ISSUE 1/2003 ▪ VOLUME 21 ▪ NUMBER 1

Hoffmann Architects

Journal of architectural technology published by Hoffmann Architects, specialists in the rehabilitation of building exteriors.

Journal

Forecasting Building Envelope Reliability:

And Preparing for Inevitable Deterioration

Arthur L. Sanders, AIA and Russell M. Sanders, AIA

According to a tale woven by centuries of story-tellers, New College at Oxford, the oldest surviving hall at the university, owes its longevity to the forethought of the college's woodsmen. Legend has it that acorns were planted by Oxford woodsmen in the nearby Buckinghamshire forest at the time of the hall's original construction in 1379. The acorns were planted so that mature oaks would be available for use in repairing the hall later. When, in 1862, the college fellows contemplated a source of wood for the hall's roof restoration, they were led by their contemporary woodsman to the oaks of legend planted centuries earlier.

Fact or fiction? Fiction. The hall's roof was replaced in 1786, with pine and slate. Buckinghamshire forest did not belong to the college until some 60 years *after* construction of the hall.

Though fictitious, the tale of New College's oak trees reinforces the value of anticipating and providing for inevitable building envelope deterioration. It speaks to the benefit of planning ahead for the eventual repair or replacement of building envelope components once they have deteriorated beyond their useful life. In short, the building envelope *will* deteriorate over time. The question is: Will you be prepared?

Prepare for the Inevitable

Whether managing a single building or a multiple building complex, it is essential to plan ahead for the routine maintenance, necessary repairs, and inevitable replacement of building envelope components—roofs, exterior walls (façades), door and window systems—as well as plazas/terraces and parking structures. It *is* possible to plan and budget for the care and preservation of facilities while minimizing disruption to tenants and maximizing return on investment. Accommodating owner and tenant needs while maintaining a building at reasonable cost, operating within realistic annual budgets, and avoiding the high cost of emergency repairs is within your reach.

Knowledge is power, and knowing what to expect of your building's performance 5, 10, even 15 years from now is critical to successful building management. Becoming familiar with the life cycles of various building envelope systems and materials—and learning how to plan maintenance and repair work accordingly—is critical to successful building management. The complexities of the building envelope are made less intimidating when ongoing, evolving programs of care are

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Forecasting building envelope reliability—and managing maintenance and repairs to best provide for the inevitable deterioration of systems and materials—is critical to maximizing the useful life of a structure.

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developed for these elements. Setting priorities and addressing minor building envelope problems before they escalate into fully compromised building systems will ensure that the useful life of your building exterior is extended for as long as possible.

The Culprits of Building Envelope Deterioration

Building envelope deterioration is the result of a variety of man-made and natural causes. Some man-made causes of deterioration include:

- inadequate design;
- defects in manufactured materials;
- installation deficiencies, including installation of materials during inclement weather, improper preparation of substrates, improper storage of materials prior to installation, and improper installation of fixtures or equipment during and after construction;
- changes in the interior use of the building that could affect the exterior;
- contaminants spilled or exhausted onto building envelope materials; and,
- abuse or vandalism.

A What may seem like minor deterioration at the surface of this EPDM roof (above) has resulted in significant deterioration to the underside of the roof deck (shown at right) viewed from the interior.

Some natural causes of building envelope deterioration include:

- exposure to the elements such as the sun, hail, lightning, winds, rain and pollution;
- structural stressors caused by building settlement, thermal expansion and contraction, seismic activity and soil displacement;
- damage caused by insects, birds and animals; and,
- vegetative or biological growths including algae, mold, moss and fungus.

