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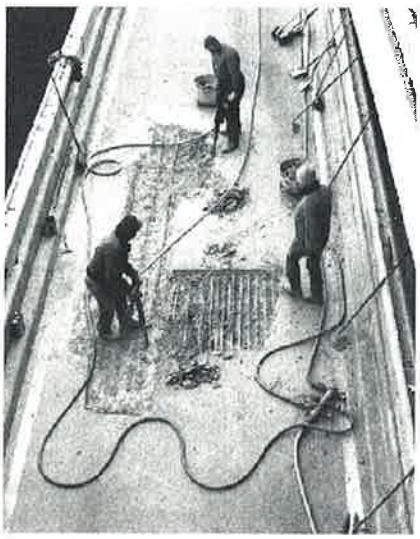
Preserving Parking Decks: A Guide to Surface Treatments

Bruce R. Soden and Scott D. Chamberlain

Ah, the lowly parking garage. Seldom glamorous, strictly utilitarian, and too often shuffled off like some poor second cousin when maintenance budget dollars are being handed around. And all quite undeservedly so. In fact, many buildings couldn't exist without the vital parking function and structural support provided by these facilities.



Workers prepare access ramp surface to receive an elastomeric coating as part of a major parking deck recoating project.

Unfortunately, parking garages require regular, ongoing care, perhaps more than other building types. That's because these facilities suffer the full force of the elements — inside and out — year-round. Add to that the damaging effects of inadequate maintenance, constant traffic, and the corrosive impact of acid rain and de-icing salts. It's no wonder that a record number of parking garages in this country are suffering from some level of deterioration, from minor cracking and spalling to imminent structural failure. No matter how well designed and constructed, no facility can hold up to this ongoing abuse without some help in the form of proper maintenance and timely repair. (Please see the related article, "The Source of Steel Corrosion", on page 6.)

Mr. Soden and Mr. Chamberlain serve as Project Managers for Hoffmann Architects. They have been extensively involved in numerous parking garage rehabilitation and recoating projects for the firm.

Maintenance and repair solutions can range from simple patching of small cracks and spalls to major demolition and replacement of decks and structural members. The most common maintenance technique, however, is recoating or sealing of the parking deck to protect new decks from corrosion and limit ongoing deterioration in existing structures. For these situations, penetrating sealers and elastomeric deck membranes are economical and effective treatments.

Choosing the Right Solution

The ultimate goal of both sealers and membranes is to prevent water from seeping through the concrete to attack and corrode the structural and reinforcing steel below. Each treatment approach offers distinct advantages — and limitations. A knowledgeable architect or engineer can determine the best solution for a specific facility by evaluating the extent and severity of damage and weighing that against the structure's life-cycle costs.

Penetrating Sealers

Penetrating sealers work by closing off the pores in the concrete, thus slowing or stopping the entry of water-borne chloride ions into the concrete. These liquid applications are low-cost solutions, but have several drawbacks.

One limitation is their relatively low abrasion resistance, due primarily to the thin (2 - 4 mils) layers of application. Re-application is usually required every few years to maintain adequate protection. Their most limiting quality,

