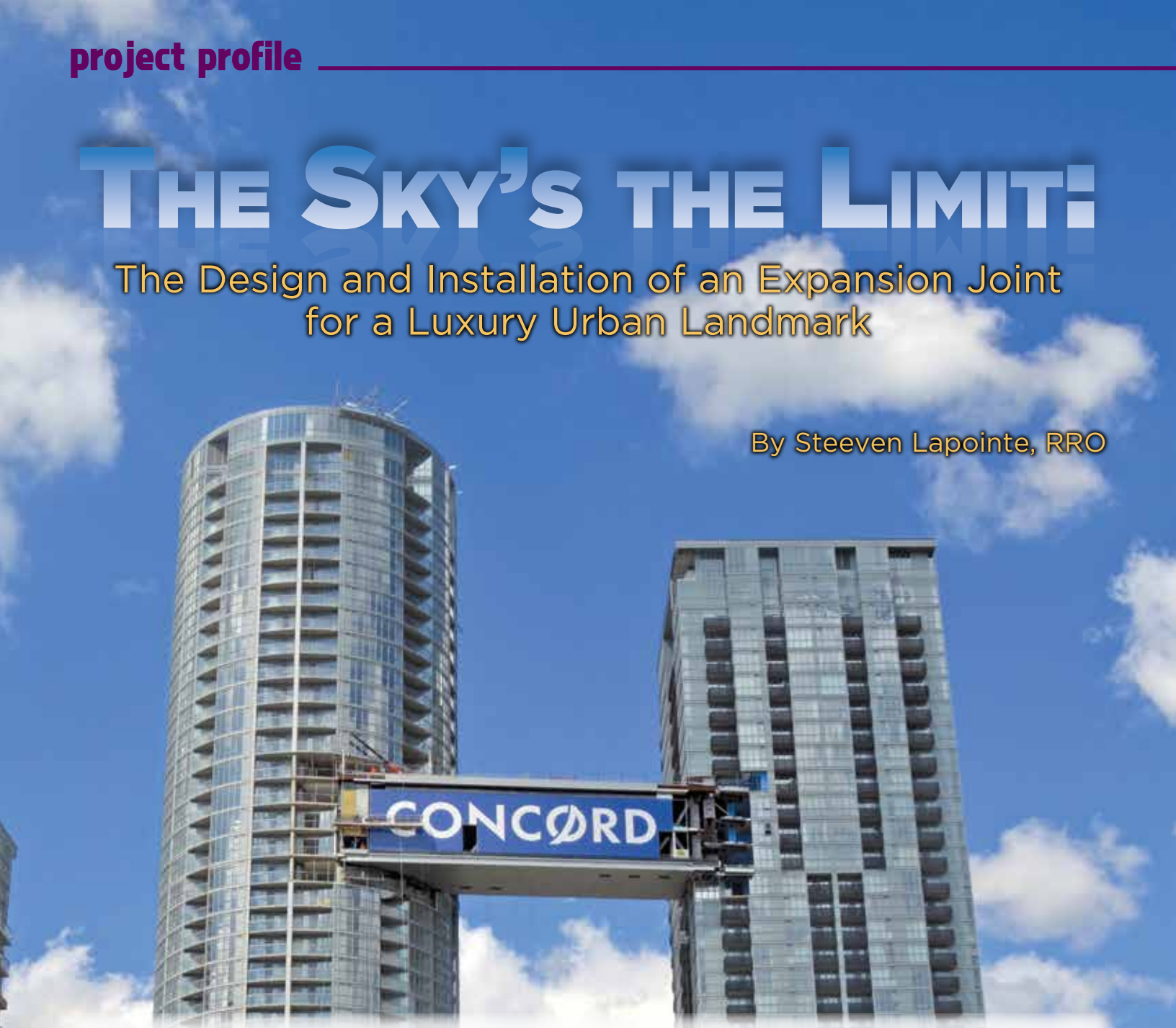
The Sky's the Limit:

