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Journal

Troubleshooting the Building Envelope:

Addressing CAUSES, Not Symptoms

John J. Hoffmann, FAIA and Russell M. Sanders, AIA

The various components of the building envelope—façades, roofing systems, windows—and parking structures, plazas/terraces/sidewalks, etc., inevitably deteriorate over time. The culprits? Water infiltration, thermal expansion and contraction, improper construction and/or substandard materials, structural movement or stress, and age. Maintenance of the building envelope is critical to preserving not only the structural integrity of a building's exterior but also to protecting a building's interior occupied spaces; it serves as a barrier from the external environment.

Water infiltration, thermal expansion/contraction, improper construction or substandard materials, structural movement or stress, and age contribute to the inevitable deterioration of building materials over time.

Critical to maintaining the building envelope is the ability of the facility manager, property manager or building engineer to recognize and address early indicators of deterioration. Costs associated with deferred maintenance increase exponentially over time. The return on interior investments—to lobbies, offices, restrooms—will significantly diminish if water infiltration disrupts tenant activities and causes irrevocable damage to ceilings, walls, windows and floor finishes.

Recognizing early indicators of deterioration is no less critical for parking structures, plazas, terraces and sidewalks. These elements suffer the damaging effects of pedestrian and vehicular traffic, and the corrosive impact of acid rain and de-icing salts. The risk associated with deterioration in these structures is severe; the threat of costly and time-consuming lawsuits associated with driving and/or tripping hazards, unacceptable.

What To Do When Trouble Strikes

Water infiltration can be counted on to exacerbate building envelope failures. Solutions to building envelope failures address CAUSES, not symptoms, and can be relied upon to keep water out of building envelope components in the future.

The key to successfully managing the building envelope is knowing what to do when trouble strikes. Temporary or cosmetic measures—band-aids, if you will—inevitably fail. The goal is to plan and implement *lasting* solutions.

When trouble strikes, the first task is to define the scope of work by:

- accurately attributing the nature and extent of problem;

- developing technically/aesthetically appropriate, cost-effective remedial solutions; and,

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- establishing probable construction cost.

Contract Documents are developed for the designated scope of work, and bids are solicited from capable and responsible contractors. Once construction is underway, the design professional ensures that the work being performed by the contractors is consistent with the work set forth in the Contract Documents.

By following these troubleshooting guidelines, a building manager can avoid the costly surprises that occur when inappropriate and/or poorly implemented repairs fail.

Troubleshooting Exterior Walls

Be they brick, stone, concrete, metal, glass or any combination of these, exterior walls are intended to separate us from the elements. Periodic surveys of exterior walls should be conducted to detect indicators of deterioration.

Brick Exteriors

Bricks have been used as building blocks for centuries, for structures ranging from the adobe (mud brick) homes and missions in the southwestern United States to all manner of contemporary buildings. Common to all brick exteriors, however, is the necessity for consistent maintenance and repairs to ensure their useful life for as long as possible.

Brick exterior walls should be checked regularly for failed/aging mortar joints. De-bonding, cracked/spalled brick, and efflorescence/water staining are indicators of deterioration.

Efflorescence, white stains and/or build-up of white, crystalline structures, is caused by the dissolution and surface deposition of naturally occurring salts.

Figure 2, facing page, indicates types of mortar joints and their effectiveness in preventing water infiltration. Note that the recommended joints are those which direct water, a leading cause of building envelope failures, *off* of the exterior wall, as opposed to those which permit water to rest in the joints.

