

# FUNDAMENTALS OF SEALANT PERFORMANCE



*...for an Expert Crowd...*



ENGINEERING THAT MAKES SENSE.

# AGENDA

- Overview of standards & performance criteria
- Sealant bond & function
- Service life considerations
- Determining renewal options
- What else?




# WAY BACK WHEN...



## BUILDING ENVELOPE MATERIALS: SEALANTS

Kevin Day



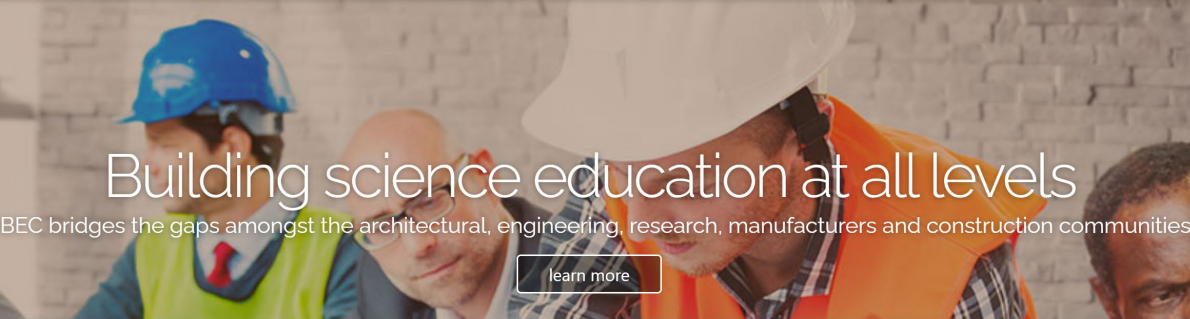


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The thumbnails cover a wide range of topics related to construction materials and techniques:

- Sealant Fundamentals:** Building Envelope Materials Sealants, General Definition, Building Envelope Sealants, Single-Component Sealants, Polyurethane Sealants, Acrylic Sealants, Butyl Sealants, Polyurethane Foam Sealant, Polymer Modified Bitumen Sealant.
- Standards & Specifications:** ASTM Standards (ASTM C 1181, ASTM C 1193, ASTM C 1195, ASTM C 1196, ASTM C 1197, ASTM C 1198, ASTM C 1199, ASTM C 1200, ASTM C 1201, ASTM C 1202, ASTM C 1203, ASTM C 1204, ASTM C 1205, ASTM C 1206, ASTM C 1207, ASTM C 1208, ASTM C 1209, ASTM C 1210, ASTM C 1211, ASTM C 1212, ASTM C 1213, ASTM C 1214, ASTM C 1215, ASTM C 1216, ASTM C 1217, ASTM C 1218, ASTM C 1219, ASTM C 1220, ASTM C 1221, ASTM C 1222, ASTM C 1223, ASTM C 1224, ASTM C 1225, ASTM C 1226, ASTM C 1227, ASTM C 1228, ASTM C 1229, ASTM C 1230, ASTM C 1231, ASTM C 1232, ASTM C 1233, ASTM C 1234, ASTM C 1235, ASTM C 1236, ASTM C 1237, ASTM C 1238, ASTM C 1239, ASTM C 1240, ASTM C 1241, ASTM C 1242, ASTM C 1243, ASTM C 1244, ASTM C 1245, ASTM C 1246, ASTM C 1247, ASTM C 1248, ASTM C 1249, ASTM C 1250, ASTM C 1251, ASTM C 1252, ASTM C 1253, ASTM C 1254, ASTM C 1255, ASTM C 1256, ASTM C 1257, ASTM C 1258, ASTM C 1259, ASTM C 1260, ASTM C 1261, ASTM C 1262, ASTM C 1263, ASTM C 1264, ASTM C 1265, ASTM C 1266, ASTM C 1267, ASTM C 1268, ASTM C 1269, ASTM C 1270, ASTM C 1271, ASTM C 1272, ASTM C 1273, ASTM C 1274, ASTM C 1275, ASTM C 1276, ASTM C 1277, ASTM C 1278, ASTM C 1279, ASTM C 1280, ASTM C 1281, ASTM C 1282, ASTM C 1283, ASTM C 1284, ASTM C 1285, ASTM C 1286, ASTM C 1287, ASTM C 1288, ASTM C 1289, ASTM C 1290, ASTM C 1291, ASTM C 1292, ASTM C 1293, ASTM C 1294, ASTM C 1295, ASTM C 1296, ASTM C 1297, ASTM C 1298, ASTM C 1299, ASTM C 1300, ASTM C 1301, ASTM C 1302, ASTM C 1303, ASTM C 1304, ASTM C 1305, ASTM C 1306, ASTM C 1307, ASTM C 1308, ASTM C 1309, ASTM C 1310, ASTM C 1311, ASTM C 1312, ASTM C 1313, ASTM C 1314, ASTM C 1315, ASTM C 1316, ASTM C 1317, ASTM C 1318, ASTM C 1319, ASTM C 1320, ASTM C 1321, ASTM C 1322, ASTM C 1323, ASTM C 1324, ASTM C 1325, ASTM C 1326, ASTM C 1327, ASTM C 1328, ASTM C 1329, ASTM C 1330, ASTM C 1331, ASTM C 1332, ASTM C 1333, ASTM C 1334, ASTM C 1335, ASTM C 1336, ASTM C 1337, ASTM C 1338, ASTM C 1339, ASTM C 1340, ASTM C 1341, ASTM C 1342, ASTM C 1343, ASTM C 1344, ASTM C 1345, ASTM C 1346, ASTM C 1347, ASTM C 1348, ASTM C 1349, ASTM C 1350, ASTM C 1351, ASTM C 1352, ASTM C 1353, ASTM C 1354, ASTM C 1355, ASTM C 1356, ASTM C 1357, ASTM C 1358, ASTM C 1359, ASTM C 1360, ASTM C 1361, ASTM C 1362, ASTM C 1363, ASTM C 1364, ASTM C 1365, ASTM C 1366, ASTM C 1367, ASTM C 1368, ASTM C 1369, ASTM C 1370, ASTM C 1371, ASTM C 1372, ASTM C 1373, ASTM C 1374, ASTM C 1375, ASTM C 1376, ASTM C 1377, ASTM C 1378, ASTM C 1379, ASTM C 1380, ASTM C 1381, ASTM C 1382, ASTM C 1383, ASTM C 1384, ASTM C 1385, ASTM C 1386, ASTM C 1387, ASTM C 1388, ASTM C 1389, ASTM C 1390, ASTM C 1391, ASTM C 1392, ASTM C 1393, ASTM C 1394, ASTM C 1395, ASTM C 1396, ASTM C 1397, ASTM C 1398, ASTM C 1399, ASTM C 1400, ASTM C 1401, ASTM C 1402, ASTM C 1403, ASTM C 1404, ASTM C 1405, ASTM C 1406, ASTM C 1407, ASTM C 1408, ASTM C 1409, ASTM C 1410, ASTM C 1411, ASTM C 1412, ASTM C 1413, ASTM C 1414, ASTM C 1415, ASTM C 1416, ASTM C 1417, ASTM C 1418, ASTM C 1419, ASTM C 1420, ASTM C 1421, ASTM C 1422, ASTM C 1423, ASTM C 1424, ASTM C 1425, ASTM C 1426, ASTM C 1427, ASTM C 1428, ASTM C 1429, ASTM C 1430, ASTM C 1431, ASTM C 1432, ASTM C 1433, ASTM C 1434, ASTM C 1435, ASTM C 1436, ASTM C 1437, ASTM C 1438, ASTM C 1439, ASTM C 1440, ASTM C 1441, ASTM C 1442, ASTM C 1443, ASTM C 1444, ASTM C 1445, ASTM C 1446, ASTM C 1447, ASTM C 1448, ASTM C 1449, ASTM C 1450, ASTM C 1451, ASTM C 1452, ASTM C 1453, ASTM C 1454, ASTM C 1455, ASTM C 1456, ASTM C 1457, ASTM C 1458, ASTM C 1459, ASTM C 1460, ASTM C 1461, ASTM C 1462, ASTM C 1463, ASTM C 1464, ASTM C 1465, ASTM C 1466, ASTM C 1467, ASTM C 1468, ASTM C 1469, ASTM C 1470, ASTM C 1471, ASTM C 1472, ASTM C 1473, ASTM C 1474, ASTM C 1475, ASTM C 1476, ASTM C 1477, ASTM C 1478, ASTM C 1479, ASTM C 1480, ASTM C 1481, ASTM C 1482, ASTM C 1483, ASTM C 1484, ASTM C 1485, ASTM C 1486, ASTM C 1487, ASTM C 1488, ASTM C 1489, ASTM C 1490, ASTM C 1491, ASTM C 1492, ASTM C 1493, ASTM C 1494, ASTM C 1495, ASTM C 1496, ASTM C 1497, ASTM C 1498, ASTM C 1499, ASTM C 1500).
- Application & Installation:** Sealing Joints, Sealing Details, Sealing Failures, Sealing Repairs, Sealing Maintenance, Sealing Inspection, Sealing Testing, Sealing Evaluation, Sealing Selection, Sealing Compatibility, Sealing Durability, Sealing Performance, Sealing Reliability, Sealing Safety, Sealing Environment, Sealing Health, Sealing Aesthetics, Sealing Cost, Sealing Time, Sealing Labor, Sealing Equipment, Sealing Materials, Sealing Tools, Sealing Techniques, Sealing Procedures, Sealing Instructions, Sealing Manuals, Sealing Guides, Sealing References, Sealing Sources, Sealing Suppliers, Sealing Distributors, Sealing Retailers, Sealing Wholesalers, Sealing Importers, Sealing Exporters, Sealing Manufacturers, Sealing Engineers, Sealing Architects, Sealing Designers, Sealing Planners, Sealing Consultants, Sealing Specialists, Sealing Experts, Sealing Professionals, Sealing Services, Sealing Solutions, Sealing Products, Sealing Systems, Sealing Components, Sealing Parts, Sealing 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Sealing Unequal, Sealing Similar, Sealing Dissimilar, Sealing Alike, Sealing Unlike, Sealing Same, Sealing Different, Sealing Identical, Sealing Distinct, Sealing Unique, Sealing Common, Sealing Rare, Sealing Frequent, Sealing Infrequent, Sealing Often, Sealing Sometimes, Sealing Always, Sealing Never, Sealing Usually, Sealing Occasionally, Sealing Frequently, Sealing Rarely, Sealing Seldom, Sealing Almost, Sealing Nearly, Sealing Quite, Sealing Very, Sealing Extremely, Sealing Superlatives, Sealing Comparatives, Sealing Degrees, Sealing Intensifiers, Sealing Modifiers, Sealing Qualifiers, Sealing Descriptors, Sealing Adjectives, Sealing Nouns, Sealing Verbs, Sealing Pronouns, Sealing Prepositions, Sealing Conjunctions, Sealing Interjections, Sealing Particles, Sealing Clauses, Sealing Sentences, Sealing Paragraphs, Sealing Chapters, Sealing Sections, Sealing Pages, Sealing Words, Sealing Letters, Sealing Symbols, Sealing Signs, Sealing Marks, Sealing Notations, Sealing Diagrams, Sealing Illustrations, Sealing Photographs, Sealing Videos, Sealing Audio, Sealing Music, Sealing Art, Sealing Science, Sealing Technology, Sealing Innovation, Sealing Progress, Sealing Development, Sealing Growth, Sealing Expansion, Sealing Contraction, Sealing Shrinkage, Sealing Swelling, Sealing Elongation, Sealing Shortening, Sealing Stretching, Sealing Compressing, Sealing Tension, Sealing Compression, Sealing Pressure, Sealing Vacuum, Sealing Force, Sealing Torque, Sealing Moment, Sealing Energy, Sealing Power, Sealing Work, Sealing Heat, Sealing Cold, Sealing Temperature, Sealing Humidity, Sealing Moisture, Sealing Dryness, Sealing Wetness, Sealing Wind, Sealing Rain, Sealing Snow, Sealing Ice, Sealing Fog, Sealing Clouds, Sealing Sun, Sealing Moon, Sealing Stars, Sealing Planets, Sealing Galaxies, Sealing Universe, Sealing Earth, Sealing Sky, Sealing Ocean, Sealing Land, Sealing Forest, Sealing Desert, Sealing Mountain, Sealing Valley, Sealing River, Sealing Lake, Sealing Pond, Sealing Stream, Sealing Creek, Sealing Canal, Sealing Dam, Sealing Bridge, Sealing Tunnel, Sealing Road, Sealing Highway, Sealing Airport, Sealing Port, Sealing Harbor, Sealing Dock, Sealing Pier, Sealing Quay, Sealing Wharf, Sealing Jetty, Sealing Breakwater, Sealing Barrage, Sealing Lock, Sealing Weir, Sealing Sluice, Sealing Dam, Sealing Bridge, Sealing Tunnel, Sealing Road, Sealing Highway, Sealing Airport, Sealing Port, Sealing Harbor, Sealing Dock, Sealing Pier, Sealing Quay, Sealing Wharf, Sealing Jetty, Sealing Breakwater, Sealing Barrage, Sealing Lock, Sealing Weir, Sealing Sluice).</



