visit. During discussions with the facility staff it was noted that this also occurs elsewhere on campus.

- Another code related issue is the working clearance in front of electrical equipment. The required working clearance is 3 feet minimum required per NEC 110.26(A)(1). The working clearance is infringed on by mechanical piping that creates the capacitor bank that is installed on the ground at this location. Refer to Figure 50 - Working Clearance Violation and Figure 51 - Working Clearance Violation for illustration (right).

- In addition to the working clearance in front of the equipment, there is a condition where the dedicated electrical space requirements above and below panelboards, per NEC 110.26(E), is not being met. Refer to Figure 52 - Dedicated Electrical Space Above (net page, top left)and Figure 53 - Dedicated Electrical Space Below (next page, lower left).

Figure 50 - Working Clearance Violation

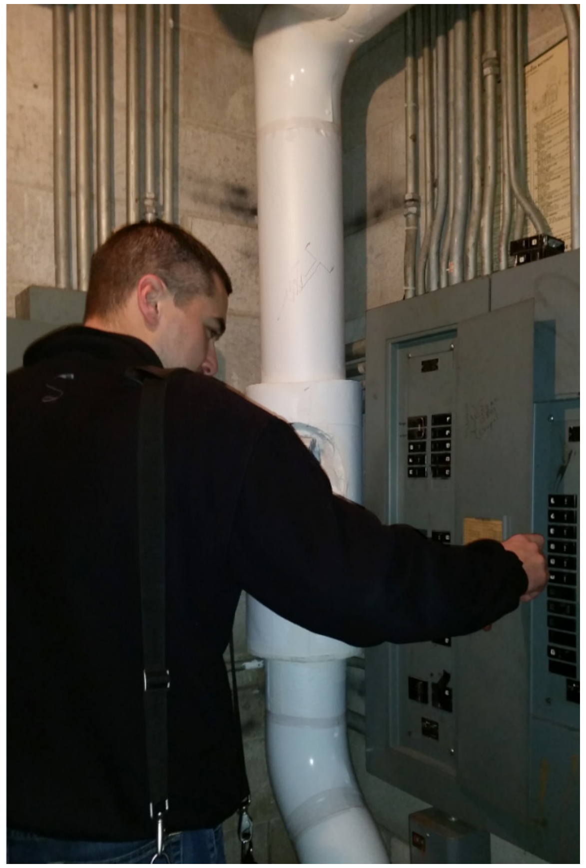


Figure 51 - Working Clearance Violation

Figure 52 - Dedicated Electrical Space Above

Figure 53 - Dedicated Electrical Space Below

Figure 54 - Conductors within Panel Enclosure

• In areas were panel covers were not fully intact or conductors were able to be observed it appeared that the conductor insulation on the feeders conductors was starting to deteriorate as the conductors are 50 plus years old. If insulation deterioration continues this could become a safety concern. Refer to Figure 54: Conductors within Panel Enclosure, preceding page).

• There were electrical boxes overserved in the building that do not have adequate free space within the box per NED 314. It was also observed that much of the electrical system is not sufficiently label which makes trouble shooting or rewiring very difficult; refer to Figure 55 - Trouble Shooting Existing Electrical System (below, left) and Figure 56 - Open Junction Boxes (below, center).

Where electrical panelboards and dimming panels are located in the truss space of the building there is a very efficient pathway and access to service lighting and branch circuit distribution from above. This allows for future flexibility to make accommodations while maintaining the architectural integrity of the building. Refer to Figure 57 - Panelboards in Truss Space (below, right) and Figure 58 - Truss Space Walkway (next page).

