Partial Rehabilitation: The Challenges of Tying-in a Drained Glazing System with a Face-Seal Wall System

ABSTRACT

A high-rise building located in Vancouver was diagnosed with water penetration at the window-wall system. The opaque walls were clad with panelized, face-sealed EIFS. The investigation found no major deterioration in the EIFS area and it was decided that the rehabilitation would include only the replacement of the window-wall system. Retaining the existing, face-seal EIFS in place brought on a number of challenges:

- ***The size and layout of the new window-wall differed greatly from the existing window system:*** *The existing window-wall was installed before the panelized EIFS making it difficult to remove without damaging surrounding elements. The new window-wall had a thicker mullion than the original, and needed to be installed in a different vertical plane. The continuity of the air barrier required special attention.*
- ***The existing EIFS had no internal moisture barrier:*** *The new window-wall system is a drained assembly with an interior secondary moisture barrier that needed to be connected to an existing system that does not incorporate an interior moisture barrier. Because of the nature of the two systems, the connection between them was very challenging and required an innovative approach.*
- ***The existing EIFS was very fragile****: The removal of the existing sealant and the installation of the new components at the transition details were very difficult. Because of the face-seal nature of the existing EIFS system, damage to the remaining system could have a great impact on future performance.*
- ***The demands of external stakeholders****: The owners were seeking a 10-year warranty period on water penetration from a third party. The interest of the warranty provider was to prevent any water entering the existing EIFS system from contaminating the new window-wall system. This brought another level of detailing that is not essentially required for the overall performance of the wall.*

This paper will discuss innovative details that were used to solve some of the design issues brought on by keeping the original EIFS system in place. In particular, it will cover how the new window-wall system was installed in the existing EIFS system, and the influence this had on the scope of work. For this purpose, the author will draw on her experience with other projects of similar nature.

BACKGROUND INFORMATION

Starting in the late 1990s, the Lower Mainland of British Columbia saw the beginning of what would become a "leaky condo crisis" whereby buildings built in the eighties and nineties were experiencing water penetration problems. Water penetrating through the cladding and windows was causing major structural damage which, to be repaired, needed a full building envelope rehabilitation. This was a major concern to many residential homeowners since such repairs were very costly. The Barrett Commission [1] was created to restore confidence in the construction industry and issue recommendations. This inquiry looked into the quality of condominium construction.

The Barrett Report made specific recommendations to address the crisis. Some of these recommendations created changes to the way the construction is carried out today in the Lower Mainland. For example, the Homeowners Protection Office (HPO) is now responsible for the administration of interest free loans and the requirement for mandatory third-party home warranty insurance. This influenced the process of construction when it came to building envelope. In respect to rehabilitation, it influenced the extent of the building envelope repairs undertaken. While targeted repairs are done, it is not encouraged by the system in place.

Other changes were initiated by the City of Vancouver. In 1999, the City of Vancouver introduced, in their Building By-Law, the requirement for a drainage cavity behind any cladding. They also introduced the requirement for a building envelope professional to be involved in any multi-residential project. These requirements, among other things, encouraged better construction practices and these practices slowly got extended throughout the lower mainland. It became second nature for professionals in British Columbia to incorporate a drainage cavity when developing building envelope details.

WATER MANAGEMENT FOR WINDOWS

Poor windows and window to wall interfaces have been linked to building envelope problems for several years. Publications discussing the need for controlling rainwater penetration through glazing were issued as early as 1964 [2,3,4]. Unfortunately, until the leaky condo crisis, little was done to improve window performance and window installation was done with minimal care.

Older window systems often used a face-sealed approach to their design. This implied that they relied on the continuity of the primary exterior seal to prevent water penetration (refer to Figure 1) and to provide the plane of air-tightness. Many of these systems have experienced water penetration problems since once the water is past the exterior seal there is no provision to contain this water or to drain it back to the exterior. This emphasizes the inadequacies of the single line of defence approach.

