ACI 362.2R-00
(Reapproved 2005)

Guide for Structural Maintenance of Parking Structures

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This guide is intended to assist parking structure owners, operators, and the consultants who advise them in developing preventive maintenance programs for parking structures. It presents typical maintenance concerns and suggests ways of addressing them.

The guide summarizes information regarding structural, operational, aesthetic, and routine maintenance for parking structures. Design suggestions to minimize maintenance are also included. A structural maintenance checklist of specific recommended tasks and references to other publications with information related to the structural maintenance of parking structures is included.

See ACI 362.1R for more complete information regarding design issues related to a parking structure's performance.

Keywords: concrete durability; condition appraisal; construction joints; contraction joints; corrosion; cracking; expansion joints; isolation joints; leakage; maintenance; membrane; parking structure; post-tensioning; precast; prestressed; ramp; scaling; sealant; sealer; snow removal; spalling.

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ACI 362.2R-00 became effective June 2, 2000.

CHAPTER 1—INTRODUCTION

All parking structures require regular maintenance to provide a satisfactory level of service and meet service-life expectations without premature deterioration, undue repair expense, interrupted service, inconvenience to patrons, or loss of cash flow. Parking structures can develop more distress and deterioration than most types of buildings because of their direct exposure to traffic, weather, deicing chemicals, and snowplows. Poor maintenance increases the likelihood of distress and deterioration and is a potential cause for damage to vehicles and personal injury. A maintenance program includes timely preventive actions to reduce system failure and premature deterioration, which can reduce the need for significant and expensive repairs. This guide is intended for owners, operators, and consultants for parking structures who seek advice on developing and implementing a maintenance program.

This guide emphasizes the maintenance of structural components to reduce risks associated with structural deterioration. The types and frequency of maintenance required for a structure are directly related to the durability features incorporated into the structure during design and construction. Deterioration problems associated with parking structures are discussed in Chapter 3. Operational maintenance, housekeeping, and aesthetic maintenance are discussed in Chapter 4. Chapter 5 provides a checklist for maintenance tasks and recommended frequencies. Appendices A and B contain information about snowplowing and deicing procedures. Appendix C also contains a worksheet for making a visual inspection. Different types of structural systems can develop different types of deterioration-related problems. ACI 362.1R contains discussion of durability considerations for parking structures. An understanding of these issues will prove helpful in developing an appropriate maintenance program. Refer also to *Sound Maintenance Extends Life Spans of Parking Facilities*, by Bhuyan.

CHAPTER 2—DEVELOPING A MAINTENANCE PROGRAM

2.1—The project maintenance manual

For many projects, a maintenance manual is developed at the completion of construction as part of the close-out process. The manual can contain the project specifications; a set of as-built drawings; product information, including warranty and maintenance information from the manufacturers of various components; and specific maintenance requirements. If a project maintenance manual exists, it is a good idea to become familiar with the manual to develop a comprehensive maintenance program.

2.2—Periodic inspections

A walk-through visual inspection should be made at least annually to provide an overview of the structure's general condition. Problems should be noted in a concise report, recommending further investigation of specific items if required. The inspection should be conducted by an engineer experienced in structural condition assessment of parking structures. A visual inspection does not involve physical testing. Maintenance personnel with proper checklists and day-to-day experience of operating the structure can also conduct a visual inspection of nonstructural maintenance concerns. Appendix C provides a checklist of specific items that should be observed during a visual maintenance inspection.

2.3—Preventive maintenance

Preventive maintenance should reduce life-cycle repair expenses and extend the service life of the structure. This is accomplished by ensuring that the structure's protective systems are functioning properly to reduce the intrusion of water and deicing chemicals. Regular cleaning to remove debris, wash-downs with water, sealing cracks, spot repairs of sealants and expansion joints, protective coatings and membranes, and periodic reapplication of sealers are all features of an active preventive maintenance program.

