Experience Music Project

– A Different Sort of Waterproofing Challenge

By Ray Wetherholt, F-IIBEC, RBEC, PE

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In 1998, the author was called by the senior project manager of the general contractor who was tasked with constructing what was then called the Experience Music Project, in Seattle, Washington, designed by renowned architect Frank Gehry. Over the years, the name and mission have changed, and the building now goes by Museum of Pop Culture or MoPOP.

The basic design was a structural steel frame of cut and welded plates to form curved T shapes, infilled with structural shotcrete, covered by exterior waterproofing and an exterior color-treated stainless-steel skin. The problem was that the shape of the shotcrete was not flat or monosloped. It was curving in all directions, meaning that a standard roll or sheet waterproofing would not work.

An additional problem was that the panels of the stainless-steel skin would be supported by an exterior framing on pipe pedestals (*Figure 1*). Sort of a structural porcupine.

The design and construction of the building used CATIA three-dimensional (3-D) CAD software (*Figure 2*). Architect Frank Gehry's technology company, Gehry Technologies, adapted the CATIA program for use on his various projects, including Guggenheim Museum Bilbao and others.[1] The CATIA program allowed for 3-D design, which was then used for the fabrication and erection of the steel and

Figure 2. Interior view of framing, looking towards the roof. Photo courtesy of Ray Wetherholt.

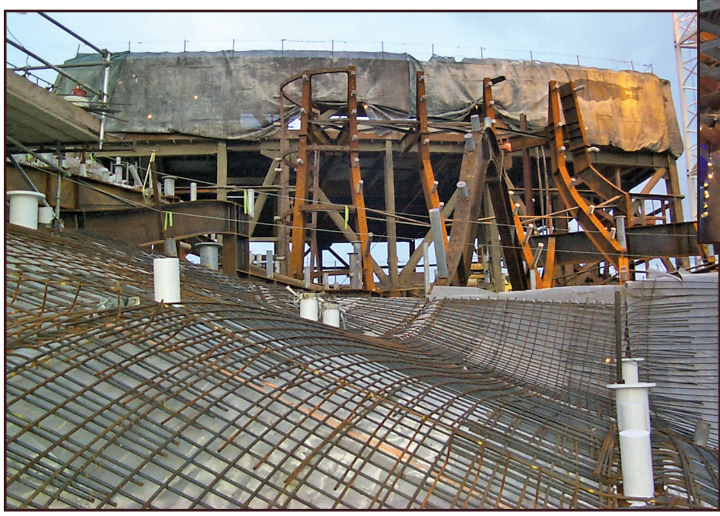

Figure 1. The structural steel framing over flexible formwork was then enveloped with shotcrete. Photo also shows a few of the many pedestals. Photo courtesy of MoPOP staff.

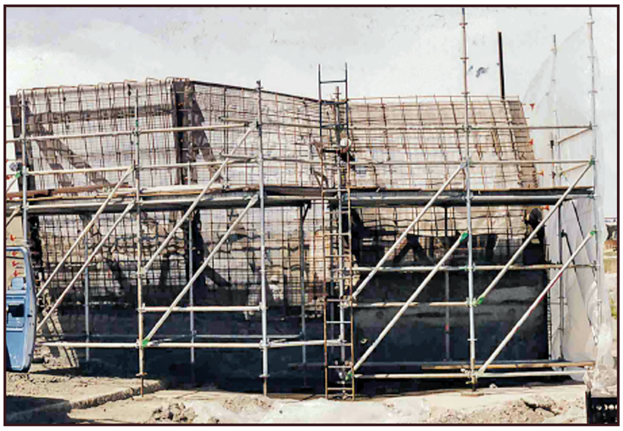

Figure 3. Reinforcement steel and scaffold of the mock-up prior to shotcrete. Photo courtesy of Wetherholt and Associates, Inc.

the formwork, instead of the 2-D standard techniques usually used in construction.

When we were retained, the waterproofing consisted conceptually of a 60-mil (1.5-mm) self-adhered modified-bitumen, polyethylene-surfaced sheet product, which is commonly used below grade. During the preconstruction phase of the project, the construction team immediately realized they needed to change the waterproofing to something more robust that would accommodate the complex geometry of the structure.

