School of Construction and the Environment

BLDG 4100 – Building Science 2

Week 5 – Sealants

What do sealants do?

- A sealant fills a gap between two or more substrates.
- Forms a barrier through the physical properties of the sealant itself and by adhesion to the substrate.
- Joint sealants are often used to create both a primary and secondary barrier to rain, snow, air, debris, and insect ingress.
- Joint sealants allow for this transition to be flexible – tolerating building movement, deflection, and differential expansion and contraction, while remaining intact.
- Maintains sealant properties for the expected lifetime, service conditions, and environmental.

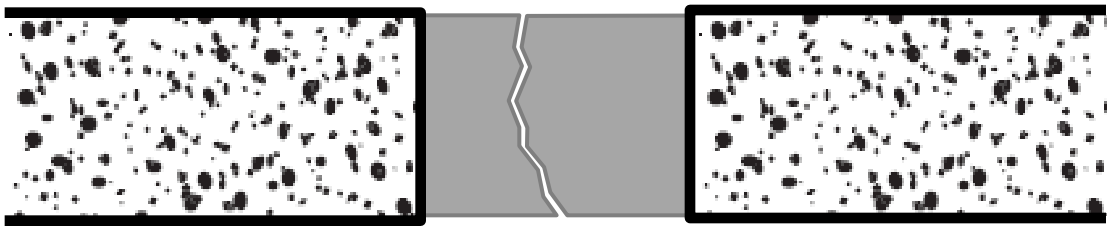
Sealant Failure Modes

Failure Mode: Adhesive Failure

- Adhesive Failure:
  - "Loss of Adhesion" is failure of the sealant to adhere along the bond line of the surface to which it is attached.
  - Possible Causes :
    - Exceeding the sealant capability
    - Improper surface preparation
    - Improper sealant joint geometry

Failure Mode: Cohesive Failure

- Cohesive Failure:
  - Cohesive Failure" occurs when the sealant fails to hold together .
  - Possible Causes :
    - Exceeding the sealant capability
    - Improper sealant joint geometry
    - Proper storage and mixing of sealant.



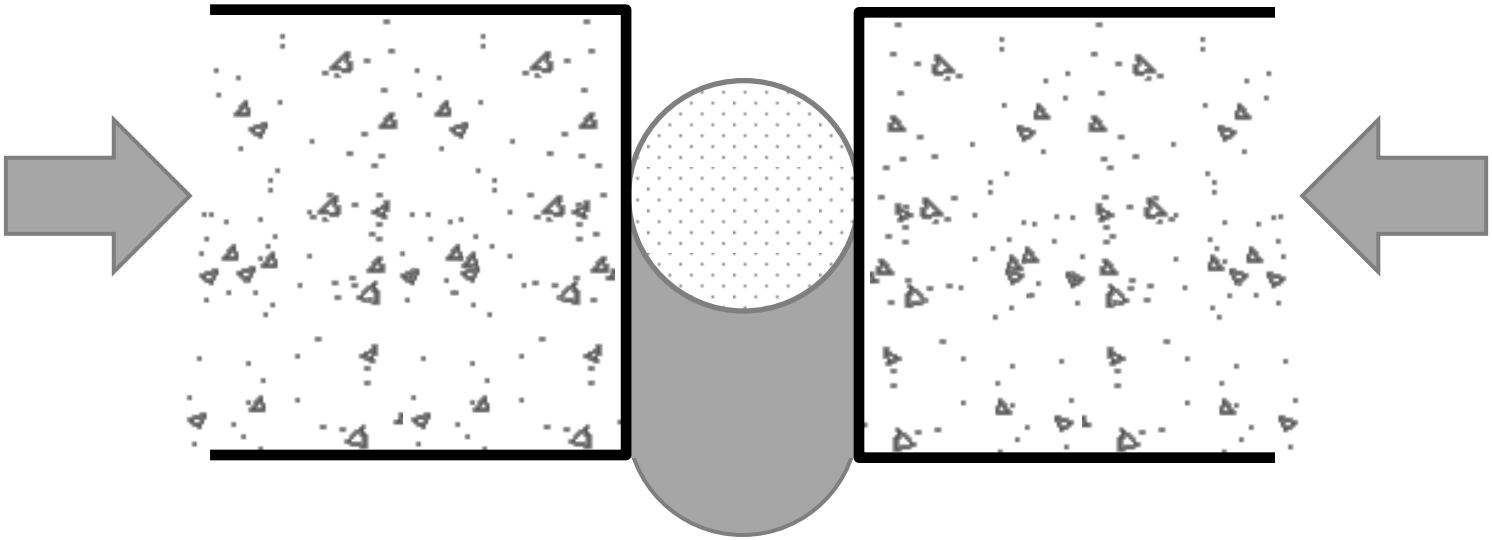
General Causes of Failures

- Improper joint design - not allowing for required movement.
- Improper sealant selection - incompatible with substrate, or not appropriate for the particular environmental exposure conditions.
- Improper installation – substrate contamination, temperature, improper sealant bead configuration, etc.

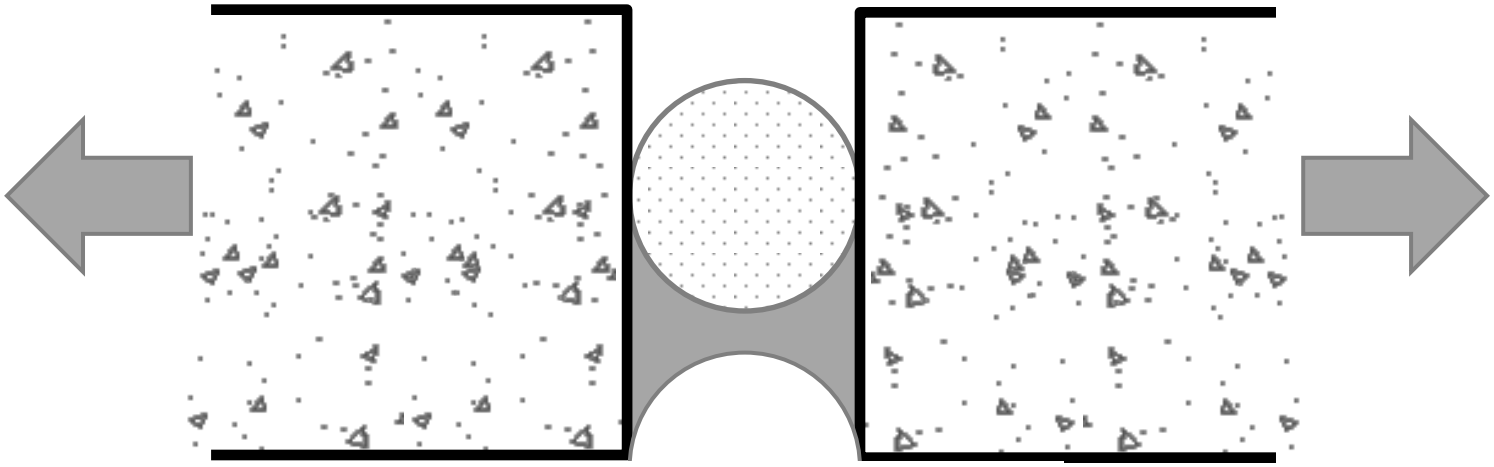
Movement Factors

- Thermal expansion and contraction.
- Moisture content changes.
- Deflection and creep.
- Sway and natural period of vibrations.
- Seismic events.
- Construction tolerances.