The Design and Installation of an Expansion Joint for a Luxury Urban Landmark

By Steeven Lapointe, RRO



Standing tall among the iconic CN Tower and Rogers Centre is a new landmark in Toronto's ever-growing, interconnected cityscape. The Concord CityPlace Skybridge, designed by Kohn Pedersen Fox Architects and Page + Steele/IBI Group, is a three-story, 130-foot (40-m) structure linking the Parade towers located near the city's prosperous waterfront.[1,3] The top two floors of the bridge feature two large luxury condominium residences (one suite at 4,200 sq. ft., the other at 3,600 sq. ft.)[1] with split private rooftop terraces. The lower level houses a sophisticated common area (SkyLounge) that includes a lounge/bar with tower-to-tower windows and a glass floor. This design provides a truly unique and modern way to take in breathtaking panoramic views of downtown Toronto and Lake Ontario suspended at a dizzying 400 feet (120 m) in the air. According to the developer, Concord Adex, the multi-million-dollar Skybridge units are the world's highest residences situated on a bridge.

The 14-hour process of raising the bridge was no small feat.[4,5] A strand jack system was employed to lift the massive diagonal steel truss-encased structure into place with its large cables and hydraulic linear winches.[2] However, even with all of the design and planning that went into the monumental undertaking, the project team still had to rely on the right atmospheric conditions to cooperate. To avoid sway in the structure due to wind, which could have led to potentially dangerous conditions causing damage to the newly constructed towers, the operation had to be performed steadily under a maximum wind speed of 20 mph (35 kph).[3]

With every impressive forward-thinking design, there are bound to be a few obstacles to overcome prior to building completion. The intricate 500-ton

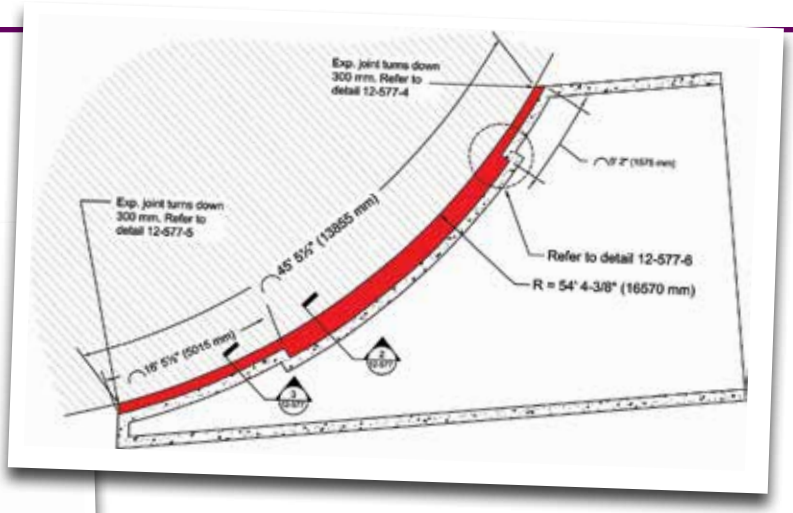
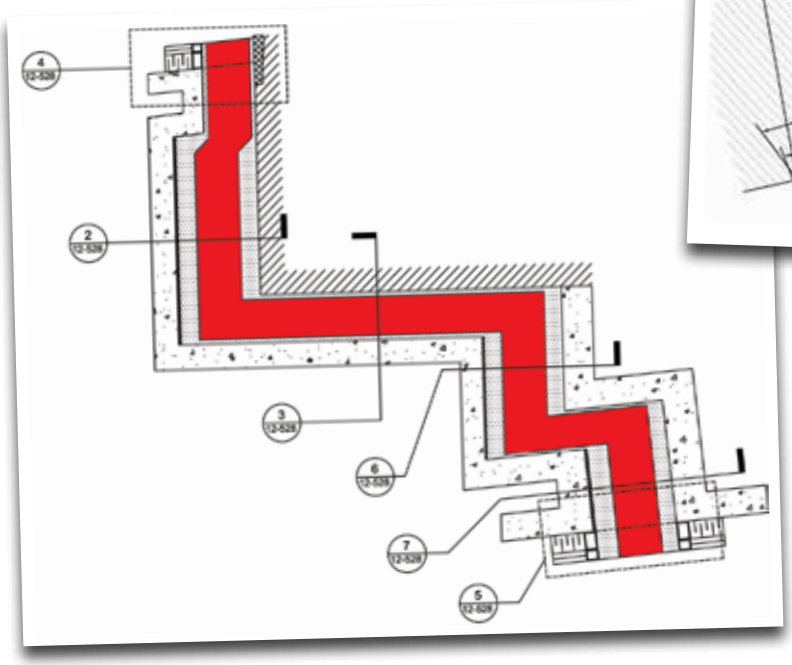


Figure 1 – Plan of the west tower expansion joint.

