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Journal

Waterproofing Solutions 1

Coatings: Friend or Foe?

John J. Hoffmann, FAIA and Bruce R. Soden

When it comes to waterproofing, there are no pat answers. A leaky building can be especially frustrating in light of the myriad remedial options available, ranging from complete materials replacement, to repair of components, to sheet membranes, to coatings. When water infiltration leaves spalled masonry and concrete, rusted reinforcing steel, and stained interior finishes in its wake, the initial reaction is to stop the leak as quickly and with as little disruption as possible. So what's an owner, manager, or building professional to do?

Gut instinct might be to coat over an offending crack in order to block more water from entering the structure. While this thinking is perfectly logical, more often than not it doesn't help the problem. In fact, using a coating in the wrong situation, or using the wrong coating for a given material, can actually exacerbate the damage.

While coatings do block water from penetrating a material, they can also have the reverse effect: stopping moisture already inside from escaping. No matter how many precautions are taken to fight water entry, small amounts of moisture inevitably find their way in. The more waterproof the coating, then, the harder it becomes for that trapped moisture to escape. Eventually, moisture may build up behind the coating and erode underlying brick, stone, or concrete. If the problem is left unattended, water can penetrate to underlying reinforcing steel, leading to structural damage and even more costly repairs.

So is there ever a right time to coat? If coatings can do so much damage by locking moisture inside a wall, why are they used so extensively? The solution lies in using a discriminating sensibility. With some knowledge on your side and an expert opinion to guide you, the choice of where and when to coat need not leave you feeling waterlogged. Follow the simple guidelines outlined below, and you'll be well on your way to a shipshape structure.

▲ A worker spray-applies a breathable elastomeric coating to a concrete corporate facility.

Steps to Waterproofing Success in the Use of Coatings

1. Find the underlying problem.

When spalled brick, deteriorating mortar joints, or delaminating concrete slabs rear their ugly heads, it's easy to mistakenly see the symptom as the cause. Patch the unsightly brick and you're done, right? Unfortunately, that's not usually the answer. Hoffmann Architects is often called on to resolve repeat repairs that have failed time and time again. These clients, understandably, throw up their hands after several unsuccessful repair efforts and ask us: *what do we do with this mess?*

(continued on page 2)

John J. Hoffmann, FAIA, Principal of Hoffmann Architects, is a nationally recognized expert on building envelope rehabilitation. As Senior Project Manager, Bruce R. Soden oversees a variety of waterproofing projects for the firm.

(continued from page 1)

The first step is a thorough investigation into the likely sites of water infiltration. Case in point: limestone may be deteriorating due to moisture infiltration at cracked mortar joints. A waterproof coating applied once failed to help, so it was reapplied two or three more times over a period of a few years. But delamination only seemed to get worse. The problem? Water repellent coatings work by changing the capillary action of the pores in the face stone from positive (suction) to negative (repellency).

Applying roofing mastic as a coating on this masonry parapet had little damage-control success, even as a temporary fix. Re-building would have ended decay from the start – and spared the expense of repairing the wall twice.

In the percentage strengths normally used (5-8%), water repellents will not bridge nor fill hairline cracks and poorly filled joints in the face of stone or masonry walls. What's worse, reapplications can reduce the permeability of the coating, resulting in greater retention of trapped moisture. That explains the *increase* in rate of deterioration following repeat application of the coating.

Other possible sources of water infiltration include old or weathered materials, poor original design or construction, and improper installation. By looking beyond the outward symptoms of the problem, the architect can develop a better, long-term solution to waterproofing issues.

When the water repellent coating applied to this exterior brick wall trapped moisture inside, holes were drilled in an unsuccessful attempt to let water back out.

Test probes, laboratory analysis, and site visits may all be necessary to develop a design that will hold up to the abuses of weather and aging. Application of a water repellent coating in lieu of necessary repairs is never a good solution.

In a new structure, it's important to think ahead to where problems could occur in the future. Trouble spots such as joints, flashing, and material intersections should be closely examined. Although water repellent coatings are often prescribed as insurance against water infiltration, they cannot compensate for quality design and construction. Good waterproofing takes into account upkeep costs, accessibility by maintenance crews, life-span and durability, material compatibility, and water entry points. Using a weather-ready facade design can better minimize water infiltration repairs down the road than can provisionary application of water repellent coatings.