Typical Performance Properties of Elastomeric Membranes

Property	Measuring Standards and Conditions	Results		
		Base Coat	Intermediate Coat VOC and Non-VOC	Top Coat VOC and Non-VOC
Hardness[1] (indentation)	ASTM D 2240 Rex Type A model 1700	60 - 80	74 -80	VOC - 90 Non-VOC 75 - 95
Tensile Strength	ASTM D 412 Die 'C' at 20 IPM	850 psi (5,9 MPa)	2450 psi (16,9 MPa)	VOC - 4050 psi (27,9 MPa) Non-VOC 2863 psi (19,7 MPa)
Elongation	ASTM D 412 Die 'C' at 20 IPM	340%	390%	VOC - 185% Non-VOC 290%
Adhesion[1] (peel strength)	ASTM D 9030 Primed canvas to concrete	18 lbs./inch. These values apply for entire system. (0,32 kg/mm)		
Moisture Vapor [1]	ASTM E 96 Procedure B • 30 mil (0,78 mm) dry film, base coat. • Composite film: 25 mil (0,64 mm) dry film base coat, 12 mil (0,3 mm) dry film top coat.	2.7 perms (1,8 metric perms) 2.4 perms (1,6 metric perms)		
Weathering Resistance[1]	ASTM D 822 Weatherometer 350 hrs. Cured film.	Slight darkening, very slight surface checking	Slight fading	VOC - no change Non-VOC slight fading only
Salt Spray Resistance[2]	ASTM B 117 28 days @ 100 F (38 C), 5% NaCl, Die 'C', 20 IPM	Tensile: 850 psi (5,9 MPa) Elongation: 340%	N/A	VOC Tensile: 3147 psi (21,7 MPa) Elongation: 130% Non-VOC Tensile: 2800 psi (19,3 MPa) Elongation: 290%
Abrasion Resistance	ASTM C 501 30 mil (0,78 mm) dry film on 4" x 4" (10, 2 cm x 10, 2 cm) metal, CS-17 wheel, 1000 rev. with 100 gram weight.	No significant weight change	No significant weight change	VOC - 0,9 grams loss Non-VOC No significant weight change
Tear Resistance	ASTM D 1004	90 lbs./in. (1,61 kg/mm)	150 lbs./in. (2,68 kg/mm)	VOC 541 lbs/in. (9,6 kg/mm) Non-VOC 300 lbs/in. (5,36 kg/mm)
Heat Resistance (accelerated)	ASTM D 573	Tensile: 850 psi (5, 9 MPa) Elongation: 340%	Tensile: 2350 psi (16,2 MPa) Elongation: 360%	VOC Tensile: 4318 psi (29,8 MPa) Elongation: 100% Non-VOC Tensile: 2128 psi (14,7 MPa) Elongation: 365%
Fire Resistance	ASTM E 108 UL 790	System rated Class "A" on non-combustible substrate.		

[1] Cure conditions were 77 F (25 C) 50% RH
[2] Tests were conducted on deaerated dry film. Liquid immersion was to 28 days @ 77 F (25 C) 50% RH.

Courtesy of 3M Construction Markets

however, is their inability to bridge cracks in the concrete, especially those which develop after the sealer has been applied. Cracking is usually an ongoing process, so the ability to bridge new cracks is an important performance criteria.

Because of these drawbacks, sealers are best used as a short-term repair measure in a low-traffic (both pedestrian and vehicular) area or in a garage slated for major overhaul or replacement within the next one to two years.

Elastomeric Waterproofing Membranes

Traffic-bearing elastomeric membranes provide a durable, waterproof, and skid- and abrasion-resistant deck surface. These systems are usually the solution of choice for parking structures which exhibit shrinkage or dynamic cracking. Membranes can provide corrosion protection for new facilities and arrest deterioration in existing structures.

As the name implies, elastomeric membranes offer the ultimate benefit of elasticity — a prime virtue, given the natural movement inherent in any built structure. In fact, rigid sealing systems shouldn't be used in any structure suffering from dynamic (active and ongoing) movement. These rigid systems are simply not elastic enough to move with the structure.

Most elastomeric membranes are designed as a two-part system: The base layer provides the waterproofing while the wear coat, usually containing an integral aggregate for skid resistance, protects the base membrane. Deck membranes are typically made of polyurethane polymers, although some systems include an epoxy top coat with a polyurethane base coat. Heavy traffic areas are best accommodated by

Application of urethane detail coat prior to base coat installation.

multiple coat applications up to 110 mils of dry film thickness, which includes aggregates such as silica sand or silicon carbide.

