SWR INSTITUTE TRINITY AWARD SUBMISSION

Project Title:

Window and Exterior Wall Repairs, Hogan Building, Northwestern University

Location:

2205 Tech Drive, Evanston, Illinois

Entry Classification:

Sealant and Restoration

Project Cost:

$1,900,000

Duration:

428 Days

Start/Completion Date:

August 11, 2008/October 13, 2009

Work Scope:

The scope of work for this project consisted of 2 major categories of work, window and limestone cladding panels.

1. The existing wood frame windows were rehabilitated to provide for improved thermal and moisture performance, and to upgrade their appearance. The scope of work related to the windows consisted of the following:

    a. Provide interior protection prior to proceeding with any window rehabilitation work. At a minimum, interior protection shall include clear 12-mil polyethylene sheets secured in place with wood frames. Protection shall be located within 18 inches from the windows and shall not interrupt interior occupancy. Protection shall also include protection of existing convector covers and adjacent built-in materials. Erection and removal of the interior protection

may be performed from the interior of the building. However, all other work shall be performed from the exterior of the building.

b. Remove the existing operable sash and hardware. Dispose all operable sash, hardware and glass off site in a legal manner.

c. Remove exterior glass stops. Remove exterior vision glass and spandrel glass. Dispose all glass and debris off site in a legal manner.

d. Cut the existing horizontal upper mullion, and dispose off site in a legal manner. Sand cut surfaces on existing window frame smooth.

e. Repair any significant frame deterioration where directed by Engineer:

   1) Perform epoxy repairs on a unit price basis (Type 1).

   2) Perform Dutchman repairs on a unit price basis (Type 2).

f. Scrape existing paint and apply wood sealer on frame.

g. Re-anchor window top clip angles where existing clip anchor is not secure (unit price work).

h. Remove insulation behind spandrel glass. Cut metal panning behind spandrel glass at lower clip angles. Provide supplemental support brackets as shown on Drawings. Patch sheet metal at panning openings and seal perimeter. Provide new insulation behind spandrel glass. Provide new opaque panning behind vision glass on first floor windows.

   1) Opaque panning behind vision glass was required on all first floor windows except at 3 locations: two single run windows, and one side of a double run window.

   2) Opaque panning behind vision glass was needed at several other selected locations. These locations included 6 locations on Floors 2 through 5: three single run windows and three double run windows.

i. Trim existing lower intermediate mullion and jambs of the operable sash opening as shown on Drawings.

j. Provide new spandrel and vision insulating glass.

k. Provide new exterior pressure bars, sealant and pre-finished aluminum caps.

l. Provide new sheet metal flashing and trim where shown on Drawings, and as needed for a complete and watertight installation.

m. Provide new sealant at the perimeter of all new caps and all other locations as shown on Drawings, and as needed for a complete and watertight installation. Where required for proper installation of window rehabilitation accessories, remove and legally dispose the existing sealant. Existing sealant contains PCB. Contractor shall follow Owner's requirements for removal, handling and disposal of hazardous materials. See "Information Available to Bidders".

n. Retrofit existing aluminum frame windows and curtain wall system at prior mock-up locations as directed by Owner and Engineer.

o. Assist Engineer in performing window testing.

2. The existing limestone cladding panels were repaired and their sealant joints were replaced. The scope of work was specified to address shifting of the limestone panels due to creep in the lead shims used during original construction. In addition, cracking of panels due to corrosion and movement in the anchors and supports was specified. The scope of work included the following:

   a. Remove and legally dispose all existing limestone-to-limestone and all other sealant joints and backer rod material.

   b. At all horizontal joints of wing walls, grout the space between the steel support member and bottom of the upper limestone panel as shown on Drawings.

   c. Provide new sealant and backer rod in all joints as shown on Drawings.

   d. Route and seal existing cracks in limestone panels where directed by Engineer on a unit price basis.

   e. Repair delaminated and/or spalled limestone where directed by Engineer on a unit price basis:

      1) Perform Dutchman repairs as shown on Drawings.

      2) Perform cementitious mortar patch repairs as shown on Drawings.

   f. Remove and replace cracked limestone bottom sections at wing walls where directed by Engineer.

The following miscellaneous work items were also specified:

1. Perform exterior painting where shown on Drawings. Paint exposed cut edges of the upper mullion on all window frames to match adjacent surfaces.

2. Provide access equipment and operators for Engineer's review of work on a unit price basis.

Alternates selected by the Owner included cleaning of the limestone panels.

