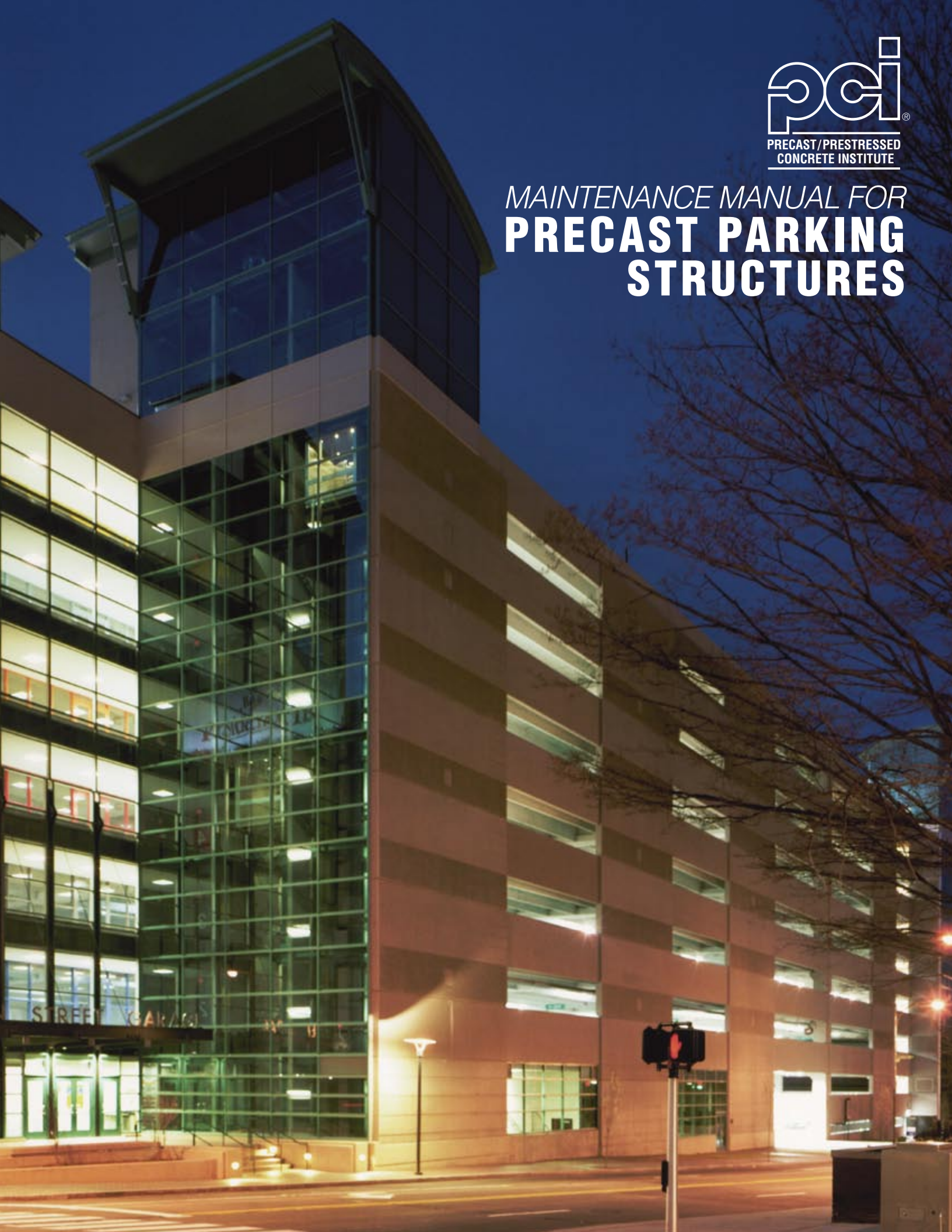




MAINTENANCE MANUAL FOR **PRECAST PARKING STRUCTURES**



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Substantial effort has been made to ensure that all data and information in this Maintenance Manual for Precast Parking Structures are accurate. However, PCI cannot accept responsibility for any errors or oversights in the use of material or in the preparation of engineering plans. This publication is intended for use by professional personnel competent to evaluate the significance and limitations of its contents and able to accept responsibility for the application of the material it contains. Special conditions on a project may require more specific evaluation and practical engineering judgment.

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1.0 INTRODUCTION

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The elements of parking structures, more than any other building type, require routine maintenance. This manual is intended for the owners, operators, architects, and engineers of precast parking structures in order to assist them in extending their structure's service life. The recommendations and procedures offered herewith will hopefully serve as a valuable resource for maintaining existing structures and for architects and engineers during the initial design phase of new parking structures.

Unlike other buildings, the structural components of parking structures are exposed directly to weather and other environmental conditions. Extreme temperature changes, rain, snow, deicing salts, road grime, and dampness directly influence the durability of parking structures and have the potential to create performance problems. The potential severity of these problems will depend on the geographic location of the structure and local environmental conditions. In all locations, the added burden of direct exposure dictates that more maintenance attention be given to the components of parking structures than other building types.

Based on national surveys, precast concrete parking structures offer superior resistance to deterioration. Since PCI certified plants are monitored for quality control, fabrication and operating procedures, the factory produced concrete elements are manufactured with a high degree of quality and craftsmanship. The controlled plant environment also enables the use of durable concrete mixes with specialty curing that conventional field placed concrete systems typically do not achieve. This clear advantage of precast concrete gives the owner/operator a decisive edge from the start. However, without proper maintenance **any** structure's life will be comprised.

