Innovative Window Injection Technique Saves Owner $500,000

By David Campbell, RWC, AIA

THE PROBLEM

Many apartment units of a recently built, four-story apartment complex in Minneapolis had experienced a history of water infiltration during heavy rains. It appeared as though the water was somehow entering the exterior wall system and migrating down into apartment units at various levels. The exterior walls were wood-frame construction with a stucco finish, and the windows were hollow aluminum-frame units.

THE INVESTIGATION

Inspec was hired to investigate the problem, determine the cause(s), and make remedial recommendations. Our investigation started with a systematic progression of spray-bar water testing at various suspect windows (*Photo 1*). The interior finishes were removed to better observe the infiltration into the wall system. By process of elimination, it was determined that the primary source of the infiltration was isolated to the windowsills. This was confirmed by flooding the windowsill tracks with water, which re-created the infiltration into the wall system between the window unit and the framed rough opening (*Photo 2*).

In addition, the exterior finish materials were removed around the window in order to examine installed flashings and weather-resistant barriers (WRB). Next, one window unit was completely removed and more closely examined for installation and/or design defects. It was discovered that some of the factory-installed gaskets, which provide a thermal break between the exterior and interior window components, had shrunk as much as one-half inch over time (*Photo 3*). It was also discovered that silicone sealant had not been installed at the base of the aluminum jamb plates (*Photo 4*).

Photo 1 – Spray-bar water testing.

Photo 2 – Re-created water intrusion into wall system.

Photo 3 – The window thermal break had shrunk ½ in.

Photo 4 – Silicone sealant missing.

THE CAUSE

By removing the aluminum jamb plate, it is revealed that, in section, the operable windowsills are composed of two main chambers with a smaller chamber between them created by the thermal gasketing (*Photo 5*). The windowsill tracks are designed to drain through holes down into the corresponding chamber below, where the water then passes from chamber to chamber toward the exterior, following the chamber floor slope. Once in the exterior chamber, the water discharges through weep holes to the exterior of the window. Since the silicone sealant was not installed at the bottom of the jamb plate, the water that accumulates within the two main chambers also drains out the chamber ends at the jamb and enters the wall system between the window unit and the framed rough opening. In addition, the water in the middle gasket chamber enters the wall system in the same way, only through the opening created by the shrinking gasket at each jamb.

REMEDIAL RECOMMENDATIONS

Since the apartment complex had 375 window units that needed to be repaired, the conventional approach of removing each unit in order to install the missing silicone and fill the gasket opening would be cost-prohibitive, not to mention the collateral damage and tenant inconvenience that would also occur. It is for this reason that Inspec devised a solution that did not require the removal of the window units. Somehow a more elegant solution had to be developed that left the windows in place.

We decided to inject an expansive grout into the jamb ends of each of the three sill chambers. This could be accomplished without removing the window by reaching to the outside of the window from the interior. Since some of the chamber interiors could still be wet from the previous rains, we decided to use a hydrophilic grout that bonds well—even to wet surfaces. However, since hydrophilic grout expands to many times its liquid volume before it solidifies, a "containment dam" first had to be injected in order to limit this expansion and avoid filling up the entire chamber completely, thereby preventing the sill tracks from draining. A quick-setting foam was chosen as the containment dam material. Finally, new exterior weep holes would be drilled in the exterior chamber to weep the middle portion

