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journal

Waterproofing Challenges

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Waterproofing failures are more easily overlooked than roofing failures, so we tend to hear less about them. But compared with a reroofing project, a below-grade or interior waterproofing rehabilitation can be far more disruptive—and expensive. While prevention is the obvious first choice for waterproofing success, there are many occasions for error: in design, during construction, and throughout operation.

Whereas a roof leak can generally be identified with simple test probes, waterproofing breaches can be challenging to diagnose. Even a seemingly superficial leak can be symptomatic of hidden moisture-related deterioration. For basements, vaults, tunnels, and water features, excavation of overburden is often necessary; kitchens and lobbies can require removal and replacement of fixtures and finishes.

A complete reroofing project can usually be anticipated, in most commercial and institutional applications, every 20 years or so. Waterproofing, because it is so difficult to access, should have a design life as long as that of the building. With so many opportunities for damage, incorrect design, or poor execution, waterproofing systems can fail well before their time. When this happens, architectural investigation is needed to determine the location and cause of the leak, the extent of the damage, and the appropriate remedy.

Once below-grade waterproofing is buried, leaks due to faulty application can be difficult to resolve.

Water infiltration doesn't fix itself. While it can be a major undertaking to properly identify and correct faulty waterproofing, it is far worse to adopt a patch-it-and-hope-for-the-best attitude. All too often, even well-meaning attempts at treating the symptoms of waterproofing failure serve only to trap or redirect moisture, compounding the problem. Until the waterproofing deficiency is resolved, the problem will only get worse.

Waterproofing 101

First, let's review the basics. Various components contribute to a waterproofing system, such as drainage composites that direct water away from the structure, tie-ins between facade and foundation membranes, and watertight plumbing in food service areas.

Impervious membranes are one critical component of waterproofing, both for below-grade applications, such as foundation walls, basements, tunnels, and vaults; and for areas subject to high moisture levels, like fountains, lobbies, kitchens, and mechanical rooms. Waterproofing membranes may be applied in one of two ways: *positive side* and *negative side*.

Richard Kadlubowski, AIA, senior vice president and director of architecture, and Dean Yates, AIA, project architect, manage building envelope rehabilitation projects at Hoffmann Architects' Washington DC area office, where they solve complex or unusual waterproofing situations for existing buildings, new construction, fountains, kitchens, lobbies, below-grade structures, terraces and plazas.

Positive Side

By creating a waterproof barrier on the side of applied hydrostatic pressure, positive side waterproofing prevents water from entering the wall. For a foundation, this would be the outside surface, closest to the soil; for a fountain, it would be the inside, where the water is.

For below-grade applications, the earth can be banked back such that a positive side membrane is installed after the foundation is set. In urban areas where every square inch comes at a premium, this may not be an option. Blind side waterproofing incorporates the waterproof membrane on the face of the shoring before the foundation is cast. Concrete is then poured, and the waterproofing fuses to the foundation wall as it cures.

Pros. Positive side systems, used both above and below-grade, are generally preferred over negative side applications for their effectiveness. The structural barrier is completely protected from corrosive chemicals in groundwater, as well as freeze-thaw cycle damage. Options include:

- *Fluid applied membranes,* similar to those used in roofing applications, roll or brush on as a liquid and cure to form a monolithic, seamless membrane.
- *Sheet systems* are also similar to those used on roofs, including single-ply thermoplastics and rubberized asphalts.
- *Hybrid systems* combine a fluid-applied membrane with embedded fabric reinforcing to create a stronger, more resilient waterproof barrier.
- *Bentonite clay* is a natural mineral derived from volcanic ash, which swells in the presence of moisture to create a solid clay barrier. It is applied as a sheet, mat, panel, or spray.

Cons. The shortcoming to positive side systems lies in leak detection and remediation. Blind side waterproofing cannot be inspected once the concrete is poured. Even for membranes installed after concrete is cast, it's too late to correct for sloppy installation once the waterproofing is buried. If the system fails, rehabilitation can involve major excavation and reconstruction of paving, landscaping, and wall systems.

