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Keeping It Together:

An Overview of Building Envelope Maintenance and Repair

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One of the most basic human needs is protection from the elements. The "building envelope," comprised of facade (or "face"), roofing, and, plaza/terrace elements over occupied space, acts as a barrier between the interior and exterior environments. It protects against wind, rain, noise, pollution, temperature extremes, and unwanted entry, while permitting sunlight, air, and necessary persons entrance and egress. To serve these many functions, the envelope must be durable and functional, as well as cost-effective and aesthetically pleasing.

As evidenced by the ever-changing materials and systems available, building envelope design is just about as diverse as the natural world. While older building systems tend to be more labor intensive to install, heavier, and more costly, newer systems can require more maintenance or have a shorter lifespan. Each type has its unique advantages and drawbacks. Older building envelope systems may use materials not readily available today (i.e. terra cotta, custom metalwork, slate/tile roofing). While these materials may make for an elegant envelope, they can be difficult and costly to repair.

Depending upon its condition, the building envelope can add to or subtract from the building's value. If properly designed and constructed, routine maintenance can extend the life expectancy of the envelope practically indefinitely.

However, if performed incorrectly, the very same routine maintenance work may have the unintended consequence of concealing conditions that are prone to spread or, in many cases, may actually exacerbate the problem. This is evidenced by the generous amount of sealants commonly used to repair defects. It is clear by the care and expense with which some cracks are sealed that the personnel performing the work were too preoccupied with keeping water out to question whether they were locking water in.

The owner then, having diligently contracted for maintenance of his/her investment, may have a false sense of security about the condition of the building. In such cases, problems are often identified only after they become obvious and pervasive.

Common Problems and Effects

Water, seemingly innocuous and benign, is one of the most destructive forces on earth. It can break down mountains and reshape the land. It is easy, then, to see that a building is locked in an endless battle with this force. In climates subject to freezing temperatures, water's effects are greatly amplified. Accordingly, maintenance efforts are generally focused on keeping water out of the building and away from building components.

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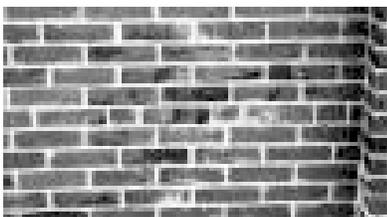


▲ Final cleaning of a reconstructed cast stone and brick facade.

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▲ Facade systems can differ widely in both materials and design principles. Pictured above are three examples (top to bottom): curtain wall, which supports only its own weight, of metal and glass; thin stone veneer curtain wall; and brick, load-bearing masonry, which supports weight beyond its own. The detail photo at right shows a thin stone panel removed from its concrete back-up.



▲ Rather than keeping water out, a coating applied over this brick trapped moisture inside the wall, leading to heavy spalling.

Repair efforts are primarily centered on reconstructing those items which water reached. It is the management of water that becomes the most important aspect of design, maintenance, and repair efforts.

Facade

All facade systems are designed to keep water out. However, a proper system is also designed under the assumption that water will get in. Of the exterior materials in use today, all can and will eventually fail. Finish material such as brick, concrete and granite can crack; mortar joints can erode or debond; sealant joints can fail adhesively or cohesively and, unfortunately, are generally only repaired or replaced after numerous failures have occurred. It is this



▲ Insufficient concrete coverage over reinforcement can lead to cracks and spalls as water begins to enter. Eventually, the steel will rust, growing many times its original size and blowing out everything around it.

need for redundancy which is the most important and misunderstood design principal.

Redundancy can be achieved by many different methods. A masonry cavity wall system, for instance, will generally use a through wall flashing and weep system to collect and expel water that enters the cavity. A solid masonry wall, on the other hand, uses multiple wythes (layers) of brick to inhibit water migration and to absorb those small quantities of water which do enter the wall. This water is then released by evaporation. Each may appear the same from the surface but act much differently. A common error made on a cavity wall system is to block or seal the weep holes. This locks water into the wall and may lead to serious problems. A misconception frequently encountered with solid masonry is that water entering the masonry can be stopped with a surface sealer. Since sealers do not bridge gaps, and water mainly enters at cracks and debonded mortar lines, they can create an outward appearance of integrity while interior degradation continues.