Abstract:

The Hogan Building at Northwestern University's Evanston, Illinois campus is a 5-story concrete frame building constructed in 1960's. The building houses several laboratories which conduct experiments all year round. The building has a complex geometry as viewed in plan (Figures 1 and 2). There were several tiers of single and double windows. At each floor, the windows were rotated 15 degrees with respect to the floor below, making the geometry more complex.

The building exterior consisted of wood-frame windows and fluted limestone panels. These panels extend the full height of each floor and measure approximately 13 feet in height. The joints between the limestone panels were sealed with sealant.

Support mechanism for the limestone panels consists of steel members which are attached to the concrete frame of the building. At the wing walls, the steel members supporting the limestone panels cantilever out from the building floor slabs at each level. In other locations, the support members consist of a steel plate attached to the top side of the floor slabs.

The windows were originally mahogany frame and extended the full height of each floor. The lower section of each window was a spandrel panel, the middle section an operable casement sash, and the upper section a fixed vision glass.

The Owner originally retained the Engineer to design new windows for the building due to extensive paint peeling, poor thermal performance, and air and water infiltration. However, after the initial evaluation by Engineer, the existing window frames were found to be in generally good condition despite some localized rotting (Figures 3 and 4).

During the evaluation of the windows, the Engineer also found significant distress in the limestone panels. The limestone panels had shifted in many locations, particularly at the wing walls; and exhibited cracking and spalling (Figures 5, 6, and 7).

Replacement windows and new curtain wall system were considered, and constructed during mock-ups. However, due to sensitivity of operations inside the building, these options were eventually ruled out by the Owner, making rehabilitation of the existing windows the best option.

Unforeseen Conditions:

Although the design provided for new gravity support brackets for the windows, these brackets could not be installed. These brackets were needed to address the improper original installation of gravity support brackets during original construction (Figure 8). To address this issue, supplementary anchors were added to the existing support brackets. This posed the challenge of drilling through steel and concrete simultaneously.

Other unforeseen conditions included encountering a few window wood frame members that had been significantly rotted (Figure 9 and 10). These embers were replaced with new mahogany members and spliced in the field.

Problems/Challenges/Solutions:

The project team faced several challenges during the design and construction phase of this project. These challenges were as follows:

1. As previously indicated, the interior of the building primarily consisted of laboratories with ongoing, around the clock, experiments. The building also had to be kept under positive air pressure to prevent contaminants from entering the building. These two factors made it difficult to remove and replace the glazing. Although the work sequence was designed to perform all of the window related work from the exterior of the building, several considerations were made. The Owner had to coordinate access to each interior space within a work tier. This was done through a painstaking process of contacting each laboratory and space tenant, and working with the Contractor to continuously update the work schedule. The work schedule was also posted by the Owner on the internet so that building occupants could obtain real time information on project schedule. Once interior access to a space was obtained, temporary interior protection was erected to isolate the windows from the interior space. All other work from that point on was performed from the exterior of the building. The work was then started and completed within 2 days (from the start of the work to when new insulated glass units were installed and sealed).

2. Odors and dust could also not be tolerated. During construction, some dust issues were reported. However, these issued were resolved by making improvements in the method of sealing the temporary protection inside the spaces. Many chemicals were used for the window restoration. These included epoxy-based consolidants, patching materials for wood, primers and sealant. All such chemicals were carefully selected to minimize the potential for odor. However, when performing the repairs on the limestone panels and their joints, odor and dust infiltration could

not be easily controlled. This resulted in several work stop orders by the Owner, and re-shifting of project schedule.

3. Quality control testing was to be performed on sealant joints and windows. These tests were to be performed after curing of the materials. This necessitated that rigging be moved back to those areas for access.

Safety Considerations:

The existing window frame paint contained lead. The existing sealant consisted of polysulfide and contained PCBs. These issues necessitated certain precautions to ensure proper handling, and safety of all workers, building occupants and students on campus. Procedures were established for removal, handling, storage and disposal of these materials. The project team worked together to ensure all required rules and regulations were strictly adhered to.

The entire project was completed accident free.

Community/Environmental Impact:

As previously indicated, lead and PCBs were found in the existing materials. These materials were removed, handled, stored and disposed off in strict accordance with required environmental agencies.

The completion of this project made a positive impact on the campus (the community) and environment. By re-using the existing window frames, disposal of existing materials was minimized. In addition, new aluminum materials were limited to new pressure bars and caps with no need for new aluminum extrusions for new window frames.

