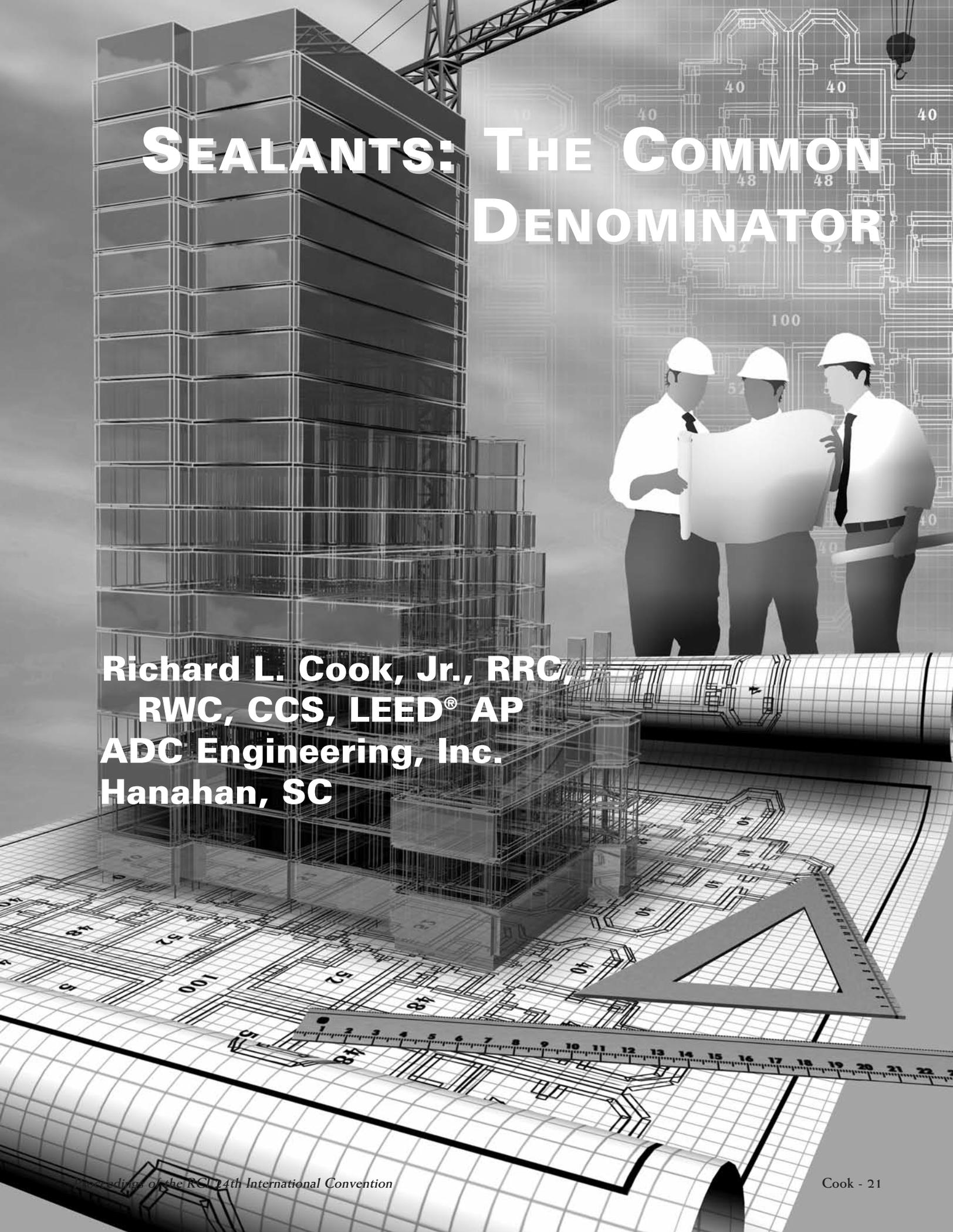


SEALANTS: THE COMMON DENOMINATOR



**Richard L. Cook, Jr., RRC,
RWC, CCS, LEED® AP
ADC Engineering, Inc.
Hanahan, SC**

ABSTRACT

In *The Construction Waterproofing Handbook*, in the introduction to his chapter on “Sealants,” William T. Kubal states, “Sealants are not only the most widely used waterproofing materials, but also are the most incorrectly used.”

Realizing the critical role sealants provide with all building envelope systems, a design professional must have a clear understanding of the criteria, standard specifications, terminology, and methods for calculating movement and designing joints. Experience with renovation projects provides the design professional the “firsthand” experience on where, how, and why joints fail. This knowledge not only helps the designer correct the specific renovations project, it also assists in designing new construction projects.