Figure 55 - Trouble Shooting Existing Electrical System

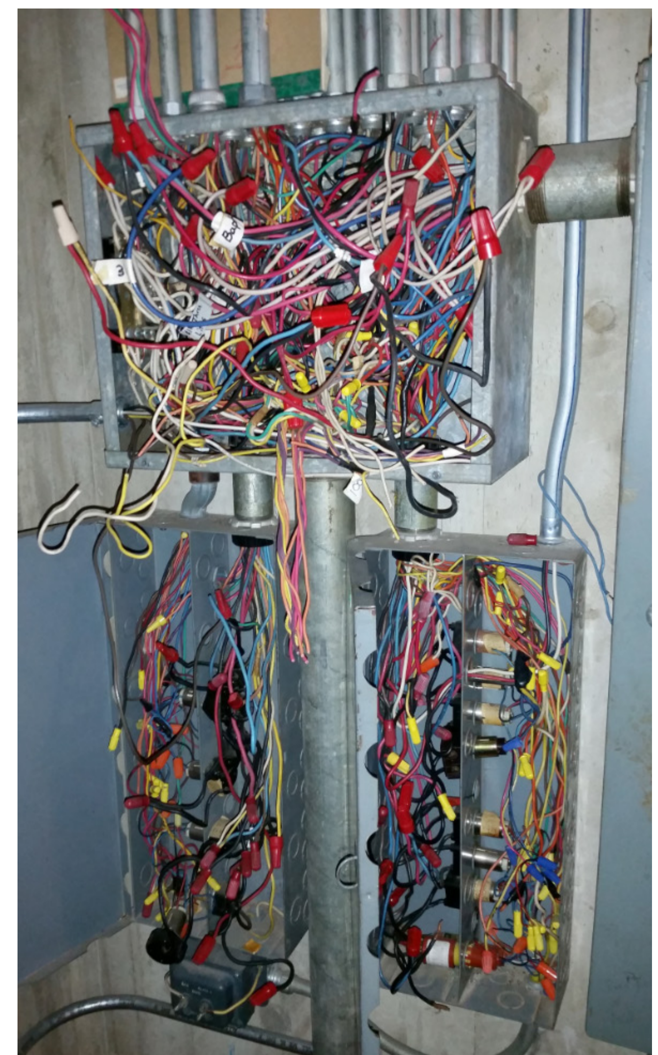


Figure 56 - Open Junction Boxes

Figure 57 - Panelboards in Truss Space

Figure 58 - Truss Space Walkway

Recommendation/Comments

General industry practice is that switches, panelboards, circuit breakers, and feeder conductors have a useful service life of 30 to 40 years. Service life depends on the performance of routine maintenance. Dunham Associates recommends maintaining electrical equipment in accordance with manufacturer recommendation and the InterNational Electrical Testing Association (NETA) Maintenance Testing Specification (MTS). Due to the quantity of items required for the facilities department to maintain on a regular basis, typically maintenance is not performed per the NETA specifications over the life of the equipment. Therefore, equipment manufactured in 1957 may need replacing.

Emergency Systems

System Overview

There were limited emergency systems observed. There appeared to be limited to no emergency egress lighting in the main Church. A small lighting battery inverter was observed in the south mechanical room on the Crypt Level as shown in Figure 59 - Lighting Battery Pack (next page, upper left).

Note: the batteries in this device were changed in 2008, and likely not able to maintain required output due to the age of the batteries. This condition has been observed on other universities were general maintenance on battery inverters is difficult for facility staff when managing multiple buildings.

Minimal exit signs were observed in the Church for directing occupants to the nearest exit. This is a major security concern due to the quantity of people that routinely occupy this building at one time, and if there were a power outage during an event the results may be detrimental to the safety of the occupants.

The Church is equipped with Emergency Call Buttons that initiate notification to Campus Security that an emergency event has occurred in the Church. This is a nice feature to have in the Church for added occupant safety, but the locations of the buttons are not very visible to the occupants and the signage is limited to approximately at 2" x 3" plate above the button as shown in Figure 60 – Emergency Call Button (next page, upper right).

Emergency System Condition

As previously described; the emergency systems within the Church are limited and the lack of emergency egress lighting is a major concern. The battery inverter system does not appear to be maintained based on the labeled dates that batteries were changed in the unit. There was no fire alarm system observed in the building.

Recommendation/Comments

Install an emergency distribution system from the generator system that feeds into the Lower Level of Alcuin Library. A new 4-pole open transition automatic transfer switch with associated 100A – 208/120V emergency panelboard and a 480V primary to 208/120V secondary 30kVA transformer is recommended for the Church. The existing generator that feeds into Alcuin Library is a diesel unit rated at 150kW – 277/480V. This generator serves as the emergency source for Alcuin Library and the Guest House.

Figure 59 - Lighting Battery Pack

Figure 60 – Emergency Call Button

LIGHTING SYSTEM

System Overview
The lighting within the church is very integrated into the architectural for the Church. Refer to Lighting section of this report produced by Schuler Shook for specific details. General observations are summarized below:

Light fixtures are integrated into the truss space and associable from the walkways in the truss space as shown in Figure 61 – Lighting from Truss Space and Figure 62 – Specialty Lighting from Truss Space (next page).

Figure 61 – Lighting from Truss Space

Figure 62 – Specialty Lighting from Truss Space

Figure 63 – Perimeter Uplight

Directional uplight is incorporated around the perimeter of the Church utilizing linear fluorescent source and spot style directional lights as shown.

Refer to image shown in Figure 65 – Parish Church Lighting (next page, upper left) for an example of lighting on the Crypt Level.

Lighting Controls

System Overview

The existing lighting controls in the Church include large switch banks, digital scene selection switches (refer to Figure 66 – Adjusting Lighting Levels in Church and Figure 67 – Scene Selector Switch, next page, right), contactors within panel enclosures (refer to Figure 68 – Contactors in Panelboard Enclosure, p. 304 upper left), wall box occupancy sensors or manual toggle switches.