GLOSSARY

Blind side waterproofing: Installation of waterproofing membranes and drainage before the concrete foundation is poured.

Capillary action: Movement of liquid in porous materials or thin tubes (capillaries), due to attraction between the molecules of the liquid and those of the solid.

Condensation: The change in phase from a gas to a liquid, as when water vapor cools to liquid water.

Damp-proofing: A coating designed to limit soil moisture penetration.

Efflorescence: A white crystalline or powdery crust, made up of dissolved salts deposited by water seepage after evaporation.

Hydrostatic pressure: The force exerted by a fluid, such as water, due to gravity.

Negative side waterproofing: A barrier opposite the side of applied hydrostatic pressure (e.g. the interior of a foundation wall), whereby water can enter the wall but not pass through it.

Positive side waterproofing: A barrier on the side of applied hydrostatic pressure (e.g. the exterior of a foundation wall), such that water is blocked from entering the surface.

Waterproofing: A system that may include coatings, membranes, drainage media, perimeter drainage, interior channels, sump pumps, or other elements, designed to prevent and manage water infiltration.

Blind side waterproofing sheet with drainage composite, installed prior to concrete.

Positive side waterproofing defects, viewed during repair excavation.

Negative side

Negative side waterproofing protects the surface opposite the side of applied hydrostatic pressure (the inside of a basement wall, for example), such that water is redirected after it enters the substrate.

Pros. Because the negative side is more accessible, it is easier to identify leak locations. Negative side coatings or injections also can be applied as a retrofit measure. Material types include:

- *Cementitious systems* combine chemical waterproofing additives or acrylics with cement and sand to achieve an impervious surface.
- *Acrylic, latex, or crystalline additives* are also available, which penetrate into the surface to provide water protection.

Cons. Moisture does enter the wall system, which can cause components to degrade over time. The constant presence of moisture can lead to mold growth, corrosion, concrete deterioration, or damage to interrelated building elements like floors or windows if not directed to escape the building system.

Combination systems

For sensitive spaces below-grade, more sophisticated systems have been used. As an example, a rare book vault built below the water table employed a wall-within-a-wall arrangement, with a pump system in the channel between the inner and outer walls to augment the positive side membrane.

Damp-proofing Demystified

Many people mistakenly use the terms *damp-proofing* and *waterproofing* interchangeably, but they are not the same.

Damp-proofing is a bitumen based or cementitious treatment applied to the positive side of foundation walls. The quick, inexpensive coating aims to discourage moisture from wicking up into below-grade walls through *capillary action.* Named for the tiny, thin apertures, or capillaries, in porous materials like masonry and concrete, capillary action moves water from damp to dry areas, sometimes against gravity.

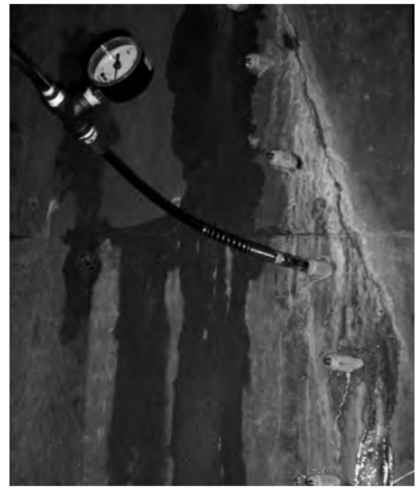
Waterproofing represents a much broader class of moisture protection. Unlike damp-proofing, which cannot bridge cracks, a waterproof membrane can stretch to accommodate some degree of differential movement, settlement, and shrinkage. Even when subjected to the *hydrostatic pressure* of a high concentration of water, waterproofing is designed to be flexible and durable.

Damp-proofing is not a substitute for waterproofing. Damp-proofing is sometimes used because it is much less expensive than a waterproof membrane. However, damp-proofing products are of a lesser grade than waterproofing materials, and they are applied as a sparse coat with little attention to detail. Waterproofing membranes demand precise application and detailing, and they can be reinforced with integral fabrics for increased stability. True, damp-proof coatings are cheaper at the outset. But the long-term durability and effectiveness of properly selected and installed waterproofing are well worth the extra up-front cost.