Windows, like wall assemblies, have evolved into incorporating rainscreen principles (refer to Figure 2). The rainscreen window has a secondary seal that provides both the moisture barrier and the air barrier. The secondary seal is different from the primary exterior seal (or shedding surface). It also includes drainage capabilities. With respect to the watertighness, the separation of the two critical barriers (moisture barrier and shedding surface) allows incidental rainwater that penetrates through the water-shedding surface to be contained and drained back to the exterior [5,6]. The adoption of this strategy of window design over the face-seal approach greatly improves the performance of a window system.

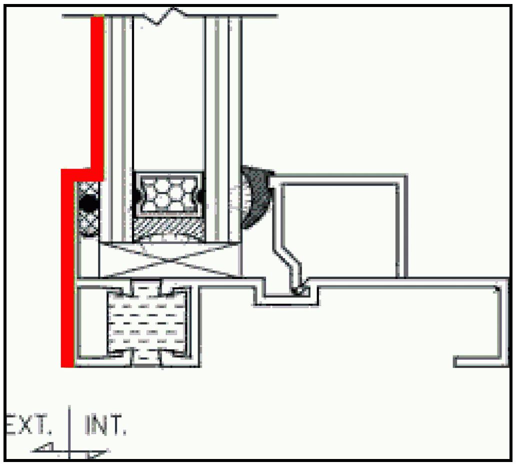


Figure 1: Face-seal window with primary exterior seal

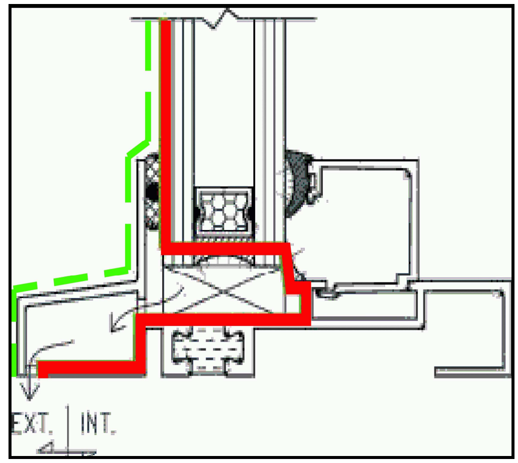


Figure 2:Drained window with primary and secondary seals

Figures 1 and 2 based on figures from "Water Penetration Resistance of Windows"(CMHC) [5]

In addition to the window system, the installation of the window within the wall system should also be considered. Even rainscreen windows can lead to water penetration problems if appropriate measures to connect the window to the wall assembly are not taken. The critical barriers such as the air barrier, the shedding surface and the moisture barrier should be continuous between the wall and the window. The incorporation of sub-sill flashing is another measure that is critical to the best performance of a window system within a wall assembly.

THE REASONS BEHIND THE PARTIAL REHABILITATION

The rehabilitation project discussed within this paper included the removal and replacement of the existing face seal window-wall system and associated slab edge cover with a new rainscreen window-wall system but did not include the replacement of any adjacent EIFS walls. The limited scope of the rehabilitation was based on the following findings:

- The window-wall system was the source of several leaks. In addition to causing damage to the interior finishes, these leaks were responsible for severe deterioration to the window-wall structural attachments to the slab.

- The punched windows also appeared to allow water ingress, but no collateral damage was found. The structural integrity of this system was still adequate.

- The EIFS walls were found to be in fair condition. While there was evidence of moisture ingress at caulking joints within the system, it resulted in only light rust and water staining. Replacing the sealant joint was part of the maintenance plan.

Based on these findings, the strata decided to proceed with only the window-wall replacement. The decision was mostly based on economic factors, whereby the strata opted to minimize the cost of the rehabilitation by proceeding with the rehabilitation of elements that were critical. In discussion with HPO and a potential third-party warranty provider, it was agreed that this approach was possible.

LIMITATIONS IMPOSED BY THE EXISTING CLADDING AND THE NEW WINDOW SYSTEM

For this particular project, the existing window-wall was actually a punched window installed from slab to slab with a metal panel at the slab edge. Figure 3 shows the sill and head detail for the existing window. The window had a 3-inch thick aluminum frame installed flush with the face of the slab. The frame was set over a U shaped clip at the sill, which was fastened down to the slab and abundantly sealed but did not incorporate end-dams. At the head, the frame was set into a deflection header, which was also set in caulking. The slab edge was covered with liquid applied membrane and semi-rigid insulation. The metal panel was protruding from the glazing system. At the jamb, the frame was oversized, extending a few inches behind the EIFS. This is illustrated in Figure 4.