Know the Warning Signs

Regardless of the causes, knowing the warning signs of deterioration in building envelope systems and materials is the

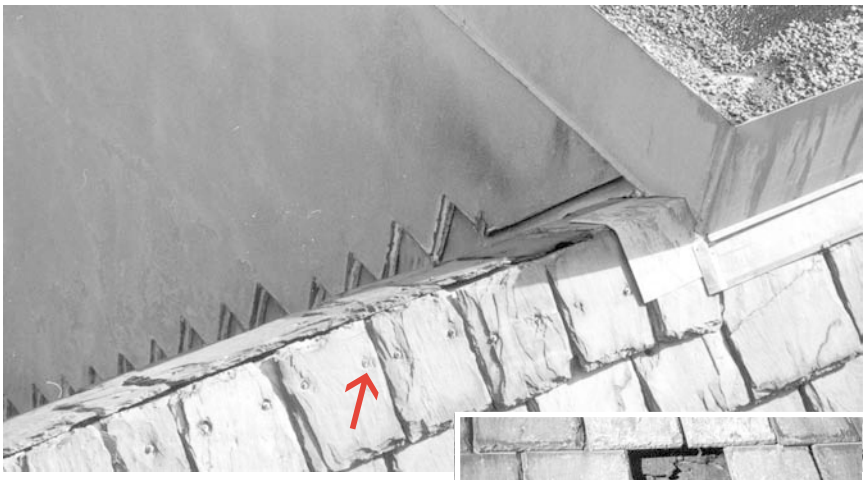
V Warning signs: Below left, water begins to pond on a low slope roof, indicative of inadequate pitch and/or drainage. Below right, a more extreme example of the same.

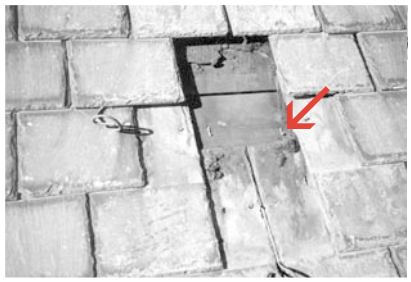
first step toward extending their long life at reasonable expense. Immediate and appropriate response to observed warning signs should follow.

Should a minor leak (a warning sign) occur in an EPDM roofing membrane, for example, its source should be identified and an appropriate program of repairs should be initiated immediately. Delays and shortcuts will result in continual and perhaps severe deterioration. What could have been patched might require replacement. Furthermore, the considerable damage and occupant inconvenience caused by even minor leaks into a building's interior spaces compounds the problem.

Ignoring the warning signs of deterioration threatens the longevity of building envelope systems and materials. Case in point: while the life expectancy of a low slope, EPDM roofing system may be 15-20 years, it can be prematurely shortened if indicators of deterioration—such as splits or openings at membrane terminations—are not identified and appropriately repaired in a timely manner.

Watch for and respond appropriately to the following warning signs of deterioration in roofing systems, exterior walls, windows and doors, plazas/terraces, and parking structures:





Above: Nails penetrating slate tiles at roof ridge may permit water infiltration and reduce useful life of roofing system. At right: Copper nails would have been preferable to the galvanized nails used to anchor these slate roof tiles. The galvanized nails have failed, causing tiles to dislodge.

<u>In Roofing Systems:</u>

- ponding, cracks, blisters, holes or splits in low slope systems;
- pitting, corrosion, open seams, solder joint failure in metal systems;
- loose tile, broken tile, failed/deteriorated fasteners in clay tile and slate roof systems; and,
- failures at parapets, copings, flashings, tie-ins and decks.

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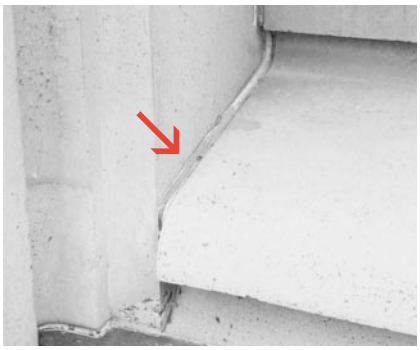
Sealant joint failures permit water entry and, when not properly repaired, result in stains/efflorescence, cracks, spalls and crazing in stone/masonry exteriors.



