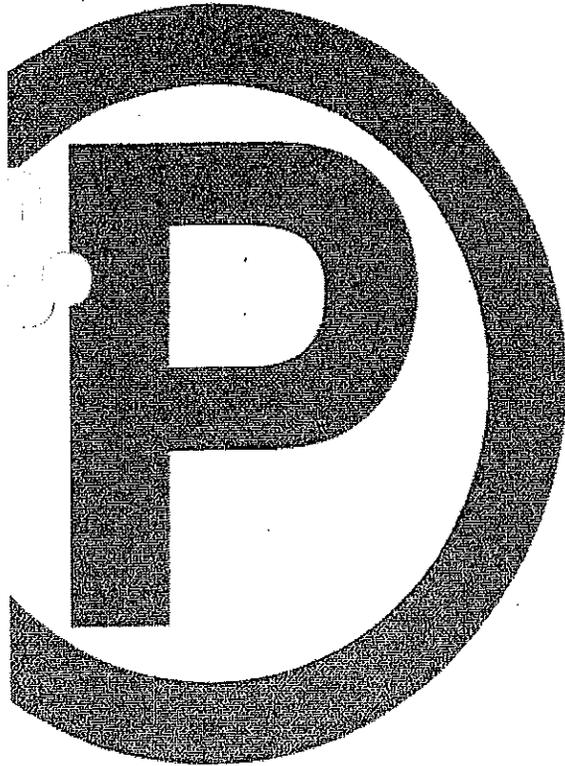


# PARKING GARAGE MAINTENANCE MANUAL

FOURTH EDITION



PARKING  
CONSULTANTS





**NATIONAL PARKING ASSOCIATION**  
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## **PARKING GARAGE MAINTENANCE MANUAL**

GUIDE FOR MAINTENANCE AND REPAIRS

**FOURTH EDITION**

**NPA - PARKING CONSULTANTS COUNCIL  
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# PARKING GARAGE MAINTENANCE MANUAL

## GUIDE FOR REPAIR AND MAINTENANCE OF PARKING GARAGES

NATIONAL PARKING ASSOCIATION - PARKING CONSULTANTS COUNCIL

### FORWARD

The National Parking Association (NPA), founded in 1951, is an international network of more than 1,100 parking professionals from across the United States and around the world. Members include: public commercial parking operators; suppliers of equipment or services to the industry; parking administrators for colleges and universities, hospitals, municipalities, airports, and public authorities; and engineers, architects, and developers. The NPA provides special services for members by sponsoring an annual international convention and trade exposition, acting as a clearinghouse for parking industry information, tracking federal legislation of interest to the parking industry, and publishing a magazine ten times a year.

The Parking Consultants Council (PCC) is a special professional group within the NPA composed primarily of engineers and architects that produce a broad range of technical publications on the design, construction, maintenance, and layout of parking facilities. In addition, they provide recommended guidelines for zoning ordinances, use of handicapped spaces, lighting and other issues of importance to traffic engineers, state and municipal officials, and parking professionals. The professional services provided by the PCC are outlined in Figure 1.

The recommended provisions that follow in this manual are intended only to be general guidelines for the maintenance and repair of parking garages. Owners and operators of parking garages must carefully evaluate whether these maintenance provisions are appropriate for the parking garages of their concern. The engineering, architectural, and operational requirements for a comprehensive maintenance program are complex, and extend beyond the scope of these basic guidelines. The requirements for garage-specific structural repairs and maintenance necessitate the assistance of professional engineering services.

The NPA and the PCC present this fourth edition and update of the *Parking Garage Maintenance Manual*, formerly published in 1982, 1991, and 1996<sup>1</sup>. This manual is the result of work headed by the committee members listed above, who have built upon the foundation of the previous editions. Since the publication of the third edition, several industry-specific maintenance manuals have been published, and we have added a maintenance bibliography to reference these

Reference # 2 - Appendix F

Figure 1.0  
Parking Consulting Services

- Parking Planning and Surveys
- Economic Feasibility
- Functional Planning and Design
- Environmental Studies
- Parking Control Systems
- Design/Construct /Maintenance Services
- Private/Public Financing
- Traffic Studies
- Research Activities
- Expert Witness

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works. The PCC's objective for this publication is not to develop an industry standard; rather, this manual presents a comprehensive coverage of many common issues one might encounter during the maintenance of a parking garage. These approaches must be interpreted and applied as appropriate to specific facility requirements. Neither the NPA nor the PCC assume any responsibility for the use or application of these parking garage maintenance guidelines.

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### 1. INTRODUCTION

#### 1.1 PURPOSE

This manual is intended to provide the owner and/or operator with guidelines for maintaining a parking garage in a serviceable condition, one that minimizes safety hazards and extends the service life of the facility.

PCC members have often been called upon as consultants in the evaluation of facilities' repair and maintenance needs. Many owners must go through a learning curve to recognize the benefit of investing in maintenance to avoid expensive repair and restoration. This manual was written to outline the importance of establishing a site-specific maintenance program tailored to the requirements of each individual garage.

#### 1.2 PARKING GARAGES

This manual is intended to apply to parking garages of all types, including freestanding multi-level parking garages, underground parking garages, and parking garages that are constructed integrally with other facilities such as condominiums and office buildings. While the term "parking garage" is used in this manual to denote all possible parking situations, users of this manual must understand the proper terminology for their specific facility and its purpose. Building codes, zoning ordinances, and local customs may incorporate other designations, including parking facility, parking ramp, parking structure, car park, garage, multi-level parking garage, open parking structure, and closed parking structure.

Operational requirements and other information presented in this manual may also be applicable to surface parking lots. However, this manual should not be consulted for automated or mechanical parking garages; for more information regarding these facilities, see the NPA publication *Guide to the Design & Operation of Automated Parking Facilities*.

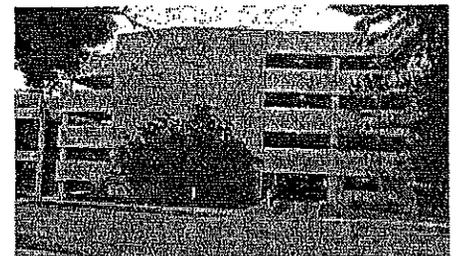


Fig 1.3 - Parking garage with more than 25 years of service.

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### 1.3 PARKING GARAGE SERVICE LIFE

The service area of a parking garage is subjected to more severe environmental conditions than that of most other buildings. In fact, a parking garage's setting more closely resembles that of a highway bridge. Like the highway bridge, the entire garage framing system is exposed to the temperature changes, moisture and environmental conditions of the outdoors, unlike other buildings with a protective envelope, which experience milder and only gradually fluctuating conditions.

Balancing the service life of a garage with the occupancy and service life of a hospital, office building or other main use is essential for the uninterrupted operation and service of the garage. Usually a facility's requirements can be determined when the garage's service life is evaluated and optimized during the planning and design phase, before construction begins. During this phase, the owner and the designer can incorporate construction details and elements to provide for durability, which can, in turn, substantially extend the service life of a garage or minimize the requirements for long-term maintenance. A facility's service life and requirements for maintenance can vary greatly, depending on construction details, environmental factors, or history of maintenance and repairs. The implementation of a comprehensive maintenance program during the first years of facility operation achieves the best results, and offers an optimized return on the initial investment. Anticipating and providing for necessary maintenance and repairs for any facility is an important step in realizing a desired service life. The recommendations and procedures presented in this manual have resulted in facilities that have provided over fifty years of service with minimal maintenance.

### 1.4 OVERVIEW OF MAINTENANCE

The following is a summary of the key elements of a comprehensive maintenance program; requirements for these programs are described in detail within this manual.

- **Routine Maintenance:** This includes periodic and corrective tasks, housekeeping tasks, and safety checks required for effective day-to-day operation of a facility.

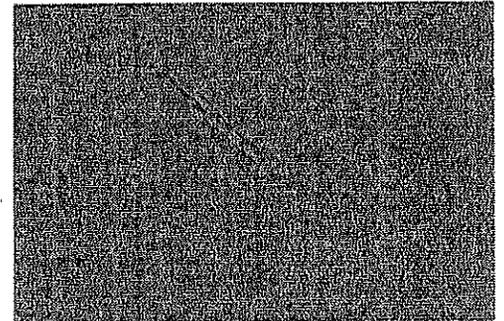


Figure 1.4 - Routed and Sealed Floor Slab Cracks

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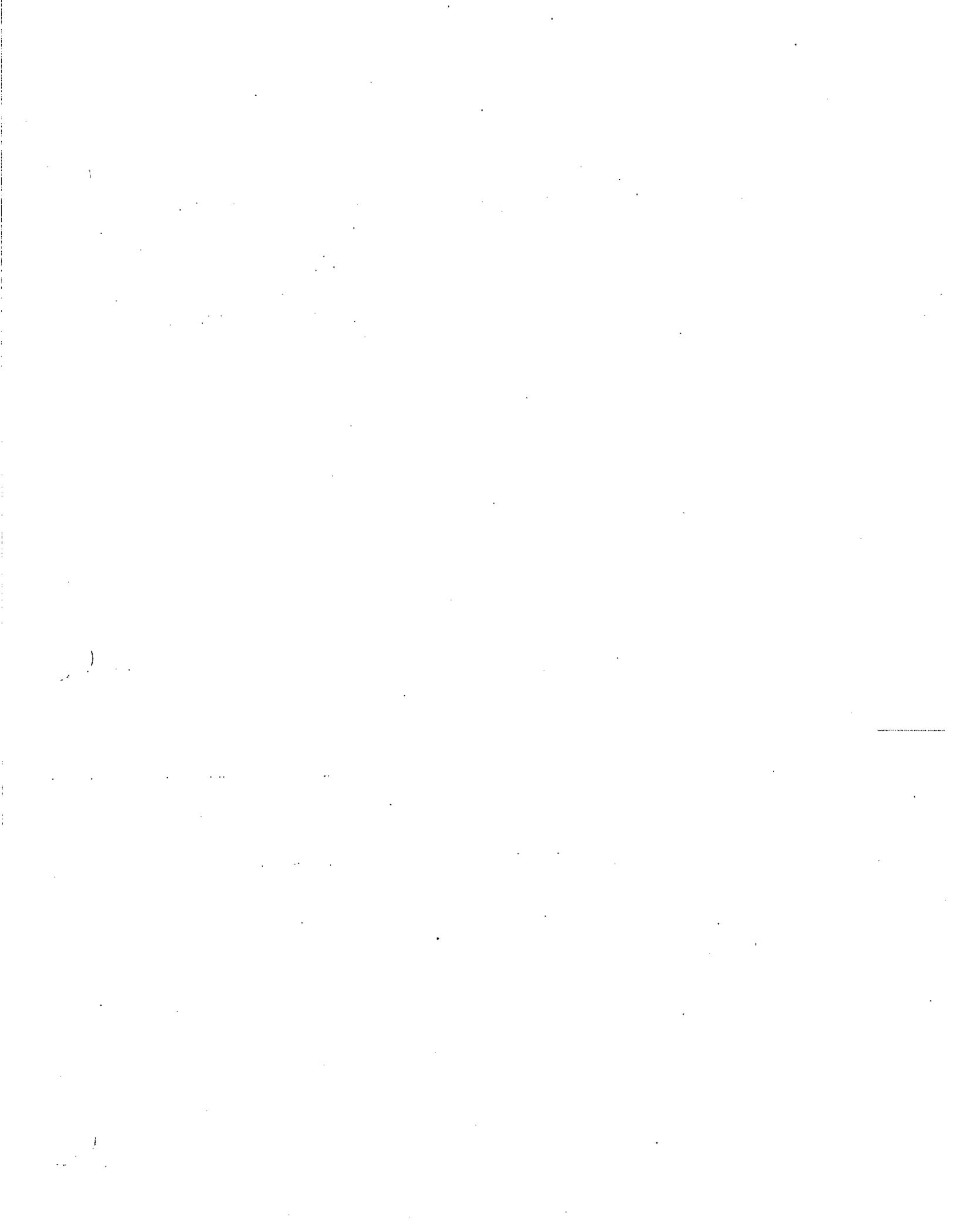
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- **Preventive Maintenance:** Tasks performed as needed to avoid future repairs and protect an owner's capital investment.
- **Repairs and Replacement Maintenance:** Actions performed to repair elements when possible or economical, or to replace them when they have reached the end of their service lives.
- **Condition Appraisals:** This provides an examination and analysis of the operational and physical elements in the parking garage, and outlines possible repairs and/or maintenance approaches to extend the service life of the garage.
- **Rehabilitation and Restoration:** Procedures often required before a comprehensive maintenance program can begin in an existing garage. Decisions made during the restoration process will directly impact maintenance requirements for the remainder of a facility's service life.
- **Maintenance Budget:** Guidance provided in planning and budgeting for an effective maintenance program.

The following is a summary of the appendices, which include supplemental charts, definitions, data, and additional details for the basic maintenance recommendations presented throughout this manual:

- **Appendix A – Maintenance Schedule:** This provides a detailed schedule of the various recommended maintenance tasks, as well as a checklist of these tasks.
- **Appendix B – Waterproofing Systems:** This details various materials and methods used in the waterproofing of structural slabs.
- **Appendix C – Abbreviations and Definitions:** Here the abbreviations and terms used throughout the manual are defined. In addition, this appendix describes the materials typically used in the construction of parking garages,



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provides explanations of typical structural systems, and outlines the most common types of deterioration.

- Appendix D – Parking Access and Revenue Control Equipment: This appendix outlines tasks necessary to keep equipment in good working order.
- Appendix E – Bibliography & References: A listing of additional sources of maintenance and repair information.
- Appendix F – Cited References: Sources of information directly referenced in this manual.

This manual offers practices and maintenance actions that have proved successful in previous parking garage maintenance and repair programs. These recommendations are broad guidelines that are not applicable in every situation, and must therefore be tailored for each garage and its specific construction, environmental exposure, and usage conditions. The process of selecting and highlighting the proper components of a maintenance program requires the combined efforts of the garage owner, the operator, and a professional engineer experienced with parking garage design, repair, and maintenance. For large garages and mixed-use facilities, the owner may consider a maintenance team that adds the resources of specialty engineers and architects.

Prioritization and scheduling of maintenance actions are important aspects of the implementation of a comprehensive maintenance program. Maintenance budgets include three primary classifications—structural, operational, and aesthetic—as shown in Figure 2.0. In the event of a reported “emergency need” for budgeted funds, owners and operators should still implement maintenance actions regardless of pressure to defer these costs until the “emergency need” is resolved; while the effects of deferring maintenance can remain latent for many years, there arise real consequences and usually much higher costs as a result.

- Structural maintenance generally warrants the highest priority, and comprises the largest percentage of cost, in the operation of a parking garage. The most significant maintenance needs are associated with floor slabs and horizontal surfaces, as they are subject to the harshest

### **FIGURE 2**

#### **Maintenance Classifications and Priorities**

##### **STRUCTURAL**

Floors  
Beams, columns, walls  
Stair and elevator towers  
Joint sealant and waterproofing systems  
Masonry  
Railings and barriers

##### **OPERATIONAL**

Cleaning & housekeeping  
Snow and ice control  
Mechanical systems  
Electrical systems  
Parking control systems  
Stair doors  
Fire protection systems

##### **AESTHETICS**

Landscaping  
Painting  
General appearance  
Architectural Finishes

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environmental conditions, abrasion, and wear from car traffic. Neglect or deferral of structural maintenance can lead to major problems and high repair costs: For example, premature deterioration of concrete floors results in costly repairs and significant loss of revenue while repairs are performed. In multi-purpose structures where parking is integrated with other building uses, deterioration of parking floors could affect the integrity and function of the entire structure.

- Operational maintenance generally receives special emphasis, as any malfunction or breakdown of an operational element can take part or all of a facility out of service, or compromise user security and safety. Routine cleaning (including sweeping and wash-downs) are a key element of operational maintenance. Parking garage problems associated with operational maintenance (such as lighting, parking access and revenue control equipment, and security-monitoring devices) are generally easier and less costly to correct than structural problems.
- Aesthetic maintenance is important, as conditions are immediately obvious to users of the garage.

Many parking garages are leased to a contract-parking operator for day-to-day operations. While maintenance is often designated as the responsibility of the operator, the desired level of maintenance and the mechanism for providing this service (and any associated capital expenditures) is sometimes omitted from a lease. Lease agreements should clearly define the party responsible for maintenance, as well as assign any responsibility for the identification and implementation of these maintenance or repair needs.

In summary, a parking garage requires a comprehensive maintenance program that is tailored to its specific situation. The assigned program for any given garage will depend upon many factors, including original design details, quality of materials, construction quality, and exposure conditions. To function at desired performance levels without interruptions in service, all elements of a parking garage require periodic maintenance.

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### **2. ROUTINE MAINTENANCE**

Routine Maintenance entails periodic and corrective actions, housekeeping tasks, and safety checks needed for day-to-day operations in the facility. These are standard duties that must be performed in order to achieve safe, effective and proper function of the parking garage.

#### **2.1 STRUCTURAL**

##### **2.1.1 Structural Systems**

The structural system is the main element of any parking garage, and usually represents up to two-thirds or more of the construction cost. Protection of this investment requires an adequate budget that provides for regular inspection and long-term preventive maintenance. Certain precautions taken during construction can also improve performance of the garage. Adequate drainage, proper concrete quality control, crack control, and proper sealant detailing are key elements that should be regularly addressed.

Routine maintenance of the structural system generally consists of frequent sweeping and periodic wash-downs of the parking garage. Wash-downs should be done with sufficient quantities of water to wash away chlorides; garden hoses are too small to do the job. Regular removal of sand and grit accumulations from drive aisles will help to minimize the loss of slab surface through abrasion, as well as help minimize damage to sealers, sealants and expansion joints. Cleaning procedures are covered in section 2.2.1.

In some cases, however, wash-downs may be detrimental to a garage. An engineer experienced with the design and maintenance of parking garages should be consulted regarding the advisability of wash-downs if the garage contains damage due to corrosion (e.g., if delamination has occurred to more than one percent of total surface area).

Care should be taken to remove excess water from slab surfaces immediately after washing. In enclosed parking garages, the parking ventilation system should be activated after wash-downs to eliminate humidity build-up. This will reduce the amount of potential moisture penetration into the structure's surfaces.

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### 2.1.2 Roofing And Waterproofing

Waterproofing systems that protect structural elements are installed to extend the life of a garage. There are many different waterproofing applications that may be used in a parking garage, including:

- Joint sealants at construction joints, control joints, and cracks in floors and walls
- Expansion joint sealant systems in floors and walls
- Concrete sealers on floors
- Membrane waterproofing systems on floors
- Membrane waterproofing systems on basement walls
- Coatings on concrete basement walls and masonry walls
- Roofing
- Sealants at doors and windows
- Rubber window gaskets

Most of these waterproofing systems have a finite life span. For example, the elastomeric materials used for joint sealants and some expansion joints generally have a life expectancy ranging between seven and ten years. In addition, materials in areas exposed to direct sunlight will often have a shorter life span than those not exposed to direct sunlight. Even the amount of traffic that an area receives has an impact on the life span of the material.

Routine maintenance requires regular assessment of visible waterproofing elements to locate any signs of failure such as leaks, stains, cracks, etc. All areas of the parking garage should be inspected for water leakage semi-annually, ideally on a monthly basis, including stairwell roofs, sealant in exterior wall surfaces, and any other waterproofing that is not normally seen. Rainstorms, hosing down of floors during washing and the thawing of snow accumulation are perfect opportunities to locate leaks from the

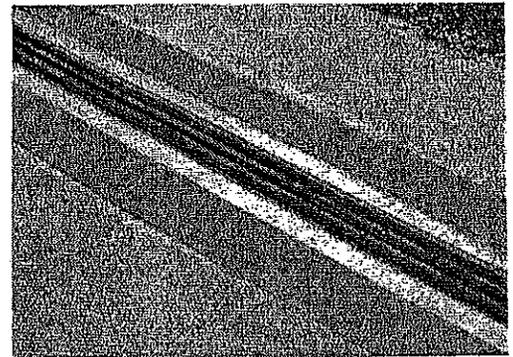


Figure 2.1.2 - Expansion Joint Sealant System

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underside of parking garage floors, roofs, and joints to assess where any problems might originate from the surface above.

### 2.1.3 Painting

Painting systems that protect structural elements are installed to extend the life of the garage. Routine maintenance requires regular assessment of visible metal elements with painted surfaces to identify areas that can be corrected with cleaning and re-painting before deterioration requires more extensive repairs.

## 2.2 OPERATIONAL

### 2.2.1 Cleaning

Cleaning affects the physical appearance of a parking garage that is presented to the user of the facility. Suggested cleaning schedules are based on the concept that people have fewer tendencies to litter in a well-maintained environment. A clean, well-kept parking garage promotes a good reputation and invites people to return, and oftentimes this increased revenue more than offsets the cost of cleaning.

One of the most overlooked aspects of parking garage maintenance is proper floor cleaning. All parking floor areas, including curbs, should be swept monthly and ideally once a week. Large facilities with a frequent turnover of parking spaces or those that are used for special events usually require special cleaning schedules. Sweeping can be done either with hand brooms or mechanized sweepers designed for use in parking garages. Between scheduled sweepings, litter should be picked-up daily. In addition, expansion joints should be cleaned of debris on a periodic basis.

