Starting Over: Reskinning Deteriorated Masonry Walls in Occupied Condominium Towers

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ABSTRACT

This presentation focuses on an innovative approach for cladding replacement (reskinning) of two 30-story towers. This will interest those who evaluate and repair older buildings. The original wall system had issues with water leakage through the cladding, brick masonry deterioration, and severe corrosion of the steel shelf angles. Localized repairs were previously completed to address one-off problems instead of the systemic issues with the wall construction. This time around, the condo decided to start over and proceed with a cladding replacement. We will walk through the multiple benefits of this approach, as well as the challenges.

SPEAKERS

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SARAH GRAY is a project principal and the restoration practice leader at WSP Halsall, a multidiscipline engineering and consulting firm based in Toronto, Canada. Sarah’s expertise includes the evaluation and repair of existing cladding assemblies, particularly thick masonry, thin veneer masonry, and curtain wall systems. She has written and presented on building envelope topics in both Canada and the U.S., including for the Ontario Building Envelope Council and RCI. Sarah is licensed as a professional engineer in Ontario.
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INTRODUCTION
What happens when a condominium complex has deteriorated brick masonry walls, corroding shelf angles, leakage issues, and limited funds to make the needed repairs? This case study focuses on an innovative approach for cladding replacement (reskinning) to address multiple problems at two 30-story towers in Toronto.

THE CONDOMINIUM COMPLEX
The Crescent Town condominium complex in the east part of Toronto (approximately 20 minutes from downtown) was constructed in the late 1960s and was completed in 1972. There are three high-rise towers and three townhouse blocks with 1,420 units combined, making it the largest condominium complex in Canada (as one corporation). See Figure 1 and Photo 1.

The buildings have conventional concrete structural framing. The wall cladding from inside to outside is plaster on 4-in.-thick concrete block backup wall, 2-in. expanded polystyrene insulation, ½-in. air gap, and 3½-in.-thick clay brick veneer. The brick veneer is supported by shop-prime steel shelf angles that are secured to the floor slabs, and galvanized steel ladder ties provide lateral restraint. No flashings were present at the window heads.

WSP Halsall (formerly operated as Halsall Associates) has been involved at this complex since 1994. During the 1990s, the condo implemented extensive garage repairs and localized wall repairs to address leakage.

HISTORICAL ISSUES
Leakage through the walls and windows had been a problem since original construction. In 1989, the top 10 stories of each tower’s east elevation were overclad with prefinished “corrugated” steel cladding hung from 3-in.-deep horizontal Z-girts secured to the original brick veneer. The overcladding included an air/vapor/moisture control layer (peel-and-stick membrane) over the brick masonry, and 3-in.-thick extruded polystyrene insulation was sandwiched between the original brick and new metal cladding. The metal cladding system reduced the leakage issues and improved thermal performance at these elevations. Elsewhere on the buildings, targeted repairs such as mortar repointing, through-wall flashing installation at the shelf angles and window heads, localized brick replacement, and sealant replacement were completed to manage ongoing reported leakage. At the end of 2012, WSP was asked to evaluate the north elevations because they had been experiencing the most leakage to date. At the time of the evaluation, there were over 20 condo units with active leaks.

UP-CLOSE VISUAL EVALUATION AND DESTRUCTIVE TESTING
Our 2012 evaluation was limited to the north elevation of 1 and 5 Massey Square (see Figure 1). To complete the evaluation we coordinated with a contractor specializing in wall repairs to provide swing stage access and complete test openings through the brick. We began by completing a visual review and found:
Significant brick masonry and mortar deterioration—particularly at the top half of the building and below windows
- Failure of existing building sealants
- Evidence of shelf angle corrosion

Our visual observations informed us where to make the test openings. The test openings revealed the following conditions.

**Shelf Angle Corrosion**

We found that 50% of shelf angles on 5 Massey and 70% of shelf angles at 1 Massey had "rust jacking." "Jacking" occurs when the steel shelf angle corrodes to the point that the horizontal leg of the angle lifts the brick masonry. (Corrosion products occupy up to ten times the area as the original steel.) We also found that the mortar at these locations had failed (see Photo 2). In many cases the mortar joints were cracked and debonded, leaving some mortar loose and at risk of falling. During the review, we removed hundreds of feet of mortar by hand.