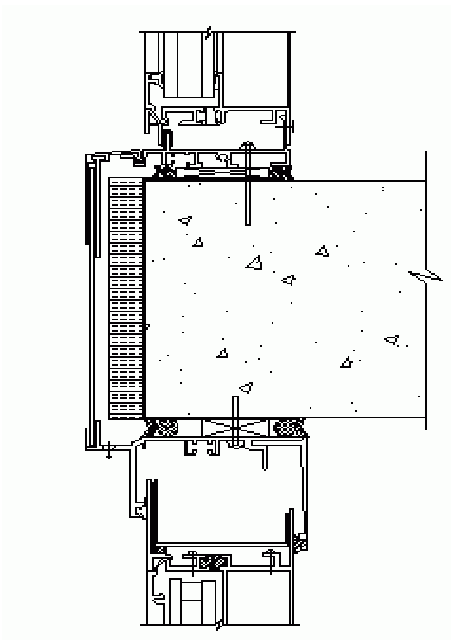


Figure 3: Existing window head and sill detail

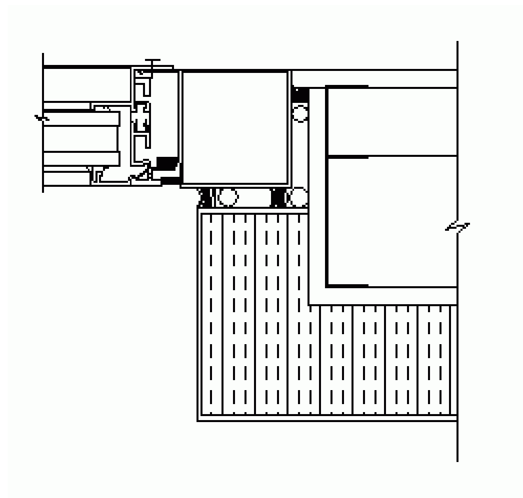


Figure 4: Existing window jamb detail

The new glazing system is a modern window-wall with a split frame overhanging the slab edge and creating a spandrel section. The frame between the slabs is 4 ½ inches thick and is installed to overhang at least 2 inches past the edge of the slab (refer to Figure 5). At the front of the slab, only the front half of the frame continues down to the next window. This is typical of most window-wall systems available in Vancouver. It gives very little flexibility in terms of the position for the window.

