**Wiss, Janney, Elstner Associates, Inc.**
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Pittsburgh, Pennsylvania 15212
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October 14, 2022

Nick Lardas
St. Nicholas Greek Orthodox Cathedral
416 South Dithridge Street
Pittsburgh, PA 15213

## Sanctuary Plaster Ceiling Collapse - Close-Range Evaluation

St. Nicholas Greek Orthodox Cathedral, 416 S. Dithridge Street, Pittsburgh, Pennsylvania
WJE No. 2022.5007

Dear Mr. Lardas:

At your request, Wiss, Janney, Elstner Associates, Inc. (WJE) visited the St. Nicholas Greek Orthodox Cathedral located at 416 South Dithridge Street in Pittsburgh, Pennsylvania, to perform additional evaluation of the sanctuary ceiling. This evaluation follows the collapse of a portion of the plaster ceiling that occurred in the cathedral's sanctuary on July 24, 2022, and a subsequent visual survey by WJE from the ground using a telephoto lens, as described in our letter dated September 16, 2022.

### BUILDING DESCRIPTION

St. Nicholas Greek Orthodox Cathedral is a two-story limestone structure built circa 1906 in the Classical architectural style. The primary roof structure of the sanctuary consists of steel and heavy timber trusses that span the sanctuary along with supplemental wood and steel framing members. The ceiling is coffered and consists of 3/8-inch-thick wood lath with a three-coat plaster. Deep coffer beams run below the trusses, and shallow coffer beams further divide the ceiling into bays (Figure 1). Plaster ornamentation is present in the coffer bays and around the dome.

In 1958, a plaster dome was constructed over the center of the sanctuary. Multiple minor renovations were completed in the late 1990s, including making openings in the plaster ceiling to accommodate lighting and mechanical ventilation systems. We understand the installation of the existing recessed lights occurred prior to the installation of the mechanical systems in 1999, but exact dates are unknown.

Steel trusses are present at the deep coffer beams running north-south across the sanctuary. Heavy timber trusses are present at the deep coffer beams running east-west across the sanctuary and frame into the steel trusses. Four additional timber trusses also frame the dome constructed at the center of the sanctuary. Nominal 2x wood joist framing, typically spaced at 16 inches on center, spans between the trusses as well as to the exterior masonry walls.

The lath (and plaster) making up the ceiling surfaces is nailed to the wood joists. As is typical for a plaster assembly of this type, at original installation, the plaster was pushed through the gaps between the lath to create mechanical engagement between the plaster and lath. The portion of the plaster that extends above and around the lath is called a key. The plaster at the coffer beams below the trusses is constructed with a combination of wood and metal lath. It appears that metal lath was used at the angled and curved

decorative areas of the beams, and wood lath was used at the flat surfaces. The application and anchorage method for the decorative features in the sanctuary such as the decorative wreaths present in some bays are unknown; however, cast plaster features of the general type present at the sanctuary ceiling were often adhered to plaster systems as ornamentation. The plaster at the exterior walls is applied directly to the masonry construction.

Gypsum board (drywall) was observed in multiple locations from the attic. At the four corner coffer bays over the main sanctuary (Bays N1, N4, S1, and S4), areas of plaster were cut away during the previous installation of mechanical equipment at ceiling penetrations. The plaster and lath in these areas was then replaced with drywall panels to fill in the gap between the original plaster and the new mechanical item. At the four bays to the north and south of the dome (Bays N2, N3, S2, and S3), it appears that drywall was installed on top of the plaster and lath around the recessed lights at the center of the bays.