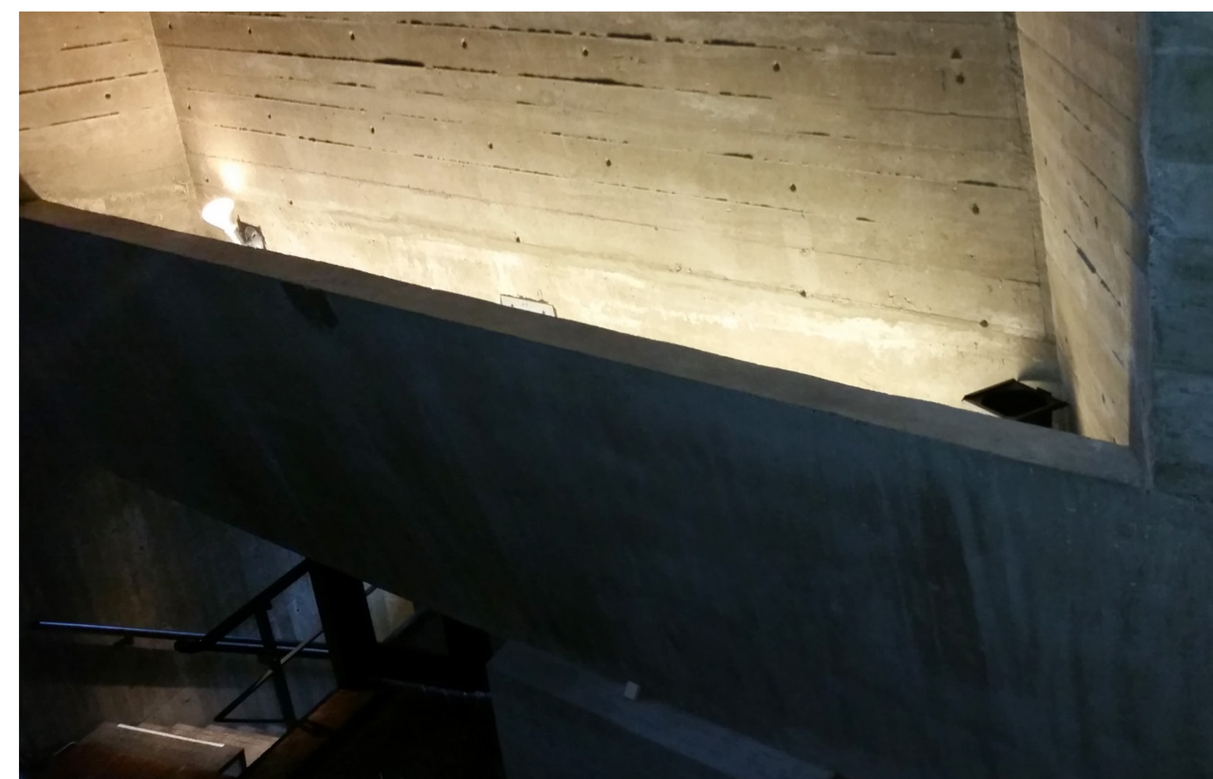


Figure 64 – Perimeter Uplight

Figure 65 – Parish Church Lighting

Figure 66 – Adjusting Lighting Levels in Church

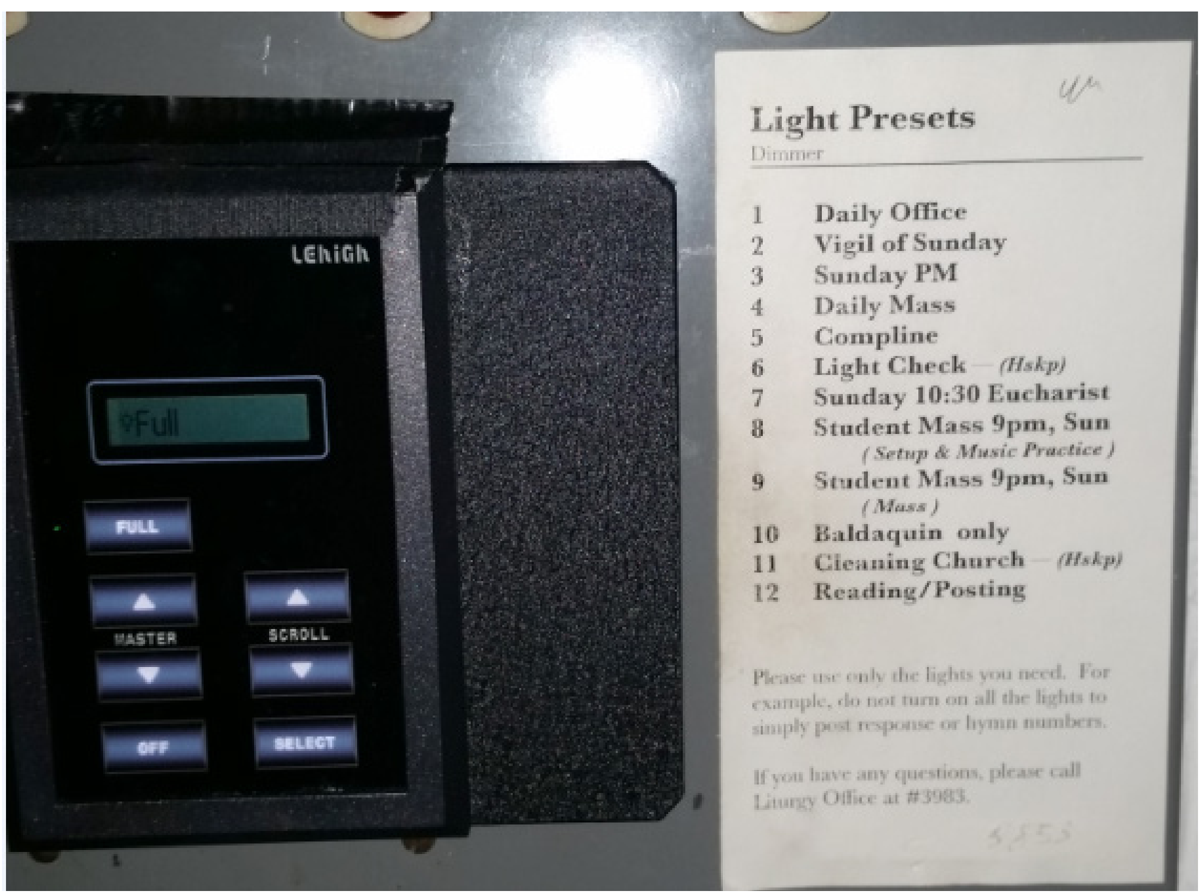


Figure 67 – Scene Selector Switch

Figure 68 – Contactors in Panelboard Enclosure

Condition

In general the lighting controls in the Church function for the occupants' needs, and staff members are able to adjust and control lights in the main Church to suit the needs of a particular event. It was observed that many areas outside of the main church or gathering areas that light switches were difficult to find, and you often walk through dark corridors to find a light switch.