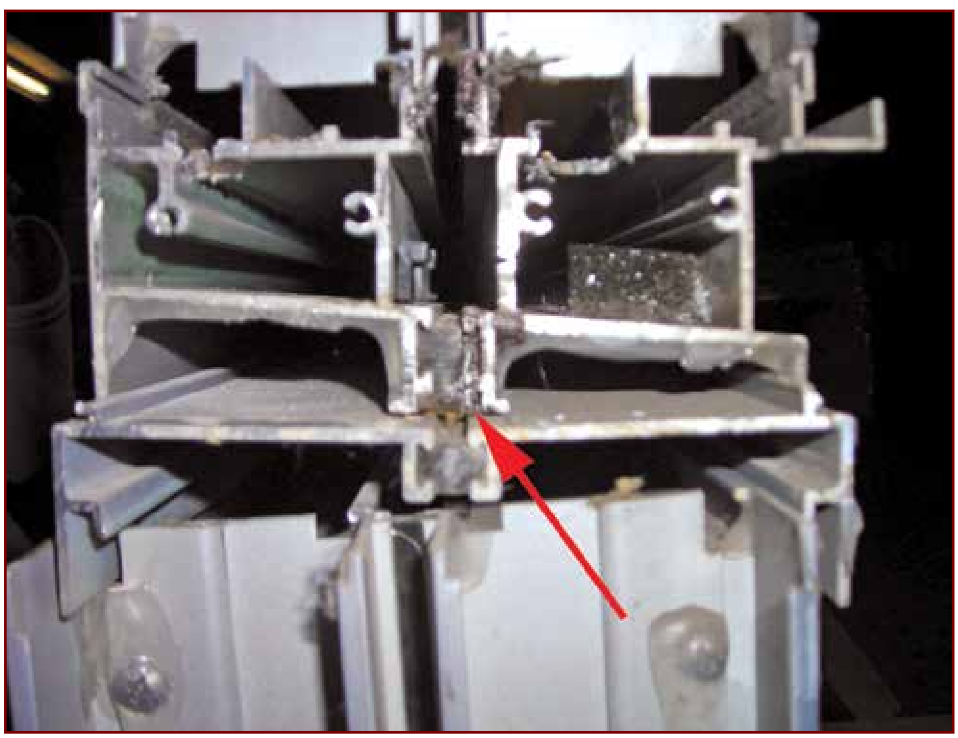


Photo 5 – Section through windowsill shows chamber created by thermal gasketing.

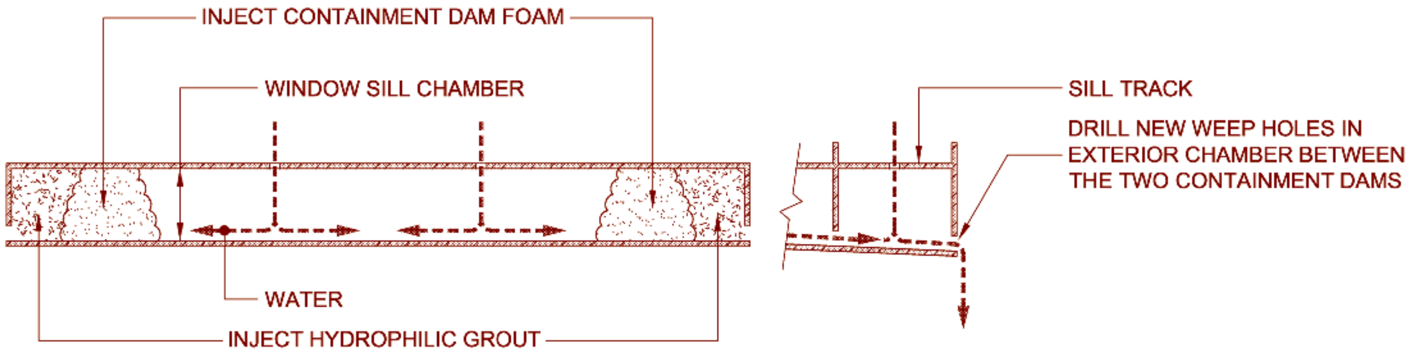


Illustration 1 – New weep holes are drilled in the exterior chamber to weep the middle portion between the two foam containment dams.

of the chamber occurring between the two foam containment dams (*Illustration 1*).

MOCK-UP TESTING

Since we were not aware of any other examples of similar window injection, we decided to test the procedure on a mock-up window first. One window was temporarily removed, taken into the building garage, and mounted upright in a wood frame to simulate the in-place condition. The window was injected with the containment dam foam first, and then the hydrophilic grout. Since hydrophilic grout not only adheres to wet surfaces but actually requires adequate moisture in order to completely activate or "kick," we had a special wand fabricated that would evenly distribute water into the chambers prior to the grout injection.