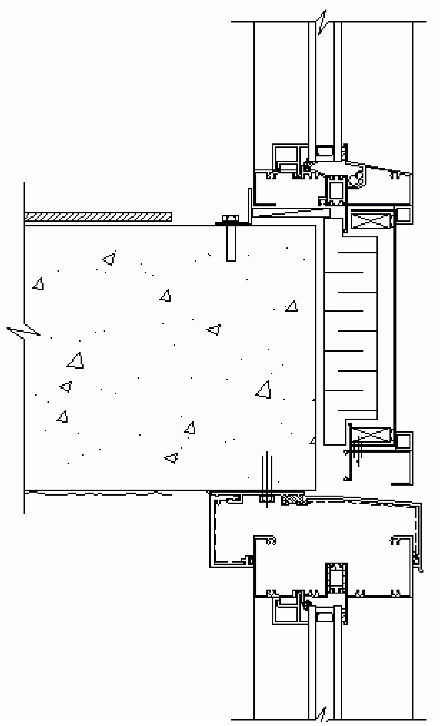


Figure 5: New window-wall head and sill profile and position

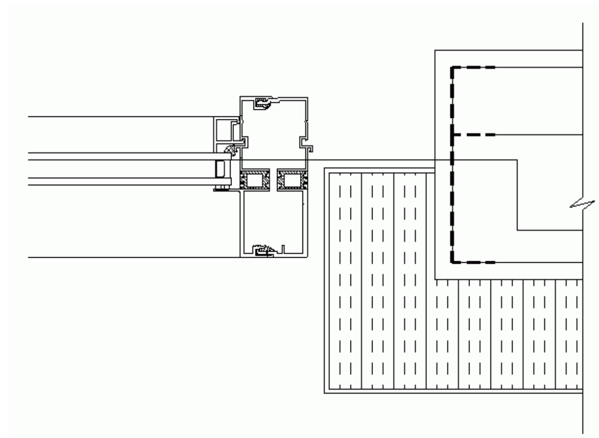


Figure 6: New window-wall jamb profile and position

The size and layout of the new window-wall differed greatly from the existing glazing system

The EIFS cladding and other existing elements of the wall assembly were evidently installed to suit the existing window. Since the new window was thicker and needed to be installed in a different vertical plane than the existing window, it created challenges with the detailing.

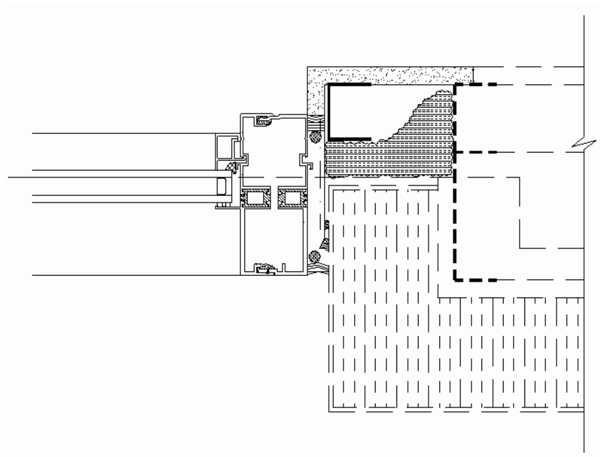
Because the interior plane of the window was pushed out to allow for the by-pass, this created a gap in the interior finishes at the head and sill. This was easily corrected by the use of trims and the installation of new finishes. In addition, because the by-pass was an integral part of the window system, the windows needed to be installed in a specific order: from the bottom of the elevation up. The window head detail could not be properly installed if the window (and by-pass) above was in place because of the limited access.

Moreover, the window frame could no longer fit behind the cladding at the jambs. This created a gap at the window jamb, exposing the edge of the EIFS panel to the interior (refer to Figure 6). How to deal with this space, and more specifically how to connect the window critical barriers to the wall assembly was the most important challenge. This was especially complicated given that the EIFS did not incorporate a secondary or internal moisture barrier.

The existing EIFS had no internal moisture barrier

It is much easier to make a rainscreen interface transition when both assemblies utilize that strategy. However, it is much more challenging to achieve continuity of the critical barriers at the window to wall interface when one of the systems utilizes a face-seal approach as opposed to a rainscreen. In this case, the window-wall is a rainscreen system whereas the EIFS wall is a face-sealed assembly.

For face-seal EIFS, the lamina is of course crucial. In terms of water management, it is both the shedding surface and the moisture barrier. In addition, the lamina is arguably the most airtight element of the wall assembly. . Therefore, it is important to connect both the window-wall shedding surface, which is located at the face of the system, and air/moisture barrier, which is located at the back of the system (refer to Figure 2), to the lamina of the EIFS to achieve continuity of these critical barriers.



Connecting to the EIFS lamina was not easy. Because the lamina is rough and thin, it was not possible to either grind it or adhere any sheet membrane to it. It seemed that the most practical way to achieve the tie-in was to install a sheet metal break-shape that would be caulked to the EIFS lamina. This sheet metal would become the support for a continuous self-adhesive membrane. The continuity in the membrane was especially important at the transition from the sill detail to the jamb detail. This is shown in Figure 8 where a 3D representation of the window detail is presented.

