Facade Repair and Rehabilitation Case Studies

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Abstract

Deterioration of brick veneer walls from freeze/thaw cycles or water damage is a problem in construction. Two solutions to brick veneer wall problems are presented in this paper as case studies. In the first case jumbo brick on a housing project in New York City suffered severe freeze/thaw damage. The restoration solution to the spalled brick veneer was to overlay the brick with a polymer modified repair mortar and a topcoat of decorative and protective acrylic finish. In the second case a brick veneer and precast office building in Toronto was being converted to a computer facility, which required a humidified interior air environment. The humid interior air conditions would have caused rapid deterioration of the brick veneer as moisture accumulated in the brick wall covering. An innovative pressure equalized rainscreen wall system was added to the exterior to provide a cost effective means of controlling air and moisture while adding to the insulation value of the wall and beautifying the structure. This paper presents details, materials and methods of construction to solve the two facade problems.

Case 1: Polymer Modified Vertical Leveler – Masonry Substrates

Lambert Houses (Photo 1) was constructed in the late 1960's as low income housing in Bronx, NY. The 14 buildings, approximately 46,000 m^2 (500,000 sq ft) of facade, are six story structures, clustered into five pods with common grounds.

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The building exteriors are single width, jumbo brick, load bearing walls. Each brick measured approximately 203 x 254 x 203 mm (8 x 10 x 8 in), with six cells. The floors are supported by a wood joist on the wall, with a 101.6 mm (4 in) soap in front of the joist.

Photo coming soon .

Photo 1: Lambert Houses

The building facade was suffering from a general problem of water migration into the face of the brick, causing the brick to deteriorate and spall. Several solutions were researched to halt the progressing deterioration. A materials manufacturer, after lengthy consultation with the property owners and design professional team, developed an overlay system that would protect the brick from continued weathering and yet, provide an aesthetically pleasing facade. It was proposed that approximately 29,700 m^2 (320,000 ft^2) of the facade be overlaid. This meant developing an economic, reproducible, architecturally pleasing system. Of greatest concern was that the system

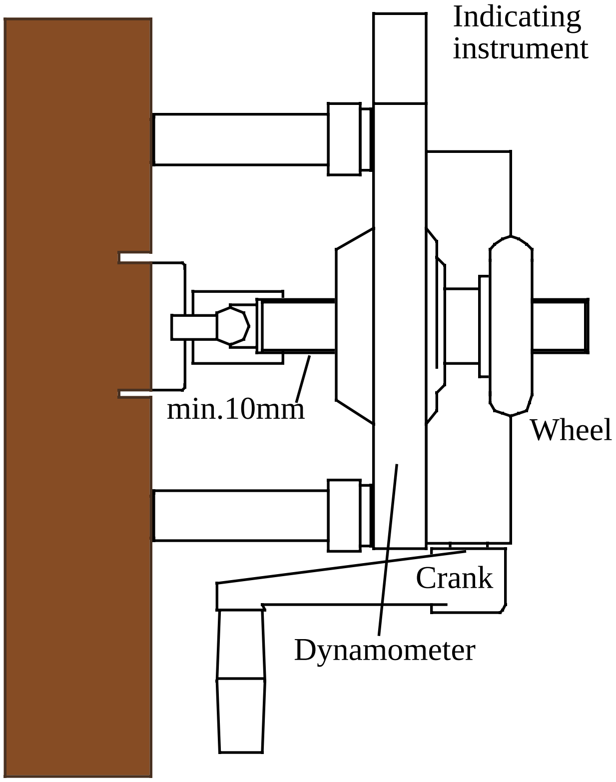

Figure 1: Dyna Pull-off Tester[3]

have the design capability of being directly applied to the existing facade and achieve an acceptable bond. In order to verify this phase, the materials supplier, along with the contractor and engineer, applied 12 samples of the proposed base system to the wall, at varying heights on the most severe weather exposure elevation of one of the buildings. Samples of the applied material were allowed to cure for 28 days, at which time the material supplier and engineer jointly made 50 mm (2 in) cores into the samples, for purpose of testing direct tensile bond pull strength. In this case, testing equipment that was used was a Dyna Pull-off Tester[3] (Fig. 1) The engineer specified that acceptable bond was failure of the brick below the bond line, or greater than 690 kPa (100 psi). Upon completion of the bond testing, a full 6 story (height) x 9m (30 ft) (width) mock-up was constructed to permit the owner to evaluate the performance and aesthetics of the system

Due to the weak surface condition of the brick facade and the need for the walls to “breathe”, a system that was compatible was of critical need. The installed system was comprised of a surface consolidating primer, a low modulus (in compression) cementitious mortar that is fiber reinforced, a fiberglass mesh, and a 100% acrylic, elastomeric weatherproof coating. The decision to use a low modulus mortar was based on the need for compatibility with the brick substrate. Normal structural polymer repair mortars would have been too rigid and dissimilar to have functioned for this installation. Galvanized grounds were affixed to the wall at all penetrations, and a control joint pattern was created to relieve the stresses caused by shrinkage of the cementitious mortar. All control joints and grounds were sealed with a polyurethane, elastomeric sealant material.