2. Consider reasons for use.

Water repellency.

In climates subject to freeze-thaw conditions, water repellent coatings can be useful for walls particularly vulnerable to water infiltration, including barrier walls and parapets. Where remedial waterproofing is called for, application of coatings should be considered only after other repair measures fail to remedy the problem. If defective mortar joints, copings, sills, or expansion joints are the culprits, adding a water repellent coating will do little to address the problem. In fact, change in the absorption properties of masonry or concrete may have no effect on the water penetration of the wall system as a whole.

Water infiltration is one of the most frequently encountered problems with exterior walls, and its effects can be devastating to the structure. When water passes through the face material, soluble salts may be liberated as moisture turns to water vapor. Ordinarily, these salts may be deposited on masonry surfaces as efflorescence. In the presence of a water repellent coating, however, they may become trapped beneath the surface. As salts crystallize, they expand, eventually leading to cracks and spalls in masonry as it tries to accommodate the increase in volume. These openings in turn create further sites for water entry, perpetuating the cycle of deterioration. Corrosion of metal reinforcement, ties, studs, and other structural members is also of paramount concern with a water infiltration problem. Wood elements are subject to rotting, mold, and mildew growth, as well as moisture-related swelling and shrinkage. Finally, and sometimes most noticeably, water penetration can leak through the building envelope to damage interior finishes.

In new construction, the potential for accelerated deterioration often outweighs any benefit of water repellent coatings. Rather than keep moisture out of the structure and protect against the aforementioned water infiltration problems, these coatings in many cases serve to lock water into the structure. Instead, quality design and workmanship are the best assurance against future moisture damage.

On an existing structure with water infiltration problems, several months should be allowed following remedial work to determine if coatings are

necessary. If the problem persists, or if budgetary constraints preclude a long-term solution, coatings may be considered. In the end, however, proper investigation and repair work tend to be the more economically sound decision, despite their initially higher investment. When the cost of maintenance is considered, in addition to potentially more costly repairs if the coating fails, the better financial choice, generally, is proper repair. Again, coatings are not a replacement for thorough remedial work.

Aesthetics.

One effect of certain coatings is a glossy, slick appearance which often darkens the material, giving it a 'wet look.' For some situations, this may actually be an undesired result of poor coating selection or application. Careful consideration must be made of coating properties and compatibility with the substrate prior to making a selection. Some coatings cause a yellowing of certain materials, or an added sheen. Unless these are desirable characteristics for a given project, alternative options must be sought. In the case of pigmented coatings, color matching is an additional hurdle. To be certain that a coating will have the desired appearance, a test area of approximately 4' x 4' that includes all textures and colors to be coated should be pretreated and allowed to cure. The design professional and the owner can then determine whether or not the material meets the intended aesthetic goals.

Another consideration for many public buildings is resistance to graffiti. Some water-repellent coatings have the added benefit of keeping graffiti and other dirt on the surface of the masonry in order to facilitate cleaning.

Protection of substrate.

On masonry with a relatively high absorption, such as that which has been sandblasted, colorless coatings are sometimes used to protect the wall from excess moisture penetration. Less water absorption may mean decreased incidence of staining or efflorescence. However, if the wall is already stained at the time of coating application, the dirt and salts may be nearly impossible to remove. Adding a coating only serves in such cases to seal stains beneath the clear surface layer.

Of particular concern with concrete is a natural phenomenon called *carbonation*. Again, moisture penetration is the culprit, but this time it's partnered with atmospheric carbon dioxide. As the two enter the concrete pores, high pH calcium hydroxide is converted to calcium carbonate, which has a more neutral pH. Without an alkaline environment, the protective passive oxide layer on underlying steel reinforcement is destabilized, and the metal begins to corrode. As it rusts, steel expands to several times its normal size, leading to spalls and cracks in the concrete, as well as to a general weakening of structural elements.