In addition to increasing service life and reducing long term structural repairs, a comprehensive maintenance program will produce a cleaner, safer and more user friendly atmosphere which promotes repeat business and discourages littering and loitering. A well maintained parking structure also reflects a positive image on the owner/operator, adjacent businesses or even an entire city for structures located at airports or major downtown areas. Thus, it is essential for a maintenance program to be a major phase in the operation of all parking structures. A routine maintenance program should be set up immediately upon turnover of the parking structure.



Well maintained parking structures provides a user friendly atmosphere and promotes repeat business.

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This manual contains guidelines for maintaining precast concrete parking structures. However, it is not uncommon to find a variety of construction materials incorporated into a parking structure such as cast-in-place concrete, steel, masonry, aluminum or wood. Although the majority of the guidelines presented in this manual apply to many building systems, non-precast systems may require special or additional consideration beyond that required for precast concrete. Non-structural systems such as elevators, escalators, people movers, mechanical units, electrical, security and landscaping will also have specific individual maintenance requirements that are typically specified by the manufacturer/supplier. These additional procedures should be incorporated into the total maintenance program. The following references are recommended for additional maintenance guidelines on non-precast concrete systems:

1. Guide for Structural Maintenance of Parking Structures, American Concrete Institute Report CI 362.2 R-00.
2. Parking Garage Maintenance Manual, National Parking Association.
3. Documentation provided by Elevator Supplier, Mechanical Unit Supplier, etc.

All parking structures require a diligent maintenance program to ensure long-term durable performance. Broad categories for maintenance of parking structures are generally accepted as: **Housekeeping**, **Preventive Maintenance**, and **Structural Repairs**. Within these categories are specific items that require periodic attention. Precast, prestressed concrete parking facilities, by their unique design, require maintenance tasks that may be slightly different than those of other construction types. In this section, we will define the types of maintenance tasks specifically required for precast, prestressed concrete parking structures.

2.1 HOUSEKEEPING

Housekeeping maintenance involves those items that enhance the aesthetic appeal and functional performance of the parking facility. The users of the parking structure tend to consider their parking experience as satisfactory if the facility is clean and safe. The owner or the operator of the structure generally performs these tasks on a scheduled basis. Housekeeping maintenance involves the following tasks:

- **General Cleaning:** *Trash removal, drain cleaning, sweeping, window cleaning*
- **Floor Wash:** *Annual high pressure wash down, oil stain removal*
- **Expansion Joints and Control Joints:** *Cleaning of debris*
- **Painting:** *Periodic touch-up of painted surfaces*
- **Landscaping:** *General upkeep of planting materials*
- **Doors and Hardware:** *Check for proper operation*
- **Striping and Graphics:** *Re-paint parking stripes and graphics*
- **Lighting Fixtures:** *Clean lens and replace burned out lamps*
- **Elevator:** *Cleaning and maintenance*
- **Signs:** *Cleaning and repair*
- **Graffiti:** *Removal*
- **Snow and Ice Control:** *Plowing and snow removal, deicing traffic areas*
- **Security System:** *Check for proper operation*
- **Parking Equipment, Revenue Control System Maintenance:** *Check for proper operation*
- **Janitorial Services:** *Lavatory, office, waiting areas*

These duties typically fall to the parking structure operators, because they generally have a primary interest in maximizing operating revenues and keeping operating expenses within budget while providing safe and convenient parking to attract the user. The housekeeping items listed above should be performed by the operator on a periodic schedule as suggested in Table A. The following additional comments should be noted:

Cleaning and sweeping are tell-tale signs of the amount of attention

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Housekeeping should include frequent cleaning of joints. Clean joints will increase service life.

the parking facility has. Lack of attention is an invitation to loiter in the parking facility and may reduce safety of use. Sweeping should remove debris and sand from drains, expansion joints, and control joints. Cleaning should include removal of litter from beam ledges and member joints.

Highly visible parking striping promotes centering of the parked cars in the parking space, thus minimizing overlap. If striping is changed, do not paint over existing striping. It is better to remove completely by shot or water blasting so that two sets of striping do not create confusion.

Lighting fixtures lose much of their effectiveness due to dirt accumulation on the lens or clear covers. Therefore, it is recommended that all fixtures be cleaned annually, immediately following the spring wash down. It is also important that lamps should be replaced before they burn out. A schedule of re-lamping based on the lamp life is recommended. Lamps should be monitored daily and replaced as quickly as possible. Lighting is usually a definable measure of security and, as such, requires special attention. To achieve this goal, replacement lamps should be stored on the premises.

Emergency lights and generators should be checked daily. Emergency lights using battery packs typically have visible status indicators and all have test buttons.

Security systems, emergency lighting via batteries, and emergency generators must be checked frequently to insure proper functioning at all times.

Time clocks may need to be corrected for daylight savings time.

Light to moderate oil stains are generally not detrimental to the structure, but their removal improves facility appearance. Heavy stains may be slippery and hazardous.

Ventilation and carbon monoxide monitoring systems in enclosed parking

structures must be checked daily.

2.2 SNOW REMOVAL

Introduction

In areas where winter weather affects the operation of a parking structure, removal of snow and ice is necessary, if not paramount, for functional performance, the public's safety, and the long-term durability of the structure. Snow and ice removal can be difficult depending on the size, timing, and type of storm, and also the area to be maintained. For these reasons, knowing with what and how to remove snow and ice can greatly affect the operation of the structure. The basic parameters for snow and ice removal include planning, proper equipment, chemical deicers, written procedures, and how-to instruction for snow removal personnel.