Figure 2 – Plan of the east tower expansion joint.



(450-tonne)[2,4] Skybridge structure incorporates large expansion joints where the bridge meets the towers. "The expansion joints were incredibly complex, both in movement requirements and in shape," says Don Delaney, PEng, of Engineering Business Development at Flynn Canada, the company responsible for the installation of the roofing membrane and expansion joint at the Skybridge.

"The bridge is pinned on the west tower and is designed to pivot about its axis. The movement is accordion-like and becomes more pronounced as you move away from the centerline of the bridge. On the east tower, the movement is more in and out like a piston, up to ±10 inches (±250 mm), but also needs to accommodate differential lateral drift of the two towers," Delaney adds.

Also being taken into consideration were the unique profiles of the expansion joint where the bridge meets each of the towers (*Figures 1* and *2*). There were large 20-in. (500-mm) openings requiring waterproofing from building to curb. The joint along the west tower curves along a 45-ft. arc between the round tower and the bridge. On the east side, the bridge meets the tower on an angle at a corner, resulting in a challenging zigzag configuration with many odd angles.

The contractor had to face not only the challenge of an unconventional and delicate installation, but also the unpredictability of Canadian weather. The towers stand a mere 1,500 ft. (450 m) from the edge of Lake Ontario, where high winds and rapid weather changes can occur. The construction time frame saw the expansion joint installation commence in mid-October and conclude in early November, when the city's

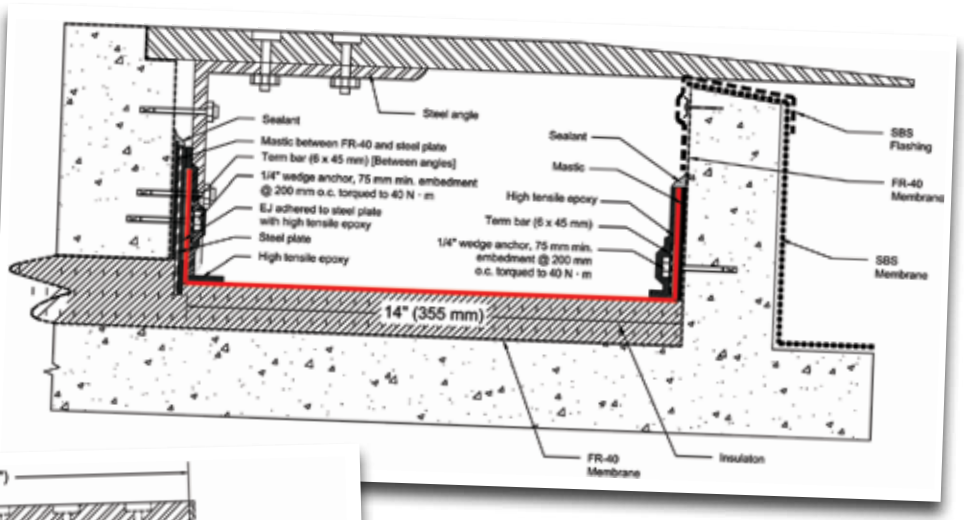


Figure 3 – Typical section of the west tower expansion joint.

