Building Enclosure Design
Moisture, Air, & Vapor Control

Presented to the
Society of American Military Engineers
2020

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Learning Objectives

✓ Understand how the building enclosure protects the interior environment and the health and safety of occupants.

✓ Understand the basics of building science and building enclosure design concepts.

✓ Understand types of Building Enclosure Performance Testing to reduce potential for indoor environmental risks and costly repairs to a building.
What is the Building Enclosure?

The primary function of the building enclosure is to separate the interior environment from the exterior environment to which it is exposed.

- Keep moisture out
- Keep conditioned air in
- Prevent water vapor condensation

Building Enclosure Components

- Foundations
- Concrete Floor Slabs
- Exterior Below Grade Walls
- Exterior Cladding
- Exterior Curtain walls and Storefronts
- Exterior Windows and Doors
- Sealant, Control Joints and Flashings
- Plaza Decks and Planters
- Roof Systems
- Skylights, etc.
- Air / Water / Vapor Barriers
- Fall Protection Systems
Building Enclosure Function

- Moisture, Air, Vapor Control
- Thermal Performance
- Light Control
- Indoor Comfort
- Security, Safety
- Fire Resistance
- Acoustical Performance
- Structural Integrity
- Maintainability/Sustainability
- Aesthetics

Consequences of Design Flaws & Construction Defects

- Uncontrolled Air and Water Intrusion
- Premature Deterioration of Building Components
- Structural Damage
- Biological Growth (Mold)
- Poor Indoor Air Quality
- Increased Energy Costs
- Decreased Worker Productivity
- Costly Investigations/Repairs
Building Enclosure Priorities

- Structural Design, Fireproofing, Accessibility
- Moisture
- Air
- Vapor
- Thermal
- Durability

Building Enclosure Principles

- Deflection (Canopies, Roof Overhangs, etc.)
- Drainage (Weeps, Sloping, etc.)
- Drying (Air Flow, Ventilation, Evaporation, etc.)
- Durability (Compatible Materials, Maintenance, Freeze – Thaw Cycles, etc.)
Basic Building Science

Thermal Transfer

- Radiation
- Conduction
- Convection

Heat transfers from hot to cold

Air Infiltration/Exfiltration

- Wind Effect
- Stack Effect
- Combustion and Ventilation

Air moves from higher to lower pressure
Basic Building Science

Water Transport

- Bulk Water (precipitation, groundwater, etc.)
- Capillary Action
- Water Vapor Diffusion

Moisture moves from wet to dry, higher vapor pressure to lower

The Ideal Wall

- Rainscreen Wall
- Control Layer Continuity – “Pencil Test”
- Exterior Insulation Out-Board of Air/Water Barrier
Performance Threats

- Transitions between building enclosure components or assemblies generally total less than 1% of the building enclosure area but can account for 90% of enclosure failures and leakage.
  - NIBS Annex U

- Uncontrolled air leakage in buildings increases the heating and cooling energy consumption by up to 40%.
  - "Commissioning the Air Barrier System" ASHRAE Journal

- Investigation of the impact of commercial building enclosure airtightness on HVAC energy use concludes that continuous air barrier systems can reduce air leakage by up to 83% and provide potential energy savings of greater than 40% for gas and 25% for electrical.
  - 2005 NIST Study

Typical Detail – Roof to Wall Transition
Typical Detail – At Grade Transition

- Cephus board
- Drainage gap
- Fully-adhered air/water/energy control layers
- Rigid insulation thermal control layers (thermoplastic polymers, expanded polystyrene, polyurethane, spray foam, semi-rigid foam)
- Transition membrane with an 80.00 mm overlap thickness
- Waterproofing control layers adhered to substrate
- Welded joints cast into slab
- Continuous steel shelf angle and stiff bracing
- Sealant
- Open drain holes at each vertical plate
- 1/4" (6 mm) dia. (not welded to underneath an drip edge)

Protection board under right installation

Typical Detail – Shelf Angle Transition

- Fully thermoset adhesive
- Lapped at base
- Carpet tape
- 1-0-150 mm gap
- 150 mm gap
- Water-based primer
- Water-based sealer
- Polyurethane
- Shelf edge supported by 3/4" (19 mm) diameter galvanized bolts
- Non-open gap
- Mortar bed top is B (mortar bed needs to be level on corners)
- Mortar bed needs to be level on edges

Traditional: no expansion
Expansion: poor performance
Mutes: cost good performance
Transitions

Thermal Continuity & Air Leakage
Thermal Continuity & Air Leakage
Performance Threats

- According to a study performed by the National Roofing Contractors Association, roofing failures are attributable to:
  - 50% to Poor Workmanship
  - 20% to Poor Design
  - 15% to Poor Maintenance
  - 10% to Material Failures

Indoor Air Quality

- Phenomena related to water intrusion, dampness and excess moisture are not only harmful to the health of a building’s occupants, but they also seriously affect the condition of the building structure, which may diminish the indoor air quality of the building.
  - WHO guidelines for indoor air quality: dampness and mold
    World Health Organization 2009
Mockups and Testing

Why?

- Quality control during construction
- Complements building commissioning process
- Holds Builders accountable
- Changes in building façade technology
- Savings on Forensic Assessment
Mockups

Test Methods - AAMA

- AAMA 501 – “The Big Picture”
- AAMA 502 – Fenestration Products
- AAMA 503 – Storefronts / Curtain Walls / Sloped Glazing
- AAMA 511 – Forensic Testing
- AAMA 501.2 – Hand-Held Spray Test
Test Methods - ASTM

- ASTM E 783 Field Air Infiltration
- ASTM E 1105 Field Water Penetration
- ASTM E 1186 Field Air Leakage Testing
- ASTM C 1153 Thermographic Imaging
- ASTM C 1521 Exterior Joint Sealant Adhesion Testing
- ASTM D4541 Air Barrier Adhesion Testing

Test Water Testing

**ASTM E1105-00, Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls, by Uniform or Cyclic Static Air Pressure Difference**
Field Air Leakage Testing

ASTM E1186-03, Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems

• 4.2.7 Detection Liquid Air Testing (Locates voids in the Air Barrier); “Bubble Test”

Field Air Barrier Adhesion Testing

• ASTM D4541, Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers
• ASTM D4263, Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method
Field Testing – Sealant Pull Test


Field Roof Testing

Other Testing Methods

- Electronic Field Vector Mapping (EFVM)
- ANSI / SCTE FX-1 Deck Strength Roofing Fastener Pull Test
- Roof Uplift Testing (FM 1-52)

After Testing . . .

- Results are reported in a written report
- Construction continues
- EVERYONE is Happy!

- Remove and reinstall assemblies
- Adjust design or method of installation
- Consult with project waterproofing consultant or manufacturer’s technical representative
- Adjust performance criteria (only recommended if original criteria deemed to be not appropriate for product application)
- Retest after adjustments are made
Thank You for Your Time!

Questions?

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