Anti-carbonation coatings are often used effectively to block the penetration of carbon dioxide into concrete structures. In order to allow moisture to escape, the coating should be breathable. Keep in mind that not all water-repellent coatings are anti-carbonation coatings and should not be used as such. Many do not form an effective carbon dioxide barrier. Use of an inappropriate coating may actually *accelerate* carbonation by drying out the concrete enough to allow more rapid entry of carbon dioxide. As always, consult a design professional for specific coating guidelines, as each building has its individual needs.

▲ Two good reasons to use coatings: improved water repellency and ease of graffiti removal. Moss growing in joints is evidence of excessive moisture in the wall.

▲ Even if masonry cracks are patched prior to coating application, the problem can recur unless the source of deterioration is also addressed.

3. If a coating is needed, select the appropriate one for the job.

If after careful evaluation by an experienced professional, it is determined that your structure would benefit from application of a coating, selection of the right one for the job becomes the next important hurdle. First and foremost to consider are the function and material properties of the substrate. Sub-grade surfaces, for example, will have significantly different considerations than will above grade ones, especially when it comes to maintenance in retrofit or repair applications. Below grade waterproofing is usually applied *negative side*, or on the side of the wall opposite water contact, whereas above grade waterproofing is most often applied *positive side* (see Glossary). Horizontal or vertical orientation is another factor to be considered. Whereas high gloss may be desirable on some exterior walls, the necessary coefficient of friction for traffic surfaces (usually 0.5) precludes use of such slippery coatings. Finally, different materials respond in different ways to a

(continued on page 4)

(continued from page 3)

Although coatings can make a facade appear neat and uniform, that may be merely a superficial integrity.
▲ *(top)* This wall stayed dry only to the depth of coating penetration – just a fraction of an inch. The rest of the brick absorbed water, which remained trapped behind the coating. Notice, too, the sheen of the coated surface.
▼ *(bottom)* Although this masonry seemed to be in perfect condition, partial removal of the face brick revealed inner wythes that had crumbled nearly to dust.

given coating, so what works on concrete may not necessarily work on brick masonry. Barrier walls without the waterproofing protection of interior air space and weep holes may also have different coating responsiveness than does a cavity wall system.

Selection Criteria

Factors to consider when selecting a coating vary depending upon the goals of the building owner and design team, as well as on the unique properties of the structure. When comparing what can be a daunting array of coating options, however, it does help to keep in mind the following criteria in order to narrow the search:

- Aesthetics
- Water penetration and water repellency
- Breathability
- Durability and life-span
- Maintenance/upkeep requirements
- Environmental issues
- Material compatibility
- Economics
- Desired effect (e.g. carbonation resistance, graffiti prevention)

The accompanying chart lists several of the more significant properties for various coating types and coating alternatives (e.g. liquid membranes). For a particular application, some coating properties may play a more important role than others in the selection process. In a concrete building designed to prevent the spread of fire, addition of a coating with low fire safety ratings would negate the structure's inherent flame retardance. A sub-grade garage in an enclosed space precludes use of certain coatings due to their high *VOC content* (see Glossary), as fumes could be hazardous to workers or tenants. Always remember to check material data sheets for specific coating properties, as values may differ significantly from product to product.

4. Use proper application technique.

Even if the right coating is selected for a given project, problems can still result if application is not executed correctly. Certain coating deterioration issues such as delamination, cracking, and blistering may be avoidable if care is taken in surface preparation and coating technique.

Before any coating is applied, surface defects must be corrected in order to create a uniform area for coating application. Any dirt, dust, grease, efflorescence, curing compounds, paint, or other foreign matter should be cleaned, and surrounding areas protected from overspray or accidental incorrect brushwork. Atmospheric dirt will interfere with proper penetration or adhesion of the coating. To clean concrete or masonry, procedures such as 'power washing' are often used, wherein high-pressure water or steam, sometimes mixed with mild detergents, forces dirt off an exterior surface. Other methods include hand-scrubbing, air blast cleaning, and simple vacuum or broom cleaning (for horizontal surfaces). On historic structures and soft masonry, long-term soaking and washing loosens hardened grime without hurting delicate materials. Sandblasting or harsh chemical washes are *not* recommended, as they tend to cause more problems by damaging the substrate than they solve by removing stains.