Recommendation/Comments

As lighting fixtures are modified or upgraded the controls associated with new light sources should be upgraded to provide appropriate dimming controls for modern lighting sources.

WIRING DEVICES

System Overview

Wiring devices were incorporated into the architectural design of the building very well as shown in Figure 69 – Receptacle near Building Perimeter (below), Figure 70 – Receptacle in Balcony Area, (below) and Figure 71 – Floor Receptacle in Brother's Chapel (next page, upper left).

Figure 69 – Receptacle near Building Perimeter

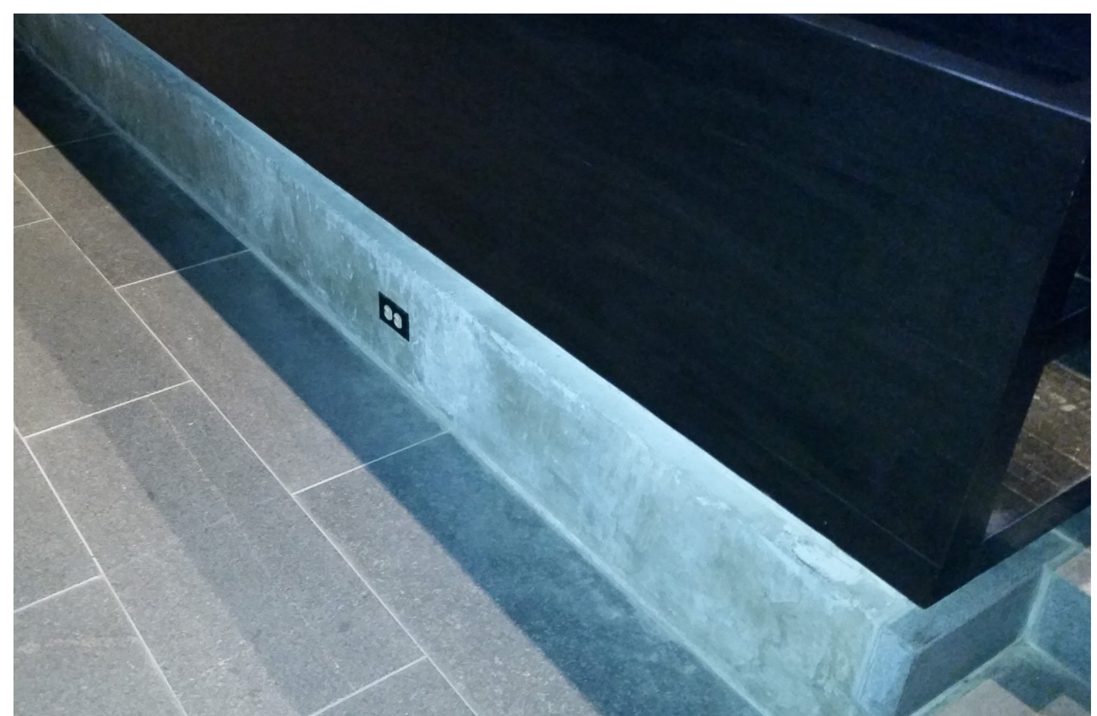


Figure 70 – Receptacle in Balcony Area

Figure 71 – Floor Receptacle in Brother's Chapel

The limitation to the wiring devices in the Church is the limited locations. At the time the Church was constructed there was not a need for the amount of receptacles that would be installed in this building if were constructed today. Examples of temporary fixes that the University has installed to remedy this situation are shown in Figure 72 – Surface Raceway in Main Entry of Church (below) and Figure 73 – Receptacle near Private Chapels (above right). These solutions include surface raceways to conceal extension cords to taping extension cords at the floor transition to the wall.

Figure 72 – Surface Raceway in Main Entry of Church

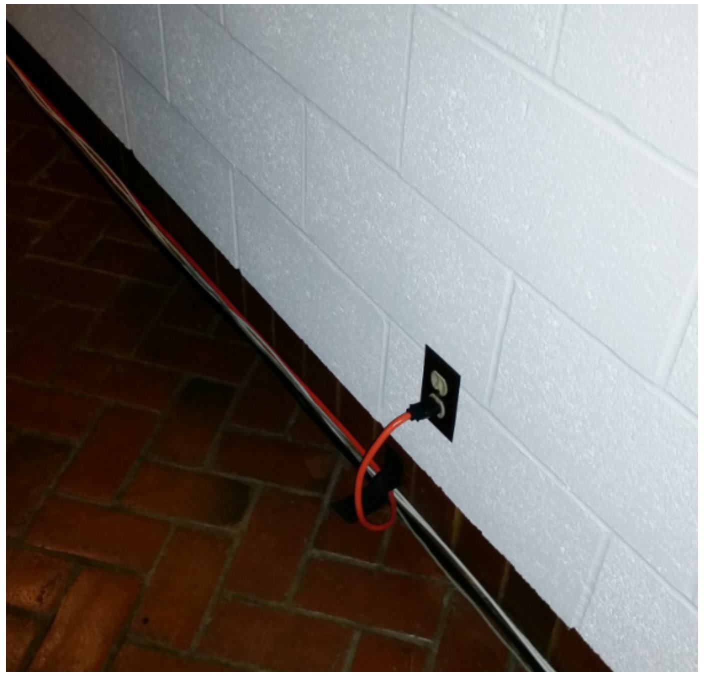


Figure 73 – Receptacle near Private Chapels

Condition

The location of electrical devices is very limited and based on input from the University Staff they would like to have additional devices located in various areas of the Church including in the Main Church by the Sanctuary, stairs leading up to Sanctuary, corridors, etc.