We found horizontal cracking of the mortar joints between the shelf angle and the first set of masonry ties. In some locations, the wall was angled outwards, likely to accommodate the rust jacking (see Photo 3).

Ideally, two-thirds of the brick depth (thickness) would bear on the shelf angle to provide adequate support to the masonry panel above. At our test openings and at the heads of the windows, we found that less than half of the brick depth was supported by the shelf angle due to short/under-designed horizontal legs. We checked the condition of the lateral securement ties at different locations over the height of the wall panels. Luckily, the galvanized steel ladder ties we exposed were in relatively good condition and provided enough restraint to prevent the brick panels from toppling over. Additionally, in the late 1990s, a 1-in. steel extension was welded to the toe of some shelf angles to provide more support (the red dashed line on Photo 3 shows the weld location).

**Efflorescence**

We found a significant amount of efflorescence on the masonry panels at the top of the buildings and below the windows (see Photo 4). This indicates that a significant amount of moisture had been present, bringing the natural salts in the masonry to the surface as the moisture dried (we did not test whether the salts were derived from the brick and/or mortar).

**Masonry Deterioration**

The mortar joints near the top of the buildings were cracked and/or eroded. The high winds at these buildings likely promoted...
water ingress into the masonry through these deficiencies.

There was significant brick deterioration, including freeze/thaw deterioration, at the corners of the walls and below the windows (see Photo 5). The windowsill flashings had very small drip edges, and the underside of the drip edges was filled with sealant ("over-caulked") such that there was no effective drip edge. Due to surface tension of water, water was shedding from the sill directly onto the wall below, further saturating the masonry.

Safety Issues

There were several locations, particularly at outside corners, where the mortar was severely deteriorated or entirely missing. Some of the bricks at these locations could be removed by hand, therefore posing a major safety risk if they were to fall. During our evaluation we had the contractor remove and replace these bricks.

Our test openings were completed at several locations on the buildings to confirm our findings in the visual review and verify the backup wall conditions. Our openings confirmed that most of the shelf angles were actively corroding. At some of our openings, the structural integrity of the shelf angles was compromised due to severe corrosion. At these locations, we advised the client to have the contractor repair the shelf angles immediately, which they did (see Photo 6).

Since we found several safety issues in a relatively small sample of openings, we recommended fencing off the at-grade areas below the walls until further repairs could be completed. The client agreed and had fencing installed to restrict access.

Other Original Wall Conditions

We found 2-in.-thick original expanded polystyrene insulation between the brick and the backup wall, but the insulation was not continuous over the slab edges. The backup wall was typical of the era: There were many open joints (missing mortar) between the blocks, and a hodgepodge of brick and block at the underside of the floor slab to make up the floor-to-floor height. There were weep holes above and below the shelf angles, but the original wall did not have an air/vapor/moisture control layer. However, there was a strip of black polyethylene (similar to a garbage bag) that was
friction-fit behind the insulation and draped over the slab edge onto the vertical leg of the shelf angle. The polyethylene was likely meant to be a flashing to promote drainage out of the wall, but it was not continuous or was missing/damaged in some of our openings.

**Weather Conditions and Geography**
Many wind-driven rain events in Toronto soak the north and east elevations of buildings. There is also no direct sunlight on the north elevation, so the north walls take much longer to dry between rain events.

There is a ravine and parkland north of Crescent Town, and a golf course at the east side. This leaves the high-rises completely exposed to high winds, which increases risk of water entry into wall defects.

**Evaluation Summary**
A good wall assembly separates the interior space from the exterior. Based on our evaluation findings, it was clear that the original cladding assembly was unsuccessful as it allowed significant leakage into the building. There was a very narrow cavity between the insulation and the brick, which the mortar bridged in some locations, allowing moisture to move into the wall and preventing water from draining to the weep holes at the shelf angle. The attempted through-wall flashing was not effectively directing the water out of the wall, and water that bypassed the brick veneer leaked into the suites through voids in the backup wall.