Anatomy of an Exterior Brick Wall

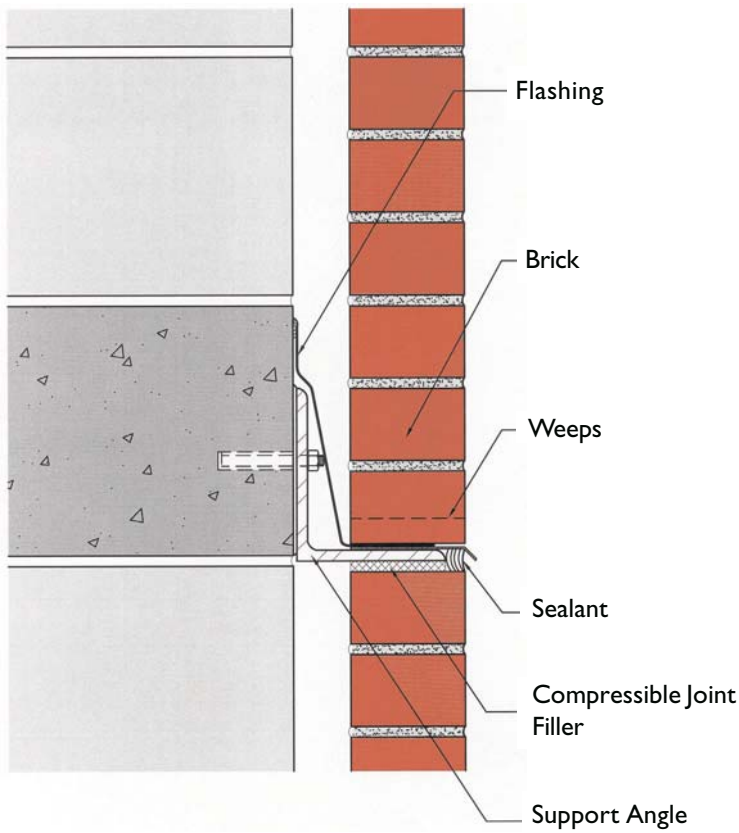
The basic components of brick veneer wall construction (refer to Figure 1) include the exterior face, the structure or "back-up," and the cavity between the two; the flashing (which prevents the passage of water into the structure from the joint); and the support angle. Typical causes of failure in this system include:

- absent or inadequate flashing;
- blocked water exit at flashing (blocked weep holes);
- failed or inadequate soft joints at relieving angles; and,
- failed mortar or expansion joints.

Stone & Pre-cast Concrete Exteriors

The proper care and preservation of sealant joints is key to preserving the useful life of concrete and stone exteriors.

Fig. 1 Relieving Angle Detail at End Wall



How exterior joints are sealed, the selection of sealant materials, and installation considerations all play important roles in determining the lifespan of a stone or concrete exterior wall.

Exterior joints must be properly sealed between:

- individual panels;
- windows, frames and exterior walls; and,
- any two or more building envelope components.

Sealant materials should accommodate differential movement in various building systems and bond properly to different building materials. At installation, consideration should be given to joint width limitations, preparation of surfaces to improve bond, and exterior temperature. Lastly, it is important to evaluate/ensure the integrity of anchor systems when conducting inspections of concrete and stone exteriors.

(Glass) Curtain Walls & Window Systems

When caring for (glass) curtain wall and window systems, a building manager should:

- routinely examine window gaskets or sealant for splits, breaks or openings;
- replace failed gaskets or sealants that have dried, cracked, shrunken or otherwise exceeded their useful life; and,

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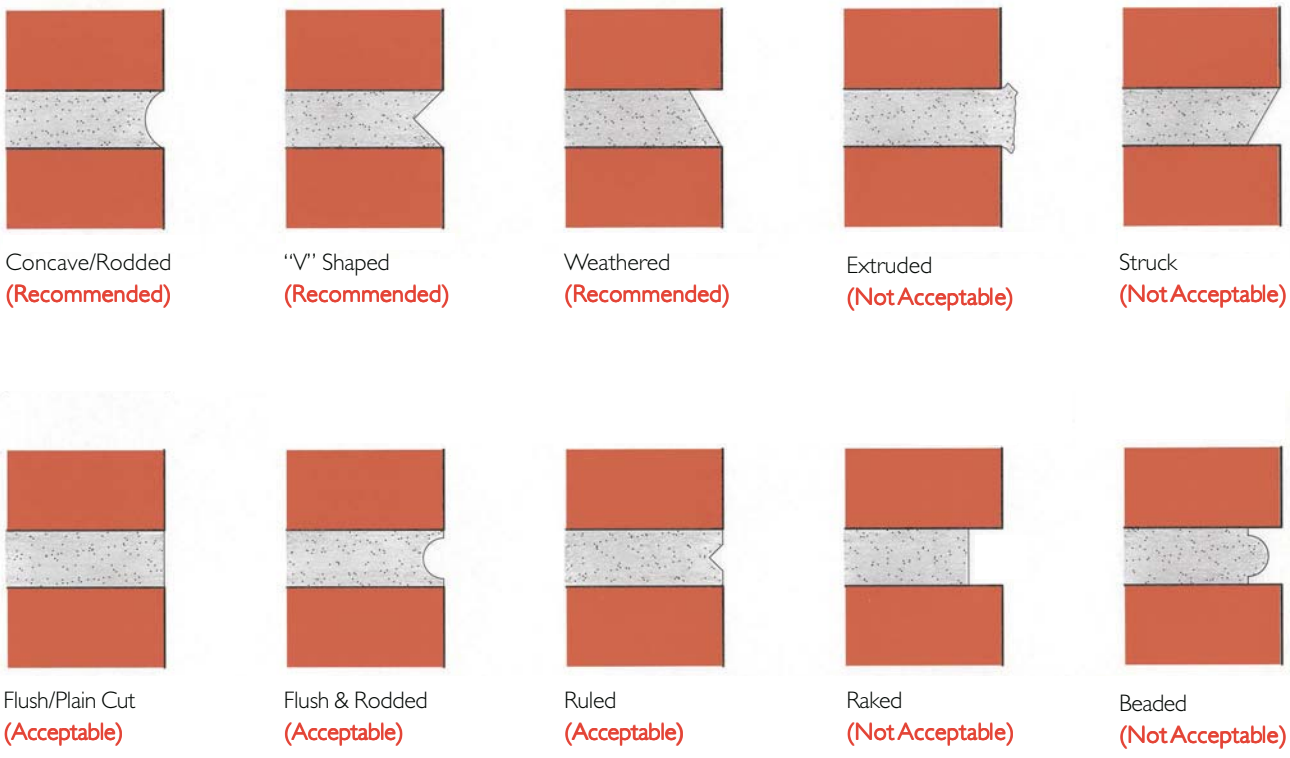
Sealant failure between aluminum panels.