All wall surfaces were power washed to clean the facade. Pressures of up to 13.8 MPa (2000 psi) were used. The contractor found that any pressures greater than 13.8 MPa (2000 psi) would begin to deteriorate the brick surface. Bricks that were missing a face were removed and replaced. Those with holes were repaired with the cementitious mortar used for the overlay then the surface consolidating primer was applied. After the primer had dried, the cementitious mortar was “scrubbed” onto the wall, with a 6.35 mm (0.25 in) lift of the mortar applied immediately to the wet “scrub” coat. The manufacturer developed a mesh system to be embedded into the applied mortar.

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[3] ASTM D 4541-95 Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers, American Society for Testing and Materials, West Conshohocken, PA

This system consisted of 100% embedment of the mesh into the mortar and a 50 mm (2 in) overlap at all re-entrant corners. In addition, another piece of mesh 76 x 152 mm (3 x 6 in) was installed on the diagonal at all re-entrant corners to reduce the potential of cracking. Then, topically applied to this material was a finish application of the cementitious mortar, in order to bring the final nominal thickness of the system to 12 mm (0.5 in). For purposes of providing an architectural finish and weatherproof coating, two coats of an acrylic flexible coating were roller applied over the cured mortar.

During construction, an unforeseen problem arose with one pod of buildings that developed a crack at the roof/parapet interface. It was determined that there was thermal movement causing the crack. The solution provided was quite unique to the manufacturer's capabilities. The cementitious mortar was removed 300 mm (12 in) from either side of the crack. The opening was filled with the cementitious mortar to within 1.6 mm (0.06 in) of the finished elevation. Then, a flexible acrylic mortar, with a mesh embedded, was installed. Over this, a flexible, acrylic, trowel applied finish was applied to simulate the finish. The entire application was overcoated with the same flexible coating as the rest of the project. This repair solution provided a reinforced flexible detail that permits the wall to move without exhibiting a crack.

Masonry areas of the parapets needed to be rebuilt. Waterproofing of the parapets was needed as well. Here, a flexible polymer modified, vapor permeable, cementitious watertight coating was applied, thus allowing the wall to "breathe", but not permit water intrusion.

To assist in the successful completion of the project, the entire construction team developed a quality assurance program. First, the contractor, who had attended a manufacturer's formal training program, brought together the entire team of project superintendent, project foreman, and masons for specific training dedicated to this project. The manufacturer supplied a technical field trainer for two days, followed then by a sales/technical representative for two additional days of training.

The contractor used his own business building and had the construction crew work for two weeks on this building, learning and honing their application techniques. Once the project started, the manufacturer made weekly job site visits, to review the actual work on these walls. As the project advanced, the wall inspections decreased to monthly visits. The contractor also performed an internal quality program, as well, to maintain the high standard set/expected by the owner. A key observation made during the inspection process was that there were no cracks found at the areas of the re-entrant corners.

In summary, this project was unique due to a critical process developed in the materials selection, i.e., mating different materials for the overlay and maintaining the breathability and flexibility in the overlay materials for a new architectural appearance. The use of polymer-modified cementitious repair materials to repair other building materials in a sympathetic manner, while providing performance and aesthetics, is beyond the normal realm within which we find a traditional use of cementitious materials.

Case 2: Retrofit with Pressure Equalized Rainscreen EIFS

This case looks at the recladding of an older masonry office building.

The masonry office building was built in the days of low cost energy. The walls were uninsulated. The brick remained resistant to the freeze/thaw actions of the environment because heat from the interior pased through the uninsulated brick keeping it warm. Humidity from the interior passed harmlessly through the warm brick.