SPEAKER

Richard Cook has authored numerous papers on the subjects of roofing, waterproofing, and building systems. He has presented several papers at national symposiums and conferences, including the American Society of Civil Engineers, the Construction Specifications Institute, RCI’s Building Envelope Symposium, RCI’s international conventions, and the Federal Construction Committee in Washington, DC. Mr. Cook has also presented dozens of papers at local and regional meetings and conferences related to waterproofing, and building envelope consulting services in the construction industry.

CONTACT INFO: rickc@adcengineering.com or 843-566-0161

Sealants: The Common Denominator

INTRODUCTION

Consider the following:

1. Wall assemblies, like other components of the building envelope, serve three important functions: (1) as part of a structural system, (2) as protection from the weather (heat, cold, rain, etc.), and (3) as the exterior finish or aesthetics of the building. The “function” of weatherproofing is the most problematic, and when it fails to perform, it can also affect the structural and aesthetics functions of the wall.
2. It is also not a big secret that wall assemblies leak when three basic conditions exist simultaneously in a wall assembly:
 - a. Water (most likely rain) is on the wall.
 - b. Openings exist within or between wall assemblies through which the water can pass.
 - c. Forces exist (gravity, surface tension, capillary action, pressure-differential and/or kinetics), which cause the water to enter the openings.
3. The wall assembly of a facility is comprised of one or more wall systems, both barrier and redundant [such as back-up/rain-screen], and a variety of fenestrations, other wall openings, and penetrations. A critical relationship exists between these various systems, which

comprise the exterior wall of the building envelope.

4. Windows, storefront, and other wall openings are similar to wall systems in that some systems are designed as “barriers” (shedding 100% of the water), while other systems incorporate redundant flashings to provide a secondary drainage mechanism. Depending on the type of wall systems and wall openings, transition or through-wall flashings may be incorporated. In many cases, the common thread that has to “hold” these various systems together is simply the sealant joint.
5. In the introduction of his chapter on Sealants, William T. Kubal, in his book, *The Construction Waterproofing Handbook*, states, “Sealants are not only the most widely used waterproofing materials, but also are the most incorrectly used,” (and, I would add, most overlooked in construction documents).

Realizing the critical role sealants provide with all building envelope systems, a design professional must have a clear understanding of the criteria, standard specifications, terminology, and methods for calculating movement and designing joints. Experience with renovation projects provides the design professional the “first-hand” experience on where, how, and why joints fail. This knowledge not only helps the designer correct the fail-

ures of the specific renovation project, but it also provides valuable insight to be used when designing new construction projects.

CRITERIA

ASTM International provides a series of documents that contain valuable information on the subject of sealants. We commonly see these standards referenced in industry guides, specifications, and manufacturers’ literature, but do we know what information they contain and how to use these standards?

ASTM C1193 – 05a Standard Guide for Use of Joint Sealants

As noted within the “scope” of this standard, this guide describes the use of a cold, liquid-applied sealant for joint sealing applications. Including joints on buildings and related adjacent areas such as plazas, decks, and pavements for vehicular or pedestrian use, it also addresses issues such as substrate, cleaner, primer, sealant backing, bond breaker, liquid-applied sealant, procured sealant, and *in situ* test methods as well as types of construction other than highways and airfield pavements and bridges. This guide primarily addresses single- and multi-component sealants, but also, secondarily, pre-cured sealants.

A sealant within ASTM C1193 must meet ASTM C834, Specification for Latex Sealants; C920, Specification for Elastomeric Joint Sealants; or C1311, Specification for Solvent Release Sealants.

As stated in the guide:

This guide does not provide information or guidelines for the use of a sealant in a structural sealant glazing application. Guide C 1401 should be consulted for this information. Additionally, it also does not provide information or guidelines for the use of a sealant in an insulating glass-unit edge seal used in a structural sealant-glazing application. Guide C 1249 should be consulted for this information.

Practice C 919 should be consulted for information and guidelines for the use of a sealant in an application where an acoustic joint seal is required.

Guide C 1299 should be consulted for information on ... [characteristics and] properties, such as hardness, tack-free time, or curing process, among others.

I. Substrate: Sealants are used to seal joints between various substrates. The type of substrates are categorized as noted below:

1. Porous Substrates – brick, masonry, concrete masonry, concrete, unpainted wood, some building stones, and most cement-based materials.
2. Non-Porous Substrates – stainless steel, lead-coated copper and anodized aluminum, factory-applied organic coatings, paints, and glass.
3. EIFS (Exterior Insulation and Finish System) – is a porous substrate and most manufacturers recommend adhering the sealant to a base coat and avoiding adhesion to the top coat, which can be

softer.

