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Sealant Joint Rehabilitation:

More Than a Quick Fix

Paul C. Lanteri, AIA

Sealant joints exist in exterior walls, in roofing systems, in parking structures, and in plazas and terraces. Their role in building envelope construction is simple, yet vital. Sealant installed in a building joint adheres to the surrounding surfaces, thereby accommodating movement and sealing the joint against the passage of air and water.

Archaeologists tell us that sealant was used as early as 36,000 years ago in the construction of stone-age dwellings. The walls of the ancient cities of Babylon and Jericho were sealed with naturally-occuring bitumen. Modern-day sealants were first developed during the early 20th century when heated tar was used to seal joints between concrete slabs. And, what were once commonly known as "joint-fillers" have increasingly become expected to not only close joints between building envelope components but also to protect the building envelope against water infiltration.

So, what do you do when sealant joints fail on your building envelope? Are you tempted to take matters into your own hands, armed with a caulking gun to merely fill the gaps? Don't be. Sealant joint failures threaten the longevity of your building exterior and require more than a quick fix. Appropriate rehabilitative action is necessary.

Ideally, sealant joint rehabilitation should begin with the identification of the cause of sealant joint failure, followed by the development and timely implementation of a comprehensive program for sealant replacement, a program which may involve resizing or adding additional joints. Why all of this? How important is sealant? Very. Effective sealant accommodates movement and prevents water from entering a building through its joints. Ineffective sealant leaves your building vulnerable to failures, such as cracking and bowing of exterior walls, and water intrusion, the leading cause of building envelope deterioration.

Why Do Sealant Joints Fail?

All sealants have a limited lifespan. They inevitably reach a point when they are no longer effective at withstanding the stresses of the environment and therefore need to be replaced. Understanding *why* a sealant joint has failed prior to sealant replacement and remedying the cause of failure will ensure that a new, appropriately specified sealant will achieve its maximum expected service life. The four types of sealant joint failure—adhesive failure, cohesive failure, substrate failure and

Sealant failure at an aluminum-framed window. Aluminum expands and contracts nearly four times as much as brick masonry due to temperatures changes. A sealant must be selected that will accommodate that movement.

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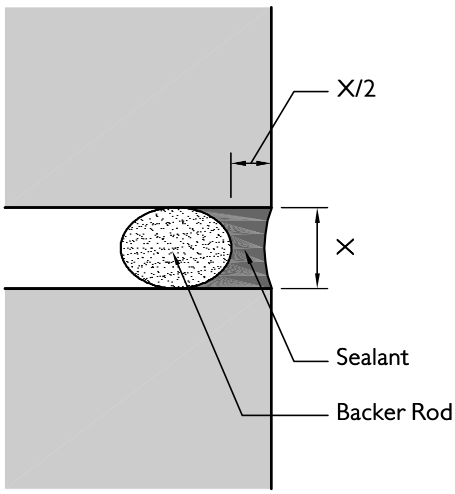
Paul C. Lanteri, AIA, Senior Architect, directs a variety of sealant replacement projects for Hoffmann Architects.

Figure 1 PROPER SEALANT JOINT DESIGN



Joint Sealant: An elastomeric material used to fill building joints, that accommodates movement and seals the joint against the passage of air and water. *Note*: Sealant that is properly tooled will be concave at the surface of the joint.

Backer Rod: A compressible/ expandable foam tube used to control the depth, shape and adhesion of sealant.

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failure due to loss of sealant properties—and other indicators of deterioration are the results of a variety of causes, from age to chemical reactions (see Figure 2).

Adhesive failure

During adhesive failure, the sealant separates cleanly from its substrate. This type of failure will result if the sealant is applied to a dirty or wet surface, or if the substrate is contaminated by a material—such as paint or a waterproofing coating—that will discourage a strong bond. Other causes of adhesive failure include improper primer application during surface preparation and improper design of the joint. A properly designed joint will reduce stress on the bond line. This includes control of the width-to-depth ratio (see Figure 1), the installation of correctly sized backing materials, and the tooling of the sealant to ensure contact with the substrate and to achieve the proper concave surface of the joint.