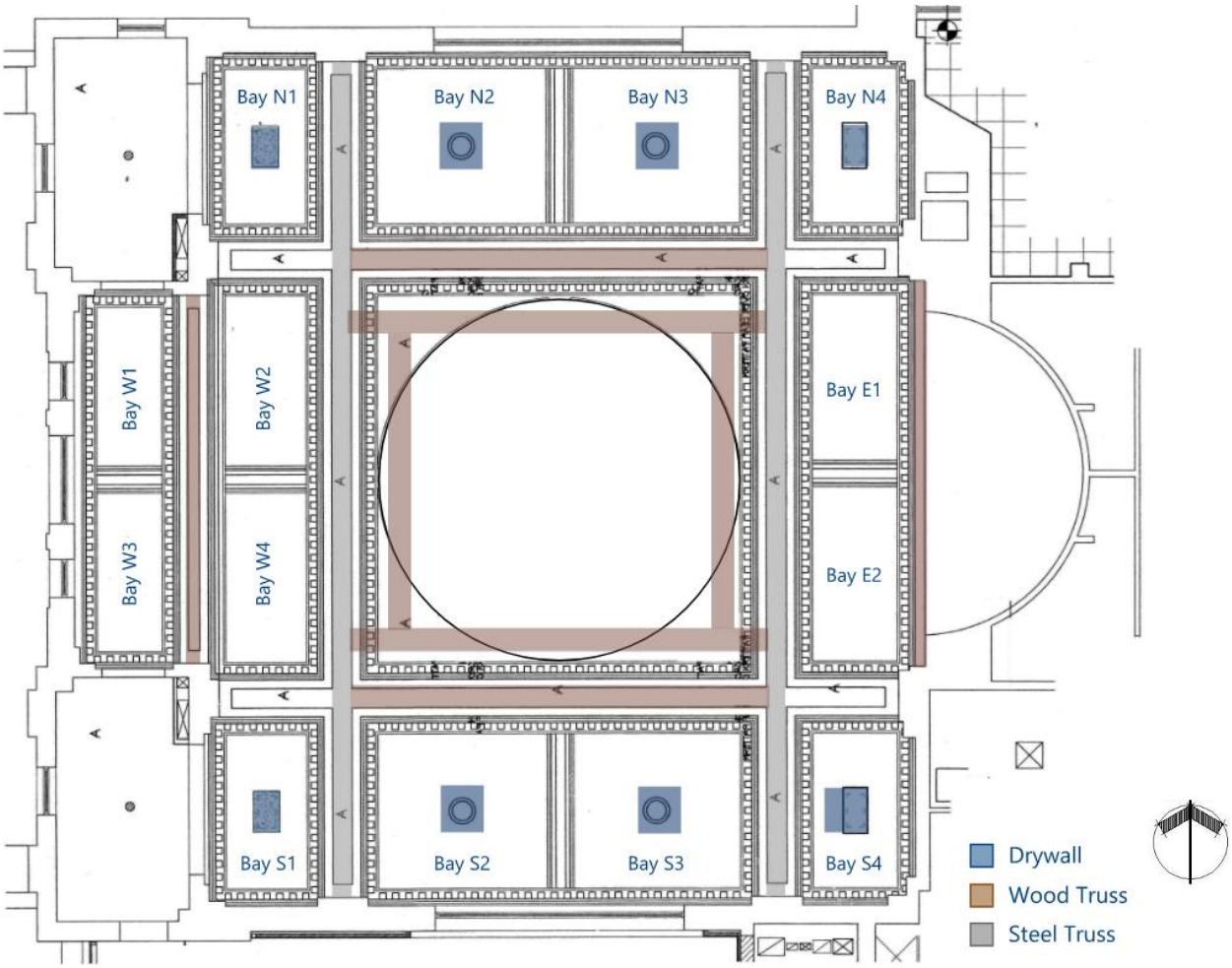



Figure 1. Reflected sanctuary ceiling plan showing locations of trusses and drywall observed from the attic level. (Drawing excerpt provided by St. Nicholas Greek Orthodox Cathedral).

## PROJECT BACKGROUND

WJE was asked to provide an opinion regarding the cause of the collapse, an evaluation of the general condition of the plaster, and recommendations for further evaluation and/or repair. Our visual review of the ceiling indicated that there were other areas of plaster that remained at risk of failure similar to the materials that fell on July 24, 2022; therefore, we recommended that the sanctuary remain closed until a more extensive survey and repair/stabilization work can be completed.

WJE issued a report on September 16, 2022, summarizing our findings from our initial inspections of the plaster ceiling from the ground and from the attic on July 26 and August 8, 2022. In that report, WJE provided recommendations for further evaluation as well as conceptual plaster repairs. Per our recommendations, scaffolding was erected in the cathedral sanctuary to provide access for an inspection of the entire plaster ceiling at close range. The purpose of this inspection was to identify additional areas of unstable plaster not previously apparent from the telephoto visual survey.

## OBSERVATIONS

WJE visited the site on October 5 and 6, 2022, to review the condition of the plaster sanctuary ceiling at close-range from the erected scaffolding and from the attic. The following summarizes the pertinent observations from all of WJE's site visits and incorporates portions of our previous report:

- An area of wood lath was exposed where plaster dislodged and fell at the south aisle, Bay S2 (Figure 3 and Figure 4). The failure area extends between a light and mechanical opening (Figure 5 and Figure 6). Batt insulation fragments in the attic around the failure area were dry, and no evidence of moisture issues (wet materials, water stains) was observed around the failure area either from below or in the attic (Figure 7).
- Plaster fragments (Figure 8) were found to be dry and brittle, with fibrous materials (Figure 9). We also noted evidence of top-side soiling in some locations on the fallen plaster fragments, indicating that the plaster was had likely debonded from the wood lath for some time prior to the failure (Figure 10).
- The plaster keys appear to have fractured near the bottom surface of the lath (Figure 11). Some plaster was able to be removed by hand from above the lath (in the attic) at broken key locations. Such conditions were observed at the south aisle collapse area and near light penetrations at other non-collapse locations, all with consistent fracture planes located at the underside of the lath.
- Areas of delaminated plaster were observed at the coffer bays, concentrated in the bays to the north and south of the dome (refer to Figure 2). The delaminated areas are larger and more heavily concentrated along the south bays.
  - An area of delaminated plaster is present in Bay N3 (Figure 12). The plaster has visible displacement at this location, with an offset of up to 1/8 inch in the plaster across a crack along the length of the delaminated area (Figure 13). Broken keys were observed in this area from the attic.
  - An area of delaminated plaster is present in Bay S3 (Figure 14). The plaster was observed to be cracked and sagged downward at a location between penetrations in the ceiling above the south pew section and aisle. Broken keys were observed in this area from the attic.

  - Additional areas of delaminated plaster were identified where no sagging was observed and no offset was visible across the crack. The delamination was apparent because the cracks closed when upward pressure was applied to the plaster around the cracks.
- Widespread cracking of varied widths was observed in the plaster (Figure 2).
  - The largest cracks occur within the bays and typically propagate from and span between penetrations through the plaster (recessed lights and mechanical ventilation equipment).
  - Cracks in the plaster at the coffer beams are typically hairline (less than 0.01 inch) and occur at regular intervals on the vertical faces of the beams (Figure 15).
  - Short hairline cracks radiate out from recessed light penetrations through the plaster at multiple locations.
  - Cracks were observed in the large decorative wreath around the perimeter of the dome (Figure 16).