Recommendation/Comments

Add additional wiring devices to fit the needs of the Church today. This will be a challenge due to the limited existing pathways and the architectural elements of the Church that must be maintained.

A path that will be explored in greater detail during the next phase of this evaluation for routing conduit for branch circuiting is the tunnel that runs from the north entry area of the building to the south side of the Church below the Crypt Level as shown highlighted in red in Figure 74 – Sub-Floor Plan (next page).

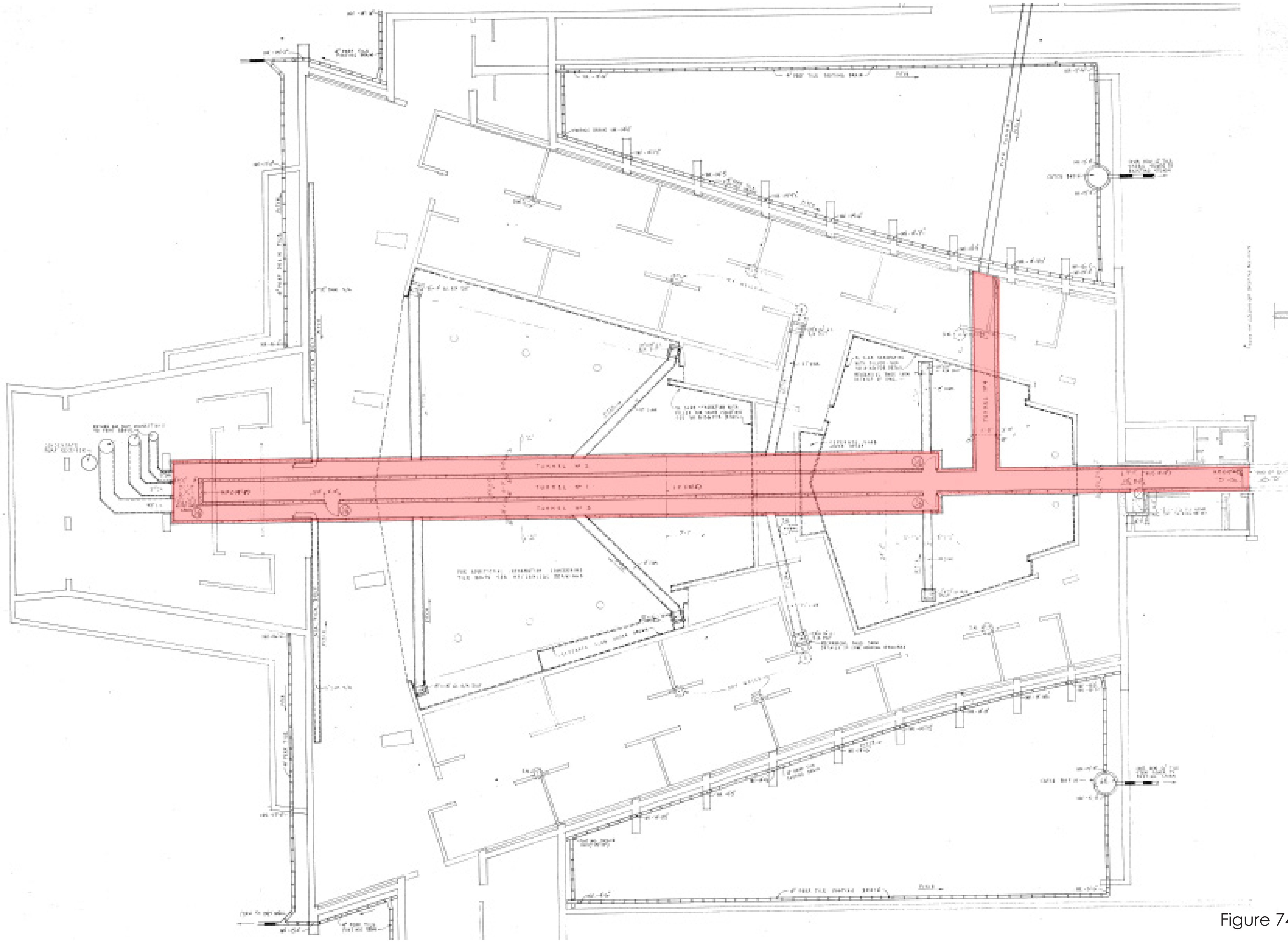


Figure 74 – Sub-Floor Plan

Figure 75 – Pipe Tunnel below Crypt Level

Figure 76 – Tunnel below Crypt Level

Images of the existing tunnel system are shown in Figure 75 – Pipe Tunnel below Crypt Level and Figure 76 – Tunnel below Crypt Level (above).