Roofing

Roofing systems come in a surprising number of flavors. They can shed water like a shingle or hold water like a membrane. They can be a prominent building feature or a hidden element. They can be designed to last 10 years or 100 years. And, to confuse matters more, they can be constructed of a dizzying array of materials. Among others, possibilities include wood, stone, metal, asphalt, coal tar, rubber, thermoplastic sheet, and foam. The benefit of this greater number of choices is less need to compromise project requirements. The disadvantage is increased room for error.

The most prevalent roofing errors include inattention to detail and the use of incompatible or inappropriate materials. When performing repairs, poor material selection can result in

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accelerated material degradation or very short repair life. A common mistake made in the repair of sprayed polyurethane foam roofs (“foam”) is the use of asphaltic mastics. Foam roofs often have a coating of silicone applied for UV protection. Since the only product that adheres to silicone is more silicone, applying asphalt is little more than counterproductive.

“Any repair effort must eliminate the *cause* of the previous failure, not just its *effect*.”

Most detailing errors occur at termination points. A great deal of effort is often expended to properly flash roofs onto walls and curbs only to find that the top edge, or termination, allows water behind the entire assembly. Another common error is improper anchorage of rooftop equipment. Take, for example, a fan resting on wood sleepers, which, rather than being anchored to the concrete deck, bear directly on the membrane. Without adequate movement control and weight distribution, such equipment can damage the membrane, leading to water entry and further deterioration. All too often, a simple oversight, like the minimum



attachment of gravel stops or roof perimeters, can evolve into a major problem, like roof blow-off.

Plaza/terrace

Plazas and terraces above occupied spaces, used for public access, are components of the building envelope. Due to the traffic, planters, and other weight on a plaza or terrace, waterproofing treatments are different than those used for roofing and are generally more costly to install and maintain. For the same reason, plazas also require more attention to appearance than do flat roofs. Still, they represent an extension of the building space and usage, and so can be worth the extra effort required for upkeep.

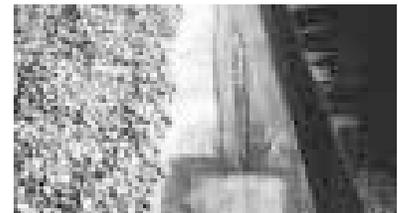
Some form of protected membrane generally shelters building areas under a plaza. This type of system is comprised of a wearing surface, such as pavers or concrete, installed over a setting bed and/or protection layer which, in turn, is installed over a membrane. Since membrane materials used are protected from degradation associated with wear and UV exposure, products are made available which would be unsuitable for roofing. Some, such as butyl membranes, will hold back water under hydrostatic pressure and are ideally suited for this use.

Plaza and terrace repairs are often a great expense and best avoided by high quality design and construction. No matter what materials are used, the most durable systems provide drainage at the surface and at the membrane.

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▲ Workers mop down the first layer of a modified bitumen roof (MBR) over mechanically attached insulation (top left). Single-ply EPDM membrane (a synthetic rubber) is applied (center). The photo above shows the nozzle through which foam roofing is applied. The light colored areas are exposed foam, and the darker sections have already been sprayed with a protective silicone coating.



▲ Due to shrinkage, this PVC single-ply membrane has split at the edge. EPDM patches have been applied in an attempt to reinforce the seam against further tearing.



▲ A fan unit resting on wood sleepers which bear directly on the membrane can cause a puncture or tear, creating a site for water infiltration.



▲ Plazas or terraces, while often a large investment to construct and maintain, can act as a showcase or focal point for a building.

“The equation for finding the most economic building option is not as simple as choosing the cheapest products and methods for the job.”



▲ The patchwork appearance of this plaza shows sites of repair work. Vegetative growth in the mortar joints indicates a constant source of moisture.

Most problems observed, such as leaks, stains and surface deterioration, usually stem from poor drainage. As an example, it is not uncommon to have the wearing (top) surface of the plaza sloped to drains, while the surface at the membrane is level. Water penetrating to the membrane then stays in place, causing the entire system to deteriorate prematurely.