# TERMINOLOGY

- Poll: Sealant vs. Caulking
- By definition:
  - Sealant moves and has “elasticity”
  - Caulking:
    - *As a noun:* it doesn't really move, it's a gap filler
    - *As a verb:* is the act of “applying” sealant
- Question: would you rename SWA as the **Caulking** and Waterproofing Association of Canada?

# TERMINOLOGY

- **Expansion Joints**

- Extend through the building assembly, e.g., building expansion or masonry control joints
- Expected to have significant movement
- Example, movement expected to be  $\geq 10\%$  joint width

- **Termination Joints**

- Seal between building envelope elements, e.g., window perimeters
- Not expected to have significant movement
- Example, movement expected to be  $< 10\%$  joint width

# TYPES OF SEALANT

- Most commonly used **exterior** sealants:
  - [Polyurethane](#) (preceded by [polysulfide](#))
  - [Silicone](#)
  - [Acrylic](#)
  - Hybrids, e.g., silyl terminated polyether
  - Foam gaskets e.g., used with silicone
- Most commonly used **concealed** sealants:
  - Butyl
  - Polymer modified bitumen
  - Spray-applied foam
  - Crack injection



# RESOURCES

- Standards - order [here](#)
  - [ASTM](#) – ASTM International
  - [CGSB](#) – Canadian General Standards Board
  - [ULC](#) – Underwriters Laboratories Canada
- Industry Guides
  - [AAMA](#) – American Architectural Manufacturers Association
  - [CPCI](#) – Canadian Precast Concrete Institute
  - [SWAO](#) – Sealant & Waterproofing Association (Ontario)
  - [SWRI](#) – Sealant & Waterproofing Restoration Institute

# RESOURCES

- ASTM Standards
- ULC Standards (for SPF)
- [Tremco's Sealant Restoration Guide](#)

SEALANT RESTORATION GUIDE

**TREMCO**  
Commercial Sealants & Waterproofing

# PERFORMANCE & SERVICE LIFE

## EXPECTATIONS:

- Stick long enough
- Flexible long enough
- Resist water, UV, pollutants
- “Easy” repair methods
- Barrier seals or rainscreen

## APPLICATION

- Priming & surface prep
- Application conditions
- Tool for bonding
- Joint proportions, width/depth
- Best before dates



# THE NAME IS BOND, SEALANT BOND...



# ASTM C1736 [WITHDRAWN] STANDARD PRACTICE FOR NON-DESTRUCTIVE EVALUATION OF ADHESION OF INSTALLED WEATHERPROOFING SEALANT JOINTS