A. Planning

When removing snow and ice, planning plays an important role for a successful operation. Basic planning and specifications for snow removal begins during the initial design phase of the parking structure. The owner, architect, engineer, contractor, and precast/prestress concrete manufacturer must all be involved in determining how snow and ice will be removed. Operations such as removal of snow and ice from the deck surface, storage of snow and ice, and the use of certain types of equipment can cause major functional and performance problems to the structure if not properly addressed during the initial design phase.

When an architect begins considering the location and layout of a parking structure, snow and ice removal operations should be based on local climate conditions. Anticipated maximum snow fall and frequency will influence planning strategies. Once parameters for snow and ice removal have been established, features for storage or removal must be designed into the structure.

Removal of snow is typically handled by moving the snow to a snow chute or snow melting equipment, or by moving to and through a gate opening in exterior spandrels.

Storage of snow requires strict operating procedures and protected dumping zones to ensure the safety of workers, pedestrians, and vehicles. Multi-level parking structures also require special procedures to prevent the penetration of falling snow onto lower structure levels. The number of dumping locations depends on the parking structure size, anticipated snow fall rate, and adjacent property locations.

When snow is stored on the top level of a parking structure, it is essential that equipment operators be provided with detailed storage guidelines before each clearing operation. If guidelines are not provided in the original design, a structural engineer must generate guidelines for maximum storage-pile size, location, and height. Consideration should also be given to obstruction of sight lines, loss of parking spaces, and the deleterious effects of concentrated salts and deicers.

Snow melting equipment comes in various forms. Before a piece of equipment is chosen, the structure needs to be checked to ensure that structural components can safely support the equipment's maximum

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working weight. Typically, if wheel loads are larger than 3000 lbs or the total distributed equipment weight exceeds 50 lbs per sq ft, a structural engineer must verify the structural adequacy of the building components. Sufficient floor drainage is required to properly dispose of melted snow without the formation of ice patches on the deck surface.

Once a plan is developed, discussions with the owner/operator of the parking structure regarding responsibility for snow and ice removal is recommended. Contracted services and/or in-house maintenance are the common options for accomplishing the removal. The developed procedures should be conveyed to the proper personnel so there is no confusion regarding removal procedures.

One-level parking structures may provide accessibility for snow equipment that is heavier than the support systems allow. It is very important that rigid enforcement restricting heavy equipment be maintained.

Once the structure is in use, planning should also occur prior to the snow and ice season. Having personnel, equipment, and deicing materials available must be setup before the season begins. A written procedure is necessary for successful snow and ice removal planning. Included in the written plan should be a checklist of pre-season preparations. The snow removal guidelines and maintenance log should be easily accessible. Records of previous years' operations can facilitate answering future questions that may arise.

Obstacles to snow and ice removal such as the structure's expansion joints, joint sealants, membranes, signage, lighting, and floor drains should be identified and emphasized to operations personnel. They must be made aware of potential damage that may be caused when removing snow and ice. Markers highlighting obstacles may be setup prior to the beginning of the winter season and then removed when the season is over.

Adequate drainage is a critical component of proper snow and ice removal. Prior to the arrival of freezing weather, water-ponding areas on the deck must be eliminated. Drains should be cleaned of debris. Water lines used for surface cleaning should be drained of all water to prevent freezing and breakage.

B. Equipment

Removing snow and ice is typically accomplished by using equipment especially designed for the operation. Determining the type of equipment to use affects operation and the longevity of the structure. For example, a pick-up truck with a plow may not be the right equipment to use for all jobs.

Snow removal equipment comes in many sizes, weights, and systems. The selection of this equipment along with its accessories will determine the efficiency of the snow and ice removal operation. The weight of the vehicle and type of attachments also impacts the amount, if any, of potential damage the structure may incur. Typically, parking structures are designed for 3000 lb wheel loads. Higher loads must be approved by a structural engineer. Plows and other snow removal implements that come in contact with the driving surface should have well-maintained rubber blades to minimize damage to the deck surface.

The right type of equipment for placing chemical deicers is also important. This equipment must be able to spread deicers properly, efficiently, and cost effectively.

C. Chemical deicers

The use of chemical deicers can affect the structure's efficiency, life safety, and longevity. Deicers must be chosen prudently because of their chemical potency, availability, and cost. Improper use of deicers may be deleterious to surfaces to which they are applied.

When using deicers, it is necessary to wash-down deck surfaces immediately following the winter season. The use of a high water volume from a 1¼ in. or larger hose is recommended. During the initial design phase, consideration for sufficient water to clean all surfaces (i.e., floor levels in addition to the roof level) contacted by deicers is important. It should be remembered that chemical deicers are also deposited by vehicles parking in the parking structure, so cleaning of all levels is important even if deicers were not directly applied to lower floor levels.

There are many types of chemicals deicers. Some, like chlorides, are relatively inexpensive but are much more harmful to the structure than ureas or calcium magnesium acetate. It is recommended that sodium or calcium chloride (rock salt) deicers not be used. Deicing chemicals should not be used until the parking structure is at least one year old.

Stairs, landings, and other areas of pedestrian egress must also be clear of snow and ice. Other chemicals with less corrosive potential to the concrete such as calcium magnesium acetate (CMA) are recommended.