Cohesive failure

During cohesive failure, the sealant is split within itself. Improper joint design—including an inadequate number of joints and incorrectly sized or located joints—is a leading cause of this type of failure, as is the installation of an inappropriate sealant. Each type of sealant has specific performance characteristics not suitable for every installation.

Substrate failure

Substrate failure occurs when the sealant remains tight to the substrate, but the substrate separates from itself. This type of failure takes place when the adhesive and cohesive strength of the sealant is greater than the cohesive strength of the substrate.

Loss of sealant properties

Reversion refers to a type of property loss that occurs when sealant returns to its uncured or original tacky state. Other types of property loss are indicative of a sealant's advanced age. Weather may harden or dry out sealant, resulting in a loss of elasticity, and exposure to ultraviolet light will also degrade sealant.

Replacement of Sealant Joints

Sooner or later, all sealant will fail, even if it has been properly specified and applied. When failure occurs, it is important to

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Sealant failures: Below left, adhesive failure at this joint on a horizontal surface. Below center, this large sealant joint where a concrete sidewalk meets a masonry wall is crazed and nearing the end of its useful life. Below right, adhesive failure at this joint on a vertical surface.

Figure 2 SEALANT DETERIORATION: CAUSES & RELATED SYMPTOMS							
	SYMPTOMS						
CAUSES	Breakdown/ Cracking/ Loss of Elasticity	Sagging	Adhesive Failure	Cohesive Failure	Bleeding	Bulging	Softness
Improper Sealant for Joint Function	x	x	x	x	x		x
Age	x						
Ultraviolet Reaction	x						
Chemical Reaction/ Improper Curing	x				x		x
Migration of Incompatible Material into Sealant	x	x	x				
Inadequately Provides for Differential Movement		x	x	x			
Improper Width to Depth Ratio		x	x	x		x	
Improper Joint Preparation			x				
Improper Mixing of Sealant	x	x	x				x
External Temperature too High for Sealant		x	x				
Reversion							x
Excess Compression of Joint						x	

Below left, substrate failure . Below center, bulging caused by excess compression of joint. Below right, cohesive failure and aging, cracked and brittle sealant.

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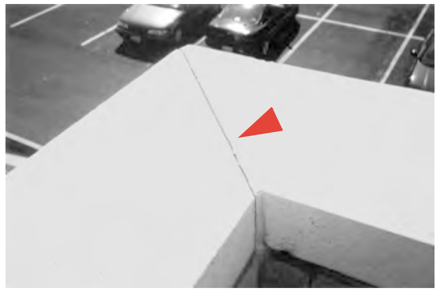
replace the failed sealant material as soon as possible to prevent water from entering the building envelope and to ensure that the joints properly accommodate movement from thermal expansion and contraction, wind loading, and moisture.

A sealant joint rehabilitation project allows for the opportunity to correct many of the original design and/or installation flaws that may prove to be the root causes of sealant joint failures. For example, it may be determined that an area requires more joints or that the joints need to be resized in order to prevent future premature sealant failures. This corrective action should occur prior to application of any new sealant.

The first step in replacing failed sealant is to remove all of the original sealant from the substrate. If it is not possible to remove all traces of the original sealant from the substrate, it is important to be sure that the newly selected sealant is compatible with the original. Next, as contaminants such as dirt or moisture on the substrate are the leading cause of premature sealant failure, the substrate should be prepared according to the sealant manufacturer's specifications. Depending on the type of substrate, this preparation may include sandblasting or grinding, solvent-cleaning, priming, or a combination of these methods. Finally, backer rods—used to fill the joint and control the depth of sealant within the joint—are installed (see Figure 1) and the new sealant is applied according to the sealant manufacturer's specifications.

At this plaza, sealant failures at perimeter walls and inadequately terminated base flashing could be allowing water to enter open joints.

Sealant failures at joints on horizontal surfaces such as this drive slab are typical in garages. Here, what may seem minor often leads to premature failure of parking decks and damage to tenant vehicles.



Above left: When is sealant at the end of its useful life? When adhesive failure allows water to enter the wall through the coping. Above right: Adhesive failure along sealant joint of pilaster.