In short, the wall needed to receive a renewed outer watershedding layer through repair of the brick or provision of a new “skin.” Otherwise, the wall needed an improved cavity drainage system (i.e., effective through-wall flashings) to manage water that leaked through the masonry. The corroded shelf angles also needed to be replaced if a brick repair strategy was to be implemented.

**REPAIR OPTIONS**
There are many possible repair solutions for under-performing masonry wall assemblies. WSP’s approach is to present its clients with options of varying cost, durability/performance, schedule/duration, and facility impact. We typically present these options in the context of being gold-, silver-, or bronze-level repair strategies, with bronze being the lowest-cost/lowest-impact solution (and potentially highest risk for future leakage or other problems) and gold having the highest cost/highest impact (and lowest risk for future issues). The cladding repair options we presented to the Crescent Town condominium board are shown below.

**Bronze (about $85/sq. ft. before taxes, in Canadian dollars)**
The most economical approach to repair the masonry deterioration and steel corrosion would include:
- Replacing the corroded shelf angles
- Installing through-wall flashings at leakage locations and where shelf angles are replaced
- Repointing all deteriorated mortar joints
- Replacing all building sealant, including window perimeters
- Applying a masonry sealer to reduce the amount of water absorbed into the brick masonry

This was presented as a “targeted repair” strategy that maintained and renewed the existing cladding assembly. Window replacement was not included in this strategy. Due to the height of the building and the repair quantities required, the bronze-level repair was still quite expensive when applied to the north elevations.

With this solution, we warned the client that this would not be a fix-all solution; over time, local repairs would be required due to new/ongoing leaks, further masonry deterioration, and continued corrosion of the original remaining shelf angles.

**Silver (about $125/sq. ft.)**
The client was quite satisfied with the performance and appearance of the overcladding strategy completed in 1989, so we presented an option to overclad the existing brick on the north elevations of 1 and 5 Massey Square. A portion of the existing metal cladding returned onto one of the drops reviewed during our 2012 evaluation, and we found the newer cladding was still performing very well.

Although the brick, mortar, flashing,
and sealant repairs did not have to be included in the overcladding option, it would still be important to have a structurally sound wall for securing the cladding. Therefore, the shelf angles and deteriorated bricks would still need to be replaced with this strategy. The overcladding option was about 45% more expensive than the bronze strategy.

**Gold (about $165/sq. ft.)**

Since the costs were so significant for the first two options, we went one step further and provided an option to remove the existing masonry and install a new exterior cladding assembly (reskinning). The new cladding would include:

- New windows
- An air/vapor/moisture control layer (membrane) applied to the backup block wall
- Eight inches of semi-rigid mineral wool insulation (important in a cold climate)
- A continuous water-resistive barrier over the insulation
- Prefinished “corrugated” steel paneling to match the existing overcladding

This strategy was about 95% more expensive than the bronze strategy and 30% more expensive than the silver option. The gold strategy clearly had a higher upfront cost, but this strategy would most effectively mitigate leakage risk over the long term. The significant advantage to this option would be reduced exterior maintenance; other than sealant replacement after 15 to 20 years of service, the next general renewal could be deferred by more than 50 years due to the expected performance and durability of the steel cladding.

**SELECTED REPAIR STRATEGY:**

**RESKINNING**

We were surprised but also impressed that the condo’s board of directors, with their property manager’s input, decided to implement the “gold-level” reskinning and window replacement option at the north elevations of 1 and 5 Massey Square. Their main driver for choosing the higher initial cost option was achieving reduced long-term maintenance costs. Better performance (particularly reduced water leaks) would also mean better resale value for the condo unit owners.

**Cladding Selection**

There are many cladding options, so why corrugated metal cladding? The board’s preference was to match the previous overcladding on adjacent elevations. The site plan illustrates that the reskinning would be applied to a small portion of the overall building. The reskinning may not be implemented on other wall areas (beyond the north elevations) if it is not deemed necessary, based on leakage reports or findings during future wall evaluations. Even if the board decides to continue the reskinning strategy at all remaining wall areas, we expect that the work would be phased over approximately 15 years, based on the...
condo’s available funding. The decision to match the aesthetics of the previous over-cladding allows the local new reskinning to blend in.