Signs of trouble: Below left, mildew and deterioration at joint between EIFS and metal base. Below center, moss growth in mortar joints of brick wall indicates water retention. Below right, crack in stone facade.

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In Exterior Walls (Facades):

- deteriorated/open mortar joints or failed/open sealant joints (permit water entry, stains/efflorescence, cracks, spalls and crazing in stone/masonry);
- cracked panels/slabs, water or rust stains, spalls in concrete; and,
- dry, cracked, shrunken gaskets and sealants, failed mullions, fogged or etched thermal window panes indicative of compromised thermal seal in (glass) curtain walls.

In Windows & Doors:

- failed hardware components; and,
- failed sealants, gaskets and mullions, fogged or etched panes indicative of compromised thermal seal in windows.

Above left: Cracking and spalling of concrete panels on an exterior wall. Above right: Corrosion of embedded steel reinforcement has caused severe spalling at this corner.

In Plazas/Terraces:

- water stains, cracks/spalls, or displacement in paved or poured wearing surfaces;
- failed or open mortar and/or sealant joints in paved surfaces or at the juncture of horizontal and vertical surfaces; and,
- water infiltration through a plaza surface (particularly at penetrations or at planter, fountain or landscape elements) into occupied space beneath the plaza.

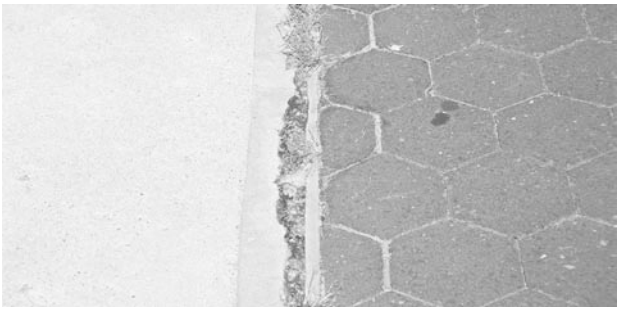
In Concrete Parking Structures:

- unprotected deck surfaces or those with peeling, cracked or ineffective protective coatings or sealers;
- corrosion of steel reinforcement within concrete slab due to migration of chlorides, often resulting in concrete spalls;
- cracks in cast-in-place concrete decks due to shrinkage or flexure;
- cracks or fractures in pre-cast components due to restraint;
- rust stains/efflorescence;
- failed sealant at control joints, construction joints, and routed cracks; and,
- deteriorated, damaged or leaking expansion joints.

Clockwise from bottom: Cracks at base of concrete column; spalled concrete and exposed steel reinforcement; severe deterioration at column base.

Nothing Lasts Forever

As it is only a matter of time before building envelope systems and materials deteriorate, the question is, 'how long will they last?' There are no hard and fast rules, no clear-cut answers, when it comes to anticipating the useful life of building envelope systems and materials. Many factors influence reliability—the integrity of an original design, the



Clockwise from above: Misaligned drain and oozing asphalt setting bed material make for a hazardous and unsightly wearing surface; deterioration at expansion joint; and, at joint between paved and poured wearing surfaces.

appropriateness of installation, the degree and consistency of maintenance, or the impact of weather and climactic conditions.

Slate roofing tiles, for example, may have a useful life of between 50 and 100 years. But the flashing materials and nails used to construct a slate roofing system can be expected to deteriorate sooner.

The useful life of sealant, for example, is contingent upon the appropriateness of the material for the joint condition (does it adequately provide for differential movement?); the adequacy of joint preparation prior to material application; and the ambient temperature at the time of application, among other things. Failure to provide for any of these requirements may lead to premature sealant failure.

The scenarios are numerous and varied, as everything can be counted on to deteriorate over time. However, anticipating the useful life of building envelope systems and materials provides a firm foundation for establishing appropriate, evolving programs of care.