It is crucial to wait a minimum of 24 hours following any kind of water washing before applying a coating, in order to allow the wall to dry sufficiently. Cleaned surfaces should be tested for moisture at various sites just prior to application. If excess hydration remains, the coating will trap it inside the wall, exacerbating any water-related deterioration problems.

Cracked or otherwise damaged materials should be repaired or replaced; coating over a crack will *not* prevent moisture infiltration. Freshly repointed mortar or sealant joints should be allowed to cure

(continued on page 6)

TYPICAL VALUES FOR SAMPLE COATING TYPES

PROPERTIES \ PRODUCT TYPES	Elastomeric Acrylic	Non-elastomeric Acrylic	Polyurethane	Cementitious	Silane/ Siloxane (Penetrating)	Liquid Membranes (Protected)
Water Vapor Transmission (Breathability)	high	moderate	low	high	high	low
Elongation (Crack-bridging)	moderate	low	very high	does not elongate	does not elongate	moderate
Tensile Strength	low	moderate/high	high	low/moderate	does not develop tensile strength	low
Adhesion	low	moderate	high	varies	penetrant; not on surface	moderate/ high
Carbonation Retardance	high	not generally effective	no data	not generally effective	penetrant; not on surface	no data
UV Resistance	high	moderate	varies	high	penetrant; not on surface	not exposed
Accelerated Weathering	excellent, no cracking or chalking	excellent	moderate, slight chalking	moderate/high	penetrant; not on surface	not exposed
Fungus and Mildew Resistance	moderate	moderate/high	high	moderate	moderate	not exposed
Wind-Driven Rain	no passage	no passage	no passage	no passage	no passage	not exposed
Flame Spread	none	none	varies	none	none	not exposed
VOC Content	low	low	varies	low	high	varies
Used For	concrete; masonry; stucco	concrete; masonry; stucco	pools; balconies; concrete	concrete; masonry; stucco	stone; brick; concrete	concealed applications

Note: Be sure to check material data sheets for each item under consideration, because individual products vary widely in their properties, even within a given category. The above table is not intended to be a complete listing of the product types available, but rather a comparison of some of the many coating options on the market in terms of properties and applications.

GLOSSARY

Water vapor transmission (breathability): Rate and amount of water which can evaporate through the coating on the exposed face of a surface.

Elongation: Measure of a material's ability to stretch, such as bridging a crack formation.

Tensile strength: Resistance of a material to longitudinal stress.

Adhesion: Tenacity with which the coating bonds to the substrate. Can be measured with a variety of tests, both in the laboratory and in the field.

Carbonation: In concrete, the reduction in alkalinity that occurs when atmospheric carbon dioxide reacts with moisture. Can lead to corrosion of reinforcing steel in concrete.

Volatile organic compounds (VOCs): Materials containing carbon, hydrogen, and oxygen characterized by low vapor pressure at ambient air temperature. Often hazardous if inhaled in significant quantity.

Positive side waterproofing: Waterproof barrier on the side of applied hydrostatic pressure (water is blocked from entering substrate). Typical applications include above-ground surfaces and below-grade structures.

Negative side waterproofing: Waterproof barrier on the side opposite to applied hydrostatic pressure (water is permitted to enter substrate). Typical applications include below-grade surfaces where positive-side, exterior application is not possible.

When coupled with proper investigation and repair, coatings can be successfully integrated into a waterproofing project. Not only does this coating improve the water repellency and carbonation retardance of these concrete columns, it enhances their appearance as well. Note the use of cloth coverings to prevent overspray from accidentally damaging surrounding surfaces.

at least 72 hours before a coating is applied, again to ensure that no excess water is locked into the structure. In weather conditions such as extreme heat or cold, wind, or rain, the area must be protected and coatings should not be applied. Avoid coating in direct heat of sun, as this may result in too rapid drying of the material and cause bubbles or wrinkling. Be sure to check the specific temperature range recommended by the manufacturer, as these vary from product to product. Keep in mind that checking the ambient temperature may not be sufficient; surface temperatures may be significantly hotter or colder.

