
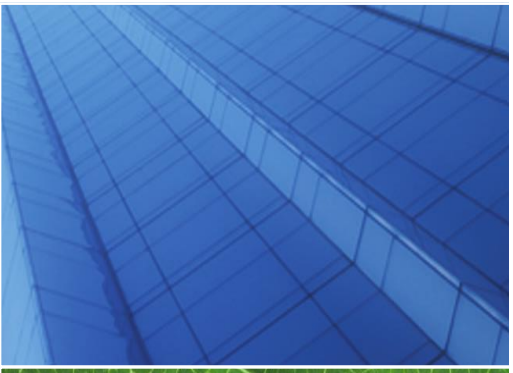

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NC STATE UNIVERSITY
OFFICE OF PROFESSIONAL DEVELOPMENT

Presents the Most Important Educational and Networking Event for Construction Professionals!

The 36th Annual STATE CONSTRUCTION CONFERENCE

High Performance Building Enclosures: Results You Can Count On Through Design, Installation, Verification and Commissioning

Presenters:
Christine M. Quigley PE RRC BECxP LEED AP BD+C
Michael W. Phifer RRO CIT REWO

Christine.Quigley@Terracon.com
704.953.8308
Mike.Phifer@Terracon.com
704.594.8951

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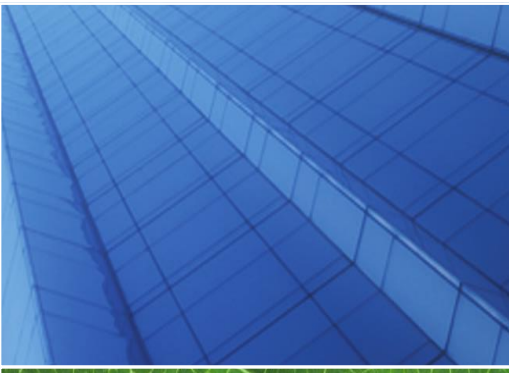

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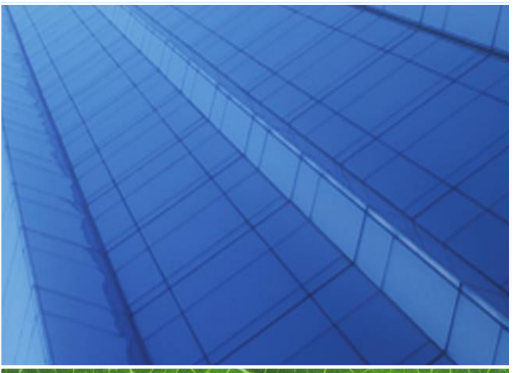
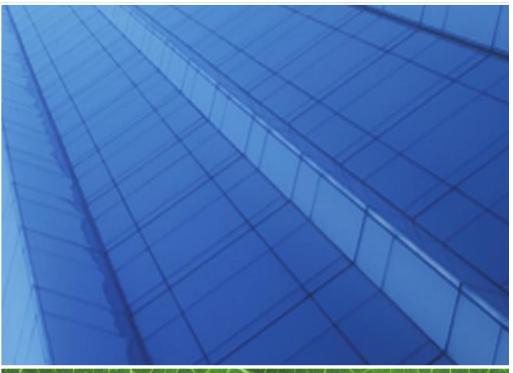


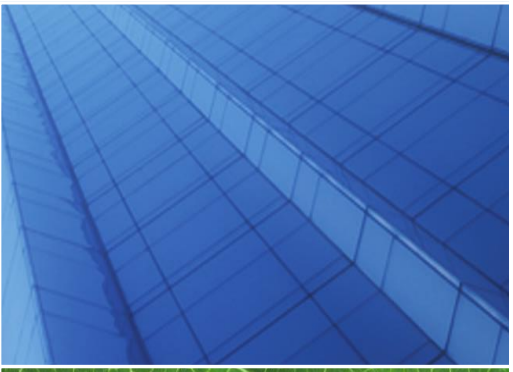
Learning Objectives

- ✓ Understand the basic components in the building enclosure and the possible threats and consequences as a result of design flaws and construction deficiencies. Lessons Learned.
- ✓ Discuss the current NC International Energy Conservation Code requirements related to Commercial Buildings building enclosures to improve building energy performance related to thermal, air and drainage continuity.
- ✓ Discuss design details, construction sequencing and installation practices that will result in energy efficient buildings to complement the MEP systems designed and installed in new construction.
- ✓ Develop an understanding of BECx, including process, design review, WUFI, and functional performance testing to a building.

Audience Poll

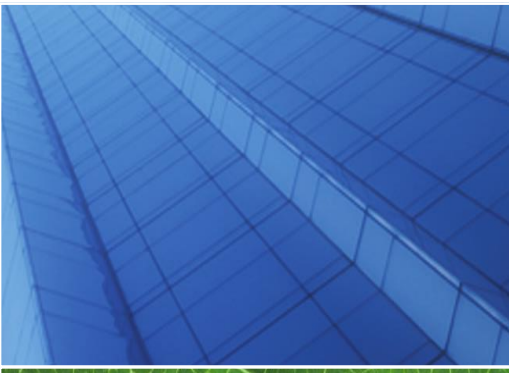
Building Enclosure
Basics & Threats

Building Enclosure

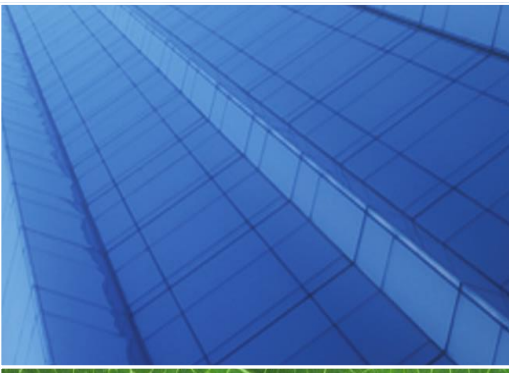
Basics

High-performance building enclosures should reliably reduce operational energy needs, provide the durability necessary for the desired service life, and ensure the comfort, health, and safety of the occupants.

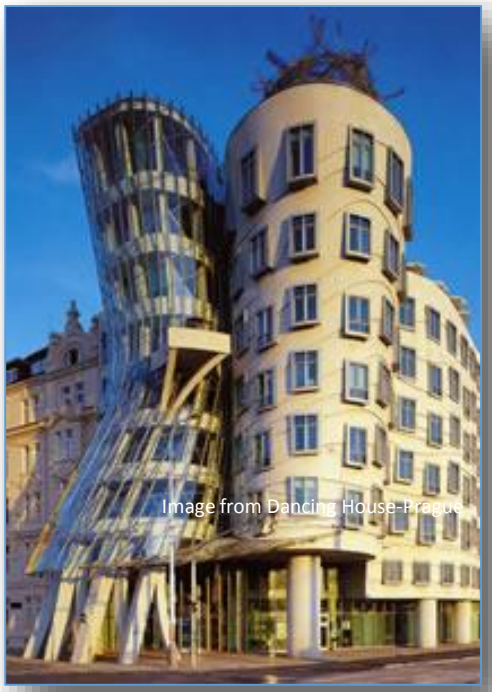
Building Enclosure Components

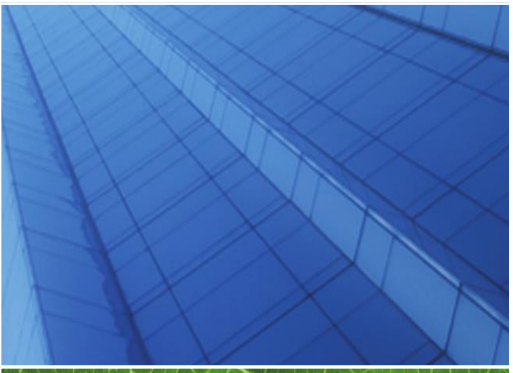
- Foundations/Concrete Slab on Grade
- Exterior Below Grade Walls
- Exterior Cladding
- Air Barriers
- Exterior Curtain walls, Storefronts, Windows and Doors
- Sealant and Flashings
- Control and Expansion Joints
- Plaza Decks, Planters and Waterproofing Systems
- Roof Systems, Skylights and Clerestories
- Fall Protection Systems

Building Enclosure Function & Performance

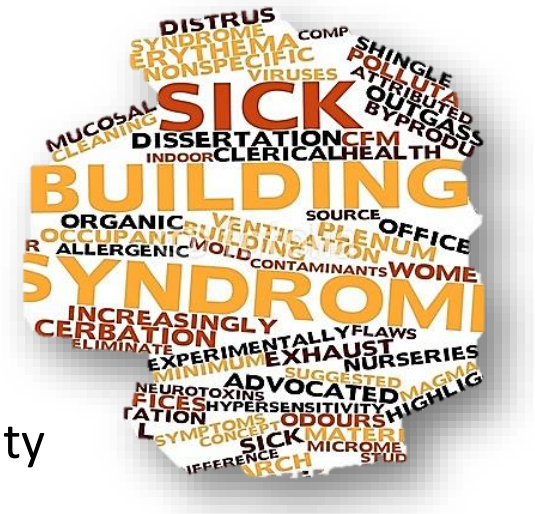
- Thermal/Air/Moisture Performance
- Energy Control
- Light Control
- Security, Safety
- Fire Resistance
- Acoustical Performance
- Structural Support
- Maintainable/Sustainable
- Economically Viable
- Visible/Aesthetically Pleasing

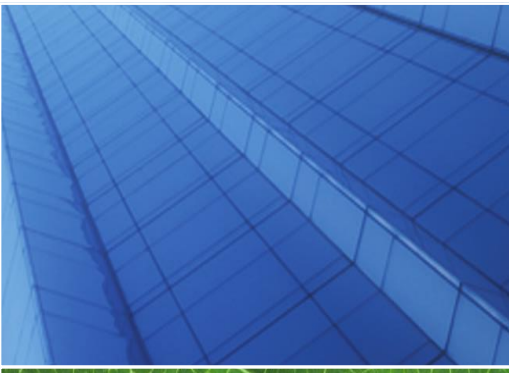


Consequences of Design Flaws & Construction Defects

- Uncontrolled Air and Water Intrusion
- Premature Deterioration
- Biological Growth (Mold)
- Poor Indoor Air Quality
- Decreased Worker Productivity
- Increased Energy Costs
- Costly Investigations/Repairs