Plan Maintenance & Repairs to Optimize Useful Life and to Maximize ROI

When it comes to building improvements, maintenance and repairs, it's not uncommon for "to-do" and "wish" lists to exceed budgets. Where is money best spent? It can be particularly tempting to defer an investment in roof or facade repairs in lieu of a more apparent tenant improvement—until the building leaks. Or worse, until the building leaks and damage is done to interior tenant improvements. What takes precedence? How do you prioritize? A step-by-step approach is best.

First, establish the current condition of your building envelope. Systematically evaluate and document the condition of all systems and materials.

Next, create a prioritized maintenance, repair and replacement program based on existing conditions and the anticipated useful life of your building envelope systems and materials. Your maintenance, repair and replacement program should be prioritized to provide appropriately for:

- the immediate repair or stabilization of hazardous/unsafe conditions;
- the effective and uninterrupted function of life safety systems (such as fire and security alarm systems);
- warranty expirations; and,
- owner or tenant considerations (budget, the impact of construction on occupied space, etc.).

Finally, establish a budget and schedule for identified routine maintenance, priority repair, and capital repair/replacement projects. Stay on track by routinely reviewing conditions and responding appropriately to the warning signs of deterioration.

It Doesn't Pay to Delay: Avoid the High Cost of Deferred Maintenance and Repairs

The bottom line: deferring maintenance and delaying needed repairs will increase costs and exacerbate deterioration in borderline building conditions, as deterioration takes on a snowball effect.

Consider, for example, cracks that develop between mortar and masonry units and spalls that occur at masonry unit faces. If left untreated, these sources of water entry can soak the individual face units, enter behind the units, or travel through the wall. In freeze-thaw conditions, the water in the face of the wall and behind the masonry units can cause further spalling or heaving of the wall. If water intrusion is not inhibited, interior degradation will occur and the cost associated with the repair of the system will be considerable.

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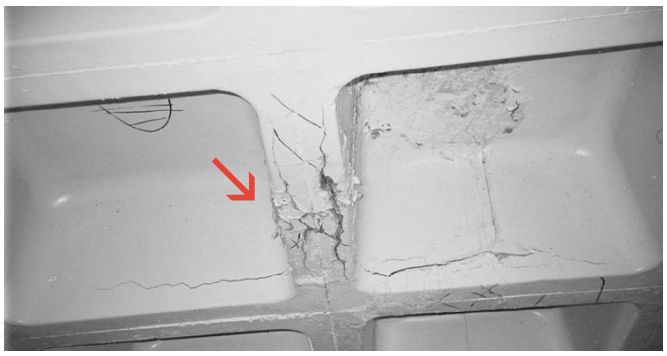

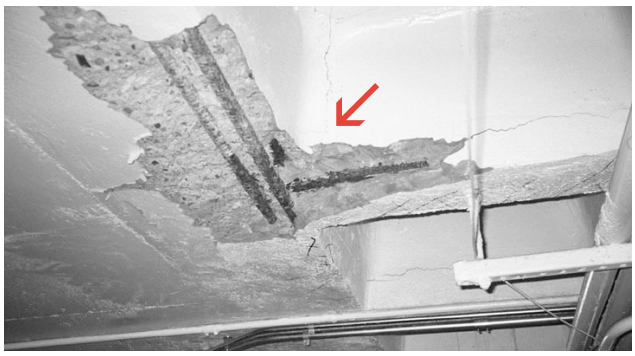

Above left: Cracks in the underside of a suspended, waffle-slab concrete parking deck. Above right: Deteriorated/loose concrete, removed as a safety precaution, reveals corroded reinforcement within the slab.

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Similarly, failure to promptly repair cracks in reinforced concrete parking decks can ultimately compromise the integrity of these structures. Cracks permit moisture and salts to migrate through a concrete slab causing the corrosion of embedded reinforcement. A relatively small amount of corrosion can cause loss in strength. Repair or replacement of the corroded reinforcement and the deteriorated concrete slab is disruptive to parking operations and can be very costly.

