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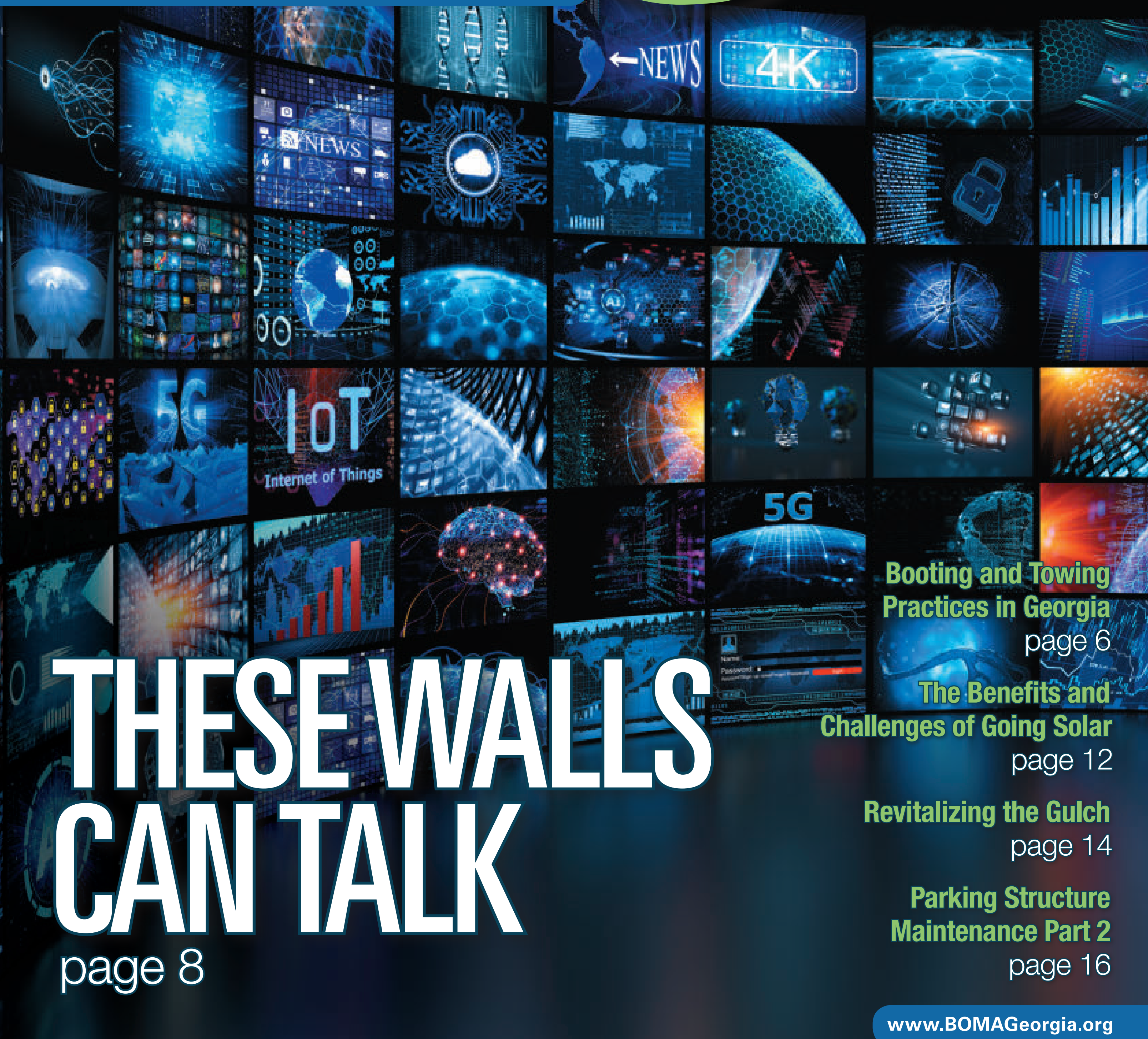

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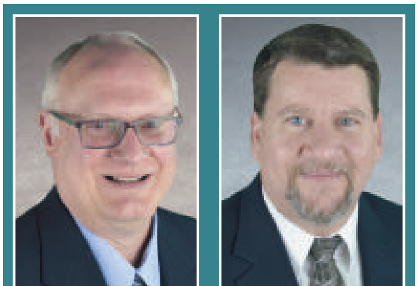
Parking Structure Maintenance PART 2



BY Scott L. Weiland PE and J. Trey Thomas PE, Innovative Engineering Inc.

PHOTO COURTESY OF INNOVATIVE ENGINEERING INC.