Deicers can adversely affect the environment. State highway departments are now minimizing the use of sodium or calcium chloride because of the detrimental environmental effects.

D. Snow Removal Procedures

The following guidelines should be followed during the snow removal process.

1. Snow plow blades should not come in direct contact with expansion joints, deck membranes, or joint sealants. Blades should be kept a minimum of ½ in. above these sensitive materials. Blades should also not impact vertical offsets between adjacent deck surfaces. Plows must be equipped with well-maintained rubber blades to minimize impact damage.
2. Reduced equipment driving speed should be used at changes in floor slopes, such as the ends of ramps, washes (i.e., raised areas of the deck surface), at the ends of double tees, and at handicapped ramps.
3. Impact forces caused by pushing equipment or snow into walls or spandrels should be avoided. Additionally, impact forces applied to deck surfaces caused by dumping snow into storage piles should be avoided.

4. Avoid storing snow directly over floor drains.

5. Frozen chunks of snow or ice that have fallen from vehicles should be removed daily, along with all hanging icicle formations.

Conclusion

Keeping the parking structure free of snow and ice and removing corrosive deicing salts are essential for proper performance, long term durability, and public safety. Sufficient planning, selection of proper equipment and chemical deicers, and adherence to proper procedures are all necessary ingredients for the successful removal of snow and ice.

2.3 PREVENTION MAINTENANCE _____

Preventative maintenance involves a periodic checkup, cleaning, and restoration of all components including structural, architectural, and mechanical elements as well as equipment maintenance and safety systems. This type of maintenance prevents premature deterioration of the structure and unexpected failure of mechanical components. Minor problems discovered and corrected with preventative maintenance will prevent expensive future repairs.

The owner has basic control over the durability of a parking structure. If the owner chooses to invest in durability-enhancing features in the original construction, preventive maintenance and future repair costs will be smaller. Therefore, it is recommended that the owner, not the operator, be responsible for preventive maintenance.

Preventative maintenance should include a yearly checkup of structural, architectural, and mechanical components to verify proper performance. For the structural system, the checkup should include a visual inspection of all structural components, preferably by a structural engineer experienced in the design and construction of precast parking structures. Of particular importance in structural system maintenance is the drainage and sealants. Over time, poor performance of these elements can lead to serious structural problems. Equipment maintenance may be performed by the owner or operator in accordance with the manufacturer's recommendations. Revenue control equipment, life safety systems, elevators, and security systems are vital ingredients for maintaining the parking structure in proper working condition. Specifically, the annual checkup involves the following tasks:

A. Structural Systems Maintenance

- **Double Tee Floor Members:** *Visually inspect for delamination, spalling, cracking, and scaling. Check flange connections for weld failures or corrosion damage.*
- **Floor and Roof Deck Members:** *Visually inspect for spalling, cracking, and scaling. For field-applied cast-in-place toppings, also visually inspect for delamination. Check pretopped double tee flange connections for weld distress or corrosion damage.*
- **Beams, Columns, and Spandrels:** *Visually inspect for spalls, cracks, and/or delaminations.*
- **Stair and Elevator Towers:** *Check handrails, stair treads and land-*

ings, metal or precast stair members, walls, and roof for deterioration. Check concrete adjacent to handrails for signs of distress.

- **Exposed Steel:** Check for corrosion of bearing plates and welded connections. Check grouted connections for rust stains.
- **Bearing Pads:** Visually inspect all bearing pads for signs of distress.
- **Sealers and Deck Coatings:** Check for tears, abrasions, delaminations, and/or other deterioration.
- **Joint Sealants:** Check all joint sealants for signs of deterioration and leaks.
- **Expansion Joints:** Check for signs of deterioration.
- **Drainage:** Check for leaking, areas of inadequate drainage, and clogged drains. Check roof of stairs for leaks.
- **Cable Barriers:** Visually inspect for damage to anchorage points. Check tightness of cables.
- **Tripping Hazards:** Check curbs, stair thresholds, and floor surfaces for potential tripping hazards

B. Equipment Maintenance

- **Parking Access and Revenue Control Equipment:** Periodic checks of system components in accordance with Owner's Manual.
- **Lighting:** Periodic replacement of lamps, checking and calibration of timers and photocells, and visual inspection of conduits and electrical panels.
- **Exit and Emergency Lighting:** Check and replace exit lighting as necessary, periodically test battery pack emergency lighting system, and inspect emergency generator per manufacturer's recommendations.
- **Security Systems:** Periodic inspection of security equipment such as television surveillance cameras, audio monitoring devices, emergency phones, panic alarms, and panic hardware on doors.
- **Fire Protection Systems:** Periodic inspection of standpipes and sprinkler systems, as well as inspection of fire extinguishers, hoses, and cabinets.
- **Elevators:** Periodic system checks in accordance with manufacturer's recommendations and local ordinances.
- **Plumbing System:** Check drains, piping, and risers for blockage or other damage. Flush system annually for cleaning. Check heat-tracing elements for proper performance.
- **Ventilation Equipment:** Periodic inspection of fans, ductwork, and support systems per manufacturer's recommendations.
- **Snow Removal Equipment:** Annual check of gates, chutes, and heating elements.

Deficiencies or deterioration uncovered during the annual checkup should be addressed in a timely manner. Minor items may be addressed as part of preventive maintenance, while more serious deterioration or malfunction may need more detailed evaluation and specialized structural repairs.