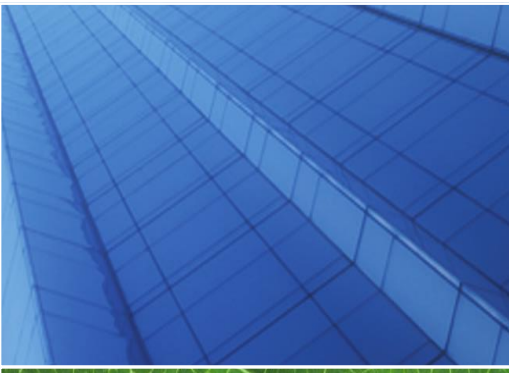



Performance Threats

- 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

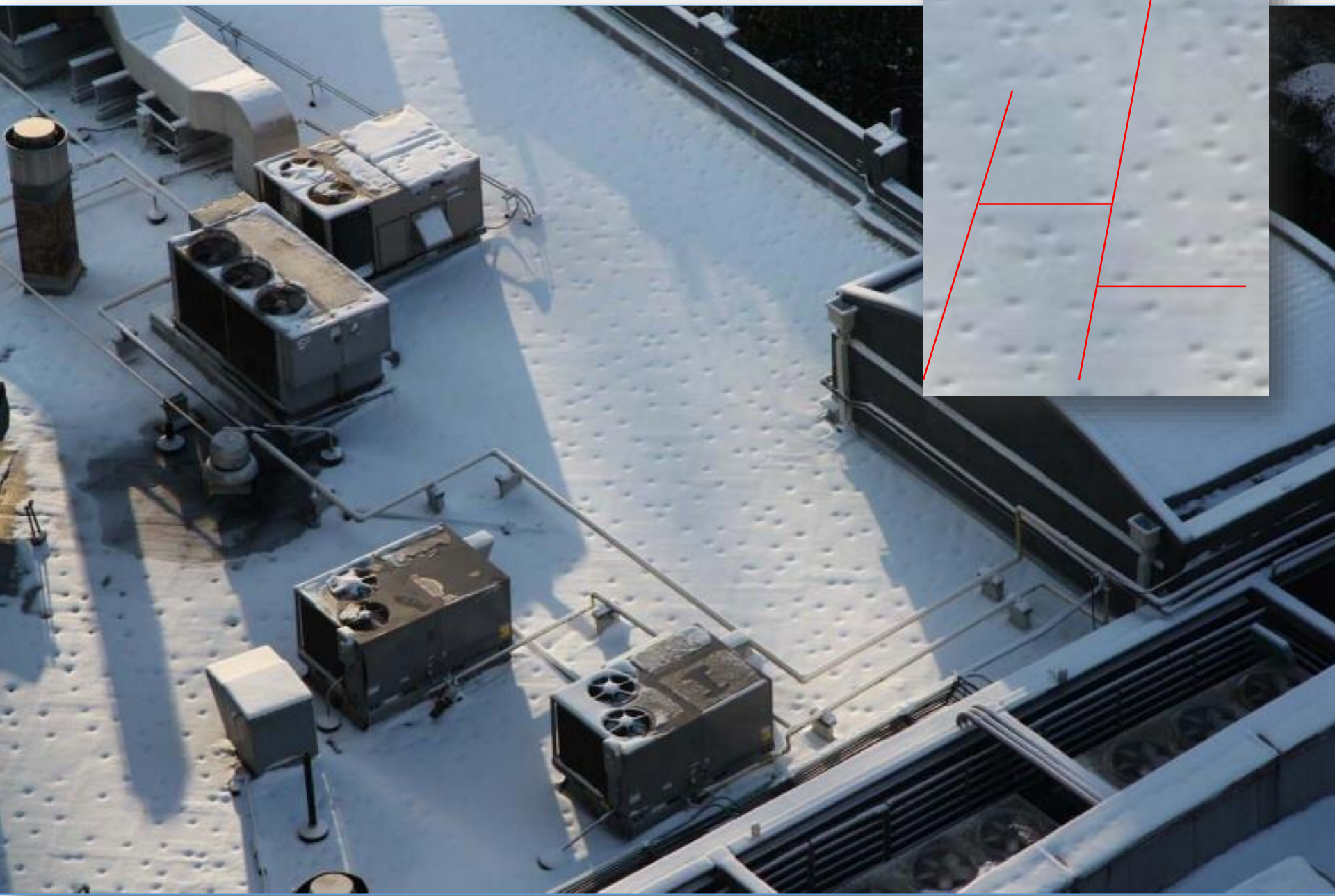
- Uncontrolled air leakage in buildings increases the heating and cooling energy consumption by up to 40%. ”Commissioning the Air Barrier System” ASHRAE Journal

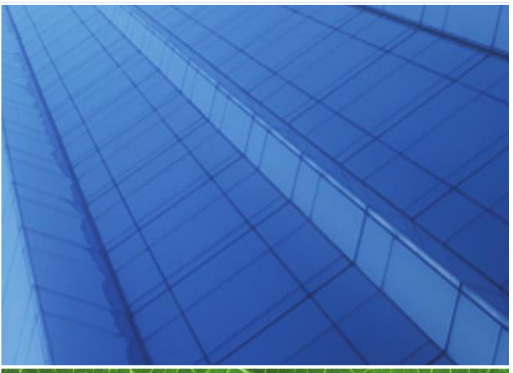
- Impact of commercial building enclosure airtightness on HVAC energy use concludes that continuous air barrier systems can reduce air leakage by up to 83% and provide potential energy savings of greater than 40% for gas and 25% for electrical. 2005 NIST Study

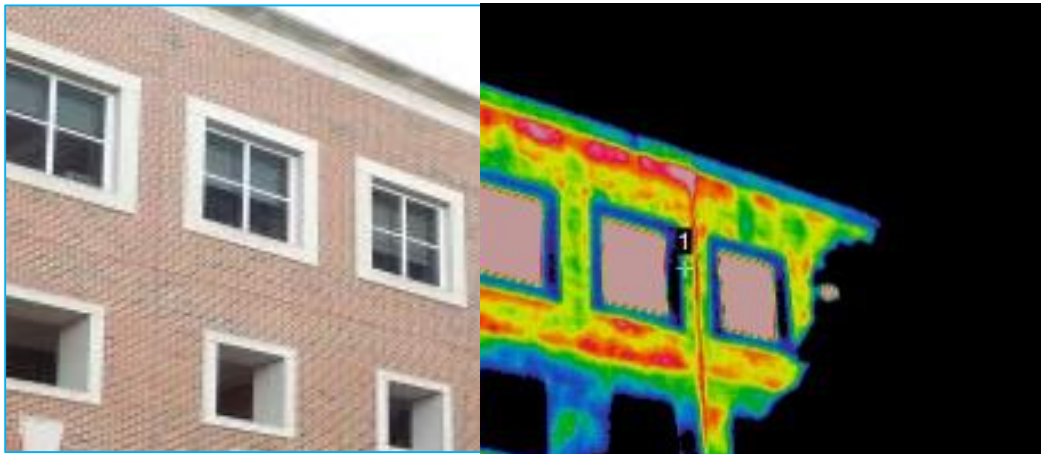
Performance Threats

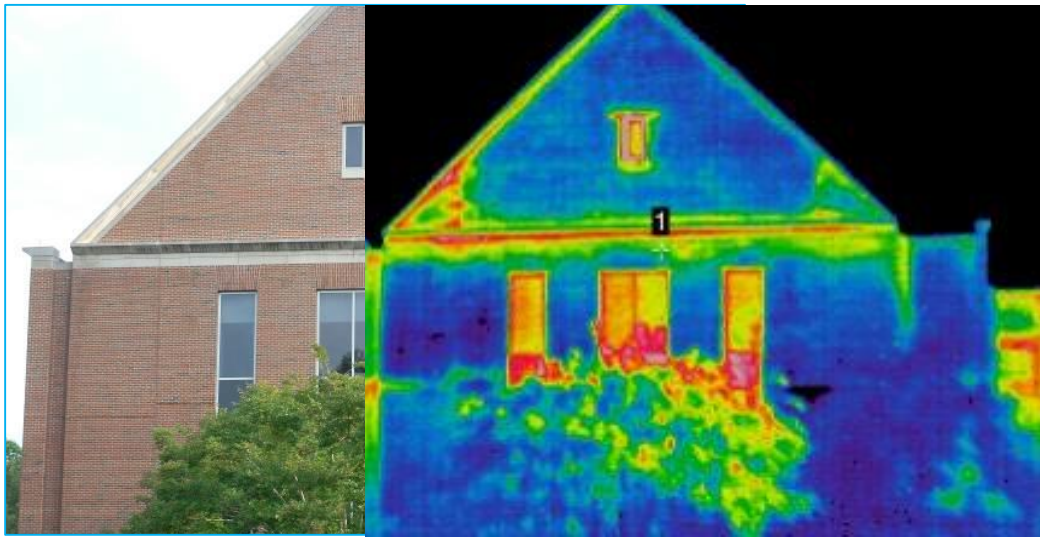
- Junctures
- Interfaces
- Penetrations
- Most problems occur at intersections or transitions of different materials or systems