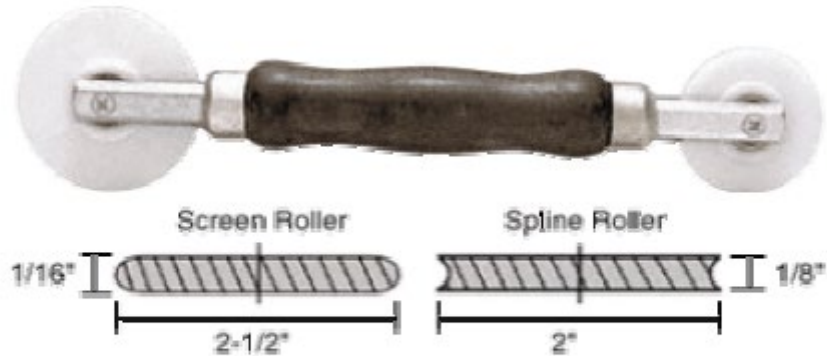


Figure 2 – Depiction of a non-pressure controlled roller device

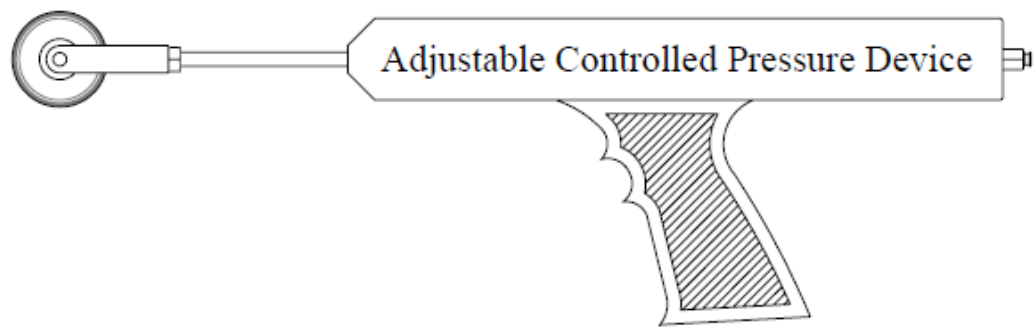
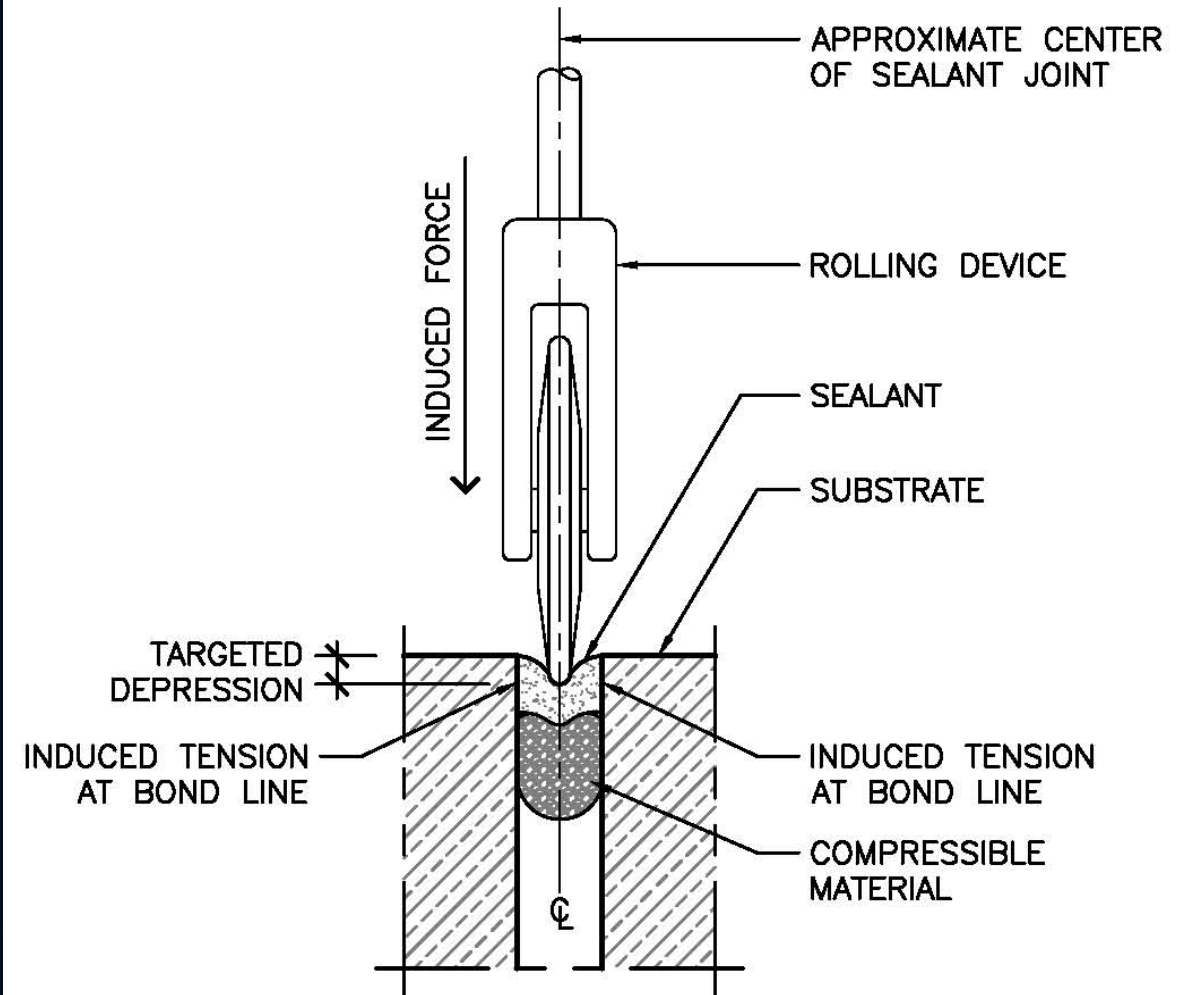
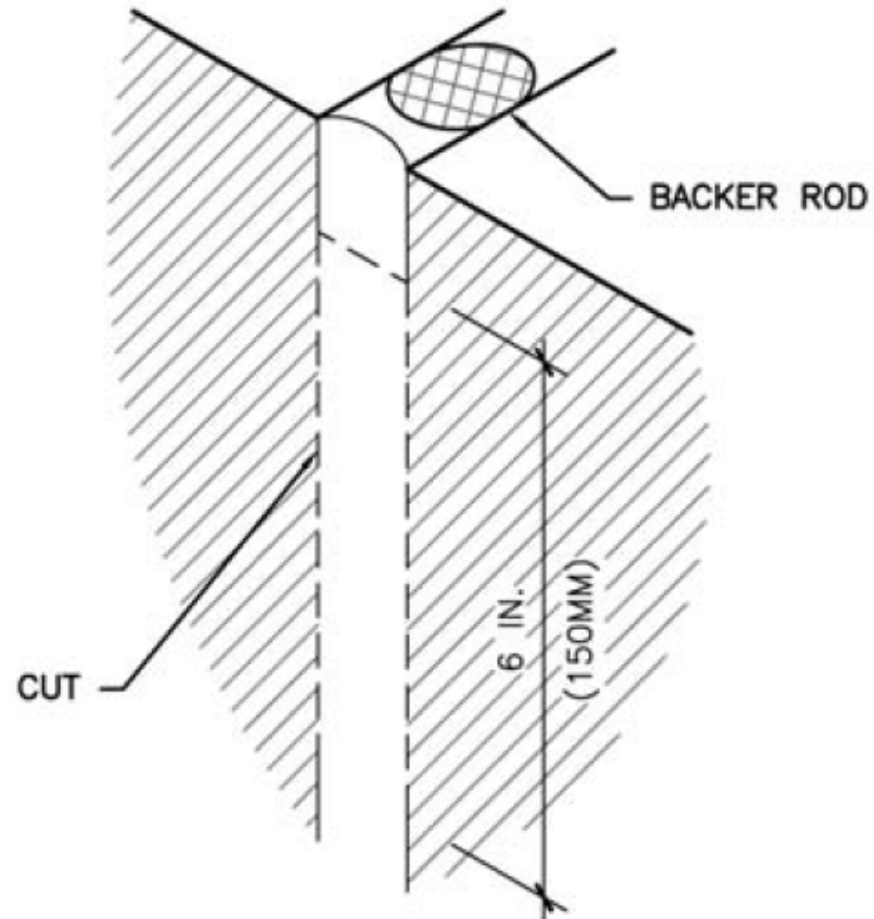


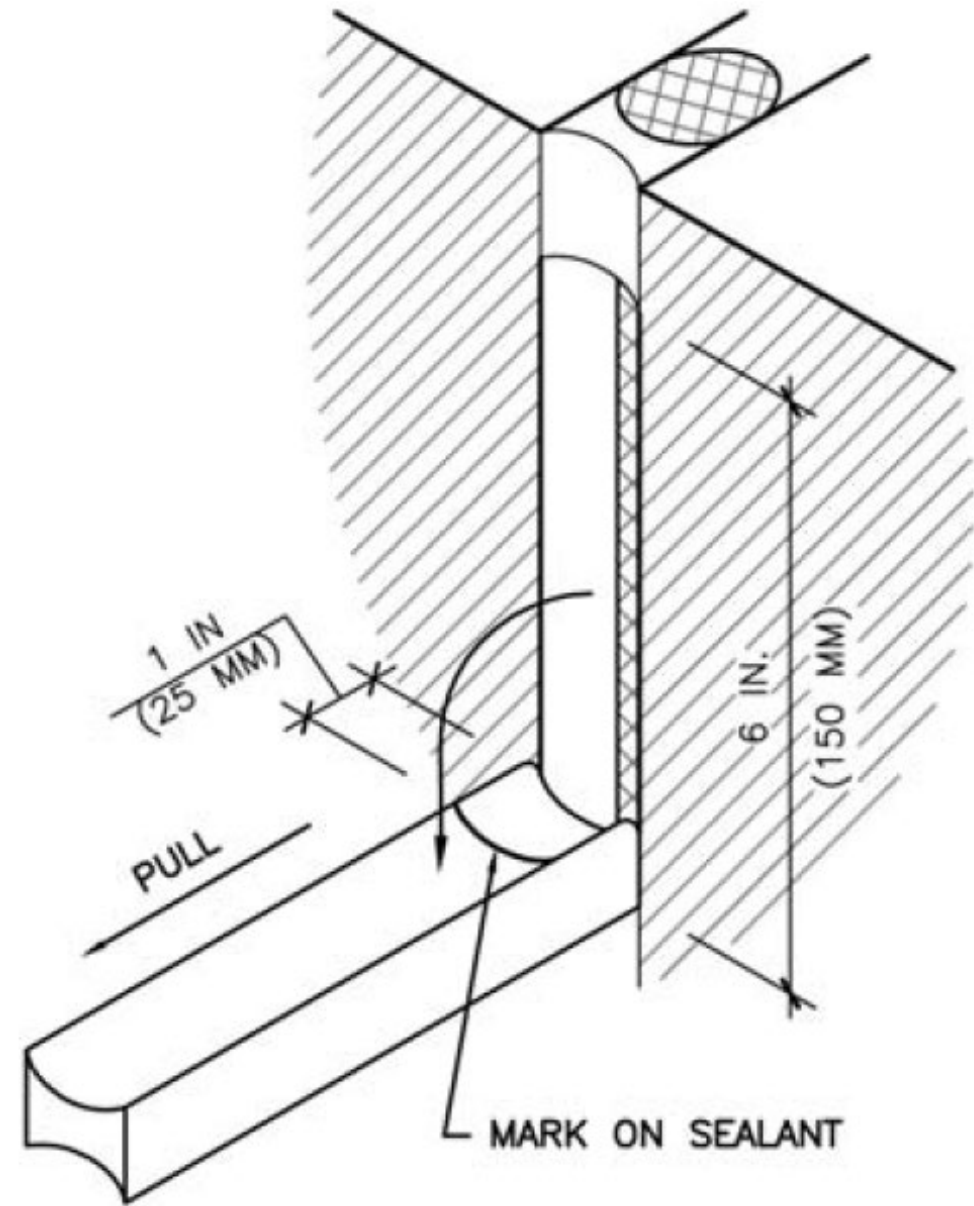
Figure 3 – Adjustable Controlled Calibrated Weatherseal Testing Device