C. Protective System Maintenance

In addition to a review of structural systems and mechanical equipment, the annual checkup should include a review of protective sys-

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tems. The following preventive maintenance procedure and schedule should keep the parking structure's protective system performing at a high level in order to minimize the intrusion of water and deicing salts into the concrete and to prevent future deterioration.

1. Semi-annually (annually for structures not within 15 miles of coastal sea water or in areas without deicing salt):

A. Flush all floor surfaces (use a fire hose or 1¼ in. hose or larger; garden hose water volumes are not sufficient). Where 1¼ in. hose pressure is not available, an outside pressure washer company should be engaged. Start from the roof and work down. In deicing salt areas, a spring flushing should be done immediately after the spring thaw. Flushing should be done with all drains protected by screens or burlap to prevent clogging. Care should be taken to avoid damage of sealants and coatings with high pressure water jets.

B. Inspect floor surfaces for excessive wear and cracking. An increase in the number and severity of cracks, or any other surface deterioration such as potholes, should be brought to the attention of a structural engineer familiar with precast construction.

Potholes should be patched and worn spots leveled with appropriate materials having compatible thermal expansion properties as the concrete. If reinforcing steel or steel plates are exposed in the pothole, the reinforcement should be cleaned of rust down to bright metal by sand blasting, hydro blasting, or power wire brushing. A qualified engineer should then specify patch materials and additional coatings.

Cracking should be noted during periodic inspections in order to ascertain whether cracks are "moving". Moving cracks will open and close as the structure contracts and expands through seasonal temperature changes. Such cracks are readily sealed with a two-part polyurethane or a silicone sealant after routing of the crack. A crack that extends through the deck surface is typically filled with epoxy if it is not moving. For aesthetic purposes, epoxy may be dusted with cement or grout to match the surrounding concrete.

Studies have shown that fine cracks (0.007 in. or less) are typically regarded as non-detrimental to the serviceability of the deck and have little influence on the corrosion process. This is due to the dense matrix of the concrete and the shal-



Drains not properly cleaned will cease to function and produce ponding, deterioration and costly repairs.

Clean drains prevent ponding of water and debris accumulation.

low depth of the crack. Also, studies have shown that where cracking is perpendicular to the reinforcement the possibility of corrosion is greatly diminished. The presence of an applied penetrating silane sealer, typical on many deck surfaces, creates a thin hydrophobic protective layer on the surface and provides additional protection against possible corrosion. It should be noted that reapplication is required periodically and manufacturer's recommendations must always be followed.

- C. Inspect floor expansion and control joints for deterioration, wear, and/or abuse (from snow plows and other cleaning equipment). Repair as required. Expansion joints are particularly susceptible to snow plow damage. Many expansion joint manufacturers void their warranties unless the snowplow is lifted over the expansion joint. Even those that allow plowing over the expansion joint require the blade to be perpendicular to the joint only. Each manufacturer has specific requirements that should be followed.
- D. Inspect and clean floor drains, repair downspouts, and remove barriers that prevent proper water flow to drains. Cleaning should include removal of drain grates and cleaning of pipes at bends and joints.
- E. Elastomeric traffic-bearing membranes should be patched when visual inspection indicates ripping, tearing, bubbling, and/or excessive wear. Discoloration is often an early sign that the membrane is approaching the end of its useful life.

2. Annually (Spring)

A. Inspect structural connections

Most structural connections between precast concrete members will not require maintenance during the life of the structure. However, the following types of connections should be monitored and periodically maintained:

Recessed Connections

It is common practice for welded connections between members to be recessed and covered with a cement grout to conceal and protect the connection plates. If the thermal properties of the protection layer vary from those of the base concrete, cracks may form over time at the edges of the recess.



Recessed connections may need periodic maintenance.

Protection over connections should be crack free.

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The following procedures should be used to properly maintain recessed connections:

Condition	Procedure
1.) Minor cracking at edge of recess; Grout material sound	Seal cracks with sealant or epoxy.
2.) Cracking and spalling of grout cover for recessed connections.	Remove grout. Inspect connection plates. If corrosion has started, clean and coat plates with zinc rich paint. Re-grout recess with non-shrink grout. Tool and seal all-around the grouted area.
3.) Cracking in members and or welds between members.	Inspection by a registered Structural engineer familiar with precast concrete behavior.

Bolted Connections

Bolted connections are often used between precast concrete members. A common example is the connection between precast spandrels and precast columns. After installation, these connections are typically filled with grout or a plastic cap and access is limited. If signs of water penetration are present at this access location, the connection should be checked for signs of corrosion and properly sealed. Also, where accessible, connections should be inspected for proper engagement of the nut.

Slotted Connections

In areas where allowance for vertical or lateral movement must be provided, slotted connections are often utilized. Where accessible, these connections should be inspected for signs of corrosion, proper engagement, and any signs of distress. Also, debris may accumulate around the portion of the connection that allows movement. This debris should be removed/cleaned during the inspection process.

- B. Inspect joint sealant and repair as required. Typically, water leakage through the joint, visible separation of the sealant from the concrete, cracking or tearing of the sealant indicates the need for replacement. Replacement is only required where failure has occurred.

Several types of joint sealants are available for precast concrete decks. Polyurethane is the most common joint sealant material; however, silicones are becoming more popular due to their longer service life. Silicones should always be used to replace existing silicone sealants.