Figure 7: New window-wall jamb detail

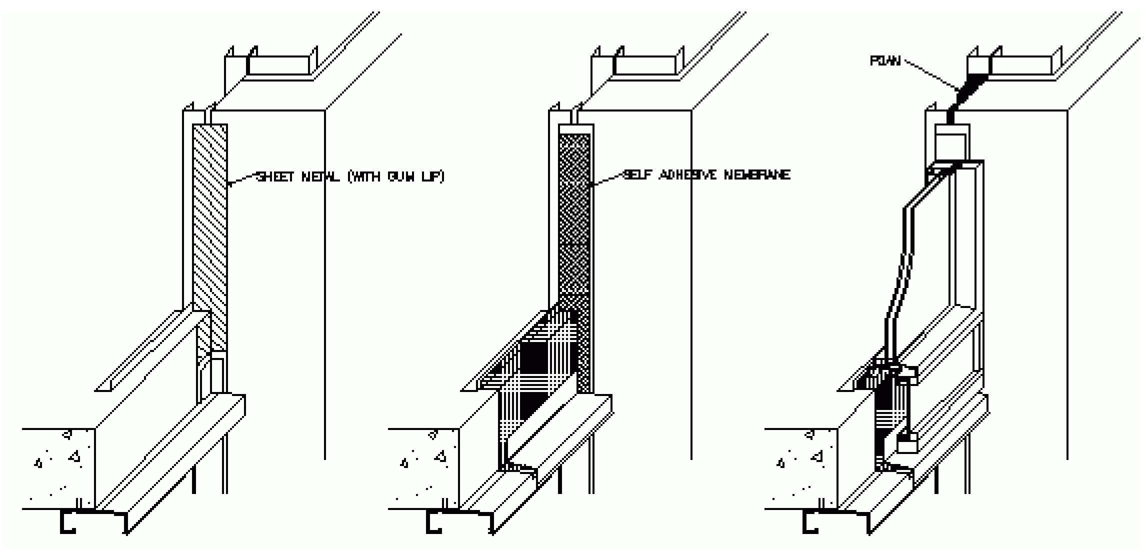


Figure 8: New window-wall detail 3-D representation

The sheet metal also made the connection to the back of the window more manageable. With this metal support, the membrane was installed within one inch of the back of the window allowing the use of caulking between the window frame and the membrane to create the continuity in the moisture barrier (and air-barrier).

Finally, to introduce some redundancy in the detailing, urethane spray foam was applied to the void space left by the old window system. The spray foam was installed to the back of the metal support and the end of the face-seal EIFS panel and it further segregated the remaining wall system from the new window system. In order to have the maximum coverage in terms of spray foam, it was important to reduce the amount of framing at that location. And to do so, it was better to have the window system self-support itself from slab to slab thus the double window frame at the jamb.

The existing EIFS was fragile

Because of the face-seal nature of the existing EIFS system, damage to the remaining system could have a great impact on the future performance. In addition, if repairs to the EIFS were needed, it could affect the scheduling for the replacement of the windows as the cementitious coating forming the lamina of the EIFS takes a few days to cure. It was therefore necessary to minimize any disturbance to the existing EIFS.

The jamb detail presented above was developed with this in mind. Instead of modifying the EIFS to continue the window up to the original position, the window was kept back to the face of the existing EIFS. Nevertheless, damage to the EIFS was unavoidable. Since the existing window frame was hard to remove and abundantly caulked in place, the removal of the window frame inadvertently caused some damage as the workers pried their crowbars on the EIFS lamina or simply, during the removal of the caulking, pulled away the EIFS lamina (refer to Photo 1).

Photo 1: Damage to the existing EIFS

Photo 2: Existing condition of the EIFS

In addition to the damage caused by the removal of the window, there was pre-existing damage to the EIFS. The majority of this damage was related to the installation of the EIFS panels around the slab edge metal panel of the existing window. Since the metal panel were installed first and they ended up extending beyond the face of the EIFS return at the widow jamb, the prefab EIFS panels were notched to fit the metal panels (refer to Photo 2).

The demands of external stakeholders

The owners and the designers were not the only stakeholders in this project. In British Columbia, there is a requirement for third-party warranty coverage on building envelope rehabilitation that exceeds a certain dollar amount or a certain percentage of a building elevation. The rehabilitation discussed in this paper qualified under that requirement and the window-wall replacement needed to have third party coverage.