Most people, including those in the design profession, see the rugged looking nature of a parking structure and assume they are bullet proof and don't require maintenance. Unfortunately, nothing could be further from the truth.

Parking structure maintenance, when performed at the optimum time, can provide a return on investment (ROI) that far exceeds that of other maintenance activities. In this two-part article, Part 1 reviewed the cost of parking. Part 2 highlights the importance of routine maintenance, specifically the optimum timing of maintenance activities to minimize life cycle costs of your parking structure.

Importance of routine maintenance

The maintenance costs shown in Figure 1 assume a maintenance plan (that includes routine inspection) and budget are in place and followed from the time the parking structure is opened. Not doing so could quadruple the maintenance costs shown. The National Parking Association has a useful "Parking Facility Maintenance Manual," but as stated in the manual, the maintenance plan should be tailored to your specific parking structure. Considerations that affect the maintenance activities and schedule include structural system type, geographic location, use of the facility (frequency of traffic) and how the facility is operated. The most important component of a maintenance program is an annual wash down (particularly on the top level), observed by a parking structure restoration engineer, as well as more in-depth condition assessments every five years by the same consultant. The restoration engineer can identify problems early and thus reduce long-term maintenance costs.

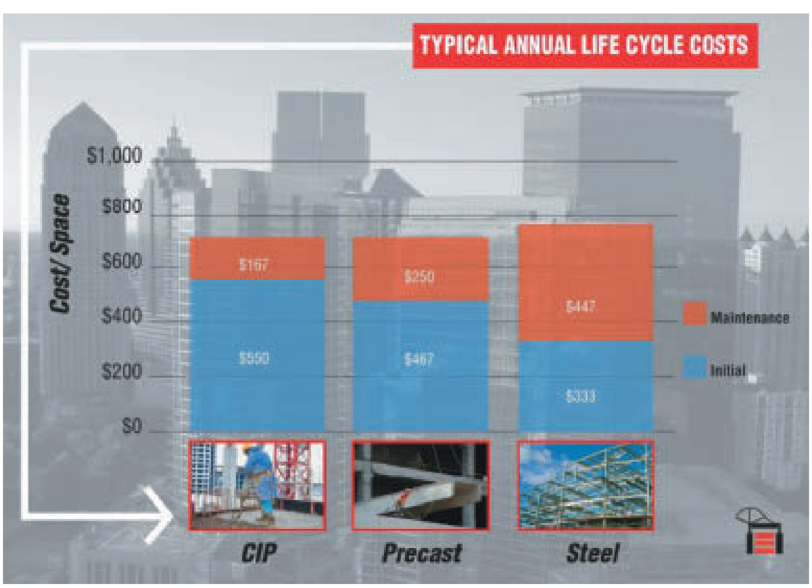


Figure 1 Structural system cost comparison IMAGE BY EVP DESIGN

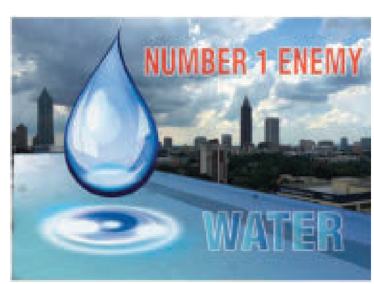


Figure 2 IMAGE BY EVP DESIGN

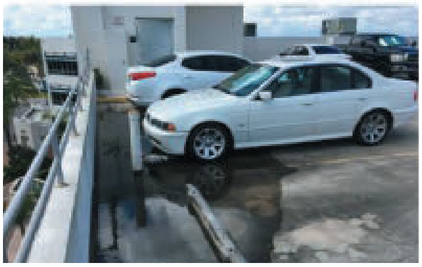


Figure 3 Ponding and concrete spall

While water is the number one ingredient for a healthy landscape, it is also the number one cause of parking structure degradation. Therefore, it is important to remove moisture in the form of rain, snow and ice from the parking structure quickly and efficiently. The top surface of the structure is the most exposed; however, wind driven rain and snow, as well as vehicular snow and ice fenderbergs laced with road salt can be carried into the structure and reach the lower levels as well.

When water freezes, it expands roughly 9 percent in volume. There is no stopping this. Therefore, exterior horizontal concrete is intentionally sloped for runoff and also air entrained with tiny bubbles that will break allowing this expansion to take place if it is exposed to freezing moisture. When preventive measures are not in place, the moisture freezes, expands, and creates a spall on the surface of the concrete. Figure 3 shows an example of ponding with adjacent surface concrete spalling. Ponding is often best dealt with by installing a supplemental drain.