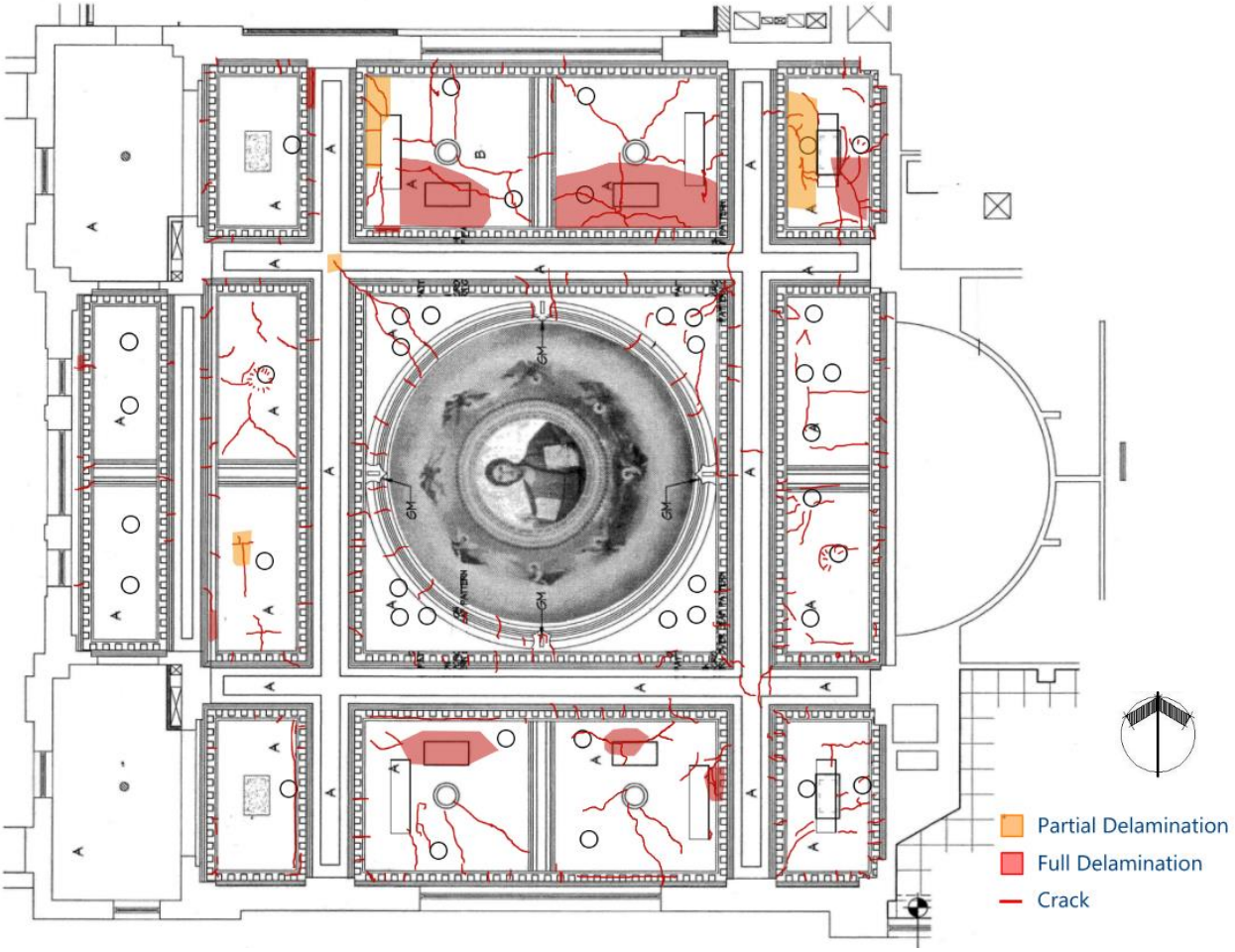



Figure 2. Reflected sanctuary ceiling plan showing locations of cracks and delaminated plaster. (Drawing excerpt provided by St. Nicholas Greek Orthodox Cathedral).

- WJE observed peeling paint coatings in multiple locations (Figure 17 and Figure 18). This condition was typical on both the horizontal ceiling surfaces as well as the vertical surfaces of the coffer beams.

## DISCUSSION

Gypsum plaster from the early twentieth century was typically a three-coat system. The first coat or "scratch coat" is composed of gypsum mixed with aggregate such as sand and often also contains reinforcing fibers such as plant fibers or animal hair. The scratch coat is typically applied to wood or metal lath. The support for plaster relies on the mechanical keying of the plaster into the spaces between lath strips. When wood lath is used, the plaster is also partially supported by adhesion to the wood, although this adhesion tends to decrease over time.

The second coat or "brown coat" is applied to the scratch coat and brings the plaster to the desired profile and configuration. Typically, the brown coat also consists of gypsum mixed with sand. The third coat is the finish coat, typically composed of gypsum blended with lime, and is applied to provide a hard and smooth finish which is then coated. Cast decorative details composed of gypsum plaster are often adhered to plaster systems as ornamentation.

Common failure mechanisms for gypsum-based plasters are often moisture related. Gypsum plasters cure relatively quickly and are hard and durable; however, gypsum is generally water soluble, and, if exposed to water, the binder can expand and dissolve. Furthermore, when exposed to moisture, the supporting wood lath may swell and cause loss of integrity of the system through the expansion and contraction of the lath within the plaster.

During WJE's inspection at St. Nicholas Greek Orthodox Cathedral, no evidence of water infiltration or condensation was observed in the attic space above the plaster ceiling, neither at the area of fallen plaster, nor at other areas where plaster distress was observed. Based on these observations, we believe it is unlikely that the plaster collapse was caused by recent saturation of the plaster or lath.

Another potential failure mechanism is cracking and debonding of the plaster due to impact or vibration that damages the plaster keys. Lath movement can be due to internal pressure from humidity changes, corrosion of fasteners, or from movement of the frame to which the lath is attached. Lath movement and breakage of plaster keys can also be due to external pressure from heavy loads; from transitory loading, impact, or vibration during construction; or from maintenance personnel or others impacting the plaster.

Based on our observations, experience with previous plaster failures, and the known history of work on the building, we believe a possible cause of displacement of the plaster is movement of the lath and plaster caused by construction activities to create holes in the plaster ceiling for lighting and mechanical equipment. The construction activities resulted in breakage of the plaster keys which support the ceiling. This opinion is supported by similar plaster cracking and displacement observed next to penetration locations other than the collapsed plaster.