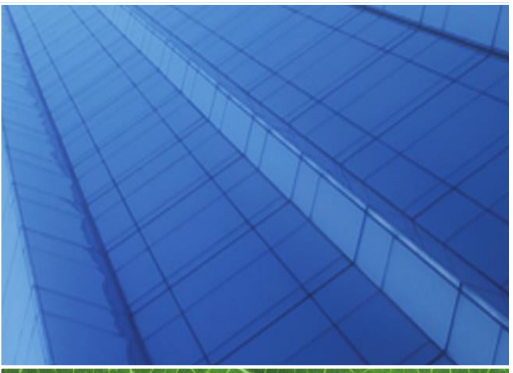


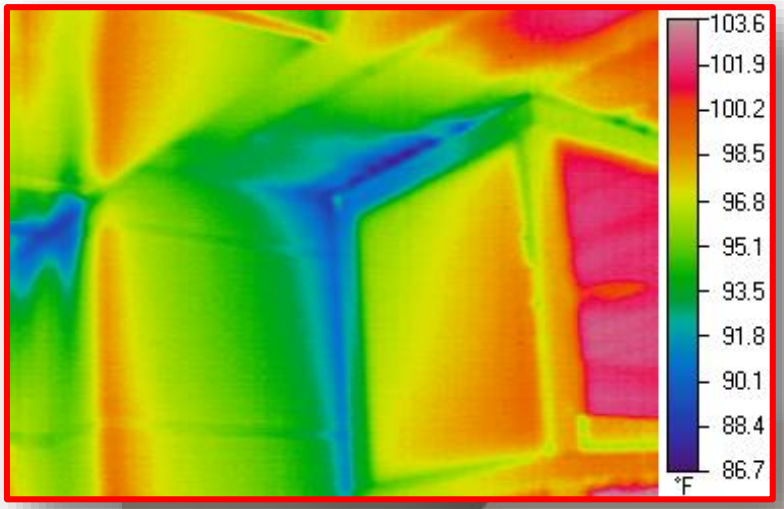


Transitions

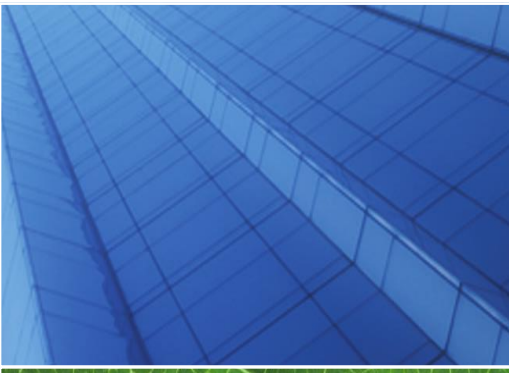




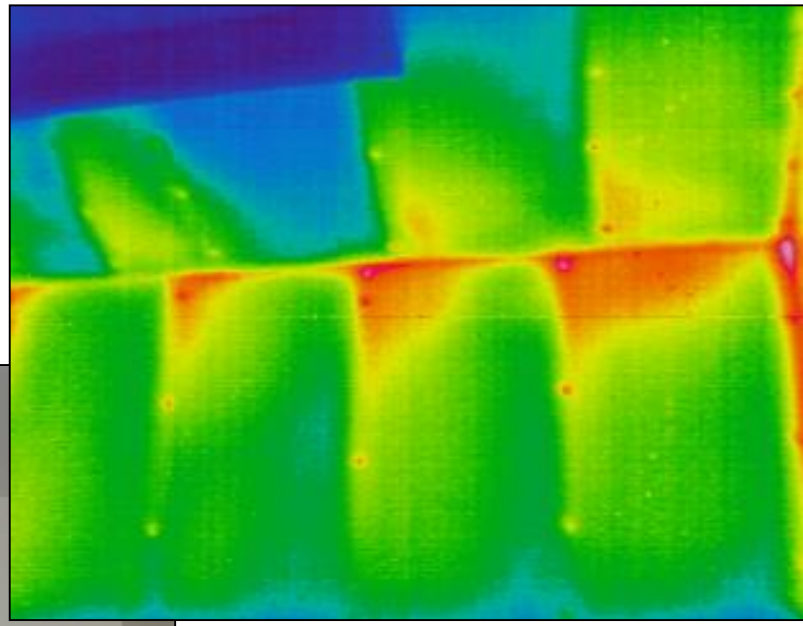


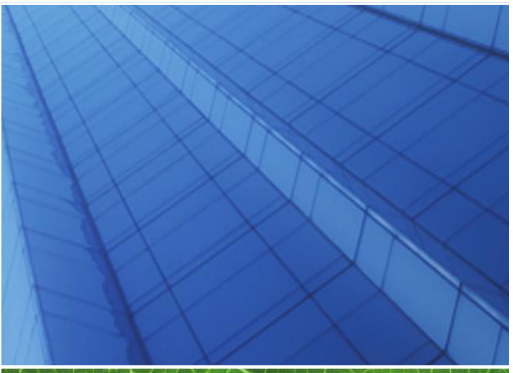


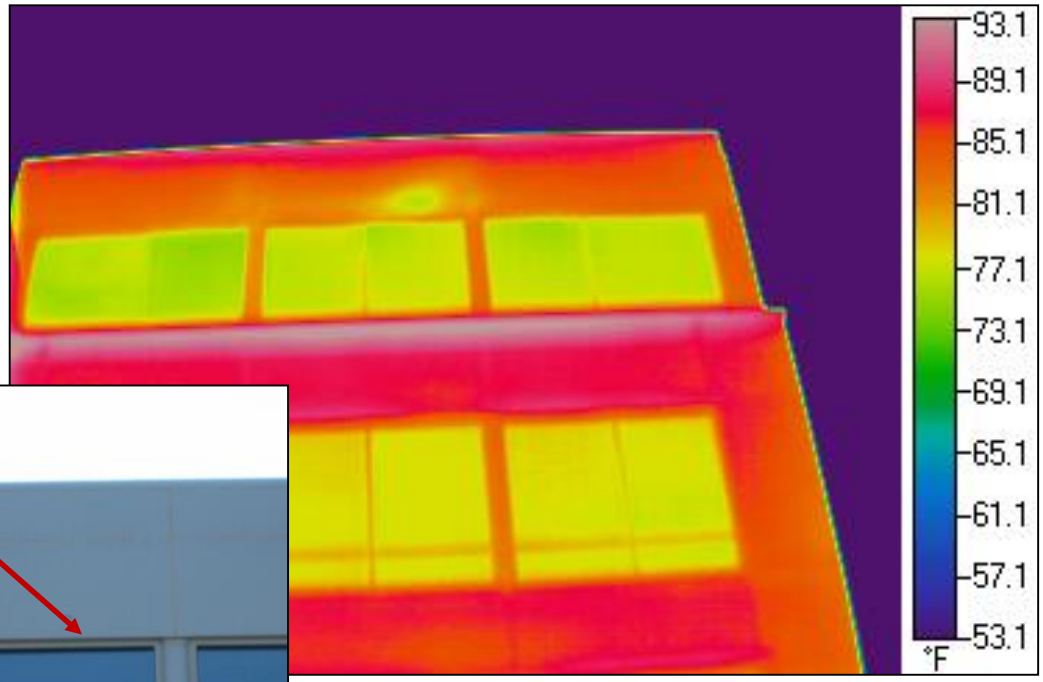
Thermal and Air Continuity

Thermal and Air Continuity

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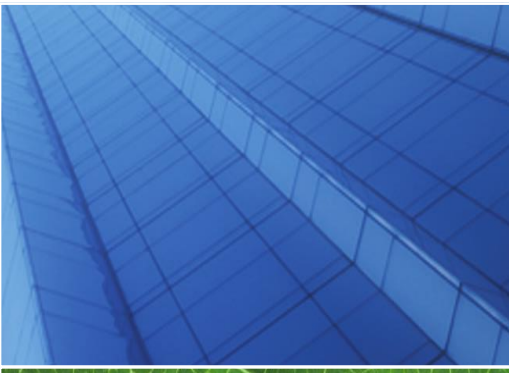
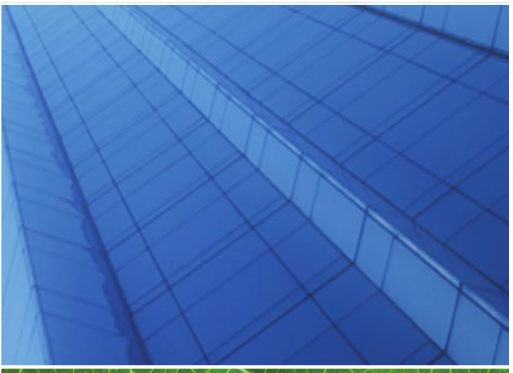
DENSGLASS
Exterior Sheathing

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.

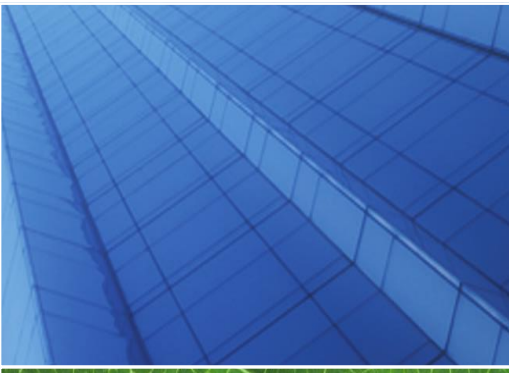
  – WHO guidelines for indoor air quality: dampness and mold World Health Organization 2009

