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Rx for Parking Garage Maintenance and Repair:

Treating the Causes Rather Than the Symptoms

John J. Hoffmann, AIA

The first line of defense against parking structure corrosion is proper design and construction. Because parking garages receive a great deal of exposure to de-icing salts, they must be constructed of concrete that resists chloride ion intrusion.

To protect the owner's investment, every parking structure, regardless of age and type of construction, requires a comprehensive preventive maintenance program. Owners and managers who invest in proper design, construction and maintenance can prevent most problems before they occur.

It is important to investigate and correct problems caused by weathering, substandard or improper material, poor workmanship, structural movement and stress before more serious, irreversible damage can occur.

Most parking structure problems result from steel reinforcement in the concrete being exposed to the chlorides in salts. As a result of this exposure, the steel rusts and swells, causing the concrete to deteriorate.

Photo / Conley Clarke, *The Construction Specifier*

Installation of new rebar became necessary after concrete deterioration led to exposure and corrosion of reinforcing steel in this concrete structure.

An authority on the rehabilitation of existing buildings and parking structures, Mr. Hoffmann is Principal and Founder of Hoffmann Architects.

Pinpointing and correcting such problems early can reverse the rust/crack/rust cycle that would otherwise result in an unsafe structure.

Walk-Through Survey

The first step in any well planned maintenance program is a regularly scheduled walk-through survey, a visual inspection of the entire garage.

During this survey, the location and extent of conditions causing concrete or steel deterioration should be observed, including:

- Surface deterioration on the top and bottom surfaces of the floor systems.
- Evidence of water leakage and/or staining through or on floors, walls or other structural elements.
- Cracks in floors, beams, columns and walls.
- Rusting of exposed steel.

Comprehensive Investigation

Parking garages should be inspected at least once every two years by an expert in parking structure design and restoration to be sure that no potentially serious conditions have been overlooked.

A review of the survey results may indicate the need for a more comprehensive investigation including testing for subsurface fractures and delamina-

tions and/or deicing salt contamination. Despite the most thorough investigation, some hidden deterioration may be revealed only after the start of repair work.

Deterioration of parking structures due to deicing and ocean salts is a complex electrochemical phenomenon which requires expert evaluation. Some remedial actions, such as overlaying a slab with an asphalt wearing course without an underlying waterproof membrane, can actually accelerate the deterioration of a parking structure slab.

Preventive Maintenance

All parking structures, even those in excellent condition, require a comprehensive preventive maintenance program to protect against deterioration and the need for costly repairs.

Such a preventive maintenance program should include regular performance of the following tasks:

- Flush/wash down all floor surfaces
- Seal cracks
- Maintain membrane coatings
- Reapply floor sealers
- Maintain sealants (caulking).

Repair Options and Strategies

A number of techniques are available for repairing and protecting concrete parking garages, but no single approach will work all the time. A flexible approach, utilizing the advantages of one system to offset the deficiencies of another, is the best way to prevent corrosion.

Factors in choosing a repair option include the owner's plans for the facility, the extent and severity of damage, the structural system of the garage, conditions to which the slabs are exposed, time and budget constraints. Life cycle costing should be used to determine which repair system is most cost effective. The high initial cost of an expensive waterproofing system can prove less costly in the long run than protection with an inexpensive sealer.

Repairs may include patching of potholes; floor slab overlays; removal and replacement of concrete; restoration of reinforcing steel; replacement of expansion joints and/or bearing pads. These repairs are often necessary because of the lack of a comprehensive preventive maintenance program.

Repair Methods and Techniques

Repairs to scaled and spalled areas must be undertaken with care. Improper repairs hide, but do not cure, the problem. An example is an asphalt patch over a spall. Asphalt is porous and will permit salt-laden water to collect unseen at the bottom of the spall. If the steel is exposed there, the salt water will attack it, and the resulting corrosion of the steel and weakening of the floor will become visible only after the corroding steel has caused a larger spall.