Once the jambs had been injected and the hydrophilic grout had adequately cured, we simulated an extreme rain event by keeping the sill tracks and the chambers completely filled with water. After 30 minutes, we observed no water leakage at the jamb ends of the window, indicating that the method worked.

EXECUTION OF THE REPAIR

The above-described repair procedure was refined further and used to repair the in-place windows of the apartment building. The final procedure was as follows:

Only the operable window units would be injected. All work would be executed from the interior of the building. Existing operable window sashes would not need to be removed—just slid from side to side during the work. All injection holes and new weep holes would be drilled into the sill frame on the exterior side, should penetrate all three internal chambers, and should follow the sloped "floor" of each chamber. The tenant would be notified in advance to move furniture and any other belongings in order to provide a clear path and work area at the window. The work should include providing all necessary protection so that no carpet or other contents were damaged or stained.

Step 1 – Temporarily remove screens.

Step 2 – Glue shut the existing weep doors on the window frame exterior with seven-minute epoxy.

Step 3 – Drill a ¼-in. hole through the exterior side of the sill frame at a point 12 inches in from both window jambs, the holes thus penetrating all three chambers and following chamber "floor" slope. Inject a small amount of the containment foam product into all three chambers (*Photo 6*).

Step 4 – Allow the containment dam one day to adequately cure and firm up.

Step 5 – Drill a ½-in. hole through the exterior side of the sill frame at a point 1 inch in from both window jambs. Holes should penetrate all three chambers and follow chamber "floor" slope. Inject water into all three chambers to prewet the chambers, and then inject the hydrophilic grout into all three chambers using a hand-held caulk gun (*Photo 7*). Grout should eventually foam up through the existing weep holes located in the sill tract at the jamb ends (*Photo 8*). The purpose of the

Photo 6 – The "containment dam" foam is injected.

Photo 7 – The hydrophilic grout is injected.

Photo 8 – Grout foaming up through existing weep holes indicating a complete seal at window jamb.

hydrophilic grout is to seal the jamb ends within each of the three internal chambers. (Note: Reduce the amount of grout as the window frame heats up.) Injection water should not be warm.

Step 6 – Allow the hydrophilic grout one day to adequately cure and seal.

Step 7 – Clean excess grout out of the window tracks and from around holes.

Step 8 – Drill four new ¼-in.-diameter weep holes down through the sill tracks at specified locations.

Step 9 – Drill two new ¼-in.-diameter weep holes on the exterior side of the sill frame. Holes should penetrate all three chambers, should follow the slope of the chamber "floors," and should be located 18 in. apart.

Step 10 – Seal injection holes with a color matching that of the window frame. Do not seal newly drilled weep holes.

Step 11 – Reinstall screens.

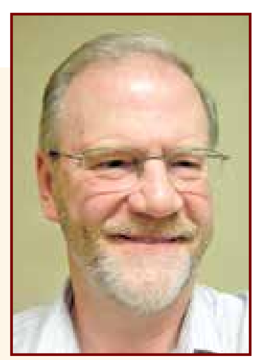
CONCLUSION

The cost of repairing the windows using the conventional method of removing them from the building would cost an estimated $650,000 (375 windows @ $1,730/window). The cost using the injection method was $150,000 (375 windows @ $400/window). This represented a savings to the owner of $500,000.

Since the windows have been exposed to numerous rain events without any reported leaks, it is reasonable to assume that grout injection is a viable repair technique as an alternative to conventional window removal and could be used for repairing windows with similar infiltration failures at great savings to building owners.

Note: A shortened version of this article was originally published in the July/August 2011 issue of Facilities Engineering Journal.

David Campbell, RWC, AIA



David Campbell is a firm associate with Inspec, Inc., where he has been employed since 1994. He is a licensed architect, a Registered Waterproofing Consultant, and an accredited Green Roof Professional. Campbell also teaches a course on the Building Envelope and Below-Grade Waterproofing at the University of Minnesota. He has received numerous awards for his work in failure investigation and design and was the 2011 recipient of the Richard M. Horowitz Award for technical article writing from RCI. Inspec, Inc. is an independent, award-winning engineering/architectural firm founded in 1973 with offices in Minneapolis, Milwaukee, and Chicago.