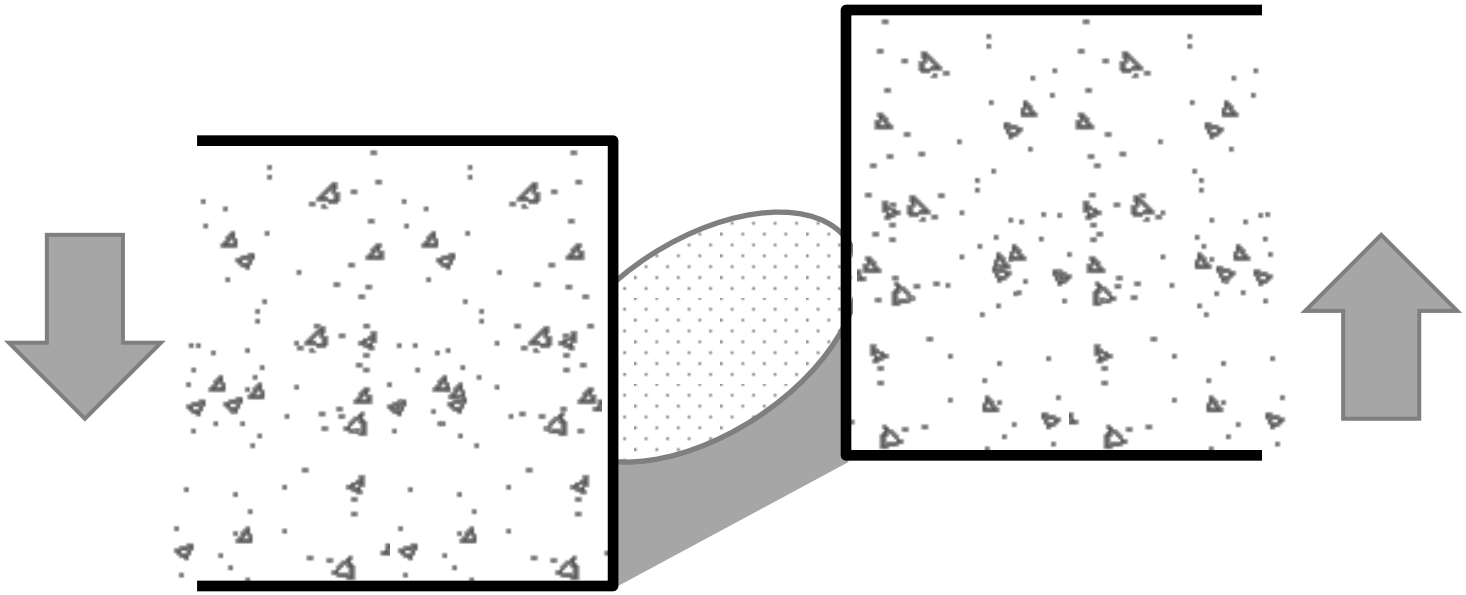
Results of Movement: Compression



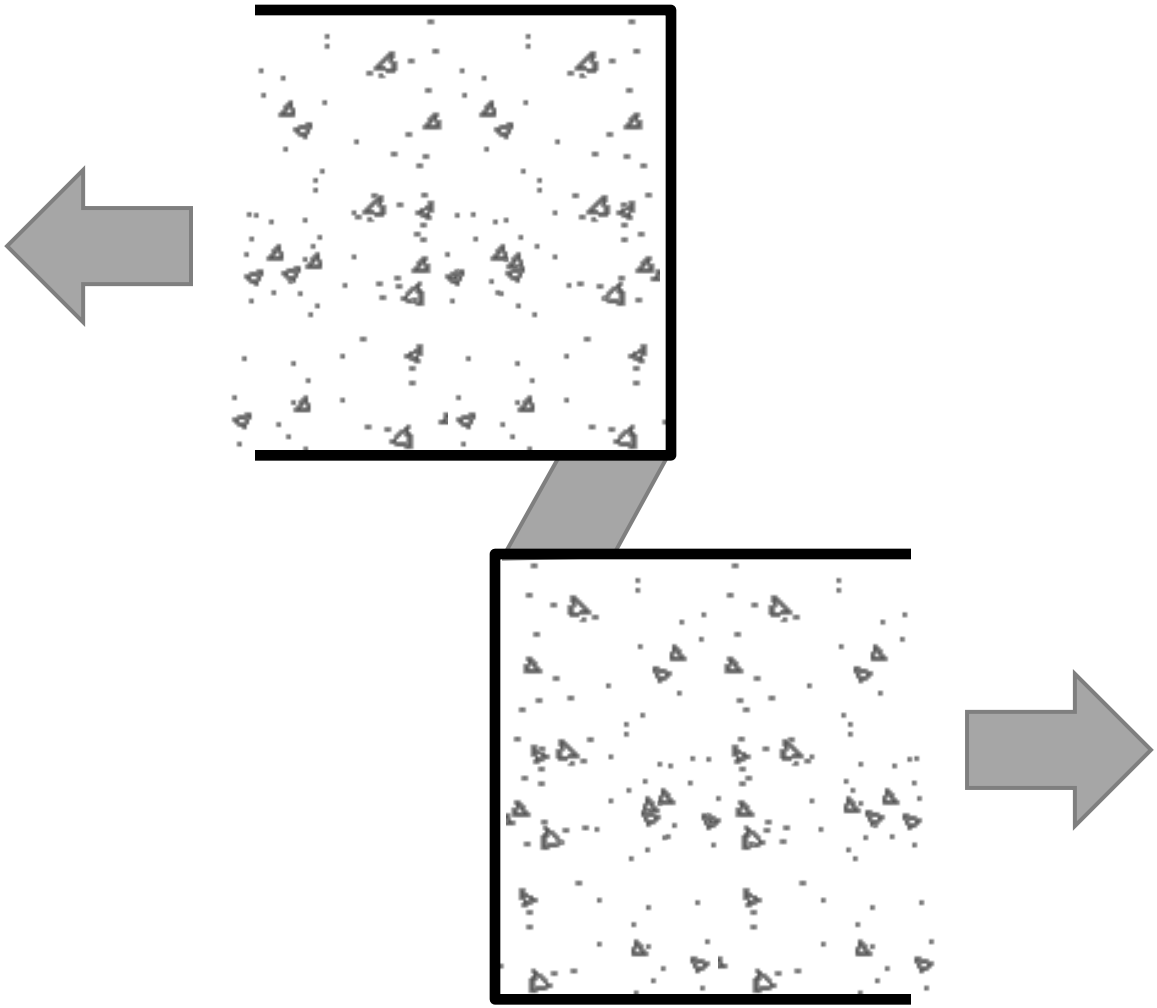
Results of Movement: Tension



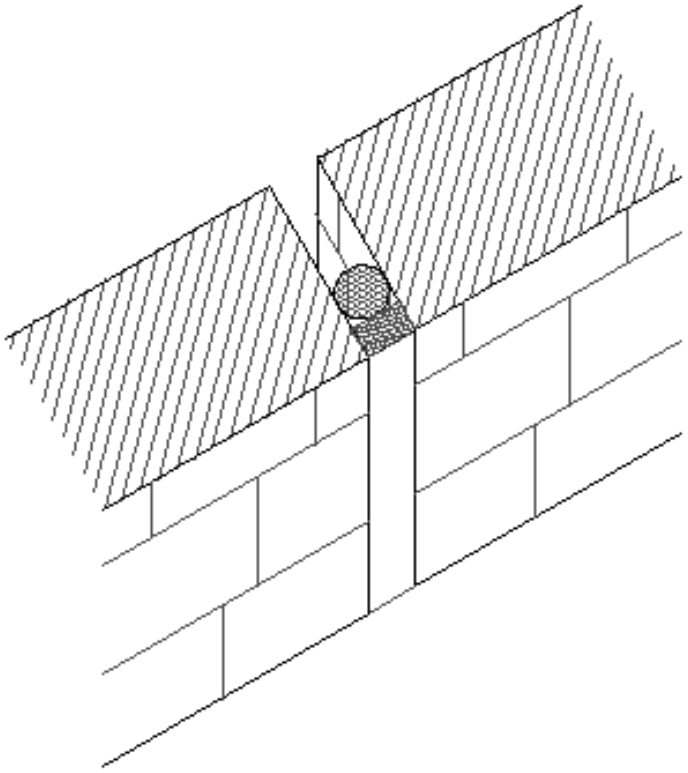
Results of Movement: Longitudinal Shear



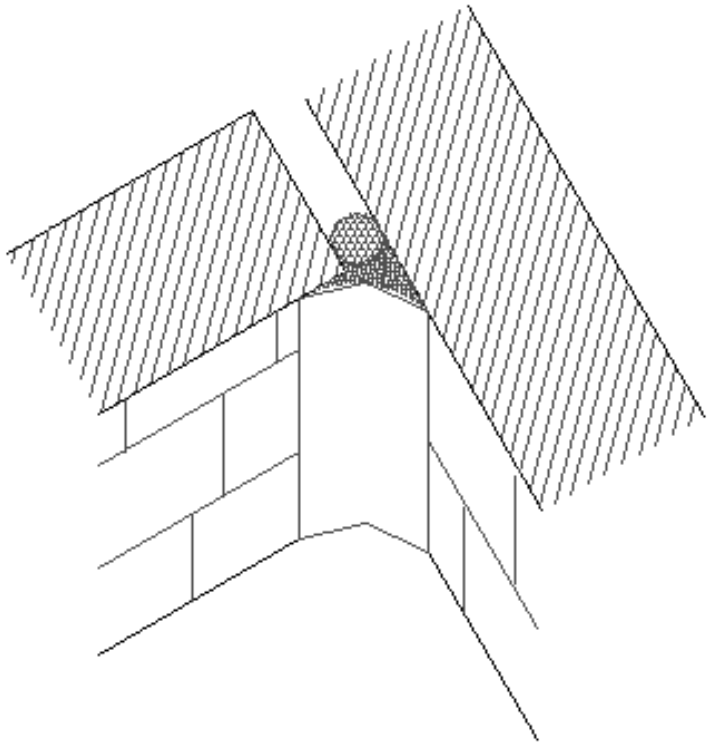
Results of Movement: Transverse Shear

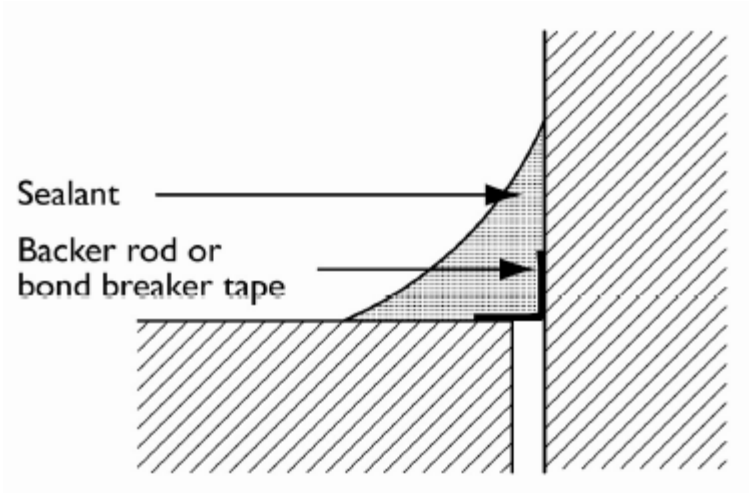


Types of Sealant Joints – Butt Joint

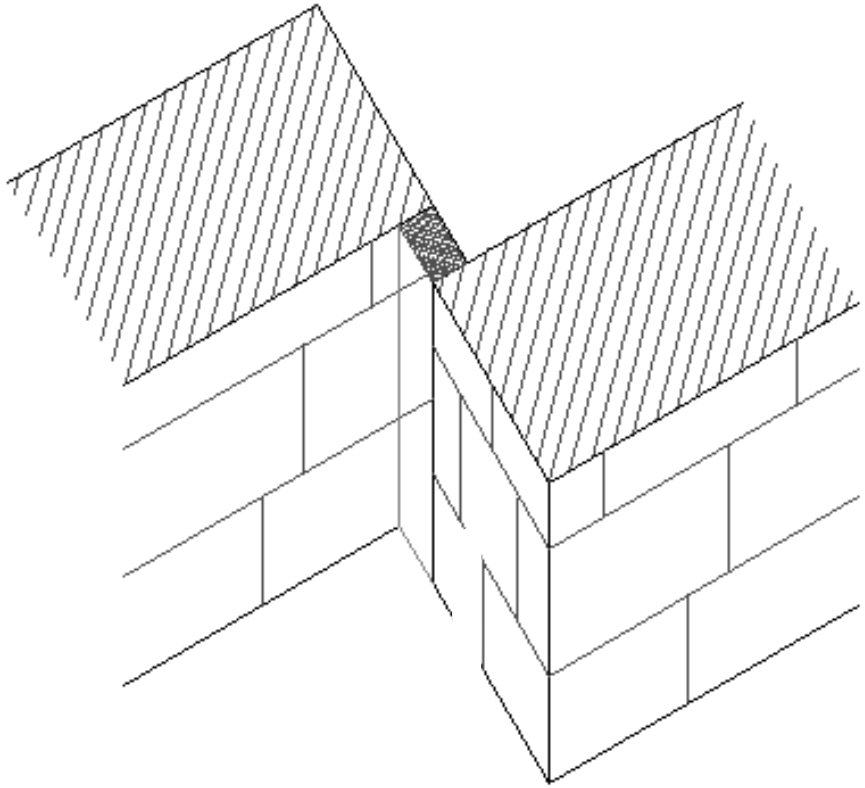


Types of Sealant Joints – Fillet Joint

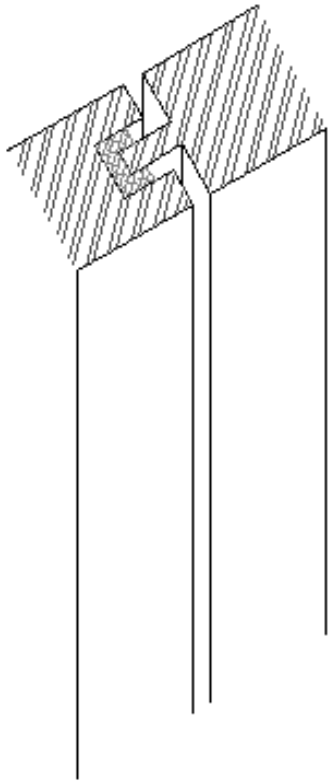




Types of Sealant Joints – Lap Joint



Types of Sealant Joints – Interlocking Joint