Patching is a generally effective repair for isolated spalls. A good patch must be durable and watertight; it must also bond well to the concrete substrate. Patch edges should not be feathered. The patch must also react to temperature changes in the same way that concrete does and must be compatible with it.

When the total area to be patched is a significant part of the floor area, an overlay of the top surface may become more cost effective than isolated patches. An overlay can also modify floor gradients to improve drainage and eliminate ponding. Overlays will add thickness to the original floor system and increase the structure weight (dead load). Headroom will be less than what was originally designed.

To be sure that the new concrete will last, there are three options for inhibiting corrosion:

- *Waterproofing Membrane*
  An elastomeric membrane provides positive protection from water entry and will bridge small shrinkage cracks.

- *Sealer*
  A sealer is a liquid applied to protect and preserve concrete by filling the pores and sealing the surface against moisture and salt penetration. A quality material, properly applied and renewed periodically, will also provide supplemental protection against freeze/thaw damage and wear.

- *Cathodic Protection*
  Cathodic protection involves running a small, low-voltage electric current through the reinforcing bars. The current reverses the flow of chloride ions away from the steel, inhibiting corrosion.

Conclusion

In summary, each strategy for reducing the risk of chloride-induced corrosion in parking structures has advantages and disadvantages. Each requires proper design and installation to work. Each costs money to implement, but the expense and inconvenience of preventing corrosion in a parking garage are far less than those of rehabilitating the structure when it fails.

The best defense against extensive parking structure deterioration and the high costs of reconstruction is a comprehensive maintenance program designed to prevent problems before they occur. ■

Parking Structure Inspection Checklist

Inspected by _____ Date _____

Name of Structure _____

Address _____

Owner _____

Construction Type _____

Age of Structure _____

Approximate Square Footage _____

Number of Levels _____ Vehicle Capacity _____

Overhead Clearance _____

Usage (Light, Moderate, Heavy) _____

Previous Repairs _____ Type _____ Location _____

Instructions

This checklist is designed for use in quick, walk-through surveys of existing parking structures. It is not intended for thorough, in-depth investigations.

Each level of the parking garage should be surveyed separately, with observations for each level recorded on a separate copy of the checklist.

Conditions to be Checked

Fissures resulting in moisture and chloride entry into concrete.

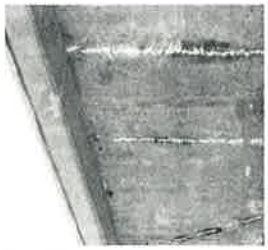
Cracking

Loss of surface of concrete caused by freeze-thaw cycle and inadequate air entrainment.

Scaling

Potholes resulting from corrosion induced stress.

Spalling



Water migration through concrete slab leading to corrosion of reinforcing steel and spalling of concrete.

Leaching

Tell-tale signs including ponding, staining and damage to floor below.

Leaking

Condition caused by concrete deterioration resulting in corrosion of reinforcing steel.

Exposed Reinforcing Steel

Courtesy / The Western Group (Western Waterproofing, Inc. and Brisk Waterproofing Company, Inc.)

Level

	Problems major	minor	none	Locations	Comments
I. Concrete Slab					
A. **Floor** (Top of Slab)					
Concrete					
Cracking					
Scaling					
Spalling/Delamination					
Potholes					
Leaching					
Water Stains					
Unevenness of deck					
Structural/Reinforcing Steel					
Exposed Rebars					
Corrosion					
Slab Protection					
Membrane					
Sealer					
B. **Ceiling** (Underside of Slab)					
Concrete					
Cracking					
Scaling					
Spalling/Delamination					
Leaching					
Water Stains					
Structural/Reinforcing Steel					
Exposed Rebars					
Corrosion					
II. Expansion Joints/Control Joints					
A. Freeze/Thaw Damage					
B. Damage from Traffic or Snow Plows					
C. Joint Failure					
D. Bearing Pads					
III. Drainage					
A. Floor Drains					
B. Ponding					
IV. Beams and Girders					
A. Concrete					
Cracking					
Horizontal					
Vertical					
Diagonal					
Scaling					
Spalling/Delamination					
Leaching					
Water Stains					

