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Rehabbing O'Hare

Parking garage expansion-joints project is the largest of its kind in North America



Forestall Sill-Flashing Failure
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By Doug Galinsky and Dave Bratek

In 1942 and 1943, O'Hare Airport was constructed as a manufacturing facility for World War II transport aircraft. At that time, Chicago's Midway airport was the primary airport serving the Chicago area. In the early 1950s, after numerous expansions and renovations of the facility, city engineers concluded that Midway would not be able to handle the upcoming new-generation jets. As a result, the engineers prepared to renovate, expand and rehabilitate the manufacturing facility. They planned to create a modern airport with capabilities that could expand to meet Chicago's future aviation demands.

In 1955, the first commercial flights began to use the new O'Hare airport. The transition from Midway was completed in the early 1960s.

The effort to meet the continually increasing air passenger demands meant that the airport was in a near constant state of upgrades and renovations. Part of that was the construction of an elevated parking structure in the early 1970s. In 1972, crews completed its construction and opened it for use. At the time, it was the largest parking structure in the world—six stories—with the capacity for about 9,300 vehicles.

Constructed of concrete waffle slab, the structure consists of a combination of reinforced concrete and post-tensioned concrete members and seven expansion joints.

By the middle 1990s, the original drainage trough and expansion-joint systems had severely deteriorated. After inspecting the parking structure, authorities determined the need to, among other tasks, replace the expansion joints and drainage troughs. In addition, the 1998 scope of rehabilitation consisted of making repairs to the post-tensioning system and ramp overlays and performing full and partial depth repairs to the elevated slabs. Engineers also planned to install a deck-protection system consisting of a membrane and sealants.

The Solution That Wasn't

By 2001, the recently installed expansion joints were already starting to show signs of problems. Thus, the next year, crews installed five expansion-joint test sections to better analyze the cause of the premature failures. In 2005 and 2006, Globetrotters Engineering (Chicago) investigated the expansion joints installed in the 1998 rehabilitation, as well as the test sections installed in 2002.

Project Specs

The physical layout of Chicago's O'Hare International Airport elevated parking structure is on a segment of a circle with the following dimensions and other specs:

- **1,657 feet.** Length of the long face in feet.
- **1,069.** Length of the short face in feet
- **460.** Width in feet.
- **9,300.** Number of vehicles the garage can accommodate.
- **6.** Number of levels to the structure.

To establish the cause of the widespread expansion-joint failure, Globetrotters' team members needed to identify and evaluate factors associated with the problem. Upon completing that evaluation, they attributed the failure to:

- Heavy corrosion of the carbon-steel side plates
- Epoxy adhesive bond failure between the steel plates and rubber seal
- Installation deficiencies
- Rubber-seal material deficiencies
- Expansion-joint size inadequacy
- Nonuniform movement transverse to the expansion joint
- Differential radial movement
- Differential vertical movement due to vehicle loads.