II. Cleaner: The cleaning methods and cleaning solutions used are important to the quality of the sealant. Procedures are typically differentiated between porous and nonporous substrates.

1. Porous Substrate – Dust, dirt, contaminants, laitance, or substances from the preparation process are ground, brushed, blown off with oil-free compressed air, and wiped with cloth.
2. Nonporous Substrate – degreasing solvents, such as MEK, toluene, xylene, acetone, and mineral spirits have been used as cleaners. To ensure no residue film exists on cleaned surfaces, a solution of 50/50 IPA (alcohol) and water is often recommended; thus, a two-step process may be necessary.

III. Primer: The purpose of a primer is to improve the adhesion of a sealant to a substrate.

1. A primer changes chemical characteristics of a substrate.
2. It stabilizes the substrate surface (fills pores and strengthens weak areas).
3. It reduces capillary pressure of moisture through the substrate surface.
4. Primers may or may not be required on porous and nonporous surfaces. If the need for priming is in doubt, adhesion testing with and without a primer is recommended.

IV. Sealant backing: Sealant backing is critical to the performance of sealant. Sealant backing should meet the requirements of C1330, Standard Specification for Cylindrical Sealant Backing for

Use with Cold, Liquid-Applied Sealants. Commonly used materials include polyurethane, polyethylene, and polyolefin foams.

1. Function: The purposes for the sealant backing (or backer rod) include:
 - a. Controls depth and shape of sealant.
 - b. Assists in attaining full “wetting” to the sides of the joint when the sealant is tooled.
 - c. Allows movement of the backside of the sealant between substrates.
 - d. Sometimes, it is claimed to serve as a temporary seal, secondary barrier, or both. Caution is needed in regards to this claim.
2. Types: The common types of sealant backing (backer rod) include:
 - a. Open-cell foam:
 - Normally polyurethane.
 - Does not have surface skin.
 - Cylindrical, rectangular, or other shape.
 - Low density and easily compressible.
 - Assists in air or moisture cure process of sealant.
 - Can wick and retain moisture.
 - Typically 50% wider than the actual joint width.
 - b. Closed-cell foam:
 - Typically made from polyethylene, but neoprene, butyl, EPDM, or combinations also exist.
 - Low density and less compressible.

- Does not tend to wick or retain moisture.
 - Typically 25-35% wider than the actual joint width.
- c. Bicellular foam:
- Typically made from polyethylene material extruded into cylindrical shapes that have a surface skin.
 - Cut ends can wick and retain water.
 - Skin can pose application problems.
- d. Others:
- Some joint applications may require use of an elastomeric material such as butyl, EPDM, neoprene, or other backing material.
 - They can be formulated as closed-cell, sponge, or dense rubber gasket, which can be used as a sealant backing but may require a bond-breaker tape.
3. Shapes: The common shapes include round, rectilinear (for standard joints), and triangular (for fillet joints).
4. Applications: Are defined in two categories – vertical and horizontal – which may affect the type of materials used.
- a. Vertically oriented surfaces
- Sloped 15° or more.
 - Open, closed, or bicellular.
 - Water absorption may be deciding factor.
- b. Horizontal surfaces
- Generally extruded, closed cell.

5. Joint filler: Commonly encountered in masonry or concrete construction to form an expansion or isolation joint for the remaining joint depth.
- a. Compressible, asphalt-impregnated cane fiber for concrete substrates.
 - b. Closed-cell polyethylene for masonry substrates.

V. **Bond breaker:** Used to prevent adhesion of a sealant to any surface or material on which adhesion would be detrimental. A bond breaker is usually a self-adhesive, pressure-sensitive tape made from TFE fluorocarbon or polyethylene to which a sealant will generally not adhere.

- Duct tape is unacceptable.
- Liquid-applied bond breaker is not recommended due to application issues.
- A bond breaker is not required with soft, flexible, open-cell-sealant backing material, in that these materials would not significantly restrict movement.
- Compatibility and adhesion testing recommended.

VI. **Liquid-applied sealant:** Common types include single and multi-component (sometimes noted as two components).

1. Single component (moisture-cured)

Typically defined by the following:

- Requires no mixing.
- Ready for application.
- Atmospheric moisture-cured, and thus, slower cure time.
- Formulated for slower cure time for extended shelf life.
- Not recommended for arid or desert regions.

2. Multi component (chemical-cured)

Typically defined by the following:

- Mixed at site just prior to application.
- Typically two components, but sometimes three.
- Rapid cure after mixing.
- Thorough and proper mixing is critical.