The appearance of the building was significantly improved through cleaning of the limestone, and the improved aesthetics of the windows (see Figures 11 and 12 for before and after photographs).

In addition to the above, the window rehabilitation significantly improved thermal performance, and resistance to air and water infiltration. These improvements resulted in significant reduction in wasted energy.

Technology/Innovation:

The design of the repairs consisted of an innovative methodology to rehabilitate the existing windows. The Owner's objectives were to improve thermal performance, air and water penetration resistance, minimal disruption to the operations inside the laboratories, and to

modify the appearance of the existing windows to replicate the modern curtain wall systems of adjacent buildings.

These objectives were achieved by removing the existing single pane spandrel and vision glass, minor modifications and repairs to the frames, installation of new insulated vision and spandrel glass, and installation of a new custom extruded aluminum cladding system over the existing frames. Some of the typical repair details are depicted in Figures 13, 14, and 15.

In order to provide for a long service life of the existing wood frames, several steps were taken. These included coating of all exposed wood with a wood consolidant. In addition, the new system was designed to provide a secondary drainage system within the glazing pockets (the original window glazing pockets did not have a secondary drainage system, causing localized rotting of the window sills).

Site Constraints:

There were several site constraints:

1. As previously indicated, the building interior spaces consisted of laboratories with round the clock experiments. This posed many constraints on scheduling and access to the building interior.

2. The building is located in the center of a college campus. Although some of the work was performed during summer months when fewer students are present, a major portion of the work was performed during regular school season.

3. There were several other academic buildings adjacent to the building. As such site storage for materials was limited. Materials were stored in a parking lot several hundred feet away from the building and brought to the site on an as-needed basis.

4. Parking at the site was limited to one vehicle for the contractor. However, deliveries and pick-up were allowed at the adjacent truck dock area.

Quality Control/Field Testing:

Prior to initiation of the repairs, a mock-up phase was implemented to ensure the repairs were practical to perform, and the custom extruded aluminum pressure bars and caps would fit properly. Two windows were repaired during the mock-up phase. The repaired windows were then tested by the Engineer in general accordance with ASTM E 1105 to ensure proper performance.

During the repairs, the Engineer performed ongoing site observations. Additional water testing of windows was also performed on a random basis. Sealant joints were subjected to random adhesion testing to ensure proper adhesion.

Rigging Approach:

The Contractor utilized mast climbers to access the window tiers (Figure 16). Mast climbers were selected due to their load capacity to carry large panes of insulated glass, etc.; and their stable platform.

The limestone panels were accessed using conventional swingstage scaffolding (Figure 17).

Sustainment:

This project represented the ultimate sustainability practice. Despite the Owner's initial desire to replace the existing windows with new aluminum frame windows, the existing windows were rehabilitated using existing window frames. This reduced the environmental impact, and rendered the existing windows and limestone facade panels in a serviceable condition that is anticipated to last many years.