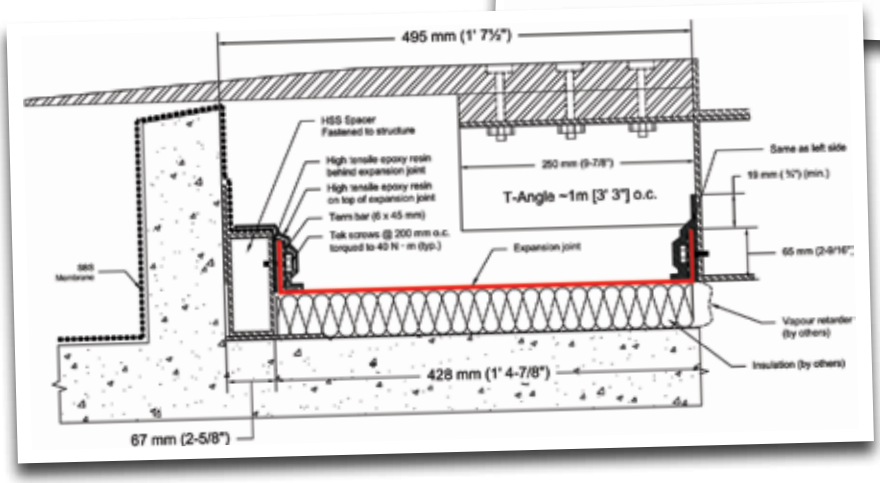


Figure 4 – Typical section of the east tower expansion joint.

Photo 1 – The east tower joint is being dry-fitted.

Photo 2 – The expansion joint is adhered to the structure with high-tensile epoxy.

daily temperature averages 40-45°F (4-8°C). Product selection, installation methods, and schedules had to adapt to these specific conditions.

In order to simultaneously address the design considerations of a very large anticipated movement range (expansion, contraction, and shear), complete watertightness for the life of the structure, and lack of access for maintenance, the project required a specially designed watertight expansion joint. Expansion joints that are available in standard shapes and sizes would have had to be assembled and spliced on-site to fit the complex geometry involved, which would have been problematic on this project.

After much detailed planning and consultation with the contractor to address these difficulties, a one-of-a-kind, custom-made expansion joint was developed as the solution for the critical roof expansion joint. This product creates an uninterrupted, monolithic waterproof seal that spans the entire length of the Skybridge and conforms to all of its complexities. It is composed of a vulcanized elastomer reinforced with polyester fleece flanges and has an operating capacity to handle up to ±10-in. (±250-mm) multidirectional movement in order to tolerate the expected sway in each tower. The joint itself is not a cover or a flashing over the opening, but rather an extension of the roofing membrane, which is anchored to the structure and remains watertight throughout. The channel shape of the joint, along with the material's watertightness, was key in facilitating drainage (*Figures 3* and *4*). Its made-to-fit configuration, based on as-built measurements, allowed for a maintenance-free and cost-effective installation.

Below the roof level, on each side of the bridge, the joint opening was sealed with a combination of standard rubber bellows and accordion-like seismic joint covers, depending on the movement criteria at each end.

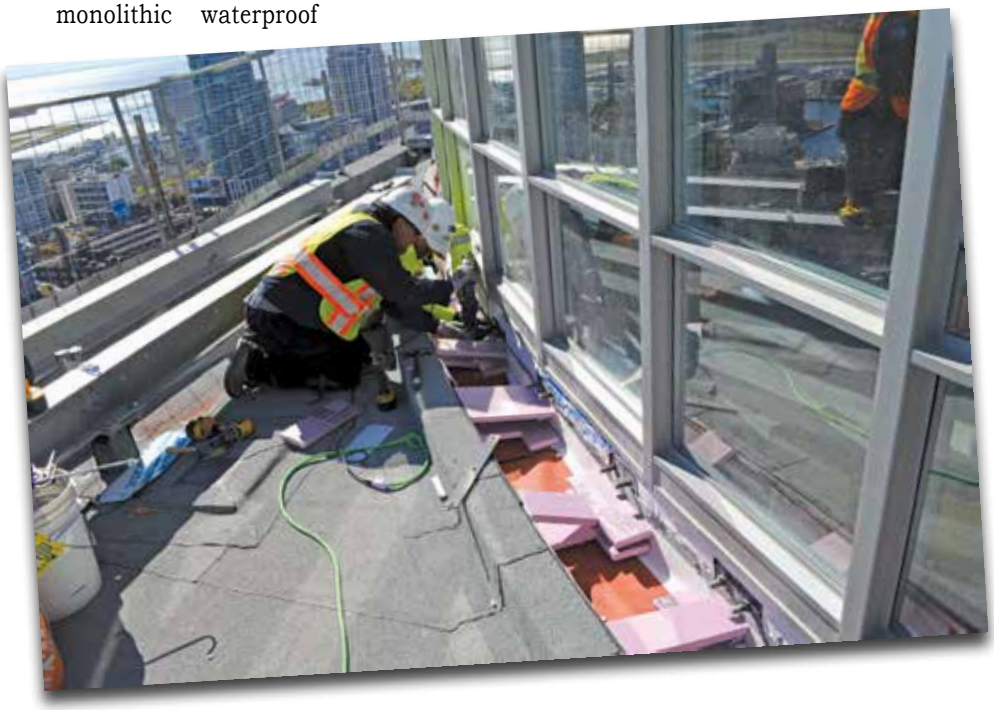


Photo 3 – A contractor fastens the ¼-in. (6-mm) steel termination bar into the tower with concrete anchors. Due to cold temperatures, the expansion joint is held in place with wedges until the epoxy cures.