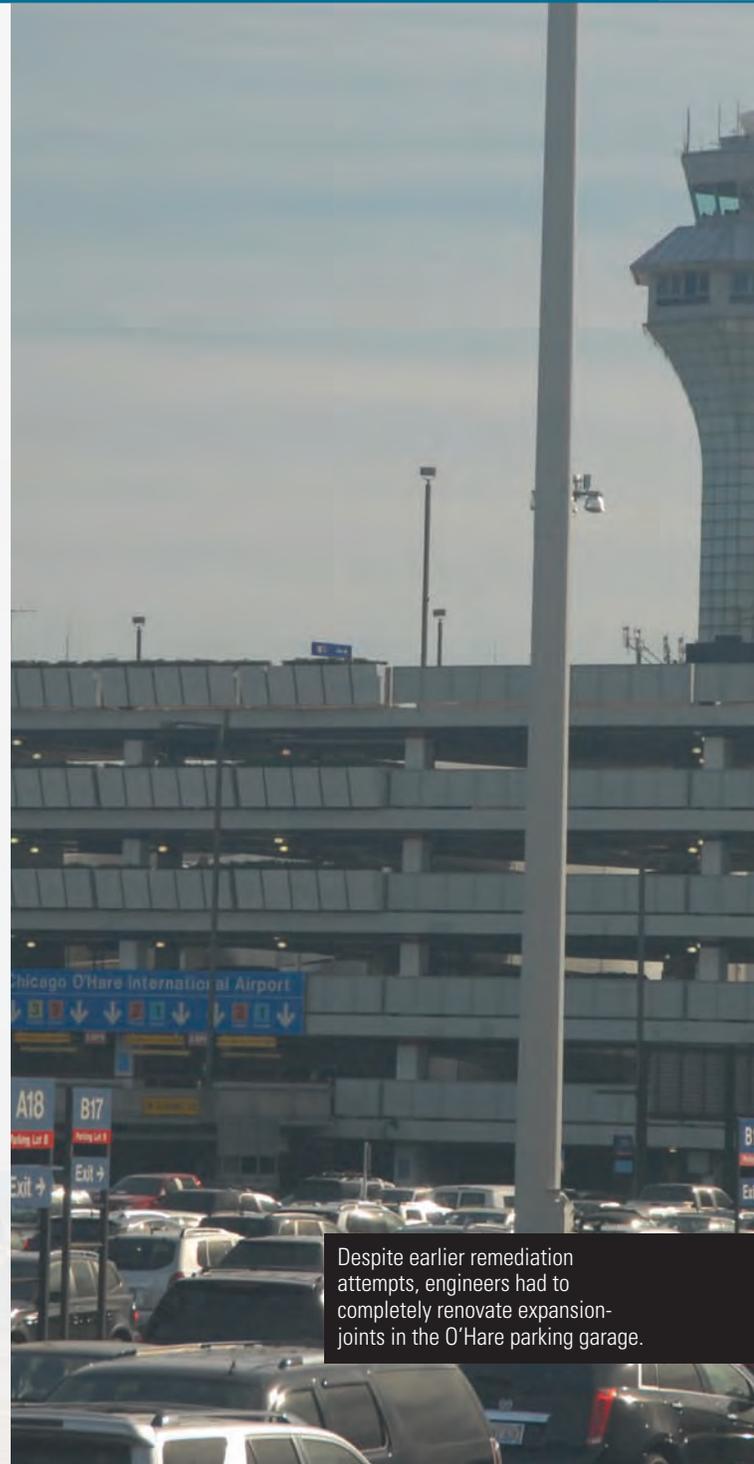
In addition to evaluating the existing expansion joints, engineers conducted concrete crack surveys and petrographic analysis. They discovered cracks present at all segments extending transversely across the bottom surface and extending up vertical faces at the expansion-joint gaps. Most cracks were small—about 1/64 inch and less—though a few were as large as 1/32 inch. The frequency of the cracks varied from less than 1 foot apart to an occasional few that ran the entire span. Generally, the cracks were about 3 feet to 5 feet apart.

Crews took eight core samples, and petrographic analysis (see photo, top right, on page 9) revealed that the concrete was of good quality with water/cement ratios ranging from 0.35 to 0.45. Air content ranged from 4 percent to 6 percent, and compressive strengths were 7,710-11,640 psi.