FIGURE APPENDIX

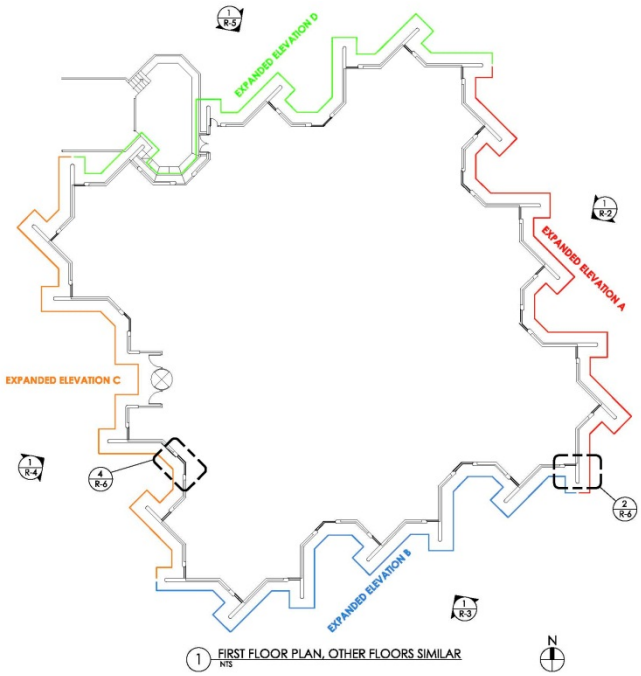

Figure 1

Figure 2

Figure 3

Figure 4

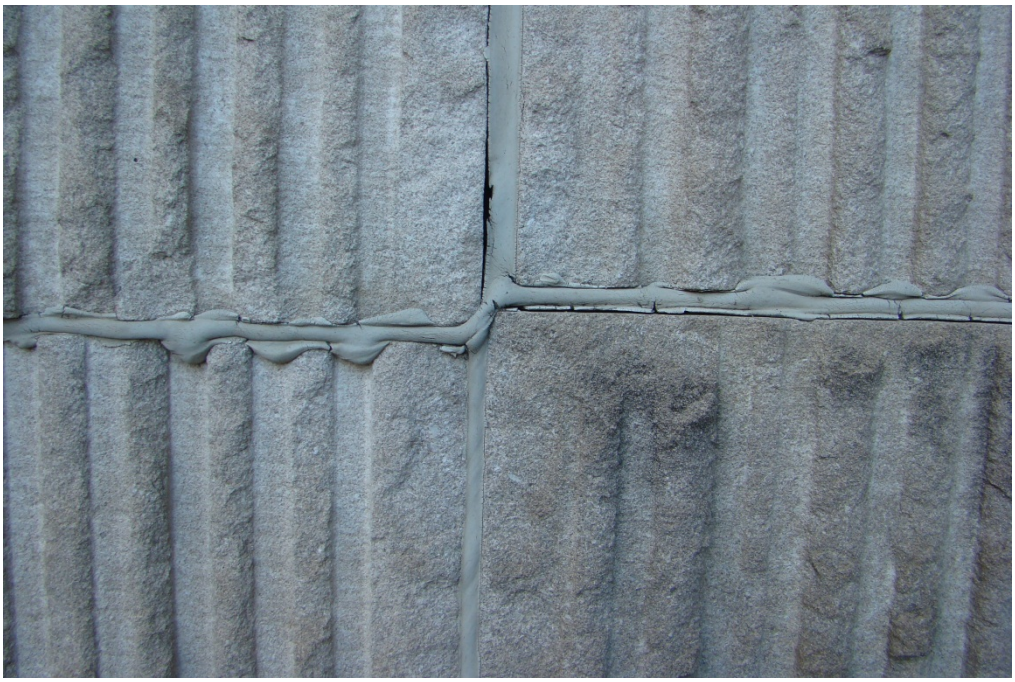

Figure 5

Figure 6

Figure 7

Figure 8

Figure 9

Figure 10