Moreover, the owners were seeking to obtain a 10-year water penetration warranty, a higher level of coverage than the minimum required by legislation. The interest of the third-party warranty provider is to avoid risk for the ten years they will provide coverage and although they may be covering only the window-wall area, they are also interested in preventing contamination from a possible leak in the adjacent assemblies.

The requests of the warranty provider needed to be incorporated in the design. Although most requests were a valuable improvement on the design, some requests were rather costly and the value of the associated change debatable. Some of the changes that came out of their review included:

- The addition of canopies above all doors
- The addition of a gum lip at the front of the jamb metal support
- The replacement of the acrylic paint for the existing EIFS with a silicone elastomeric coating.

There is no doubt that all of these items have some value. However, since the interest of the warranty provider is not to weigh the risk but rather to eliminate it, the additional cost associated with some of these changes may have ended up being disproportionate to the improvement they provided. The last item (elastomeric coating) was the subject of considerable debate. The reasoning was that the elastomeric coating "installed over the caulking joint would substantially improve the performance of the joint between the new window and the existing EIFS". The windows and the caulking joint being perpendicular to the EIFS wall and a different colour than the EIFS coating created a real problem; the coating would have to be applied with a taped edge and would be able to cover only a small portion (approx.1/8") of the caulking joint. Even after it was demonstrated through pull tests that the adhesion of the new caulking was adequate, the warranty provider insisted on the change and it came with an increase in cost of approximately $38,000.

Photo 3: Window-wall to EIFS / window installation below.

Photo 4: Window-wall to EIFS / window installation above

THE INFLUENCE ON THE SCOPE OF WORK (scope creep)

The scope of work for the project had a simple concept: replacing the window-wall while leaving the EIFS wall system in place. The reality was somewhat different. First, the configuration of the building had some influence. The external stakeholders, such as the third-party warranty provider, also had some say in the extent of the work, as previously discussed. And finally, the as-built conditions encountered during the repairs also created some changes in the scope.

The existing details that were causing problems and needed to be replaced were the slab by-pass conditions. Because of the lack of end dams and the way the windows were secured in place, most of the damage was happening at these locations. Any window with the problematic by-pass condition was therefore included in the scope of work. Some of the windows incorporating these details were not spanning all the way to the slab above or below (refer to Photo 5 and Figure 9). These were referred to as the double window-wall and were mostly located at the upper floors of the building. The challenge with those windows was to efficiently separate the EIFS from the window-wall at the head so that contamination could be prevented. This was impossible without removing some EIFS.

Photo 5: Double window-wall at upper floors

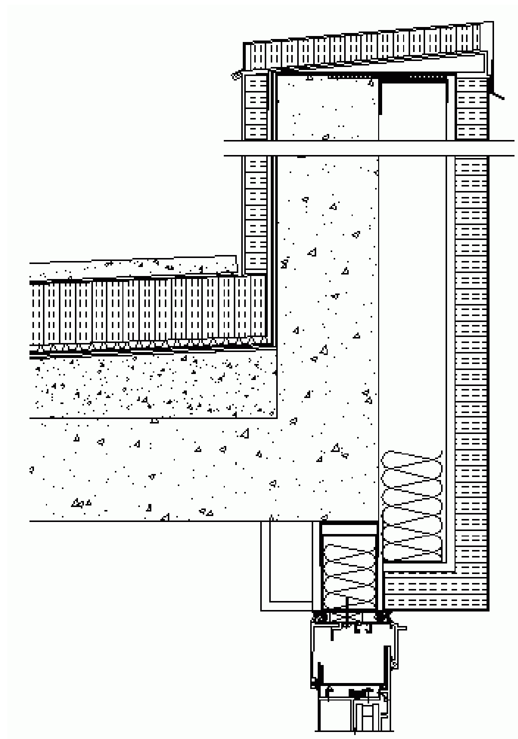


Figure 9: Double window-wall head and sill detail

During the course of construction, it was also discovered that the steel studs located at the front of the concrete up-stand at the base of these windows were, in some cases, badly deteriorated. Therefore, more EIFS needed to be removed. Eventually, it was decided that the upper three floors of the building, which incorporated most all of the double window-wall located in the face seal EIFS would be fully rehabilitated.