Be aware that resealing projects require specific temperature and weather conditions. Humidity levels, temperature extremes, and even temperature swings during curing can adversely affect the new sealant's performance.

Furthermore, it's vital that joints on horizontal surfaces—such as on plazas/terraces, sidewalks, and parking decks—be able to withstand water infiltration from rain, ice and snow. In addition, these joints must be able to endure the effects of the sun's full-arc exposure. Special diligence in detailing, sealant selection, installation and maintenance is necessary for these vulnerable joints.

Selecting an appropriate sealant

It's important to select the most appropriate sealant for each type of joint application. In order to do so, it is important to understand the various properties of sealant. For example, sealants are manufactured with varying degrees of elasticity to accommodate different joint expansion requirements. A qualified architect or engineer can help in evaluating these requirements and in determining which sealant should be used.

Some of the most important properties to evaluate during sealant selection are:

- Dynamic movement capability, or elongation: the ability of sealant to stretch without tearing. Expressed as a percentage of the original joint size, elongation directly relates to cohesive strength;

- Modulus of elasticity: the tensile strength of sealant at a given amount of elongation. High modulus or hard sealants are recommended where high strength is required and little movement is expected. Low modulus or soft sealants are recommended where high movement capability is required;

- Elasticity and recovery properties: relate to a sealant's ability to return to its original shape after being compressed or elongated. A sealant that will not return to its original shape after compression or elongation will prematurely fail;

- Adhesive strength: the ability of a sealant to bond to its substrate. This property can vary greatly between a particular sealant and different substrates;

Figure 3 PERFORMANCE COMPARISON OF COMMON EXTERIOR SEALANTS						
	SEALANT					
PROPERTY*	Acrylic Latex	Butyl	Polysulfide	Polyurethane	Silicone	Silyl-Terminated Polyether
Expected Service Life	3-6 years	10-15 years	7-12 years	10-12 years	15-20 years	10-20 years
Adhesion	Fair	Excellent	Good	Very Good	Excellent	Excellent
Dynamic Movement Capability	3-8%	5%	25%	25-50%	50-100%	50-100%
Recovery Rate/Elasticity	50%	Poor	80%	90%	100%	100%
Shrinkage	15%	18%	10%	5%	3%	3%
Shore Hardness	10	15	35	35	25	20
Below Grade/ Water Immersion Applications	No	No	Yes	Some	No	No
Standard Color Availiability	Good	Limited	Good	Excellent	Limited	Limited
Paintability	Yes	Yes	No	No	No	Yes
Surface Preparation	Minimal	Minimal	High	Moderate	High	Moderate
Resistance to Dirt Pickup/ Ability to Stay Clean	Fair	Fair	Fair	Good	Poor	Excellent

* *Properties of sealant types may vary greatly between manufacturers or between formulations of a particular sealant type.*

- Shore hardness: a sealant's resistance to impact, or its puncture resistance, measured with a durometer gauge. The higher the reading, the harder the material and the higher its resistance; and,

- Paintability: the ability of paint to adhere to sealant. However, sealant typically has greater movement capability than paint, causing the paint on the sealant to crack. Painting is therefore not recommended for sealants with a movement capability of more than 10%.

Common exterior grade sealants

There are numerous sealants available to the construction industry, and the properties of each type of sealant vary (see Figure 3). When selecting a sealant for a replacement project, its properties should accommodate the expected conditions of that particular installation.

Acrylic latex

Acrylic latex sealants are general-purpose sealants typically used for filling joints between woodwork and non-moving cracks. Silicones are sometimes blended into the acrylic latex sealants to increase adhesion and weatherability. Because of their low movement capability and poor weathering properties, acrylic latex sealants are typically not recommended for exterior use.

Butyl

Butyl sealants are produced by blending isobutylene and rubber. Because of their low movement capability and poor elastic recovery rate, the use of butyl sealants is primarily limited to glazing applications.