Different coatings require different application methods, but common practices involve use of a brush, roller, or spray, moving in one direction. Working in smaller areas helps to reduce the incidence of 'lap marks,' which are color, sheen, or texture variations where one freshly coated area overlaps another. Thorough mixing of the coating, along with proper dilution according to the manufacturer's instructions, will contribute to a uniform final appearance. To obtain the recommended coverage, two or more applications may be necessary. Occasionally, different techniques must be used for subsequent coats, so consult the product application guidelines for details.

5. Promote coating life-span.

Even the most scrupulous surface preparation and application technique cannot correct for an improperly selected coating, or for using a coating where repairs would have been more appropriate. Likewise, extensive research into materials compatibility and product selection is no match for sloppy application. For a coating to last its full anticipated life-span, careful selection, preparation, and application procedures must all be in order, coupled with good maintenance practice.

Always apply a coating according to the manufacturer's instructions to ensure full warranty benefits in case the coating should fail earlier than promised. Hoffmann Architects often prescribes more stringent field requirements in order to extend the life of the coating.

Advance testing can be a good way to determine a coating's durability under stress. Field tests of adhesion and water repellency are useful guides, as are laboratory tests like that of accelerated weathering. Bear in mind that these are not firm indicators of a coating's actual life-span, however, as building conditions and site location also play important roles in coating durability. Coatings in areas subjected to heavy foot traffic and weather conditions, for example, would break down much more readily than those applied to a vertical surface shielded from wind-driven rain. Certain coatings are also highly susceptible to UV radiation, and degrade more rapidly than others in areas receiving a high level of direct sunlight. Greater depth of penetration or film thickness also implies increased durability, along with resistance to environmental stressors.

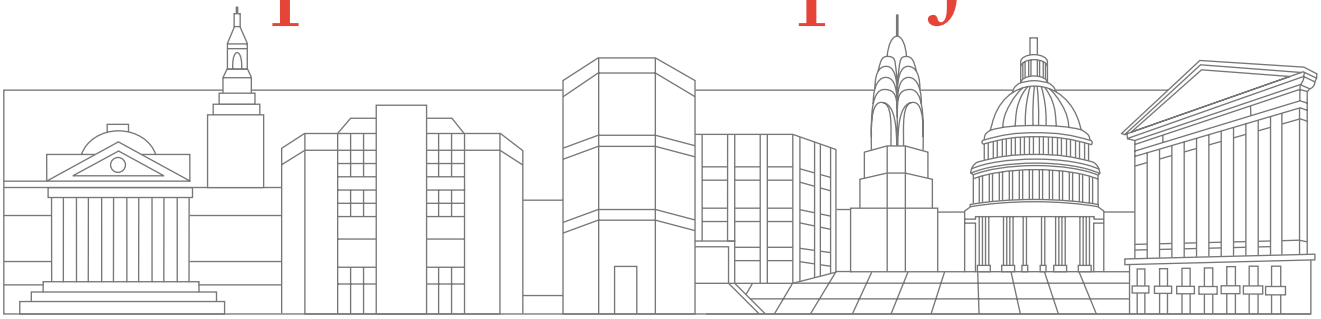
When selecting a coating, be sure to use one from a well-known manufacturer with a good track record. If possible, investigate references of projects with similar scope and conditions in which the product was used successfully. Don't be afraid to request test reports of performance criteria such as water repellency, VOC emissions, and water vapor transmission, as well as a written warranty from the coating manufacturer. When it comes time to apply the coating, verify qualifications of the contractor and be certain that they have ample experience in the work to be performed. A design professional should be on hand for construction management to ensure that coating application is performed as specified in the documents.

6. Keep up maintenance work.

Once the decision is made to apply a coating, it is extremely difficult or, often, impossible to return to an uncoated surface. In coating a structure, you create a long-term maintenance issue, one which must be taken into account in the initial budgeting of water infiltration solutions.

(continued on page 8)

representative projects



Waterproofing

Hoffmann Architects understands the frustration a less-than-watertight structure can cause. As specialists in the rehabilitation of building exteriors, we have extensive experience in water infiltration diagnosis and repair, which enables us to rectify waterproofing problems as efficiently and with as little disruption as possible. Working with clients to meet budget and design goals, we develop a custom waterproofing program for each project.