Maintenance and Rehabilitation Goals

While each project has its individual agenda, the three goals that generally make the top of the list are aesthetics, durability, and cost.

Aesthetics

Sensitivity to the surrounding architecture, as well as to that of the building itself, should guide the work. Tenants and the public should always see a finished appearance on all building areas, including visible roofs and plazas.

Before choosing a repair material, compatibility with facade elements and other building systems should be investigated; any products used should match existing materials in color and texture. Often, great care must be taken to blend new products with older, weathered (and consequently discolored) materials. In order to maintain this uniform appearance, repaired sections

should weather similarly to adjacent, existing areas. If landmarked, a building is required to maintain its original appearance following any repair work, and applicable codes and regulations should be investigated before proceeding.

Durability

Any repair effort must eliminate the cause of the previous failure, not just its effect. Without replacing missing snow guards, for instance, damage on lower roofs could be repaired again and again until the cause of the problem (sliding snow) is eliminated. Similar lifespan and properties of new material to old not only improves the building's appearance, it also increases its durability. If existing brick is rated to tolerate severe weather exposure, new brick should be of the same grade, not less. Design and materials should be adapted to the specific building condition, not the other way around. Selecting a product without knowledge of the condition or context will only lead to additional, potentially more costly repairs down the road.

Cost

The equation for finding the most economic building option is not as simple as choosing the cheapest

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Samples of Common Deficiencies

FACADE

Symptom	Description	Probable Cause
<ul style="list-style-type: none"> CRACKING 	Continuous breaks in the surface exhibited as lines of varying width and depth.	Restrained expansion or contraction preventing free movement of the assembly. Settlement or structural deficiency.
<ul style="list-style-type: none"> SPALLING 	Surface delamination or flaking of the finished surface.	Expansive forces of retained moisture.
<ul style="list-style-type: none"> EFFLORESCENCE 	White staining or deposits formed on masonry.	Crystallization of salts in solution. Typically originates from the lime content.
<ul style="list-style-type: none"> EROSION 	Deterioration or wearing leaving a recessed surface.	Severe weather exposure and breakdown of the components.
<ul style="list-style-type: none"> STAINING 	Dark spots formed beneath the finished surface.	Absorption of a foreign substance (e.g. oils or salts) or rusting of supporting anchors.

ROOFING

Symptom	Description	Probable Cause
<ul style="list-style-type: none"> BLISTERING 	Bubbles in the membrane.	Trapped moisture vapor.
<ul style="list-style-type: none"> ALLIGATORING 	Patterned crevices or surface separation resembling the back of an alligator.	Loss of volatiles in the asphalt coating.
<ul style="list-style-type: none"> FISHMOUTH 	Semi-spherical openings in the laps of the membrane.	Improper laying of the felts, preventing full contact at the edge of a roll.
<ul style="list-style-type: none"> SPLITTING 	Tears in the membrane at points of resistance.	Fatigue, shrinkage of the membrane, or stress relief of the material.
<ul style="list-style-type: none"> BRITTLEMENT 	Hardening of the membrane surface, sometimes resulting in discoloration.	Lack of material elasticity resulting from plasticizer migration.

PLAZA/TERRACE

Symptom	Description	Probable Cause
<ul style="list-style-type: none"> HEAVING 	Shifted, displaced, raised wearing surface.	Poor drainage and expansion during freeze cycles. No allowance for expansion.
<ul style="list-style-type: none"> VEGETATIVE GROWTH 	Plant life taking root between pavers and in cracks.	Accumulation of organic matter and insufficient maintenance.
<ul style="list-style-type: none"> SLIPPERY SURFACE 	Icy, wet, or highly polished wearing surface with insufficient traction.	Poor choice of material or finish. Improper snow/ice removal. Poor drainage.

45th STREET

EXISTING FASCIA

EXISTING METAL DECK

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products and methods for the job. At times, it may be desirable to use a cost-effective repair based on a pre-determined time schedule. If the owner plans to sell a building, for example, then continuing to patch the existing roof membrane may be the best answer. But if the owner plans to keep the building for a while, rehabilitation or complete replacement may be the best, albeit initially more costly, option.