Photo 4 – A close-up showing the adhered and anchored expansion joint at the protection plate supports.

Photo 5 – Completed installation of the west tower joint with the protection plate supports installed.

In the less-critical areas under the bridge, the metal cladding support panels were modified to allow for the movement.

The variety of substrates and materials interfacing at the roof expansion joint required the use of several different waterproofing and anchoring methods. The expansion joint material is compatible with most roofing and waterproofing materials such as modified-bitumen membranes, cold-applied adhesives, structural sealants, and epoxies used on this project. For the CityPlace Skybridge installation, the prefabricated joint was encapsulated in a high-tensile-strength epoxy and was mechanically anchored to the structure using wedge anchors, TEK screws, and steel plates to ensure proper fixation at the maximum anticipated movement.

Photo 6 – Completed installation of the east tower expansion joint.

Photo 7 – Finished private rooftop patio looking at the west tower expansion joint.

The contractor began the installation by unrolling the expansion joint material and positioning it over the joint opening to dry-fit the joint according to the supplied layout (*Figures 1* and *2*). Once the material was correctly positioned, it was set into a bed of high-tensile-strength epoxy. Although epoxy provided the best method of affixing the expansion joint to the concrete and steel substrates of the joint opening, the cold temperatures necessitated the use of wedges to hold the product in place until the epoxy cured (up to 24 hours in some cases). The contractor also had to contend with several different air/vapor barrier membranes at certain portions of the joints. In these areas, a high-solid-content asphalt mastic was used as the fixative adhesive behind the product before the material was anchored to the structure.

After adhesion was complete, the expansion joint material was secured to the structure using torqued wedge anchors and a ¼- x 1¾-in. (6- x 45-mm) steel termination bar. Heavy rebar placement in the concrete ledge adjoining the bridge created a challenge for the contractor when positioning the anchors. However, the anchor size and spacing used were suited to resist the stresses from the expansion joint material at the maximum 10-in. (250-mm) anticipated movement.

The final step involved flashing in the top portion of the material to the substrate. The same waterproof epoxy was used to completely encapsulate the top of the joint

Photo 8 – Finished private rooftop patio (facing the east tower expansion joint).

Photo 9 – The SkyLounge in the lower level of the Skybridge.

Photo 10 – If you're afraid of heights, don't look down! Here's the view down from 400 ft. (120 m) through the glass floor in the SkyLounge.

flanges and the termination bar and was tied back into the substrate above the joint.

Due to the level of advance planning and detailing, the installation, although a new concept for the contractor, progressed smoothly and efficiently, and the desired result was successfully achieved.

"The condominiums below these expansion joints are some of the most expensive real estate in Toronto. Having potential leaks in these joints was simply not an option," Delaney says. "This was the only product that we had confidence in to provide a leak-free, long-term solution for such complex and demanding movement joints."

The priority was to produce a solution that not only satisfies all project requirements, but also adds value to the overall structure. For the residents of CityPlace, the Skybridge has become a unique feature that has solidified itself as one of Toronto's significant architectural icons in the heart of a distinct and modern neighborhood.

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Demand for Construction Engineering Pros Drives Pay Hikes

According to a recent survey by construction consulting firm FMI, new-business acquisition complexities are requiring higher-skilled and better-paid staff. Among design-firm jobs, FMI says field engineers gained the largest base-pay hike since 2009, at 24.1%. Those in quality assurance and proposal management were next at 23.5% and 19.3%, respectively. Pay levels overall have risen 10% since 2008, a survey revealed. Marketing managers also received steep hikes. Technology needs also caused a 30% base pay bump for building information modeling (BIM) professionals.