Grease and oil drippings from vehicles can build up within parking spaces and at entrances and exit lanes, which poses a potential safety hazard to pedestrians. These buildups and deposits should be removed at least twice a year with appropriate degreasers, such as an industrial detergent. For parking garages with membrane waterproofing coatings, membrane manufacturers should be contacted for recommendations regarding cleaning materials and

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procedures, and degreasers should be tested to assure that the membrane is not harmed.

Stairs should be cleaned with the same frequency as parking areas; heavily used stairs should be checked daily for trash, and should be swept at least weekly. Stair handrails should also be cleaned, preferably each time the stairs are swept. The floors of lobbies, toilet rooms, cashier booths, offices, elevators, elevator lobbies and entrance and exit lanes should be swept and mopped daily.

Glass surfaces in cashier booths, lobbies, and elevator cabs should be cleaned daily. Other surfaces (non-glass) in these public areas - such as those found in office areas, lobbies, stairways, elevator cabs, or elevator shafts should be cleaned at a frequency of once a month to once a quarter.

Walls in rest rooms and other public areas need to be cleaned regularly. Trash receptacles should be emptied on a regular basis, preferably daily. For facilities that produce large amounts of trash, the use of a large trash receptacle (such as a dumpster provided by a refuse hauling service) may be appropriate.

### **2.2.2 Doors And Hardware**

All doors and hardware should be checked daily to verify that they operate properly. This check should include latch sets, panic hardware, door closures, door sweeps, hinges, locks, mechanized opening and closing equipment, and tracks for sliding, rolling, or overhead doors. When a malfunction is discovered, it should be corrected as soon as possible to maintain the safety and security of the parking garage.

In addition, pedestrian doors that are left open or propped open may reduce safety and security functions of the parking garage.

For example, propping open of doors can violate fire or building code requirements, and a breach of security could lead to a negligent action if it is determined that this action may have contributed to an assault or robbery.

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### 2.2.3 Electrical Systems

Operating a parking garage requires sufficient lighting and electrical power to ensure that users can move easily and securely within a facility. The most common problems with lighting are dirty lenses and burned-out lamps and ballasts. Lamps should be replaced regularly, either as needed (as determined by regular inspections), or by following a replacement schedule based on anticipated lamp life. Lamps and ballasts should be adequately stocked for prompt replacement.

Operating controls for lighting, such as time clocks and photocells, should be checked monthly and maintained as required. Time clocks that are not astronomically corrected may require resetting periodically to compensate for changes of time.

Pedestrian "exit" lights and other illuminated signs and lamps should be checked frequently. Battery-powered emergency lights are usually located near lighted exit signs and should be checked at the same time. All battery packs have test buttons that should be activated at regular intervals to confirm working condition, and most have a visible status indicator light that indicates whether the unit has power and is operative. Battery packs should be maintained according to individual manufacturers' recommendations.

Electrical metallic conduit (EMT) exposed to water leaks or the elements should be protected from potential corrosion problems. Damaged conduit (EMT or plastic) or exposed or improperly installed wiring should be repaired or replaced, and junction boxes and electrical outlets should be in safe working order and adequately protected with cover plates.

### 2.2.4 Elevators

The overall performance of an elevator system should be reviewed during peak usage times. Long waiting times may discourage parkers from returning to a facility, and a sudden change in an elevator's response time could indicate an equipment malfunction.

Elevator cabs should be maintained in a clean, neat manner. Window cleaning from within the elevator shaft requires certain

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safety precautions, and may involve qualified elevator maintenance personnel.

All lamps, including ceiling and indicator lights located inside and outside the cab and emergency lighting required by most codes should be checked daily and replaced as required, as should emergency phones and intercoms.

### **2.2.5 Heating, Ventilation, & Air Conditioning (HVAC)**

Ventilation equipment must be inspected daily to ensure proper operation, either manually or by employing automatic equipment. It is especially important that carbon monoxide sensors be checked for proper operation, as dangerous levels of carbon monoxide can build up quickly if a ventilation system fails to operate.

Noisy operation of HVAC equipment can indicate dirty air filters, inadequate lubrication, or bad bearings, and should be repaired or replaced immediately. Any water leaking into equipment rooms should be reported and corrected upon detection, as corrosion, freeze-ups and electrical short-circuit grounding can render HVAC equipment inoperable. Parking control booths typically have self-contained heating and cooling units, and filters should be cleaned and replaced frequently.

### **2.2.6 Fire Protection Systems, Equipment, & Facilities**

The fire protection system should be inspected, maintained, and checked periodically in accordance with local fire code requirements. Sprinklers and standpipe systems can be wet or dry, depending upon the garage location and environment. For example, garages located in the Snow Belt require dry systems to prevent freezing of pipes during winter months. All fire protection systems require inspection, testing, and maintenance in accordance with NFPA 25, "Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems." Automatic fire alarm systems require inspection, testing, and maintenance in accordance with NFPA 72, "National Fire Alarm Code." In addition, standpipe outlets should be checked to ensure proper operation.

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When an automatic fire alarm or automatic fire extinguishing system is installed, adequate supervision is required to ensure reliable operation. The following are provisions that must be met in order to guarantee effective system function:

1. The extinguishing or alarm system must be electrically connected, either directly or through a central station facility or other approved method, to the fire department legally committed to serve the area where the parking garage is located.
2. Where a system might become inoperable due to a closing of valves, interruption of power or other disruptions of service, adequate supervision should be provided to sound at least a local trouble alarm when the system is disabled.
3. Where parking garage fire alarm facilities are provided, actuation of the fire detection or fire extinguishing system should cause the audible parking garage alarm to sound.

As fire hoses and portable fire extinguishers and their cabinets are often a target of vandalism, they should be checked often for theft or damage and proper function, and replaced when necessary. If permitted by local authorities, a glass-front cabinet with a lock and/or alarm can provide both security against theft and vandalism and access in the event of a fire.

### **2.2.7 Parking Access and Revenue Control Equipment**

All parking access and revenue control equipment should be checked at least once each day to ensure proper function. This can minimize or even eliminate downtime during peak activity periods. Ticket stocks in ticket dispensers must be replenished as required for each ticket dispenser.

### **2.2.8 Plumbing Systems**

Sanitary and storm lines and plumbing fixtures should be tested regularly and maintained in acceptable working order. Floor drains, roof drains, and trench drains should be cleaned on a periodic basis by removing all grates and baskets. If an oil/water

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separator or a sand trap is installed, these systems should be cleaned out at least once a year.

The washdown system should be winterized in areas where temperatures fall below freezing, including the draining of risers and branches. If a washdown system is heat-traced, the entire system must be inspected during winter months to avoid power failure.

### 2.2.9 Safety Checks

Safety checks of some items should be made daily, or at least weekly. These items include:

- Carbon monoxide monitors
- Guardrails and handrails
- Pedestrian exit signs
- Emergency lights
- Fire safety equipment
- Tripping hazards
- Air handling systems

Carbon monoxide monitors, noise alarm systems, and communication systems are often employed in enclosed or underground parking garages. These systems should be checked daily to ensure proper performance, and operation manuals for these instruments should be consulted and followed.

Metal handrails and guardrails at the edges of parking floors are frequently subjected to damage from impact and corrosion. It is recommended that these handrails and guardrails be checked at least monthly to verify that they are rigid, are not damaged, and can adequately serve their intended purpose. Less susceptible to damage but equally deserving of periodic safety checks are concrete guard walls, stair handrails, railing bases, and stair nosing.

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Most building codes require that illuminated exit signs be placed at each stairway on all floors and at other locations of pedestrian ingress and egress. These signs are generally white with red letters. These illuminated signs should be checked daily to verify that light bulbs are working properly, and that sign faces are intact. Special emergency lights and the total lighting system should also be checked regularly for proper operation. See Section 2.2.3 for additional information.

### **2.2.10 Security Systems**

Various types of security systems are employed in parking garages, including the following:

- Audio monitoring devices placed in stairs, elevator cabs, and/or parking areas.
- Two-way audio systems located in elevator cabs, stairways, and other locations, equipped with an audio monitoring system and/or activated by a "call for assistance" button.
- Telephones in elevator cabs, cashier booths, or other locations.
- Alarms in elevator cabs, cashier booths, and offices.
- Alarms or other warning devices on stairway doors, to indicate that they have been opened and/or are not closed properly.
- Closed-circuit television in special areas or throughout the parking garage.

Each type of system requires daily inspection to verify proper function, and can be included as a part of a regular walk-through of the facility.

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### 2.2.11 Signs (Graphics)

Signs throughout any parking garage play an important role in directing and informing users. These signs may include graphics (illuminated or otherwise) mounted or painted on walls, posts, floors, beams, columns, or suspended from ceilings.

All mounted signs should be checked weekly to verify that they are in place and visible. Illuminated signs (such as variable message signs, "full" signs, fee indicators and exit signs) should be checked daily to ensure their proper function.

Cleaning or replacement of signs and graphics should be performed at least quarterly to maintain all signs and graphics in a clean and legible condition.

### 2.2.12 Snow And Ice Control

Snow or ice that has fallen from vehicles or accumulated on roof areas should be removed before vehicle tires pack the snow, or create slippery and potentially hazardous conditions. Before employing a snowplow for snow removal, check that vehicle axle weights will be below 4,000 pounds, garage headroom clearances can be met, and that the plow blade will not damage the garage floors and equipment. If a safe vehicle weight is not known for the garage, the garage's designer should be consulted regarding acceptable vehicle weights to avoid over-stressing the parking garage's structural system. A snowplow's blade can damage a concrete floor, sealants, toppings, or expansion joints if proper precautions are not taken. A heavy rubber blade edge or plow shoes or casters adjusted to keep the steel plow edge a minimum of one half inch above the floor may help to prevent damage.

Snow may be plowed to predetermined locations in a parking garage, particularly to the top level, and simply left to melt. It may also be removed from the garage by a small front-end loader, such as a "Bobcat," or by a heavy-duty snow thrower. If snow is left to melt in piles on parking garage floors, care should be taken to avoid overloading the floor slab beyond its design load. See Table 2.2.12.

As melted snow may refreeze at night, snow piles should be located where the resulting snowmelt will not flow across driving

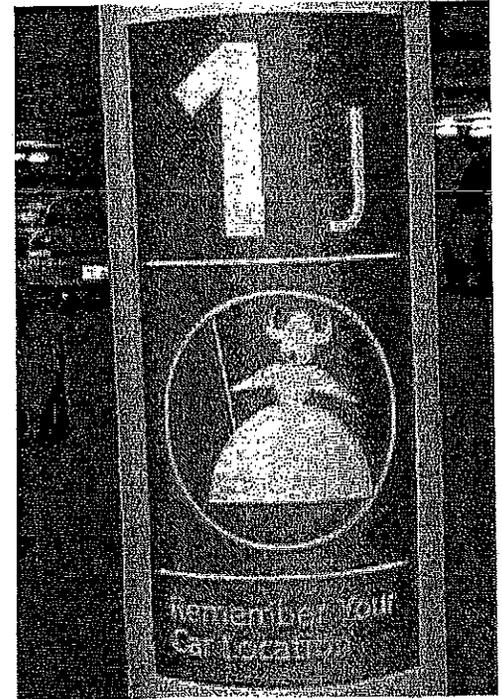


Fig 2.2.11 – Signs and Graphics

TABLE 2.2.12 – SNOW AND ICE CONTROL - Consider Weights

Dry Fluffy Snow:	7-15 lbs/cf
Wet Snow:	20-40 lbs/cf
Mixed Snow & Ice:	40-60 lbs/cf
Plowed, wet snow:	50-60 lbs/cf

30 psf Design snow load allows snow depth of about:

- 6" for plowed wet snow
- 10" for loose wet snow
- 2' for drift of dry fluffy snow

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aisles and pedestrian walkways. Where freezing does occur, icy areas can be treated with sand. The use of heated sand or a mixture of sand and non-salt deicer may control substantial ice build-up. The non-corrosive deicers (such as calcium magnesium acetate) may not work as effectively as road salt at clearing packed snow and ice; they need more time, higher temperatures or the assistance of solar action to complete the melting.

Try to avoid applying de-icing chemicals containing chloride directly to concrete, as the chloride particles are known to be detrimental to concrete and can promote corrosion of structural elements. Because of the previous history of chloride damage, recent technology has seen the development of products that can help reduce the effects of chloride damage from road salts. To best avoid potential damage, however, any sand/salt mixture should be applied to concrete only as needed for operational safety in the garage. As weather permits, the parking garage should be flushed with a high-volume water wash; a fire hose or a minimum 1-1/2 inch diameter hose is recommended, as a garden hose does not produce sufficient volume. Drains should be protected against runoff-related sand accumulation during ice control operations; temporary burlap or straw filters may be used to prevent drain and piping clogging.

Reasonable and prudent measures should be taken to avoid personal injury or property damage during snow removal operations. If snow is dumped over the side of the parking garage, care must be taken to avoid damaging walls, panels, connections, sealants, or other elements of the garage and surrounding structures. Gates or other provisions can be employed in the exterior spandrels to facilitate removal and ensure that snow is directed to a designated area. Snow dumped over the side may be left on the ground to melt, if space allows, but care must be taken to not pile snow on or against another structure or to obstruct sight distances or emergency access or cause damage to existing landscaping.

Congested areas or local ordinance may dictate that snow be removed from the parking garage. Removal may have to occur during specific hours, so as not to disrupt garage traffic.

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### 2.2.13 Painting

Operations- and/or safety-related painted elements (including curb delineations and parking garage surface painted signs) should be inspected monthly to verify they are adequately performing their intended purpose. Cleaning or repainting should be performed promptly when paint begins to fade, becomes soiled, or begins to wear away. Raised curbs should be repainted semi-annually, as their purpose is generally safety-related.

Parking space striping is a basic fixture of all parking garages, and should be restored whenever paint fades or deteriorates. The range of vehicle sizes that utilize a particular facility should be carefully considered whenever re-striping is anticipated. When reapplying the striping, old stripes should be removed completely through shot blasting or water blasting, as painting over old stripes will usually result in two visible sets of lines, and will only serve to confuse the user.

It is recommended that local and state officials be consulted to determine if there are required striping colors and basic dimensions in a specific area's parking stall specifications. Typically, white or yellow striping paint is used. Gravity-fed paint specifically designed for parking stall striping tends to last longer as compared to sprayed paint, but the type of paint must be compatible with the parking surface; a water-based paint will generally not adhere to a concrete surface that has been treated with a water repellent such as a silane or siloxane sealer.

Signs and symbols on walls, beams, and floors may also be painted (as referenced in Section 2.2.11) and should be inspected as often as other painted elements of the garage.

## 2.3 AESTHETIC

### 2.3.1 Landscaping

Landscape watering, grass cutting and weeding should be scheduled and performed regularly. Trees and shrubs should be pruned annually. Rate of frequency for performing landscaping work will vary depending on the time of year, the type and extent

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of the plant material, and the geographical area of the country. A landscaping specialist should be consulted to assist in developing schedules for this work. These tasks may be contracted out to a landscape service, or performed by in-house staff. If landscaping work is to be performed by in-house staff, however, there must be adequate on-site storage for supplies and equipment.

Lawns should be edged, and trees and shrubs pruned, to prevent encroachment onto sidewalk areas and other pedestrian and vehicular traffic paths. As adequate sightlines must be maintained at entrances and exits, extensive pruning of vegetation may be required in these areas. Pruning is also crucial to eliminate potential hiding places for criminals.

Automatic sprinklers are an effective method of watering, but systems must be checked periodically for proper operation and drainage. It is important to ensure that sprinkling and plant drainage systems do not create slippery or hazardous surfaces. In cold-weather climates, irrigation systems must be properly drained and shut down during the winter season. At the time of spring "start-up," each irrigation head should be adjusted. This is also an excellent opportunity to leach salts through the topsoil by extending daily watering periods.

### 2.3.2 Architectural Finishes

Routine maintenance of stairway and garage finishes includes cleaning and touch-up action for painted and finished walls, ceiling, floors, or elements in the garage. Related elements are discussed in sections 2.2.11 and 2.2.13.

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### 3. PREVENTIVE MAINTENANCE

Preventive maintenance includes tasks or actions performed to avert the need for future repairs and to protect the owner's capital investment.

#### 3.1 STRUCTURAL

##### 3.1.1 Structural Systems

The first step in any well-planned preventive maintenance program for a new or old parking garage is a regularly scheduled walk-through conditional appraisal survey of the entire facility. Refer to Chapter 5 for detailed information on condition appraisals.

During any walk-through survey, observe the location and extent of conditions that could cause, or already have caused, concrete or steel deterioration. Items to look for include surface deterioration on the top and bottom surfaces of the floor system, evidence of water leakage and/or staining through or on the floors, walls, or other structural elements, and cracks in floors, beams, columns, walls, or other structural elements.

Leaking and staining are often early indicators of future problems. A conscientious observer must do a walk-through condition appraisal. If evidence of deterioration, scaling, spalling, cracks, or leaks is observed, an engineer experienced with parking garage restoration should be consulted.

An inspection should be performed at least every two years by a qualified engineer experienced in parking garage design and restoration, to ensure that no potentially serious conditions have been overlooked.

##### 3.1.2 Roofing and Waterproofing

The first step in maintaining a waterproofing system is a regularly scheduled visual inspection of the entire facility. Items to be noted include visible wear of surface sealers or membranes, cracking, bubbling, de-bonding, discoloration, softening, tearing, or displacement of membranes, sealants, and wear-course overlays.

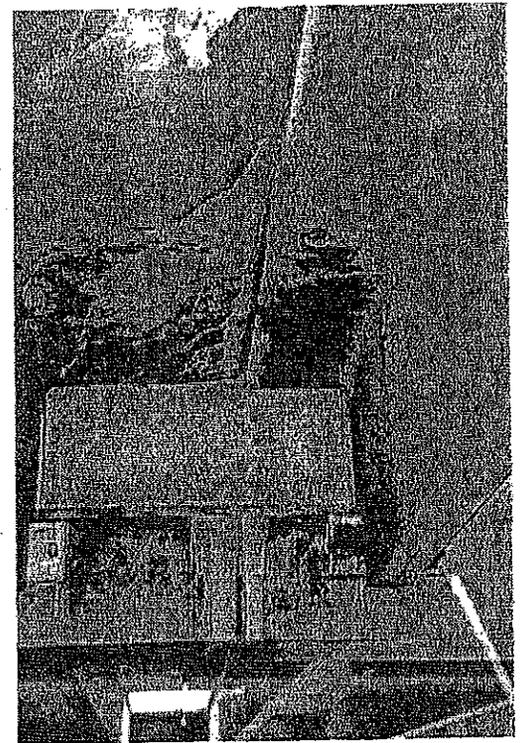


Figure 3.1.1 - Leaking Joint

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If possible, the visual inspection should be done during and after a wash-down of the parking garages. This provides an opportunity to detect any leakage through the structure that may be indicative of a membrane or sealant failure. In addition, inspection of a clean surface ensures that any damage does not go un-noticed under a layer of sand or accumulated debris.

### 3.1.3 Painting

Painting helps to protect the many metal structural elements used throughout the garage. Painting can help prevent corrosion damage and therefore serve as one of the lowest cost preventive measures to extend the life of garage elements. All painted metal surfaces should be inspected to determine their condition; small rust spots should be cleaned and touched up, and complete repainting should be performed whenever required by type of paint and/or conditions resulting from exposure to the elements.

Paint's ability to perform as a protective coating depends upon its quality of adherence to the underlying surface. Before painting, it is extremely important to properly clean and prepare any surface. Preparation for painting may include removal of rust or previous coats of paint, application of caulking or sealant, waterproofing concrete or masonry, or other preparation appropriate to the surface and exposure conditions. Care should be taken that selected paints are appropriate for each particular application. If deterioration of structural metal is observed, further professional evaluation by an experienced engineer is recommended.

## 3.2 OPERATIONAL

### 3.2.1 Cleaning

A regular cleaning program should be established for each parking garage. In addition to periodic sweeping, a semi-annual wash-down of parking garage floors is recommended for all climates. A thorough sweeping should precede this wash-down. In areas where salt is used to melt snow and ice and in coastal salt-water areas, it is especially important to wash floors in early spring to remove the wild up of de-icing salts. This washdown is also essential in the fall



Figure 3.1.2 - Installing Traffic Topping Membrane System

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to clean away fall debris and make sure the drainage system is operational during the coming winter months.

High-traffic areas such as entrance lanes and main driving aisles should be washed more frequently than other areas of the garage. In cold climates this can be performed in winter during periods of moderate temperatures. If moderate temperatures do not occur, however, squeegees or brooms can be used to remove salt-laden slush or water.

Before and after washing floors, all drains should be checked to see that they are functioning properly. Sand washed from floors can clog drains, and temporary burlap or straw filters may be employed to prevent this. Temporary filters must be removed immediately after washing.

High-pressure water may be used for removing grease spots on the parking garage floors. Care must be taken, however, to avoid damage to joint sealant materials and membrane waterproofing.