It is probable that plaster failure initiated at the underside of the lath near the penetrations during construction. Plaster did not dislodge initially because of adjacent load sharing. In addition, there was likely a limited amount of adhesion between the plaster and the wood lath that remained when the keys were broken, although this adhesion is not reliable in the long term. Over time, normal thermal and

moisture cycles as well as mechanical vibrations likely induced stress on the displaced areas, causing the extent of fractured materials to increase. Once the fractured/damaged area was large enough, adjacent materials could no longer support the underside plaster.

## RECOMMENDATIONS

In addition to the portion of the plaster ceiling that fell in July 2022, there are other areas of the ceiling with cracking and apparent displacement that are at risk of a similar failure. Based on observations from our close-range inspection, the most apparent risk of dislodged plaster is located along the north and south coffer bays above the pews and aisles, particularly near recessed light and mechanical penetrations. In addition, the widespread cracks in the plaster have the potential to develop into additional delaminated areas.

WJE recommends removal and replacement of fully delaminated plaster, stabilization of the remainder of the plaster ceiling using button washers at regular intervals, and crack repairs (depending upon the width of the crack) as shown in the attached repair sketches. Following plaster repairs, the ceiling should be primed and painted. As part of this work, areas of delaminated or marginally adhered paint should be removed by sanding or scraping prior to repainting.

The significance of the cracks observed at the ornamental plaster "wreath" trim around the base of the dome is uncertain at this time. Additional investigation is recommended to determine the existing means of support for this molded trim and if supplemental anchorage or other repair is required.

## CLOSING

Thank you for the opportunity to conduct this investigation for the St. Nicholas Greek Orthodox Cathedral. Please feel free to contact us with any questions you may have.

Sincerely,

**WISS, JANNEY, ELSTNER ASSOCIATES, INC.**

Jamie M. Hudson
Project Associate

Phillip T. Elgin, PE
Associate Principal and Project Manager

Figure 3. Area of plaster failure; viewed looking toward south wall of sanctuary (Bay N2).

Figure 4. Fallen plaster at the south aisle.

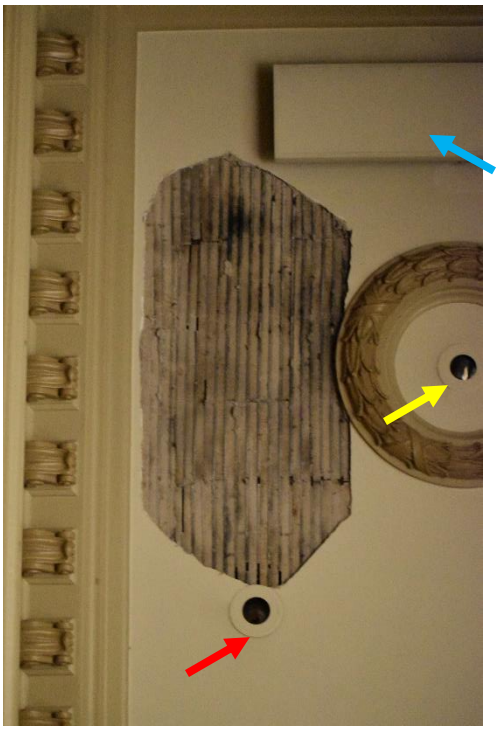


Figure 5. Area of plaster failure, looking overhead (Bay S2). West is oriented up.

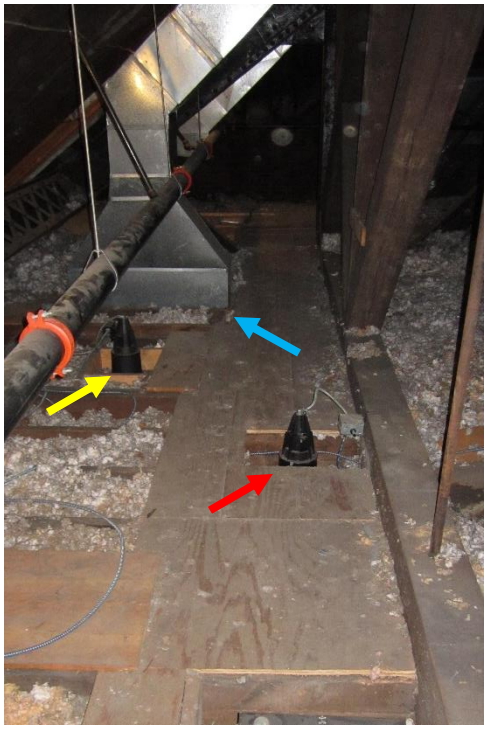


Figure 6. Area above plaster failure, in attic, looking west.

Figure 7. Light adjacent to failure area with no evidence of moisture.

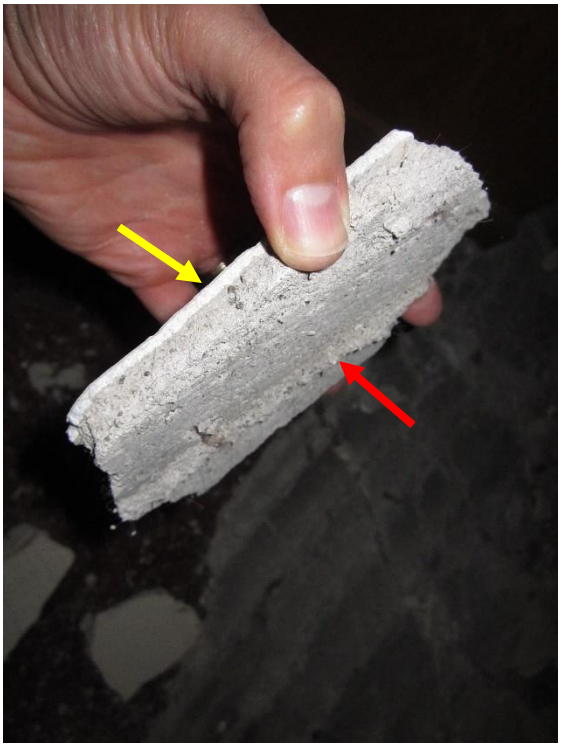


Figure 8. View of side of fallen plaster, the underside (exposed ceiling) is indicated with a yellow arrow. The fracture plane is indicated with a red arrow.