Installation procedures and specifications are dependent on the sealant material and manufacturer. It is recommended that an experienced professional installer be retained for surface preparation and installation of joint sealants. Critical issues to consider in sealant installation include:

- 1.) Sealants should be installed at average seasonal temperatures

and not during extremes of heat or cold.

- 2.) Sealant depth should be a minimum of $\frac{3}{8}$ in. The width-to-depth ratio of the sealant should ideally be 2.0, but may vary between 1.0 and 3.0. Special precautions may be required at very large or narrow joints. Manufacturer's specifications should be followed for specific sealants.
- 3.) Backer rods and bond breakers should be used to shape the sealant and prevent bonding at the sealant bottom.
- 4.) Joint preparation is critical in sealant performance. Joints must be clean and free of defects such as spalls and damaged areas. Grind, clean and prime concrete surfaces coming in contact with sealants. Grind all surfaces which have the potential to create a joint failure such as sharp edges exposed to wheel pressure.

C. Inspect all elastomeric bearing pads. The function of a bearing pad is to distribute load between two structural elements and allow horizontal and rotational movements to occur through deformation of the pad. Typically, pads are functioning if direct contact between the structural elements has not occurred and a majority of the pad area is transferring load. If cracking has occurred in the pad or in the adjacent bearing surface, or if the pad is not in its proper position, an engineer should be consulted.

D. Inspect mortar joints, remove loose mortar, and repair with new mortar or sealant. Extensive or recurring mortar failure may signify an underlying problem that should be evaluated by an experienced engineer.

E. Clean and coat unprotected steel or corroded areas with corrosion-inhibiting paint. Repaint large areas as required to cover graffiti or to restore the surface finish. Surface preparation is critical when painting any surface. The service life of a coating can be substantially reduced by inadequate surface preparation. Surface preparation should include removal of oils, dirt, salts, rust, loose paint, and contaminants by solvent cleaning, hand or power brushing, or by blast cleaning. Surface preparation specifications by The Society for Protective Coatings provide additional painting guidelines which should be followed.

4. Periodic Maintenance

A. If a surface sealer such as polyurethane, epoxy or other sealing material was applied during construction as a floor surface water repellent, it should be reapplied every four to five years or as specified by the manufacturer allow space. Areas of abrasion such as turns and acceleration areas may require reapplication more often.

B. If a penetrating silane or siloxane sealer was applied, it should be reapplied every seven to ten years with reapplication more often in high abrasion areas.

C. Traffic bearing membranes have a limited life. They should be inspected twice a year, repaired as required and planned to be recoated and replaced at least every 20 years.

D. Metallic electrical conduit (EMT) exposed to water leaks can corrode. Periodic painting may extend its life. If damaged, conduit should be immediately repaired and all water leaks corrected.

E. Table B shows an inspection schedule for other elements of

parking structures. Also, refer to Table A.

- a. Doors and Hardware
- b. Metal Stair Treads
- c. Elevators
- d. Painting
- e. Plumbing System
- f. HVAC System
- g. Electrical System
- h. Landscaping
- i. Parking Operating Equipment
- j. Roofing and Flashing
- k. Signs (Graphics)

2.4 STRUCTURAL REPAIRS

Even the best maintained parking structures may require some structural repairs during their service life. Parking structures are subject to harsh environmental exposure, dynamic loading conditions, extreme temperature variations, and destructive chemical attacks from de-icing materials. If required, structural repairs must be designed and specified by a structural engineer experienced in parking structure repair techniques. Repairs that may be required for older precast structures include the following:

- **Concrete Deterioration –**

More common in cast-in-place portions of the structure such as field placed toppings and pour strips than in precast concrete components. Deterioration mechanisms include:

Scaling: The shallow disintegration of cement paste at the concrete surface. Usually associated with freeze-thaw cycles, scaling produces an unsightly rough surface that poses a tripping hazard and recesses for water ponding. Repairing with a surface overlay or topping is common.

Spalling: Fracturing of the outer surface of concrete from rebar corrosion or isolated impact loads. Spalls tend to have a surface area of several inches and depths of 1 in. or more. Repairing of spalled areas should include a structural assessment to determine the cause of the spall along with a specification of proper repair materials that are compatible with the base concrete properties.

Cracking: Well distributed fine cracks are typical and normal for non-prestressed concrete elements. A typical cracking can occur from mishandling precast units, improper placement, finishing or curing of cast-in-place toppings, thermal movements, corrosion of embedded metal, structural overload, or from foundation settlement.

Minor non-moving cracks in deck surfaces are non-

structural and need only a surface seal to prevent water intrusion. (See Section 2.3, Section C, Paragraph B.)

Structural cracking requires an engineering appraisal to determine the origin of structural degradation and proper repair specifications.

Delaminations: Fractures which occur below and parallel to a concrete surface. In precast parking structures, these typically occur in field placed toppings due to corrosion of reinforcing steel or due to improper placement (surface preparation) of the cast-in-place topping. Extensive delamination requires engineering evaluation and significant remedial repair to stop the deterioration process.

- **Expansion Joints –**

Expansion joints are typically installed on structures with lengths greater than 300 ft, structures with irregular shapes, or to isolate stair and elevator towers. Their purpose is to limit the build-up of stresses in structural members or connections due to volume change movements created by seasonal temperature variations and customary drying-shrinkage of concrete. Expansion joints work by providing a flexible link between two separate portions of the structure. Typical movements will range from 1 to 3 in. which can be accommodated by a variety of joint styles and brands.