Particular care should be given to frequent and regular cleaning of tracks and grooves in elevator sills, found in both the elevator cab doorsill and each landing doorsill. Dirt build-up in these tracks can cause the elevator doors to malfunction.

Cleaning is referenced further in section 2.2.1

### 3.2.2 Doors and Hardware

Doors and hardware require regular lubrication, scheduled in accordance with the manufacturer's recommendations and at least semi-annually. Painting of doors and hardware should be included in a preventive maintenance program, and is referenced in Section 3.2.13.

### 3.2.3 Electrical Systems

Periodic inspection of the entire electrical system is an important aspect of the preventive maintenance program. Electrical equipment and conduits should be inspected for corrosion and deterioration wherever exposed to moisture or the elements. If exposed electrical equipment is not designed to withstand the rigors of weathering

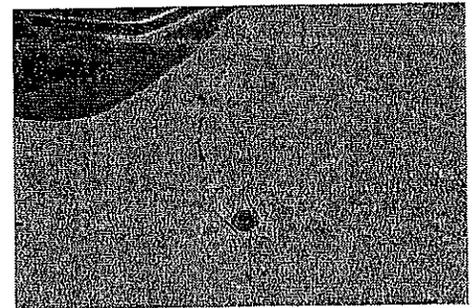


Figure 3.2.3 – Corrosion on Electrical Junction Box and Conduit in Slab

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typical of open parking garage environments, it should be provided with a corrosion-resistant treatment to prevent damage. All exposed electrical conduit and boxes should be painted when necessary.

Regular inspection and maintenance is required for battery-powered emergency lighting. Some battery systems require replenishment of a water/electrolyte supply. Electrical service for parking access and revenue control equipment is discussed in greater detail in Appendix D.

Time clock control of exterior lighting systems should be checked periodically to insure proper function of time-switch-controlled applications. Photocell controls should also be calibrated and adjusted.

In a planned preventive maintenance program, a group re-lamping program should be instituted when lamp burn time reaches approximately 70 percent of its rated life. This will insure the reliability of adequate lighting at all times, particularly in high-security applications. The interiors and plastic refractors of lighting fixtures should be inspected at this time, as many plastic refractors and light diffusers tend to yellow after a period of approximately five years, resulting in diminished light output. These discolored diffusers should be replaced, and the insides of the fixtures should be cleaned; the execution of an inspection and replacement program is an ideal opportunity to institute a fixture cleaning program as well.

### 3.2.4 Elevators

Preventive maintenance is imperative for proper operation of elevators and their associated hardware. The level and frequency of an inspection program will vary with the type of equipment, its intended use, and the appropriate state and local code provisions: the American National Standard Safety Code for Elevators requires periodic safety checks and maintenance services for all elevators, shafts, and hardware; local building codes may have more stringent requirements.

Most elevator equipment problems result from an accumulation of water. Leakage into the elevator shaft or equipment room must be corrected as soon as it is discovered. Elevator pit sump pumps

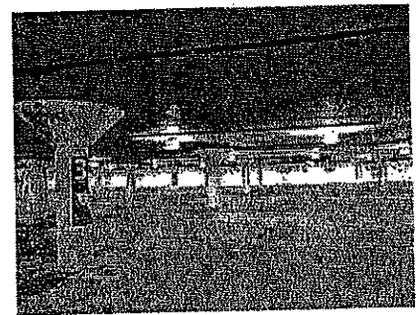


Figure 3.2.3 – Maintenance of metal halide lighting provides high levels of uniform lighting.

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should be checked periodically to ensure proper performance, and pumps and elevator pits should be cleaned regularly.

Equipment rooms should be monitored to ensure that heating and ventilation systems are operating properly. Allowing equipment to become too hot or too cold may result in improper operation or damage to computer chip components.

Overall, it is generally more practical and cost-effective to place elevator equipment under a service contract with a reputable elevator service company than to furnish a staff of properly trained in-house specialists.

### 3.2.5 Heating, Ventilation, & Air Conditioning (HVAC)

Service manuals provided by the manufacturers of HVAC equipment should be reviewed for appropriate maintenance action. All required servicing should be performed as specified by the manufacturer.

The control systems should be calibrated annually, either by trained maintenance personnel or by a control system contractor. All control system components should be checked for proper operation in accordance with the manufacturer's specifications, including temperature and/or containment sensors, relays, switches, actuators, etc.

Filters should be replaced or cleaned on a regular basis, as required by local conditions, as dirty filters increase fan-operating costs. Heating and cooling coils should be checked at least annually for build-up of foreign matter, because dirty heating and cooling coils increase operating costs as they reduce heat transfer. If filter failure is observed, coils, dampers and fans downstream should be checked and cleaned as necessary.

Motors, motor drives, and fan wheels should be checked monthly, and lubricated according to manufacturer's instructions. Dampers and their actuators should be checked quarterly for proper operation. This equipment may seize up, resulting in improper ventilation and excessive energy use. Belt drives should be checked for proper belt tension to prevent slippage. Worn or damaged belts or other parts should be replaced to minimize the chance of a

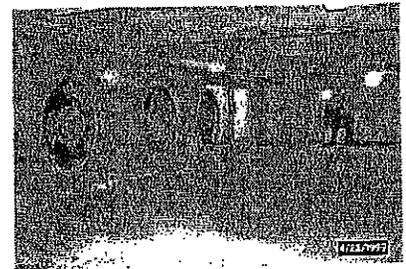


Figure 3.2.5 – Garage ventilation maintenance is important for safe air quality in the garage.

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breakdown, and replacement belts and pulleys for fans should be kept in stock.

### **3.2.6 Fire Protection Systems, Equipment, and Facilities**

Fire standpipes in parking garages are usually dry. They may be interconnected, and are supplied through a Siamese pumper connection at street level. Connections should be checked periodically for lubrication and damaged threads, and check valves at Siamese inlets should be monitored for proper operation.

Whether a system is wet or dry, regular inspection and maintenance procedures should be implemented. Fire protection sprinklers used in parking garages are usually dry systems. Components of the sprinkler system include an air compressor, dry pipe valve, alarm devices, tamper switches, and test drains and should be inspected and serviced by qualified personnel. Dry systems should be drained and left dry after each use. Sprinkler heads must be checked for operation and corrosion.

Garages commonly require fire pumps and emergency generators. These special pieces of equipment require lubrication, and cleaning, and other specialized maintenance as shown in the equipment maintenance and operations manuals.

### **3.2.7 Parking Access And Revenue Control Equipment**

A preventive maintenance program should be implemented to minimize breakdown of parking equipment. A service agreement with an authorized parking equipment supplier is recommended, and should include regular preventive maintenance service as well as emergency repair service. Quick response to calls for emergency service in addition to local availability of appropriate replacement parts should be considered when selecting a service firm. Special training for in-house staff should be considered, which could possibly take care of preventive maintenance and most emergency situations.

Copies of operating and service manuals for all equipment in the parking garage should be kept on hand for easy reference. It is advisable to establish a log of maintenance and service work completed on each piece of equipment, as well as an inventory of

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critical replacement parts so that equipment can be repaired quickly.

A maintenance program should be based on the following key items:

- Safety first
- Good, low-surge electrical power using CVT's, UPS systems, lightning protection, etc.
- Installation per manufacturer's specifications
- Operation, supervision, and maintenance training
- Documentation

Additional information regarding parking service and access equipment is presented in Appendix D.

### 3.2.8 Plumbing Systems

The water supply piping for sanitary facilities (e.g., toilets, wash-basins, mop sinks) is generally protected against freezing and usually requires only a periodic check for leaks and working order. However, the piping for wash-down and irrigation, if exposed to freezing temperatures in the winter, must be drained each fall, in addition to periodic checks. For all plumbing systems in a parking garage, the pipes, sleeves, and pipe-hangers must be kept free of rust.

If there is a water heater, it should be checked and flushed annually. A check of sanitary plumbing can be done at the same time that the water supply is checked, while inspection of heater components such as relief valves, gas pilots, etc., should be performed regularly.

The most extensive plumbing system in a parking garage is associated with storm-water collection and drainage piping, and neglect of this system can have expensive consequences. Floor drain inlets and basins must be kept clear of rubbish and sediment to prevent clogging and ponding; drains at the lowest floor may

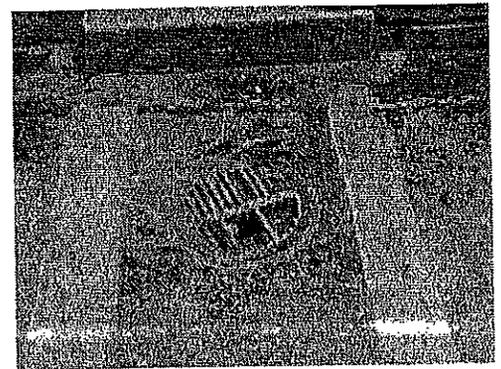


Figure 3.2.8 - Maintenance Includes Cleaning Floor Drains and Fixing Broken Grates

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have backwater valves, which should be checked for proper function.

When washing down the floors, temporary filters of burlap may be put over the drain inlets to keep them clear. Periodically, especially before and after wash-downs, sediment basins and traps, sump pumps, sand buckets in drains, pump motors, and control switches should be checked to ensure continued proper operation.

Backflow prevention devices are necessary to minimize the risk of contamination of potable water supply. Periodic inspection and/or maintenance of these devices are essential.

### **3.2.9 Safety Checks**

Due to deterioration, concrete floors, sidewalks or other walkway surfaces can develop holes or pockets that can result in tripping hazards. Obviously, even temporary patches of these holes will help make the garage safer for patrons.

### **3.2.10 Security Systems**

Preventive maintenance and repair of security system equipment is best left to those experienced with the specific system. Elaborate systems may also merit a service contract, to assure the quick response of qualified personnel when assistance is needed.

### **3.2.11 Signs (Graphics)**

Quarterly, the sign or facing material should be examined for deterioration and dirt. Graphics applied to floors should be carefully inspected twice annually to determine their legibility to the motorist. Dirt, oil, etc., should be removed and the graphics replaced as needed.

### **3.2.12 Snow And Ice Control**

Some parking garages contain gas-fired, electric-powered, or steam snow melters. These units should be checked for proper operation each fall, and periodically during winter months. To operate effectively, some units may need to be turned on several hours before a predicted snowfall. Other systems have a "snow

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sensor" that activates the unit when snowfall begins; however, if the sensor is not operating properly, a manual switch should be installed.

Some parking garages have a snow melting system embedded in certain areas the floor, such as outside stairs or driveways. Such systems are generally composed of either electrical cable or piped ethylene glycol fluid. The snow melting system should be checked for operation before the first snowfall of the season, and maintenance should follow the appropriate system manual. Since breaks in electrical cables or fluid system pipes are difficult to trace, the system installer should be contacted if operational problems arise, as it may be indicative of a complicated and difficult concern.

Another type of snow melting system consists of infrared heat lamps mounted above the surface. Maintenance of these lamps is similar to other types of lamps. Lamp operation should be checked daily during the snow season. Installation of infrared lamps must account for vehicle queuing at entry and exit locations, as vehicles standing in the same position below lamps for long periods of time can experience finish damage. Qualified installers should be consulted when contemplating this type of equipment. No matter what type of system is used, an indicator light should be installed in a highly visible location to indicate when the system is in operation. Without the indicator light it may be difficult to tell the heating system is operating.

### 3.2.13 Painting

Painting helps protect many operational items in the garage, and can serve as one of the lowest cost preventive measures to extend the life of garage operational equipment. All painted metal surfaces should be inspected to determine their condition, and any small rust spots should be cleaned and touched up. Complete repainting should be done whenever warranted by the equipment, type of paint, and/or surface conditions.

Paint as a protective coating depends on its adherence to the underlying surface, and should be carefully selected so as to be appropriate for each particular application. Before painting, it is

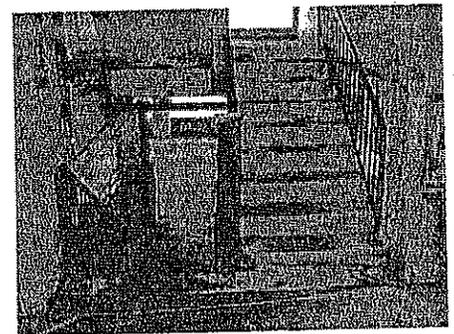


Figure 3.2.13 - After repairing the leakage into the stairs, the metal handrails need painting

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extremely important to properly clean and prepare any surface. This preparation may include removal of rust or previous coats of paint, application of caulking or sealant, waterproofing concrete or masonry, and other preparations appropriate to the surface and exposure conditions. If deterioration of metal elements is observed, the impact on the equipment should be evaluated.

Regular painting of exposed metals such as doors, doorframes, pipes, and pipe guards helps to prevent corrosion, and provides an attractive appearance. Metal pan stairs must be inspected and painted on a regular basis. Handrails and guardrails serve as safety-related functions, and should be inspected and painted as required to retain their operational capacity.

Some metals such as anodized aluminum and stainless steel do not require painting. Galvanized steel surfaces do not initially require painting; however galvanizing is sacrificial, and under some exposure conditions cleaning and painting may be required to maintain corrosion protection as the surface ages.

### **3.3 AESTHETIC**

#### **3.3.1 Landscaping**

Timely maintenance is a must to preserve landscaping. A maintenance schedule should be developed and adhered to; working with a local landscaping specialist will aid in determining when basic tasks, such as cultivation, fertilizing, reseeding, etc., should be performed, as well as insect and disease control.

The type of landscaping materials installed should be selected to minimize the amount of required maintenance. Plants requiring minimum watering should be used in dry areas, while plants that can tolerate cold weather should be used in northern states.

Care should be taken to place plants in locations where they will not be damaged by salt spray during winter months. The installation of salt-resistant plants is one option, while other landscaping alternatives such as timbers, rock gardens, etc., can be considered. These non-plant materials may be considered in desert areas as well, as they require minimal maintenance.

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Maintenance of automatic sprinkler systems should be incorporated in the landscaping maintenance program.

Landscaping materials placed on supported structural members, should be limited to the load limits of the structure (an engineer should review the proposed landscape loading). Appropriate waterproofing is required to protect the structure from moisture and the risk of chemical attack. Placing landscaping over a garage has become more common because of economic or green building benefits.

### 3.3.2 Architectural Finishes

Any painting or staining of interior or exterior concrete and masonry is usually done for appearance, but some masonry paints can serve waterproofing purposes as well. These elements should be repainted at regular intervals, depending on exposure conditions.

Anti-graffiti paints are effective, and should be considered where graffiti is a problem.

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### **4. REPAIR - REPLACEMENT MAINTENANCE AND SERVICE LIFE**

Although accommodations are made in a comprehensive asset management plan for repairs extraneous to routine and preventive maintenance, they require special considerations beyond those intended for maintenance. Repairs can interrupt normal operations in the parking garage and require the expenditure of capital funds. Repairs or replacements are generally required when the serviceability or service life of the element has been reached.

#### **4.1. STRUCTURAL REPAIRS**

##### **4.1.1 Repairs and Rehabilitation**

Repairs and rehabilitation actions are often required before beginning a comprehensive maintenance program. To evaluate the need for repair and maintenance items, a parking consultant will conduct a condition appraisal of the current conditions in the garage. The elements of a condition appraisal are described in more detail in section 5 of this manual, and the elements of structural repair and restoration programs are described in more detail in section 6.

##### **4.1.2 Replacement Maintenance**

Replacement maintenance refers to the replacement of garage elements at the end of their expected service lives. Individual elements or equipment components in the garage may have service lives that vary from five to twenty-five years. The following sections provide a description of the replacement maintenance for structural, operational, or aesthetic maintenance.

Before beginning repairs or rehabilitation of a parking garage, it is necessary to evaluate the extent of deterioration of physical elements. A condition appraisal provides an examination and analysis of these elements, and helps the owner choose the best repair and maintenance approach for their garage. Repair alternatives are usually evaluated based on cost and operational impact on the garage.

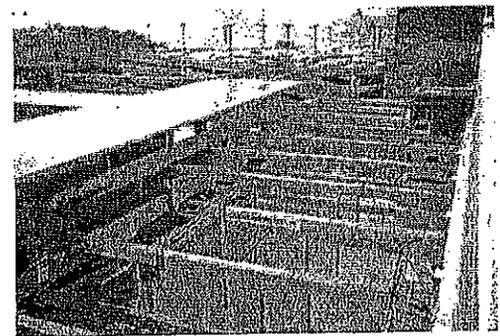


Figure 4.1.2 - Full Depth Slab Replacement

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The owner who has completed capital expenditures often associated with repair programs understands well the importance of a comprehensive maintenance program. The implementation of maintenance actions immediately following repairs brings about the best results, and results in the lowest long-term cost.

### 4.1.3 Structural Systems

Structural repairs are actions taken to rebuild or reconstruct an item within a garage's structure, to extend the useful life of the entire facility. Generally, options for repair or replacement will exist for all structural elements in a garage. A clear understanding of the expected life of a garage, and the expected service life for repairs or replacements, will lead to the selection of appropriate repair or rehabilitation actions. The use of modern materials can provide an extended service life for structural elements. Choices in the selection of repair options, materials, and preventive measures can often provide a range of expected service life from two years to more than sixty years.

### 4.1.4 Waterproofing & Roofing

Waterproofing materials that occasionally require repair include traffic-bearing membranes, sealers, caulking, expansion joints, and compression seals. Readers should consult Appendix B for useful life and other information regarding these materials.

Caulk is often used to seal non-structural joints between architectural elements. An example is a joint between precast concrete members and curtain wall systems. This caulk can fail, allowing water inside an enclosed space such as a stairwell, which can start to corrode connection materials. Owners should anticipate a useful life of 7 to 10 years for caulk.

Roofing materials age from exposure to sunlight and the elements. An entire roof should be replaced when leaks cannot effectively be repaired. Owners should anticipate a 25-year life for roofing systems.



Figure 4.1.3 - Floor Spalling

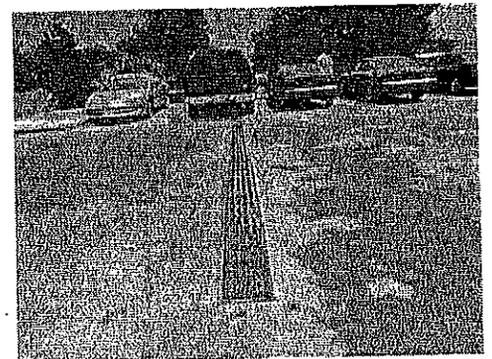


Figure 4.1.4 - Roof Parking with Traffic Topping Membrane Wear

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### 4.2 OPERATIONAL REPLACEMENT

Operational replacement maintenance refers to non-structural items, which reach the end of their useful life prior to the overall useful life of the structure. The end of the useful life is defined as the point in time where the cost of total anticipated maintenance is higher than the cost to replace these same elements.

#### 4.2.1 Doors

Doors are susceptible to corrosion from water accumulation on slabs. If not maintained, doors and frames can become rusted through. Their life expectancies vary by location and environmental factors, so we estimate 10 to 20 years of life depending on the severity of the exposure.

#### 4.2.2 Electrical Systems

Electrical systems degrade in several ways. Metal conduit can corrode, and light fixture lenses can become discolored. Owners should expect replacement of fixtures after 25 years.

#### 4.2.3 Elevators

The need to replace elevator mechanisms will depend upon the type of elevator used. Hydraulic equipment will need to be replaced every 25 to 30 years, while traction equipment will need to be replaced every 30 to 40 years. Electronic components should be replaced every 20 to 25 years. Please note that these timeframe estimates assume that an owner has established a regular elevator maintenance program.

As the life of materials inside an elevator cab varies based on the amount and type of use, the expected life cannot be generally quantified.

Owners frequently undertake elevator modernizations. These programs replace worn or outdated components, and upgrade interior materials. These programs generally take place every 15 to 20 years.

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### 4.2.4 Heating Ventilating Air Conditioning

The most common type of HVAC equipment found in parking garages is a ventilating system. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) recommends anticipating a 15-year service life for fans, and a 30-year service life for ductwork.

### 4.2.5 Fire Protection

Fire protection systems normally incorporate dry standpipes and, for enclosed structures, dry sprinkler systems. Piping should last the life of the structure. Owners should watch for sections of pipe that may rust at intersections with floors. Fire pumps may need to be replaced every 15 years.

### 4.2.6 Parking Control Equipment

See Appendix D for information on maintenance and service life of parking control equipment.

### 4.2.7 Plumbing

Plumbing systems include washdown systems and piping to offices, restrooms and utility closets. These systems should last for more than 25 years. Owners should watch for sections of pipe that may rust at intersections with floors.

### 4.2.8 Safety Checks

Changes in the way we use the garage and changes in codes and laws may require safety replacements in various elements of the garage. Security requirements in the United States have changed dramatically after 9/11; fire safety is no longer the single main concern. For personal safety of patrons, more openness is often provided in stairs (see Fig 4.3.1). Other recent changes include replacement of barriers and handrails for reduced opening sizes (4" maximum), increased stair exit width, provisions for rescue assistance areas, and upgrades for Americans with Disabilities Act (ADA) accessibility.