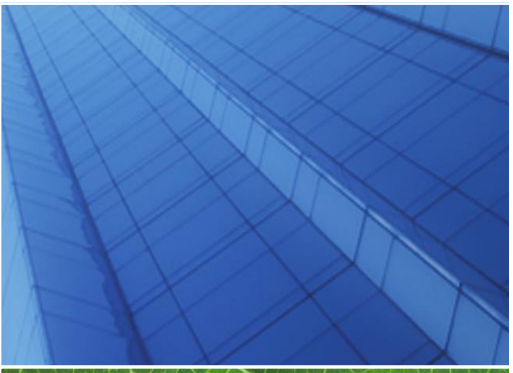
Performance Threats

- 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

Through-Wall flashings

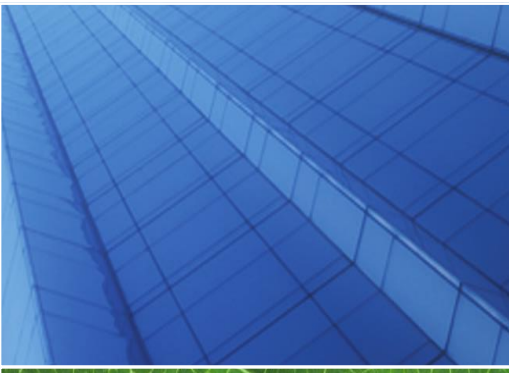



Mortar Clutter



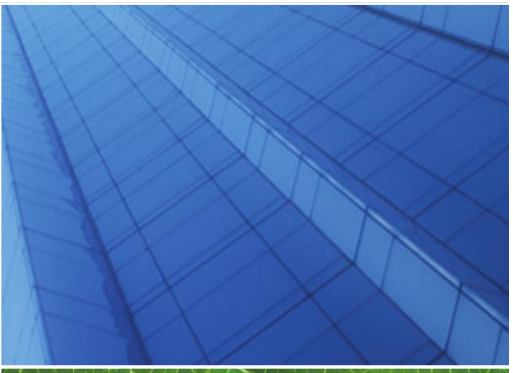
Structural Degradation

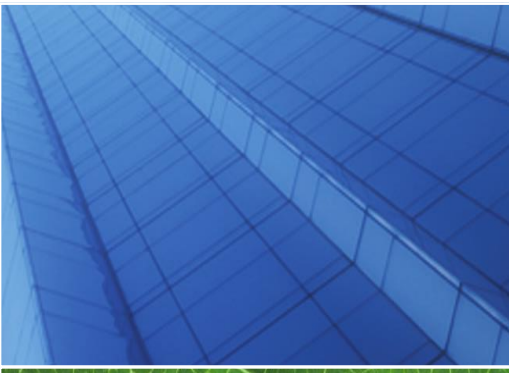
Structural Degradation

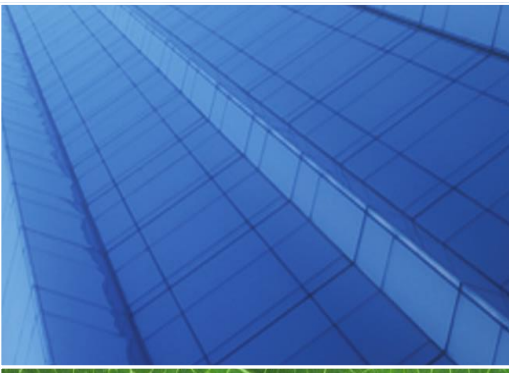
Structural Degradation

Structural Degradation/Material Compatibility

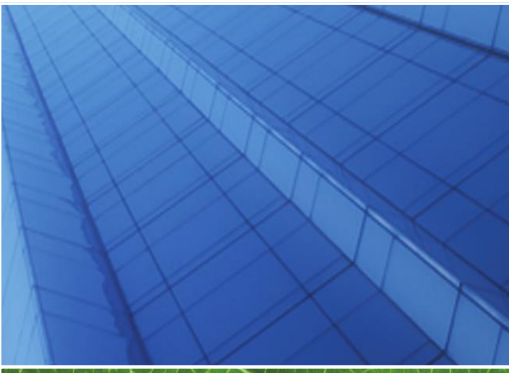




Fenestration Systems

Design for High Performance Building Enclosures

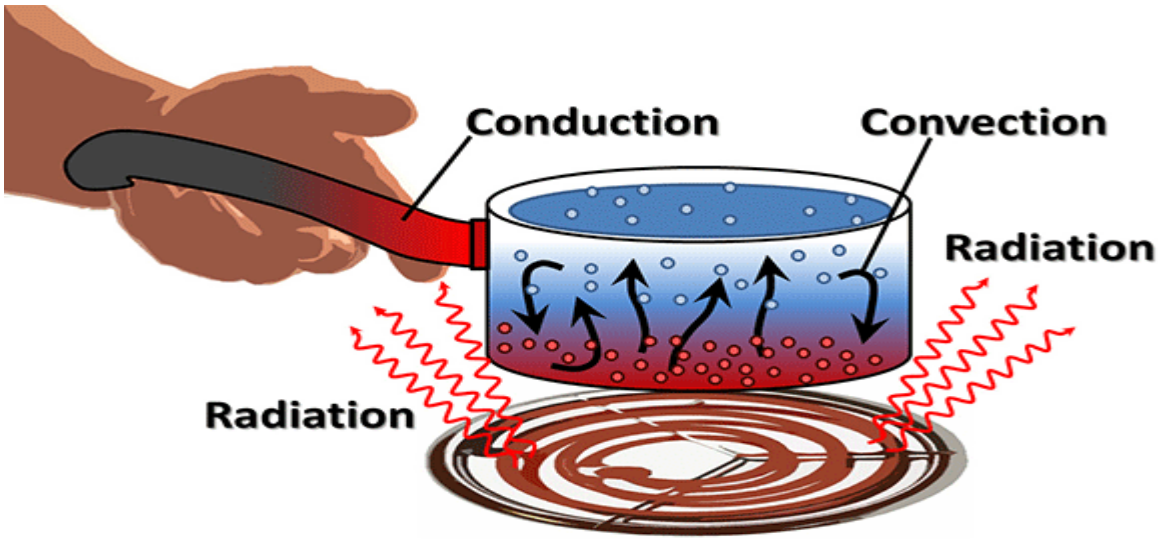



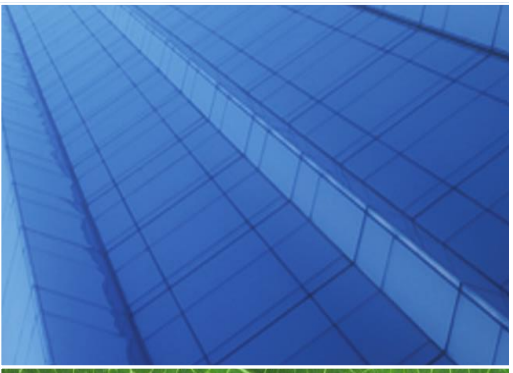
Basic Building Science

Thermal Transfer

- Radiation
- Conduction
- Convection

heat transfers from hot to cold



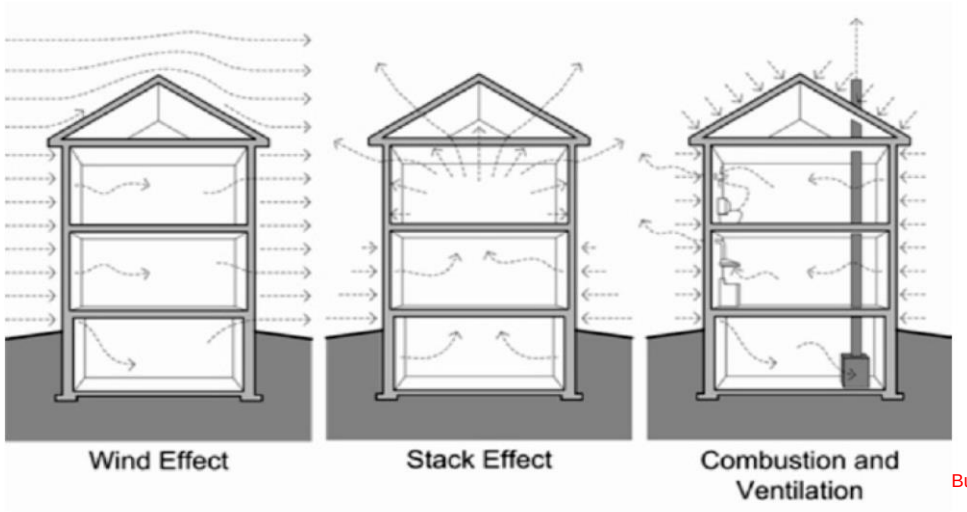



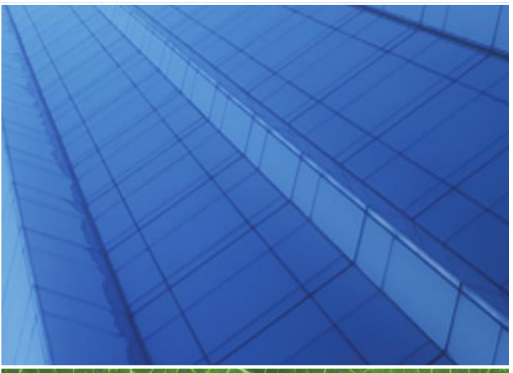
Basic Building Science

Air Infiltration/Exfiltration

- Wind Effect
- Stack Effect
- Combustion and Ventilation

air moves from higher to lower pressure



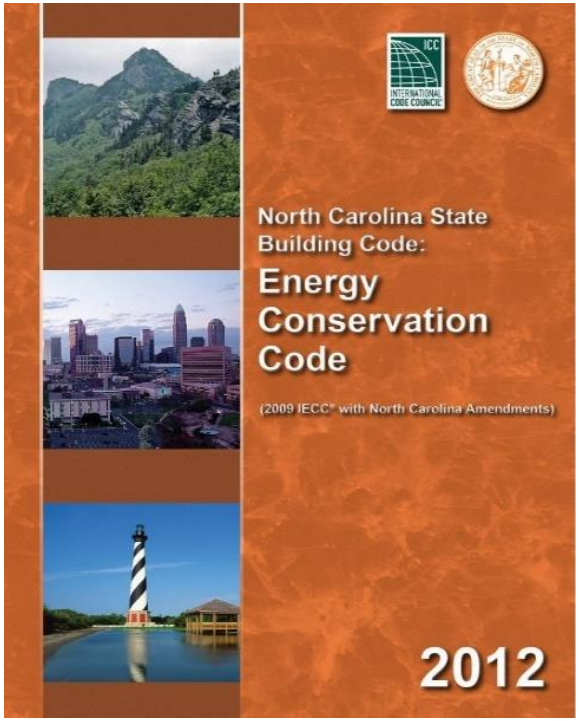
Basic Building Science

Water Transport

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

water moves from wet to dry, higher humidity to lower humidity

North Carolina Current Building Code

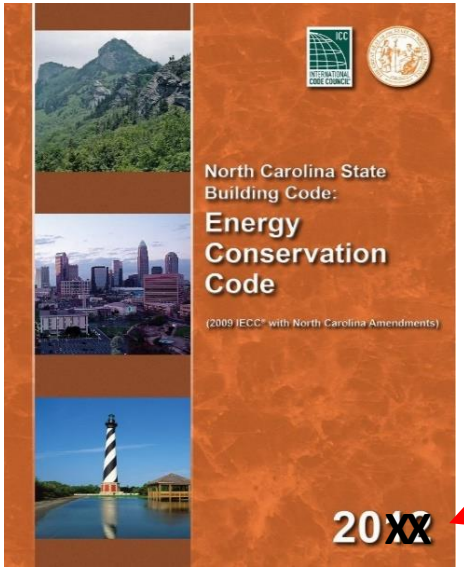


502.4.3 Sealing of the building envelope. Openings and penetrations in the building envelope shall be sealed with caulking materials or closed with gasketing systems compatible with the construction materials and location. Joints and seams of the air barrier system shall be sealed in the same manner or taped or covered with a moisture vapor-permeable wrapping material. Sealing materials spanning joints between construction materials shall allow for expansion and contraction of the construction materials. See construction details in Appendix 2.1.