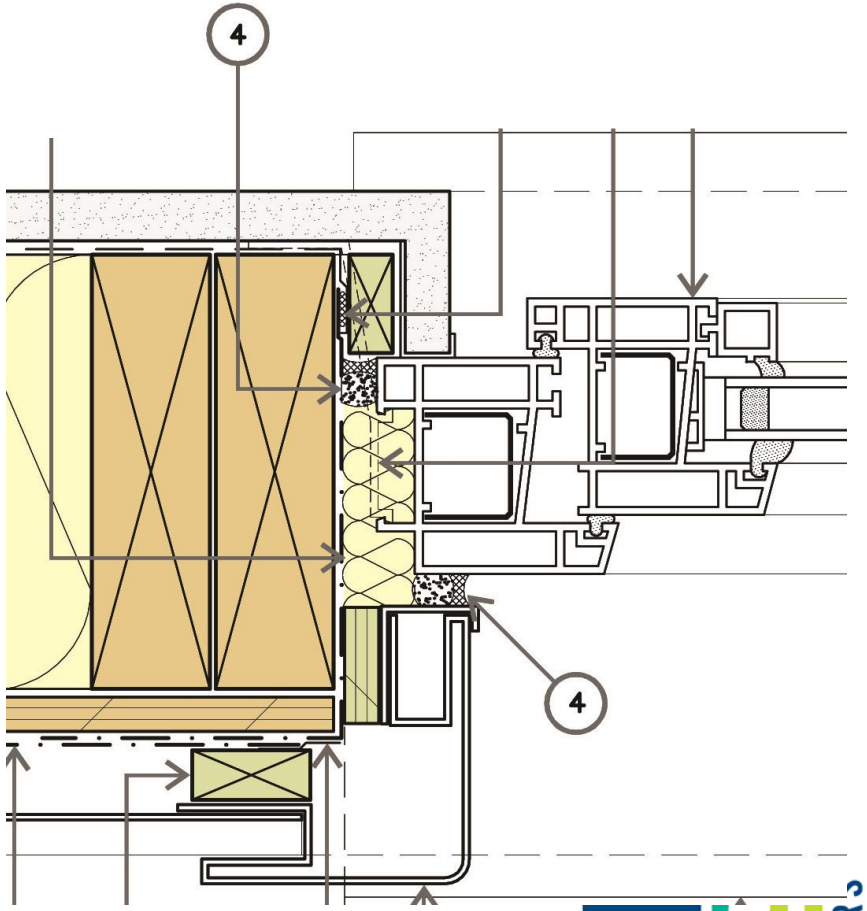


Location of Sealant Within Joint

- Design the joint so that the sealant is positioned with adjacent materials that make up the barrier that the sealant is a part of. (i.e. water resistive barrier, air barrier, water shedding surface.)
- Moving the sealant bead to an inner location (relative to the exterior face) protects the sealant from UV rays and other damaging environmental conditions.
- A two-stage seal method is consistent with a rainscreen type assembly; sealant at both inner and outer locations separate the functions that these sealant beads must provide.