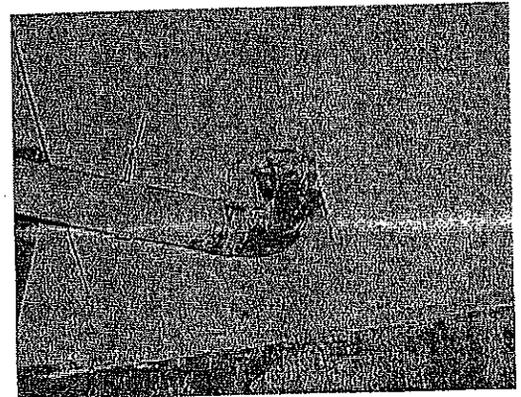
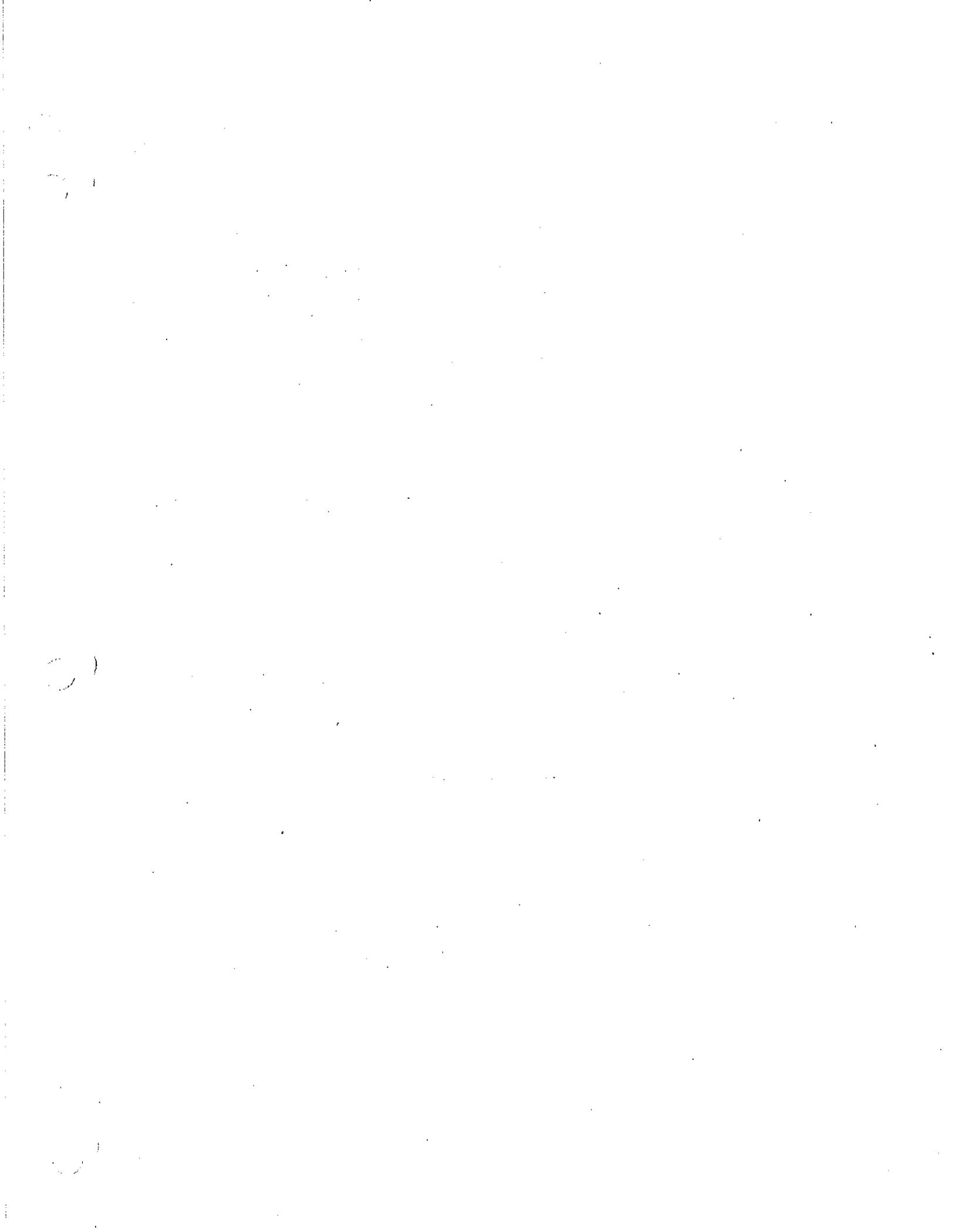


Figure 4.2.7 – Leaking and Rust at Floor Drain



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### 4.2.9 Security Systems

Security systems have long service lives, but technology changes often render the equipment obsolete. Owners should assume replacing equipment every 10 years

### 4.2.10 Signs and Graphics

Painted floor graphics are worn off concrete by vehicle and pedestrian traffic. Owners should assume replacement of graphics every 5 years, unless the graphics are replaced when sealers or traffic coatings are replaced.

Wall or ceiling mounted signs must be replaced if they fade. Owners should assume replacement of graphics exposed to sunlight every 20 years.

### 4.2.11 Snow and Ice Control

Snow and ice control systems can last 5 to 20 years depending on usage and environmental conditions. Elements embedded in concrete garage ramps are difficult to repair or replace and special considerations are required during initial construction to provide an acceptable service life. Mounting heaters above the ramp surface provides access to the heating units for repairs and maintenance and replacement of heating elements.

### 4.2.12 Painting

Replacing painted finishes should be planned for at 5 to 15 year intervals depending on the characteristics of the original coatings used, environmental conditions, and interim cleaning and recoats.

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### 4.3 AESTHETIC REPLACEMENT

#### 4.3.1 Landscaping

Replacement of landscaping depends upon the plants selected and environmental conditions.

#### 4.3.2 Architectural Finishes & Painting

Walls, beams and ceilings in parking garages can be enhanced greatly through repainting. While repainting schedules vary depending upon garage usage, effectiveness of routine or touch-up painting, and environmental factors, planning for repainting in 5 to 10 year intervals is common.

Due to the environmental conditions in a garage, many areas may have exposed structural members without architectural finishes. The architectural finishes are often limited to stairs, lobbies, and main entry areas. Replacement of the finishes in a stairway can dramatically improve appearances, improve openness and security and reduce maintenance problems as shown in Figure 4.3.1.

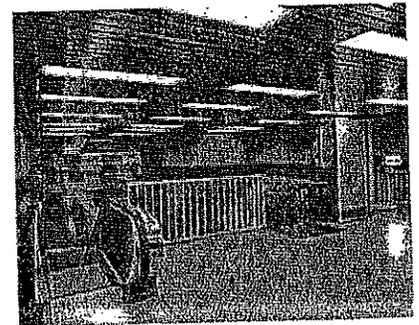
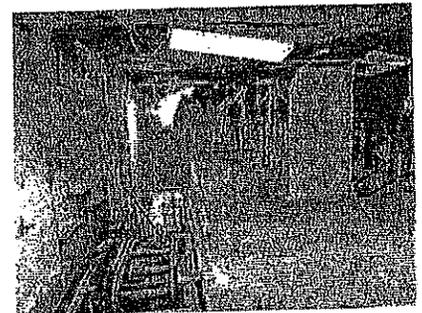
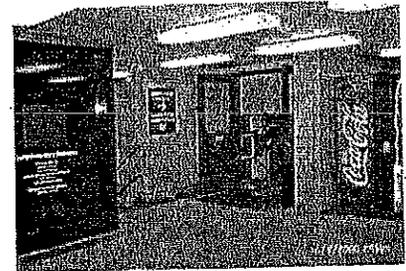


Figure 4.3.1 Maintenance of dated architectural finishes like terracotta (top photo) can be difficult. Garage rehabilitation (middle photo) removes dated architectural finishes and (bottom photo) provides modern finishes, more openness for security, and achievable maintenance requirements.

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### 5. CONDITION APPRAISALS

#### 5.1 BACKGROUND

Condition appraisals are an important part of maintenance programs established by facility owners to manage parking facility assets. Properly managed facilities can often avert expensive future repairs. The following discussion of parking facility deterioration was adapted from cited reference 3 to help explain why parking garage deterioration differs from deterioration in other structures.

Parking garages are directly exposed to the natural elements and experience very harsh conditions that contribute to accelerated deterioration and premature failure of the concrete structure. The deterioration of parking garages is represented<sup>1</sup> in Figure 1.

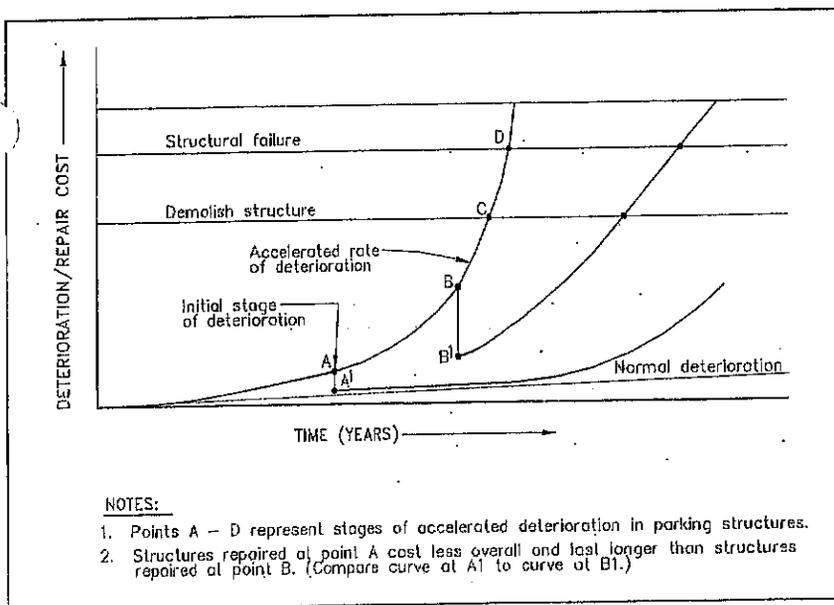


Figure 5.1.1: Deterioration of parking garages<sup>1</sup>.

Most concrete structures deteriorate gradually over time, as represented by the line labeled "Normal Deterioration" in Figure 1. Structural elements of buildings that are enclosed, protected, and

<sup>1</sup> Appendix F- Reference #3, Anthony Chrest, Mary Smith, Sam Bhuyan, Donald Monahan, Mohammad Iqbal "Parking Structures: Planning, Design, Construction, Maintenance and Repair".

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maintained in a controlled environment tend to experience a normal rate of deterioration, as represented by gentle slope of this line. In comparison, the accelerated deterioration rate experienced by parking facilities is shown by the curve connecting points A through D.

This curve indicates that initially, during the early stage of their service life, parking garages also deteriorate at a normal rate. However, after they have been in service for a period of time, they tend to experience an abnormally high rate of accelerated deterioration and premature failure that can primarily be attributed to exposure to an aggressive environment, temperature extremes and dynamic (vehicular) loads.

### WHY PARKING GARAGES DETERIORATE

There are several mechanisms that contribute to this accelerated deterioration and that reduce the service life of a structure. In northern regions of the USA, corrosion of embedded reinforcement by chloride contamination from road salt is a primary contributor. Another commonly-observed instance of concrete deterioration results from little or no air-entrainment in concrete, where setting, freezing and thawing can contribute to progressive and rapid concrete deterioration. Some structures in southern regions are exposed to an equally harsh environment, such as those located in coastal regions. These garages are susceptible to corrosion-induced deterioration, as airborne chlorides and marine water spray can be just as damaging as road salts.

Deterioration mechanisms such as cracking, leaching, carbonation, and abrasion can also adversely affect structures in both severe and moderate climates. In addition, inadequate design details, poor drainage conditions, poor quality concrete and joint deterioration can have a significant impact on a structure's service life.

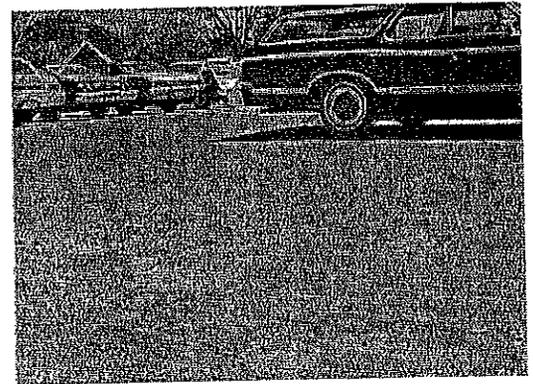


Figure 5.1.2 - Floor Slab Scaling

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### CONDITION APPRAISAL SUMMARY

Condition appraisals are an integral component of any maintenance program. An appraisal is a combination of visual observation and analysis that provides:

- An evaluation snapshot of the condition of the structural, architectural, MEP, parking and revenue control, and fire protection systems.
- Options for needed repair and maintenance.
- Estimates of capital and operating expenditures required to repair and maintain a structural system in a desired condition.

Condition appraisals require evaluations and judgments of the parking garage, which, depending on the purpose of the evaluation, can include a wide range of tasks. The following sections present the tasks associated with two common types of condition appraisals: a walk-through condition assessment and a general condition appraisal.

### 5.2 WALK-THROUGH CONDITION ASSESSMENT

A walk-through condition assessment provides a facility owner with a road map of maintenance and repair options, including an estimated cost range of necessary construction. Steps in this process include:

- A kickoff meeting with the owner to review goals and expectations.
- Visual examinations by a qualified parking consultant.
- A condition assessment report.
- A review meeting with the owner.

#### 5.2.1 Kickoff Meeting

The owner and parking consultant must meet before a project begins, to define the goals and expectations of the condition appraisal. Typical topics for discussion include:

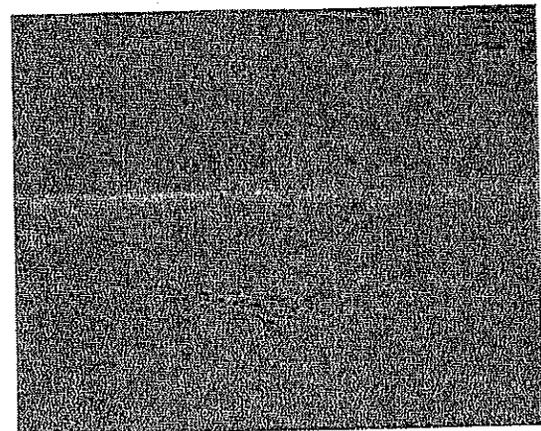


Figure 5.2.1 - Traffic Topping Wear at Vehicle Turn path

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- Expected outcomes of the appraisal, usually including a description of the current condition and a recommendation of means to meet service life expectations.
- A list of tasks to be included in the process.
- A schedule of the process.
- A transfer of existing information, such as original plans and specifications, test results and other maintenance reports.

If necessary, the parking consultant will modify the intended process based on the results of this meeting.

### 5.2.2 Visual Examinations

The next step in the process is a walk-through of the existing facility. This is an intermediate step, and is intended to generally determine the condition of the facility. This procedure will not, however, result in a detailed determination of the quantities required in potential repair. Typical steps in the visual examination include a review of existing information, a development of base plans used in the mapping of items in need of repair and field observations of representative areas of the garage. The area to be observed varies from project to project, but would typically involve less than half of the total garage area. Inspection procedures and observations usually include:

- The sounding of concrete to determine areas of delamination. Sounding methods include chain drags of horizontal surfaces and tapping vertical and overhead surfaces with hammers or other instruments.
- An examination of rust stains and leaching.
- A check for scaling.
- A check for cracks.
- A survey of any rusting connections.
- A location of failed caulk and sealants.
- Testing for poor drainage.
- A survey of damage to waterproofing.

All observations are documented in field notes and on the base plans. In addition, the parking consultant should define testing programs to be included in the next phase of the process.

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### **5.2.3 DATA ANALYSIS**

Once the fieldwork has been completed, the parking consultant can begin the process of developing maintenance and repair plans. The first step in this process is to quantify the areas observed in the representative areas of the visual examination to be in need of repair. These quantities are then projected to areas not observed, leading to a preliminary summation of repair for the entire facility.

### **5.2.4 Condition Assessment Report**

Based on estimated quantities and anticipated unit costs, the parking consultant will determine the type of program needed, and will prepare a report for the owner's review.

### **5.2.5 REVIEW MEETING**

The final step in the preliminary condition appraisal process is a meeting between the parking consultant and the owner, to review repair options. Discussion topics include:

- A description of the garage's condition.
- Repair recommendations, and a preliminary construction cost estimate or cost range.
- A discussion of work that requires additional evaluation or testing.
- Anticipated deterioration without repair or maintenance.

### **5.3 CONDITION APPRAISAL**

The condition appraisal provides an evaluation of a facility, and summarizes repair options, maintenance alternatives and estimated construction costs to extend the service life of a parking garage. The condition appraisal provides a more detailed evaluation and report than the walk-through condition assessment, and will include:

- Observation and mapping of repair quantities for areas identified to be repaired.
- Testing to evaluate existing materials and causes of deterioration.
- An estimate of construction costs and, possibly, life cycle costs.

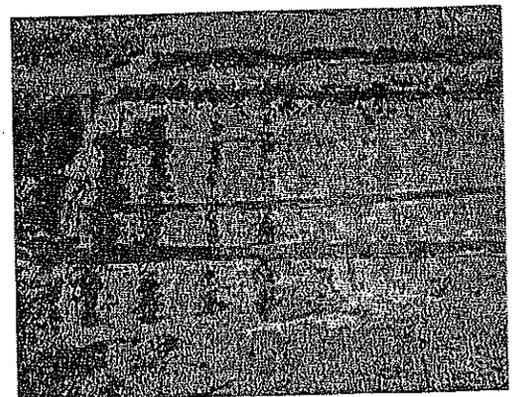


Figure 5.3 - Test Excavation to Evaluate Corrosion

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- An assessment of impact of the repair program on day-to-day operations and revenue stream.
- A design and construction schedule.
- Any limitations or assumptions associated with the repair program.

The following sections describe the tasks required to complete the condition appraisal process.

### **5.3.1 VISUAL AND ENGINEERING EXAMINATIONS**

While the preliminary condition assessment provides observations made on representative areas of the facility, a repair program must be based on observations of all the areas to be repaired. The final condition appraisal applies the same techniques as the preliminary appraisal, but observations are more detailed and take place over a larger area. This task will result in plans and tables that graphically and numerically define any necessary repair work.

### **5.3.2 FIELD AND MATERIALS TESTING**

Often visual observations alone will not provide sufficient information to evaluate the condition of structural components of a parking garage. Material testing is required to evaluate the level of deterioration, corrosion and likely consequent degeneration of a garage. The parking consultant can recommend a variety of methods to evaluate existing conditions, including tests to determine:

- Levels of chloride ion contamination in concrete.
- Corrosion activity or delaminations.
- Condition of concrete cover, from the surface of concrete to reinforcement.
- Concrete strength and other structural characteristics through petrographic examinations.

### **5.3.3 CONSTRUCTION COSTS**

The parking consultant will compile the information gathered in observations and testing to estimate an approximate cost of necessary repairs. Owners should be aware that the final cost of

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the project can vary significantly from this estimate, especially if unanticipated conditions arise during construction.

The parking consultant may be able to calculate life cycle costs of various repair options. A life cycle cost includes every repair expenditure performed or anticipated for the remainder of a parking garage's service life. Future expenses are generally submitted as present value costs. Accurate life cycle pricing of repair programs is difficult due to the varying life of repair methods. Any life cycle cost should be considered as approximate.

### **5.3.4 OPERATIONS AND REVENUE EVALUATION**

Repair programs can have an impact on day-to-day operations, especially for major repair programs: spaces are taken out of service; users are affected by noise, dirt and, in some cases, vehicle damage; access to elevators and stairs can be limited; and electrical systems can be damaged during construction. In some cases facilities must be closed entirely so that ramping areas can be repaired. All of these can lead to temporary and, in some cases, permanent decreases in use and revenue. The parking consultant and owner should discuss these impacts during early planning, to minimize any adverse impacts.

### **5.3.5 DESIGN AND CONSTRUCTION SCHEDULE**

After a condition appraisal, the parking consultant will develop a design and construction schedule. Development of the schedule should include evaluations of the following:

- Time of bidding, as certain times of the year can be advantageous to construction.
- The effects of winter or cold weather construction, and its potential impact on the quality of the finished product.
- Work during off hours or multiple shifts.
- An impact on revenue stream.
- Contractor penalties and incentive clauses.

The design and construction schedule should be addressed in the final contract documents.

### **5.3.6 Repair Option Analysis**



Figure 5.3.6 - Strip Patch Repairs

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The parking consultant should further analyze the repair options developed for the owner to consider appropriate cost and operational issues such as:

- Initial cost
- Life-cycle cost
- Disruption to users
- Loss of revenue
- Disruption to adjacent properties due to noise, dust, etc.
- Anticipated long-term use of the structure

The owner and consultant should prioritize each option, to best comply with the owner's needs.

### **5.3.7 Report**

The consultant should prepare the report so it can be fully understood by the owner's non-engineering staff, such as the Chief Financial Officer. Technical jargon should be kept to a minimum, and confined to appendices. The report should include:

- A brief summary of goals and objectives considered during the condition assessment.
- A description of the structure.
- Conditions observed during the visual examination.
- All test results.
- Photographs and/or drawings illustrating conditions of the structure.
- A description of potential repair options.
- Professional recommendation regarding the implementation of a specific course of action.
- Recommendations for any further testing or analysis, if needed.