2.4—Condition appraisals

A condition appraisal should be performed if extensive deterioration or unexplained problems are observed during the walk-through visual inspection. The appraisal should evaluate and define the extent of deterioration, the associated problems observed, their causes, the causes of the problems observed, and the corrective options available. Typically, the appraisal focuses on the deterioration of deck slabs and their supporting structural elements that can reduce structural capacity or cause safety hazards.

Material samples can be taken and a variety of tests performed. The most important tests are those that determine the extent of corrosion and bond loss of the reinforcement and those that quantify the amount and extent of chloride ingress into the concrete. See ACI 201.1R for additional information regarding concrete durability. Testing may include compressive strength, chain dragging, and half-cell testing to locate

active corrosion and delamination, and chloride-ion content. In addition, petrographic analysis can be done to identify specific concerns regarding the makeup of the concrete.

Information gathered from the condition appraisal, along with resulting lab analyses, should be reviewed by an engineer experienced with structural-condition appraisals. If necessary, a materials consultant can confirm the causes of deterioration. These experts should provide a report with specific recommendations, including restoration priorities, options, and repair budgets.

The owner should maintain accurate maintenance and inspection records to provide historical information that can assist in future appraisals of deterioration and identify potential problems observed.

CHAPTER 3—DETERIORATION PROBLEMS ASSOCIATED WITH PARKING STRUCTURES

The implementation of a proper maintenance program requires an understanding of the deterioration mechanisms and their symptoms. Most deterioration involves water intrusion and corrosion of reinforcement.

Problems that are left unattended during the early stages of their development can lead to safety hazards for users, increased liability for owners, and can require expensive repair programs for correction. Structural maintenance requirements are those actions necessary to preserve, restore, and enhance structural members and improve or enhance protective functions of various waterproofing and anticorrosion systems. See ACI 201.1R, 222R, and 224R for additional information regarding deterioration mechanisms briefly described in this guide.

3.1—Concrete-related deterioration

Concrete-related deterioration is often associated with scaling, spalling, joint failure, or cracking of the concrete members. Delamination of concrete, however, is not a prerequisite for concrete-related deterioration. Sections 3.1.1 through 3.1.7 discuss various deterioration mechanisms.

3.1.1 *Scaling*—Scaling is the disintegration of cement paste at the concrete surface. Commonly associated with cycles of freezing and thawing, it results in progressive deterioration. Severe scaling can result in a loss of concrete surface integrity to depths of more than 25 mm (1 in.). Scaling in deck slabs can create depressions that pose tripping hazards and create ponding areas that can lead to further deterioration. See Fig. 3.1.

3.1.2 *Corrosion*—Corrosion is an electrochemical process that results in the deterioration of reinforcement and other metals embedded in the concrete or exposed to the weather. Chloride ions from road salts or other deleterious airborne chemicals accelerate the corrosion process. Moisture and oxygen also play a direct role. Corrosion can lead to serious deterioration and repair problems. As corrosion progresses, the corrosion byproducts occupy a greater volume than the original metal, creating internal pressure on the concrete that can eventually lead to cracking, delamination, and breaking of the concrete substrate. Corrosion of unbonded post-tensioning tendons represent a special case.

Fig. 3.1—Scaling is deterioration of concrete surfaces usually caused by exposure to freeze-thaw cycles.

Fig. 3.2—Corrosion of reinforcement can lead to deterioration of concrete surfaces.

Post-tensioned tendons can corrode or even fail without cracking or delaminating the surrounding concrete. A post-tensioned tendon failure is often accompanied by the eruption of the tendon either at the tendon end or through the concrete slab. Other post-tensioning problems to look for include exposed tendon sheathing or dislodging of post-tensioning anchors.

Mitigating the corrosion process should be a priority of any maintenance program. The most practical way of controlling corrosion is to incorporate corrosion-protection systems into the original construction and then to reduce or eliminate moisture penetration into the structure (Fig. 3.2). See ACI 222.R for a more complete discussion of the corrosion process and its causes, and ACI 423.4R on corrosion and repair of unbonded single-strand tendons.