Cohesive joint failure.

Fig. 2 Types of Mortar Joints (In Profile)



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Glass curtain wall and window systems at a suburban corporate office park.

· inspect mullions for deterioration.

Glass that appears "fogged" should not be neglected. It may be symptomatic of a compromised thermal seal.

Troubleshooting Roofing Systems

Whether low slope or steep slope, regardless of materials and/or construction, all roofing systems inevitably deteriorate over time.

During a roof inspection, problem areas should be examined to detect the root causes of deterioration and to determine the most effective repair solutions. Deterioration increases exponentially over time. To put it simply, the longer it sits, the more damage it will do to the structure. Early detection and pro-active maintenance and repairs enable a building manager to avoid more costly roof repairs and/or replacements in the future.

Successful design solutions for roofing systems allow for differential movement, properly integrate/curb rooftop equipment, and provide for foot traffic.

Indicators of failure differ with the various types of roofing systems. They include:

· in low slope systems: ponding, cracks, blisters, holes or splits;

· in metal systems: pitting, corrosion, open seams/solder joint failure; and,

· in clay tile and slate roof systems: loose tile, broken tile, failed/deteriorated fasteners.

The most prevalent roofing application and repair errors are the results of inattention to detail, the use of incompatible or inappropriate materials, and improper installation.

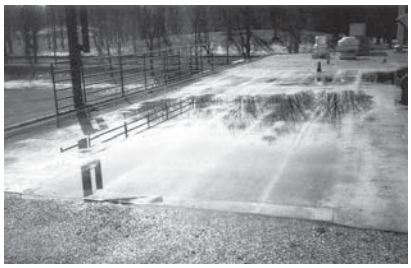
Troubleshooting Plazas/Terraces

Plazas/Terraces often serve as popular gathering places, for both building tenants and area pedestrians. These heavily trafficked areas may incorporate landscaping and lighting design, reflecting pools and fountains, and may even showcase the work of area sculptors. At the hands of Mother Nature, plazas/terraces are continuously exposed to the full force of the elements.

What about plazas will plague you?

Plazas over occupied spaces are part of the building envelope. While water is clearly the enemy of *any* part of the building envelope, it is particularly harmful to horizontal surfaces. Standing water on horizontal surfaces, on plazas and terraces, accelerates deterioration.

Inadequate drainage and prematurely failed waterproofing membranes are detrimental to a plaza's useful lifespan. Ponding, water stains, cracks, spalls and heaved pavers (which create tripping hazards) are the indicators of trouble. Protection of the waterproofing membrane and sufficient drainage are the solutions.