### **5.3.8 Review Meeting**

A meeting should be held to present the completed report to appropriate members of the owner's staff, and to thoroughly discuss its findings and recommendations. It is important that the owner fully understands the report, and that all questions are answered.

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### **5.3.9 LIMITATIONS AND ASSUMPTIONS**

Repair programs are usually riskier than new construction projects. A few factors lead to this increased risk:

- A lack of "X-Ray" vision. As parking consultant engineers cannot see inside concrete, they must use their experience, visual observations, and materials testing to evaluate and predict necessary repair work. At times, however, the actual condition is masked, which can lead to unforeseen matters during construction of repairs.
- Ongoing deterioration. The level of corrosion activity and any associated damage continues and can accelerate, especially in severely damaged facilities. Necessary repairs can escalate, especially if there is a lag between the time of observation and initiation of construction.

)A well-thought-out appraisal process can minimize, but will not eliminate these risks.

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### **6.0 REPAIR AND REHABILITATION**

Repair and rehabilitation procedures differ from regular maintenance tasks. They generally involve concrete removal and replacement, and can involve the removal and replacement of reinforcement and tendons. This procedure is unavoidable in all structures as they age, but can also be called for in newer garages as the result of lack of maintenance, poor design or substandard construction.

Methods of identifying repair strategies are included in Chapter 5. As methods of preparing plans and specifications are beyond the scope of this chapter, additional counsel on this subject can be found in Appendix E – Bibliography & References.

Repair and rehabilitation construction also differs greatly from new construction. As garage operations generally need to be maintained throughout the repair process, construction will therefore require staging or phasing to allow the ongoing use of at least some portions of the garage. In addition, the quantity and type of work may need to be adjusted as construction proceeds. Owners need to include contingencies for unforeseen conditions and unexpected repairs. Cooperation between the owner, parking consultant and contractor is critical to the success of the repair project.

#### **6.1 TEAMWORK DURING CONSTRUCTION**

As design proceeds, the parking consultant prepares plans, specifications, and an estimate of the necessary repairs. The project team should plan to effectively manage construction. As communication is critical, owners should consider the following:

- The owner and consultant should discuss a potential for change as design proceeds. This potential for change and any procedures for managing change must be communicated to the highest level of the owner's organization, to minimize unexpected circumstances.
- A course of action to manage change must be built into the contract between the owner and the contractor. This

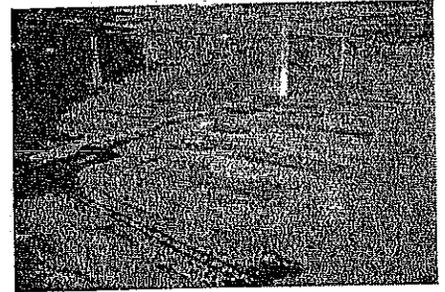


Figure 6.0 - Removal of spalled Concrete

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procedure may also need to be discussed with potential contractors during the bidding process.

- The procedure should be reviewed at a pre-construction meeting, where suggestions for modifying the procedure should be considered.
- A good line of communication is most important during the actual construction process. At times the contractor might discover latent or unforeseen conditions that need quick evaluation and response from both the consultant and the owner. Key decision makers must be available on short notice to handle these situations.
- Weekly meetings are often very beneficial. During these regular meetings, overall progress should be evaluated, and the schedule adjusted as needed. Actual and estimated quantities should be compared.
- Additional and unexpected on-site observation by the consultant may be necessary, and all findings should be documented and distributed to the entire team.

The key to success is proactive, positive cooperation from all team members.

### 6.2 CONTROLLING BUDGETS AND SCHEDULE

All parties must expect the unexpected during repair and rehabilitation projects. While change in plans may occur, the team must be able to adjust the type and quantity of work to fit within the owner's budget and schedule. Several strategies have been successful:

- Pre-qualification of Contractors: Many general contractors do not have the experience and specialized equipment necessary to complete these projects. The owner should pre-qualify or pre-select contractors invited to bid for the work.
- Use of Unit Costs: Most owner/contractor contracts include the implementation of unit costs for work that is difficult to quantify. The contract should employ language that allows owners to add or deduct work at will, without change in unit prices. However, owners should consider requests for a change in unit cost if the

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quantity differs significantly from that of the original bidding documents.

- Plan for Schedule Extensions: Contractors normally plan on using all of the time allotted to complete the work. Changes in work quantities may require schedule extensions. Any extensions, and their subsequent impact on operations, should be considered during the design process.
- Plan for Special Events: Owners may need to maximize available facility use for special events. For instance, the need for parking near retail facilities increases during the Christmas shopping season. These periods and events should be identified in contract documents.
- Winter Construction: Winter construction in northern climates is often avoided, to save the expense of heating the concrete construction. It is difficult and expensive to heat most garages because they tend to be open structures. Even enclosed garages will be difficult to heat if the structure remains operational during construction.

Budgets and schedules can be very difficult to predict and control. Owners will have a higher rate of success if all risks and procedures are identified early in the design process, included in the contract documents and taken into consideration during construction.

### 6.3 MANAGING PARKING OPERATIONS DURING CONSTRUCTION

The construction process will present all parties, especially users, with several challenges. The facility will be dirty, the quantity of available spaces will be reduced, and travel paths will be disrupted.

The loss of parking spaces during construction must be considered during design. Alternative facilities may be required during construction; if so, this must be communicated to users. The number

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If spaces allowed to be taken out of circulation at a time should be included in the contract documents.

Circulation paths may be impacted, particularly if ramping systems need to be repaired. Helixes and express ramps are most vulnerable. Repairs may even force closure of an entire ramping system. In this case, if alternative paths are not available, a temporary closure of the entire structure may be necessary. Access to stairs and elevators must also be considered. Closure of stairs because of lack of access or repairs to the stairs themselves may eliminate a required exit path. This should be discussed with the local municipality and code officials.

Repairs may force closure of part or all of access and revenue control functions. Temporary entry and exit lanes may be required.

The project team must consider the safety of the users. Vehicles and pedestrians should not be allowed to circulate through construction zones. Temporary walls may be necessary to block users from entering the construction zones, and to prevent debris from entering the public spaces. The contractor may need to close the level beneath the floor undergoing repair, to prevent falling material from damaging vehicles or injuring pedestrians.

Construction debris must be managed. The owner should identify an area to place dumpsters, and contractors should be required to clean public areas on a daily basis, and should provide a method of preventing construction debris from entering the drain system.

Damage to customer vehicles from construction operations can occur. Most often these result when the contractor is required to operate outside of the construction zone, such as when driving to and from the work area with materials or supplies. The contract documents must define how repairs are to occur; frequently complaints are directed to the contractor without owner involvement. The likelihood of additional complaints needs to be discussed with management staff. A complaint resolution process should be formulated before construction proceeds.

All impacts on users need to be communicated before and during the construction process. Additional staff may be necessary to assist

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users. Temporary signs are key, and descriptions of upcoming activities posted at stairs and elevators have proven very effective.

In conclusion, repair and rehabilitation projects pose a unique set of challenges. Planning for repair and rehabilitation procedures will help to prepare owners to meet these challenges, and limit their impact on all affected parties. Proactive management and communication are keys to a successful project.

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## 7.0 MAINTENANCE BUDGET

Ideally, an owner should develop and implement a maintenance program from the very first day of operation. Maintenance should be provided at regular intervals if the full benefit of the effort is to be realized; as irregular or incomplete maintenance provides a marginal return on the initial investment.

### 7.1 BUDGETING FOR MAINTENANCE

A parking garage maintenance budget is dependent upon the existing physical condition of a garage, and its maintenance history. Budgeting typically begins with a condition appraisal—a visual examination or walk-through assessment—of the entire facility. For existing or restored garages, materials testing may be required to evaluate construction materials and as-built conditions.

An engineer's initial assessment will identify maintenance elements, and set up procedures and schedules for upkeep of the garage. Follow-up examinations will then monitor and document the effectiveness of applied maintenance programs.

To effectively budget for the maintenance of a facility, three types of maintenance costs are identified:

- Routine maintenance: This includes the cost of periodic repairs and/or corrective actions necessary to maintain serviceability and facility operations.
- Preventive maintenance: These costs include actions required to extend the service life of the facility.
- Repair and replacement maintenance: These costs include replacement of structural and operational elements at the end of their estimated service life.

Routine costs often coincide with the same items listed in preventive maintenance costs. These are not duplicates, however, as the timing and frequency are different from the preventive action. For example, the initial installation of a traffic topping is a preventive maintenance action, while the annual patching of the scrapes in the

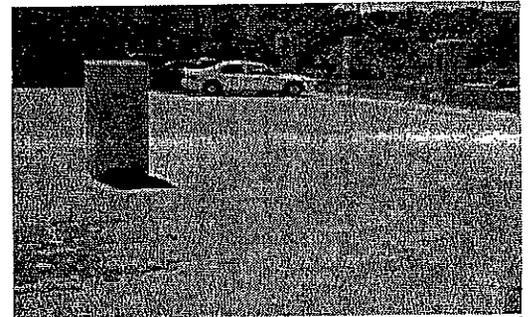


Figure 7.1 - Traffic Topping Wear

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traffic topping is a routine maintenance action. Similarly, initial costs should be listed as preventive, while annual cleaning, inspection and repairs should be considered routine.

### **7.2 ROUTINE MAINTENANCE**

Routine maintenance costs include day-to-day or regular items to keep the garage functioning. These items may include:

#### **7.2.1 Structural**

- Repairs to small areas of spalled or delaminated concrete.
- Repairing leaking joint sealant and traffic toppings.
- Repairing expansion joint seals.

#### **7.2.2 Operational**

- Clearing plugged drain lines.
- Repairing damaged light fixtures.
- Housekeeping tasks.
- Other operational maintenance.

#### **7.2.3 Aesthetic**

- Trimming and pruning of landscaping.
- Touch-up painting.

The guidelines provided in this section generally address minimum levels of effort. However, increased frequency of maintenance may be warranted, depending upon need and use. For example, in certain environments, more frequent cleaning and washing down of the floor surfaces (when permitted by weather) and prompt repair of early signs of problems can reflect significant cost savings in future repairs and maintenance.

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### **7.3 PREVENTIVE MAINTENANCE**

Preventive maintenance expenses incorporate items that extend the service life of the facility including:

#### **7.3.1 Structural**

- Corrosion protection, waterproofing, traffic membrane, joint sealants, and expansion joint seals.
- Structural protection.

#### **7.3.2 Operational**

- Equipment maintenance.
- Electrical system maintenance.
- Elevator maintenance contracts.
- Other operational maintenance.

#### **7.3.3 Aesthetic**

- Landscaping maintenance.

Note that a preventive maintenance plan does not include structural repairs.

### **7.4 REPAIR AND REPLACEMENT COST**

Replacement demands include the cost to replace garage elements, systems, and equipment at the end of their service life. These items include:

#### **7.4.1 Structural**

- Structural repairs to concrete, steel, or other members.
- Replacing architectural and structural railings and barriers.

#### **7.4.2 Operational**

- Replacing plumbing drains and lines.
- Replacing light fixtures, conduit, and equipment.

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- Replacing parking and access and control equipment and systems.
- Replacing stair treads, doors, etc.
- Other operational maintenance.

### 7.4.3 Aesthetic

- Landscaping.
- Architectural finishes.

## 7.5 REPAIR AND REHABILITATION

Assignments of repair and rehabilitation costs fluctuate according to location, availability of materials, and availability of labor, and are therefore beyond the scope of this maintenance manual. For additional information, refer to the bibliography in Appendix E for references that can provide greater detail.

## 7 BUDGET TEMPLATES

Included in this manual is a cost template<sup>3</sup> that provides a basic checklist for computing anticipated annual maintenance costs for a facility. For each facility, the maintenance expenditure should include the cost for routine (day to day actions), preventive actions and replacement expenses.

Costs are based on regular, timely maintenance that results in favorable long-term operation of the garage. They rely on the selection of maintenance alternatives utilizing current technology to control or mitigate long-term deterioration. The costs shown do not eliminate long-term repairs, but instead help to keep long term repair costs manageable. These templates do not include standard daily operational and housekeeping costs.

The following is a list of important factors that can impact the cost of future repairs and maintenance:

<sup>3</sup> Reference #3, Anthony Chrest, Mary Smith, Sam Bhuyan, Donald Monahan, and Ahmad Iqbal "Parking Structures: Planning, Design, Construction, Maintenance and Repair".



Figure 7.3.3 - Aesthetic Maintenance at Garage Entrance Ramp

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- The type of corrosion protection of the existing garage.
- The type of waterproofing system installed.
- The level of chloride contamination and extent of concrete removals specified during construction of repairs.
- The condition of the existing structural system, any design deficiencies and adverse conditions related to drainage, water leakage, joint deterioration and concrete quality.

### **7.7 MAINTENANCE MANAGEMENT COST**

As the expense of maintenance management will vary with the type of garage and the amount of maintenance required, we have not attempted to show the soft costs of managing this process.

### **7.8 ADDITIONAL OPERATING COST**

Operating a parking garage requires other procedures and expenditures aside from the maintenance items presented. We have not attempted to show the soft costs of operating the facility, or the daily operating procedures and costs (such as housekeeping, cleaning, security, utilities, etc.).

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### Annual Maintenance Cost New Facility - xx Parking Garage

Location	Construction	Current Age	Cars	SF
Chicago, Illinois	Cast-in-place	0	883	265,900

Item Description	Quantity	Unit Price	Total Cost	Time	\$/car/YR	\$/SF/YR
<b>Preventive Maintenance</b>						
Sealants Floor Slab	2,900	3.00	9,000	10	1.01	0.003
Cove Sealant	6,300	3.00	19,000	10	2.13	0.007
Architectural Sealants	1,800	3.50	6,000	10	0.67	0.002
Architectural Sealer	24,000	0.75	18,000	5	4.03	0.014
Expansion Joints	550	60.00	33,000	10	3.7	0.012
Penetrating Sealer	218,000	0.50	109,000	5	24.41	0.082
Traffic Topping	8,900	3.00	27,000	15	2.02	0.007
Supplemental Drains & Piping	-	-	-	25	-	-
Miscellaneous	-	-	-	1	-	-

**Subtotal Preventive Maintenance** 221,000 \$ 37.97 \$ 0.13

<b>Routine Maintenance</b>						
Maintain Sealants	1	2,250	2,000	2	1.12	0.004
Maintain Arch Sealants	1	3,000	3,000	5	0.67	0.002
Maintain Traffic Topping	1	3,000	3,000	10	0.34	0.001
Interim Slab Patching	-	-	-	1	0.00	0.000
Interim Beam & Column Patching	-	-	-	1	0.00	0.000
Maintain Drainage System	1	1,000	1,000	1	1.12	0.004
Maintain Lighting	1	13,300	13,300	1	14.89	0.050
Maintain Parking/Revenue Control	1	4,000	4,000	1	4.48	0.015
Inspections	1	5,000	5,000	3	1.87	0.006
Maintain Elevators	2	6,000	12,000	1	13.44	0.045
Miscellaneous	1	4,000	4,000	1	4.48	0.015

**Subtotal Routine Maintenance** 47,300 \$ 42.41 \$ 0.14

**Average Annual Maintenance Cost (Preventive + Routine)** \$ 80.38 \$ 0.27

**Maintenance Cost @ 5 year intervals** \$ 1.35

Item Description	Quantity	Unit Price	Total Cost	Time	\$/car/YR	\$/SF/YR
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<b>Replacement Maintenance</b>						
Replace Drainage System	265,900	0.75	199,000	25	8.91	0.030
Replace Lighting System	265,900	1.75	465,000	25	20.83	0.070
Replace Parking Revenue Control	265,900	0.32	85,000	6	15.86	0.053
Replace Signage & Graphics	1	50000	50,000	20	2.8	0.009
Replace Elevators	2	200000	400,000	25	17.92	0.060
Miscellaneous	-	-	-	-	-	-

**Average Replacement Maintenance Cost** 1,199,000 \$ 66.32 \$ 0.22

Note: Does not include cost for standard operating management and other operating procedures such as housekeeping, security, utilities, etc.

Source: "Parking Structures: Planning, Design, Construction, Maintenance and Repairs", by Anthony Chrest, Mary Smith, Sam Bhuyan, Mohammad Iqbal, Donald Monahan. 2001, Published by Kluwer Academic Publishers, Norwalk, MA

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## **APPENDIX A: MAINTENANCE SCHEDULE**

### RECOMMENDED MAINTENANCE PROGRAM AND CHECKLIST

The recommended maintenance program that is outlined in this manual is intended to cover the most typical aspects of maintenance, including those related to cleaning, safety, equipment, and structure. For convenience, the maintenance program is divided into three categories and each of these into descriptive sections. These sections are:

#### STRUCTURAL

1. Structural Systems
2. Roofing & Waterproofing

#### OPERATIONAL

1. Cleaning
2. Doors and Hardware
3. Electrical Systems
4. Elevators
5. Heating, Ventilating, Air Conditioning (HVAC)
6. Parking Control Equipment
7. Plumbing Systems
8. Safety Checks
9. Security Systems
10. Signs (Graphics)
11. Snow and Ice Control

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### AESTHETICS

A. Landscaping

B. Painting

It is recommended that for each parking garage, a facility-specific maintenance program be developed. The specific maintenance program should include the following items:

A. A schedule of cleaning, inspection, lubrication, and other recurring maintenance activities.

B. A catalog of all equipment, including manufacturer's service manuals for the installed equipment. Product warranties should be included.

C. Records of preventive maintenance performed on any element, and logs of both service calls and types of repairs made.

D. Establishing responsibility for implementing and carrying out all portions of the program.

E. A management control system to verify that the maintenance program is being carried out and is effective.

The checklist that follows is a guide to many of the items in a parking garage that should be checked and maintained at regular intervals. A suggested frequency of observation or attention is indicated.