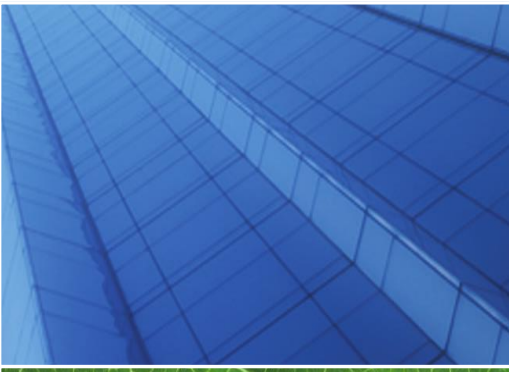
The following connections shall be air sealed:

1. Joints around fenestration and door frames
2. Junctions between walls and foundations, between walls at building corners, between walls and structural floors or roofs, and between walls and roof or wall panels
3. Openings at penetrations of utility services through roofs, walls, and floors including but not limited to electrical, plumbing, mechanical, security, and communications
4. Site-built fenestration and doors
5. Joints, seams, and penetrations of the air barrier system
6. Other openings in the building envelope

North Carolina Proposed Building Code



- Proposed 2018 Energy Conservation Code
  - Started with 2015 I Codes and modified for NC
  - Draft Code is now available for review
  - If approved, code would go into effect January 1, 2019

Roof Assemblies

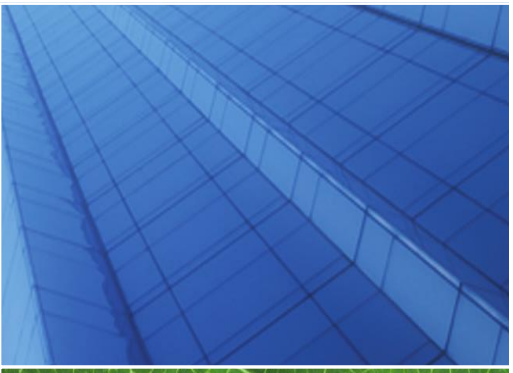
R-value does not change

- Where two or more layers of continuous insulation (ci) are within the assembly - edge joints between each layer shall be staggered

- Skylight curbs – insulated to the level of roofs with insulation entirely above deck or R-5 whichever is less.

Exceptions –

- Skylights listed and labeled in accordance with NFRC 100
- Where tapered insulation is used with insulation entirely above deck, the R-value where the insulation thickness varies 1 inch or less from the minimum thickness of tapered insulation shall comply with the R-value specified in Table C402.1.3.

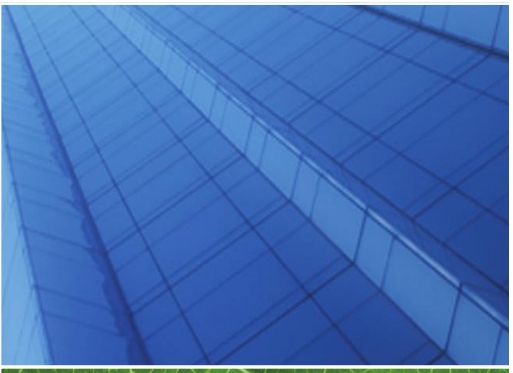
Air Barrier

- Previously, only air sealing was required – penetrations, junctions, fenestration, etc.

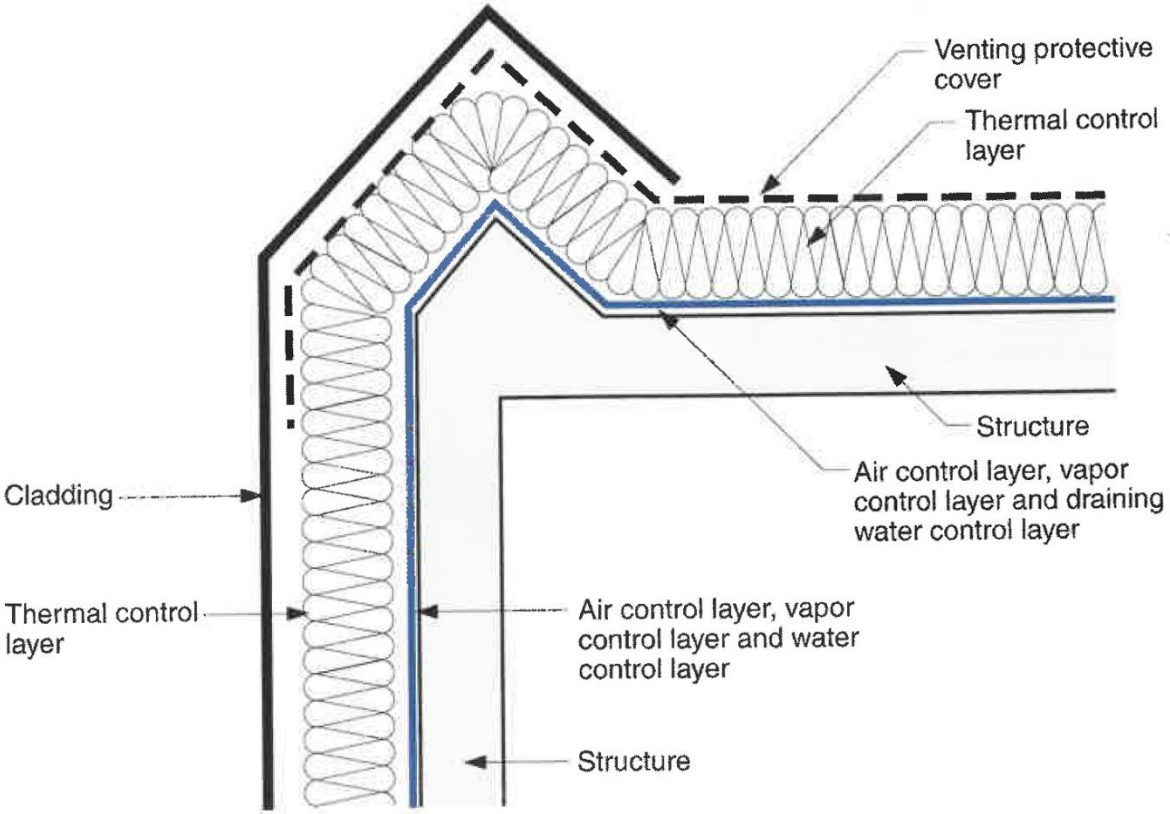
- Now, a continuous air barrier is required throughout the building thermal envelope

- <u>Compliance</u>
  - Meet provisions within the code.
  - ASTM E779 with a pressure differential of 0.3 in. water gauge (75pa)

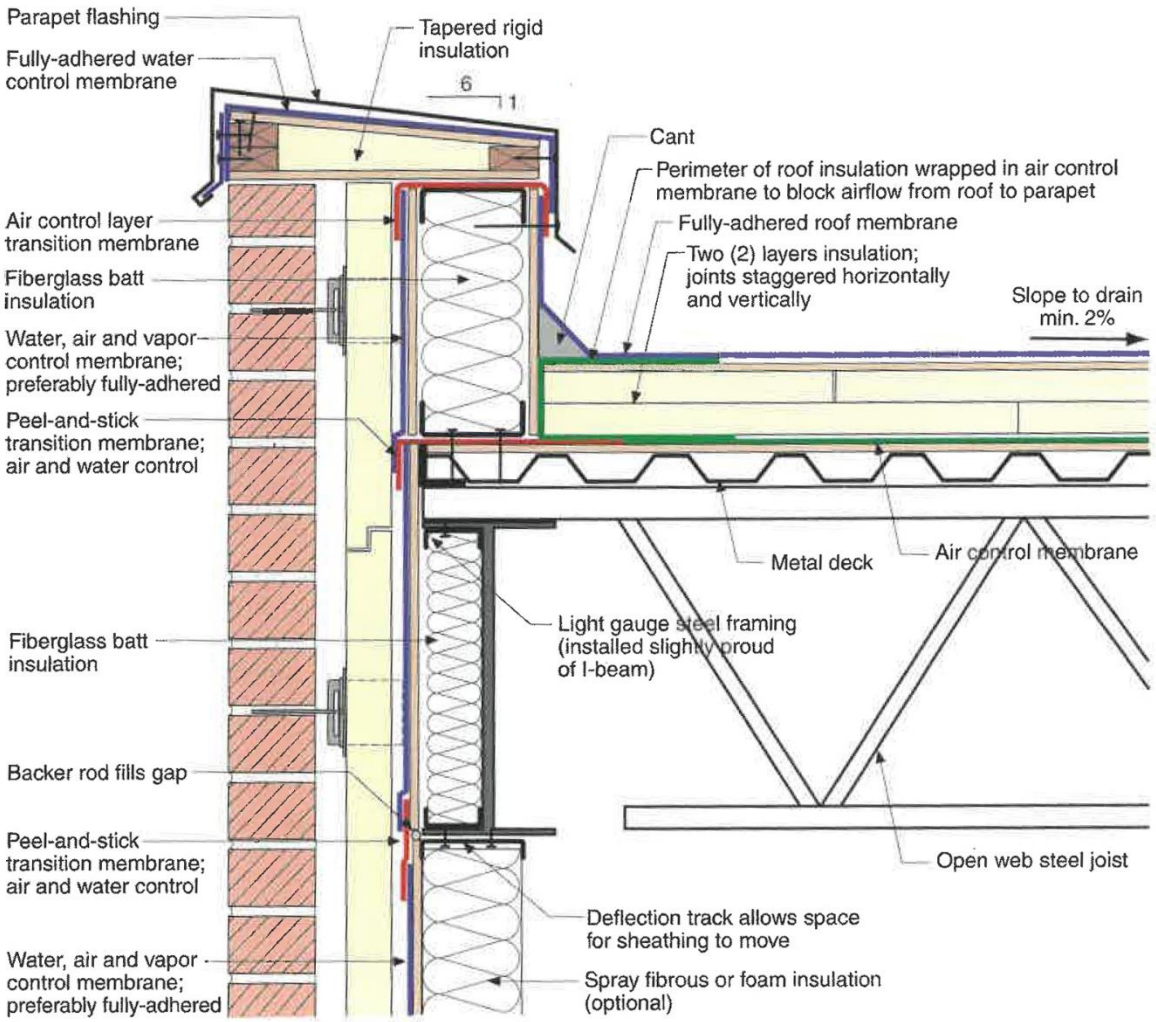
- <u>Performance</u>
  - COMcheck will still be used to demonstrate compliance
  - 2012 IECC - ASHRAE 90.1 2010
  - 2018 IECC – ASHRAE 90.1 2013