Waterproofing Failures

Don't discount seemingly minor evidence of moisture, which may presage waterproofing distress:

- Blisters or peeling paint
- Mold, mildew, and vegetative growth
- Dampness or dribbles of water
- Stains and rust
- Odors
- Efflorescence, or white powdery deposits
- Cracked walls
- Wood rot



▲ **Negative side waterproofing** injection via ports along a foundation wall crack. Gauge monitors pressure of injected resin.

Moisture-related deterioration becomes more costly to repair the longer it is allowed to progress. Keeping a record of water infiltration symptoms is important to establishing how, where, and when moisture is penetrating the waterproofing system. What to do if you spot signs of water entry:

1. Review the leak history.

Note how the building responds to weather events, such as high humidity, rain, or snow. Temperature fluctuations affect building materials, so record any correlations with moisture observations.

If the leak is worse after it rains, surface runoff is the likely cause. Check joints between walls and slabs, as well as conduits.

If the leak is constant, uncorrelated with rain, it may be caused by a water line, either potable or sanitary sewer. Even an adjacent excavation or infill construction can indirectly lead to leakage by causing differential settlement cracks or changing water flow.

If the leak occurs after using certain equipment in a kitchen or mechanical room, perform usage tests to identify the faulty component.

If water bubbles up between the foundation wall and the slab on grade, rising groundwater levels may be the issue, or a combination of groundwater and surface runoff. Flash storms may overflow combined sanitary and storm sewers, raising the water table. Clogged or inadequate perimeter / footing drains can also contribute to the problem.

2. *Identify the water source.*

A water test can tell you which type of water is leaking.

If the water contains chlorine, it is potable (drinking) water, and the source is likely a plumbing leak.

If the water has a high coliform count (e.g. e. coli bacteria), a sewage waste line is the problem.

If the water tests negative for both of the above, it is most likely groundwater or storm water.

3. *Rule out ambient moisture.*

Where there is a significant temperature differential between inside and outside, condensation—not leakage—may be the culprit. To test, secure a piece of impervious material, such as aluminum or plastic, to the wall where you have observed moisture, and wait a few days.

If the sheet is wet on the side facing the wall, water intrusion through the wall surface is most likely the problem.

If moisture appears on the side facing the room interior, condensation may be to blame, which can be addressed by adjusting HVAC equipment or improving ventilation.

4. *Determine the leak location.*

Water is deceptively migratory, such that the spot where stains or cracks are observed can be quite remote from the site of water entry.

Correlate with events. When, where, and under what conditions you have noticed signs of moisture can help determine the water access pathway.

Correlate with design. Original as-built drawings and construction specifications provide clues as to potential weak spots in the waterproofing system.

Non-destructive testing. Flood tests saturate an area, such as the backfill at a foundation wall, to generate conditions conducive to moisture penetration. Waterproofing failures can then be noted and addressed. Additives, such as dyes or scents, incorporated into the flood test water can help identify leaks that are otherwise difficult to detect.

Exploratory openings. Test probes can verify the source of a leak once investigation points to a probable source.

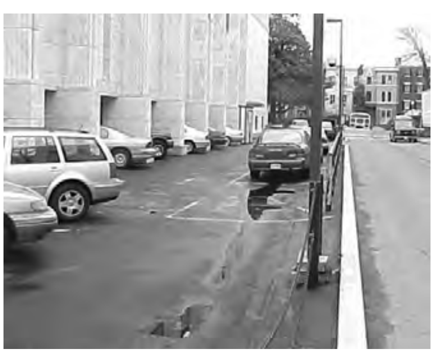
5. *Resolve the leak.*

With the likely water type, source, and location of the leak pinpointed, your architect or engineer will recommend a course of corrective action, which may include:

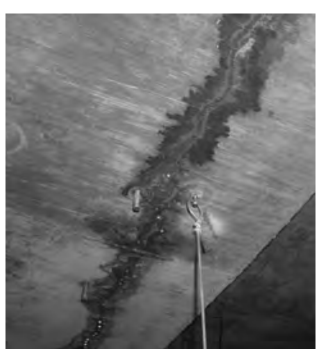
Drainage improvements. Storm water leaks can often be resolved by redirecting water away from the foundation. Repair areas include:

- Improperly connected leaders and gutters
- Downspout extensions too close to foundation walls
- Clogged roof drains and gutters
- Flashing failures in pools or planters
- Expansion joint failure at plazas and pedestrian tunnels
- Leaking underground oil storage tanks causing membrane disintegration

Below-Grade Vault Waterproofing: Folger Shakespeare Library



Below-grade vault is under parking deck.



Leaks at underside of deck.

Excavation to expose vault and deficient waterproofing.

- Backfill settlement directing surface water to footings
- Improper drainage and seals at stairways, window wells, and openings
- Inadequate subsurface drainage

Injections at interior surfaces. Resolving cracks through injection with epoxy, hydrophobic or hydrophilic resins can be an economical way to solve minor waterproofing problems without excavation and reconstruction. The danger, though, is that this approach can be a shot in the dark, as it is nearly impossible to know what conditions are on the other side of the wall without seeing firsthand.

In one anecdote from a waterproofing contractor, injections were used to resolve failures in an aquarium tank. The job went over budget as more and more material was required to fill cracks. When the team finally finished and tried to refill the tank, nothing happened. The sealer had penetrated directly into the water system, filling conduits and clogging the pump. Repair costs far exceeded the initial project budget. The moral: where injected material has the potential to penetrate subsurface systems, it's probably best to take the known cost of investigation, excavation and repair over the unknown cost of blind injection.

Water barriers at penetrations. Appropriate moisture protection, including sealants, should be installed at penetrations. However, unless moisture problems are stopped at their source, such barriers may only serve to re-direct water to another weak point. Good sealant integrity is important, but it is really a secondary waterproofing provision. The primary measure is to control moisture levels.

6. *Repair the damage.*

The leak is resolved, the deterioration arrested. But the damage has been done. To repair walls, fixtures, and finishes, your design professional may recommend:

Concrete rehabilitation. Where water infiltration has led to reinforcement corrosion, steel should be repaired and sealed, followed by application of a compatible concrete patching mortar. Migrating corrosion inhibitors, either integrated into the patching compound or applied as a surface sealer, can provide additional protection.

Mold remediation. Moisture can lead to mold growth, a health hazard which may require professional removal and cleaning.

Plaza, sidewalk, and landscape restoration. If excavation is necessary, or if leaks have damaged fixtures or dislodged pavers, then outdoor finishes and plantings may need to be reconstructed following waterproofing remediation. Portions of the facade may also require rehabilitation.

Interior repair. Where leaks migrate into occupied space or originate at an indoor area, water-damaged drywall, trim, paint, ceiling tiles, flooring, and fixtures may need to be replaced once the new waterproofing system is installed.

The longer a leak is allowed to progress unchecked, the more extensive the underlying deterioration can become. Stopping a minor leak is far easier than rehabilitating the damage from a major one.

Causes of Waterproofing Failure

Design Omissions

In cases where unusual intersections, multiple penetrations, or differential pressures demand elaborate detailing, designers are sometimes guilty of leaving these vital junctions to the discretion of the contractor. Where a waterproofing construction team has had success with similar configurations in the past, this may not cause a problem. But in the more likely event that the general contractor is facing an unusual arrangement that demands sophisticated design, relying on standard details is probably not sufficient.

Bent water stop in vault wall.

Spray-applied liquid waterproofing.

Application of deck waterproofing with reinforcing fabric.

Flood test of waterproofing on rehabilitated deck.

It is the responsibility of the designer to detail any situations in which waterproofing might be compromised.