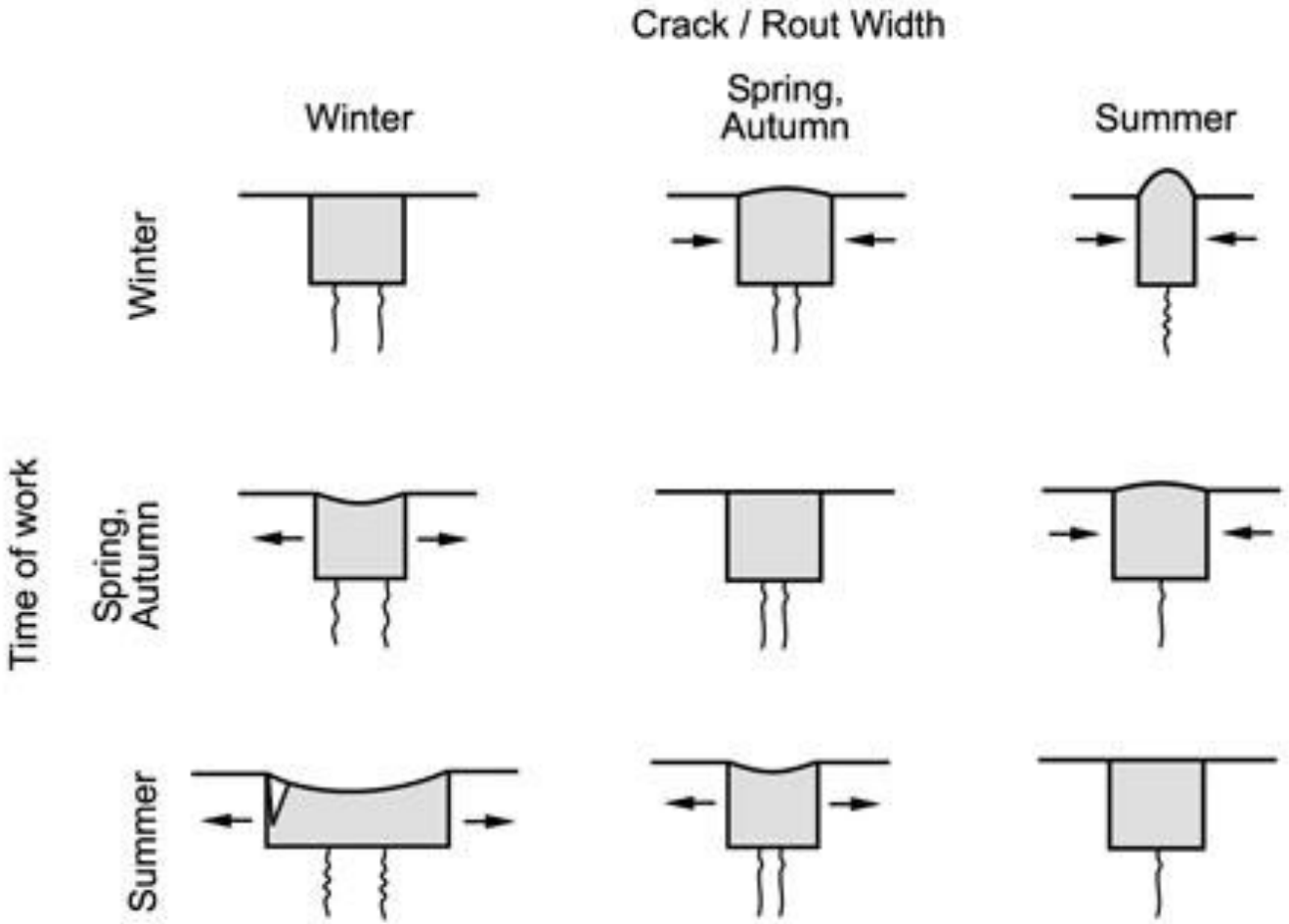
Location of Sealant Within Joint

- The inner seal typically provides the function of water resistive barrier (WRB) and air barrier (AB). It is protected from weathering and damage by it's concealed location.
- The outer seal provides the function of making an otherwise *discontinuous* water shedding surface (WSS) *continuous*. The sealant at the water shedding surface will weather over time, but is not the inner line of defense against water penetration, so sealant failure has low-risk of moisture damage to the building.