	Problems major	minor	none	Locations	Comments
B. Structural/Reinforcing Steel					
Exposed Rebars					
Corrosion					

V. Support Columns

A. Concrete					
Cracking					
Scaling					
Spalling/Delamination					
Leaching					
Water Stains					
B. Structural/Reinforcing Steel					
Exposed Rebars					
Corrosion					
C. Out-of-Plumb					

VI. Walls

A. Concrete					
Cracking					
Horizontal					
Vertical					
Diagonal					
Scaling					
Spalling/Delamination					
Leaching					
Water Stains					
Sealants					
B. Structural/Reinforcing Steel					
Exposed Rebars					
Corrosion					
C. Out-of-Plumb					

VII. Spandrels and Guard Rails

A. Concrete					
Cracking					
Scaling					
Spalling/Delamination					
Leaching					
Water Stains					
Sealants					
B. Structural/Reinforcing Steel					
Exposed Rebars					
Corrosion					
C. Out-of-Plumb					

The Facility Manager's Bookshelf: Concrete Parking Garages

A. American Concrete Institute
P.O. Box 19150
Detroit, MI 48219-0150
(313) 532-2600 (for inquiries, not orders)

Michigan residents add 4% sales tax.

1. ***Corrosion, Concrete, and Chlorides,*** SP-102 (1987). Soft cover, 175 pages. $41.95.
2. ***Design of Concrete Parking Structures,*** SCM12-86 (1986). $48.95.
3. ***Guide for Making a Condition Survey of Concrete in Service,*** 201.1R-68 (84) (Revised 1984). $11.25.
4. ***Guide to Joint Sealants for Concrete Structures,*** 504R-90 (1990). $43.75.
5. ***Long-term Serviceability of Concrete Structures,*** SP-117 (1989), 293 pages. $49.50.
6. ***Repair and Rehabilitation of Concrete Structures,*** ACI Compilation No. 10 (1990), 92 pages. $19.95.

B. Construction Specifications Institute
Specifier Reprints
601 Madison Street
Alexandria, VA 22314-1791
(703) 684-0300

Cost: $4 each, $10 minimum. VA residents add 4.5% tax.

1. Brainerd, Michael L. "Evaluation and Rehabilitation of Deteriorated Parking Decks." ***The Construction Specifier,*** December 1989, pp. 66–74 (Vol. 42 No. 12).
2. Meyers, Martin. "Applications in Reinforced Concrete Repair." ***The Construction Specifier,*** December 1990, pp. 76–82 (Vol. 43 No. 12).
3. O'Connor, Jerome P. and Thomas R. Kline. "Case Studies in Concrete Repair Technology." ***The Construction Specifier,*** December 1990, pp. 84–93 (Vol. 43 No. 12).

C. Prestressed Concrete Institute
175 W. Jackson Boulevard
Chicago, IL 60604
(312) 786-0300

1. "Parking Structures: Recommended Practice for Design and Construction" (1988).
2. "Survey of Precast Prestressed Concrete Parking Structures" R&D-7. $24.00. ■

Compiled by Alan Eddy, Technical Librarian

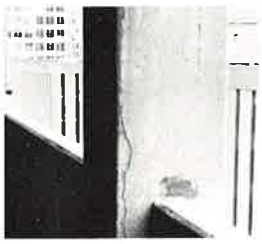
Structural Elements to be Checked

Check floors and ceilings for normal wear, initial and advanced deterioration.

Concrete Slabs

Conduct visual survey to detect exposure and corrosion of reinforcing steel.

Concrete Beams



Examine for signs of cracking or stress.

Support Columns

Check for obstruction causing water to pond and possibly leach through concrete slabs.

Drains

Check for joint failure or damage from traffic or snow plows.

Expansion and Construction Joints

Courtesy / The Western Group (Western Waterproofing, Inc. and Brisk Waterproofing Company, Inc.)