The owner let the contractor guide the design along with Frank Gehry's project architects.

A waterproofing system using hot, rubberized asphalt (HRA) was selected to be applied over the shotcrete exterior. The surface of the shotcrete was similar to stucco, not rough, and not steel-troweled smooth. We thought the HRA would adhere relatively well to the shotcrete, but would the workers of the waterproofing contractor be capable of applying the HRA to the vertical, curvy, and sometimes overhead surface? In order to validate the concept, both the waterproofing subcontractor and the manufacturer were engaged. HRA and an asphalt-modified coating were reconsidered, both with reinforcement.

After review of the modeling, a mock-up (*Figure 3*) was constructed off-site to test and refine the application techniques. Roofing workers were able to use squeegees, trowels, and big, long-nap rollers. The reinforcing was changed to a woven polyester mesh that could conform to the shape and that was light enough not to pull the HRA off the surface of the shotcrete. The surfacing sheet varied depending on the slope of the surface for the HRA, so as not to pull the HRA off.

The mock-up included both the HRA and a roller-applied, asphalt-modified urethane coating (*Figure 4*). The modified-asphalt coating bubbled and blistered, did not adhere as well as the HRA, and was soon abandoned.

As demonstrated by the mock-up, we then considered the application of foam insulation and acrylic coating. Over the nominally 220-mil- (5.6-mm-) thick, reinforced HRA, a layer of sprayed polyurethane foam (SPF) was carefully applied. The concern was that the SPF would shrink and pull the HRA off the shotcrete. The author had experienced SPF pulling waterproofing off of a shotcrete surface, finding that the surface roughness of the shotcrete was important to achieving good bonding of the HRA, which, in turn, helped resist the shrinkage and delamination of the SPF. In this case, the surface roughness of the HRA couldn't realistically be controlled. Some of the shrinkage appeared to be mitigated by spraying smaller areas of SPF at a time, and by the cladding

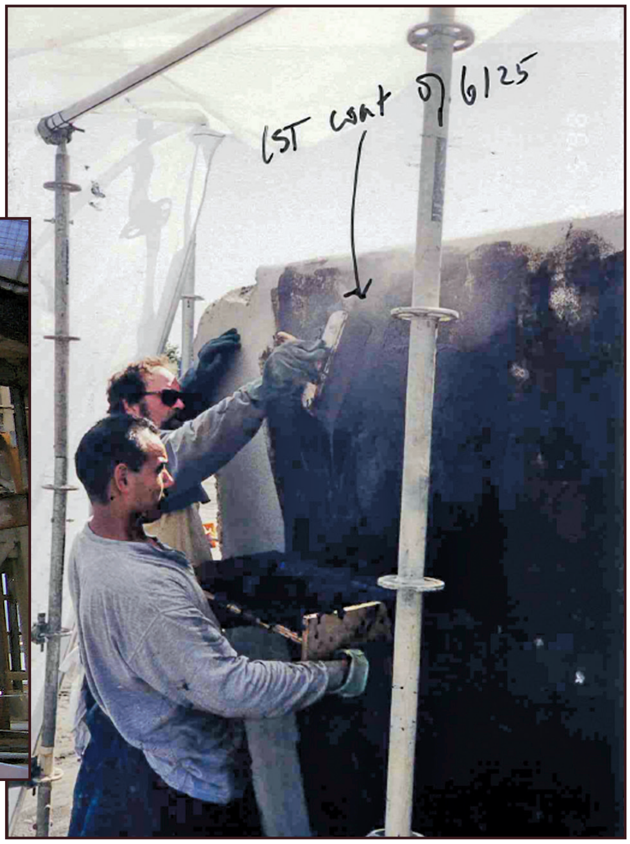

Figure 4. Troweled-on HRA with trough held by worker in foreground. Photo courtesy of Wetherholt and Associates, Inc.

Figure 5. Photo shows acrylic coating, SPF exposed at repairs, and active monorail. Photo courtesy of MoPOP staff.

pedestals, which were numerous, penetrating the HRA and SPF. An additional layer of acrylic coating was applied over the SPF (*Figure 5*).