Looking Ahead

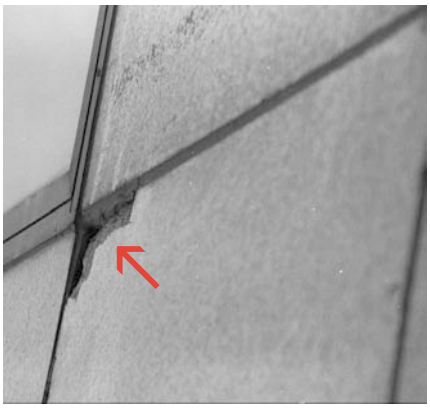
How do you get the most out of your building envelope 5, 10 or even 15 years from now? By being prepared.

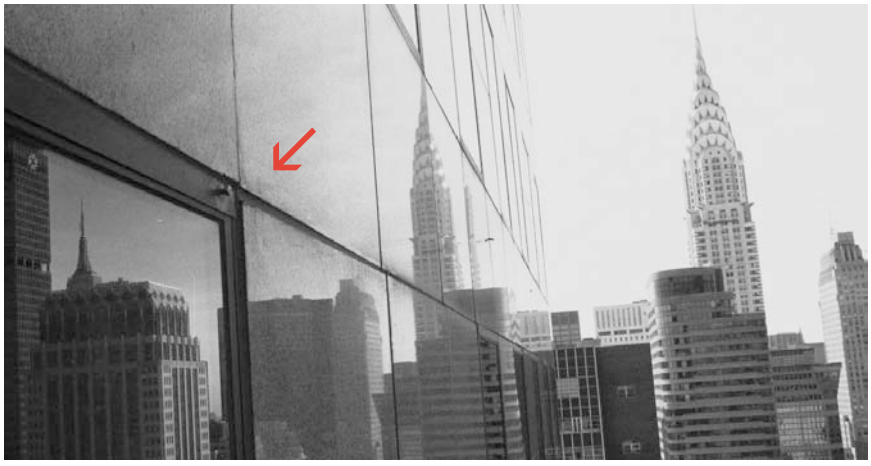
Forecasting building envelope reliability, anticipating the inevitable deterioration of building envelope systems and materials, will enable you to plan ahead for repairs and replacements once systems and materials prove beyond their useful life. Extend the useful life of your building's exterior for as long as possible by:

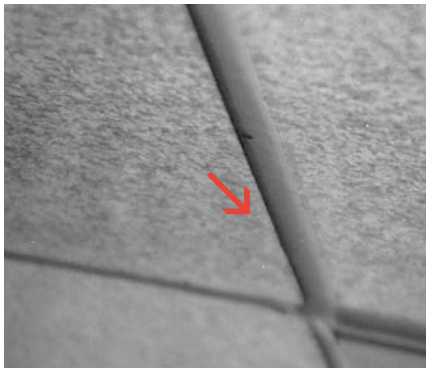
- assessing current conditions;
- establishing maintenance, repair and replacement priorities necessary to achieve your building envelope goals (based on anticipated useful life of building envelope systems and materials); and,
- developing and implementing effective maintenance and rehabilitation programs.

Stay on track and keep ahead of inevitable deterioration by continually re-evaluating and responding to the current condition of your building envelope systems and materials. ■

Scaled concrete at drain may be indicative of standing water or inadequate drainage.