# ASTM C 1521



6 IN. (150 MM) CUT THROUGH SEALANT AT BOND LINE OF BOTH SUBSTRATES AND ACROSS ONE END TO CREATE TAIL

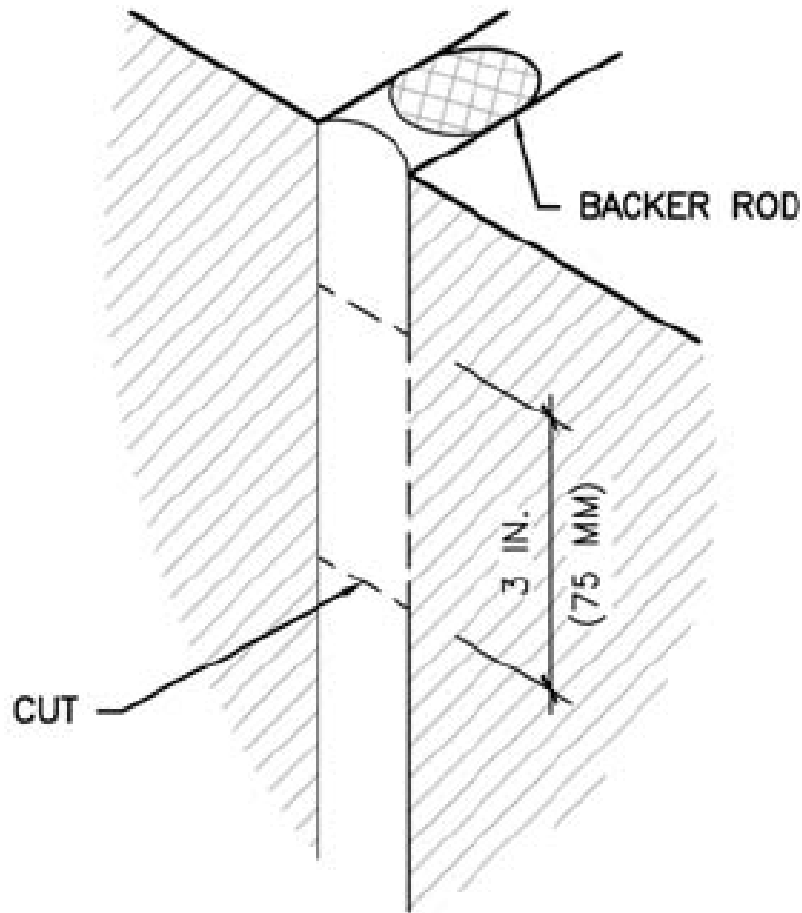


MARK CUT PORTION OF SEALANT 1 IN. (25 MM) FROM ADHESIVE BOND. PULL TAIL.

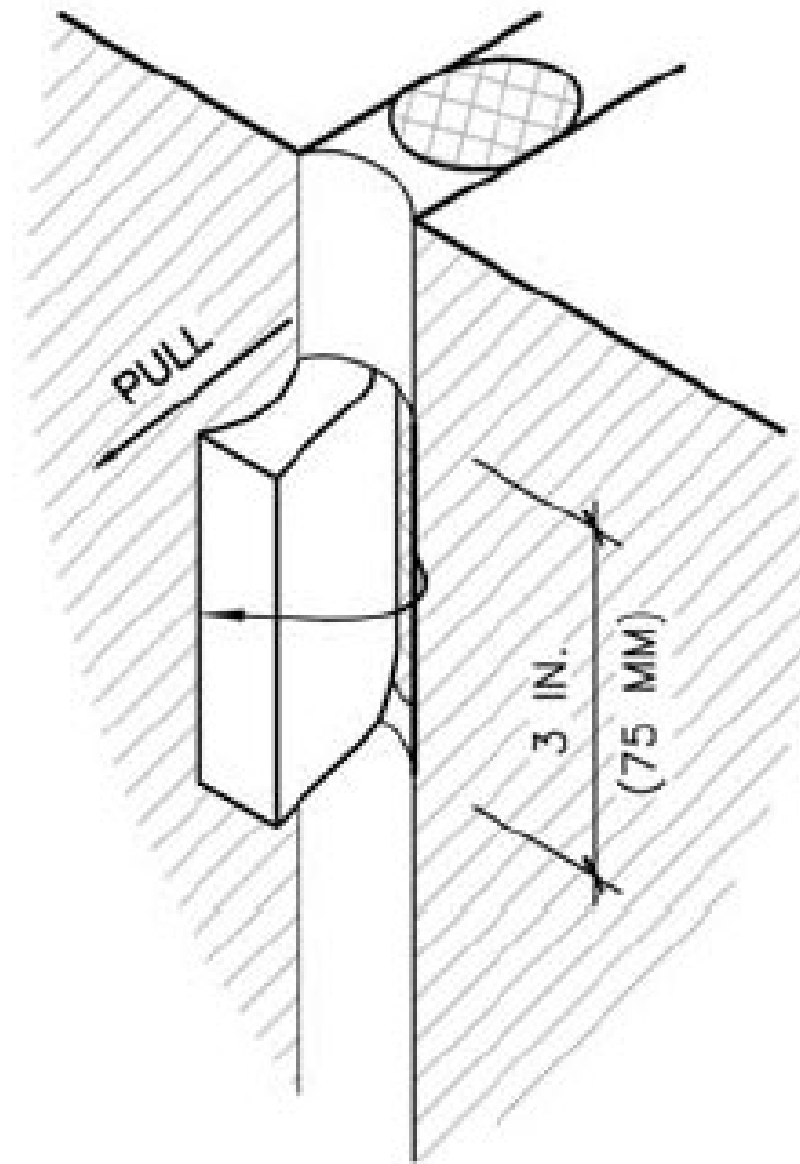
FIG. 2 Tail Procedure



# ASTM C 1521



CUT THROUGH SEALANT 3 IN. (75 MM) ALONG BORDER OF ONE SUBSTRATE. CUT ACROSS SEALANT BEAD ON BOTH ENDS OF THE 3 IN. (75 MM) CUT.



PULL FLAP.