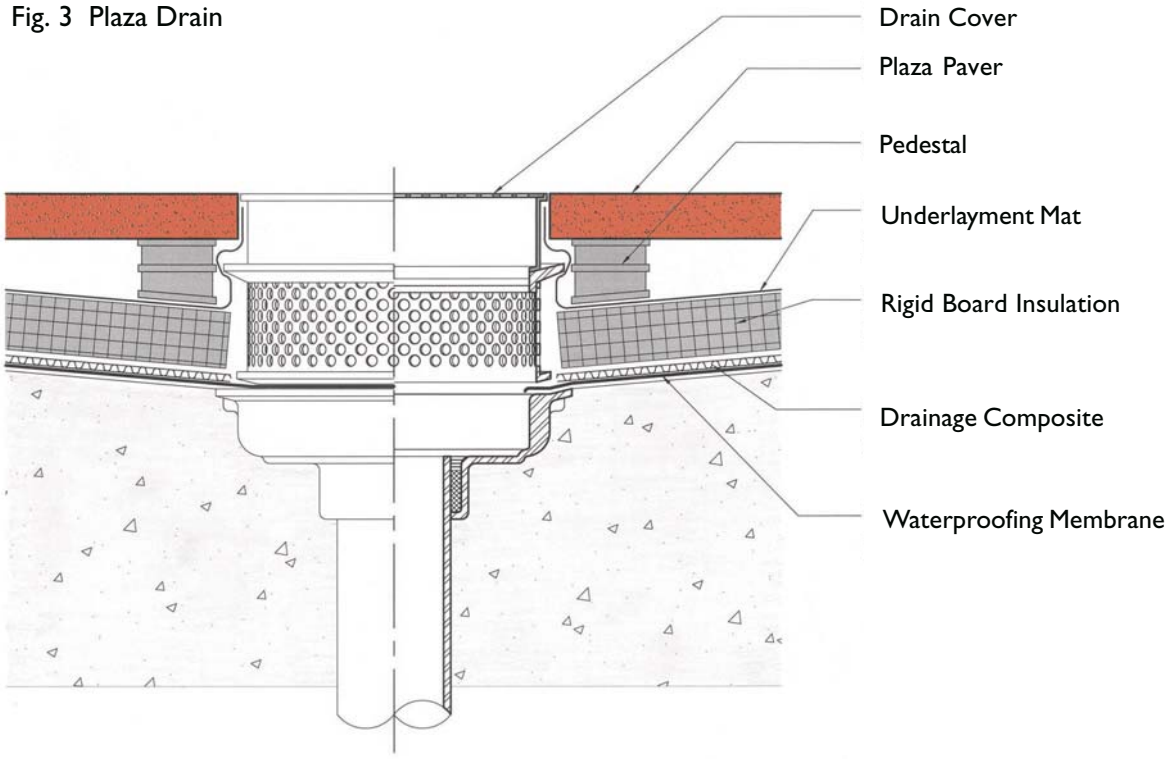
Ponding (water retention on the roof membrane) can occur in low slope roofing systems.

Note cracks in these damaged ballast pavers (in a low slope system).

Open seams/solder joint failure are indicators of deterioration in metal systems. Proper care during application of roofing materials is critical to preserving a roof's useful life.

An historic mansard roof (having on each side a steeper lower part and a shallower upper part) with terra cotta tiles.

Fig. 3 Plaza Drain



Water should be allowed to drain both at the wearing surface and beneath the plaza surface at the membrane. Drainage may occur at varying degrees of slope: paved surfaces with tables and chairs should be more level, while it is generally recommended that drainage at the membrane should occur at 1/4" per foot. In order for drainage systems to remain effective, drains must be consistently maintained. They should be periodically checked and cleared of debris.

The bi-level plaza drain assembly in Figure 3 above shows a loose laid assembly, but the same results are achievable with pavers in a mortar setting. Typical trench drains are not manufactured as bi-level drains, causing water to stand at the membrane level.

Troubleshooting Parking Structures

In a society where drivers abound and land is at a premium, parking structures are an integral part of the commercial landscape. They can be constructed of pre-cast concrete, cast-in-place concrete, or steel with a concrete deck.

Parking structures deteriorate more rapidly than other built structures as they suffer the damaging effects of vehicular traffic and the corrosive impact of acid rain and de-icing salts. This is in addition to water infiltration, thermal expansion and contraction, improper construction and/or substandard materials.

Symptoms of water infiltration in parking structures include efflorescence, cracks and spalls.Building managers should beware of cracks on surface slabs that permit water to enter the concrete. But it should be remembered that deterioration begins within the slab, out of view. Damage visible from the deck is often only the tip of the iceberg.

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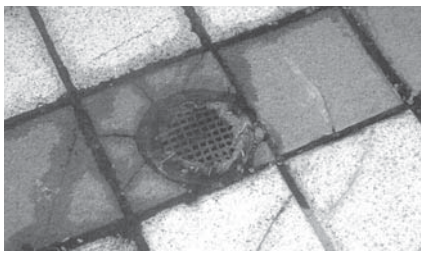
Plazas/terraces often incorporate seating, planters, and lighting design, all of which must be considered when planning maintenance and repairs.



Debris should be cleared of drains to ensure their effectiveness. Note cracks which permit water entry.