Figure 9. Fibrous material, likely plant fibers, in plaster.

Figure 10. Fallen plaster with evidence of top-side soiling (darker areas), indicating previous debonding between the plaster and the wood lath.

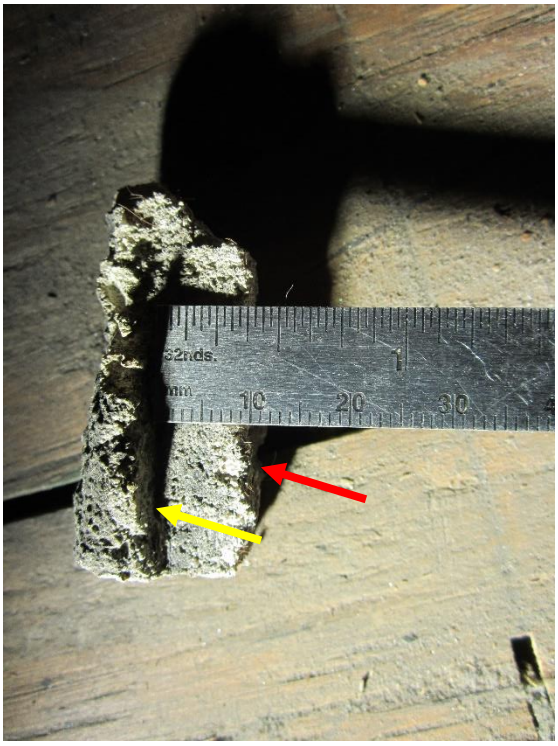



Figure 11. Fragment of broken plaster key removed from the attic side of the wood lath. The yellow arrow shows the plaster interface with the topside of the wood lath. The red arrow shows the fracture plane below the lath.

Figure 12. Cracked and bowed plaster at the north aisle (Bay N3).

Figure 13. 1/8-inch offset across crack at delaminated area of plaster in Bay N3.

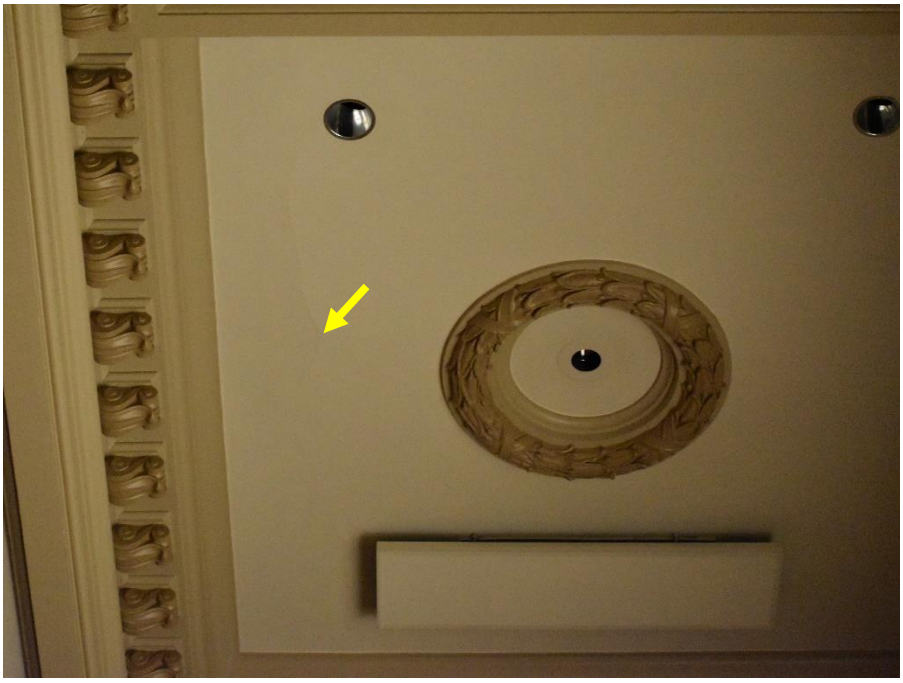


Figure 14. Cracked and bowed plaster at the south aisle (Bay S3).