One of the keys to the successful waterproofing and SPF application was full-time monitoring of the application of the various layers. Another was the cooperation among the various team members (see *Teamwork* sidebar).

During the construction process, the areas of work were protected by tenting and enclosure of the scaffolding. However, unlike during most construction projects, the Seattle Monorail, connecting downtown Seattle and the Seattle Center, remained active through the site during construction.

The areas surrounding the monorail portals were waterproofed at night, between 11 p.m. and 5 a.m., and utilized removable scaffold and lifts. *Figure 6* shows the monorail at upper left, HRA installation in progress, and tenting at right.

Once the waterproofing work was complete, the only leakage reported was due to an open hole in one of the cladding pedestals that inadvertently had not been plug welded.

In November 2020, the author met with MoPOP management staff who indicated that no leaks have been reported to date from the areas waterproofed, after 22 years in service.

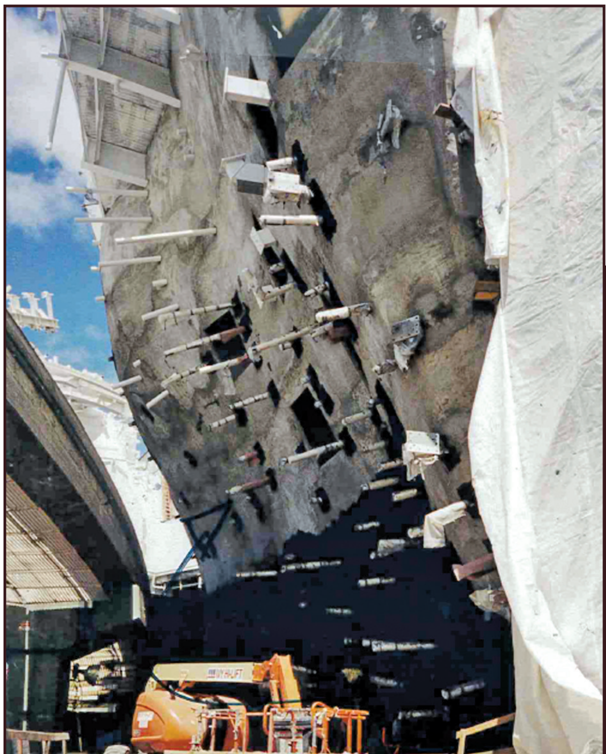

Figure 6. This photo shows the monorail at upper left, HRA installation in progress, and tenting at right. Photo courtesy of MoPOP staff.

TEAMWORK

A key to this successful project was cooperation among the various team members.

Owner: Vulcan, now MoPOP

Architect: Frank Gehry

General contractor: Hoffman Construction

Roofing/waterproofing contractor: Snyder Roofing

Waterproofing manufacturer: American Hydrotech

Shotcrete contractor: Johnson-Western

SPF and coating contractor: Walker Specialty Construction

Waterproofing consultant: Wetherholt and Associates, Inc.

There have been leaks at the intersection of skyward-facing glazing with the shotcrete at gaskets (*Figures 7* and *8*).

This complicated project was a "once in a lifetime" experience for the writer. It was a great demonstration of how thinking outside the box forced creative solutions to be reviewed and evaluated. The most promising solutions were then mocked-up by skilled craftsmen. Once the project was underway, the entire team worked cooperatively to achieve the goal of a successfully waterproofed building. This author is grateful to the MoPOP staff for a tour of the facility during COVID-19 restrictions, and for receiving permission to use their photo archives for research, and to include some of those photos in this article. IIBEC