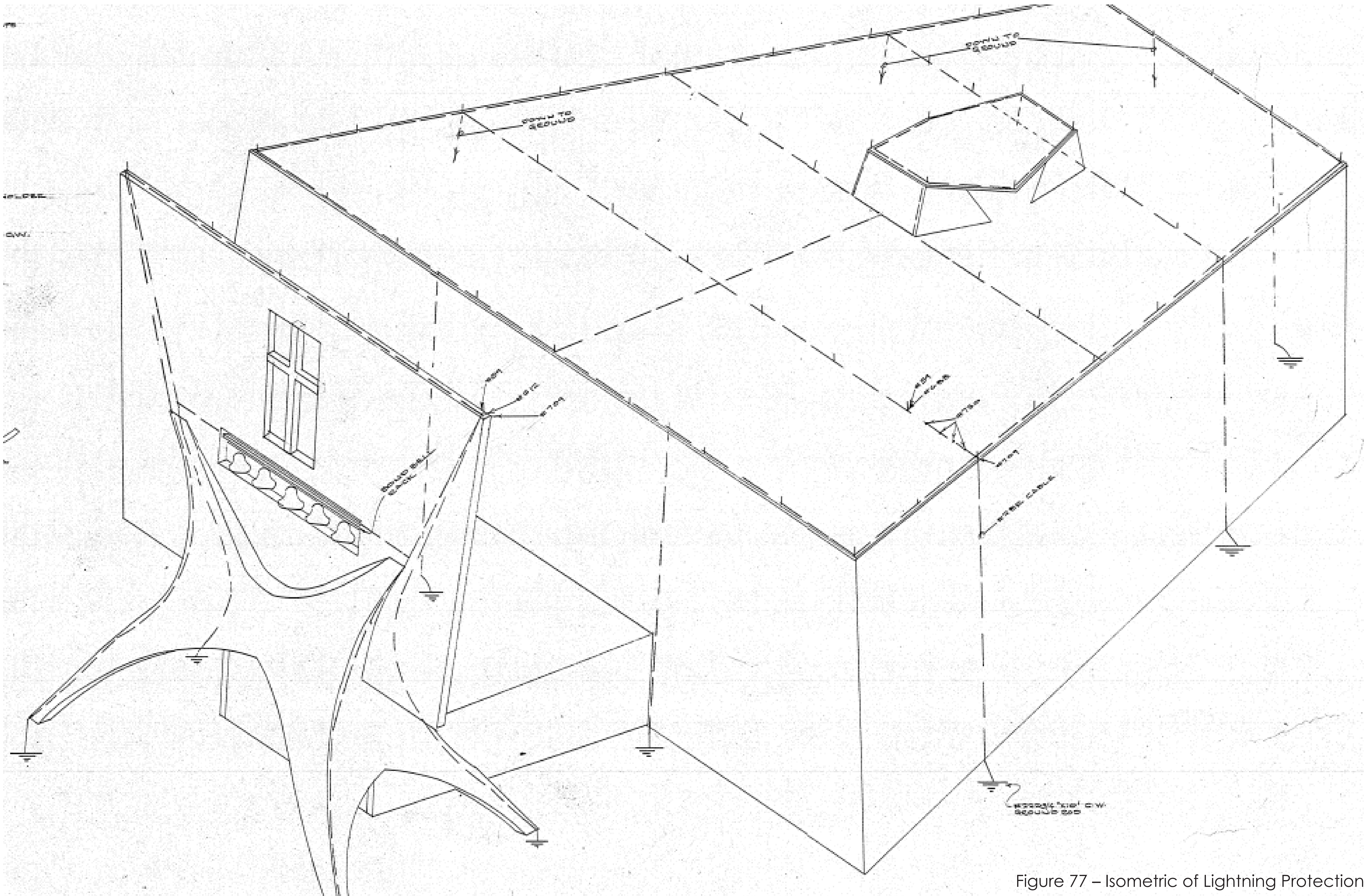


Figure 77 – Isometric of Lightning Protection System

LIGHTNING PROTECTION SYSTEM

System Overview

The building has an existing lightning protection system with air terminals and downleads that are integrated into the exterior architectural of the building masterfully. The installation of this system really took into account the nature of the main entry to the Church.

An isometric view of the building shown the bell banner and associated downleads to ground rods is shown in Figure 77 – Isometric of Lightning Protection System (previous page) for reference.

Some examples of integrating the lighting protection system into the building are shown in Figure 78 – Back Side of Bell Banner (below, right), Figure 79 – Download at Base of Bell Banner (below, left), and Figure 80 – Exterior Elevation of Church (next page).

Figure 78 – Back Side of Bell Banner

Figure 79 – Downlead at Base of Bell Banner

Condition
The existing system has been tested in the past for integrity and continuity. Based on visual inspection from the ground the system appears to be intact and functioning as intended.

Recommendation/Comments

Due to the complexities of testing this system, it is recommended that a certified testing agency review this installation to determine if the lightning protection system is compliant with the latest standards. If the system is deemed acceptable there are no recommended modifications, but if the system is not intact it is recommended that additional downleads, air terminals, ground rods, and connections be replaced.

FIRE ALARM SYSTEM

System Overview
There is no fire alarm system present in the Church at this time. As noted in the fire protection system description there is no sprinkler system in the Church either.

The adjacent Monastery building has and EST fire alarm system that has been upgraded since the original construction of the Abbey Church and the Monastery.

Recommendation/Comments

A fire alarm system is recommended for a building of this type and occupancy, but as directed from the University a new fire alarm system will not be evaluated at this time.

COMMUNICATION SYSTEMS

Communication System, Communication Devices and Wireless Access System

System Overview
The voice and data communication systems are limited in the Church due to the typical nature of the Church. It did not appear that the users or the University desires to add extensive additional communication equipment. There was no wireless access system present in the building.