REPRESENTATIVE PROJECTS

Parking Garage Rehabilitation

Hoffmann Architects specializes in the rehabilitation of the exteriors of existing facilities.

A major portion of the firm's practice involves the diagnosis and solution of deterioration and water infiltration problems within corporate and institutional parking structures.

Based on a parking structure's individual characteristics, the interaction of its various components, the type and extent of deterioration, life cycle costs and budget constraints, project managers resolve deterioration and water infiltration problems before more serious, irreversible damage can occur.

The firm investigates existing conditions, prepares construction documents, and administers construction contracts for rehabilitation of existing buildings and parking garages.

Hoffmann Architects has provided parking garage rehabilitation and waterproofing services for major corporate and institutional facilities including:

Temple Street Garage
New Haven, Connecticut
(City of New Haven)

Bell Laboratories Garage
Short Hills, New Jersey
(Prudential Insurance Company of America)

Designed by Paul Rudolph, 1961

Temple Street Garage in downtown New Haven, Connecticut.

One Champion Plaza Garage
Stamford, Connecticut
(Champion International Corporation)

One Strawberry Hill Road Garage
Stamford, Connecticut
(Strawberry Hill Condominium Association)

White Plains Plaza Garage
White Plains, New York
(Prudential Insurance Company of America)

132nd Street Parking Garage
New York, New York
(New York Telephone Company)

Buckingham Condominium Garage
Stamford, Connecticut
(Buckingham Condominium Association)

Norwalk Central Office
Norwalk, Connecticut
(Southern New England Telephone)

222 Bloomingdale Road Garage
White Plains, New York
(NYNEX Properties Company)

Atria Complex Garage
Garden City, New York
(Chase Manhattan Bank, N.A.)

Norstar Bank Garage
Albany, New York
(Theodore Nelson, P.E.)

600 Steamboat Road Garage
Greenwich, Connecticut
(General Reinsurance Corporation)

Williams Center Parking Garage
Tucson, Arizona
(Hartford Insurance Group)

129th Street Garage
New York, New York
(New York Telephone Company)

Midwest Plaza Garage
Minneapolis, Minnesota
(Goldman, Sachs & Company)

777 Long Hill Road Garage
Stamford, Connecticut
(Tishman Speyer Properties)

Union Carbide Corporation
Danbury, Connecticut
(Union Carbide Corporation) ■

Hoffmann Architects Study of U.S. Capitol Dome Wins NERC/AIA Award

The New England Regional Council/ American Institute of Architects honored Hoffmann Architects with a 1991 NERC/AIA Design Award for its Water Penetration Study—Dome of the United States Capitol, Washington DC.

Hoffmann Architects collaborated with The Architect of the Capitol on the comprehensive study of the U.S. Capitol Dome where moisture intrusion created problems for the structure and for its inhabitants, the United States Congress.

Designed by Thomas U. Walter, the Dome was constructed during the Civil War and completed in 1865. Built entirely of cast iron, it rests on the masonry wall of the original rotunda which was completed in 1824.

The Hoffmann Architects study is only the second such review commissioned in the dome's 125 year history.

For the Dome of the United States Capitol, the firm:

- Conducted on site investigations of existing conditions.
- Assessed all relevant drainage systems in terms of capacity, overall design, details and installation.
- Reviewed original construction documents.
- Submitted comprehensive report documenting existing conditions, recommending appropriate corrective action, evaluating causes of problems, and presenting opinion of probable construction costs.
- Developed preliminary design.
- Recommended complete rehabilitation of the dome, similar in scope to that done over thirty years ago.
- Currently is preparing construction documents for maintenance access, interior gutter and drainage system modifications.

Members of the project team include John J. Hoffmann, AIA, Theodore F. Babbitt, AIA, Robert E. Hale, and Arthur L. Sanders, CSI. ■

JOURNAL is a publication of Hoffmann Architects, specialists in investigative and rehabilitative architecture/engineering, including the analysis and solution of problems within roofs, exterior walls, glazing and structural systems of existing buildings, plazas and parking garages.

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