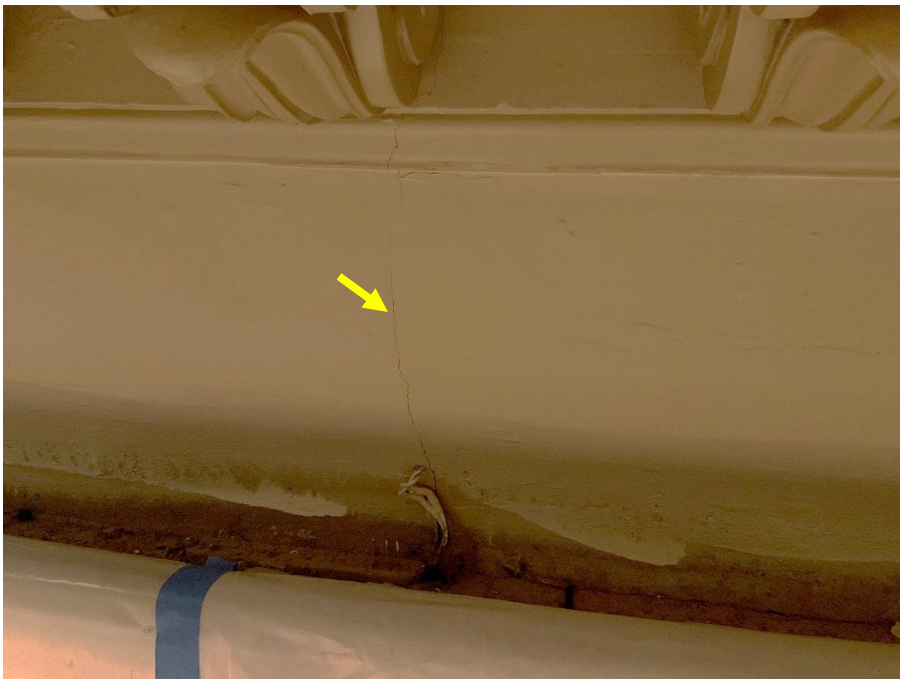


Figure 15. Hairline crack at vertical face of coffer beam (Bay W3). Multiple similar conditions were observed at the coffer beams at regular intervals.

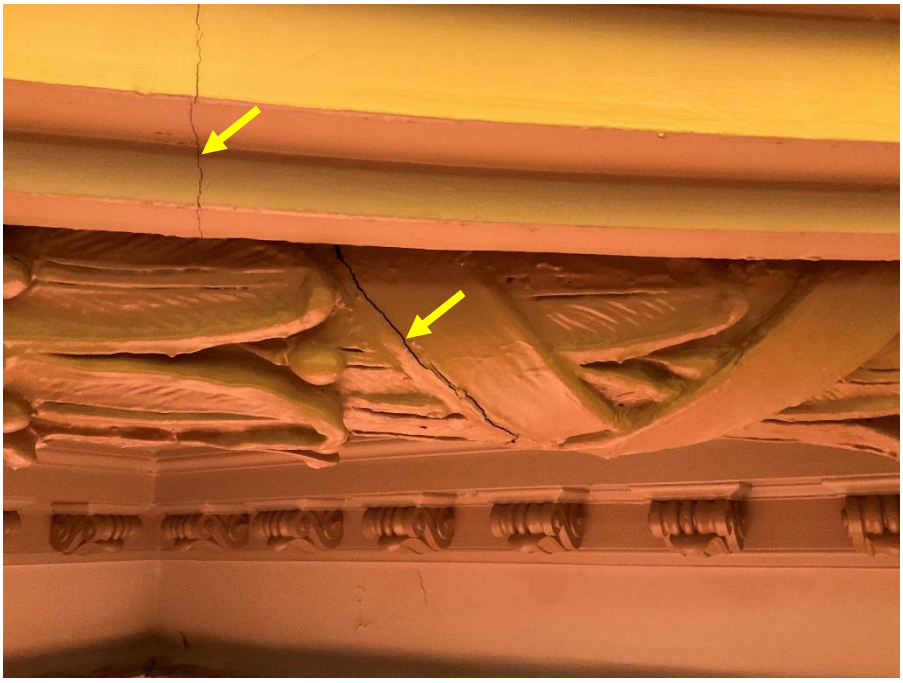
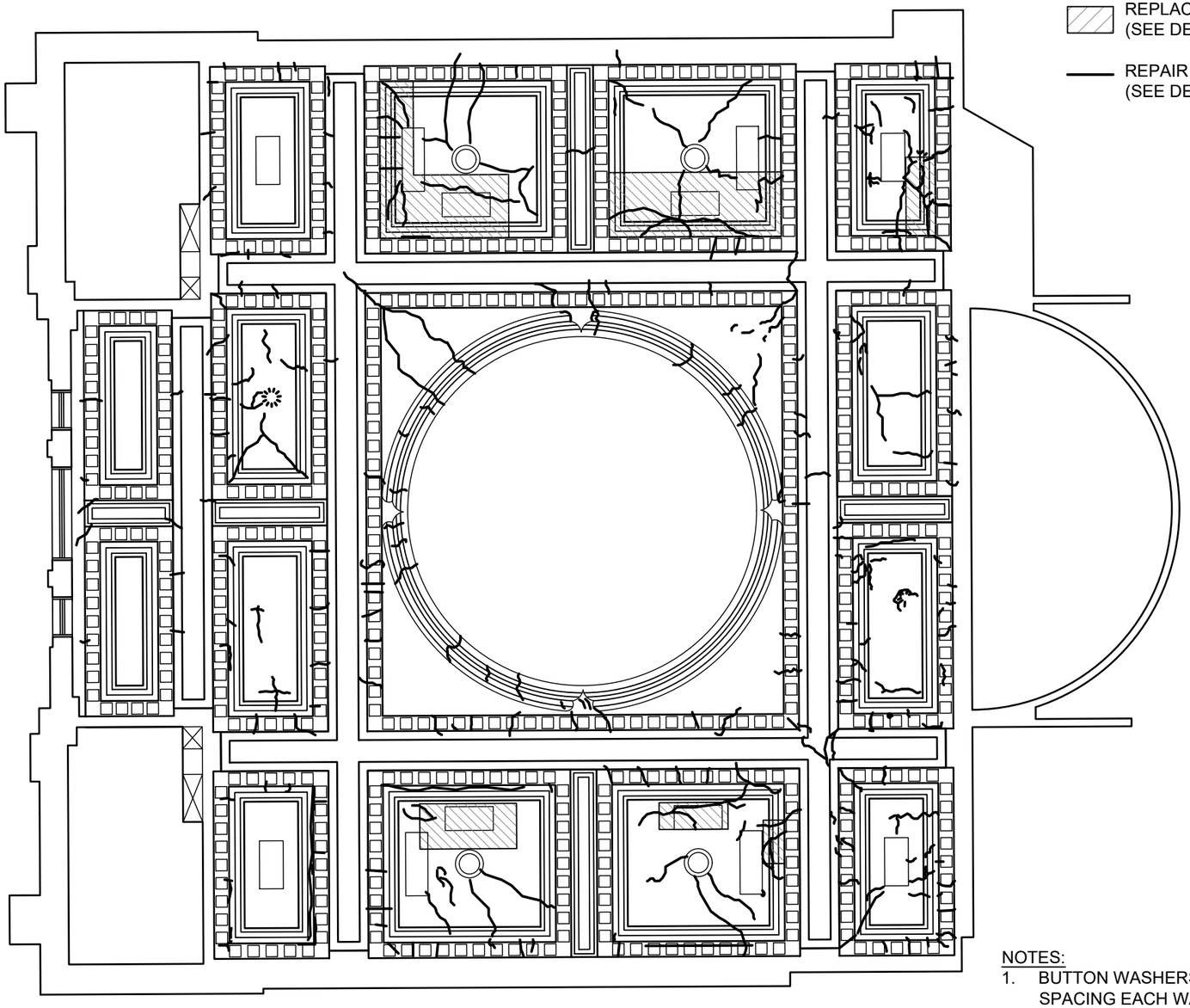


