Designing for Efficient Maintenance

Considerations that will help owners minimize a parking structure's life-cycle costs

— By Francesco Genoese and Rick Petricca

To provide the ultimate service to parking-structure clients, designers must consider the long-term operational expenditures in their design considerations. Designers can play a key role in educating owners to ensure the structure's efficiency and effectiveness throughout its service life.

The proven durability of concrete, and the 50-year plus service life it can provide, can delude owners into believing that maintenance is not important. The reality is, just as with other buildings, parking structures must be regularly maintained regardless of the materials with which they are constructed. With parking structures, due to the constant exposure to weather and the environment, maintenance becomes an even more important part of ensuring safety and reducing life cycle costs.

Designers should stress that a regular maintenance program will maximize service life and provide the owner with the greatest return on investment. Effective maintenance programs have proven to be the key to long-term durability and to avoiding major unplanned repairs by detecting problems early and solving them before they grow to be cumbersome and more expensive. Well-maintained parking structures have a much lower maintenance cost per square foot than those in which little or no maintenance is performed. In addition, designing a structure that is easy to maintain throughout its life with planned and predictable maintenance reflects well on the designer and will win repeat and referral customers.

Design Features

Designers can make a significant impact on prolonging the life of a parking structure during the design process. For starters, they should take the time to address maintenance concerns early in the design process and follow through with a comprehensive maintenance program. This is especially true in evaluating several facets of the design of the structure including drainage, water supply, and winter maintenance (if applicable).

The role of proper drainage in minimizing deterioration cannot be overstated. It requires careful attention to details, as any errors can result in increased long-term maintenance costs that are hard to avoid after the fact.

Most importantly, the designer must avoid any situations that allow ponding to occur, which can increase water penetration into the concrete and the potential for freeze-thaw damage. These situations arise in details that are overlooked, such as drain locations, maintaining slopes of 1.5%

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A key goal for designers when planning the structure is to work to eliminate any aspects that encourage water ponding, which can increase water penetration into the concrete and the potential for freeze-thaw damage.

or more, and detailing around stair towers and other elements. For example, at stair towers, a raised curb can be used to redirect water away from the tower, minimizing hazardous conditions, particularly in the winter months. It also is important to ensure positive drainage that minimizes ponding.

Likewise, providing adequate spigots on each level can aid in quickly and easily washing down floors to remove salt, chemicals, and dirt that can harm the structure. For example, chlorides contained in deicing salts can lead to corrosion of connections and reinforcing steel. When spigots are provided only on the lowest level, it makes it difficult or expensive to pump water to the structure's top levels.

Winter maintenance should also be considered during the design stage. Discussing how snow and ice will be handled is important in evaluating the use of designated snow storage areas, dump zones with snow gates, and the use of special admixtures and waterproofing details. In too many cases, owners ask about these activities after the fact when it's too late for the designer to take them into account, hence a designer can be proactive in bringing these concerns up early.

Routine maintenance, such as inspecting and repairing joints, will keep parking structures in good shape and prevent expensive repairs that often result from neglect.

Concrete Quality Key Element

Another key consideration is the quality of the concrete being used. This is one of the most important considerations and will directly impact life-cycle costs. Using a high-quality concrete provides greater durability, including increased resistance to chloride ingress and freeze-thaw damage. Two key factors are using concrete mixtures with low water-to-cementitious ratios and paying close attention to the curing of the concrete, which includes protecting early-age concrete against moisture loss and maintaining temperature within specified limits.

Since all parking structures use concrete, it is important to understand the differences between the two primary methods of casting concrete.

Precast concrete is manufactured offsite, in a controlled environment, which provides a high-quality concrete with consistent qualities. The desired factors mentioned above are inherent in the precasting process: precast concrete uses low water-cementitious ratios (typically between 0.32 – 0.40) and is cast in controlled environments where pieces are protected against moisture loss and temperatures are monitored and maintained.

As a result, precast concrete typically has compressive strengths greater than 6,000 psi. It also arrives on site already meeting or exceeding its design strengths, so daily weather at the site does not impact strength development or quality.