Figure 80 – Exterior Elevation of Church

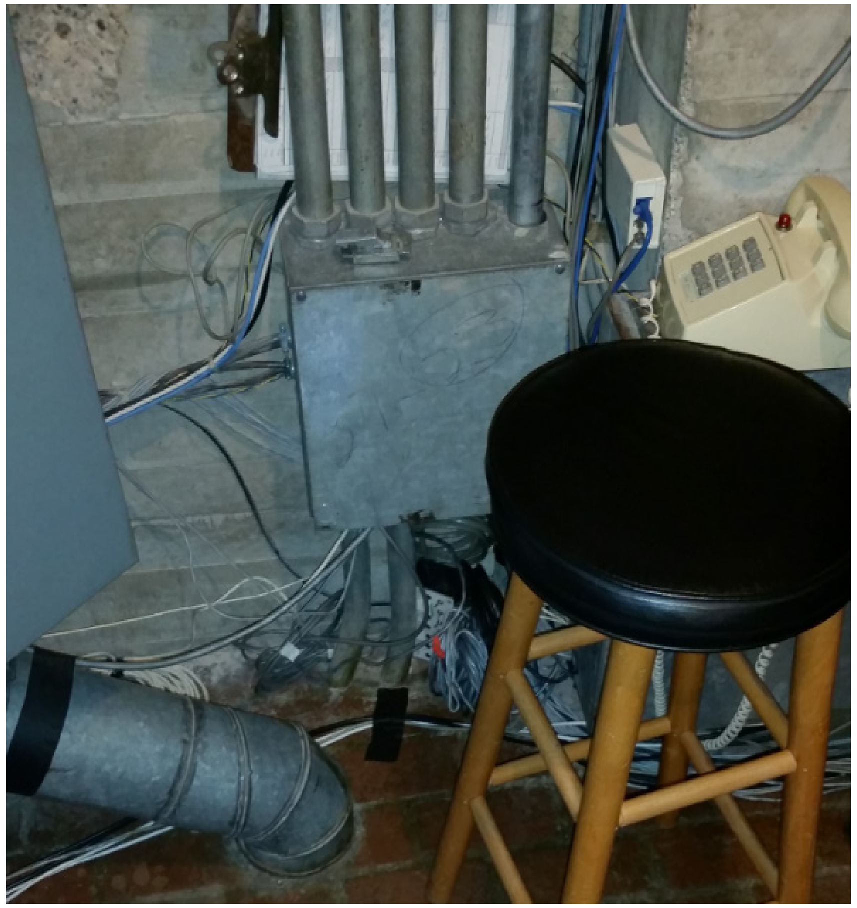


Figure 81 – Exposed Communication Cabling

Where communication cabling was observed much of the cabling was exposed as shown in Figure 81 – Exposed Communication Cabling (above).

Recommendation/Comments

Add minimal voice and data devices to suit the needs to the Church today. Device will be limited to computer jacks or wall phone connections were desired.

PA / Sound System

System Overview
There are multiple sound systems located in the building. The majority of the systems were installed about 25 years ago. The main level of the Main Church has speakers mounted below the seating area that work well for the occupants in this area. An image of the speaker is shown in Figure 82 – Speaker in Main Level Church, and the wiring to the speaker is shown in Figure 83 – Speaker Wiring in Main Level Church (next page, upper right).

Figure 83 – Speaker Wiring in Main Level Church

The main headend sound system equipment is located on the south side of the building on the Main Level. Images of the equipment are shown in Figure 84 – Headend Sound Equipment (right, above) and Figure 85 – Headend Sound Equipment (right, below).

The balcony speakers have been turned off due to echoing as seen in Figure 86 – Sign Regarding Balcony Speakers (next page, upper left). The sound quality on the balcony is poor due to the surfaces in the building and the distance from the speakers as seen in Figure 87 – Speakers Located in Truss Space (next page, upper right).

Condition
The sound system in the building is marginal and showing its age. The issues with the balcony system were previously discuss, and it should be noted that the sound system in the Parish Church is very loud and there is limited adjustments that users can make on the system.

Recommendation/Comments

It is recommended that all speakers and associated cabling and equipment be removed during the renovation. The quality requirements that you would expect for a Church of this nature require a modern sound system.