Figure 16. Crack at dome decorative wreath. Multiple similar conditions were observed around the perimeter of the dome.

Figure 17. Peeled coating at coffer beam (Bay W1). Multiple similar conditions were observed on the sanctuary ceiling.

Figure 18. Peeled plaster coating within coffer bay (Bay N2). Multiple similar conditions were observed on the sanctuary ceiling.



LEGEND:

REPLACE DELAMINATED PLASTER (SEE DETAILS ON SK-02 AND SK-03).

REPAIR CRACKED PLASTER (SEE DETAILS ON SK-04 AND SK-05).

NOTES:

1. BUTTON WASHERS TO BE INSTALLED AT 16"+/- SPACING EACH WAY AT ALL HORIZONTAL (FLAT) CEILING LOCATIONS.

1 PLAN - LOCATION OF CRACKED AND DELAMINATED PLASTER

NO SCALE

N

PROJECT NORTH


WJE ENGINEERS ARCHITECTS MATERIALS SCIENTISTS

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Seal

Consultant

Project

Sanctuary Plaster Ceiling Repairs

Client

Saint Nicholas Greek Orthodox Cathedral
416 South Dithridge Street,
Pittsburgh, PA 15213

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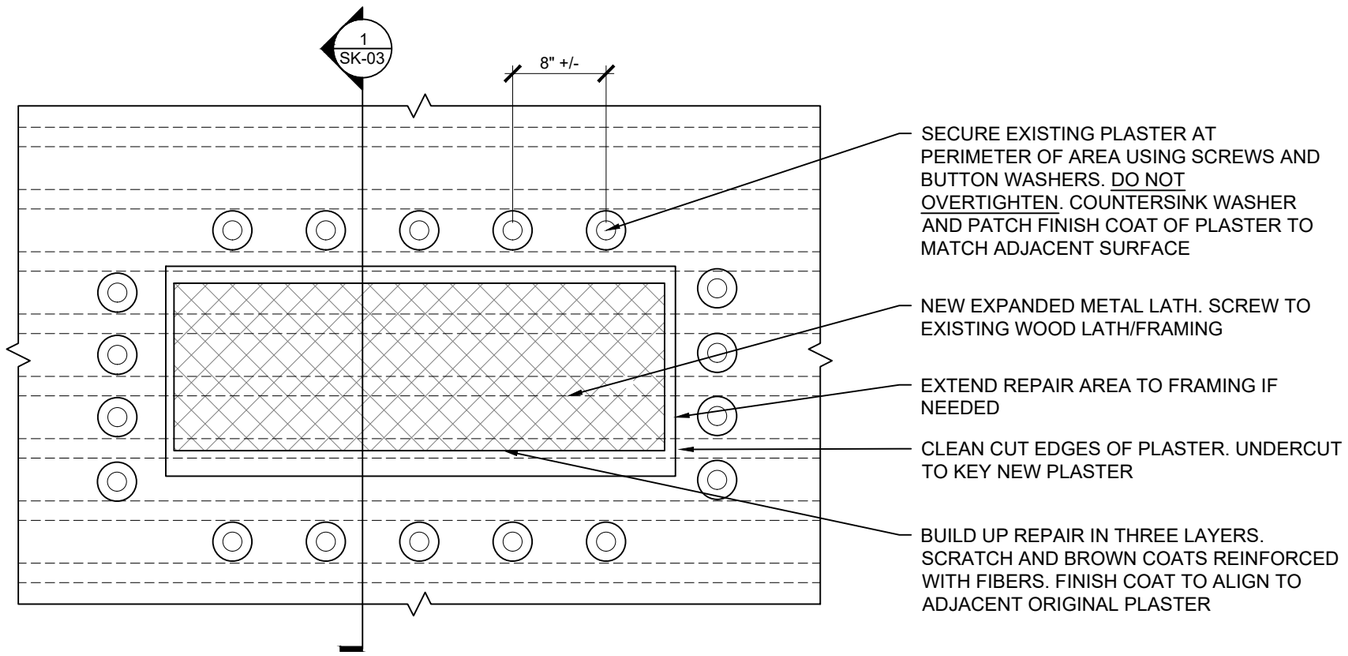
Plaster Repair Locations

Sheet Title

Sheet No. **SK-01**




1 PLAN - LOCALIZED REPLACEMENT OF PLASTER ON WOOD LATH

NO SCALE

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Plaster Repair Details

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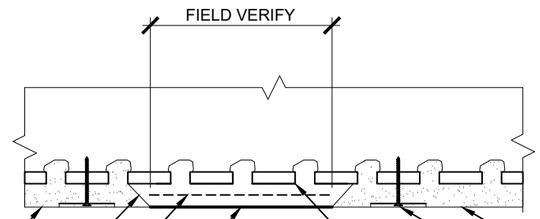