**Cladding Design**

Reskinning requires significant design work in order to be successful. We designed a custom detail for every wall connection and interface. We went back to the basics and used drafting paper, a scale, and a pencil to draw the wall assembly that would remain after stripping off the existing brick and insulation layers (Figure 2). We used our test opening measurements to come up with our “blank canvas” to build from. Next we calculated the sizing of z-girts required to support the cladding and resist wind loads. After that, there were many design iterations to determine how to tie everything together to be watertight, thermally efficient, and durable.

Although all the design work sounds tedious, in many ways, reskinning simplified the repair strategy. We no longer had to worry about the original brick, shelf angles, and sealants, as they were all going to be removed. We did not need to estimate localized repair quantities for pricing; this simplified the bidding process, as most repairs were lump sum amounts.

The design includes 6-in.-deep vertical z-girts that span from floor slab to floor slab as the main support for the new cladding (see Photo 7). In order to install the corrugated metal cladding with the ribs running vertically, secondary horizontal z-girts were installed over the primary vertical girts (see Photo 8). This arrangement also reduces thermal bridging, as there is insulation between the primary vertical girts and also between the secondary horizontal z-girts (two layers of insulation).

The insulation layer was covered with a water-resistive barrier to reduce wind washing and air movement through the insulation and to improve watershedding. The corrugated steel cladding was secured to the secondary horizontal girts.

**Corrosion Protection**

There is a lot of steel in the new wall assembly, so how did we protect it from corrosion? Our design included using Galvalume (AZ50) on all steel z-girts and cladding panels. Galvalume is a hot-dipped coating comprised of 55% aluminum and 45% zinc. Based on industry testing, it provides a higher corrosion resistance than other galvanizing products. All of the fasteners and girt anchors are stainless steel. The corrugated steel cladding is Galvalume with a high-quality, factory-applied, silicone-modified polyester paint. This coating is designed for 40-year paint film integrity, but with the northern exposure, will likely last longer. We specified Galvalume as the base material with other galvanizing materials as optional items. The pricing between the different materials was very close, and for the additional protection, we recommended that the client choose the slightly more expensive and better-performing Galvalume.

**Window Replacement**

The original windows at the north walls were located at inside corners of the building plan (Figure 3). If we left the original windows in place, the additional thickness of the new cladding assembly would block a few inches of the window on one side. The existing windows were 40 years old, single-glazed, leaky, and in need of replacement, so we included new windows that were slightly narrower than the original windows at these corners. A steel stud box installed at the same time as the new windows gave the extra width necessary to support the deeper exterior cladding at the corner. The new windows have aluminum, thermally...
broken frames with fixed insulating glass units (IGUs) above a double layer of single-pane sliders.

We designed the cladding to last for at least 50 years, and we anticipate that the new windows may have to be replaced before the cladding. To make future window replacement easier and cause minimal damage to the cladding, the new windows were installed independently from the cladding, using metal angles attached to the existing building structure (Figure 3). The vertical leg of the angles also provided a termination surface for the membrane flashings around the window perimeter.

Access Considerations

We took lessons learned from our initial condition evaluation and applied them to the reskinning project requirements. The evaluation used swing-stage access, and we had a lot of difficulty and shutdowns because high winds were beyond the safety limits of the swing stage. Even when the winds allowed use of the stage, the stage was not stable enough to allow for efficient work, which could have led to significant delays during the reskinning project. We would not normally direct bidders on the type of access equipment to use on a project, but we made an exception for Crescent Town. Due to the site’s high winds and high loads from brick removal/conveyance, we specified the use of a mast climber for the cladding project.

Construction Impacts

The towers are occupied residential buildings, and our repair strategy needed to take that into account. To keep water out of the units, we specified for the air/vapor/moisture control layer (membrane) to be installed the same day that the brick was removed. Due to the slenderness of the backup wall during removals, temporary shoring of the wall on the exterior was necessary.