Contractor Negligence

Even the most rigorous and exacting drawings and specifications are of little use when contractors don't take care with materials and installation. Careless backfilling is a primary source of waterproofing failure, as is damage from heavy equipment. As an example, the contractor at a below-grade book vault rushed to pour concrete walls without regard for delicate water stops, crumpling them in the process and rendering them useless. The resultant water infiltration required extensive excavation, concrete repair, and waterproofing rehabilitation to resolve.

Deficient Quality Assurance

Oversight and review during construction by an owner's representative is an essential part of the quality control process. Should site conditions differ unexpectedly from design documents, or unforeseen circumstances present themselves, an on-site architect or engineer can respond to last-minute changes without delaying the construction schedule. The design professional can direct the general contractor to protect the work of the waterproofing installer from damage during construction.

Fountains demand extra attention to waterproofing detail, especially when over occupied space.

Dishwashers and other kitchen equipment introduce a high-volume water source with a high potential for leaks.

Moreover, the site representative is there to see that construction proceeds according to design intent. Eliminating this important part of the design process is often justified by owners with claims of guarantees or, failing that, litigation. Pointing the finger of blame, however, doesn't fix the problem. While field reports and photographs can serve as evidence at trial, the real benefit to on-site quality assurance lies in avoiding waterproofing failure in the first place. Submittal review and formalized inspection can make the difference between a successful waterproofing project and catastrophic failure.

Special Waterproofing Situations

Water Features

If a fountain sits above occupied space, even a small leak may be immediately noticeable as damage to interior fittings or finishes. For water features on grade, however, the only sign of trouble may be an uptick in the volume of make-up water added to keep the water level consistent. Pools and fountains are closed systems, so water loss should be minimal. If you're adding far more water than would be necessary due to evaporation, you may have a leak.

Kitchens, Lobbies, and Tank Rooms

Where numerous penetrations, complex plumbing systems, liquid storage units, and heavy traffic combine, waterproofing distress is hard to avoid. Pumps, dishwashers, and tanks add a high-volume water source to a space—and a high potential for leaks. From the brewing room at an entertainment complex to the lobby of an urban hotel, water infiltration at essential operational facilities is as logistically difficult to resolve as it is challenging to diagnose. Such functional spaces cannot be closed down for weeks at a time while waterproofing remediation proceeds. Thoughtful phasing is needed to take advantage of usage downtimes and to permit continuous operation during critical periods.

Tunnels

Where high basements or tunnels penetrate foundation walls, water entry is a common problem. If the floor of a tunnel is a slab-on-grade, where the concrete rests directly on the ground, and the foundation wall extends below this slab at the intersection, water will follow its natural

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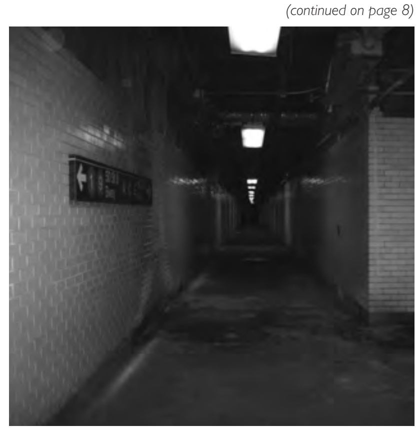


Pedestrian tunnels offer convenient access, but their location under busy areas makes waterproofing particularly challenging.

representative projects

Waterproofing

From fountains to foundations, from vaults to tunnels, lobbies, even beer rooms, Hoffmann Architects' waterproofing experience is both diverse and specialized, as we apply focused expertise to a range of settings and situations. Our architects and engineers provide waterproofing consultation and review for new construction, as well as for the rehabilitation of existing structures.