Polysulfide

In the 1950s, polysulfide became the first widely used elastomeric sealant. This sealant has good resistance to weathering, to chemicals and to ultraviolet radiation. Polysulfide is

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More is not better. The use of too much sealant, especially one that is inappropriate for a particular joint application, will result in not only an unpleasant appearance but also premature sealant failure.

Here, a building owner used duct tape to seal open joints. This is *NOT* the answer. Only properly selected and applied sealant should be used in joint rehabilitation projects.

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relatively hard and therefore performs well in horizontal applications where heavy foot traffic or light vehicular traffic is encountered. It also performs well below grade and is suitable for applications that are totally immersed in water, such as joints in swimming pools. However, these sealants have low movement capability and poor elastic recovery rate, and require a great deal of surface preparation.

Polyurethane

Polyurethane sealants adhere well to most substrates with minimal surface preparation and are therefore favored by many contractors. They have excellent elastic recovery properties and perform well in horizontal applications subject to moderate foot traffic, such as plazas. When compared to other sealants, polyurethane sealants are ranked in the mid-range for joint movement capability and expected service life. They also have the potential for reversion failure.

Silicone

Silicone sealants have extremely high thermal resistance and dynamic movement capability. They have a high elastic recovery rate and exhibit excellent adhesion when applied to properly prepared substrates and to most cured sealants, making silicone an ideal choice for sealant replacement projects. Their expected service life exceeds that of other sealants. However, silicone sealants do not perform well when subject to foot traffic, below grade or at locations subject to water immersion. These sealants may stain some natural stones, if not properly installed. They also tend to hold atmospheric particles, resulting in a dirty appearance.

Silyl-terminated polyether

Silyl-terminated polyether is a relatively new sealant type, and therefore its expected service life can only be estimated. Its manufacturer claims that silyl-terminated polyether combines the best properties of silicone and polyurethane. These sealants have high movement capability and are reported to be especially effective when used in joints of exterior insulation finish systems (EIFS).

Testing of sealant

As part of a sealant rehabilitation project, many sealant manufacturers will test their product in the lab for compatibility with your building's substrate materials. This testing includes evaluation of the sealant's ability to adhere to the substrate, its compatibility with the substrate, and its stain resistance. The latter test is important for porous substrates such as marble and limestone, as the sealant will penetrate these stone surfaces and cause stains. Testing services are usually provided free-of-charge by the manufacturer and will confirm the appropriateness of a selected sealant for a particular application.

In addition to lab testing, on-site test applications should be conducted before replacing sealant. These on-site tests are highly effective in achieving proper adhesion and compatibility, and in establishing proper surface preparation standards that should be followed during installation. For example, an architect may direct that some test joints be prepared with—and others without—primer prior to the application of sealant. Then, a comparison of the two types will be made when the sealant is tested for adhesion and peel, commonly referred to as a pull test, after 14 days.

Substrate preparation

Whether the foundation for sealant is stone, brick, concrete, steel or any other building envelope material, preparation of the substrate plays a significant role in the success of a sealant joint. Substrate preparation varies depending on the type of sealant used, but the desired result is always the same: a clean, dry surface that will permit adhesion of the sealant. And, in order to ensure proper adhesion, the unique characteristics of various substrates must be addressed.

For example, concrete and masonry may exhibit weak surface conditions caused by additives and poor formulation, unfavorable curing conditions and/or ineffective finishing techniques. These conditions may contribute to sealant joint failure if not corrected with sandblasting, grinding, or wire brushing. Additionally, surface primers (used to seal pores) are often recommended for use with concrete and masonry to improve sealant adhesion at the bond line. As these materials are so highly absorbent, extra care must be taken to achieve a dry surface. Solvents are generally not recommended for cleaning concrete and masonry, as they will drive any contaminants present into the substrate.