VII. The **modulus** is typically defined by the following:

1. Stress at a corresponding strain (elongation).
2. Expressed as a percent of the original at-rest dimension.
 - a. Low modulus:
 - High movement capability.
 - When extended, creates a relatively low stress at the sealant and substrate interface (good for EIFS).
 - b. Medium modulus:
 - Used for general-purpose joint sealant applications.
 - Represents the majority of the products in the industry.
 - c. High modulus:
 - Normally not used for joints that experience movement.
 - Common for glazing sealant wherein glass or other panels are sealed to framing system (that exhibits no or very low movement).

ASTM C 920-05 Standard Specification for Elastomeric Joint Sealants.

This is the most widely recognized ASTM standard for sealants in that it is referenced throughout the majority of guide specifications and manufacturers' literature.

This standard specification for elastomeric joint sealants covers "the properties of a cured single- or multi-component, cold-applied elastomeric joint sealant for sealing, caulking, or glazing operations on buildings, plazas, and decks for vehicular or pedestrian use, and types of construction other than highway and airfield pavements, and bridges." This standard defines types, classes, grades and uses.

Classification of sealant by type, grade, class and use.

1. Types are labeled "S" for single component (typically moisture-cured) and labeled "M" for multi component (typically chemical-cured).
2. Grades are differentiated by the designation of "P" for pourable or self-leveling for horizontal joints under specific conditions; and "NS" for nonsag or gunnable for vertical joints.
3. Classes are defined based on their abilities to withstand an increase of a minimum percentage and a decrease of a minimum percentage of the joint width measure at the time of application and meeting all other requirements of this specification (i.e., Class 100/50, Class 50, Class 35, Class 25, and Class 12.5).
4. This last classification indicates the intended use for the sealant:
 - Use T – for use in pedestrian and vehicular traffic areas.

- Use NT – for use in non-traffic areas.
- Use I – for use when continuously submerged in a liquid (if Class I and II exist).
- Use M – for use with mortar specimens based on required testing within this standard.
- Use G – for use with glass specimens based on required testing within this standard.
- Use A – for use with aluminum based on required testing within this standard.
- Use O – for use on substrate other than the standard substrate based on required testing within this standard.

This standard also addresses general requirements such as stability, color, and issues of surface condition and primers.

ASTM C717-06a Standard Terminology of Building Seals and Sealants

With inconsistencies in terminology in the industry, ASTM C717-06a, Terminology of Building Seals and Sealants, covers "the terms, related standard definitions, and descriptions of terms used or likely to be used."

Definitions for commonly misunderstood or misused terms can be found within this document.

Examples from ASTM C717 include:

Adhesive failure (n): in building construction, failure of the bond between the sealant, adhesive, or coating and the substrate surface.

Caulk (v): in building construction, to install or apply a sealant across or into a joint,

crack, or crevice.

Caulk (n): *See sealant.* In building construction, a material that has the adhesive and cohesive property to form a seal.

Caulking (n): *See sealant.* In building construction, a material that has the adhesive and cohesive property to form a seal.

Caulking compound: *See sealant.* In building construction, a material that has the adhesive and cohesive property to form a seal.

Elastomeric (adj): having the characteristics of an elastomer.

Elastomer (n): a macromolecular material that returns rapidly to its approximate original dimensions and shape after substantial deformation by a weak force and release of the force.

ASTM C1472-06, Standard Guide for Calculating Movement and Other Effects When Establishing Sealant Joint Width

The standard guide for calculating movement is C1472-06, Standard Guide for Calculating Movement and Other Effects When Establishing Sealant Joint Width. This document "provides information on performance factors such as movement, construction tolerances, and other effects that should be accounted for to properly establish sealant joint size. It also provides procedures to assist in calculating and determining the required width of a sealant joint, enabling it to respond properly to those movements and effects. Information in this guide is primarily applicable to single- and multi-component, cold-applied joint sealants and secondarily to pre-cured sealant extrusions when used with properly prepared joint openings and substrate surfaces."

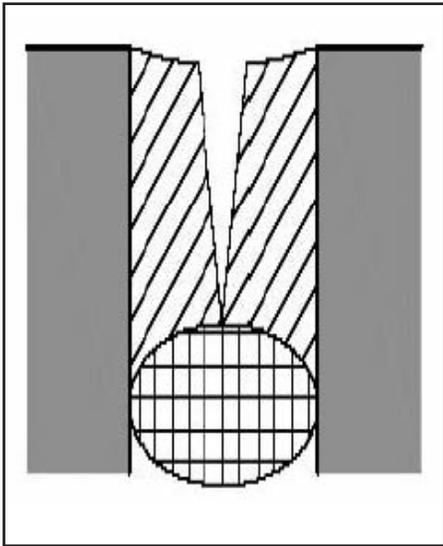


Figure 1 - Cohesive failure.