There are three performance criteria to use when choosing a deck membrane system:

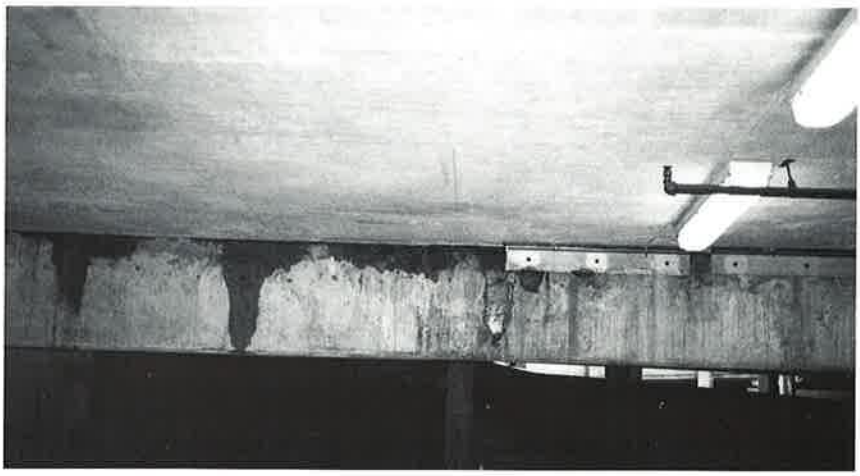
Adhesion: The membrane should create a seamless bond with the concrete deck. Proper surface preparation prior to installation is of major concern.

Elasticity and Elongation: The primary attribute of a good membrane system is its ability to bridge cracks in the concrete of less than 1/16" in width without special provisions other than a detail coat. (A detail coat is an application of base membrane coating applied directly over the crack prior to applying the base waterproofing coat. Larger cracks, which are usually dynamic cracks, can be safely coated once they have been routed and sealed with a compatible sealant.)

The membrane system should be capable of bridging cracks that develop after the system has been installed. As well, the membrane should be able to expand and contract within seasonal temperature extremes without losing its innate structural integrity. It should also be able to bridge cracks up to 1/16" without losing its bond to the adjacent surfaces. It's equally important that the membrane's elasticity be compatible with the movement of the concrete deck to which it is applied, so that both move in concert during normal expansion and contraction cycles. This elasticity is typically found in urethane systems.

Comparatively, urethane-based systems have greater elongation capabilities (350% - 450%) than epoxy-based systems (0 - 10%). Because of this, epoxy-based systems are best used in interior parking structures that are protected from the elements and undergo minimal temperature variations, precluding excessive cracking in the concrete. They are, however, quite suitable for bridging static cracks.

Durability: Traffic-bearing membranes are subjected to many potentially destructive forces: temperature extremes, expansion/contraction, friction/abrasion, damage from ultraviolet radiation, acid rain, pollution, and a host of chemical compounds, including automotive fluids. The selected system should be able to withstand these forces over a long period of time without tearing and cracking. In particular, the wear coat should be designed to resist abrasion and



A good deck membrane system can prevent damaging water infiltration to lower levels, as has occurred in this parking garage.

The aggregate is applied to provide a skid-resistant surface and is then covered with the top coat; together, these make up the wear surface.

ultraviolet (UV) damage from sun exposure, which can leave the base coat vulnerable to damage from punctures and abrasions. The base coat is also more vulnerable to UV damage, as it typically contains a lower percentage of inhibitors than the top coat, which is formulated to resist UV exposure.

A Formulation for Every Situation

Deck membranes are available in three formulations: solvent-based, low-VOC, and low-odor. Each is designed to meet the needs of specific repair situations and are differentiated, in part, by their unique curing processes.

The solvent-based membranes have been on the market the longest and have a demonstrated track record for adhesion and durability. These formulations remain the preferred systems, but environmental concerns over VOCs (Volatile Organic Compounds) has prompted the development of new formulations.

Specifically, the VOCs in solvent-based membranes react with sunlight to produce ozone, which is believed to cause lung damage. Governmental regulations over the use of VOCs have become more stringent, particularly in California, New York, and New Jersey. The second drawback to solvent-based membranes is the strong odor produced during installation and curing. In many cases, building owners and occupants perceive odors to be a health-safety risk; however, there are VOC formulations which are odorless.

In response to these two limitations, manufacturers have devised two alternate formulations. The low-VOC formulation is designed to comply with stricter environmental laws and to help improve air quality. "Low-odor" systems are just that — low odor — and have helped ease occupants' concerns during installation. Low-odor systems are also available as low-VOC formulations.