Natural stones, steel and stainless steel, EIFS, aluminum, glass and porcelain, rigid

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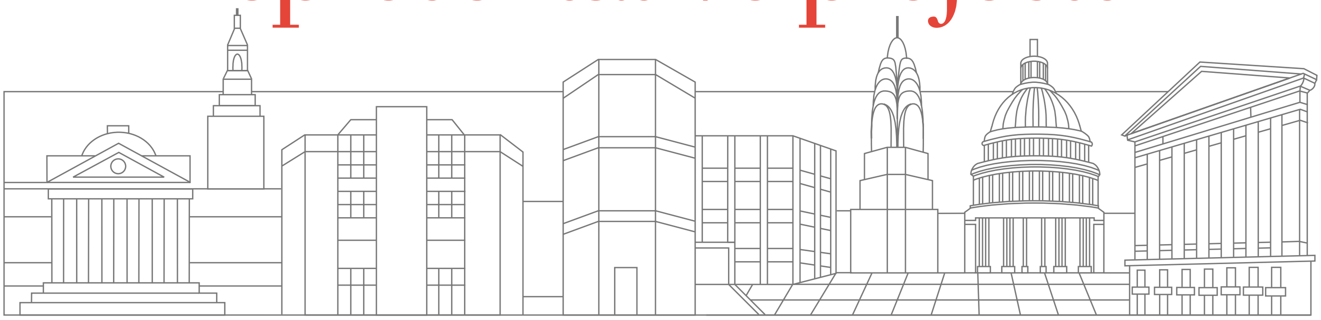
representative projects



Sealant Joint Rehabilitation

The following representative projects included sealant joint rehabilitation:

One Beacon Street
Office Building and Parking Garage
Boston, Massachusetts
Sealant Replacement and Concrete Rehabilitation

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

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

Smithsonian Institution
The Renwick Gallery
Washington, District of Columbia
Water Infiltration Remediation

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

1801 L Street
Office Building
Washington, District of Columbia
Facade Panel and Sealant Rehabilitation

The Bank of New York
1 Wall Street
New York, New York
Roof and Exterior Wall Condition Study and Master Plan of Repairs

MetLife Building
200 Park Avenue
New York, New York
Facade Rehabilitation

Chase Manhattan Centre
Wilmington, Delaware
Water Infiltration Investigation and Facade Rehabilitation

25 Sigourney Street
State of Connecticut Office Building
Hartford, Connecticut
Facade and Roof Rehabilitation

Xerox Corporation
Corporate Headquarters
Stamford, Connecticut
Facade Rehabilitation

Southern New England Telephone
Company Headquarters
New Haven, Connecticut
Facade Restoration

The George Washington University
Funger Hall
Washington, District of Columbia
Facade Panel and Sealant Rehabilitation

Bayer Corporation
West Haven, Connecticut
Sealant Joint Construction Inspection

780 Third Avenue
New York, New York
LL 11 Investigation and Facade Restoration

Pfizer, Inc. Global Development Facility
New London, Connecticut
Sealant Rehabilitation ■

▼ **Xerox Corporation Headquarters** Stamford, Connecticut. Hoffmann Architects provided design and construction administration services to restore the limestone and glazed curtain wall facade, including replacement of all joint sealant, at this corporate headquarters.

Sealant replacement was integral to the rehabilitation of this modern office building. The exterior walls are brick with "punched" windows and glazed curtain walls.

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plastics, rubber and flexible plastics, wood, and painted or lacquered surfaces all possess individual qualities that dictate what measures should be taken to prepare them for sealant installation. Accommodating these characteristics will form the basis for a successful sealant rehabilitation project.

Conclusion

To summarize, a plan to rehabilitate sealant joints should include:

- identification of the cause of sealant joint failure;
- action to correct any of the original design and/or installation flaws;
- selection of an appropriate sealant that best accommodates a particular installation;
- testing of sealant, both lab and on-site;
- substrate preparation in accordance with the sealant manufacturer's specifications and with the specific characteristics of a particular substrate;
- installation of backer rods and application of selected sealant according to manufacturer's specifications; and,
- troubleshooting during application of sealant to avoid failures (such as temporarily ceasing work during temperature highs or lows that may negate a sealant's performance, for example).

While sealant replacement usually comprises only one part of a building envelope rehabilitation project, its proper and timely implementation is no less critical than that of any other portion of the project work. Quick fixes serve as mere band-aids on sealant joint failures. Appropriate rehabilitative action is necessary in order to achieve a lasting solution. ■

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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