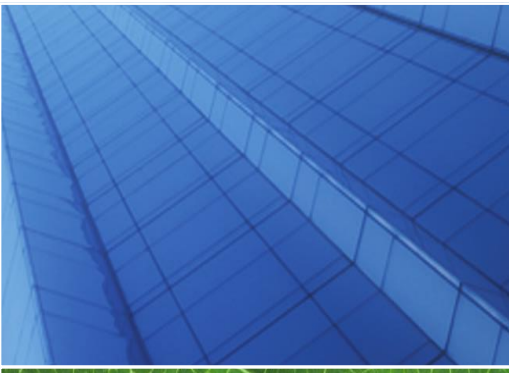


The Ideal Wall



Roof To Wall Transition

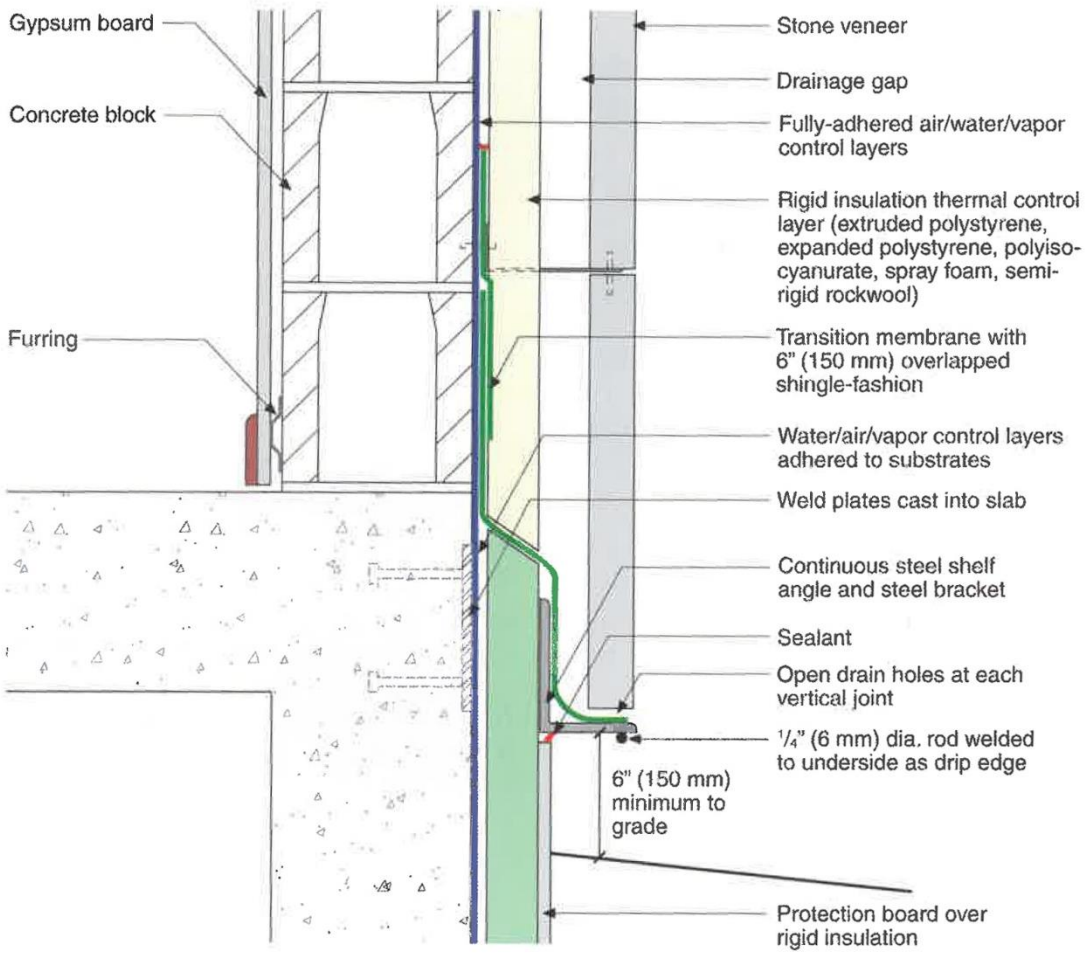


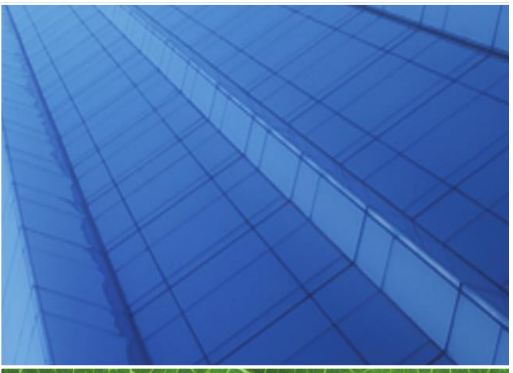



At Grade Transition

If the exterior insulation "perfect wall" approach is used, it becomes relatively easy to continue the other control layers from the above-grade system to that below grade (Figure 5.8).

In those enclosures that use interior insulation, it too should be continued downward to the footing and connect with the sub-slab insulation.



Penetration (Jamb) Transition

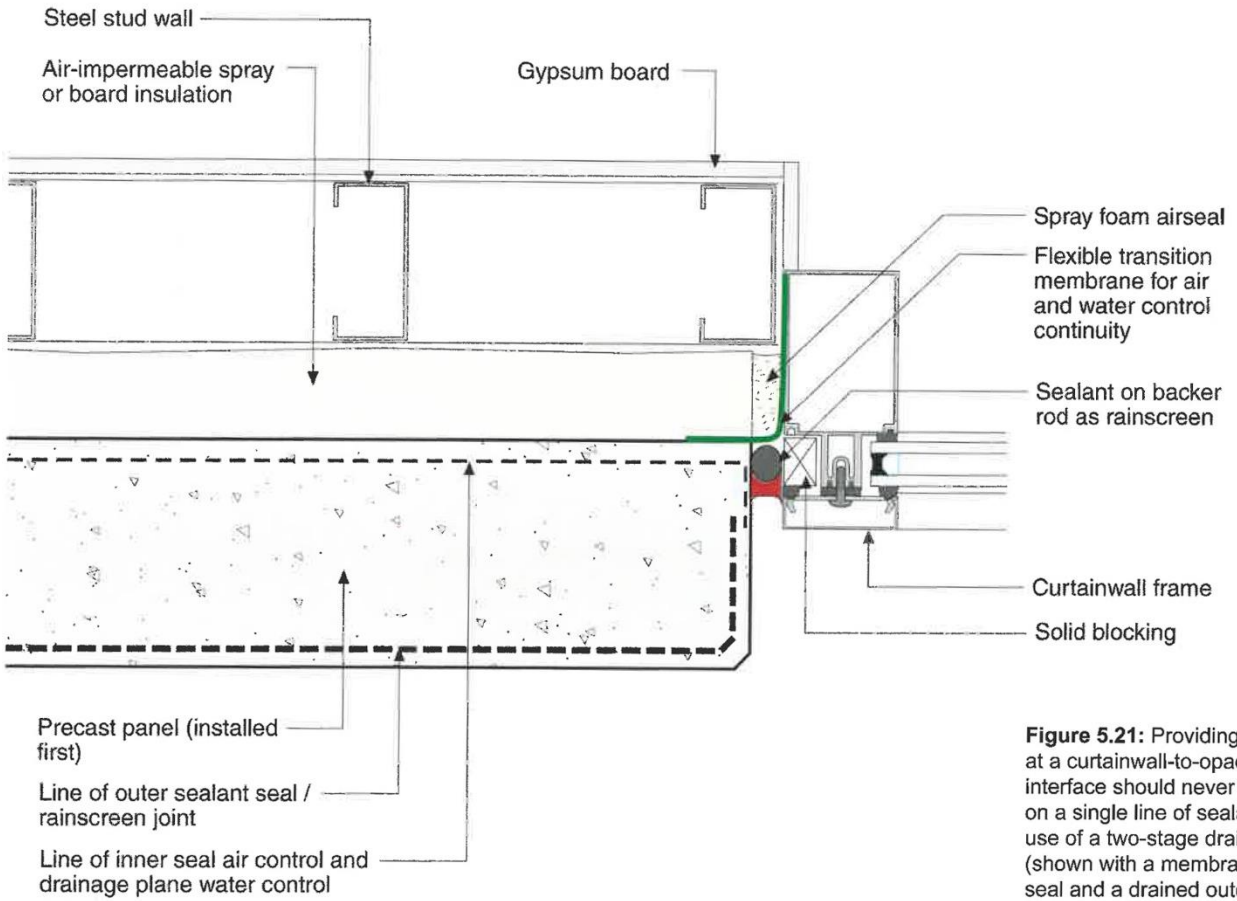
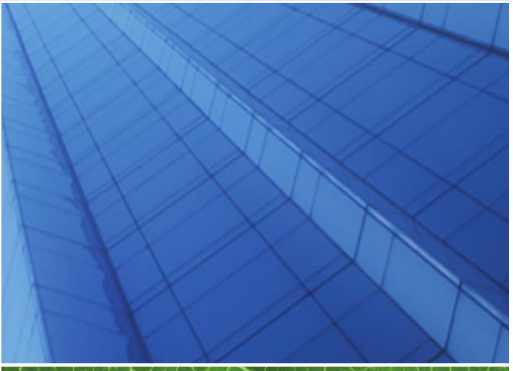
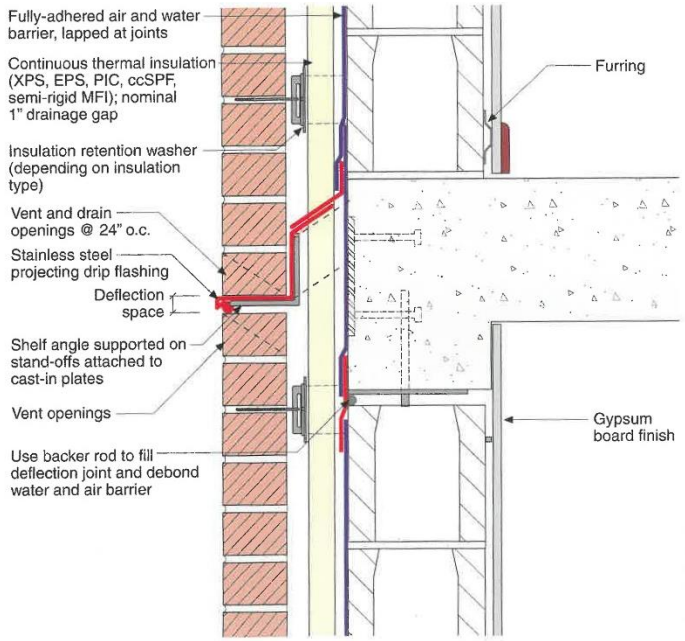
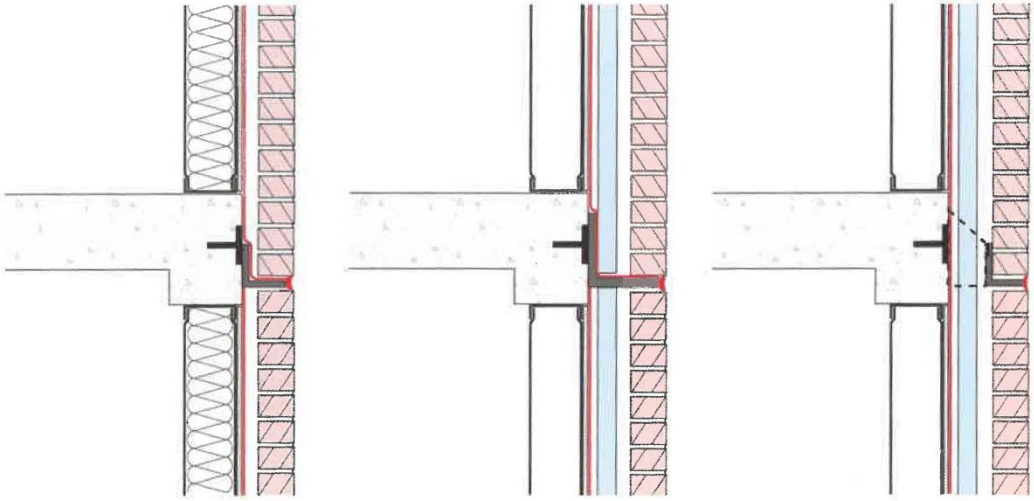