EXECUTION

The project scope was tendered to pre-qualified Toronto-area restoration contractors and the client awarded the work. Due to the level of detail for this repair, the beginning of the project required a lot of lead time for reviewing shop drawings (with multiple revisions due to the complexity) and building mock-ups of the cladding and window installation before general work could begin.

The window mock-up was very important because it uncovered a few inconsistencies in the original construction and previous repairs. We expected that the concrete block backup would be continuous from the floor slab to the underside of the windowsill; in fact, we found 2 in. of mortar and a course of clay brick below the original marble sill. The mortar was not sound and needed to be removed, but the clay brick was not structurally adequate to receive the new window securement (because of the size of the brick cells). As we brainstormed solutions, we listened to ideas from everyone. The property manager who was with us during the mock-up suggested installing an aluminum tube under the window to receive the window anchors. The entire project team liked that idea because it also allowed for the vertical dimension of the window opening to be standardized. (The height of the existing window openings varied from suite to suite, but with the aluminum tube, a slightly smaller window could be installed and the tube used as the height adjustment.)

Another window installation issue was that false walls were previously installed in many units to manage leakage without actually repairing the exterior walls. In order to properly install the windows, this meant that a lot more drywall and plasterwork were required beyond what was expected in the design phase. This unforeseen condition did not affect the cladding or window design, but added time and cost to the project and disruption to the residents.

We also found that each unit had electrical conduits that ran floor-to-ceiling to a wall-mounted interior outlet. The original builder broke open the exterior side of the concrete block cells in the backup wall to run the conduit. Based on the corrosion of the conduits and interior plaster damage, the cell openings were a leakage path into the suites. We could have filled the cells with mortar, but the cure time would have delayed installation of the membrane. This would not only slow down production, but also leave a portion of the wall unprotected if it rained or snowed. Instead, we installed sheet metal pin-bolted to the two sides of the opening, this provided a sound sub-
strate to adhere the continuous membrane across the void.

There will always be minor issues with every project, and this project was no exception. However, the extra time we spent during the planning, design, and mock-up phases was a good investment and led to a fairly trouble-free construction process.

While as consultants we were focused on design and engineering, there was a lot of coordination and effort on the part of the property management and the contractor to make this project a success. The project got off to a slow start, but as the contractor refined construction sequencing and coordination of its forces and subtrades, work progressed more quickly. Property management and the board provided quick answers when needed to avoid delays in construction and helped to coordinate interior access for the window installation.

The important thing is to not make the same mistakes again, so we applied the lessons learned from the Phase 1 reskinning work into the specifications for the subsequent phases of the multiyear project.

VALIDATION

Our test openings during the evaluation exposed only a small percentage of the total wall area. To determine if the extrapolation of our evaluation findings was correct (i.e., that the shelf angles were typically significantly corroded), we had the contractor mark the floor number on the original shelf angles before removing them, and then they stored the original angles for our review. We found that our evaluation estimates were similar to the actual shelf angle deterioration, but also found areas of severe corrosion next to areas with no corrosion (Photo 10). This could mean that some severe corrosion areas could have been missed if a localized shelf angle replacement repair strategy had been implemented (such as the bronze-level repair proposed), leaving the client with risk for future significant repairs. Our findings supported our initial recommendation and the client’s choice to proceed with the reskinning solution.

CLOSING

Reskinning was an innovative solution to address multiple issues identified with the existing exterior masonry wall assembly. Reskinning may not be the right solution for every building type or client, but in this case, it met the client’s objectives for a long-term, lower-maintenance solution. The added moisture resistance and knowing that the structural safety concerns have been removed outweighed the added costs. Although this project’s primary purpose was not to improve the energy efficiency of the building, the added insulation and airtightness provide energy savings and improved resident comfort.

To date, the reskinning project has been completed only on a small portion of the building to address immediate public safety concerns and leakage. Further phases of reskinning will be completed based on further evaluation and determination of priority areas.

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