**FIG. 3 Flap Procedure**

# TOO PRIME, OR NOT TO PRIME?

*THAT IS THE QUESTION...*



# PAINING SEALANTS





# BLISTERS





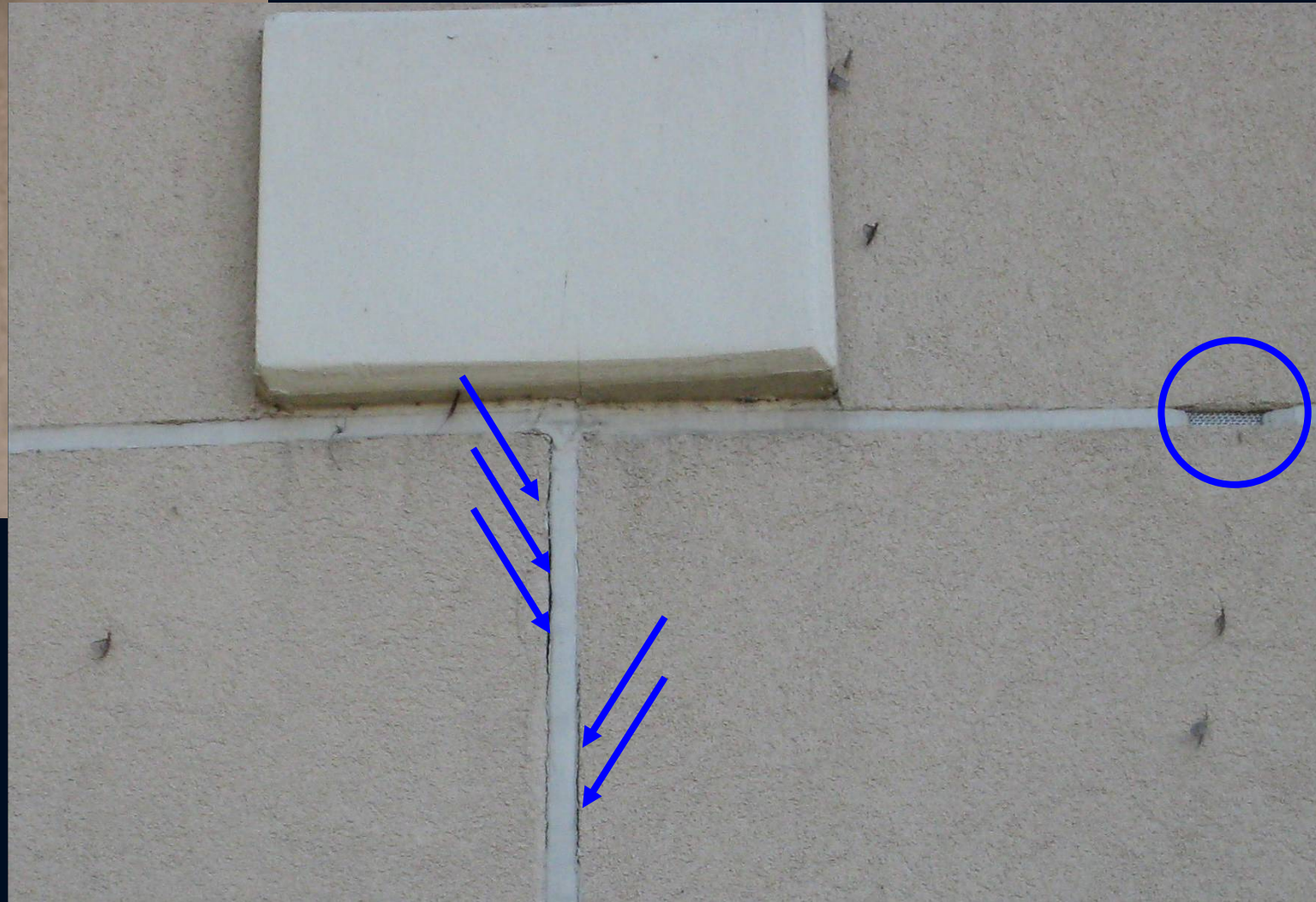
**SEALANT  
Too  
THIN**





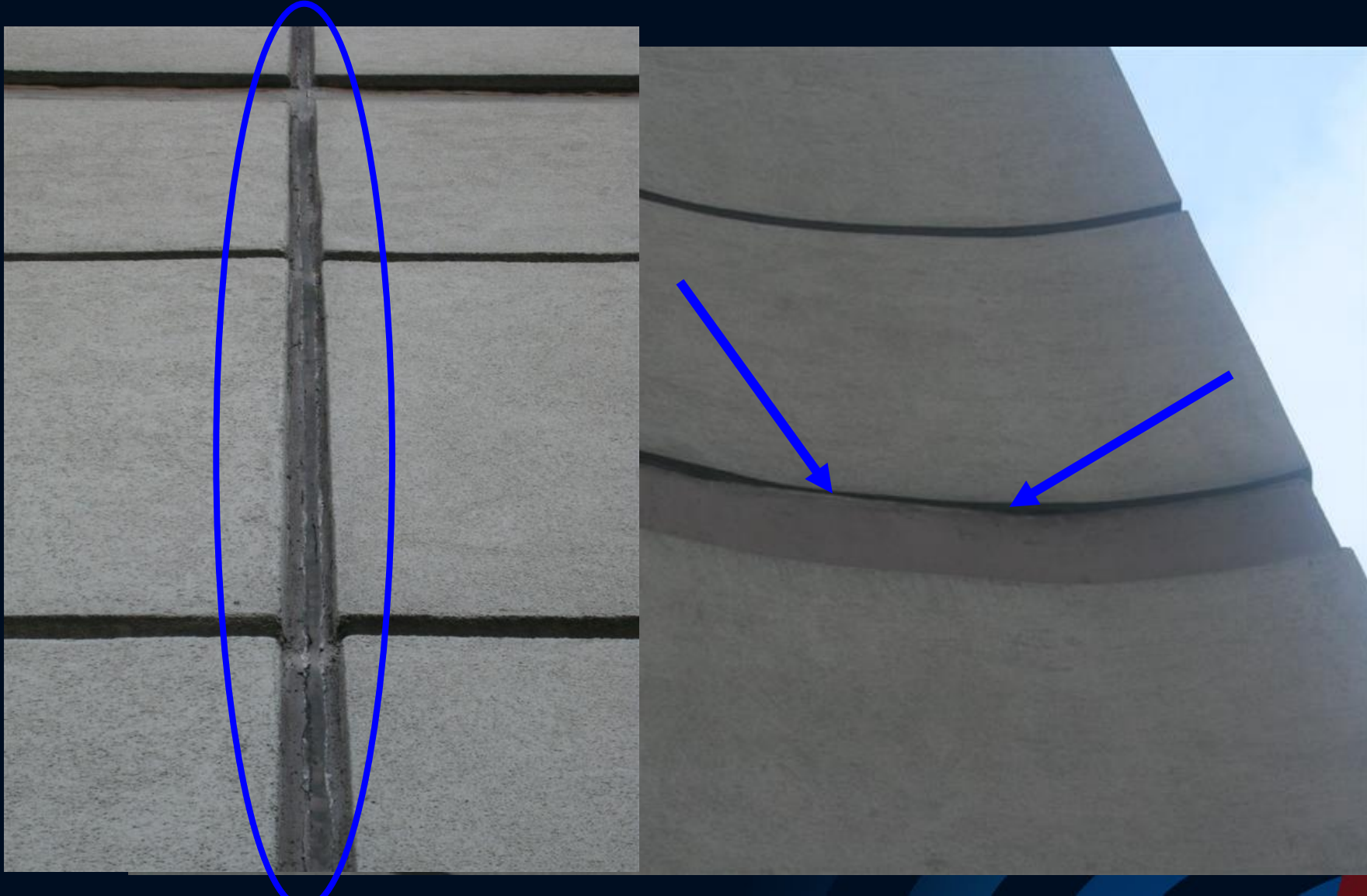


Know whether or not your wall is a rainscreen – if not, sealants aren't as critical





# LOOKING FOR TROUBLE





# JOINT DESIGN

$$J_{\text{WIDTH}} = |J_T| + |J_M| + |J_C| + |J_\delta|$$

- $J_{\text{thermal}} = (100/S_m) \cdot (C_t) \cdot (\Delta T) \cdot (L)$ 
  - $S_m$  = Sealant Movement Capability
  - $C_t$  = Coeff. Linear Thermal Expansion
  - $\Delta T$  = Range of Temperature Difference
  - $L$  = Nominal Panel Length
- $J_{\text{moisture movement}} = (C_m/100) \cdot (L)$ 
  - $C_m$  = Moisture Absorption Coefficient
- $J_c$  = minimum construction tolerances
- $J_\delta$  = minimum joint width required for deflection, frame shrinkage, creep



Key



Key

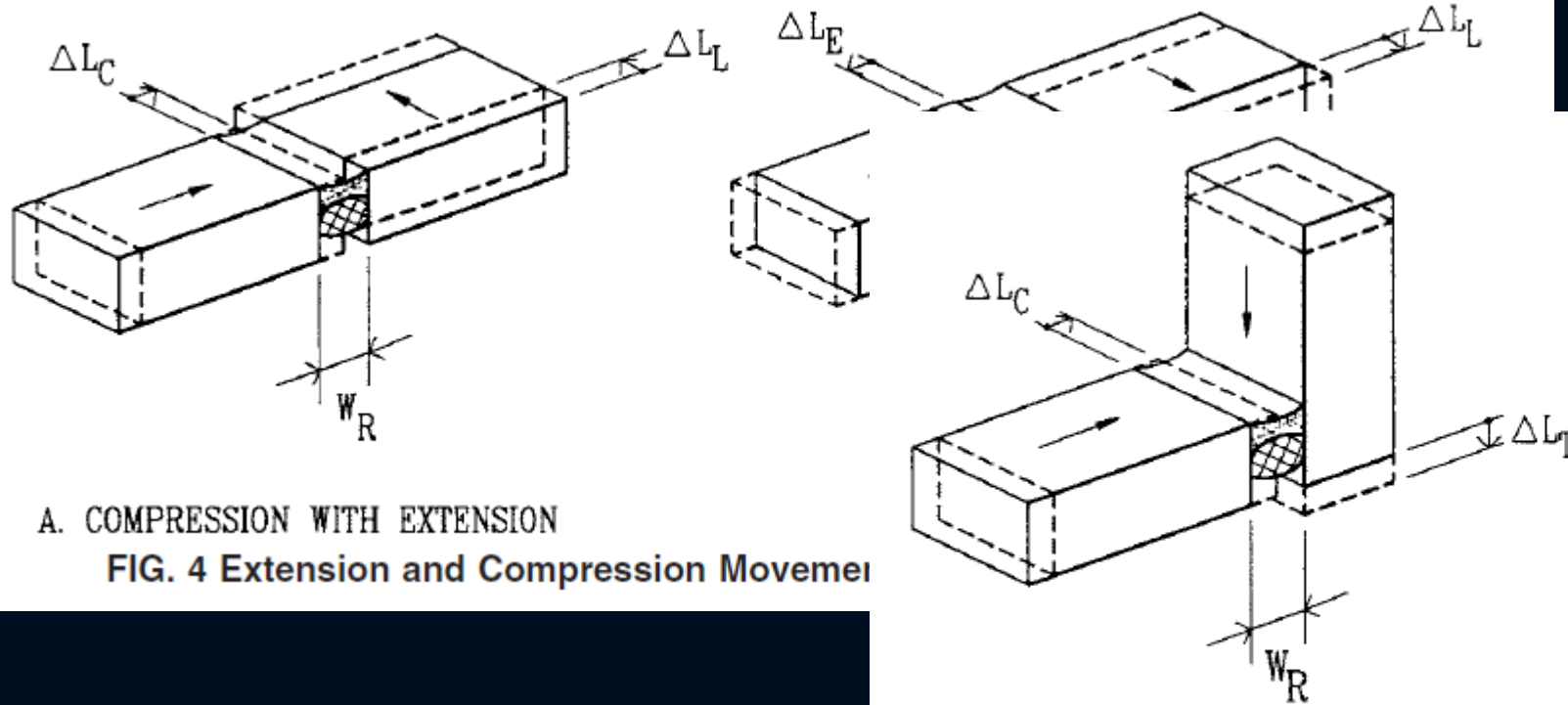
# ASTM C 1472

## Want to do the calculations?

- *Thermal movement*
- *Thermal (environmental induced) movement*
- *Moisture induced growth*
- *Live load deflection*
- *Dead load deflection*
- *Wind load movement*
- *Seismic load movement*
- *Movement during sealant curing*
- *Elastic frame shortening*
- *Creep*
- *Shrinkage*
- *Construction Tolerances*