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PARKING GARAGE MAINTENANCE						
	Daily	Weekly	Monthly	Quarterly	Semi-Annually	Other (see notes)
<b>STRUCTURAL MAINTENANCE</b>						
<b>A. STRUCTURAL SYSTEM</b>						
<ul style="list-style-type: none"> <li>▪ Check for:               <ul style="list-style-type: none"> <li>• Floor surface deterioration</li> <li>• Water leakage</li> <li>• Cracking of concrete</li> <li>• Rusting of steel</li> </ul> </li> </ul>				• • • •		1
<ul style="list-style-type: none"> <li>▪ Repair</li> </ul>	As per engineer's recommendations					
<ul style="list-style-type: none"> <li>▪ Replace protective concrete floor coating</li> </ul>	As per engineer's recommendations					
<b>B. ROOFING AND WATERPROOFING</b>						
<ul style="list-style-type: none"> <li>▪ Check for leaks               <ul style="list-style-type: none"> <li>• Roofing</li> <li>• Joint sealant in floors</li> <li>• Expansion joints</li> <li>• Windows, doors and walls</li> <li>• Floor membrane areas</li> </ul> </li> </ul>			• • • • •			
<ul style="list-style-type: none"> <li>▪ Check for wear and deterioration</li> </ul>			•			
<b>OPERATIONAL MAINTENANCE</b>						
<b>A. CLEANING</b>						
<ul style="list-style-type: none"> <li>▪ Sweeping – localized</li> </ul>	•					
<ul style="list-style-type: none"> <li>▪ Sweeping – all areas (including curbs)</li> </ul>		•				
<ul style="list-style-type: none"> <li>▪ Expansion joints</li> </ul>		•				
<ul style="list-style-type: none"> <li>▪ Empty trash cans</li> </ul>	•					
<ul style="list-style-type: none"> <li>▪ Toilets               <ul style="list-style-type: none"> <li>• Floors, fixtures</li> <li>• Walls</li> </ul> </li> </ul>	•		•			
<ul style="list-style-type: none"> <li>▪ Cashier booths               <ul style="list-style-type: none"> <li>• Floors, fixtures</li> <li>• Walls</li> </ul> </li> </ul>	•		•			

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PARKING GARAGE MAINTENANCE						
	Daily	Weekly	Monthly	Quarterly	Semi-Annually	Other (see notes)
<b>A. CLEANING (continued)</b>						
▪ Elevators						
• Floors, doors, tracks	•					
• Windows, glass backs						
▪ Stairs						
• Floors, handrails	•					
• Windows			•			
▪ Lobby, office						
• Floors	•					
• Windows		•				
▪ Wash down parking floors			•			2
▪ Parking control equipment		•				
<b>B. DOORS AND HARDWARE</b>						
▪ Doors close and latch properly	•					
▪ Mechanized doors	•					
▪ Panic hardware at security doors	•					
▪ Lubricate mechanized doors			•			
<b>C. ELECTRICAL SYSTEM</b>						
▪ Check light fixtures and exposed conduit		•				
▪ Re-lamp fixtures		•				
▪ Special units - inspect						3
▪ Distribution panels					•	
<b>D. ELEVATORS</b>						
▪ Check for normal operation	•					
▪ Check indicators and other lights	•					
▪ Preventive maintenance service					•	4

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PARKING GARAGE MAINTENANCE						
	Daily	Weekly	Monthly	Quarterly	Semi-Annually	Other (see notes)
<b>E. HEATING, VENTILATION &amp; AIR CONDITIONING (HVAC)</b>						
▪ Check for proper operation		•				
▪ Check ventilation in enclosed or underground garage	•					
▪ Preventive maintenance service				•		3
<b>G. PARKING CONTROL EQUIPMENT</b>						
▪ Check for proper operation	•					
▪ Preventive maintenance						5
<b>G. PLUMBING/DRAINAGE SYSTEMS</b>						
▪ Check for proper operation						
• Sanitary facilities	•					
• Irrigation		•				
• Floor drains		•				
• Sump pump		•				
• Fire protection system			•			
▪ Drain water systems for winter					•	
▪ Check for icy spots	•					
▪ Remove snow and ice	•					
<b>H. SAFETY CHECKS</b>						
▪ Carbon monoxide monitor	•					
▪ Handrails and guardrails		•				
▪ Exit lights	•					
▪ Emergency lights	•					
▪ Tripping hazards	•					

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PARKING GARAGE MAINTENANCE						
	Daily	Weekly	Monthly	Quarterly	Semi-Annually	Other (see notes)
<b>I. SECURITY SYSTEM</b>						
<ul style="list-style-type: none"> <li>▪ Check for proper operation                             <ul style="list-style-type: none"> <li>• Closed circuit TV</li> <li>• Audio surveillance</li> <li>• Panic buttons</li> <li>• Stair door locks and alarms</li> </ul> </li> </ul>	• • • •					
<b>J. SIGNS (GRAPHICS)</b>						
<ul style="list-style-type: none"> <li>▪ Check signs for:                             <ul style="list-style-type: none"> <li>• In place</li> <li>• Clean</li> <li>• Legible</li> <li>• Illuminated</li> </ul> </li> </ul>	•	•		• •		
<b>AESTHETIC MAINTENANCE</b>						
<b>LANDSCAPING</b>						
<ul style="list-style-type: none"> <li>▪ Remove trash</li> <li>▪ Gardening – mow, trim, weed</li> </ul>	•	•				
<b>B. PAINTING</b>						
<ul style="list-style-type: none"> <li>▪ Check for rust spots                             <ul style="list-style-type: none"> <li>• Doors and door frames</li> <li>• Handrails and guardrails</li> <li>• Pipe guards</li> <li>• Exposed pipes</li> <li>• Conduits</li> <li>• Other metal</li> </ul> </li> </ul>				• • • • •		
<ul style="list-style-type: none"> <li>▪ Check for appearance                             <ul style="list-style-type: none"> <li>• Striping</li> <li>• Signs</li> <li>• Walls</li> <li>• Curbs</li> <li>• Touch-up paint</li> </ul> </li> </ul>			• • • •	•		
<ul style="list-style-type: none"> <li>▪ Re-paint</li> </ul>						3

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### **NOTES FOR MAINTENANCE CHECK LIST**

1. It is important that this inspection be performed in the spring so that any resulting maintenance or repairs can be performed in the summer months.
2. Wash downs should occur monthly in northern and coastal regions, where salts can accumulate on the structure. In other areas, wash downs should be performed quarterly, or, as a minimum, in the Spring and Fall.
3. A frequency should be selected that is appropriate for the element in the parking garage. Spot repairs or replacements should be performed as needed.
4. This equipment should be under a service contract for regular preventive maintenance and emergency service. The equipment manufacturer's recommendations for inspection and preventive maintenance should be followed.
5. This equipment should either be under a service contract for regular preventive maintenance service and emergency service or in-house staff should be specially trained to provide the required service. The equipment manufacturer's recommendations for inspection and preventive maintenance should be adhered to, to maintain warranty and maximize service life of equipment.

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### APPENDIX B: WATERPROOFING SYSTEMS

Waterproofing systems in parking garages are installed for several reasons:

- Provide prevention or correction of leakage within the garage itself. i.e., from the floor slabs above, onto vehicles and patrons below.
- Provide prevention of leakage into occupied space, such as retail or office space that may be located below the parking facility, or to prevent leakage into a parking area from plazas above the garage.
- Provide protection of the concrete or steel structural members of the parking garage against the adverse effects of water and deicer salts.

This appendix considers systems used for one or more of these reasons. These systems range from those intended to truly "waterproof," to those intended to reduce the moisture permeability of the concrete of the floor slab. Wherever possible, information for each system is provided regarding the following:

- Expected range of installed unit cost in 2004 dollars (without CM, PM or A/E fees; general contractor mark-ups; or other burdens).
- Expected service life before reapplication or renewal.
- Whether or not the system must be installed during original construction or whether it may be retrofit at a later date.

1. **Traffic-Bearing Membranes:** These systems cover the top surface of a concrete floor slab. They are generally liquid-applied in multiple coats; the upper layers or topcoats containing grit aggregate for slip resistance. When intact and in good condition, they are impervious to water and de-icing salts. They may be installed during the initial construction period, or at any later date. These systems are used both to prevent leakage and to protect concrete structural members from water and deicer salts. In some retrofit maintenance efforts traffic-bearing membranes are specified to reduce the moisture content in concrete floor slabs already contaminated with deicer salts, with the intent of slowing the acceleration of corrosive deterioration.

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- a. **Polyurethane membranes** are by far the most widely used traffic-bearing membranes. They are semi-flexible, and can bridge small- to moderate-width cracks. Their multiple-coat applications result in installed thicknesses ranging from 40 to 70 millimeters. The cost and service life of polyurethane membrane systems are relative to the quality of surface preparation, the installed thickness and the durability (wear resistance and UV stability) of the membrane's top coats.

Cost Range:           \$2.50 to \$3.50 per sq. ft., with  
                                  blast-track surface preparation.

Service Life:           8 to 12 years.

- b. **Epoxy membranes:** Otherwise known as membrane systems employing epoxy top coats with polyurethane base coats, this waterproofing method is less widely used than complete polyurethane systems. Epoxies have a limited flexibility, which restricts their ability to bridge moving cracks. However, systems with epoxy top coats are generally much more wear-resistant than those using only polyurethane. Installed thicknesses for epoxy membranes vary widely, from 20 to 60 millimeters, depending on cost. Service life also corresponds to the quality of surface preparation, the installed thickness and the durability of the membrane topcoats. Epoxy materials are not UV stable and require special treatment when exposed to sunlight.

Cost Range           \$1.50 to \$3.50 per sq. ft., with  
                                  blast-track surface preparation.

Service Life           5 to 15 years

2. **Membranes below Wearing Courses:** Otherwise known as buried membranes, these systems are sometimes used to prevent leakage into occupied spaces below a parking garage, or to prevent leakage into a parking area below a plaza or roadway. If they are installed as an upgrade to an existing parking garage, special consideration needs to be given to the load capacity of the existing slab and beams. The structure

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must be able to support the added dead weight of the system and wearing course. In Canada and some eastern US areas, buried membranes are more frequently used on exposed parking garages due to heightened concerns regarding wear and/or snowplow-induced damage to traffic-bearing membranes. These membranes are impervious when intact and in good condition, and have an extended service life as they are protected from abrasion by the wearing course. Membranes below wearing courses are either adhered to the structural substrate or loose-layed and non-adhered.

- a. **Adhered membranes:** This type of waterproofing system is bonded to the substrate. Adhered membranes are specifically developed for use below an overlay, and are the most successful waterproofing method available. This method generally consists of rubberized asphalt that remains pliable, and is self-healing above small to moderate width cracks. Rubberized asphalt membranes can vary widely in thickness, from 50 to 80 millimeters for a single layer system, to over 200 mils for a fabric-reinforced system.

Polyurethane and built-up roofing systems are sometimes used as alternatives to buried membranes. However, these alternative systems do not perform as well, as cracks that open after a system's initial application often fail these systems and permit leakage.

A more durable membrane system is provided when the membrane is protected by a concrete or asphalt wearing course. When overlaid with concrete, a drainage board is an important feature between the concrete slab and the membrane. This drainage board allows the concrete slab to dewater, and protects it from freeze/thaw deterioration. Asphalt toppings can be directly applied over rubberized asphalt systems.

Cost Range:           \$4.00 to \$12.00 for thin membrane systems including asphalt or concrete wearing surfaces and up to \$50.00 per sq. ft. for a system including an architectural wearing surface, soil fills

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for landscaping, drainage, or insulation.

Service Life: 10 to 25+ years.

- b. **Loose-laid membranes:** These systems are not adhered to the substrate. They consist of sheet goods with field-bonded seams (bituthene, rubber or plastic). Loose-laid membrane systems include a protective overlay of concrete slabs or asphalt toppings. Loose-laid membranes perform well when intact, but they are vulnerable at their many seams, and volume change movements in garages can lead to leaks through the sheets.

Locating and correcting leakage problems after the installation of a loose-laid system is quite difficult, as water tends to migrate below the membrane. When visible leaks finally develop at cracks in the substrate, they may be many feet away from the tear in the membrane.

Cost Range: \$5.00 to \$12.00 for thin systems including concrete or asphalt wearing surfaces and up to \$50.00 per sq. ft. for complex systems including architectural surfaces, soil fills for landscaping, concrete or asphalt topping, drainage, or insulation.

Service Life: 8 to 15 years.

3. **Sealers:** Sealers partially waterproof the top of a concrete slab by either coating the surface or penetrating the top ¼-inch of the entire slab. Sealers are liquid-applied, and may be installed during the initial construction period or at any later date. They are used to prevent leakage and to protect concrete structural members from water and de-icer salts. Immediately after initial application, silane sealers screen 80% to 90% of chlorides and water molecules. Silane sealers are more effective than surface sealers because they penetrate and bond with the materials in the concrete and therefore do not require re-application as frequently as the sealers subject to surface wear. Because sealers can "waterproof" narrow cracks, but are



Figure B.1 - Application of Concrete Sealer

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ineffective in waterproofing moderate to wide cracks, separately-installed sealants are typically used on cracks wider than the hairline variety.

- a. **Penetrating sealers** are small, molecular materials that permeate the top  $\frac{1}{8}$ -inch to  $\frac{1}{4}$ -inch of the concrete slab, and repel water by creating a hydrophobic barrier at the surface. Existing concrete slabs should be blast-track cleaned before application for the best performance from a penetrating sealer.

Silanes are by far the most widely-used penetrating sealers. Siloxanes (partially-reacted silanes), methylmethacrylates and thin epoxy formulations are also used as penetrants. The silane penetrating sealers are applied in liquid solutions of 20% to 100% solids, and have the following cost and service life:

Cost Range: \$0.50 to \$1.00 per sq. ft., with blast-track surface preparation.

Service Life: 5 to 10 years.

- b. **Surface sealers:** These systems create a film on the concrete floor slab. Surface sealers were widely employed in the past, but are much less common today. While epoxies are typically used as surface sealers today, multiple formulations of materials were once used. Sand is sometimes broadcast on the freshly coated surface for slip resistance. Before applying this type of sealer in an existing parking garage, surfaces should be power washed or blast-track cleaned

Cost Range: \$0.30 to \$0.50 per sq. ft., with power washing.

Service Life: 2 to 5 years.

4. **Concrete Additives:** This method can reduce the permeability of the concrete, and provide benefits similar to those provided by membranes and sealers. On a microscopic

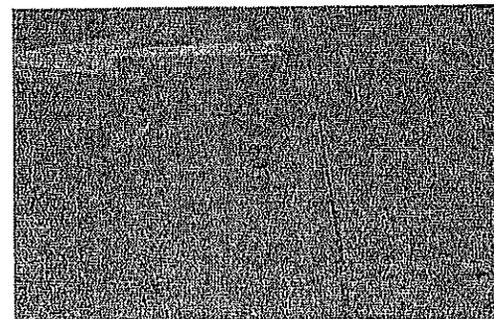


Figure B.2 - Concrete Patch at Joint and Electrical Conduit

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level there exists a pore structure in hardened concrete through which water can permeate. While this degree of permeability can be reduced somewhat by controlling the concrete mix (i.e., lowering the water/cement ratio), the permeability can be further reduced by incorporating additives into the initial mix that are specially formulated to fill the pore structure.

- a. **Micro Silica:** Micro silica (silica fume) is a by-product in the manufacturing of producing silicon metal or ferrosilicon alloys. It consists of tiny particles about the same size as smoke particles. Silica fume is a highly effective pozzolanic material used in concrete to improve its properties. It has been found that Silica Fume improves compressive strength, bond strength, abrasion resistance, and reduces permeability. These enhancements help in protecting reinforcing steel from corrosion. Usage rates of micro silica of 5% to 7% of the cement in a concrete mix are common in recent years in new parking garage construction. However silica-fume concrete requires special attention on the part of the concrete contractor for mixing, placing, finishing, and curing the concrete. Life cycle cost analysis can demonstrate economic value and savings.

Cost Range: \$0.50 to \$1.00 per sq. ft., for a beam and slab post-tensioned system. Cost will vary with variations in concrete volume per sq. ft. of floor area.

Service Life: Life of garage.

- b. **Latex:** In liquid form, this material has been used for several decades as an additive to provide durable patches and concrete overlays with a low rate of permeability. Due to the high cost of latex-modified concrete, it is generally limited to repairs in small areas, repairs with special placement requirements or for long-term performance.

Cost Range: \$5.00 to \$10.00 per sq. ft. for a latex modified concrete overlay. Latex modified concrete is \$350 - \$450 per cubic yard; pre-bagged

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repair concretes usually contain latex concrete, and cost \$1000 to \$2000 per cubic yard.

Service Life: Over 20 years.

- c. **Crystalline-forming additives:** These methods have been employed recently in tunnel and marine construction. They reduce the permeability of the concrete by filling the existing pore structure in the same manner as micro silica. To date, however, crystalline-forming additives have seen little, if any, use in parking garages.
  - d. **Fly Ash:** Fly ash and other pozzolans used in the concrete mix can reduce concrete permeability by filling the concrete pores to various degrees. More commonly, fly ash is used to reduce the amount of cement in the mix. Reducing the cement reduces cost and can provide better concrete properties – like less shrinkage and cracking. This reduction of cement can also contribute towards LEED certification as a recycled material. The use of fly ash is common, but it requires a good concrete mix design and appropriate quality control to get the desired results.
5. **Crack-Sealing:** This method is often necessary in parking garages to prevent nuisance leakage and saltwater intrusion. Moderate-width and wider cracks can occur in any cast-in-place slab, regardless of construction type or the additives used in the slab's concrete. If a concrete slab is to be waterproofed, any wide cracks must be individually treated, as sealers will not perform adequately. Special crack-sealing preparation is also necessary before the installation of traffic-bearing membranes. The effectiveness of any type of crack-sealing system is directly associated to the care taken by the individual tradesman installer and their training.
- a. **Routing and Caulking:** The routing and caulking of cracks is the most widely used method of waterproofing floor slab cracks. The routed groove along a crack located at the surface of a concrete slab provides a recess for caulking sealant. In addition, this method allows small



Figure B.3 - Routing Floor Slab Cracks for Sealant

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movements of the crack without tearing the caulk. Polyurethane caulking is the most widely used sealant, but other materials such as silicones have been more widely used in recent years. Silicones provide longer service life and larger movement capabilities, but they have poor abrasion resistance to car tires.

Cost Range: \$3.00 to \$5.00 per foot of crack, including routing.

Service Life: 8 to 15 years before sealant replacement.

- b. **Pour-in-crack sealants:** The greatest advantage of pour-in-crack methods is their relatively low cost. They are not as effective as other crack sealing methods however, and unsightly mounds of sealant material may remain if installation is not performed carefully. Thin epoxies are generally used as pour-in sealants, although some formulations of polyurethanes and methymethacrylates are also currently available. Some products have been formulated to foam and grow within the crack upon installation.

Cost Range: \$1.00 to \$3.00 per foot of cracks.

Service Life: 2 to 8 years.

- c. **Crack injection:** This method can be used either to restore structural integrity or to waterproof a crack. Crack injection epoxy or polyurethane materials are pumped into the crack, but polyurethanes remain soft and do not restore structural strength. As a result, epoxy is much more widely used as the injected material because hardens and restores a portion of the structural strength along a static crack. Dynamic or moving cracks cannot be effectively repaired with epoxy, however, since any movement simply re-cracks the epoxy or concrete materials.

Cost Range: \$20.00 to \$50.00 per foot of floor crack.

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Service Life: Life of Garage for non-moving cracks.

6. **Control Joint Sealants:** These materials are used to waterproof intentional construction joints in both cast-in-place and precast parking garages. Good performance of joint sealants is necessary in both structural types, but it is particularly critical in precast parking garages because they contain many more joints than a cast-in-place garage. Polyurethane is the most widely-used joint sealant material, as it was for crack sealing. Although other materials such as silicones have better properties for movement and longevity, the silicones need to improve abrasion resistance to gain usage in garage floor slabs. Joint sealants are frequently installed in a recess at a depth of half the recess width. As joints are expected to experience movement, the sealant should be adhered on either side of the joint, and not adhered to the bottom of the recess. A backer rod or bond breaker tape is often used to prevent this bottom adhesion.

Cost Range: \$3.00 to \$5.00 per foot of  $\frac{3}{4}$ " wide joint.

Service Life: 8 to 12 years before sealant replacement.

7. **Expansion Joint Seals:** Expansion joint seals are necessary in many parking garages. Most seals are costly to install, and are easily impaired by poor attention to details in installation, as well as abuse from snowplows, floor sweepers and dragging tailpipes. Failed expansion joint seals can result in excessive leakage into interior levels, which impacts the serviceability of floors. In northern climates, salt contaminated leakage through failed expansion joint seals can result in corrosive deterioration of beams and columns exposed to this leakage.

Several forms of expansion joint seals are manufactured for parking garages, with varying associated costs. Oftentimes joint seal systems are selected for garages based on low cost or convenience, and are not necessarily appropriate for a particular type of joint, exposed condition or installation time frame. For the systems listed below, service life ranges assume

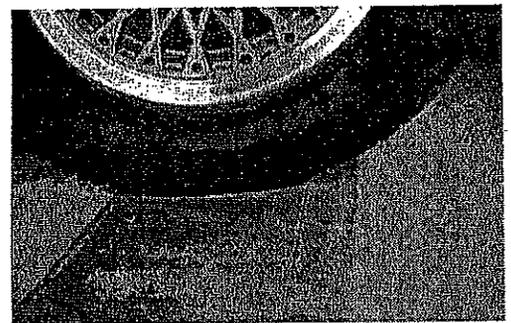


Figure B.4 - Expansion Joint

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the appropriate selection of joint seals; service lives can be considerably reduced if systems are incorrectly applied.

- a. **Polyurethane Traffic (T-joint) Seals:** These seals are typically factory pre-molded in  $\frac{3}{8}$ -inch or  $\frac{1}{2}$ -inch thickness, in varying widths. They are then set in recessed blockouts in floors, and fixed in place with hard polyurethane or epoxy nosings. Seals can be textured for improved pedestrian slip resistance. This type of seal is prone to damage from snowplows and dragging tailpipes, but can be repaired in segments with splices or polyurethane sealant materials.

Cost Range: \$50.00 to \$80.00 per foot for typical width seal installations.

Service Life: 8 to 12 years.

- b. **Gland Seals:** This type of seal, pre-manufactured with wings, are set in hard polyurethane or epoxy nosings in recessed blockouts in floors. They are typically extruded from neoprene or santoprene materials, and can be configured to form stiffened flat surfaces in joint openings, thereby conducive to pedestrian traffic. Some seals can be heat-welded for efficient transitions at curbs and intersecting joints, and for easy repair in the event of damage by snowplows and dragging tailpipes.

Cost Range: \$80.00 to \$120.00 per foot for typical width seal installations.

Service Life: 8 to 12 years.

- c. **Compression Seals:** These seals are comprised of a composite of several materials, and are designed to be installed in oversized configurations in joint openings. Typically epoxy, silicone or polyurethane adhesive is used to fix the seals in the openings.

Cost Range: \$30.00 to \$60.00 per foot for typical size seal installations.

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Service Life: 8 to 12 years.

- 2 **Miscellaneous:** Miscellaneous forms and configurations comprised of specialty expansion joint seals can be found throughout the US and Canada. Some capture significant market-share in isolated areas, mainly due to a local manufacturing presence or strong local installer or customer allegiance.