Photo 1 - Cohesive failure.

Movements most consider thermal movements (coefficient of linear expansion), moisture movements (such as in a masonry walls), shrinkage/creep (as in concrete walls), and load-imposed movements (such as seismic and wind).

LESSONS LEARNED

With renovation projects, we have the opportunity to see firsthand where, how, and when joints succeed and when and why they fail. Thus, instead of just adhering

to general criteria and guidelines and calculating “anticipated” movements, we can actually view how the joints performed under specific conditions.



Photo 2 - Adhesive failure.

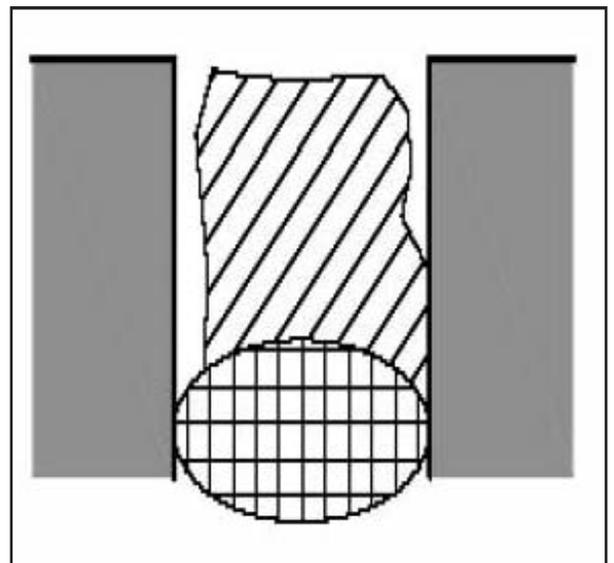


Figure 2 - Adhesive failure.

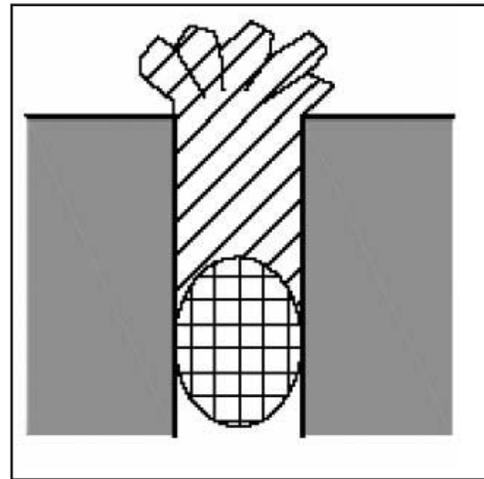


Photo 3 (left) and Figure 3 – Compression failure.

By understanding how sealants fail in the field, we can adjust the design and/or materials to address the sealant joint needs on existing facilities and apply this knowledge when working on new construction projects.

1. Cohesive failure

- a. A failure of the sealant characterized by a rupture or separation within itself when subjected to external forces.

2. Adhesive failure

- a. A lack of or a failure of the bond between the sealant and the substrate surfaces.

- b. Commonly due to a lack of or improper joint design in the contract documents, improper/insufficient sealant materials, or improper depth-to-width ratios during application.

- b. Commonly due to a lack of or improper tooling, incompatible materials, contaminants on the substrates, or lack of primer on substrate.

3. Compression failure

- a. A failure of the sealant due to the substrate compressing the sealant out of the joint due to improper joint design.
- b. Commonly due to improper joint design or failure to anticipate wall material movements.

4. Untooled joints

- a. An insufficient tooling or lack of tooling of the



Photo 4 – Untooled joint.

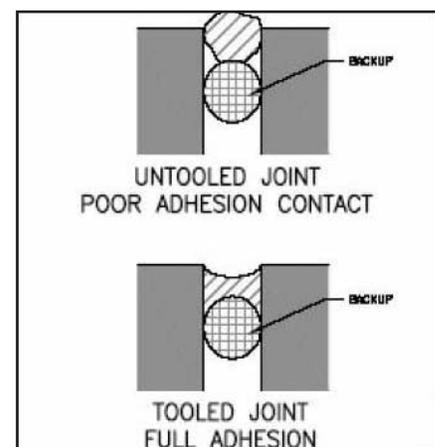
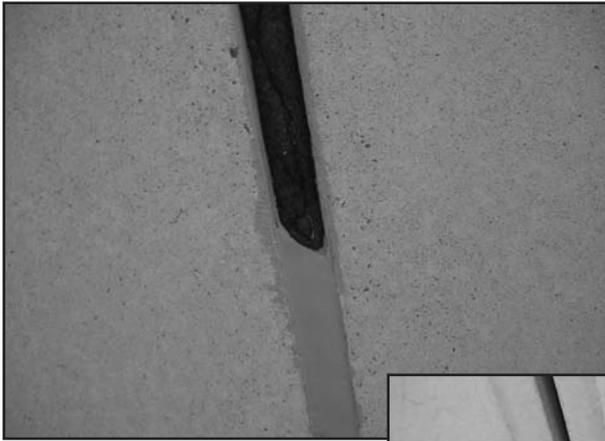