Field-cast, or cast-in-place, concrete typically requires more effort to achieve similar qualities. Casting concrete onsite can be challenging due to the varying weather conditions, temperature fluctuations and potential additional steps necessary to ensure quality, including proper curing procedures. Designers should also specify low water-to-cementitious ratios, which may not be as common for cast-in-place concrete.

Because of its lower design strength and higher water-cement ratio, cast-in-place concrete typically has a silane penetrating sealer applied periodically to enhance its durability. This sealer reduces moisture

Designers should discuss snow and ice removal with the owner to determine if any snow-storage areas, dump zones with snow gates or special admixtures or waterproofing details should be provided.

Ensuring that both the owners and operators are aware of maintenance needs as spelled out in a customized manual for the structure is critical to the success of the maintenance program, which can ensure a long service life.

ingress. Precast concrete structures often have cast-in-place concrete pour strips around their perimeter. Waterproofing details around these areas are important to minimize water penetration.

Periodic chloride-ion tests should be conducted per the manufacturer's recommendations to ensure the alkaline environment of the concrete remains intact. This environment helps create a passive protection around embedded reinforcing steel, but continual exposure to salt and deicing compounds lowers the pH value and turns the composition acidic, which can promote corrosion.

Consider Life-Cycle Costs

Life-cycle costs are important when selecting a material and building system for a parking structure. Typical life-cycle cost evaluations should include routine cleaning and preventative maintenance.

Some routine and preventative maintenance will vary depending on the material system used to build the structure. For example, cast-in-place concrete structures and components often require additional surface sealers be routinely applied to maintain protection against contaminates such as chlorides.

Although precast concrete structures typically provide higher-quality concrete and better protection against chloride ingress, there may be more joint sealants to be maintained and replaced as needed, which can vary depending on the sealant selected, its installation, and exposure environment. Of course, sealants are used in every type of building system, so this would apply to all parking structures and should always be part of the preventative maintenance program.

Other considerations for life-cycle costs include the energy needed to light and operate the structure. This includes electronic exiting and payment systems, as well as any conditioned spaces, such as pay booths or vestibules. Light-fixture selection can also have a great impact on life-cycle costs, since these typically account for about 85% of the energy costs (see Meeting the Design Challenges of Today's Parking Structures on page 30). For hybrid structures, utilizing structural steel, additional costs for painting and maintaining the fire protection of the steel should be included.

> Copies of the maintenance schedule should be given to the maintenance personnel, or they may never learn of the program.

When evaluating life-cycle costs, the long-term service life needs to be taken into account. For example, if a parking structure is to have a 50-year service life, the total costs should include all of the above, as well as first costs, when performing comparisons.

Generally, most systems end up being fairly close in overall life-cycle costs. The primary differentiating factor that results in higher overall costs is usually the lack of routine and preventative maintenance, which in turn escalates repair costs and shortens service life.

Three Levels

Required maintenance can be divided into three general types: housekeeping, preventive maintenance and repairs. These typically are spelled out in a maintenance manual detailing procedures and activities required of the owner or operations personnel. Designers should discuss these needs with the owner and present him with a manual customized to the structure's needs. When a parking structure is made of precast concrete, the precaster can supply much of the information that is compiled in this manual.

1. Housekeeping. These activities are performed by the owner or operator and include general clean-up, window cleaning, elevator maintenance, restriping, fixture cleaning, sign maintenance and security-systems checks. Some of these items, such as cleaning, will take place daily or weekly; others, such as restriping, will occur annually. These details can be spelled out in the manual.

2. Preventive maintenance. These activities are performed on a periodic basis and include washing down the floors twice-per-year, sealing cracks, reapplying floor sealers, inspecting caulked joints, repointing and recaulking as needed and tightening guardrail bolts. These activities are the responsibility of the owner, or the operator, as they are geared toward preserving the owner's investment. Some of these items can be self-performed, but frequently a qualified contractor is engaged to complete this work.