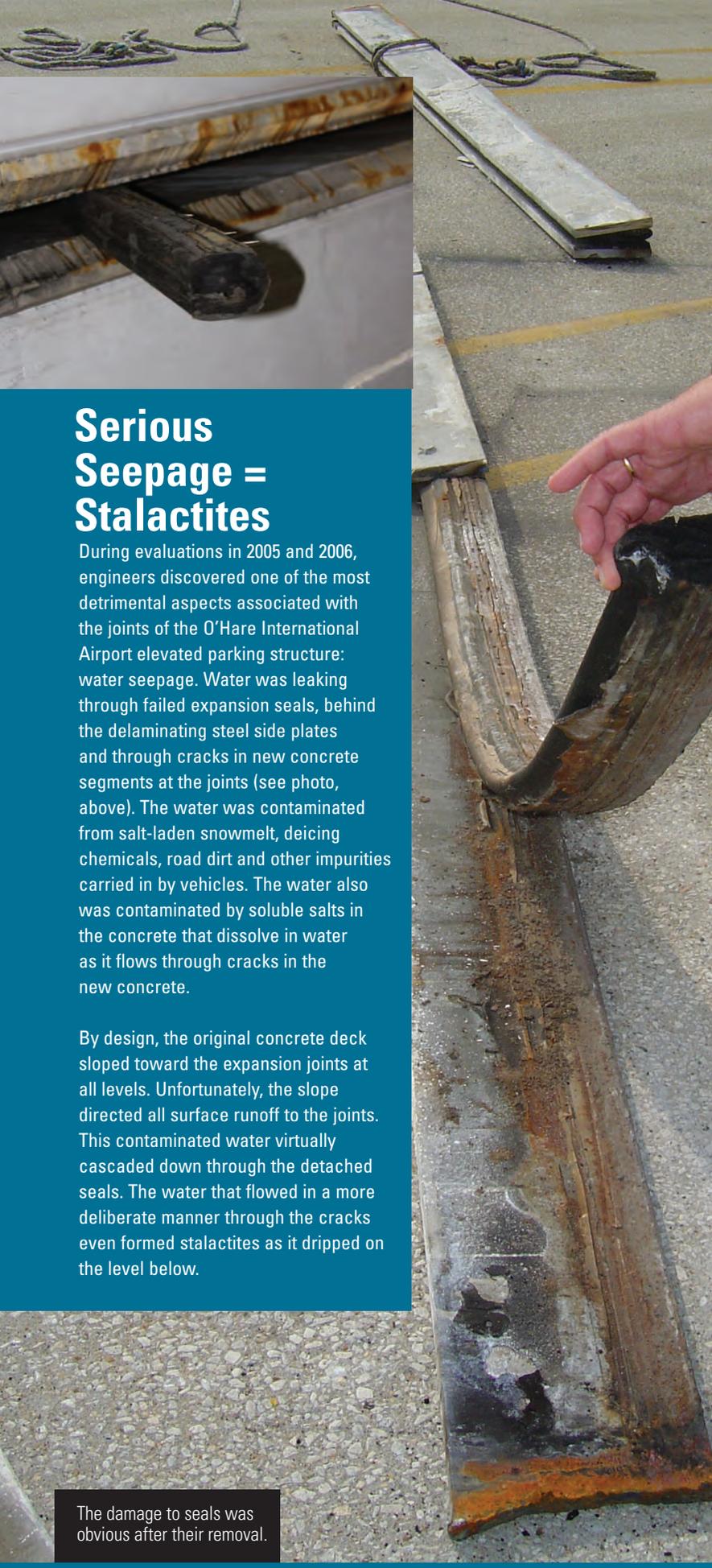
Identifying the Guilty Party

Knowing the concrete was in good shape led investigators to conclude that the primary culprit for the problems was the original expansion-joint design and the slope of the deck (with the associated water infiltration). Engineers soon determined that the existing expansion joints required a concerted remedial effort. They also understood that no cost-effective means was available to repair and reattach the existing seals to the steel side plates. Accordingly, they decided to remove and replace all 13,450 feet of both seal and the steel side plates in their entirety.

It was important to recognize the fundamental theory behind the structural opening of the expansion joints and mechanisms used to fill or bridge over the opening. Specifically, they must be



Despite earlier remediation attempts, engineers had to completely renovate expansion-joints in the O'Hare parking garage.



Serious Seepage = Stalactites

During evaluations in 2005 and 2006, engineers discovered one of the most detrimental aspects associated with the joints of the O'Hare International Airport elevated parking structure: water seepage. Water was leaking through failed expansion seals, behind the delaminating steel side plates and through cracks in new concrete segments at the joints (see photo, above). The water was contaminated from salt-laden snowmelt, deicing chemicals, road dirt and other impurities carried in by vehicles. The water also was contaminated by soluble salts in the concrete that dissolve in water as it flows through cracks in the new concrete.

By design, the original concrete deck sloped toward the expansion joints at all levels. Unfortunately, the slope directed all surface runoff to the joints. This contaminated water virtually cascaded down through the detached seals. The water that flowed in a more deliberate manner through the cracks even formed stalactites as it dripped on the level below.

The damage to seals was obvious after their removal.



capable of accommodating a wide range of performance characteristics, such as:

- Meet ADA requirements and not be a tripping hazard.
- Be watertight and leak-free.
- Accommodate multidirectional movement (expansion, contraction, shear and vertical displacement in the X, Y and Z axes).
- Resist weather, ozone and ultraviolet radiation.
- Resist chemical attack from gasoline, oils and deicing agents.
- Absorb vehicle-impact loads from deflection across the joint.
- Shed water, ice, dirt and debris.
- Resist snow-plow damage.
- Resist abrasion and not deteriorate under normal use.
- Be fire-rated if required by local uniform building codes.