Reputable, well established products and companies, although generally

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▲ Restricted movement at a joint prevented expansion of this masonry tile, which then broke under the pressure.



▲ Differential movement of the steel and foam on this roof has led to severe cracking. Like wood, foam also expands and contracts with moisture, further exacerbating the damage.

On the Move

Over time, building envelope materials expand, contract, and shift. Without a tolerance for this activity, and for the differential movement of materials which come in contact with one another, a building envelope can heave, crack, tear, and crumble. Causes of materials' motion include:

- Thermal expansion and contraction
- Shrinking and swelling due to moisture
- Intrinsic tendency to grow or shrink

Materials will move according to their natural tendencies, whether the building is prepared or not. Where two or more materials meet, allowance must be made for their sometimes vastly different rates of expansion and contraction. The intersection of face brick with concrete anchors should include adequate compressible material between the two. Otherwise, as the brick expands and the concrete contracts, the wall will bow to allow for the movement. Within the face material, or between plaza elements, the same considerations must be made, such as a stone band in a brick facade.

A dramatic example of differential movement is that of a foam roof meeting steel termination. Foam's rate of expansion/contraction is ten times that of steel, and it will pull away from the roof edge if meeting steel directly. Softer components are always sacrificial in cases of material incompatibility.

Temperature plays as important a roll in materials' movement as do their inherent properties of expan-

sion and contraction. At night, a roof temperature is cool, but during the day, exposure to sun can elevate it to well above the ambient air temperature, sometimes as high as 120°F. Light and dark colored materials also behave differently according to their absorption properties.

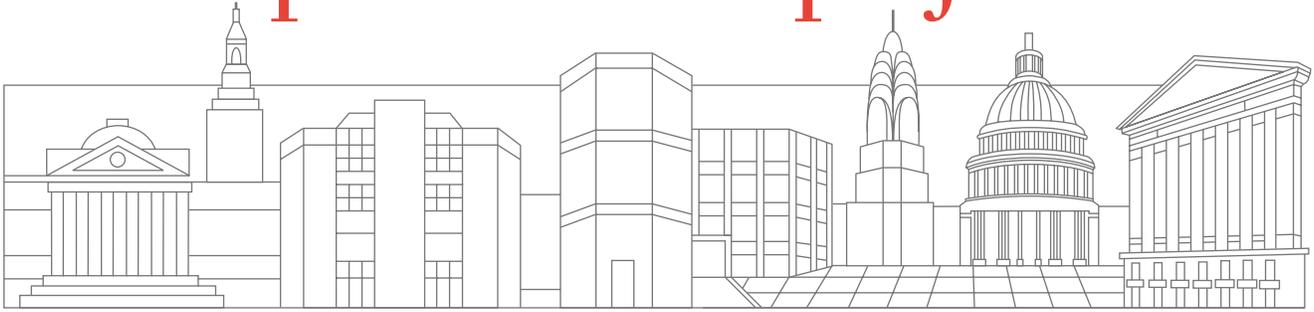
Even the orientation and position of a building can affect its components. The south and west sides of a structure receive greater exposure to

“Materials will move according to their natural tendencies, whether the building is prepared or not.”

sunlight than do the north and east sides, exacerbating the expansive problems in those areas. In a city, certain buildings are always in shade from surrounding, taller structures. On paper, it is easy to neglect these factors, and to design as though the building were standing alone, with equal movement on all sides.

A building envelope is always “on the move.” The key is an understanding of materials' properties, and of how they interact, both with each other and with the environment. With proper design, expansion/contraction, differential movement, and thermal forces need not be a source of future trouble. **FA**

representative projects



The Building Envelope

As specialists in the rehabilitation of building exteriors, Hoffmann Architects has experience in a wide spectrum of envelope deterioration issues. Whether it is a leaking plaza or a crumbling parapet wall, Hoffmann Architects has the expertise to guide the project to a successful completion. Beginning with a review of original drawings and documents, the team then heads to the field to conduct visual observations and test probes and, if necessary, retains samples for materials analysis.