Similarly, when moisture and oxygen penetrate the concrete deep enough to reach the ferrous metal reinforcing or rebar, the metal corrodes and in the process the parent metal expands 6 to 10 times its original volume. Again, there is no stopping this. This expansion creates cracks, spalls and delamination (a larger spall involving multiple rebar). The corrosion process is shown in Figure 4, and a sample spall due to rebar corrosion is shown in Figure 5. An interesting observation that can be made from close inspection of Figure 5 is the presence of marking paint at the sub-surface of the previous spall repair, which would have been removed had the sub-surface been prepared properly. Thus, the repair was short lived. The formation of spalls can be detected early through sounding and repaired before further damage occurs. Figure 6 shows the use of a delamination sounding tool that is used to locate future concrete spalls before they occur, so they can be repaired early and at a lower cost.

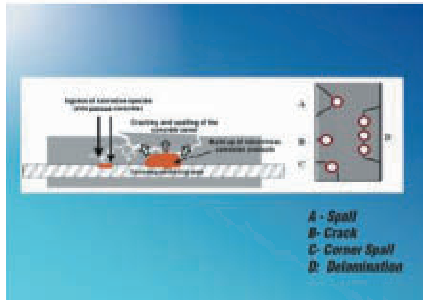


IMAGE BY EVP DESIGN

Figure 4 Rebar corrosion process

Figure 5 Rebar corrosion and failed repair

The rate of corrosion or rusting of the reinforcing steel is increased by the presence of deicing salts (chloride ions) that have penetrated the concrete to the level of the reinforcing steel, and by what is referred to as carbonation. Concrete in its natural state has a pH high enough to create a natural protection against rebar corrosion. However, with exposure to carbon dioxide in the atmosphere, this pH level lowers, allowing for a more corrosive environment. This process is called carbonation. Chloride Ions and Carbonation continue to penetrate the concrete and eventually reach the depth of the rebar. The penetration of these two phenomena can be measured periodically by testing relatively small concrete samples. Figure 7 shows a Chloride Ion and Carbonation test being performed.

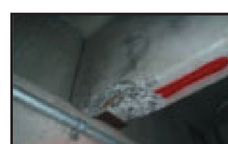
Figure 6 Sounding

Figure 7 Chloride Ion & Carbonation Testing

The results of this testing are used to help determine the service life expectancy of the areas tested. As either (or both) chloride ion and carbonation penetration approach the depth of the rebar, an elastomeric traffic-bearing membrane or traffic coating can be installed on the surface in jeopardy to protect the substrate from moisture and further deterioration. This is a last resort however, as they are relatively expensive and typically have a service life of 5 to 10 years, after which they need to be either top coated or replaced.

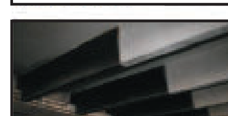
Precast concrete parking structures are made up of concrete pieces that contain carbon steel embedments that are welded together when the parking structure is erected on site. Most of this steel is left exposed to the elements and associated rusting. Furthermore, when subjected to temperature changes, precast structures suffer thermal expansion and contraction damage. Like expanding freezing water and rusting steel, there is no stopping this. Figure 8 shows an example of rusted steel embedments, damage caused by thermal expansion and typical repairs utilizing steel and fiber-reinforced polymer (FRP).

Figure 8 Typical Precast Seat Repair



Typical Failed Precast Seat

Typical Steel Seat Repair



Typical FRP Repair, Photo by Structural Technologies

Structural steel parking structures often have a cast-in-place concrete deck supported by vented metal decking and a structural steel superstructure. These ferrous steel components are subject to rusting as shown in Figure 9.