This was a direct consequence of the EIFS being a face-seal system. Because there is no moisture barrier membrane behind the cladding, there is nothing to naturally tie the window into, especially at the head where gravity is at work. The more vulnerable nature of the face-seal system also influenced the decision. Case in point, the double window-wall units located at lower floors were found in a brick veneer that incorporated a secondary moisture barrier. These were easily replaced with the new system with minimal tie-in problems (refer to Figure 10).

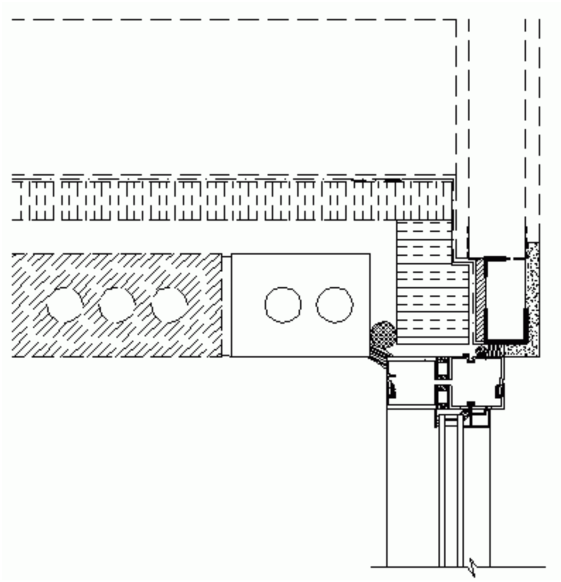


Figure 10: Double window-wall in brick

THE PERFORMANCE OF THE DETAILS DEVELOPED

For this project, the window installation was tested during construction. There were at least two types of tests performed on site that were relevant to the overall performance of the installation:

- The caulking installed between the window frame and the existing EIFS was tested. In that regard, the greatest concern was with the adhesion of the caulking to the EIFS lamina. The test cuts were performed at numerous locations using the technique described in Dow Corning's manual "Standard Field Adhesion Hand Pull Test". The caulking showed a good elongation (200%) without bond loss or damage to the EIFS lamina.
- The water tests, which were performed to a CSA-A440 B4 level following ASTM E-1105 "Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors and Curtain Walls, by Uniform or Cyclic Static Air Pressure Difference", challenged both the window and its installation within the existing cladding. The detail presented in figure 7 was therefore challenged during the field-testing. No leaks developed as a result of the testing.

The field-testing provided a certain level of comfort as to the adequate performance of the typical detail (figure 7). Long-term performance of the detail will only be demonstrated after several year of service. It is part of the Strata's maintenance plan to review the condition of the different building elements implemented during the rehabilitation.

CONCLUSION

When proceeding with a partial rehabilitation, there are technical aspects to consider. With respect to the building envelope, the continuity of the critical barriers (i.e. the shedding surface, the secondary moisture barrier and the air barrier) between the new and the existing assemblies is probably the most important and challenging aspect to consider. The solutions are often unconventional.

In this case, the size and layout of the new window system gave the designer very little choice as to the position of the window. In addition, the lack of secondary or internal moisture barrier in the remaining EIFS wall forced the designer to bend the perceptions of good design. Since for the face-seal EIFS, the lamina is both the shedding surface and the moisture barrier, the connection of the window moisture barrier was done to the face of the EIFS. The result was a transition detail that needed to include some redundancy, especially at the termination of the EIFS wall assembly, which was exposed to the inside. Multiple lines of caulking and foam were used to create that redundancy.

Further constraints were created by the fragility of the EIFS, which had less impact on the design but still influenced the schedule and the cost of the project. And finally, there were the political influences. With this project as with any project, it was important to understand the perspective and demands of the different stakeholders. In particular with the third-party warranty provider, it was important to grasp that the approach to detailing can only be discussed within their perspective.

Ultimately, the complexity of such a project needs to be recognized and dealt with upfront. Avoidance is not an option given the multitude of factors that influence the design and the construction process.

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