At Hoffmann Architects, our remediation designers investigate and correct water infiltration conditions at schools, corporate headquarters, libraries, nonprofit foundations, national landmarks, and other critical facilities, including:

Folger Shakespeare Library
Washington, District of Columbia
Book Vault Waterproofing Rehabilitation

Helmsley Medical Building
Greenwich Hospital
Greenwich, Connecticut
Foundation Waterproofing Rehabilitation

InterContinental Hotel at the Cleveland Clinic
Cleveland, Ohio
New Construction Below-Grade Waterproofing Consultation

Severence Hall
Wellesley College
Wellesley, Massachusetts
Foundation Waterproofing Rehabilitation

The Ford Foundation
New York, New York
Basement Water Infiltration Consultation

Foxwoods Resort Casino
Mashantucket, Connecticut
Beer Pump Room Waterproofing and Floor Repairs

Lerner Hall
The George Washington University
Washington, District of Columbia
Classroom Water Infiltration Remediation

American Express Tower
New York, New York
Kitchen Waterproofing Rehabilitation

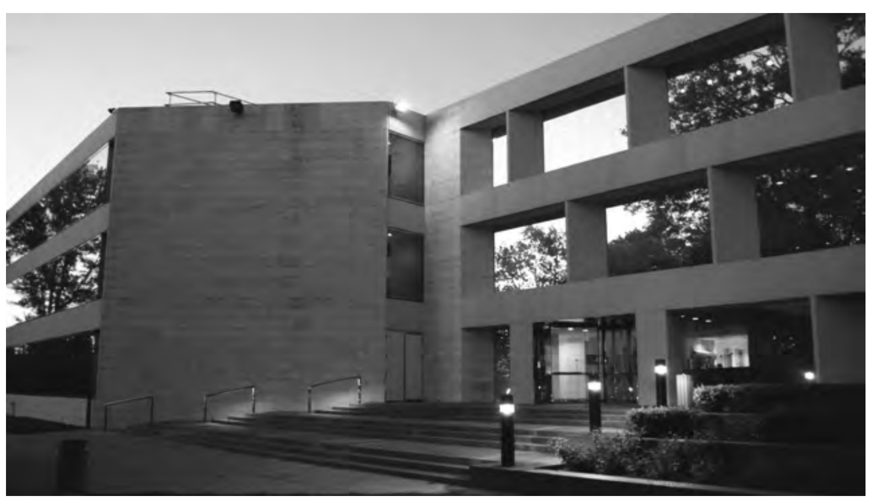
UBS Headquarters
Stamford, Connecticut
Kitchen Waterproofing Investigation and Repairs

Special Collections Library
University of Virginia
Charlottesville, Virginia
New Construction Waterproofing Consultation for Below-Grade Structure

ARINC Headquarters
Annapolis, Maryland
Below-Grade Waterproofing Rehabilitation

Pfizer World Headquarters
New York, New York
Lobby, Kitchen, and Vault Waterproofing Rehabilitation

Orchestra of St. Luke's
DiMenna Center for Classical Music
New York, New York
Below-Grade Waterproofing Rehabilitation



MasterCard Headquarters in Purchase, New York. *Plaza and kitchen waterproofing investigations and rehabilitations.*

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Suspending kitchen operation for waterproofing rehabilitation is hardly desirable. But if leaks are ignored, water damage to structural systems and finishes will only make things worse.

tendency and run downhill, into the deeper below-grade space. Transitions such as these demand extra attention to detailing and construction sequencing to prevent failures.

Waterproofing Success

Bad apples don't go good. For even the best performing systems, keep a watchful eye out for signs of trouble, so that you can stop burgeoning problems before they have a chance to get out of hand.

In new construction situations, owners can avoid costly waterproofing rehabilitation through appropriate design, correct application, and due diligence during construction. Owners and managers of older buildings have to deal with what they've got—and, often, that means addressing inexpertly designed or incorrectly installed moisture protection systems.

With some thoughtful detective work and creative water management strategies, you can find the right resolution for even the most demanding waterproofing applications. The best bet is to waterproof basements, tunnels, mechanical rooms, below-grade levels, kitchens, vaults, water features, and sensitive spaces diligently and correctly from the outset. ■

JOURNAL is a publication of Hoffmann Architects, Inc., specialists in the rehabilitation building exteriors. The firm's work focuses on existing structures, diagnosing and resolving problems within roofs, facades, windows, waterproofing materials, structural systems, plazas/terraces, parking garages, and historic and landmark structures. We also provide consulting services for new building construction, as well as litigation and claim support.

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