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Case in point: when cracks (which can develop on the top surface for any number of reasons) permit water to enter the concrete, the steel reinforcing bars that are embedded within the concrete for stength begin to rust. As the steel rusts, it pushes the concrete away, causing it to chip and spall—risking damage to vehicles and injuries to people.

Spalls, laminations that break off due to corrosion of reinforcement/embedded items, are among the indicators of failure in parking structures.

Pro-active Maintenance Is Key

Parking structures require consistent maintenance. Conducting regular visual examinations to identify potential problem areas goes a long way toward preventing the development of negative conditions. And, preventative maintenance techniques, such as the application of an appropriate coating or sealer to protect new decks from corrosion, can be effective.

When repairs become necessary, the extent of the damage must be determined and the area properly quantified to effect lasting solutions. This can be accomplished using simple methods such as chain dragging or sound tapping the surface to identify delamination. More extensive testing of concrete may be needed to determine its integrity and the true nature and extent of deterioration. Tests that measure compressive strength, depth of carbonation (which reduces the natural ability of concrete to protect embedded reinforcement steel), and chloride ion content (from road salts) can be instrumental in developing appropriate repairs that go beyond surface damage and correct deterioration at its core.

Troubleshooting Historic & Landmark Structures

Historic/landmark building exteriors are often constructed with materials and techniques uncommon to contemporary construction and can present maintenance/rehabilitation challenges. It is often essential to develop a concise approach to address maintenance needs, remedial repairs, and modifications or restoration work to the building envelope.

Other considerations for the successful management of historic/landmark structures include:

- landmark status (national or local) and related rehabilitation guidelines/ restrictions;
- local building codes;
- primary building function and tenant requirements; and,
- budget.

A tremendous financial burden can be placed on the building owner of a historic/landmark structure. The proper remediation or restoration of the exterior may cost two to three times the value of the building.

Unique Materials & Techniques

Construction materials that are more prevalent in historic structures than in contemporary structures include terra cotta, tile (mosaic, clay, ceramic), and decorative/ornamental grating (iron, aluminum, stainless steel). Construction techniques include intricate patterns within brick, stone, terra cotta, and tile; narrow joint widths among brick and stone; and obsolete structural/anchor systems.

Large, stainless steel replicas of automobile hood ornaments adorn the landmarked Chrysler Building. Over the years, roofing mastic, sealant and other incompatible materials were used to make repairs, all of which exacerbated negative conditions.

Intricate patterns and decorative elements can present challenges when rehabilitating historic structures.

Conclusion

Failure to identify and address building envelope "hot spots"—portents of deterioration—will ultimately result in significant expense to building owners. People, the power of nature, and the passage of time can be relied upon to adversely impact the building envelope. Early detection, however, can be a powerful weapon in the fight against building envelope deterioration; it allows for the development of pro-active maintenance and repair programs that minimize tenant disruption and maximize a building owner's return on investment. ■

representative projects

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New York, New York
Facade & Roof Rehabilitation

The Goodwin Hotel*
Hartford, Connecticut
Facade & Roof Restoration

Verizon Communications
New York, New York
Facade & Roof Rehabilitation

Columbia University
New York, New York
Roof & Facade Rehabilitation

J.P. Morgan Chase & Co., Incorporated
New York, New York
Building Envelope Survey & Facade Restoration
23 Wall Street Complex
23 Wall Street
15 Broad Street
37 Wall Street
43 Exchange Place

IBM Corporation
Poughkeepsie, New York
Roof & Masonry Rehabilitation

Rockefeller Center Complex
New York, New York
Exterior Restoration

Trinity College
Hartford, Connecticut
Rehabilitation Master Plan

One Beacon Street
Boston, Massachusetts
Parking Garage Repair & Plaza Rehabilitation

The Bank of New York
New York, New York
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Smithsonian Institution
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Copper Roof Restoration
National Museum of American Art, National Portrait Gallery & Archives of American Art

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New York, New York
Facade & Roof Rehabilitation

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

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

United Nations Complex
New York, New York
Dome & Roof Rehabilitation

United States Capitol Complex*
Washington, District of Columbia
Restoration

Xerox Corporation Headquarters
Stamford, Connecticut
Facade Rehabilitation

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Verizon Communications Headquarters
New York, New York.

Hoffmann Architects designed an award-winning program to restore the Queen Anne-style Goodwin Hotel, originally constructed in the 1880s.

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Foxwoods Resort Casino
Mashantucket, Connecticut
Rehabilitation
Grand Pequot Parking Garage
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Prudential Insurance Company Eastern Operations Office
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Metropolitan Opera House
Avery Fisher Hall
Vivian Beaumont Theatre ■

* Denotes an award-winning project.

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