3. Repairs. Generally, repairs are necessary due to a lack of preventive maintenance, which allowed the problems to grow beyond the point where prescriptive measures could stop the

deterioration. These activities may include patching potholes, removing and replacing reinforcing steel, repairing floor-slab overlays, replacing expansion joints and bearing pads. These become costly not only due to the repair expense but because spaces often are eliminated while repairs are done in each area.

In many cases, more costly repairs arise because a maintenance program was not in place to identify and remedy small items when they first appeared. Sometimes, the symptom is cheaply or improperly addressed without finding the root cause that created the outward signal of a problem.

This 'Band-Aid' approach will have a short life and potentially create a worse condition. Any indication of a problem should be traced to its source and the flaws resolved or the problem will recur, creating ineffective use of maintenance funds and increased repair costs in the future. Depending on the severity and nature of the deterioration, a design professional should be consulted. A qualified contractor familiar with parking structure restoration and repair should be engaged to make any structural repairs.

Developing a Maintenance Plan

Developing a maintenance plan for the owner of an existing parking structure may require additional considerations than those needed for an original design. This situation will arise if the designer becomes involved in additions, repair work or renovations for an existing parking structure.

A key factor in developing a maintenance and repair program for an existing structure is the age of the parking structure, or more specifically its design era. Every five years or so, designs evolve sufficiently due to new material introductions and casting techniques. These are additional considerations to evaluate beyond a structure's age. Designers cannot assume that parking structures from even a few years earlier feature current design techniques.

Some of the elements that may be different include:

- Pre-topped double tees
- Black steel rather than stainless-steel connections
- Black reinforcing bar rather than epoxy-coated bar
- Areas of field-poured concrete
- Ductility of connections and use of expansion joints
- Use of recycled materials in the concrete mixture
- Concrete admixtures, such as corrosion inhibitors, fly ash, silica fume, air entrainment, etc. as well as the quantity of supplementary cementitious materials
- Changes in code requirements affecting design and rigidity of structures

Code requirements have changed little regarding the allowable cracking in a newly designed parking structure, but seismic design issues have tightened significantly in most areas. These especially will affect the ductility of connections and shear walls.

A survey of all conditions must be done in conjunction with an eye on identifying any looming or immediate safety or structural issues. The goal is to create a plan that is within the owner's repair budget but focuses on the most critical issues first.

Ideally, a plan can be developed that can bring the structure up to date with a three- to five-year plan that incrementally improves maintenance each year. From there, a five- to ten-year plan can be developed. A yearly survey of all repairs and maintenance needs should be completed by a qualified professional, with an annual review of the plan to adjust it for budget needs and additional concerns that have arisen.

Creating a maintenance program for an existing structure will depend on its age and the amount of maintenance performed over the years. A survey of all conditions should identify immediate safety issues while working to create a three- to five-year plan for restoring the structure's condition.

With any maintenance program created by the designer, copies should be given to the owner when the project is completed. Even more importantly, the plan should be given to and reviewed directly with the maintenance personnel. Ensuring that facility staff is provided with education and training is critical to the success of the maintenance program—and the structure itself. Copies of printed warranties should be included, too, to ensure all involved with maintaining the structure know their protection.

Maintaining a parking structure is an on-going activity that requires a dedicated plan that is respected and carried out. That effort will be repaid many times over by avoiding more significant repairs that can be costly and disrupt service to users. ■

For more information on these or other projects, visit www.pci.org/ascent.

For More Information

For guidelines on developing a maintenance program for parking structures, check out these resources:

- Precast/Prestressed Concrete Institute (www.pci.org), specifically "Maintenance Manual for Precast Concrete Parking Structures" and "Maintenance of Precast Prestressed Concrete Parking Structures Brochure." Both are available on the site; search "parking."
- National Parking Association (www.npa.org), especially its "Parking Garage Maintenance Manual."
- American Concrete Institute (www.concrete.org), especially its "Guide for Maintenance of Parking Structures Manual."