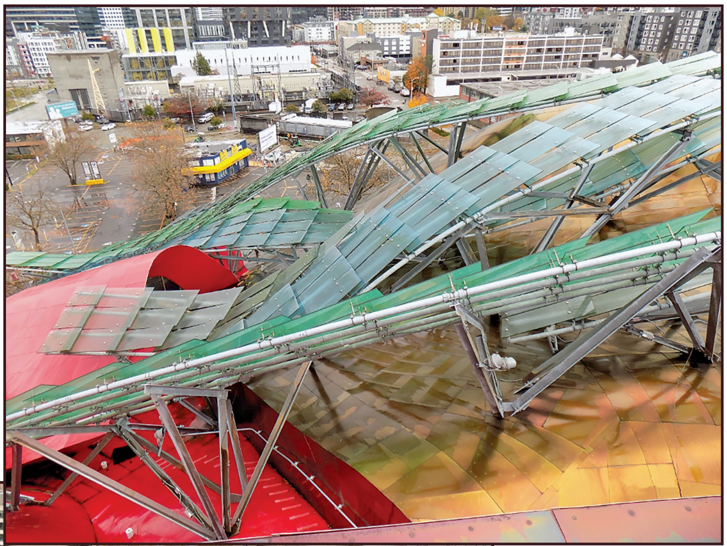

Figure 7. Looking down from an upper element at lower skin and flow elements. Photo courtesy of Ray Wetherholt.

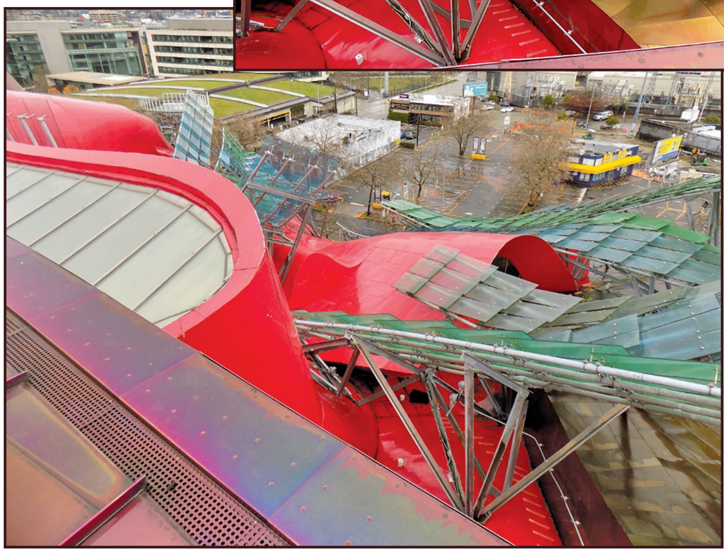

Figure 8. Looking down on lower elements and the curved edge of the glazing at the skylight at left; some of the glazing is experiencing a limited amount of leakage. Photo courtesy of Ray Wetherholt.

REFERENCES

1. https://en.wikipedia.org/wiki/Digital_Project

Ray Wetherholt

Raymond Wetherholt, F-IIBEC, RBEC, PE, started Wetherholt and Associates in Redmond, Washington, in 1984. Prior to that he worked for a commercial construction inspection and testing company as their inspection supervisor and special projects troubleshooter. He has consulted on a broad array of projects throughout the Pacific Northwest, ranging from commercial projects to residential green roofs, manufacturing buildings, and the Experience Music Project. In 2013, he received IIBEC's Outstanding Educator Award, and he was named a Fellow of IIBEC the same year.

Solar Panels at High Altitude on Hawaii's Big Island

In an effort to reduce their carbon footprint and in line with their desire to be "good stewards of the planet," the W. M. Keck Observatory on Hawaii's Big Island now has 332 solar panels. The panels will provide 259.1 MWh of power annually, or about 10-15% of the observatory's energy requirements.

Duke Energy's REC Solar company, who installed the panels, had to contend with several particularly difficult factors. First, the panels are 13,600 ft. above sea level, which is reportedly the highest a solar panel array of this size has ever been installed. High wind gusts are typical several times a year, so wind resistance was a major consideration. The 20,940-sq.-ft. ballasted roof has no structural framework to which the system can be anchored, so specialized mechanical attachments were created. When it came time for the actual installation, there was also the issue of working at such a high elevation, where there is about 40% less oxygen than at sea level.

The panels are "strategically located" between two of the observatory's domes, Keck I and Keck II, to prevent ice and snow from atop the domes from impacting the solar panels.

Watch a brief video here: https://vimeo.com/489504779

— keckobservatory.org, *Daily Energy Insider*

Photo by Mark Devenot