When expansion joints deteriorate or malfunction, water leakage through the joints may lead to deterioration of the concrete structure. Frequent monitoring, cleaning and repair of local damage will extend service life, but frequent problems require a specialist to evaluate and resolve.

- **Connection Distress –**

Thermal movements or structural overload can occasionally create cracking or distress in connections between precast members. Connections, which can consist of welded plates, bolted plates, bolts through members or bearing pads between members serve a variety of functions during and after construction of the structure. For this reason, it is recommended that an experienced engineer familiar with precast concrete construction investigate any sign of connection distress.

2.5 PERIODIC STRUCTURAL AUDIT _____

While most aspects of the preventive maintenance program of Section 2.3 are not performed by an engineer, it is prudent for the parking structure owner to periodically retain an engineer experienced in precast concrete design and restoration to perform a structural audit. An engineer with experience in restoration of parking structures will see potential problems that may not be apparent to an inexperienced or untrained person. For example, using an asphalt wearing course, without an underlying waterproof membrane, can actually accelerate the deterioration of a parking structure slab. Many problems can be easily treated when they are discovered in a timely fashion. Early detection of rebar corrosion which causes deterioration cannot occur

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through a visual inspection alone. Only experienced personnel with the proper testing equipment can detect corrosion of unseen rebar before cracking or delamination occurs.

A reasonable structural condition audit interval would be three or four years, with shorter intervals (preferably annually) for parking structures older than ten years or in locations that have large seasonal temperature changes or for structures that have undergone prior structural repairs or rehabilitation.

The first structural audit should occur immediately upon the completion of construction. Ideally, the precast engineer, the structural engineer of record, the general contractor/construction manager, and the third party inspector should perform this audit. It is essential to obtain a baseline audit to determine whether the precast parking structure has been properly constructed and to identify any initial areas of concern. The initial audit should produce a file which contains all of the precast drawings and details. The file should also include documentation of all field repairs and any deviations from the design drawings. The initial audit should include photos and sketches of any areas of concern, recognizing that any conditions which do not meet applicable design criteria and codes must be corrected. This file should be maintained by the owner and provided to subsequent Auditors. It should also be transferred to new owners if the parking structure is sold. The engineer performing subsequent Structural Audits should be provided with the Audit File. (See Section 3.0 on documentation and planning.) All areas of past concern should be checked and recorded with photographs, measurements, detailed notes and other appropriate information.

The Periodic Structural Audit should, as a minimum, include visual inspection of the items listed in Section 2.3 as well as:

- **Bearing Regions** – *Check for cracking, bearing pad performance and adequate bearing area.*
- **Ledges, Pockets and Daps** – *Inspect for cracking, spalling and deterioration.*
- **Connection Protection Areas** – *Inspect for cracking and spalling.*
- **Deck Flange-to-Flange** – *Check welds and concrete for distress.*
- **Grouted Joints** – *Inspect for soundness and deterioration.*
- **Topping and Pour Strip Conditions** – *Check for delaminations, cracking and ponding.*
- **Double Tee Joint Sealants** – *Inspect sealant for condition and adhesion and signs of leakage.*
- **Expansion Joints** – *Inspect integrity and load transfer mechanism and signs of leakage.*
- **Chloride and Rebar** – *Test for chloride concentration levels and rebar corrosion rates.*

The development of a maintenance program should include the documentation and recording of materials, systems, and past procedures used in the construction and maintenance of a facility. Although these documents do not affect the performance of the structure they are beneficial for planning, scheduling and developing repair procedures. Significant cost savings can be achieved by knowing original durability, specifications, manufacturer's maintenance procedures and internal reinforcing of structural members.

Ideally, an indexed system containing the following documents should be created and stored electronically or otherwise:

1. Construction documents
 - a. Architectural Drawings
 - b. Structural/Civil Drawings
 - c. Mechanical, Electrical, Plumbing Drawings
 - d. Design Specifications
 - e. Precast concrete production and erection drawings
 - f. Part drawings for plate assemblies embedded in precast concrete members
 - g. Design drawings for specialized manufactured products such as elevators, lighting and mechanical systems
2. Record of modifications or changes to the original construction documents (typically referred to as an "as built" set of construction documents)
3. A catalogue of all equipment and specialty materials, such as sealants and coatings, with manufacturer's service manuals and warranties
4. Record of all previous maintenance and repair procedures

This documentation will be developed at the end of initial construction. For parking structures which have been in service without a maintenance program, a condition survey by a professional engineer can be conducted to establish and document the condition of the structure at the start of the program.

After all documentation has been gathered, a maintenance program can be developed for a specific structure. Assistance from the original design team should be obtained to develop the program since original construction materials and details will influence maintenance procedures. For example, stainless steel or galvanized materials will require little or no maintenance, while painted exposed surfaces will need standard periodic work. Maintenance on mechanical equipment such as elevators and ticket dispensers will be dependent on manufacturer's recommendations and scheduling, which the original design team should be familiar with.

A specific maintenance program should include:

1. Establishment of a maintenance budget.

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2. Assignment of personnel to implement the program.
3. A schedule of cleaning, inspections, painting, lubrication and other maintenance activities.
4. Recording procedure to log maintenance activity.
5. A management control system to oversee and administer the program.

Periodic assessment of the program is also essential to account for budget changes, personnel changes, age of the structure and to review previous procedures.