Figure 9 Rusting structural steel and metal deck

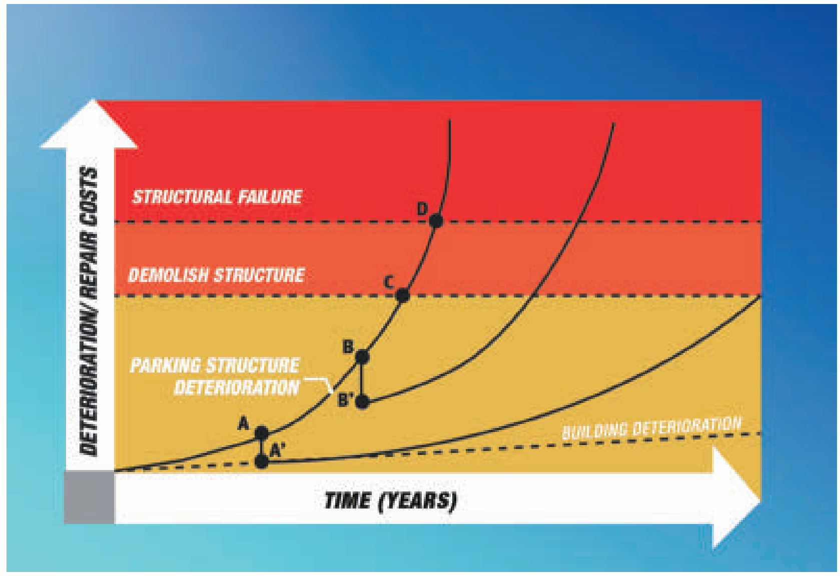


IMAGE BY EVP DESIGN

Figure 10 Maintenance cost curve

The cost of doing nothing

It is often assumed that parking structures will last forever without maintenance. However, in reality, parking structures exposed to the elements as well as dynamic vehicle loads start to deteriorate before they are in operation and continue to do so at an accelerated rate after only a few years. Figure 10 shows a graph of deterioration and repair costs as a function of time for both a parking structure as well as the enclosed building served by it. The relatively flat line represents deterioration of the enclosed building structure that is protected by a building envelope. By contrast, the deterioration and repair cost of an exposed parking structure is gradual at first but quickly accelerates over time. When deterioration is repaired at the optimum time as designated by Point A on the graph, the condition of the parking structure is partially reset, and the service life will reach that of the building served. However, if needed repairs are deferred as designated by Point B, not only are the repairs more expensive and disruptive, but reaching the service life of the parking structure is in jeopardy. The cost of doing nothing is represented by Point C, requiring reconstruction of the structure much sooner than originally planned. Point D represents a structural failure or collapse due to inadequate maintenance.

Okay, so what should I do?

1. Select a parking structure restoration engineer—The engineer should be selected using qualification-based selection (QBS) and then a fee negotiated. It has been shown that selection based on price simply does not work as it leads to unintended consequences including poor service and quality, excessive and expensive change orders, and worse yet, litigation over disputes.

However, you will want to check references (both from other clients and contractors in the restoration industry), review sample condition assessment reports checking for thoroughness, clarity, construction estimates and test results for Sounding, Chloride Ion and Carbonation testing. You will also want to know how accurate their construction estimates are, as no one likes surprises (including unforeseen conditions) at bid time. Estimates within 10 percent of actual cost are desirable. You can also ask what their professional liability claim history has been to see if they have had issues in the past. Beware of low fees that represent the need to cut corners and make up for discounted fees during a possible later stage of the project. The time to know the true condition of the parking structure is now, not during construction which can lead to change orders and damaged reputations.

2. Schedule a walk through—Have a walk through conducted by your parking structure restoration engineer. An experienced restoration engineer can conduct a Level I visual assessment, including limited chain drag or sounding, to determine the structure's general condition and locate hidden problems. The engineer can then recommend the next steps which may include: future inspections, evaluating the current maintenance plan, performing a more in-depth condition assessment and/or generating restoration design documents. Restoration engineers can also assist you with comprehensive maintenance, capital assessment and management plans, as well as the selection and management of a restoration contractor.

Conclusion

Parking structures represent a major capital investment. Deferred maintenance can lead to serious structural deficiencies that are very expensive to repair, a shortened life span, or both. Given the harsh environment in which parking structures exist and the accelerated rate of deterioration compared to most other buildings, maintenance and repairs done early are less expensive and provide a return on investment (ROI) that far exceeds that of many other maintenance activities. A parking structure restoration engineer can help you determine the current condition of your parking facility, plan and budget for maintenance and repairs and assist you with how to fund these activities. An ounce of prevention is worth a pound of cure.

Be sure to read the first part of this two-part article in a previous edition of *BOMA Georgia Insight Magazine* that provides the ground work for establishing parking structure life cycle costs as they relate to maintenance.

1. *National Parking Association, Parking Facility Maintenance Manual, Fifth Edition*
2. *National Parking Association, Guide to Selecting a Parking Consultant, Copyright 1997, 2013*

ABOUT THE AUTHORS

Scott L. Weiland PE, Principal with Innovative Engineering Inc. has over 38 years' experience helping owners reduce parking structure maintenance costs. He can be reached at **sweiland@ieiusa.com**.

Trey Thomas PE, Associate with Innovative Engineering Inc. has over 15 years' experience helping owners with parking structure condition assessment and repair. He can be reached at **tthomas@ieiusa.com.**