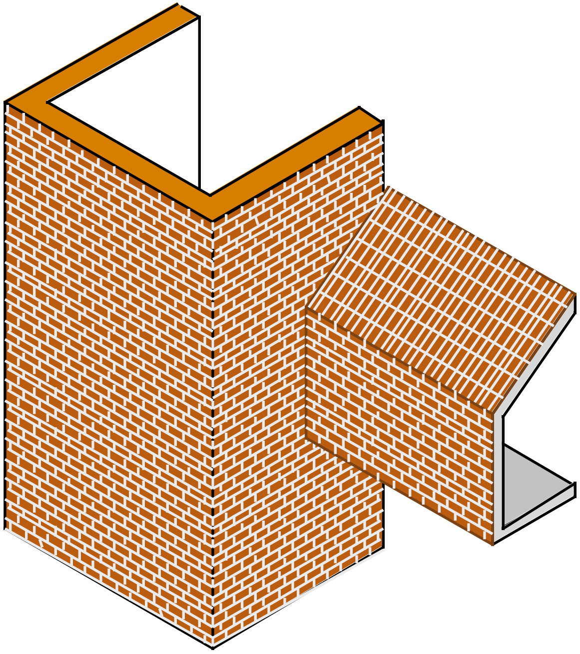

Figure 2: Masonry and precast substrate

The structure was consistent with construction of the time. Poured reinforced concrete was used for the supporting columns and flat floor slab. At the corners and mid point of each elevation masonry column covers were constructed. Between the columns, precast concrete spandrel panels were hung (Fig. 2). A matching face brick was cast into the precast panels to provide a monolithic appearance to the building and blend with a group of buildings in the area.

The interior environment was controlled by hot water heating. Supply and return piping were installed in the concrete floor slab making future renovation and relocation difficult, if not impossible. The heating units were installed below the windows, as would be expected, directly in front of the interior wall finish (Fig. 3). Interior humidification was not a consideration when this building was constructed so vapor barriers were not required or installed in the wall. This would lead to substantial difficulties when renovating the building to meet modern requirements.

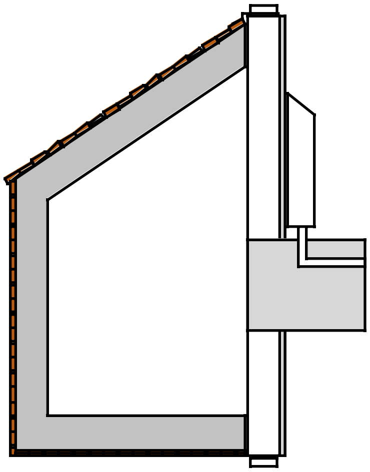

Figure 3: Section through precast

In the early 1990's the City of Metropolitan Toronto acquired the building, with the intention to convert the building into a computer facility. It was planned that the new facility would become the nerve center for emergency telephone calls (911), and traffic controls throughout the entire metropolitan area. Such a dedicated computer facility has exacting environmental requirements, including the need for humidification to reduce the chances of static electric discharge around sensitive components.

The project would grow in complexity as all the requirements for a "post-disaster" building that housed emergency facilities were considered. The concrete structure had to be re-engineered to take earthquake loads and the interior space modified to accommodate the raised floor for computers. Of particular interest to this paper was the redesign of the wall cladding assembly to handle the changed interior environment.

As noted above, the existing brick and precast concrete walls were built with no insulation or vapor barrier, nor was any consideration given to air leakage as a potential cause of heat loss and moisture deposit in the walls. The change to elevated interior humidity introduced environmental engineering and design challenges. A new physical plant had to be designed to accommodate the mechanical equipment. As space in the existing building was restricted, a mechanical penthouse was added to the structure. The additional dead load was a concern. In addition, the increase in water vapor pressure against the existing wall assembly would have led to distress and failure of the cladding. Design guidelines called for increased thermal performance of the walls. If the insulation were to be added to the interior wall cavity, the exterior brick temperature would drop in winter months. Given the increased vapor drive, condensation within the brick combined with the lower temperatures would result in spalling and failure of the brick.

The traditional solution would be to install a vapor-retarding layer on the warm side of the wall. In this case, because of the location of the heating units, access to the wall was restricted. In addition, Canadian building codes required a continuous air barrier system within the building envelope. Clearly, the best and most economical solution to the wall redesign was to insulate the exterior of the brick. For this the design team requested a pressure-equalized rain screen (PER) cladding system.

One of the principal causes of water penetration in a high rise building is pressure difference across the wall cladding. Wind generated pressures can force water through small openings into the wall assembly. By venting the exterior cladding to the outside the pressure difference across the cladding is reduced and the likelihood of water penetration is also reduced. This system is known as a pressure-equalized rainscreen (PER).

A PER has five basic components: an air barrier, airspace, venting, outer screen and compartmenting. The air barrier becomes the primary resistance to wind pressure as the load is transferred around the outer skin of the cladding via the vents to the air barrier. The outer skin of the cladding becomes a screen shedding water away from the air barrier, hence the term ‘rainscreen’.