Long-term solutions begin with a thorough investigation into the cause of water entry. Once the team locates problem areas, design options are considered, and the owner and architect work together to select the best remedial strategy. To ensure quality workmanship, Hoffmann Architects oversees implementation of the design—from blueprint to balustrade. When the new system is in place, the project team develops a program of maintenance that will keep the structure free from leaks for years to come.

▲ Pu'u Po'a Condominiums Princeville, Kauai, Hawaii (Pu'u Po'a Association of Apartment Owners)

Among Hoffmann Architects' waterproofing projects are the following:

Alderman Library
Charlottesville, Virginia
(Hartman-Cox Architects for University of Virginia)

G.E. Corporate Headquarters
Fairfield, Connecticut
(General Electric Corporation)

55 Messerole Street Plaza
New York, New York
(EMTEC Consultants, Inc. for Bell Atlantic)

Chase Manhattan Centre
Wilmington, Delaware
(Bassett Partners)

Buckingham Condominiums
Stamford, Connecticut
(Buckingham Condominium Association)

Taft High School
New York, New York
(New York City School Construction Authority)

605 Third Avenue
New York, New York
(605 Third Avenue LLC)

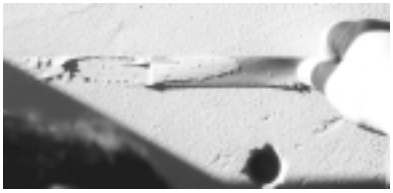
Downstate Medical Center Parking Garage
Brooklyn, New York
(New York State University Construction Fund)

Funger Hall, Ross Hall, Stockton Hall
Washington, District of Columbia
(The George Washington University)

1211 Avenue of the Americas Plaza
New York, New York
(TechSource Services, Inc. for Rockefeller Center Management Corporation)

Xerox Document University
Leesburg, Virginia
(Xerox Corporation)

▲ Prudential Eastern Operations Office
Dresher, Pennsylvania (The Prudentatial Insurance Company of America)



To determine if a coating will be appropriate for a given application, field tests can be used to measure effectiveness. Here, an adhesion test *(left)* and a thickness reading *(right)* are conducted on sample areas of coating.

(continued from page 6)

Most coatings must be reapplied every seven to fifteen years, and many require much more frequent application, on the order of one to three years. Future maintenance issues may be problematic when an existing coating is incompatible with a newly introduced material. For example, a penetrating sealer may prevent proper mortar adhesion when re-pointing or may require special primers for re-caulking. In some cases, reapplication of the coating is difficult, because the hydrophobic nature of the coating prevents adhesion of the new layer. It may then be necessary to strip off the existing coating before a new application. However, the hazardous chemicals often needed for this procedure may be restricted or prohibited by environmental regulations. Such coatings would then need to wear off naturally before a fresh coat could be added, even if water infiltration problems called for more immediate reapplication.

Any additional maintenance work stipulated for the manufacturer's warranty or recommended by the design professional would also need to factor into the long-term budget. When considering the expense of recoating and upkeep, using coatings as cheap, quick-fix solutions becomes less attractive as an economic alternative. Only when coupled with thorough investigation and repair methodology do they become a viable part of a sound waterproofing design.

Conclusion

As a building owner, facility manager, or designer, you want to solve and prevent water infiltration problems in the most efficient, cost-effective manner possible. While it's tempting to reach for one of the many products available, coat over a leaking wall, and be done with it, this approach can lead to some complicated maintenance issues, as well as to even greater deterioration down the road. By following the advice outlined in this issue, you can establish a realistic, economically feasible plan of attack.

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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432 Washington Avenue
North Haven CT 06473-1309
203 239-6660

500 Fifth Avenue, Suite 830
New York NY 10110-0899
212 789-9915

1001 Connecticut Avenue NW
Washington DC 20036-5525
202 530-1100

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Editor: Alison B. Hoffmann
Graphic Services: M&M Design

Hoffmann Architects

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North Haven, Connecticut 06473

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