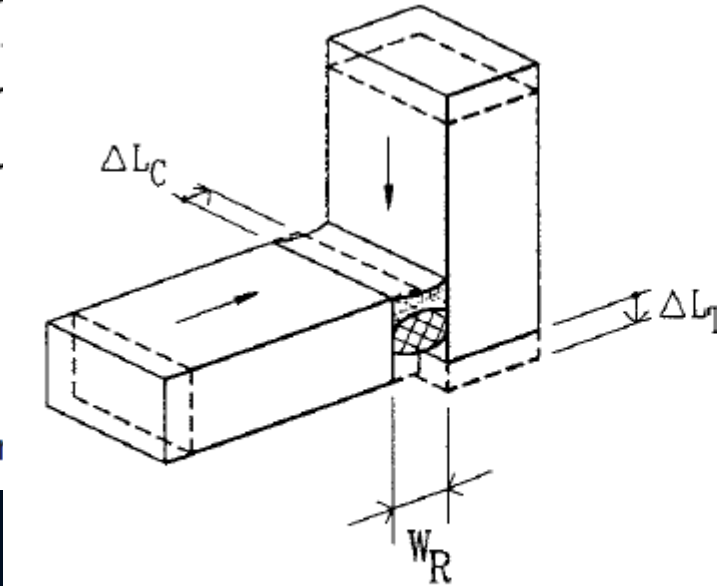
# JOINT MOVEMENT – ASTM C 1472

How many dimensions, 1, 2 or 3?



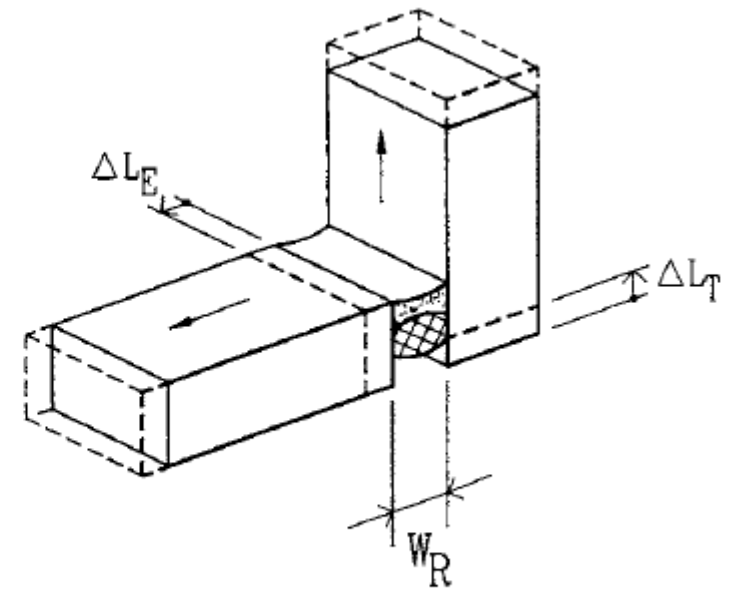
A. COMPRESSION WITH EXTENSION

FIG. 4 Extension and Compression Movement



A. COMPRESSION WITH EXTENSION

FIG. 3 Extension and Compression Movement with Transverse Extension



B. EXTENSION MOVEMENTS

# ASTM C 1472

Want to do the calculations?

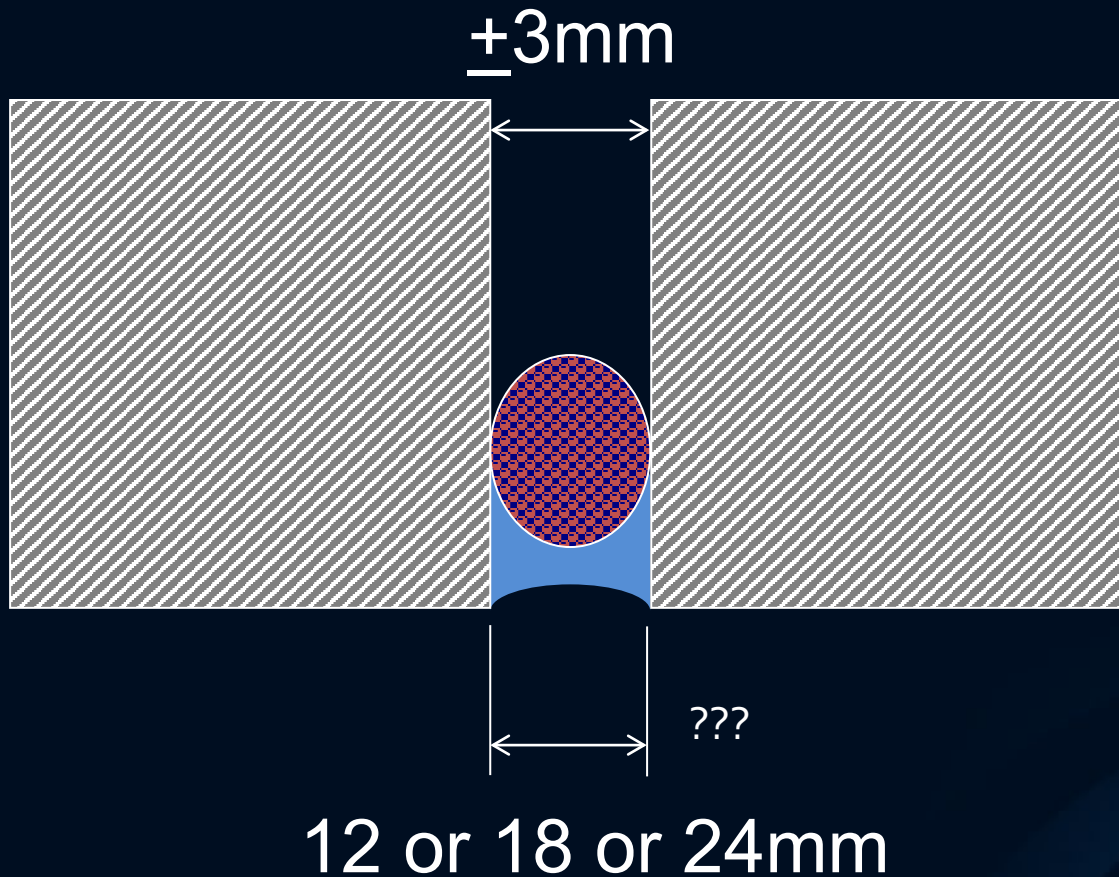
- 23.5755 mm  $\pm$  6 mm...
- What do you think the normal construction tolerance of concrete structural framing would be?

$$W_R = \frac{-[2(6.2484)] - \sqrt{[2(6.2484)]^2 - 4[(0.25)^2 - 2(0.25)][-(6.2484)^2 + (3.5230)^2]}}{2[(0.25)^2 - 2(0.25)]} = 23.5755 \text{ mm}$$



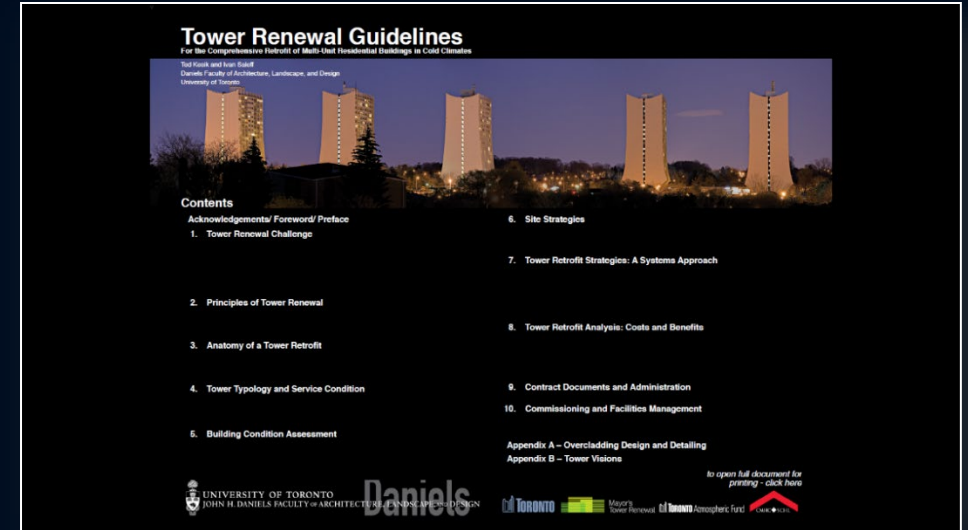
# OR... RULE OF THUMB?