During the forensic evaluation period, those involved with the project asked MM Systems Corp. (Pendergrass, Ga.) to get involved. They wanted MM Systems to develop an expansion joint that would incorporate the positive attributes of traditional expansion joints common in contemporary parking garages.

After holding several design workshops, Globetrotters Engineering and MM Systems decided the following criteria was necessary for the final O'Hare Elevated Parking Structure expansion-joint design:

- Armored, stainless-steel edging to protect against vehicular impact loads and snowplow damage.



New state-of-the-art expansion-joints will meet the rigorous demands of one of the busiest parking structures in the world.



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Core samples revealed that concrete was sound with good water/cement ratios.

- Multi-directional movement capabilities.
- Continuous, elastoprene rubber seals that could be replaced if damaged.
- A secondary, water-containment, fabric-reinforced, rubber gutter system.
- A structural base frame with a bolted connection to the concrete deck.
- Elastomeric concrete (of polyurethane technology with a blend of aggregates) for use as a shock-absorbing, block out, infill material.
- A pedestrian-friendly, ADA-compliant design.
- A five-year product performance warranty.

Within two months, the teams had engineered, prototyped and manufactured the new “hybrid” expansion-joint design. That quick effort allowed them to install and monitor it over the winter snow-removal season. Based on a yearlong field trial, coupled with previous trials and historical expansion-joint-performance research, they ultimately decided to recommend the new “hybrid expansion joint” to the airport authority with the ultimate goal of substantially curtailing, if not totally eliminating, the seepage of contaminated water through the expansion-joint assembly at the previously identified seepage paths. (See illustration on page 10.)

Cooperation Is Ultimately Key

The actual installation of the new expansion joints was not without a few challenges. For the most part, however, the process went very smoothly based on the collaborative team atmosphere of those involved. That

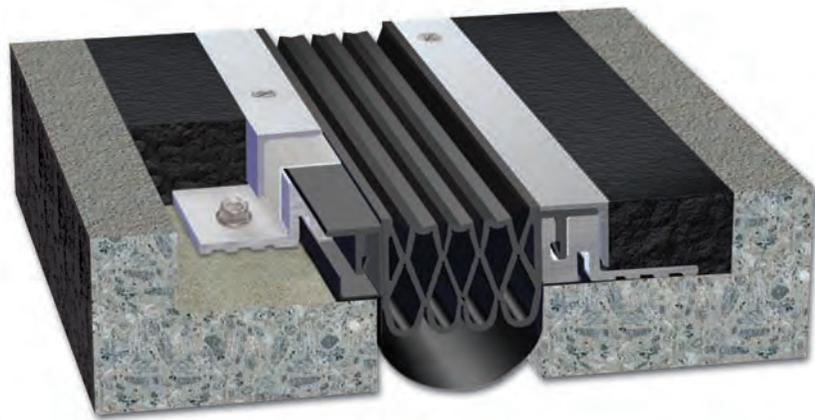


Engineers designed a new, “hybrid” expansion-joint design to eliminate previous problems.



Workers on the O'Hare project didn't install new expansion-joints until after a yearlong field trial proved they would be successful.

A prototype illustration shows the individual layers of the new "hybrid" expansion-joints.



atmosphere resulted from several factors:

- *A preconstruction meeting.* Those involved met early to review all necessary quality-assurance measures between general contractor W.E. O'Neil Construction (Chicago), certified installation contractor G&C Construction & Sealants Inc. (Alsip, Ill.) and MM Systems (the manufacturer).
- *The implementation of phases.* Engineers decided to rehabilitate the structure in three 4,845-foot phases over two seasons.
- *An analysis of steel-plate removal methods.* Upon reviewing several techniques, the teams agreed as to which one was best for their situation.
- *The use of new concrete blockouts.* Rather than saw cutting, engineers decided to mill new concrete blockouts (pockets).
- *An expansion joint workshop.* All involved met at MM Systems' manufacturing facility for a dry run of the project before actually starting it.
- *Use of a third-party, independent, field-testing firm.* This business monitored all progress to keep everyone on track.

Selecting the proper expansion joint depends on a variety of factors. On this particular project, the rehabilitation requirements, service-condition attributes, life-cycle expectations and budget were primary motivators. Combining these elements with a cooperative team mentality, the O'Hare elevated parking structure project now has 13,345 linear feet of state-of-the-art expansion joints that meet the rigorous demands of one of the busiest parking structures in the world.

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