Figure 5.21: Providing continuity at a curtainwall-to-opaque-wall interface should never rely solely on a single line of sealant. The use of a two-stage drained joint (shown with a membrane inner seal and a drained outer sealant bead) is preferred as a more durable and reliable transition.



Shelf Angle Transition

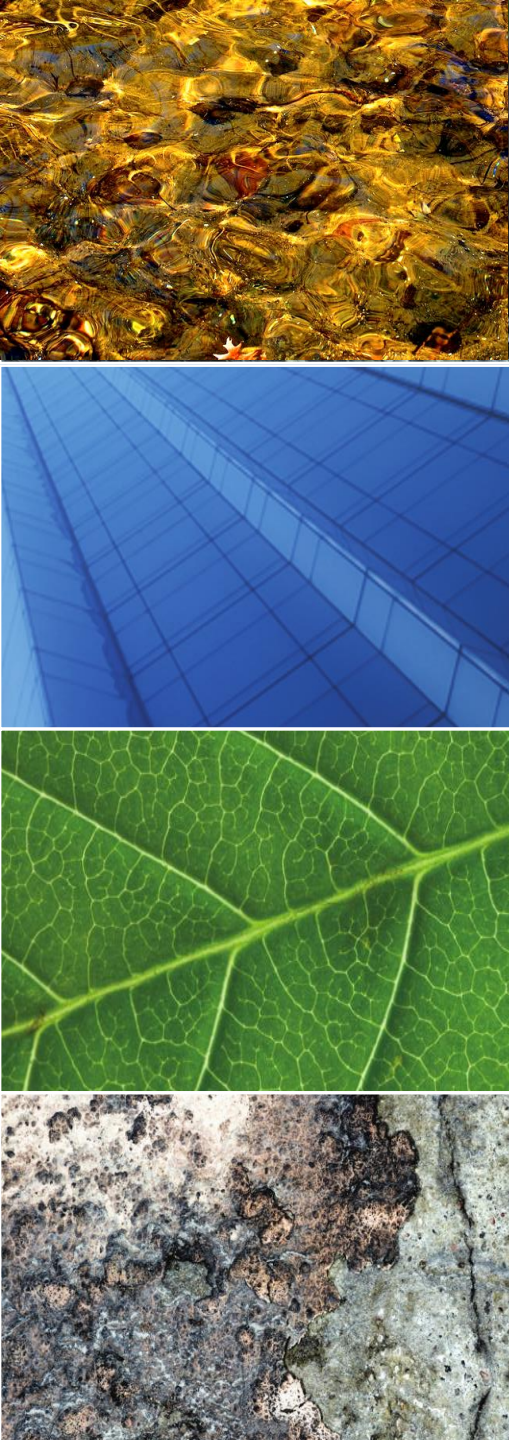




Traditional: no thermal control

Expensive: poor performance

Modest cost: good performance



Building Enclosure Commissioning (BECx)

What is it?

PROCESS

Multiple Drawing & Specification Reviews

Product Submittal Reviews

Collaborative Evaluation → Verification → Documentation

Kick-Off Meeting & Monthly BECx Meetings

Construction Monitoring

Functional Performance Checklists and Testing

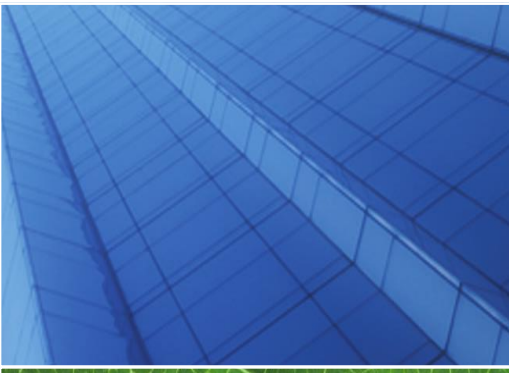
Image: Courtesy of Balfour Beatty Construction

LEED Certified Buildings

2009	Systems	Phases
EA Pre-Requisite	▪ HVAC & Controls ▪ Domestic Hot Water System ▪ Lighting & Controls ▪ Renewable Energy Systems	▪ Construction ▪ Acceptance
EA Enhanced: (2 Points)	▪ No additional systems, only additional services	▪ Design ▪ Post Acceptance

LEED Certified Buildings

V4	Systems	Phases
EA Pre-Requisite	▪ HVAC & Controls ▪ Domestic Hot Water System ▪ Lighting & Controls ▪ Renewable Energy Systems ▪ Plumbing Pumps & Controls ▪ Electrical Service & Distribution ▪ Envelope	▪ Design ▪ Construction ▪ Acceptance
EA Enhanced: Option 1 (3-4 Points)	▪ No additional systems, only additional services	▪ Post Acceptance
EA Enhanced: Option 2 (2 Points)	▪ Building Envelope	▪ Design thru Post Acceptance

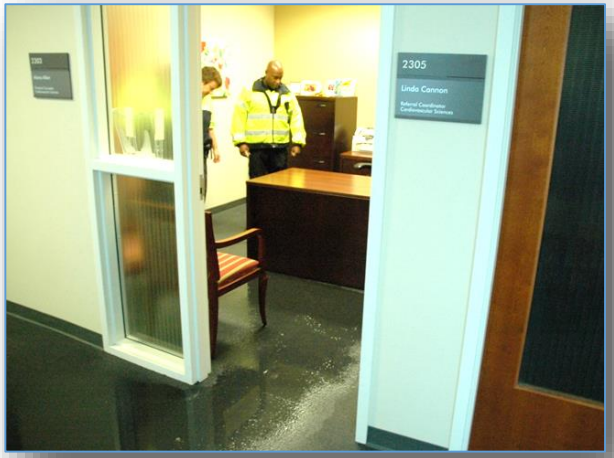



Cost of BECx

- ~0.25% of Total Construction Cost
- $1,000's in design & construction
- $1,000,000's in forensics and repairs
- Just bricks and sticks…
  - Do you have swing space for building occupants during repairs???
  - Impact Costs