Once the underlying cause of the problem has been determined, the firm works out a scheme based on the client's short- and long-term needs. Hoffmann Architects has designed everything from minor repair work to comprehensive master plans. Keeping with the goals of aesthetics, durability, and cost-effectiveness, Hoffmann Architects works with each client to create a program of maintenance and repair that best meets the project objective.



▲ 1166 Avenue of the Americas in New York City. Plaza and Facade Rehabilitation.

Among Hoffmann Architects' exterior envelope projects are the following:

York Correctional Institution 21 Buildings

Concrete Masonry/Roof Rehabilitation
Niantic, Connecticut

25 Sigourney Street High-Rise Office Building

Roof Coping and Masonry Repairs
Hartford, Connecticut

Southern New England Telephone Company

Central Office Buildings
Roof and Masonry Rehabilitation
Various Connecticut Locations

**Southern Connecticut State
University**
Buley Library and Farnham,
Wilkinson, Chase, and Neff Halls
Building Envelope Condition Survey
New Haven, Connecticut

Bell Atlantic
15 Metro New York Buildings
Facade, Roof, Window, Interior
Condition Investigation and
Rehabilitation
New York, New York

One Park Avenue
Facade, Roof, and Parapet
Investigation and Rehabilitation
New York, New York

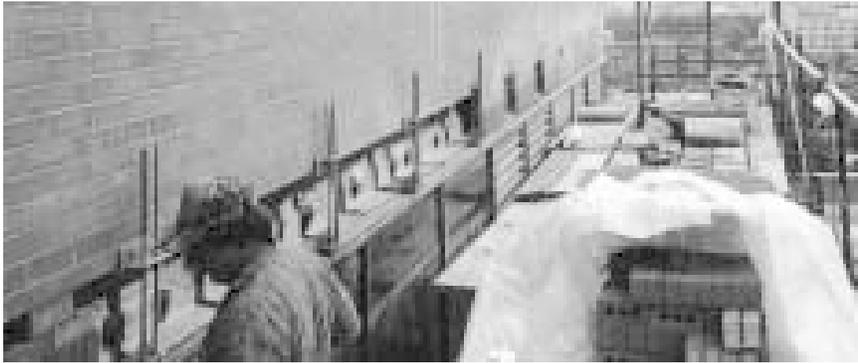
University of Maryland Eastern Shore
Physical Education and Health Center
Roof Investigation
Princess Anne, Maryland 



▲ Columbia University Morningside Campus, 60 Buildings. Facade and Roof Investigation and Rehabilitation.



▲ MetLife Building in New York City. Facade Condition Investigation and Rehabilitation.



▲ When repairs become necessary, temporary shoring and protection of surrounding areas may be required. The cost of such additional measures should be calculated into the overall budget for the project.

more expensive, should be used to solve continuing problems, rather than “bargain” competitors. Often, lower-grade products have the same installation cost as premium ones; performance differences, however, can be significant. Never assume that implied warranties will make up for the disparity in prices. What good is a warranty that assures a leaky roof is always repaired, if the roof leaks frequently? Properly diagnosed, designed, and installed remedies will provide the best cost savings.

Plan of Action

With the seemingly endless quantity

of products on the market for restoring and maintaining exterior building elements, it's no surprise that inappropriate materials, poor installation, and improper maintenance work often conspire to bring about building deterioration. Combine this with factors such as age and severe weather, and building envelope rehabilitation can seem a daunting task.

To determine the root cause of the problem, a thorough investigation and review of original plans and specifications, along with a physical inspection, should begin the repair effort. An understanding of material compatibility and of proper waterproofing design is essential; what works on a new, non-load bearing facade won't necessarily hold up on an older, load-bearing system. Expert preparation and execution of the construction contract will protect against errors and, consequently, against more costly future repairs. ■

JOURNAL is a publication of Hoffmann Architects, specialists in the rehabilitation of building exteriors. The firm's work includes investigative and rehabilitative architecture/engineering services for the analysis and resolution of problems within roofs, facades, glazing, and structural systems of existing buildings, plazas/terraces, and parking garages.

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