Reference: CMHC: Windows - Best Practice Guide
Building Technology and Graham Finch

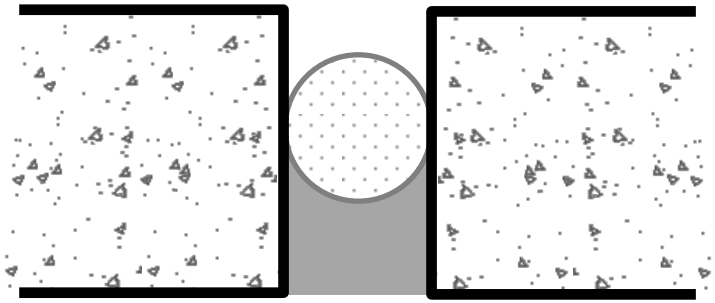
Sealant Joint Movement

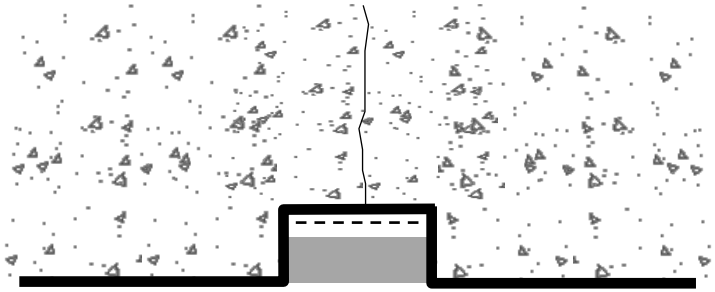


Reference: http://www.nrc-cnrc.gc.ca/ctu-sc/ctu_sc_n49

Bond Breaker

- Only two sided adhesion.
- Bond breaker is used to prevent adhesion of sealant on a third side.
- The most common bond breakers are:
  - Backer rod
  - Tape
  - Crayon





Backer Rod Types

- Three main types:
  - Open Cell
  - Closed Cell
  - Hybrid (Closed Cell Soft Rod)

Backer Rod Types – Open Cell

- Open Cell rods are typically made of polyurethane foam and are porous.
  - Advantage: Allow air to move through, therefore, can assist with sealant curing process.
  - Disadvantage: They wick and hold water

Backer Rod Types – Closed Cell

- Closed Cell rods are made from polyethylene foam, they are more rigid and non-porous.
  - Advantage: Do not store water and water can not transfer through.
  - Disadvantage: If punctured off-gassing may occur, which may result in air bubbles in the sealant reducing its cohesive strength.

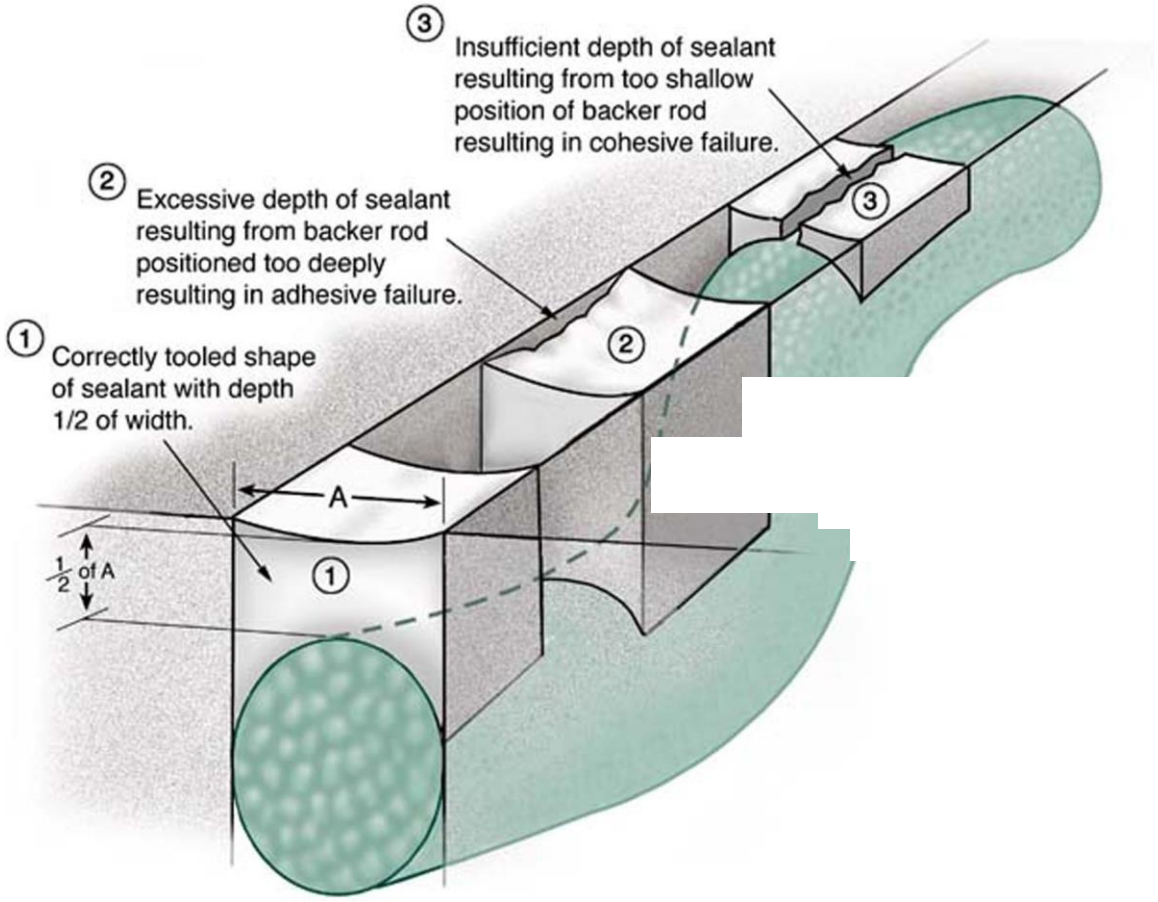
Backer Rod Types – Hybrid

- Closed Cell Soft Rod is most commonly used, and is non-gassing, but still largely resistance to water absorption.

Backer Rod Installation

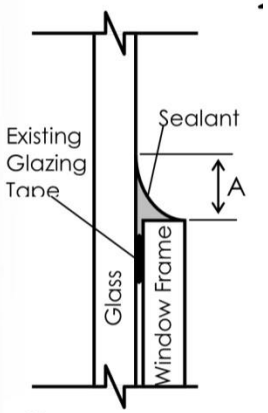
- Position the backer rod to achieve the appropriate sealant profile.
- Backer rod is to be 25% - 50% larger then width of joint.
- Backer rod is to not move during sealant installation.