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### **APPENDIX C - DEFINITIONS & ABBREVIATIONS**

#### **C.1: ABBREVIATIONS**

ACI	American Concrete Institute
ADA	Americans with Disabilities Act
ADAAG	Americans with Disabilities ACT Accessibility Guidelines
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
ATBCB	Architectural and Transportation Barriers Compliance Board
CCTV	Closed Circuit Television
CF	Cubic Feet
GUI	Graphical User Interface
GVW	Gross Vehicle Weight
HVAC	Heating, Ventilation, & Air-Conditioning
IBC	International Building Code
LF	Lineal Feet
NFPA	National Fire Protection Association
NPA	National Parking Association
PCI	Precast Prestressed Concrete Institute
PCC	Parking Consultants Council of the National Parking Association
PTI	Post-Tensioning Institute
P/T	Post-Tensioning (reinforcement)
SF	Square Feet
SUV	Sport Utility Vehicle

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### C.2: DEFINITIONS

Aesthetic Maintenance	Actions performed for the general appearance and operational convenience of users of the garage. These maintenance actions are apparent to users of the garage, and are therefore important in effectively conducting parking garage operations.
Architect	A professional licensed by a state government to provide architectural services. Some architects also have experience in parking, and can provide parking consulting or parking restoration services.
Car-Park	British and European terminology for a parking garage.
Chloride Ion	Ions from highway de-icing (road salt) that migrate into concrete members and cause corrosion. See also 'Deterioration Mechanisms.'
Cast-In-Place Concrete	Concrete that is constructed by field casting or depositing in the place where it will harden, as opposed to precast concrete.
Concrete	Mixture of Portland Cement, water, sand and stone.
Construction Joint	Joint placed in concrete at a temporary termination of the construction.
Contraction Joint	Joint placed in concrete to allow shrinkage or cracking at that position.
Conventionally Reinforced Concrete	Concrete reinforced with mild steel reinforcing bars, as opposed to post-tensioned or prestressed reinforcement.

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Corrosion-Induced Spalling	Spalling of concrete caused by corrosion of metal embedded in the concrete. See also 'Deterioration Mechanisms.'
Cracking	A split, break or narrow opening in a parking garage structural member. See also 'Deterioration Mechanisms.'
Delamination	A separation of the garage floor slab layers. Generally caused by corrosion of the layers of reinforcing steel in the slab. See also 'Deterioration Mechanisms.'
Durability	The capacity of a garage to withstand wear and tear from operations and the environment.
Garage	<p>In this manual, this term is intended to apply to parking garages of all types. This includes free standing multi-level parking garages, underground parking garages and parking garages that are constructed integrally with other facilities such as condominiums and office buildings. In addition, the term "Parking Garage" is used in this manual to apply to all situations and for all other descriptions.</p> <p>Users of the manual will need to understand the proper terminology for their specific facility and purpose. Building codes, zoning ordinances and local customs may require the use of other terminology, possibly including: parking facility, parking ramp, parking structure, car park, garage, multi-level parking garage, open parking structure and closed parking structure.</p>
Housekeeping	Routine tasks and procedures in a garage that are necessary to maintain normal operations of the facility.

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Maintenance	<p>Sustaining a proper condition, for continued effective operation of a parking garage..</p> <p>To successfully prioritize garage maintenance, the following classifications have been used throughout this manual:</p> <ul style="list-style-type: none"><li>• Structural</li><li>• Operational</li><li>• Aesthetic</li></ul> <p>To effectively plan and budget for the maintenance of a facility, three types of maintenance costs can be identified:</p> <ul style="list-style-type: none"><li>• Routine Maintenance</li><li>• Preventive Maintenance</li><li>• Repair or Replacement</li></ul> <p>Routine maintenance costs include periodic repairs and or corrective actions that are necessary to maintain serviceability and facility operations.</p> <p>Preventive maintenance costs cover actions performed to extend the service life of the facility.</p> <p>Repair and replacement maintenance costs concern the replacement of structural and operational elements at the end of their estimated service lives.</p>
Operational Maintenance	<p>Actions required to maintain regular parking activities and operations in the garage.</p>
Parking Consultant	<p>A professional experienced with the special requirements of parking garages. Parking consulting includes structural, architectural,</p>

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civil, and functional design. It also requires special knowledge of codes and other professional disciplines applicable to the specific requirements for garages.

Parking Deck : See 'Garage'

Parking Garage : See 'Garage'

Parking Ramp : See 'Garage'

Parking Structure : See 'Garage'

Post-Tensioned Concrete : Concrete reinforced with high-strength steel tendons (as opposed to mild steel reinforcing bars) that are stressed (tensioned) after the concrete has reached the required minimum strength.

Precast/Prestressed Concrete : Concrete created by plant casting in a form and shipped to the construction site where it will be erected and undergo final construction. The concrete members often include prestress reinforcement. As opposed to 'Cast-In-Place Concrete.'

Preventive Maintenance : Tasks performed as needed to protect against future repairs and protect the owner's capital investment.

Professional Engineer : A professional licensed by a state government to provide engineering services. Some professional engineers have experience with parking structures, and can provide parking consulting or parking restoration services.

Restoration Engineer : An engineer experienced in restoration of structures, garages, or building elements.

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Routine Maintenance	Periodic corrective and housekeeping tasks and safety checks necessary for effective day-to-day operation of a facility.
Scaling	See C.3, "Definitions of Deterioration Mechanisms"
Sealant	See C.4, "Descriptions of Structural Systems."
Sealer	See C.4, "Descriptions of Structural Systems."
Slab	See C.4, "Descriptions of Structural Systems."
Spalling	See C.3, "Definitions of Deterioration Mechanisms."
Structural Maintenance	Actions necessary to maintain good condition of structural members and elements, to ensure continued operation of a garage.
Structural Engineer	A professional licensed by a state government to provide structural engineering services. Some structural engineers also have experience with parking structures, and can provide parking consulting or parking restoration services.
Traffic Topping	A waterproofing system that directly supports vehicle traffic. This system consists of a waterproofing membrane and surface treatment applied to the top surface of a garage floor slab.

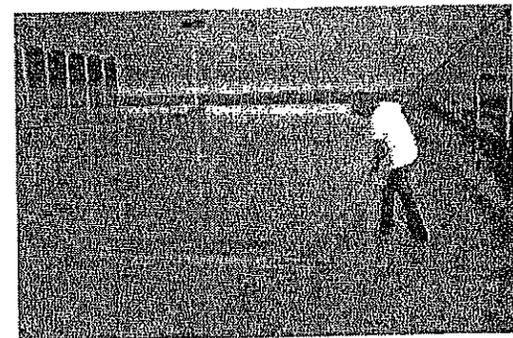


Figure C.1 - Traffic Topping

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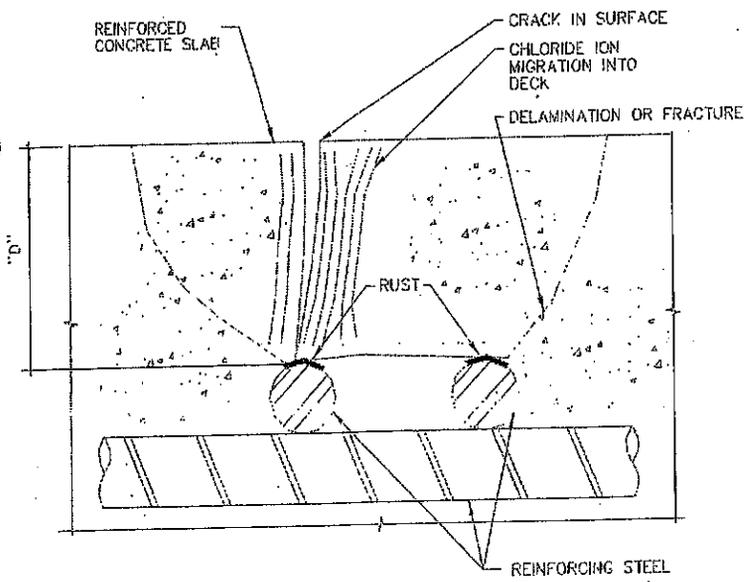
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### C.3: DEFINITIONS OF DETERIORATION MECHANISMS

The following is a list of descriptions of the types of deterioration and serviceability problems that could occur in parking garages.

**Corrosion** of reinforcing and other metals embedded in a concrete parking garage is the most severe and costly form of deterioration in a parking garage. This is normally caused by chloride contamination from de-icer salts, or from exposure to marine salts. As reinforcing corrodes, it not only slowly destroys itself, but also **spalls** and **delaminates** surrounding concrete as a result of the expansive pressure of the growing rust. Corrosive deterioration has led to the demolition of a number of garages, and in others has resulted in repair costs in excess of initial construction cost.



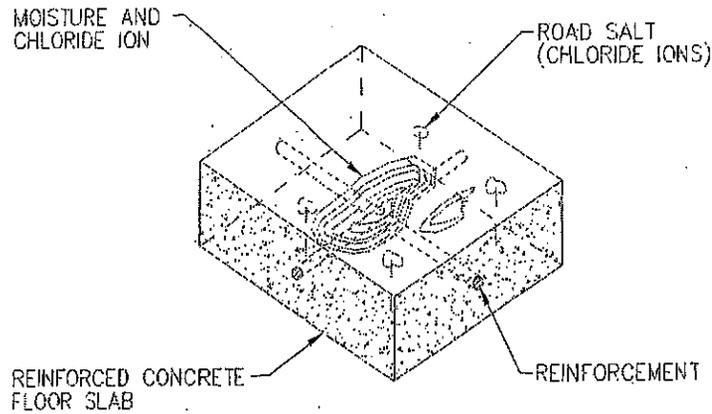
"D" = DEPTH OF CLEAR COVER OVER REINFORCING STEEL

Figure C.2  
Rebar Corrosion Spalling Mechanisms

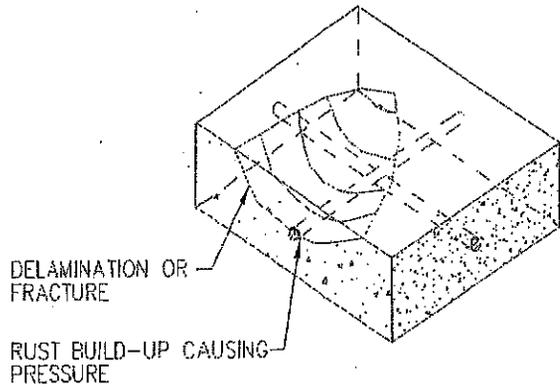
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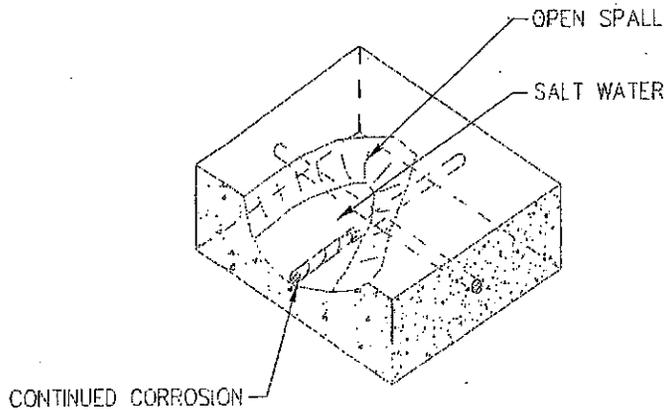
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1. CHLORIDE ION PENETRATES CONCRETE SURFACE.



2. RUST BUILDS UP AROUND REINFORCEMENT CAUSING HIGH STRESS OR PRESSURE AND EVENTUALLY CRACKING THE CONCRETE.



3. CONCRETE BREAKS AWAY LEAVING OPEN SPALLS OR POTHOLES.

Figure C.3  
Corrosion Induced Spalling  
Process

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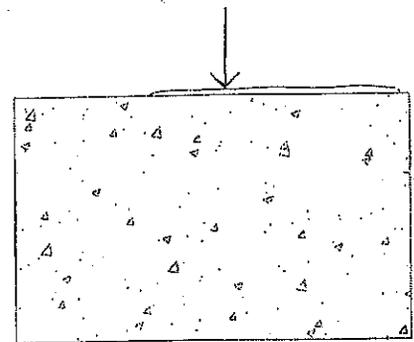
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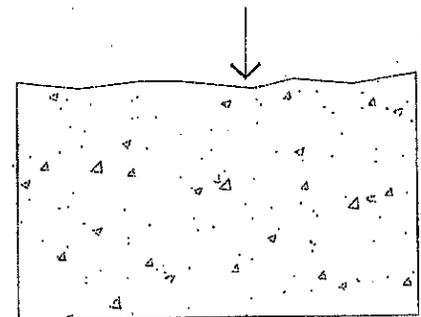
**Freeze/thaw** deterioration is a progressive internal fracturing, and eventual breakdown, of concrete due to repetitive expansive stresses of cyclic freezing and thawing of moisture within the material. It is not associated with any particular structural system, rather this type of deterioration is the result of defective design or construction. It can be caused by a use of poor quality concrete (usually deficient in air-entrainment), high water-cement ratio or other deficient material properties of a concrete mix. Concrete of marginal freeze/thaw durability will usually be aggravated by adverse exposure conditions that increase the concrete moisture content or the number of freezing/thawing or wetting/drying cycles. The most common of these detrimental conditions include: allowing water to continually pond on a concrete surface; trapping water against concrete in conditions where it is not permitted to dry naturally (such as below an asphalt overlay); or allowing water to continually pond below a topping slab and wick up into the topping slab. Freeze/thaw deterioration, if widespread, can be as severe and as costly to remedy as corrosive deterioration.

**Scaling** is a form of freeze/thaw deterioration that affects the finished surface of slabs, and is not associated with any particular structural system. Cyclic freezing can eventually disintegrate the concrete paste at a slab's surface. In severe cases scaling can reach depths of an inch, and can result in tripping hazards. It is normally caused by a lack of air entrainment in concrete, improper finishing of the slab, poor drainage or a combination of factors. In warm weather locations that do not experience freezing, a similar process known as "weathering" can occur, wherein concrete surfaces deteriorate similarly to freeze/thaw scaling. Weathering deterioration is generally a result of wetting-drying cycles.

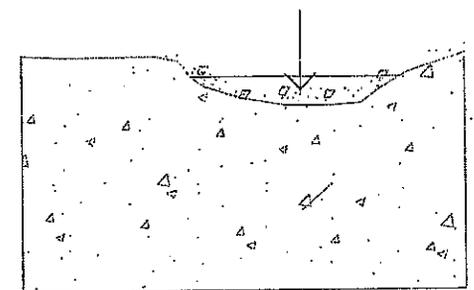
**Cracking** in a parking garage is, at best, a nuisance due to leakage that results. These **leaks** often seep a calcium carbonate **leachate**, which can permanently spot car finishes. Cracks also promote corrosive deterioration if salt water is allowed a direct path to top steel reinforcing or permitted to pass through a slab and run along soffit and beam sides. If this occurs, salt water contaminates concrete on the underside of a slab, and can lead to corrosion of bottom-reinforcing steel.



1. Concrete becomes saturated by water penetrating through pores and capillaries.



2. Concrete is frozen in a saturated state causing high stress. Loose flakes appear on the surface as the mortar breaks away.



3. As flaking progresses, aggregate is exposed and eventually breaks away, exposing more paste to freeze thaw damage. In extreme cases concrete can be reduced to gravel like state.

Figure C.4  
Concrete Surface Scaling

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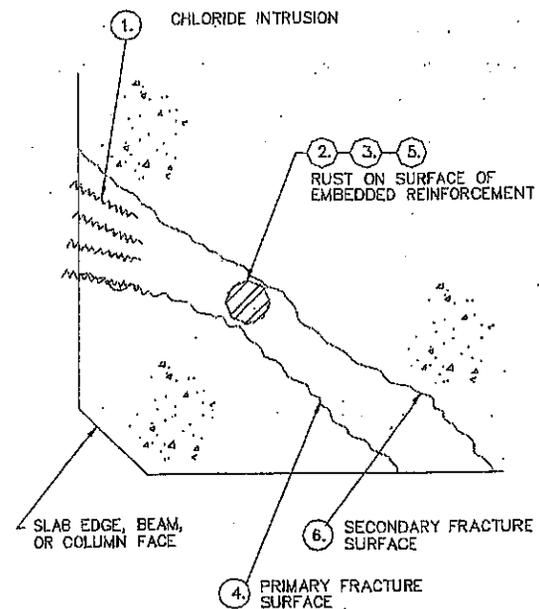
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**Topping disbondment** can occur in systems placed in two pours, or between precast members and field cast overlays. The resulting disbondment plane tends to collect water, which when frozen expands and can further enlarge the disbondment plane. The water within a disbondment plane also promotes freeze/thaw damage to the concrete surfaces above and below. When large areas of an overlay are disbonded, wheel loads can fracture an overlay, eventually causing potholes.

**Movement** occurs in all concrete structures as a result of changes in gravity loading, changes in temperature and moisture content, shrinkage after initial casting, creep and varying lateral loads. Parking garage design requires a balance between stiffness (for structural stability) and flexibility (to accommodate the movement.) A structural system that is too rigid for movement will be subjected to such deterioration and serviceability problems as:

- Cracking in floor slabs and in other members
- Fracturing of connections
- Subjection of joints to greater movement than a sealant can absorb, resulting in sealant failures
- Subjection of expansion joints to greater movement than a gland can absorb, resulting in gland failures



1. Chloride ion intrusion contaminates concrete, lowers pH and induces corrosion of embedded reinforcement.
2. Corrosion by-products "rust" develops at bar surface require expansion room.
3. Rust expansion causes pressures, which crack surrounding concrete.
4. Additional water and chlorides enter cracks.

Figure C.5  
Spall Development in Beam  
and Column

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### **C.4: DESCRIPTION OF STRUCTURAL SYSTEMS**

The following is a list of descriptions of the types of structural systems commonly used in parking garages, and their associated deterioration and serviceability problems.

**Conventionally-reinforced** cast-in-place concrete has been used in parking garages since the advent of structured parking. Some degree of cracking and leakage normally takes place in many of these garages. Corrosion of internal reinforcing has occurred in most conventionally reinforced garages occupied for 15 years or more in regions using highway de-icer salts. Some older parking garages of this type that had performed well for over 30 years began to exhibit reinforcing corrosion when de-icer salt use intensified in the 1960s

The performance of conventionally-reinforced cast-in-place parking garages can be improved through design intended to minimize cracking, and through the sealing of cracks that do occur. In regions where salt is a concern, any potential for corrosion of reinforcing can be reduced by employing one or more of the following techniques:

- Increased reinforcing bar cover
- Epoxy-coated reinforcing
- Reduced concrete permeability
- Use of a corrosion inhibitor
- Application of a surface sealer
- Application of a waterproofing membrane

Nearly all conventionally-reinforced cast-in-place concrete parking garages have been constructed of one of four structural types: flat plates, beam and slab, pan joist or waffle slab systems. Cracking is more prevalent in systems with large changes in cross section, such as pan joists and waffle slabs. These systems consist of many repetitive transitions between thin slabs and thicker beams. In regions using de-icer salts, corrosion of both top and bottom reinforcing is common in garages employing pan joist and waffle slab systems.

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**Post-tensioned** cast-in-place concrete has been used in parking garages for over forty years. These structural systems consist of internal, high-strength steel tendons that are jacked with a force of many tons after concrete has hardened. These tendons are then anchored in a stretched state, creating beneficial internal compression within the concrete. This internal compression minimizes cracking of structural members, resulting in nearly "crack-free" parking garages.

A reduction in cracking enhances durability, and minimizes leakage. Other benefits of post-tensioned systems include:

- Better, higher early strength concrete, which is desirable to a contractor to allow early jacking of the tendons. The result is a somewhat less permeable concrete parking garage that is usually more resistant to salt contamination than conventionally-reinforced concrete.
- Post-tensioning can minimize the need for mild reinforcing in the floor slab. Consequently, much less internal steel exists, reducing corrosion potential if a floor slab were to experience salt contamination.
- The primary reinforcement of structural members is protected from salt-induced corrosion. The steel tendons within the concrete slabs and beams are required, per regulation, to be completely encapsulated with a waterproof sheathing in regions where de-icer salts are used.

The requirement for complete encapsulation of tendons potentially exposed to salt became a building code requirement in the mid-1980s. Prior to that time, some parking garages employed unprotected tendons, such as those with paper wrapping or discontinuous sheathing, or tendons in metallic sheathing. As a result, tendon corrosion has occurred in some of these garages due to salt contamination. In some garages built prior to the code change, tendons have even failed due to corrosion.

Post-tensioning may be bonded or unbonded. In bonded systems, grout is pumped into the sheathing after the tendon is jacked. The grout hardens and bonds the tendon to the sheathing, which in turn is bonded to the surrounding concrete. In unbonded systems, the orifice in the sheathing is filled with grease. The tendon, before



Fig C.6 - Post-Tensioned Tendon Grout Pocket Cracking and Leaking

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and after jacking, is free to slide. With respect to durability, the performance of bonded and unbonded systems is approximately equal.

Most post-tensioned parking garages are of beam-and-slab construction. Slabs about 6 inches thick span about 20 feet between beams, which in turn span about 60 feet between columns. This layout is popular, as it provides a column free parking bay. Some post-tensioned parking garages, however, are of flat-plate construction. In these garages, solid slabs 8-10 inches thick span about 30 feet in each direction to columns. This layout is popular if the structure is of mixed-use with an over build of a different occupancy such as an office building. Both flat-plate and beam-and-slab post-tensioned garages perform roughly the same with respect to durability.

**Precast concrete** structural systems have been employed in parking garages for over forty years. In precast structural systems, the columns, beams and floor slab units are manufactured in a factory, shipped to a site and erected. The precast units, which make up the floors of the garage, are normally pre-stressed as well as precast. These units are cast in very long forms containing high strength steel tendons, which are jacked with a force of many tons prior to concrete placement. When the concrete hardens, the tendon jacks are released, which transfers the forces in the internal tendons (now surrounded and bonded within the hardened concrete) to the precast member. This "prestressing" produces a beneficial compression in the concrete members of structured floor slab and beam units, thereby effectively reinforcing them. The floor slab units in clear-span precast garages are normally "double tees".