Hurricane Irene & East Carolina University

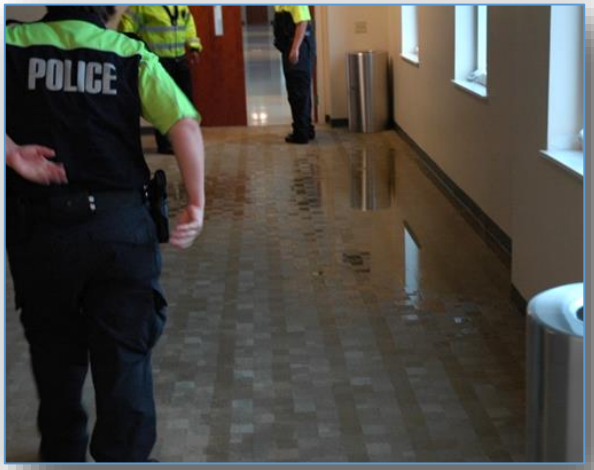
East Carolina University



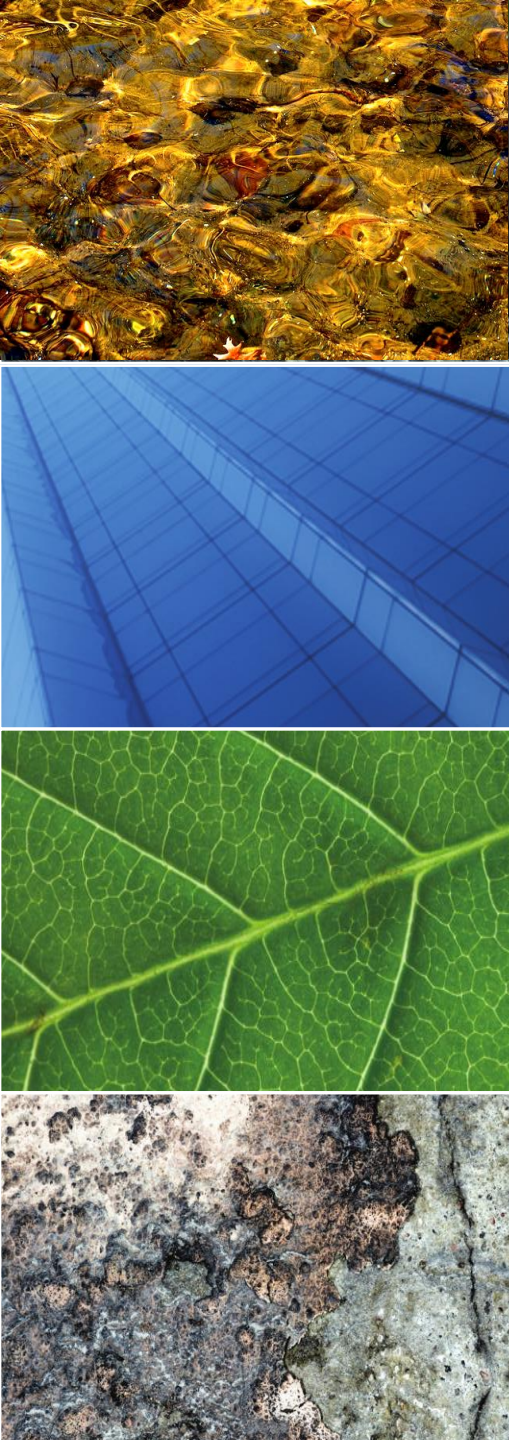
2nd Floor
North Corridor
Interior Office

2nd Floor
North Corridor

4th Floor



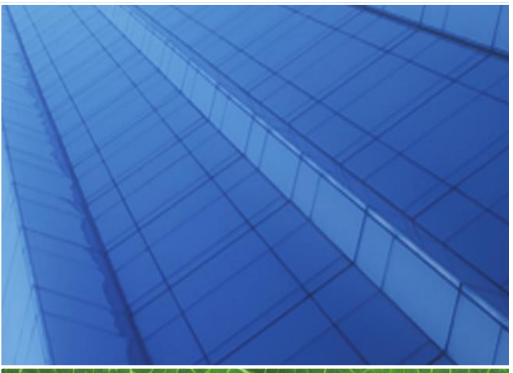
3rd Floor
North Corridor



The AHA! Moment

Cost of BECx

Building / Project Name	Total Project Cost	MEP Cx Costs	BECx Costs	Envelope Issues?	Forensic Testing
Health Sciences Building	$ 61 M	INA	Not Done	Yes	$300k +
Heart Institute	$ 60 M	$ 243 k	Not Done	Yes	$58k
School of Dental Medicine	$ 60 M	$ 370 k	$ 32 k	No	$0
Clement Residence Hall	$ 20 M	$ 30 k	$ 60 k	No	$0
Gateway Residence Hall	$ 58 M	$ 323 k	$ 64 k	No	$0
Student Union	$ 122 M	$ 537 k	$ 181 k		Construction Phase

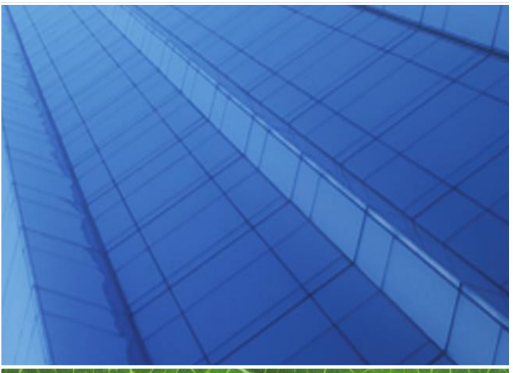
Hygrothermics - WUFI Pro 5.2

Warme Und Feuchte Instationar (Warm and Humid Fluctuations) Transient Heat And Moisture

- Transient Hygrothermal behavior of multi-layer building components
- Data validated and derived from outdoor and laboratory tests

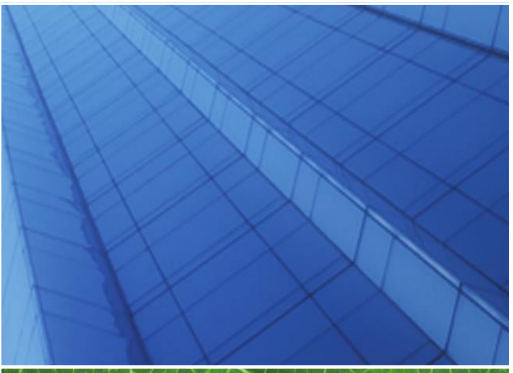
Can be used for:

- Drying time for masonry w/trapped moisture
- Danger of interstitial condensation
- Influence of driving rain
- Effects of repairs
- Analyze roof and wall systems in different climate zones

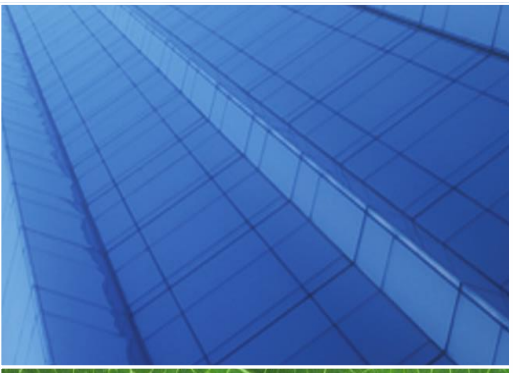
When is WUFI Beneficial?

- Peer review of design and/or construction documents
- Quality control during design (assist in outlining potential systems and quantify the pros and cons of each)
- Quality assurance during design (used during internal review of designs prepared by others)
- Trouble shooting existing systems
- WUFI quantifies building enclosure systems' performance over time.
- Building Enclosure Commissioning (BECx)

Mockups and Testing

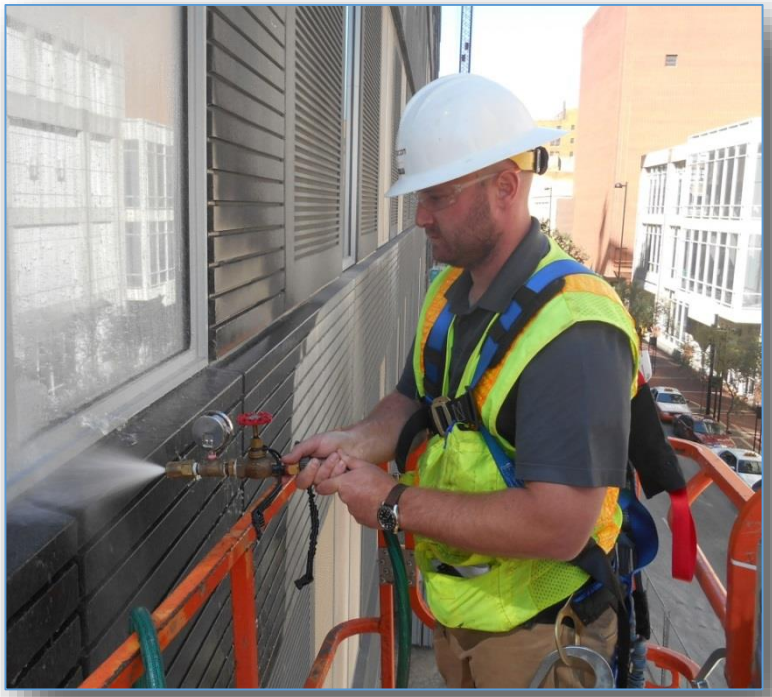
Mock Ups



Test Methods

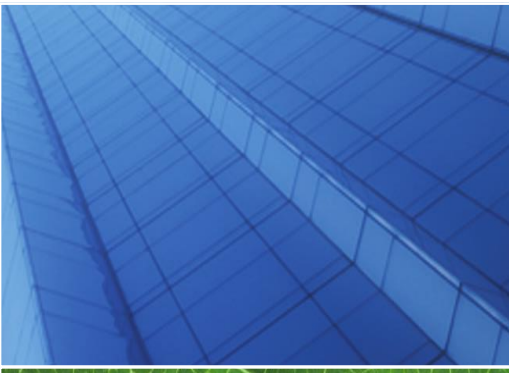
AAMA

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



Test Methods
ASTM

- ASTM E 783 Field Fenestration Air Infiltration
- ASTM E 1105 Field Water Penetration
- ASTM E 1186 Field Air Leakage Test
- ASTM C 1153 Thermographic Imaging
- ASTM F 1869 Concrete Vapor Emission Test
- ASTM C 1521 Exterior Sealant Adhesion Test
- ASTM D 4541 Air Barrier Adhesion Test
- ASTM C 601 Masonry Water Penetration Test
- ASTM E 7877 Electronic Waterproofing Methods
- ASTM E779 Air Leakage Rate by Fan Pressurization



Thank You
For Your Time!

This concludes the American Institute of Architects Continuing Education Systems Programs

Terracon

2020 E Starita Road, Charlotte, NC