Sealant Joint Failure



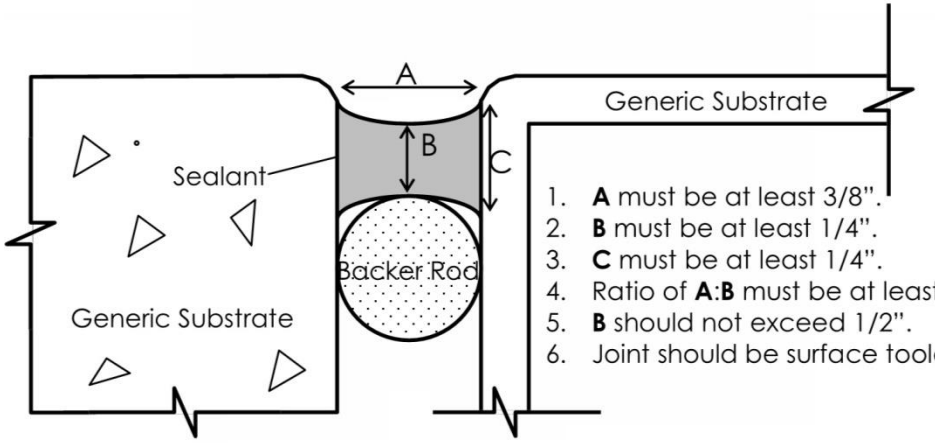
http://www.emseal.com/Knowledge/HybridSealants/HybridSealants.htm

Sealant Joint Dimensions



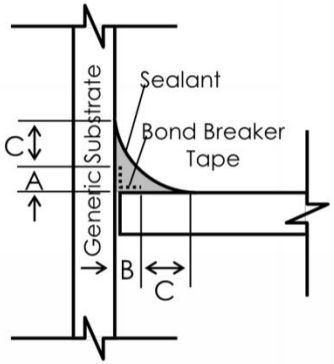
Cap

1. A must be at least 1/4".



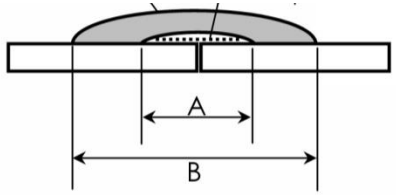
1. **A** must be at least 3/8".
2. **B** must be at least 1/4".
3. **C** must be at least 1/4".
4. Ratio of **A**:**B** must be at least 2:1.
5. **B** should not exceed 1/2".
6. Joint should be surface tooled.

Backer Rod & Sealant



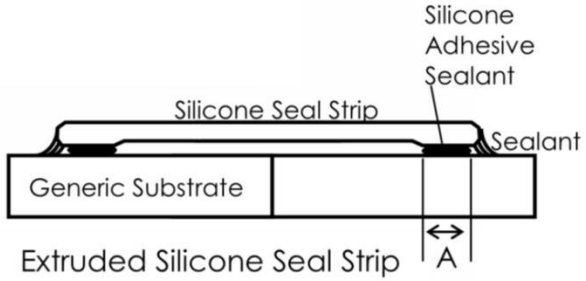
Fillet

1. **A** and **B** must be at least ¼".
2. **C** must be at least ¼".
3. A bond breaker tape must be used.
4. Joint must be tooled flat or slightly



Band-Aid Joint

1. **A** must be at least ¼".
2. **B** must be at least ½".



Extruded Silicone Seal Strip 3" wide over Butt Joint

1. **A** must be at least 3/8".
2. Edges of strip should be sealed with a fillet bead.

Reference: RDH Building Engineering Ltd.

Sealant Selection

- When selecting a sealant some of the items that should be considered include:
  - Expected movement
  - In-service conditions
  - Sealant types
  - Sealant features
  - Type of substrate
  - Material compatibility
  - Surface preparation

Common Sealant Types

- High-performance neutral cure silicone sealants
- Polyurethanes
- Polysulphide sealants
- Thermo-plastic elastomeric sealants
- Mildew-resistant silicones
- Acetoxy silicones
- Acrylics
- Acrylic latex one part
- Acoustical
- Butyl
- Oil-based
- Silane terminated polyurethane sealants (STP)

Sealant Features

- Substrate compatibility
- Movement capability
- Elastic recovery and stress relaxation
- Hardness
- Ultraviolet resistance
- Aesthetics

Sealant Features

- 1 Part versus 2 Part
- Chemical Cure versus Neutral Cure

Sealant Types: Oil-Based Compounds

- Typical uses:
  - Seldom used or produced; obsolete technology. “Caulking.”
  - Glazing applications from years past.
- Features:
  - Fast skinning.
  - Can be painted in less than 24 hours.
- Limitations:
  - Not for dynamically moving joints under any circumstances.
  - Stains light coloured stone.
  - Movement capability: ± 2% to 5%

Reference: Graham Finch

Sealant Types: Butyl Sealants

- Typical uses:
  - Bedding compounds.
  - Non-moving joints.
- Features:
  - Non-hardening cure.
  - No priming necessary.
  - Good adhesion.
  - Good water resistance.
- Limitations:
  - Stains porous substrates.
  - Slow curing.
  - Low recovery.
  - Resists movement in cold temperatures.
  - Movement capability: ±7.5%

Reference: Graham Finch

Sealant Types: Acrylic Latex Sealants

- Typical uses:
  - Interior joints.
- Features:
  - Fast-skinning.
  - Paintable.
  - Non-staining.
  - Adheres without priming.
  - Does not become brittle with time.
- Limitations:
  - Indoor use only.
  - Poor tear resistance.
  - Poor recovery.
  - High initial bead shrinkage.
  - Movement capability: ± 7.5% to 12.5%

Reference: Graham Finch

Sealant Types: Solvent-Release Acrylics

- Typical uses:
  - Low-movement dynamic joints.
  - Metal to metal.
- Features:
  - Non-staining.
  - Resists UV and ozone.
  - No priming typically required.
  - Minimal preparation and cleaning.
- Limitations:
  - Poor recovery.
  - High initial bead shrinkage.
  - Poor water resistance.
  - Pungent odor during installation.
  - Movement capability: ± 10% to 12.5%

Reference: Graham Finch

Sealant Types: Polysulfides

- Typical uses:
  - Very rarely used or produced for construction applications; older technology.
  - Used by the insulating glazing industry in the production of some IGUs.
- Features:
  - Movement capability up to 25%.
  - Good adhesion.
  - Resists some solvents.
  - Good resistance to weathering.
- Limitations:
  - Moderate recovery (75%).
  - Primer usually necessary.
  - Often stains if primer not used.
  - 24 hour tack free time (picks up dirt during curing).

Sealant Types: Urethanes

- Typical uses:
  - EIFS joints.
  - Pre-cast concrete joints.
  - Exterior joints where paintability is a primary concern.
- Features:
  - Movement capability up to 50%.
  - Good adhesion.
  - Abrasion Resistant.
  - Fairly good resistance to UV and ozone.
  - Good recovery (80% - 90%).
  - Resists some solvents and chemicals.
  - Tear resistant.
  - Negligible initial shrinkage.
  - Paintable.
- Limitations:
  - Deterioration can occur during extremely high service temperatures.
  - Very sensitive to moisture during installation and curing.
  - Primer necessary in most applications.
  - Some types stain if primer is not used.
  - 12 – 36 hour tack free time (picks up dirt during curing).