Installation

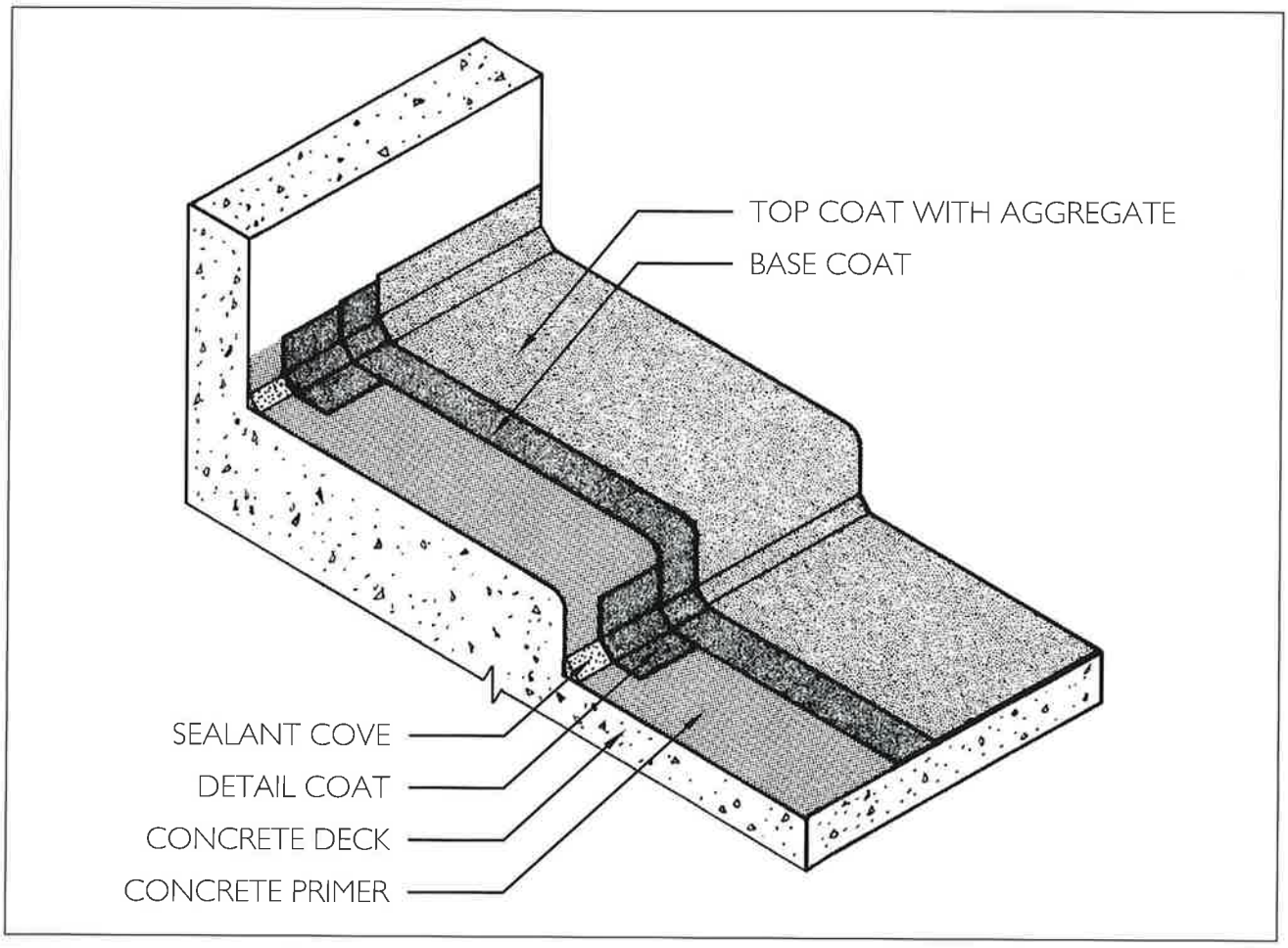
Identifying the extent and severity of deck damage is the first step in remediation. Assessment of structural damage is critical, and should be performed by a qualified architect or engineer specializing in restoration. Visual evidence of surface damage may not reveal the full extent of deterioration.