- Size the joint 2 to 3 times the expected range of movement
- For EIFS, size the joint 4 times the range of movement



# TOWER RENEWAL

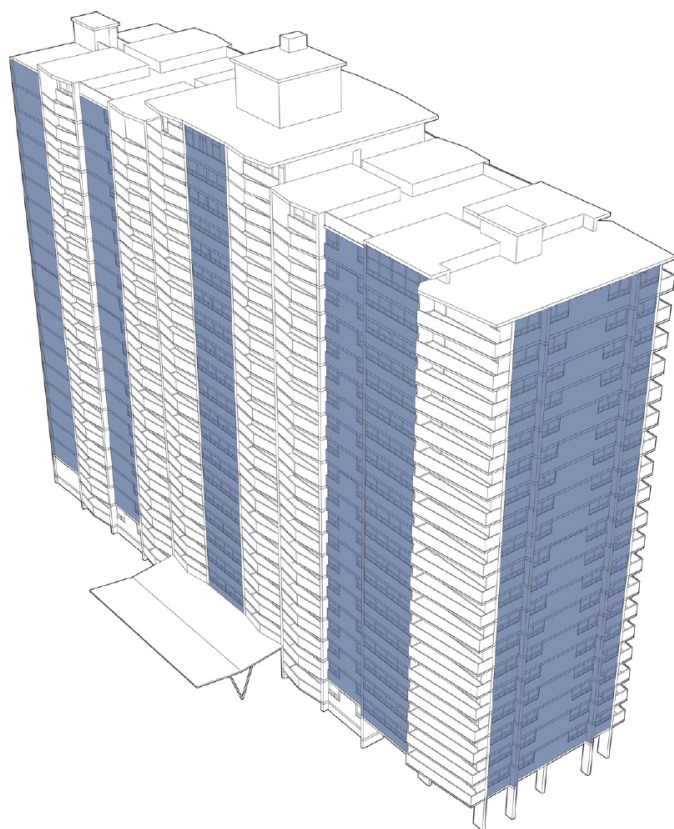
- Comprehensive guide on how to retrofit multi-unit residential buildings – adding/replacing:
  - Insulation – enclosing the structure and mitigating thermal bridging
  - Windows and doors
  - Air tightness and thermal comfort
  - Reduce passive heating/cooling loads
  - Mechanical systems/ventilation



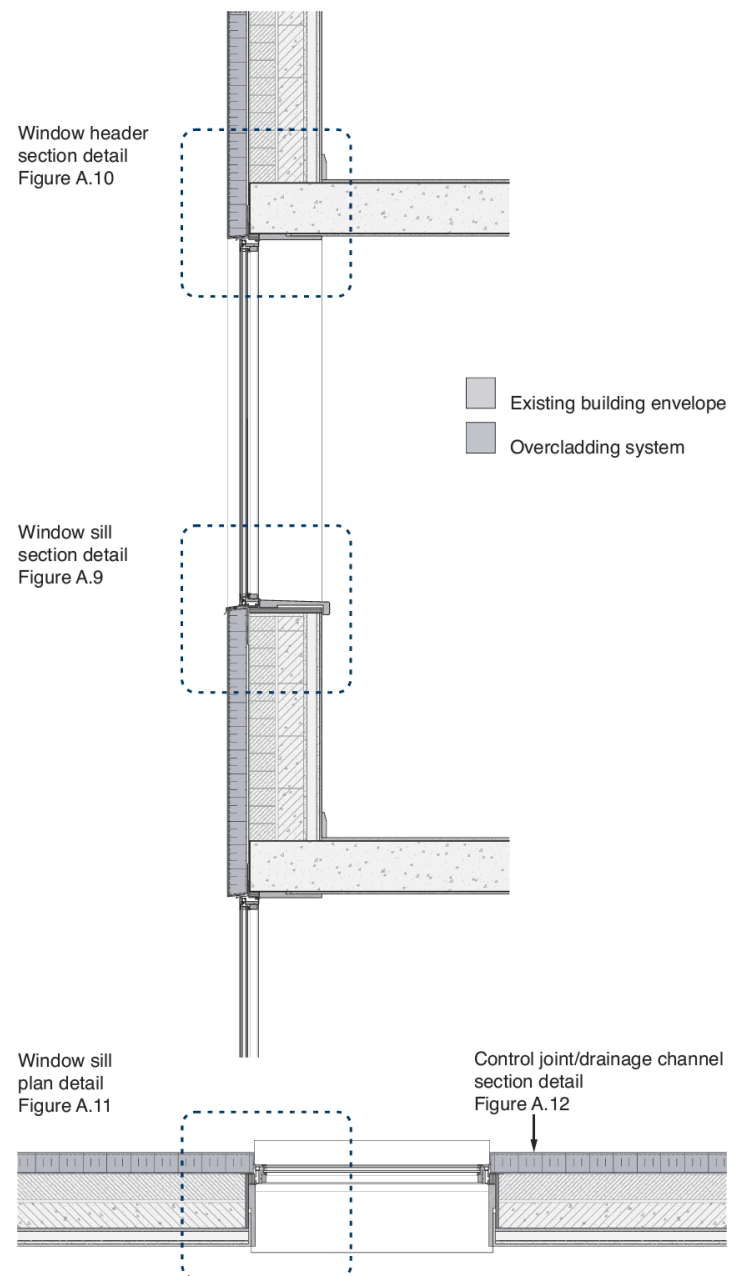
**Tower Renewal Guidelines**  
© 2009 University of Toronto  
(Kesik & Saleff)

## EIFS Wall Overcladding and Replacement Windows

This section of details and sequence assemblies depicts the design of external insulation and finish systems (EIFS) overcladding and window replacements for plane wall elements without balconies or projections. The shaded areas on the archetype tower building represent typical locations for these types of overcladding and window replacements.



A comprehensive discussion of EIFS technology is beyond the scope of this document, and it is assumed most design professionals are familiar with EIFS for new building applications. In the case of tower retrofits, it is important to ensure that the existing substrate is sound, and that if found to be otherwise, appropriate repairs must be carried out prior to the commencement of retrofit work. In Canada, the EIFS Council of Canada has recently launched the EIFS Quality Assurance Program to ensure the highest quality of materials, design, workmanship and inspection of EIFS projects. This is a voluntary program and there a number of critical requirements under the program that should be observed for all EIFS overcladding projects. The details and assembly sequences that follow conform to EIFS industry best practices, but these are not comprehensive. Building envelope designers and cladding engineers are ultimately responsible for the proper design and specification of overcladding systems, and it sound practice to work collaboratively with EIFS suppliers and contractors to develop appropriate and effective solutions.

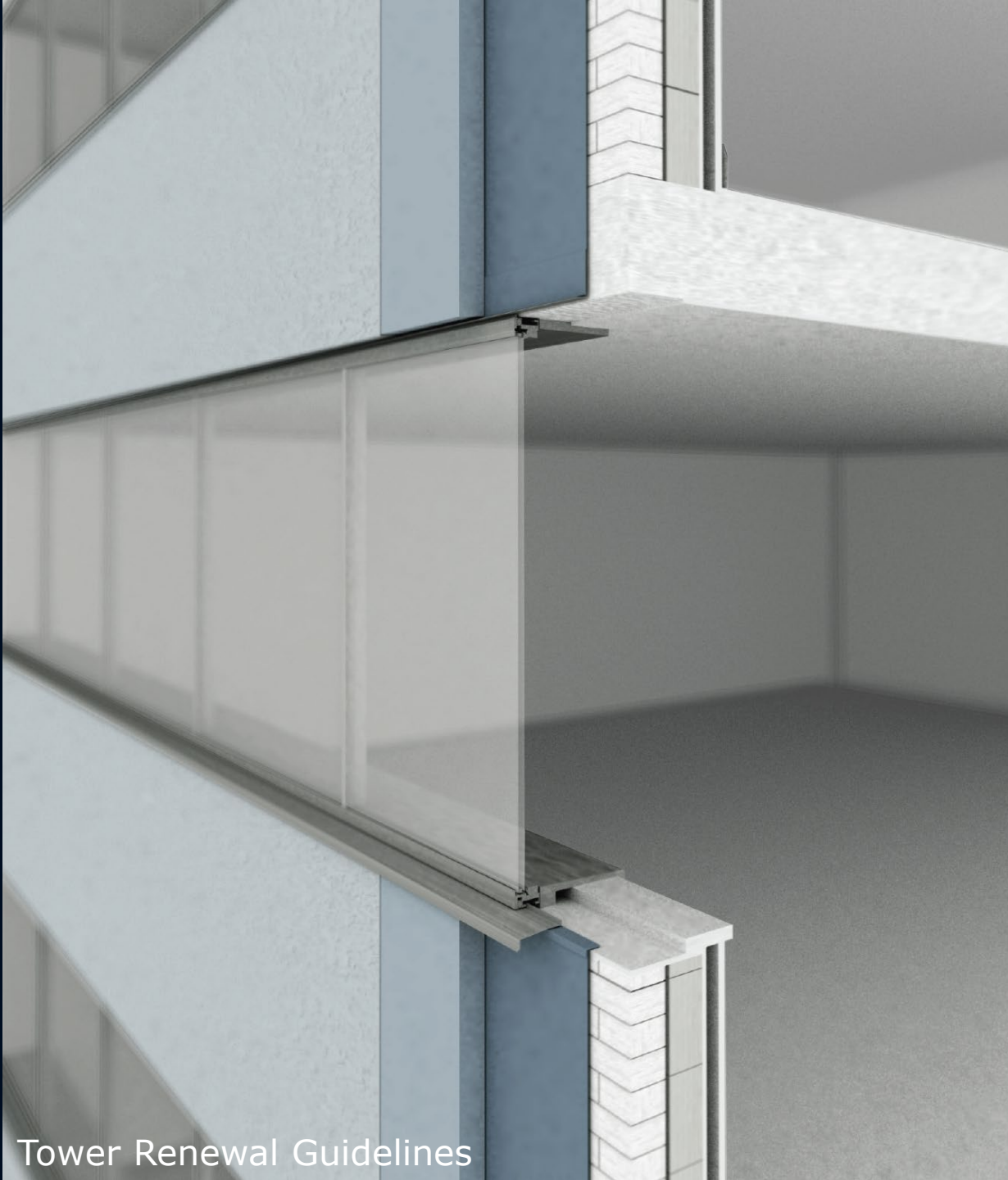


**Figure A.8.** Section and plan views of a typical wall and window assembly with corresponding detail drawings denoted.

# EIFS Overcladding

- One of the most cost-effective exterior insulation strategies
- Add up ~R30
- Adapts well with window replacement