Reference: Graham Finch

Sealant Types: Silicones

- Typical uses:
  - Dynamic joints.
  - Glazing.
- Features:
  - Movement capability up to 50%.
  - Good adhesion.
  - Fairly good resistance to UV and ozone.
  - Good recovery (80% - 90%).
  - Primer is not necessary in most applications.
  - Tear resistant.
  - Negligible initial shrinkage.
  - Performs well in high and low temperatures.
- Limitations:
  - Deterioration can occur during extremely high service temperatures.
  - Very sensitive to moisture during installation and curing.
  - Primer necessary in some applications.
  - 12 – 36 hour tack free time (picks up dirt during curing).
  - Static charge present at surface (picks up dirt throughout its life-span, and is hard to clean).
  - Short pot life.
  - Not abrasion resistance.
  - Non paintable.
  - May stain some substrates.

Reference: Graham Finch

Performance

Joint Function	Best Performance	Moderate Performance	Not Recommended
Perimeter of exterior openings and windows at joints with exterior façade of building (typical cementitious and metal-based materials and associated coatings such as stucco, EIFS, masonry, most aluminum and steel coating systems)	1, 2	3, 4	5-11
Perimeter of exterior openings and windows at joints with exterior façade of building (typical vinyl-based and coated materials such as siding, windows, and some stucco trims)	1	2, 3, 4	5-11
Expansion and control joints in exterior surfaces	1, 2	3, 4	5-11
Joints in prefinished metal flashings exposed to the exterior	1	2, 3, 4	4-11
Joints in metal gutters exposed to the exterior	1, 4	6	2, 4, 5, 7-11
Interior joint around the perimeter of window to wall flashing as detailed on drawings		4, 10	1-3, 5-9, 11
Interior control and expansion joints in floor surfaces	1, 2, 3		4-11
Perimeter of bath fixtures (e.g. sinks, tubs, urinals, stools, waterclosets, basins, vanities)	5		1-4, 6-11
Exposed interior control joints in drywall	7, 8		1-6, 9-11
Perimeter of glass surfaces	1	6	2-5, 7-11
Sealing laps in polyethylene vapour retarder or drywall for sound attenuation or air seal	9	10	1-8, 11
Air barrier seal between joints in exterior sheathing	1, 2	3, 4, 10	5-11

KEY:

1 High performance neutral cure silicones
2 Polyurethanes
3 Polysulfides
4 Thermoplastic elastomerics (kreytons)
5 Mildew resistant silicones
6 Acetoxy silicones
7 Acrylics
8 Acrylic latex one part
9 Acoustical
10 Butyl
11 Oil-based

Reference: CMHC: Windows - Best Practice Guide Building Technology

Substrates

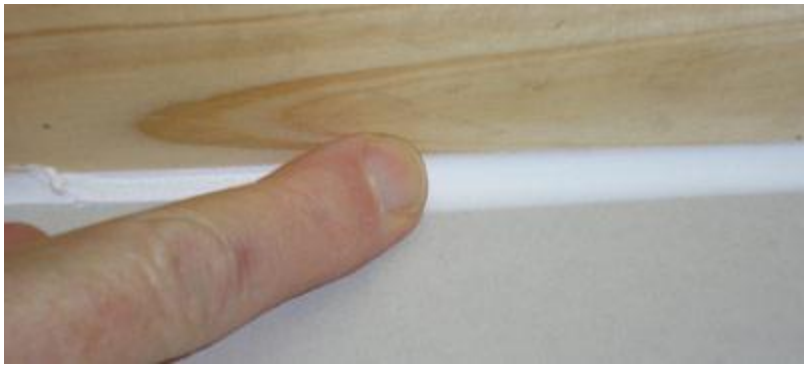
- Two categories of substrates
  - Porous (i.e. concrete, masonry, wood).
  - Non-porous (i.e. metal, glass, vinyl, fiberglass, tile).

Primers

- Primers, if required, are used to help prepare a substrate for sealant application.
- Primers are typically used for the following reasons
  - Adhesion
  - Cohesion
  - Staining

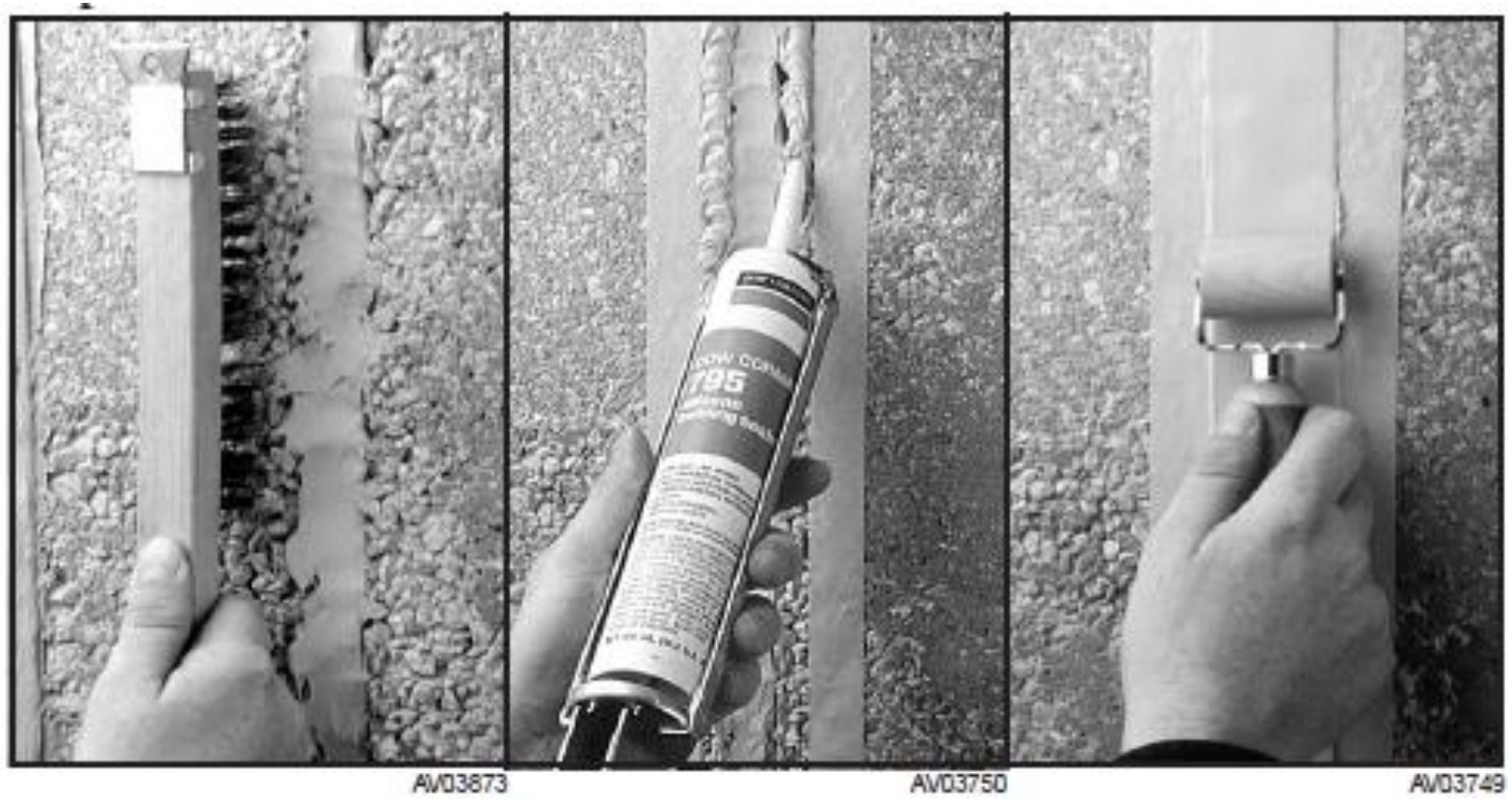
Tooling

- What is tooling?
- Why tool?
  - To achieve the desired shape and appearance
  - To achieve the desired adhesion