Figure 4 – Sealant tooling.



Photos 5A and 5B – Compressed or braided backer rods.



sealant joint can substantially affect the level of adhesion to the substrates (adhesive failure) and the water resistance of the joint.

- b. Due to improper application.

5. Compressed or braided backer rod

- a. A backer rod is oversized so that the backup material is between 25-50% compression, based on type of material.
- b. Undersized backer rod will not limit the depth of the cavity during sealant application.
- c. Oversized backer rod or twisted/braided backer rod creates creases or crevasses within the backer material. These can cause failures within the sealant joint.

6. Craze cracks (crazing or alligating)

- a. A maze or random pattern of fine cracks in the sealant surface that can

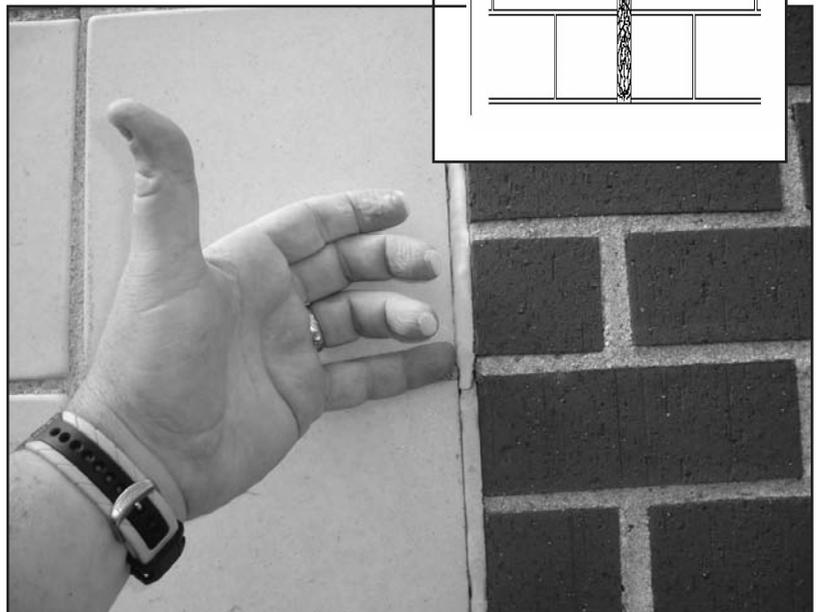
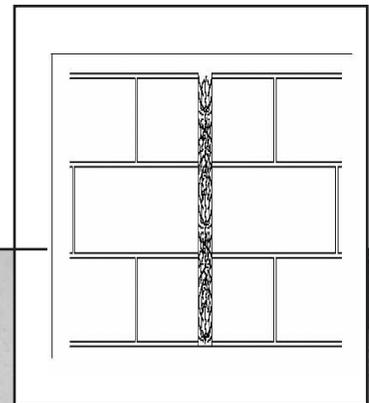
be caused by extreme cold, internal stresses, or lack of elasticity under external forces of weathering.

- b. Chalking of the sealant is also evident in some instances.
- c. A false crazing can also occur when a nonflexible paint is applied over a sealant joint. Due to the joint movement and the inflexible paint, a crazing of the paint occurs.

7. Reversion

- a. The depolymerization of a high-performance sealant causing the cured elastomeric network to return to its original mastic state. This is caused by UV degradation, moisture, or a combination of both.
- b. Sagging has a similar appearance, but is a flow of uncured sealant within the joint resulting in

Figure and Photo 6 – Crazing (chalking) and alligating.