Figure 11

Figure 12

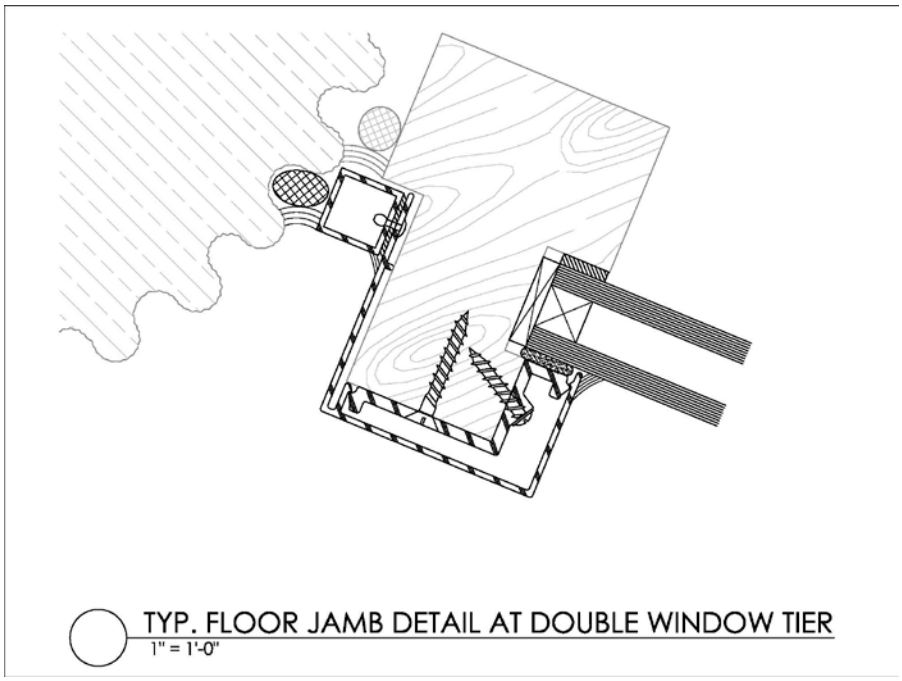

Figure 13

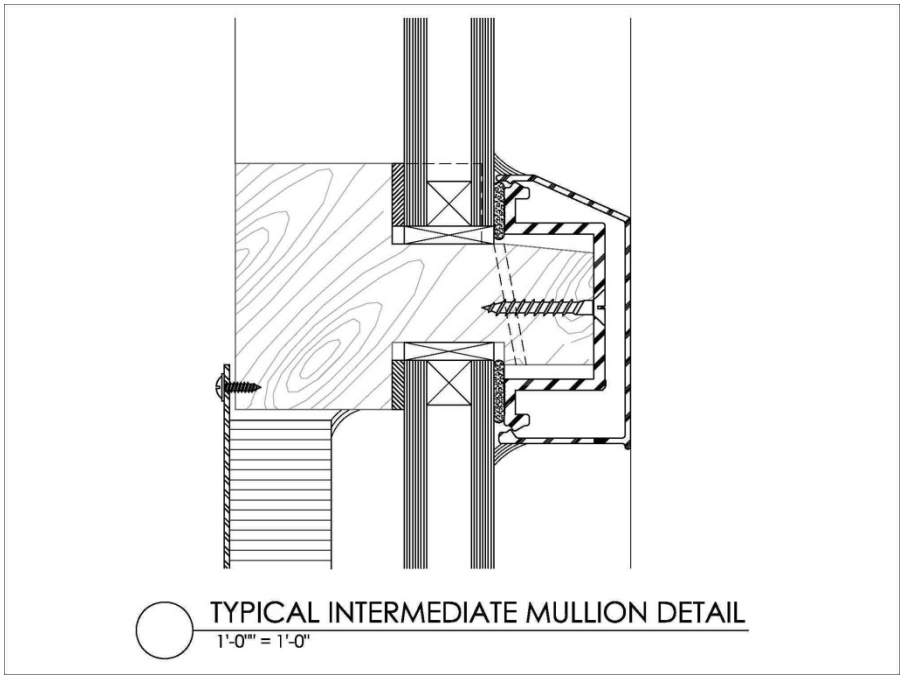

Figure 14

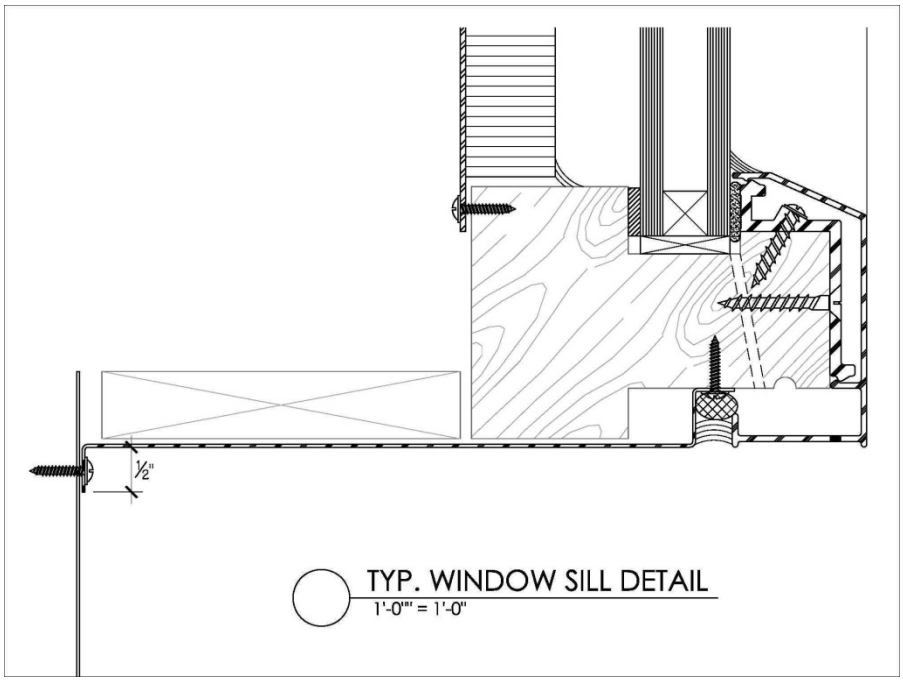

Figure 15

Figure 16

Figure 17