TABLE A Housekeeping Schedule	Daily	Weekly	Monthly	Quarterly	Semi Annually	Annually	As Required	Other
Sweeping								
Localized	*							
Overall		*						
Trash Pickup	*							
Control Joint Cleaning					*			
Expansion Joint Cleaning		*						
Elevator Cleaning	*							
Elevator Maintenance					*			
Window Cleaning								
Stain Cleaning		*						
Parking Space Restriping			O				*	
Remove Oil Stains	O						*	
Relamping	O	*						
Check Light Fixtures and Exposed Conduit and Repair			O				*	
Light Fixture Cleaning						*		
Floor Drain Cleaning		O			*			
Lavatory, Office, Waiting Room, Janitorial Service, Cashier Booths	*							
Graffiti Removal		*						
Graphics Cleaning						*		
Graphics Repair & Maintenance								
Non-Illuminated				O			*	
Illuminated	O						*	
Parking Equipment Maintenance	O						*	
Security System Check	*							
Landscaping		*						
Doors & Hardware	*							
Ventilation	O							
Snow Removal	*						*	
Ice Removal	O						*	
Safety checks	O						*	
Carbon Monoxide Monitor	O						*	(3)
Exit Lights	O						*	
Emergency Lights	O						*	
Tripping Hazards	O						*	
Handrails & Guardrails							*	
Control Joint Cleaning		O			*			

O = Inspect

* = Perform Operation

TABLE B Preventive Maintenance Schedule Inspect and Repair as Necessary	Daily	Weekly	Monthly	Quarterly	Semi Annually	Annually	As Required	Other
Floor Washdowns					*			(1)
Floor Potholes & Cracking		O			*			
Scaling		O			*			
Expansion Joints					*			
Joint Sealants						*		
Bearing Pads						O	*	
Rust (Exposed Steel)				O		*		
Repaint			O				*	
Drain Water Systems for Winter						O		
Floor Surface Sealer								(2)
Stair Repair	O						*	
Plumbing		O				*		
HVAC Equipment			O				*	(3)
Fire Protection Systems			O				*	
Floor Drains		O			*			
Check Sanitary Facilities Operation	*							
Roofing & Flashing			O			*		
Floor Membranes			O				*	
Check for Water Leakage		O						
Check for Rusting Concrete Reinforcement		O						
Inspect Mortar Joints and Repair						O	*	
Inspect and Repair Concrete Cracks					O		*	

O = Inspect

* = Perform Operation

Notes:

(1) Minimum twice, per year (spring and fall) in snow or coastal regions, otherwise minimum once per year.

(2) Surface sealer (three to five years), Penetrating sealer (seven to ten years more often in abrasive areas).

(3) Daily enclosed garage (warning to management office recommended).

(4) For additional notes, see text.

(5) Tables utilize information in part from the National Parking Association Consultants Council "Parking Garage Maintenance Manual."

WEEKLY MAINTENANCE REPORTS
STRUCTURE NAME: _____

WEEK START DATE: _____ WEEKEND DATE: _____

Activity	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Area	Comments	Performed by
CLEANING										
1	Localized sweeping									
2	Trash									
3	Toilets									
4	Cashier booth									
5	Lobby, Office									
6	Floor drains									
7	Remove snow & ice									

OPERATION CHECK

	Hand doors									
	Mechanical doors									
	Sanitary facilities									
	Lights									
	Elevators									
	Elevator lights									
	Emergency lights									
	Pkg. control equip.									
	Security system									
	Close circuit TV									
	Audio surveillance									
	Panic buttons									
	Stair door alarms									

SIGN CHECK

	In place									
	Clean									
	Illuminated									
	Visible									

Non working items _____

MONTHLY MAINTENANCE REPORT

Structure Name: _____

For the month of: _____

Activity	Date performed	Location	Performed by	Comments
----------	----------------	----------	--------------	----------

Floor sweeping				
----------------	--	--	--	--

LANDSCAPE

Trash removal				
Maintenance				

Wall cleaning				
---------------	--	--	--	--

Window cleaning				
-----------------	--	--	--	--

HAVAC system check				
--------------------	--	--	--	--

Touch-up paint				
----------------	--	--	--	--

Lubricate doors				
-----------------	--	--	--	--

Sump pump check				
-----------------	--	--	--	--

Check for Leaks:

Roofing				
Joint sealant				
Expansion joints				
Windows, doors, walls				
Floor membrane areas				
Clean expansion joints				
Check handrails & guardrails				
Clean signs				

Non-working items: _____

SEMI ANNUAL MAINTENANCE REPORT

Structure Name: _____

Season: _____

Maintenance Record Check List

Activity	Date	Location	Performed by	Comments
----------	------	----------	--------------	----------

Check Structural System:

Floor surface deterioration				
-----------------------------	--	--	--	--

Water leakage				
---------------	--	--	--	--

Cracking of concrete				
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Rust				
------	--	--	--	--

PAINTING

Check for Rust Spots:

Doors & door frames				
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Handrails & guardrails				
------------------------	--	--	--	--

Pipe guards, exposed pipes & conduit				
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Other metal				
-------------	--	--	--	--

Check for Appearance:

Striping				
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Signs				
-------	--	--	--	--

Walls				
-------	--	--	--	--

Curbs				
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Touch-up paint				
----------------	--	--	--	--

Repaint				
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Check Electrical System:

Check light fixtures				
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Relamp fixtures				
-----------------	--	--	--	--

Special units – inspect				
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Distribution panels				
---------------------	--	--	--	--

Wash down deck				
----------------	--	--	--	--

Items requiring further attention: _____

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