REMOVE FINISH COAT TO INTEGRATE REPAIR WITH EXISTING PLASTER

UNDERCUT EDGES OF INTACT PLASTER, TYP

NEW METAL LATH. SCREW TO EXISTING WOOD LATH FRAMING MEMBERS

BUILD UP REPAIR IN THREE LAYERS. SCRATCH AND BROWN COATS REINFORCED WITH FIBERS

EXISTING INTACT PLASTER

SECURE EXISTING PLASTER AT PERIMETER OF DELAMINATED AREA USING SCREWS AND BUTTON WASHERS. DO NOT OVERTIGHTEN. COUNTERSINK WASHER AND PATCH FINISH COAT OF PLASTER TO MATCH ADJACENT SURFACE

EXISTING INTACT WOOD LATH

## 1 SECTION - PLASTER REPAIR ON WOOD LATH

NO SCALE

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Plaster Repair Details

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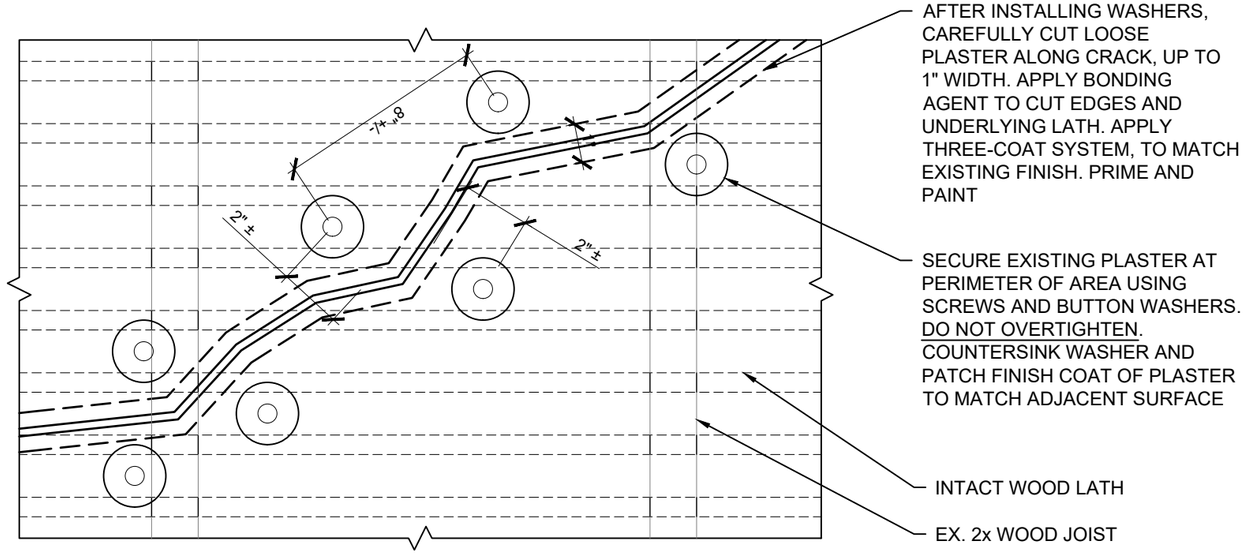
Sheet No. **SK-03**




1 CRACK REPAIR ON PLASTER WITH WOOD LATH - WIDTH GREATER THAN 1/16"
NO SCALE

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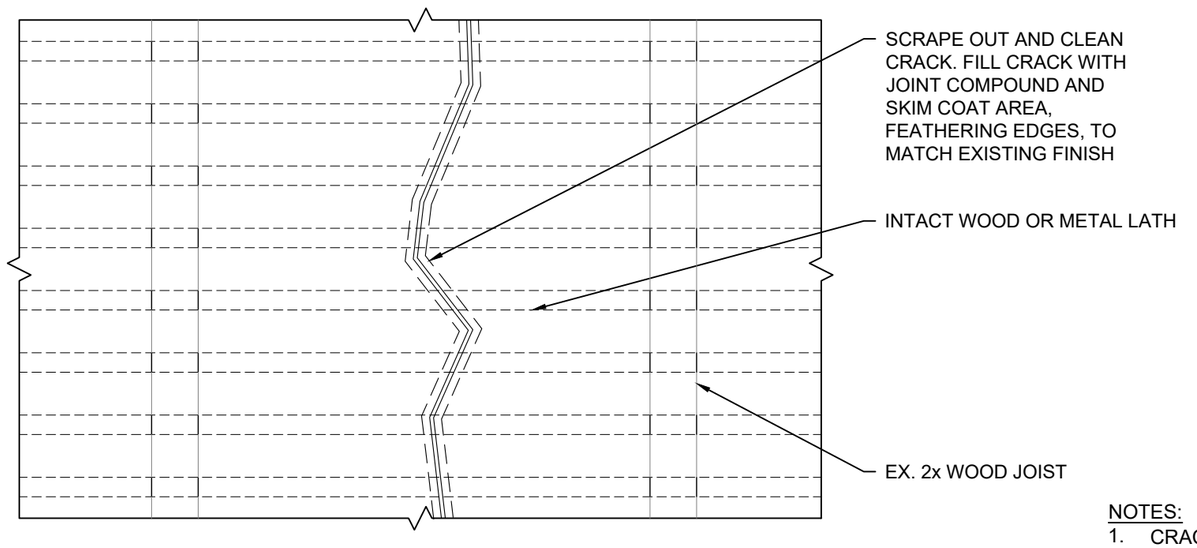
Sheet No. **SK-04**




NOTES:

1. CRACKS WITH WIDTHS LESS THAN 1/32" DO NOT REQUIRE REPAIR, PRIME AND PAINT OVER.

1 CRACK REPAIR ON PLASTER WITH WOOD LATH - WIDTH LESS THAN 1/16"

NO SCALE

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