Carriage or Sausage

Installation of Silicone Strip

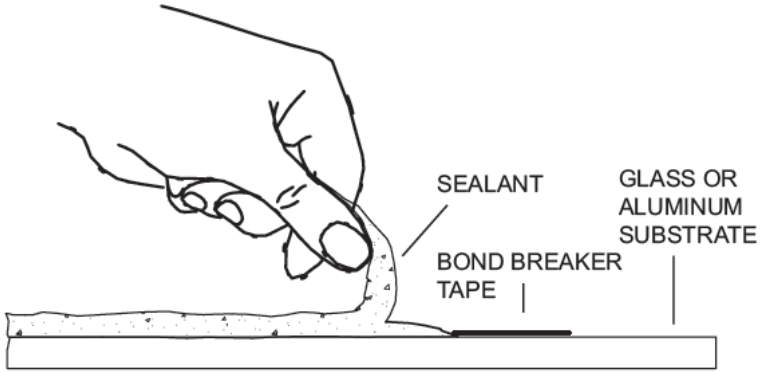


Reference: Dow Corning

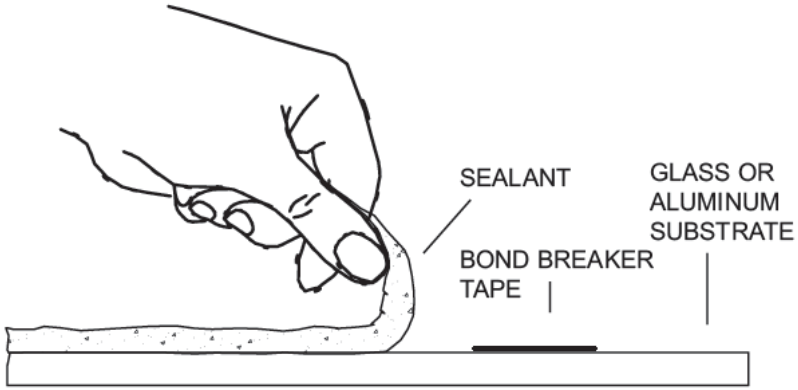
ASTM Testing

- **ASTM C1193 – Standard Guide for Use of Joint Sealants**
  This guide provides information and guidelines for consideration by the designer or applicator of a joint seal
- **ASTM C794 – Standard Test Method for Adhesion-in-Peel of Elastomeric Joint Sealants:** This test method covers a laboratory procedure for determining the strength and characteristics of the peel properties of a cured-in-place elastomeric joint sealant, single- or multicomponent, for use in building construction.
- **ASTM C1248 – Standard Test Method for Staining of Porous Substrate by Joint Sealants:** This test method covers four types of laboratory tests to determine if a joint sealant has a probability of staining a porous substrate (such as marble, limestone, sandstone, and granite)..

Adhesion Testing



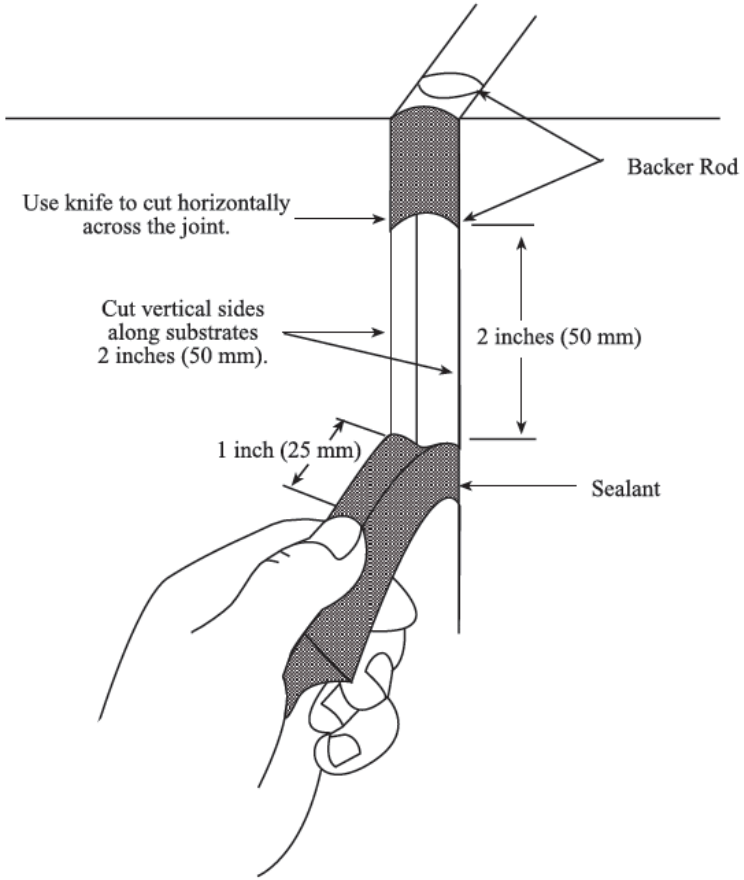
Peel Adhesion Test: Cohesive Failure



Peel Adhesion Test: Adhesive Failure

Reference: Dow Corning

Adhesion Testing



Dow Corning® Sealant	Adhesion Requirement
756 SMS Building Sealant	Pull tab 1.5" (150% extension) without bond loss
758 Weather Barrier Sealant	Pull tab 2.0" (200% extension) without bond loss
790 Building Sealant	Pull tab 3.0" (300% extension) without bond loss
791 Weatherproofing Sealant	Pull tab 1.5" (150% extension) without bond loss
795 Building Sealant	Pull tab until it breaks without bond loss
995 Structural Glazing Sealant	Pull tab until it breaks without bond loss
999-A Building & Glazing Sealant △	Pull tab until it breaks without bond loss
Contractors Concrete Sealant	Pull tab 3.0" (300% extension) without bond loss
Contractors Weatherproofing Sealant	Pull tab 1.5" (150% extension) without bond loss
Parking Structure Sealant FC	Pull tab 4.0" (400% extension) without bond loss
Parking Structure Sealant SL	Pull tab 4.0" (400% extension) without bond loss
Parking Structure Sealant NS	Pull tab 4.0" (400% extension) without bond loss

Reference: Dow Corning

Recommendations: Installation

- Ensure the sealant has not exceeded its shelf life.
- Ensure the sealant is properly stored.
- Ensure the sealant is mixed properly (if applicable).
- Ensure the substrate is cleaned properly.
- Ensure the sealant is compatible with any coating on the substrate.
- Ensure a proper backer rod or bond breaker is used and positioned properly in the joint.
- Ensure an adequate primer is used properly (if applicable).
- Ensure the sealant is installed at such a time when the temperature is not at an extreme.
- Ensure the bead configuration adheres to the manufacturer's product specifications.
- Ensure the beads are properly tooled.
- Ensure the curing process is not disturbed.

Reference: Graham Finch