The author’s company had developed a PER exterior insulation and finish system (EIFS) using mineral wool insulation. The system consists of the following: substrate (1), air barrier (2), Roxul Wall Insulating Lamellas (3), internal compartment (4), base coat, reinforcing mesh and decorative finish coat (5) and venting (6). The mineral wool, which is 90% air, becomes the pressurization chamber.

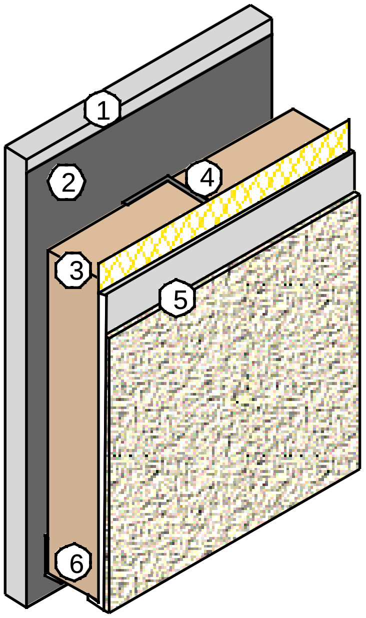

Figure 4: EIFS Components

This system was chosen as the cladding system because it provided a continuous air barrier; it insulated and protected the masonry; and it integrated the addition into the overall appearance of the building while adding only 9.8 kg/m^2 (2 lb/ft^2)to the structure.

The first step in installing the cladding was to provide a continuous air barrier over the exterior of the building. A cementitious air barrier was troweled over the masonry piers. The precast spandrel panels were considered to be airtight so no additional coating was required. A 'peel-and-stick' membrane was applied to the joint between the coating on the masonry and spandrel panel to make the cladding air barrier continuous (Fig. 4).

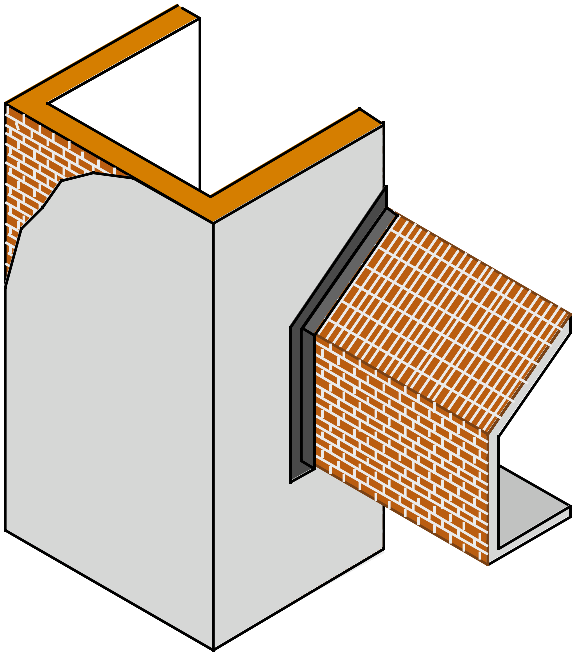

Figure 5: Air barrier

The second stage was to adhesively install the 75 mm (3") mineral wool lamellas. The insulation is unique in that it is cut in such a way that the mineral wool fibers are perpendicular to the surface of the wall. This provides a direct, positive link between the wall coatings and the substrate. It is described as being like bonding a hairbrush to the wall. A 3/4" (20mm) joint was installed at the floor lines. Traditional EIFS installation methods call for "back-wrapping" all terminations. This technique allows the edge of the insulation to be wrapped with base coat material and reinforcing mesh. At the floor joint, the reinforcing mesh was wrapped but a strip of base coat was left off the underside of the panel. This created the venting to allow the mineral wool to pressure equalize.

Once the insulation was in place it was rasped and finished as on a traditional EIF system with base coat, reinforcing mesh, and finish coat. Two colors of silicone-emulsion, textured-finish were installed over the basecoat (Photo 2).

The joints were left open, without sealant. As there was a water resistive air barrier at each joint, it was decided sealant was not required. This eliminated the maintenance requirement of sealants.

This installation was the first pressure-equalized, rainscreen exterior insulation and finish system installed. Five years after its completion, the City of Metropolitan Toronto Engineering Department made a detailed inspection of the cladding. They found no problems with the installation and it continues to perform as installed.

Photo coming soon .

Photo 2

Conclusions

1. Retrofitting the exterior of older masonry structures with an EIF system is an effective method of upgrading thermal and moisture performance.

2. An EIF system retrofit can be done without disruption of interior spaces in the building.

3. An EIF system retrofit can provide enhanced value, not only by improving thermal and moisture performance, but also by changing and improving the appearance of the structure.