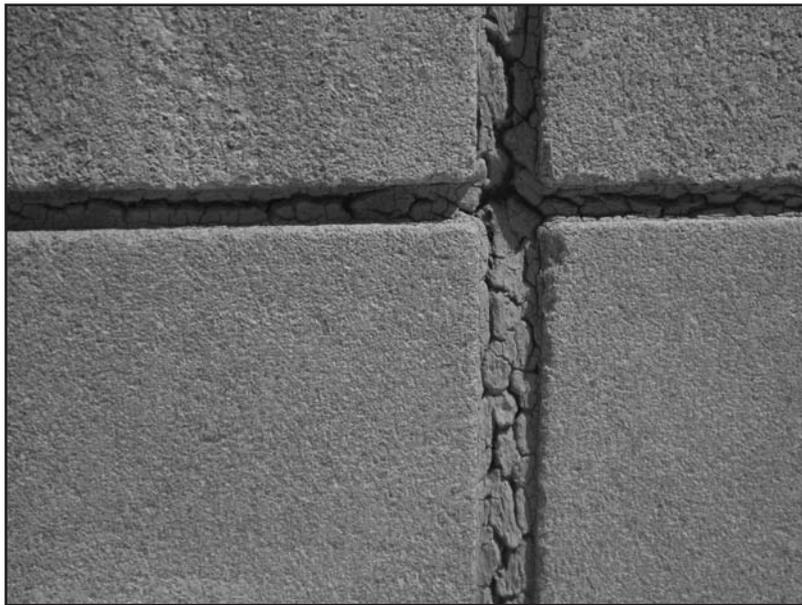
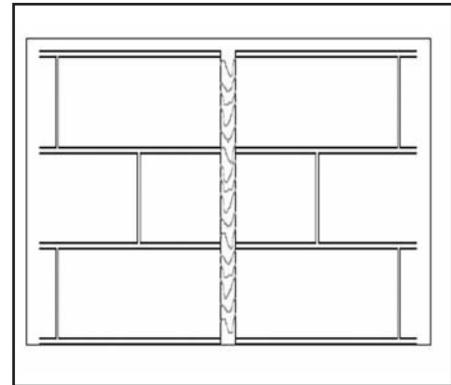


Photo 7 – Reversion.

Figure 7 – Reversion or sagging.



the loss of the sealant's original shape.

8. Window gasket repair (wet seal/cap bead)

- a. Window and curtain wall system include gaskets made of various materials (vinyl, neoprene, etc.).
- b. Examples of an interim repair to failed gaskets include partial or complete

removal of the failed, disengaged, or shrunken gasket.

- c. An interim repair requiring removal of the gasket and a backer rod and cap bead installed or the upper lip cut off and a wet seal applied. Incompatibility of the existing material with new sealants can be an issue.
- d. Removal of the gaskets in whole or in part can affect

the window system's resistance to wind forces.

9. Redundant sealant system

Although many sealant systems act as a barrier with no redundancy, redundancy can provide a cost-effective option to owners in many cases. A method used to provide redundancy (a secondary drainage path with a sealant joint) is the "double" sealant joint system. It is commonly used with concrete tilt-up panels. In theory, these monolith-

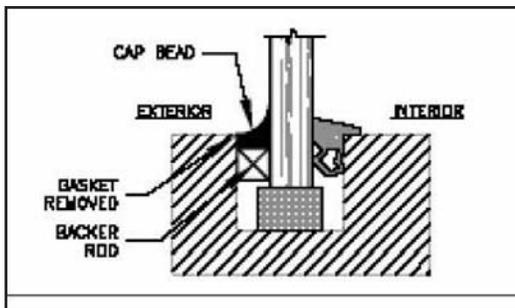


Figure 8A – Cap bead.

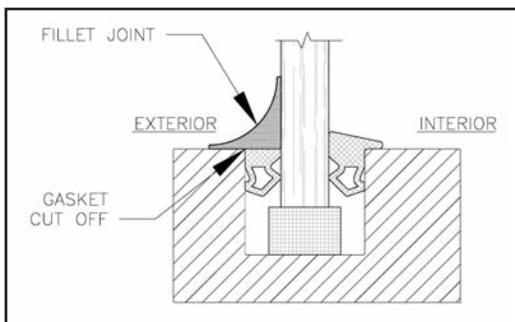


Figure 8B – Wet seal.



Photo 8A – Window gasket.



Photo 8B – Window gasket.

ic panels do not allow water penetration through the panels, but potential deficiencies (cracks, etc.) panel termination, and the movements that occur at these locations justify the redundancy. This exterior sealant joint redundancy also “protects” the inner sealant

joints from the exterior environment – a key contributor to sealant deterioration, weathering, and failure.

The redundant joint can also be an effective method to address wall systems (such as exposed aggregate and split-faced block) in which it is more difficult to attain a quality application due to surface irregularities and variations.