## Tower Renewal Guidelines



# EIFS Overcladding

- One of the most cost-effective exterior insulation strategies
- Add up ~R30
- Adapts well with window replacement

**Tower  
Renewal  
Guidelines**











# CMHC CASE STUDY

- Overcladding masonry with EIFS in 1997
- Inner wall temp always *higher* than dew point – no condensation
- Temp of brick was stagnant with +20°C temp gradient
- Full insulation value achieved even though EIFS was detailed as rainscreen cladding
- Positive vapour drive

## RESEARCH HIGHLIGHT

Technical Series 01-104

### Monitoring the Performance of an EIFS Retrofit on a 15-Storey Apartment Building

#### INTRODUCTION

In March 1995, a 15-storey, 112-unit cooperative housing complex in Toronto, Ontario commissioned an extensive rehabilitation plan to address issues of air and water leakage and general deterioration. Among its many recommendations for the renewal of the building, the rehabilitation plan included the replacement of the existing windows and doors and installation of an exterior insulation finish system. The objectives of the wall retrofit included bringing the building into compliance with Ministry of Housing requirements, improving the durability and appearance of the wall systems, reducing air and water leakage and realizing energy cost savings.

The successful bid for the exterior cladding retrofit was an Exterior Insulation Finish System (EIFS) manufactured by Dryvit Systems Canada Inc., specifically their "Infinity MD" system which includes a means of draining moisture from within the applied EIFS overcladding. While not promoted as a pressure-equalized rainscreen system, venting of the vertical drainage channels cut into the interior face of the insulation panels was expected to provide some localized pressure equalization of the EIFS system. As moisture draining or rainscreen EIFS systems were a relatively new concept at the time this work was undertaken (1997), this rehabilitation project provided an excellent research opportunity; Canada Mortgage and Housing Corporation initiated a project to evaluate the retrofitted walls. The research project had the following objectives:

- document the development of a building envelope retrofit strategy for a high-rise apartment building;
- monitor, assess and document the performance of a high-rise apartment building envelope retrofit with respect to heat, air and moisture control;
- assess the degree to which the monitoring protocol can be implemented as part of regular operation and maintenance activities for new and existing buildings; and
- assess the potential for the development of a commercially viable, building envelope performance monitoring protocol.

#### RESEARCH PROGRAM

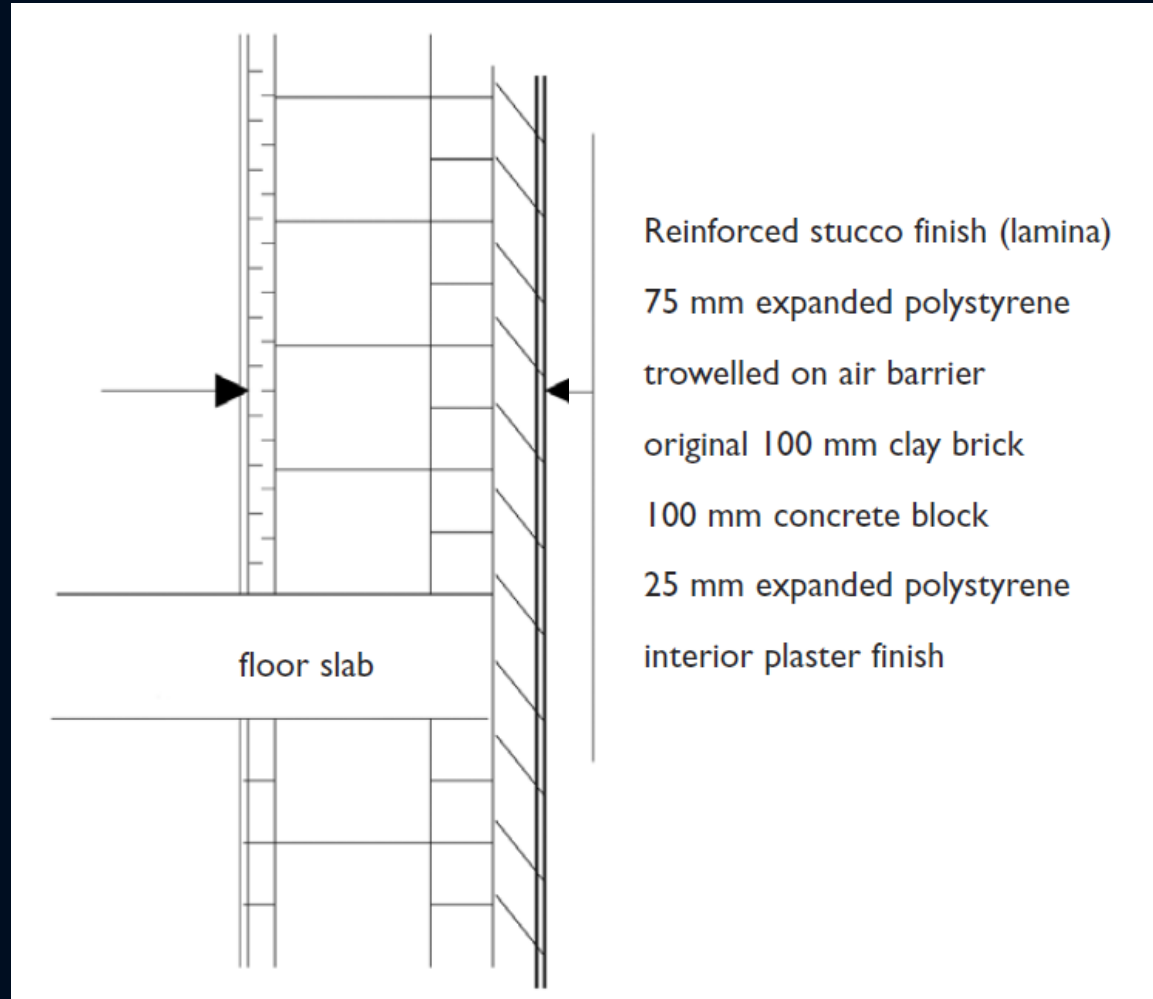
The existing exterior walls of the building were solid masonry infill within the reinforced concrete structural frame. The assembly consisted of clay brick with a raked face; filled 25 mm collar joint; concrete block backup; 25 mm thick expanded polystyrene foam insulation and an adhered, approximately 12 mm thick, plaster finish on the inside.

The new EIFS over-cladding system consists of an acrylic stucco lamina (base coat, reinforcing mesh and finish coat) installed over 75 mm expanded polystyrene insulation. As a fully adhered system, the insulation is applied directly to the brick masonry (substrate) using a two-coat trowel-applied proprietary Dryvit material; the first coat prepares the surface while the second coat adheres the insulation to the prepared surface. The coating is intended to operate as the air barrier and drainage plane and may also function as the vapour barrier. The lamina and insulation act as the first line of defense against precipitation. The second line of defense is the flashed drainage plane located at the substrate. Vertical channels located in the interior face of the insulation are intended to drain rainwater that penetrates to the coating (see Figure 1). The channels are flashed to the exterior every five stories and also laterally within the cavity above window heads. Intersections of the trowelled-on air barrier and other elements are sealed with self-adhering, rubber-modified bitumen sheet membrane, tape and/or sealant. Further, spray urethane foam is installed between the window frame and the rough opening.

Two data acquisition systems were installed for the full monitoring period (from the fall of 1997—the time of the retrofit—to early 1999). One was installed at the 12th floor and the other at the second floor, both with west exposures; the building has a fairly open exposure on the west side. A third data acquisition system was moved over the course of the research project between three other monitoring stations: the 12th floor east exposure, 12th floor north exposure, and 2nd floor east exposure. Each monitoring station consisted of up to

# CMHC CASE STUDY

- Pressure across the lamina  $\pm 20\text{Pa}$  (nominal)
- During gusts, lamina bears  $\sim 50\%$  of the wind pressure
- Stops rain, insulates walls, & improves aesthetics







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