The factory manufacture of precast structural members generates some durability benefits, including:

- Improved quality control measures through controlled factory processes.
- The use of better, higher early strength, concrete and curing to rapidly cycle forms. Both somewhat reduce the permeability of the concrete, and often result in structural members that are more resistant to salt contamination than field-cast concrete.

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- A minimized amount of mild steel reinforcement in floor slab units. As they contain less internal steel, there are fewer available elements to corrode if floor slab units become contaminated with salt.

While factory manufacture brings about benefits, the non-monolithic segmental nature of a precast parking garage's floor construction creates a need to seal and waterproof joints between double-tee or floor slab units. These continuous joints occur every eight to ten feet in double tees, and as often as every two feet in hollow core slabs.

Early precast double tee parking garages built before the 1980s had topping slabs (generally 2-to-3 inches thick) which were field cast over the double tees. While precast double tee garages are still constructed with topping slabs, detailing practice changed when cracking of the topping slab along the joints between the double tees was found to create leakage problems. Use of sealed control joints in the topping above the double tee joints then became widespread as a result.

In the 1980s precasters began marketing "pre-topped" double tees that do not require a field cast topping; rather their top flange is thickened by two or more inches in the factory ("pre-topped"), and the top surface serves as the riding surface in the garage. Most precast double tee garages manufactured today are pre-topped because they require a less costly initial construction than precast garages with field cast toppings.

Today nearly all precast, double tee garages, whether topped or pre-topped, have sealed joints between double tees as well as at ends of units along beam supports or perimeter walls. For leak-free performance it is important that the sealant, usually a polyurethane caulking, be properly installed and renewed as needed. Beyond the nuisance of leaks, salt-water leakage through joints in garages exposed to salt can corrode connections between tee flanges. Salt water can also run down tee stems, contaminating concrete surrounding the highly-stressed tendon in the stem. In worst case situations this can eventually corrode the tendon.

The many joints in a precast garage (for example, a 1000-car, six-story precast garage has about six miles of sealed joints), dictates that leakage is the primary serviceability and durability concern.



Fig C.7 - Leaking at Double Tee Joint Causing Corrosion Damage to Tee Flange and Stem.

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Other durability issues found in precast garages are noted below. All can be resolved by conscientious design and construction practices.:

- Field cast toppings in precast garages have, at times, not received the same attention to durability as the precast units themselves. Instances of scaling, cracking, disbondment and freeze/thaw deterioration have resulted.
- Movements due to both volume change and changes in gravity loading have fractured connections between precast units. When this occurs, it is usually due to a lack of ductility in the connectors and their anchorages.
- Corrosion of connections between precast units has occurred in regions exposed to salt. Tendon corrosion has also occurred in these regions where sealant failures are not repaired, thereby resulting in leaks above tendons.

A form of precast concrete featuring precast/cast-in-place composite systems have been used on a limited basis in parking garages. Precast single tee frames with field-formed and cast infill slabs were first installed as composite systems in parking garages 35 years ago. More recently Filigree systems have been used in parking garages. These systems feature precast soffit elements that act as forms for field cast main structural slabs.

These composite precast/cast-in-place systems have many of the same vulnerabilities to deterioration and serviceability problems as conventional cast-in-place and precast systems. Additionally, they sometimes contain voids within the slabs and beams that are formed by polystyrene fills used to reduce cast-in-place concrete weights. In regions of frequent freezing and thawing, water collecting and expanding in these voided zones can result in fractures and cracking.

**Structural steel** frames have been used in a limited quantity of garages since the advent of structured parking. The main advantage of a steel frame is a lighter weight, when compared to concrete frames. Code requirements for fire ratings may require supplemental fireproofing or other code variances in order to permit an exposed steel frame. Steel frames require excellent protection from floor slab drainage and water, as well as periodic painting, to mitigate corrosion damage. With appropriate design

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and durability concerns taken into consideration, steel beams and columns perform well in garages.

Concrete floor slabs on steel frames have similar performance and durability issues as those on concrete frames. However, unique issues related to structural steel garages include:

- If required by code, and if the garage is located in an area of frequent wetting, fireproofing systems should be of a type that does not hold moisture against the steel, as this accelerates corrosion.
- Stay-in-place, metal form decking should be avoided, as it is highly susceptible to corrosion.

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## **APPENDIX D: PARKING ACCESS AND REVENUE CONTROL SYSTEMS (PARCS)**

Maintaining parking access and revenue control systems are important to ensure the long-term success of any parking garage. Properly functioning equipment is paramount to secure the maximum amount of revenue. In addition, since the most visible equipment components are located at the front door to the facility, it is equally important that equipment look good as well. Furthermore, it is cost effective to maintain the equipment, as well-maintained equipment generally lasts longer, assures maximum revenue intake, ensures more accurate access control, reduces management obstacles, and presents the image of a professionally managed parking garage.

### **OWNERS AND MAINTENANCE MANUALS**

The importance of obtaining and retaining copies of equipment manuals, as well as following any recommended maintenance schedules, cannot be overstressed. Manuals should be included with the purchase of every piece of Parking Access and Revenue Control (PARCS) equipment. If any manuals are missing, contact the manufacturer to obtain replacements. One copy of the manuals should be kept safe and unused, while a working copy should be used for routine reference. If possible, obtain electronic versions of the manuals on CD.

### **MAINTENANCE AGREEMENTS**

Today's PARCS equipment relies heavily on advanced and complex computer technology. Most manufacturers and/or equipment installers offer maintenance agreements, and the purchase of a maintenance agreement is generally advisable. Maintenance agreements are particularly beneficial at high volume/high fee parking facilities, as the revenue generated at these facilities warrants constant vigilance. A local service provider will be able to obtain and install replacement parts faster than an owner/operator might, which results in reduced equipment downtime, and electronic/computer expertise needed to maintain and repair the equipment is often beyond the capability of many

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facility owners and operators. In addition, improperly performed maintenance or repair actions can damage equipment, and may void any warranties.

Maintenance agreements should explicitly define the items that will be covered under the agreement, and should also establish the conditions and components that are not covered. Agreements can be obtained to cover preventive maintenance, emergency repairs, or both.

A preventive maintenance agreement should define a schedule of required maintenance for each component. The agreement should also establish a method for documenting the completion of maintenance actions. An agreement that includes emergency repair services should define required response times, and time periods covered. For example, five days a week, eight hours a day coverage is sufficient for some facilities. Other facilities require a 24 hours a day, 7 days a week service.

The quality of service provided by a local service provider is vital. Be sure to check the reputation and references of a provider. Determine if the service center is located close enough to adequately provide the expected service. Good service on average equipment is often better than poor service on great equipment.

### **TRAINING**

Regardless of who will maintain a facility's PARCS equipment, some maintenance training is required for an owner/operator's personnel. A facility's personnel should be taught how to perform simple day-to-day functions such as loading tickets and receipt paper, clearing minor ticket jams, replacing broken gate arms, etc. It is also important to show an owner/operator's personnel which problems are best left to a trained service provider.

If an owner/operator's personnel is responsible for preventive maintenance, additional instruction may be warranted. A preventive maintenance training session is often included with the purchase and installation of new equipment.

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Training for repair personnel may require a more intensive multi-day instruction course. Some experience with electronics may be a required prerequisite for troubleshooting and repair classes.

### **SAFETY**

Safety should be the primary consideration when performing any maintenance activity on PARCS equipment. Electrical shock is possible when inexperienced personnel attempt to inspect inside equipment. Moving parts inside some equipment can also cause injury. In addition, maintenance personnel should take appropriate measures to protect themselves from traffic entering and exiting the parking garage.

### **GENERAL HOUSEKEEPING**

All PARCS equipment should be checked at least once a day for proper operation. Checking equipment during slow periods may avert the chance of a major problem arising during the busy time of day. Consumable items, such as ticket stock, should be checked and replenished as needed. Change vaults should be checked for adequate supply. Equipment status monitoring can be simplified and streamlined if PARCS equipment is connected online to an equipment-monitoring computer. With this system, the operating status of equipment and the supply of consumables are continuously monitored by on-line systems.

A daily visual check of equipment is also needed to spot housekeeping problems that cannot be detected by computer systems. Equipment housings should be kept clean and free of graffiti and stickers, while the interior and exterior of cashier booths should be kept neat and clean.

### **PREVENTIVE MAINTENANCE**

Owner's and maintenance manuals remain the best source of information regarding any particular component's maintenance

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needs. Some general preventive maintenance guidelines are as follows:

### *Equipment Housings*

- Inspect housings for vehicular damage or vandalism. Replace severely damaged housings.
- Equipment housings, especially equipment located outdoors, should be waxed with an automotive-type wax twice a year to help prevent corrosion and prolong cabinet life. Scratches in the paint should be treated with a color-matching touch-up paint.
- All mounting bolts and miscellaneous hardware should be mechanically sound and tight. Verify that all housings and stands are securely mounted.
- Heaters and thermostats should be checked for proper operation, especially in cold climates.
- Indoor components, such as automated pay stations, should be kept clean and polished. A good paradigm to emulate is the vending machine industry, which recognizes the value of a clean and shiny machine.

### *Mechanical Components*

- All nuts, bolts, screws, flanges, connecting rods and other mechanical fasteners should be sound and tight.
- Gate-operating mechanisms should be checked and readjusted as appropriate.
- Mechanically-operated switches should be mechanically and electrically tested.
- Gate-operating mechanisms should be lubricated as appropriate, and reservoirs should be topped off with the proper lubricant.
- Ticket dispensing mechanisms are particularly prone to failure from exposure to dirt and dust. Use compressed air

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and a soft brush to keep mechanisms free of ticket dust and other impurities.

- Ticket cutter mechanisms should be degreased and lightly lubricated as needed.
- Clocks should be time-corrected and adjusted.
- Printer mechanisms should be cleaned and lubricated as recommended by the manufacturer.
- Coin-accepting mechanisms should be checked that they work freely without binding.
- The coin ejector mechanism should be cleaned, and foreign materials should be removed.
- Verify that the coin acceptor accepts only the proper coins.
- Interlock switches on cash drawers should be checked to ensure proper operation.
- Verify that access cards can be smoothly inserted and removed.
- Card reader heads should be cleaned using compressed air, soft brushes or factory-recommended cleaning materials.

### *Electrical and Electronics*

- Sockets, cables, and connectors should be unplugged and re-plugged several times to clean corrosion and oxidation from the contacts and to ensure electrical and mechanical integrity.
- Test all buttons on keypads for proper performance.
- Use compressed air to clean keyboards.

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- Ensure that all displays, lights, etc. are clear, bright and functional.
- Verify that all surge protectors, lightning protection equipment, uninterruptible power supplies, etc. are working properly.
- Polish the contacts of circuit breakers and relays.

### *Vehicle Detectors and Loops*

- Verify that all loops are properly sealed with an appropriate caulk.
- Test loops for electrical integrity. Specialized testing devices are available for this purpose.
- Verify correct function of each specific lane operation.
- Ensure that sensitivity settings are properly calibrated.

### *Software*

Software requires maintenance too. Even if hardware is perfectly maintained and operating flawlessly, a software-generated problem can shut down a PARCS system.

- Necessary updates and bug fixes for the operating system, software and firmware should be installed when made available by the manufacturer.
- Backups should be made and maintained for software and the system generated data. These backups should be able to completely restore a system.
- Databases should be kept up-to-date, and backed-up as necessary.

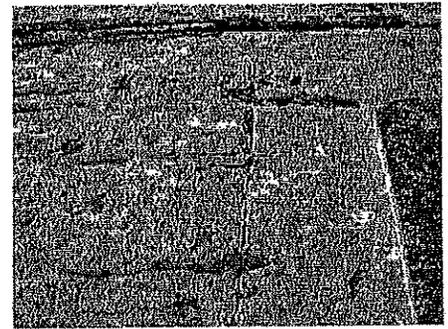


Figure D.1 - Use care when installing detector loops – Avoid cutting into slab and through Post-Tensioned reinforcement.

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### *Cashier Booths*

- Window glazing should be kept clean. Glass can be washed with any commercial glass cleaner. But care should be taken when washing plastic glazing as some glass cleaners can damage plastic.
- Regularly wash the exterior of the booth with a mild detergent and cold water. Use manufacturer-recommended touchup paint on chips and scratches. An annual application of high-quality wax will help maintain the exterior finish of the booth.
- Roof coating should be inspected following initial installation, and annually after that.
- Sliding window and door tracks should be cleaned at regular intervals, and drain holes must be kept unobstructed. Weather stripping should be checked for shifting or damage.
- Flooring should be kept free of dirt and standing water. Wash floors with mild detergents and cold water, as salts used to melt snow can damage flooring.
- Keep light fixture lenses clean to insure maximum light output.
- Vacuum dirt and lint from the grills of heating and cooling units. Clean or replace filters for energy-efficient operation.

### MAINTENANCE INTERVALS

The specific intervals for scheduled preventive maintenance will vary by equipment type and manufacturer. Equipment with many moving parts may need more maintenance. In addition, the number of transactions processed also determines the frequency of necessary preventive maintenance. PARCS for a busier facility needs maintenance that is more frequent.

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General minimum preventive maintenance intervals for common PARCS equipment are:

Barrier Gates:	30 days
Ticket Dispensers:	30 days
Ticket Readers:	30 days
Coin/Token Acceptors:	30 days
Fee Computers:	90 days
Card Reader Heads:	90 days
Vehicle Detectors and Loops:	90 days
Power Supplies:	180 days

### **SPARE PARTS**

An inventory of spare parts is usually required to keep PARCS running smoothly. In addition to a stock of expendable items, large Parking Access and Revenue Control Systems (PARCS) usually require maintaining an inventory of critical spare parts that are prone to breakage or damage. For example, many airport parking operations stock spare ticket dispenser mechanisms, as these are frequently taken out of order by malfunction and damage.

### **MAINTENANCE LOGS**

All maintenance procedures should be recorded in a log for each component. A log of preventive maintenance activity can provide useful information in setting future budgets. Likewise, a repair log can help to identify equipment that is wearing prematurely. A log of equipment downtime can provide the information necessary to justify upgrading or the purchase of new equipment.

Standard database software provides a good platform for sustaining maintenance logs. Complete records on maintenance and repair activity for a specific component can be easily retrieved and compared against other components. In addition, consideration should be given to incorporating a calendar function that reminds the staff when preventive maintenance should be performed.

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### **USEFUL LIFE**

Even the most meticulously maintained PARCS equipment will eventually need to be replaced to maintain the overall successful operation of the parking garage. Some components simply wear out and no replacement parts will be available, while other components become too costly to maintain and operate. Computerized PARCS equipment is more likely to become technologically outdated long before the useful life of the equipment has expired.

New PARCS equipment, when properly installed and maintained, can provide long-term service. Generally, PARCS equipment in a high-volume parking facility has a useful life of at least five years. Equipment installed in a lower-volume facility may have a useful life of ten years or more. The physical environment of installed equipment also has a significant impact on the useful life of PARCS equipment. For example, equipment installed indoors will generally last longer than equipment exposed to the elements.

Choosing the best time to replace PARCS equipment should be a business decision that compares financial and operational benefits with the costs for acquisition, operations and maintenance.

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### **APPENDIX E - BIBLIOGRAPHY & REFERENCES**

A considerable number of publications have been published on the subject of repair and maintenance items. Listed below are selective basic references that provide an overview of garage repair and maintenance:

#### **PARKING GARAGE BIBLIOGRAPHY**

1. Urban Land Institute & NPA, 2000, *"The Dimensions of Parking"*, Fourth Edition Washington DC
2. Parking Consultants Council, *Parking Garage Maintenance Manual*, National Parking Association, 1982; 1991, 1996, Washington, D.C.
3. Anthony P. Chrest, Marry S. Smith, Sam Bhuyan, Donald R. Monahan, Mohammad Iqbal, *Parking Structures: Planning, Design, Construction, Maintenance and Repair*, Third Edition, 2001, Kluwer Academic Publishers, Norwell, Ma
4. American Concrete Institute, ACI 362.1 R97, *Guide for the Design of Durable Parking Structures*, Farmington Hills, Michigan
5. American Concrete Institute, ACI 362.2 R00, *Guide for Structural Maintenance of Parking Structures*, Farmington Hills, Michigan
6. Weant, Robert A., and Levinson, Herbert S., 1990, *"Parking"* published by the Eno Transportation Foundation, Westport, CT

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## **NATIONAL PARKING ASSOCIATION/PCC PUBLICATIONS**

1. *Guide to the Design and Operation of Automated Parking Facilities, 2003*
2. *The Dimensions of Parking, Fourth Edition*
3. *Guidelines for Parking Geometrics, 2002*
4. *Security Design for a Parking Facility – A Workbook, 2002*
5. *Recommended Zoning Ordinance Provisions for Parking and Off-Street Loading Spaces, May 1992*
6. *Guide to Selecting Parking Consultants, 1997*
7. *Parking Studies, June 1992*
8. *Planning Guidelines for Intermodal Parking, 1997.*
9. *Employee Handbook, 1997*
10. *Personnel Management: From Recruitment to Termination*

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## **PARKING GARAGE MAINTENANCE MANUAL**

GUIDE FOR REPAIR AND MAINTENANCE OF PARKING GARAGES

NATIONAL PARKING ASSOCIATION - PARKING CONSULTANTS COUNCIL

### **AMERICAN CONCRETE INSTITUTE PUBLICATIONS**

1. ACI 201.1 R92 Guide for Condition Survey of Concrete in Service
2. "Guide to Durable Concrete." American Concrete Institute, ACI 201.2R-92.
3. ACI 224R90 Control of Cracking in Concrete Structures
4. ACI 224.1 R 93 - Causes Evaluation and Repair of Cracks in Concrete Structures
5. ACI 301 R99 - Standard Specifications for Structural Concrete.
6. ACI 330 R92 - Guide for Design and Construction of Concrete Parking Lots
7. ACI 364.1 R94 "Guide for Evaluation of Concrete Structures Prior to Rehabilitation"
8. ACI 365.1 R00 - "Service Life Prediction State of the Art Report"
9. ACI 423.4 R 98 - Corrosion and Repair of Unbonded Single Strand Tendons
10. ACI 504 R90 - Guide to Joint Sealants for Concrete Structures
11. ACI 546 R96 - Concrete Repair Guide

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### **INTERNATIONAL CONCRETE REPAIR INSTITUTE PUBLICATIONS AND REFERENCES**

1. "Concrete Repair and Maintenance Illustrated; Problem Analysis, Repair Strategy, Techniques." Published by R.S. Means Company, Inc.
2. Removing Stains and Cleaning Concrete Surfaces
3. International Concrete Repair Institute - Concrete Repair Terminology: Website and reference  
<http://www.icri.org/onlineresources/ConcreteRepairTerminology.pdf>

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## **PRECAST CONCRETE INSTITUTE PUBLICATIONS**

1. "Precast/Prestressed Concrete Parking Structures Maintenance." Prestressed Concrete Institute.
2. "Research Project No. 7 - Survey of Precast Prestressed Concrete Parking Structures, 1986." Precast Prestressed Concrete Institute.
3. "PCI Design Handbook, Precast and Prestressed Concrete." Fourth Edition 1992, Precast Prestressed Concrete Institute.
4. "Precast Prestressed Concrete Parking Structures: Recommended Practice for Design and Construction." 1988, Precast Prestressed Concrete Institute.

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## **NATIONAL FIRE PROTECTION ASSOCIATION PUBLICATIONS**

1. NFPA 25, "Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems."
2. NFPA 72, "National Fire Alarm Code."

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## **OTHER PUBLICATIONS & REFERENCES**

1. "Parking Structure Maintenance." Canadian Parking Association
2. Cement and Concrete Reference Laboratory (CCRL) National Institute of Standards and Technology (NIST) in Gaithersburg, Maryland.  
<http://www.bfrl.nist.gov/862/ccrl/front.htm>

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## **APPENDIX F - CITED REFERENCES**

1. Parking Consultants Council, *Dimensions of Parking*, Third Edition, 1993, Washington DC Urban Land Institute and National Parking Association.
2. Parking Consultants Council, *Parking Garage Maintenance Manual*, National Parking Association, 1982, 1991, 1996, Washington, D.C.
3. Anthony P. Chrest, Mary S. Smith, Sam Bhuyan, Donald R. Monahan, Mohammad Iqbal, 2001 "*Parking Structures: Planning, Design, Construction, Maintenance and Repair*" Third Edition. Published by Kluwer Academic Publishers, Norwell, MA
4. American Concrete Institute, *ACI 201.1R Guide for Making a Condition Survey of Concrete In Service*, Farmington Hills, Michigan
5. American Concrete Institute, *ACI 362.1R 97 "Guide for Design of Durable Parking Structures"*. Farmington Hills, Michigan
6. American Concrete Institute, *ACI 362.2R 90 "Guide for Structural Maintenance of Parking Structures."* Farmington Hills, Michigan