CONCLUSION

Construction remains imperfect, as does manufacturing and designing; but a better understanding of criteria, standard specifications, terminology, and materials will always improve the process from manufacturing through to design, construction,

and maintenance. Understanding how sealants fail further clarifies our understanding, allowing us to improve the “common denominator” of the numerous wall assemblies for renovation projects and new construction.

REFERENCES

1. SWRI (Sealant, Water proofing, and Restoration Institute) has made significant strides in improving the manufacturing process through validation of materials.
 - SWRI’s Sealant Validation Program established three priority performance character-



Photo 9 – Double joint detail.

istics and their respective ASTM standards.

They have documented construction considerations through their manuals, such as:

- *Sealants: The Professional's Guide*, SWRI, 1995.
2. RCI, Inc. is making comparable strides within the education of the design professional. The association for roofing, waterproofing, and exterior walls has developed two 2-day courses for Advanced Waterproofing and for Exterior Walls and has corresponding registration programs.

3. ASTM International

- ASTM C1193-05a, *Standard Guide for Use of Joint Sealants*
- ASTM C834-05, *Specification for Latex Sealants*
- ASTM C1311-02, *Specification for Solvent Release Sealants*
- ASTM C 920-05, *Standard Specification for Elastomeric Joint Sealants*
- ASTM C1401-02, *Standard Guide for Structural Sealant Glazing*
- ASTM C1249-06a, *Standard Guide for Secondary Seal for Sealed Insulating Glass Units for Structural Sealant Glazing Applications*
- ASTM C919-02, *Standard Practice for Use of Sealants in Acoustical*

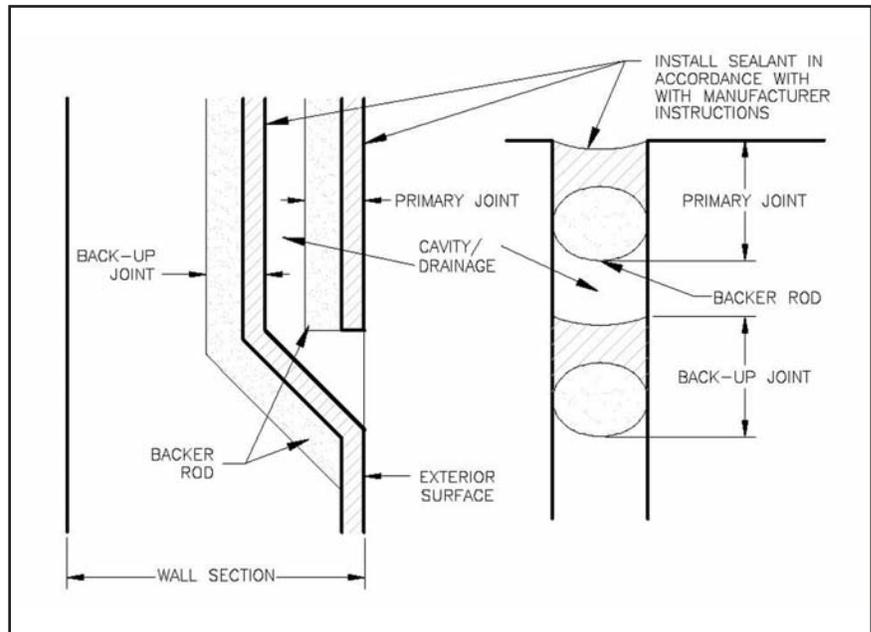


Figure 9 - Double joint detail.

Applications

- ASTM C1299-03, *Standard Guide for Use in Selection of Liquid-Applied Sealants*
- ASTM C1382-05, *Test Method for Determining Tensile Adhesion Properties of Sealants When Used in Exterior Insulation and Finish Systems (EIFS) Joints*
- ASTM C1328-05, *Standard Specification for Plastic [Stucco] Cement*
- ASTM C1330-02, *Standard Specification for Cylindrical Sealant Backing for Use with Cold Liquid Applied Sealants*
- ASTM C717-06a, *Terminology of Building Seals and Sealants*

- ASTM C1472-06, *Standard Guide for Calculating Movement and Other Effects When Establishing Sealant Joint Width*

4. Julian R. Panek and John Philip Cook, *Construction Sealants and Adhesives*, 3rd Edition, 2004.
5. Michale T. Kubal, *Construction Waterproofing Handbook*, McGraw-Hill, Inc., 2000.
6. Joseph Amstock, *Hand book of Adhesives and Sealants in Construction*, 2000.
7. *Water in Exterior Building Walls, Problems and Solutions*, Thomas A. Schwartz, editor, ASTM STP 1107, February 1992.