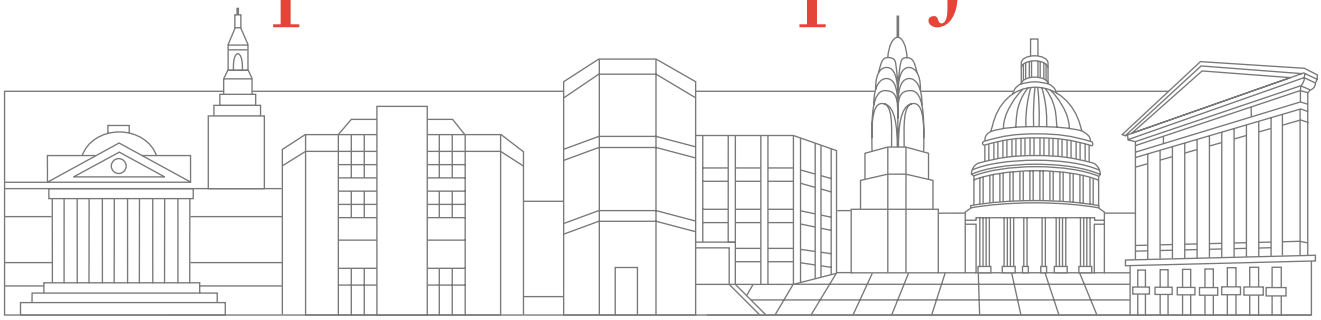






Clockwise from top: A cracked stone panel; displaced panels result from failed anchor system.

representative projects



Building Envelope Rehabilitation

Hoffmann Architects assists building owners and managers to provide for the eventual repair or replacement of roofing systems, facades, plazas/terraces and parking structures. The firm has developed custom-tailored rehabilitation programs for a variety of projects, including:

New York Stock Exchange
New York, New York
Facade and Roof Rehabilitation

The Goodwin Hotel
Hartford, Connecticut
Facade and Roof Rehabilitation

Columbia University
New York, New York
Roof and Facade Rehabilitation

IBM Corporation
Poughkeepsie, New York
Roof and Masonry Rehabilitation

1801 L Street NW
Washington, District of Columbia
Parking Garage Rehabilitation

The Bank of New York
New York, New York
Roof and Facade Rehabilitation

Smithsonian Institution
Washington, District of Columbia
Copper Roof Restoration
National Museum of American Art, National Portrait Gallery & Archives of American Art

General Electric Company Corporate Headquarters
Fairfield, Connecticut
Facade, Roof and Parking Garage Rehabilitation

Chrysler Building
New York, New York
Spire and Facade Restoration

Pfizer, Inc. World Headquarters
New York, New York
Facade and Roof Rehabilitation

25 Sigourney Street
Hartford, Connecticut
(State of Connecticut)
Facade and Roof Rehabilitation

United States Capitol Complex
Washington, District of Columbia
Dome Restoration, Terrace and Fountain Rehabilitation

New York City School Construction Authority
New York, New York
Building Envelope Rehabilitation

Verizon Communications
New York, New York
Facade and Roof Rehabilitation

Xerox Corporation Headquarters
Stamford, Connecticut
Facade Rehabilitation

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104 Broad Street New York, New York. When the original copper roof proved beyond its useful life, Verizon Communications retained Hoffmann Architects to design and direct a minimally disruptive copper roof replacement effort for this telecommuniations' hub.

Pond View Corporate Center Farmington, Connecticut. Hoffmann Architects conducted a water infiltration investigation of the facade and developed a program to rehabilitate this corporate facility.

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1166 Avenue of the Americas
New York, New York
Plaza Rehabilitation

One Financial Plaza
Hartford, Connecticut
Parking Garage Rehabilitation

The Landmark at Eastview
Tarrytown, New York
Roof Rehabilitation

Greenwich Capital
Greenwich, Connecticut
Plaza Rehabilitation

The George Washington University
Washington, District of Columbia
Facade, Roof and Plaza Rehabilitation

500 Park Avenue
New York, New York
Plaza Rehabilitation

Dow Chemical Company
Danbury, Connecticut
Parking Garage Rehabilitation

1330 Avenue of the Americas
New York, New York
Roof Replacement

Foxwoods Resort Casino
Mashantucket, Connecticut
Parking Garage Rehabilitation

MetLife Building
New York, New York
Facade Rehabilitation

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