Figure 84 – Headend Sound Equipment

Figure 85 – Headend Sound Equipment

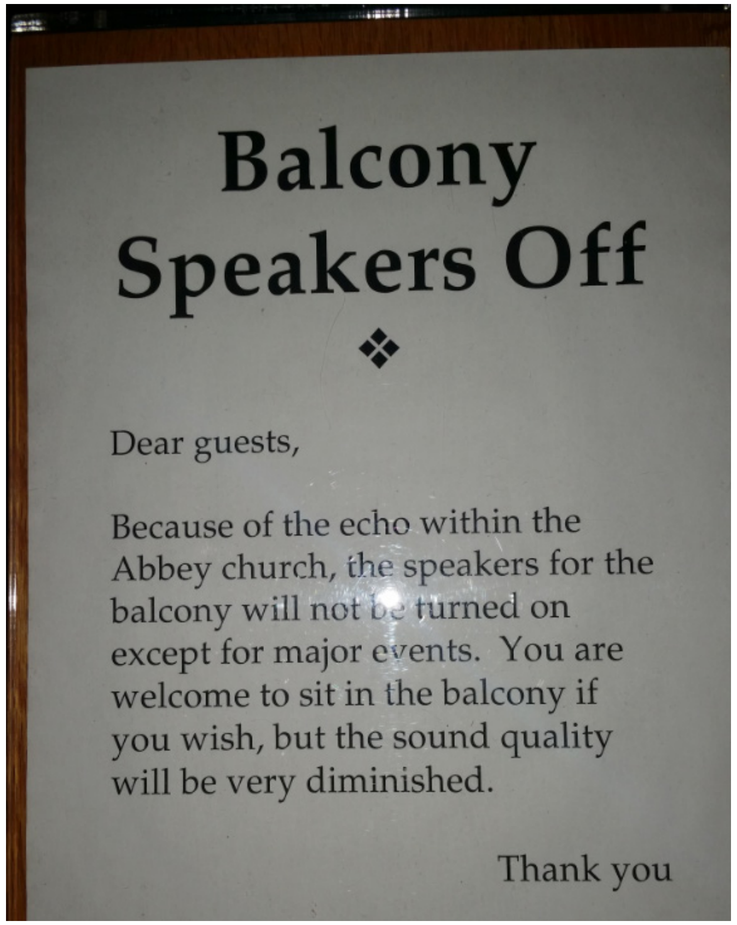


Figure 86 – Sign Regarding Balcony Speakers

Figure 87 – Speakers Located in Truss Space

Audio Visual Systems – Video Recording System

System Overview
The existing video recording system in the Church was recently upgraded in 2015. The Church has three high definition cameras that allow them to broadcast events as they occur. Two cameras are located on the face of the north balcony, and one camera is located on the south side of the Sanctuary. An example of a typical camera is shown in Figure 88 – Speakers Located in Truss Space (next page, upper left).

The headend equipment for this system is located in the electrical equipment room on the south side of the building. The headend equipment is shown in Figure 89 – Headend Camera Equipment (next page, lower left), Figure 90 – Users Adjusting Cameras (next page, upper right), and Figure 91 – Camera Control Board (next page, lower right).

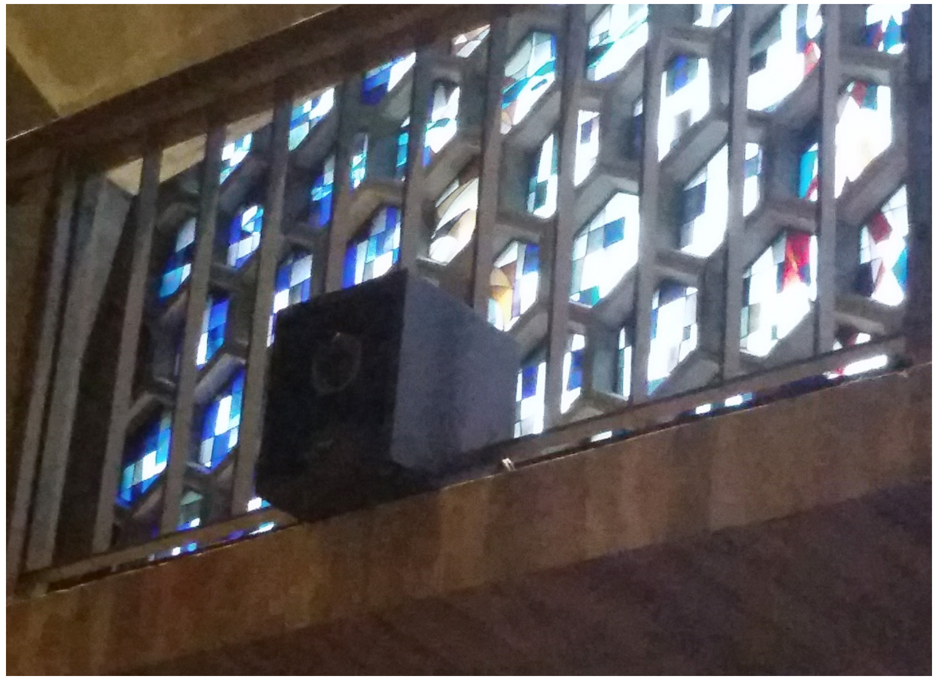


Figure 88 – Speakers Located in Truss Space

Figure 89 – Headend Camera Equipment

Figure 90 – Users Adjusting Cameras

Figure 91 – Camera Control Board

Figure 92 – Exposed Camera Cabling

Condition
The camera system is in great condition, and this system gives the University the capabilities to broadcast any events that occur in the Main Church. The only modifications recommended for this system is to conceal exposed cabling to the camera on the Balcony Level. Cables were not able to be pulled through the existing pipe that was recessed in concrete to the camera location, refer to Figure 92 – Exposed Camera Cabling (above) for exposed cabling image.

Recommendation/Comments

No future equipment modifications required for camera system. During the next phase of this documentation alternate cabling paths will be explored in an attempt to conceal exposed camera cabling.

ACCESS CONTROL AND SECURITY SYSTEMS

Access Control

System Overview
Minimal access control systems were observed in the building. No card readers were present.

Recommendation/Comments

Further review is required to determine the extent of access control that would be desired on the Church during the upcoming phase of this documentation.

Security Camera System

System Overview
No security cameras were observed during site observation of the Abbey Church.

Recommendation/Comments

Further review is required to determine the extent of security camera requirements that would be desired in the Church during the upcoming phase of this documentation.

REFERENCES

ASHRAE (2003), 2003 ASHRAE Handbook; HVAC Applications Chapter 36, Atlanta.

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Life Expectancies of Electrical Equipment by the US Department of Energy and US Department of Interior Bureau of Reclamation