Prior to installing the membrane system, the area to be treated should be thoroughly cleaned by sand-, water-, or shot-blasting to expose the aggregate and remove any dust, laitance, grease, or other debris. Water-blasting helps minimize the dust during the cleaning process, but doesn't clean as thoroughly as the other two methods unless very high pressures are used. As well, additional time is needed with water-blasting for the concrete to dry thoroughly before installing the membrane.

All structural repairs should be made first. Cracks should be evaluated for severity and extent of damage and the underlying cause of damage should be identified and rectified.

A typical installation schedule for most membrane systems is approximately

Large cracks, such as that shown above, must be routed and sealed before the detail and base coats are installed.



Typical composite waterproofing system.

five days, once the surface preparation has been completed. This includes 3 days to install and 2 days to cure before allowing load-bearing use of the membrane. Because of the complex installation requirements for these systems, most manufacturers will only allow approved contractors to install their products.

Ongoing Care

Most manufacturers of parking deck membranes provide a five-year warranty against damage by gasoline, oil, brake fluid, and battery acid as long as regular maintenance procedures are followed. The membrane should be washed regularly with a non-phosphate commercial detergent or appropriate solvents recommended by the manufacturer. On open-air decks where snow removal is required, snowplow blades should be fitted with rubber edges to prevent tearing of the membrane.

As with all maintenance programs, the parking facility should be inspected on a regular basis for any sign of deterioration and steps taken immediately to prevent further deterioration. The related article, "A Proper Maintenance Plan", on page 8 outlines specific maintenance strategies and schedules to help prevent corrosion and decay.

Conclusion

Unless proper care is followed in maintaining parking structures, serious deterioration can occur. That usually means costly and time-consuming replacement of damaged reinforced concrete. As always, prevention is the best course to pursue. And prevention means just one thing: Keep the water out. Take steps now to halt existing deterioration and prevent future risks to both the concrete deck and its reinforcing and structural steel. ■

The Source of Steel Corrosion

Water, of course, is the age-old enemy of the built environment. Parking garages, by their very nature, are particularly vulnerable to water damage. With a primarily open facade, these structures are subject to wide variations in ambient temperatures, which can cause volume changes in the concrete itself.

These volume changes vary in proportion to the degree of exposure throughout the facility, adding yet another level of destructive stress on the garage. Live loads (moving or parked vehicles) and roof loads of snow and rain also exert compression and volume changes on the structural system. In turn, the necessary restraint of these forces causes floors, beams, columns, and slabs to crack.

It's an inescapable fact that all concrete cracks. Even when properly designed and placed, all concrete will exhibit very small cracks over time. Usually, however, these seldom affect structural integrity or allow significant intrusion of damaging moisture.

The real problem comes when dynamic cracking occurs from structural shifts and volume changes in the concrete.

Pollution and airborne contaminants also pose a serious risk to concrete as they can cause deterioration of the concrete. In either case, the path has been opened for water, acid rain, and chloride-laden de-icing salts to penetrate down to the reinforcing steel.

From there, corrosion is just a matter of time. What's worse is the snowball effect of the corrosion process: With up to ten times the volume of steel, the corrosion causes the concrete to crack from the added force.

The freeze-thaw cycle adds its own destructive force. Over time, the resultant deterioration will lead to loss of structural integrity and a potential safety hazard. ■

The Facility Manager's Bookshelf: Traffic-Bearing Membranes for Parking Garages

If your company does not have a source for ordering copies of these articles, call Michigan Information Transfer Source (313-763-5060) at the University of Michigan, Ann Arbor, MI to inquire about their document delivery services.

A. Membrane Technology

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2. Gaffney, A. "Protecting Parking Structures from Water and Chemical Damage." *Public Works.* Volume 122, pps. 70 - 72+. June 1991.
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C. Related Topics

1. Middaugh, J. Kendall III and Scott S. Cowen. "Five Flaws in Evaluating Capital Expenditures." *Business Horizons.* Volume 30, pps. 59 - 68. March - April 1987.
2. Burnett, John. "Building-Security Basics." *Architectural Record.* Volume 180, Number 8, pps. 38 - 39. August 1992.

D. Additional Information

Two past issues of Hoffmann Architects' JOURNAL provide related information on parking deck repair. These are: "Rx for Parking Garage Maintenance and Repair", Second Issue 1991 and "Preventing Reinforcement Corrosion in Parking Garages", Third Issue 1988. Copies are available by calling Emily D. Dowden at (203) 239-6660.

Compiled by Alan P. Eddy, Records and Technical Information Manager ■

REPRESENTATIVE PROJECTS

Parking Deck Rehabilitation

Hoffmann Architects specializes in the rehabilitation of the exteriors of existing facilities. A major portion of the firm's work involves the diagnosis and solution of deterioration and water infiltration problems within parking structures.

The firm's project architects and engineers focus on resolving deterioration and water infiltration problems before more serious or irreversible damage can occur. Their recommendations are based on a thorough review of the parking structure's individual characteristics, the interaction of its various components, the type and extent of deterioration, life cycle costs, and budget considerations.

Midwest Plaza Garage in Minneapolis, Minnesota

The firm's services include investigation of existing conditions, preparation of construction documents, and administration of construction contracts for renovation and restoration.

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

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

Xerox Centre
Kenner, Louisiana
(Xerox Corporation)

Atria Complex
Garden City, New York
(Chase Manhattan Bank)

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

Union Carbide Corporate Headquarters
Danbury, Connecticut
(Union Carbide Corporation)

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

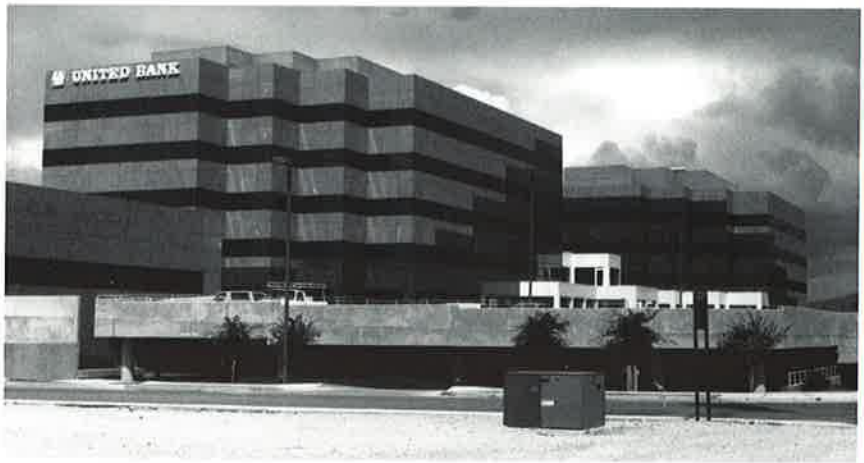
Bell Laboratories Garage
Short Hills, New Jersey
(Prudential Insurance Company of America)

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

One Financial Plaza
Stamford, Connecticut
(General Reinsurance Corporation)

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

Buckingham Condominiums
Stamford, Connecticut
(Buckingham Condominiums Owners Association) ■



Williams Center Parking Garage in Tuscon, Arizona

A Proper Maintenance Plan

Inadequate maintenance, usually due to budget constraints, is one of the leading causes of parking deck deterioration. For starters, the decks are seldom washed down sufficiently or frequently enough to remove the build-up of road salts and other pollutants. The effects of chlorides are made even worse by poor slab drainage that leaves standing water on the concrete deck.

In a properly designed and constructed facility, regular maintenance can mean all the difference in protecting and preserving the structure. Too often, however, these four most basic maintenance steps are neglected:

1. Ensuring proper drainage by keeping drains clear of debris, leaves, etc.

2. Routinely sweeping and cleaning decks, including washing with an appropriate solution. This should be done at least weekly.

3. Replacement of failed sealants.

4. Repair of minor spalls.

It is equally important to visually inspect the facility on a regular basis to find early indicators of any developing deterioration. These inspections should be done, at minimum, twice a year: in the spring, to catch any damage caused by the winter, and again in the fall to correct any deterioration that the oncoming cold weather could exacerbate. If caught early, small problem areas usually can be treated quickly and economically before they turn into massive, costly rehabilitation projects.

More extensive deterioration should be reviewed by an architect or engineer experienced in parking structure rehabilitation. ■

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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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