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The Construction Specifications Institute Northern Illinois chapter

14th Annual Building Enclosure Event
February 28, 2017

CSI Chicago Chapter

BECx: Building Enclosure Commissioning – Growing trends toward higher energy performance and operation excellence

Presented by:
John Runkle, P.E.,
Vice President - Building Sciences Solutions,
Intertek - Architectural Testing, Inc.

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Course Description

Today's building industry demands FASTER, BETTER, CHEAPER construction, making BECx more vital in achieving high performance.

In today's presentation Mr. Runkle will cover how BECx enhances project performance, discussing building enclosure-related testing, pertinent codes and standards, building science concepts, and current material science which serve as a foundation to this new practice area.

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Learning Objectives

1. Review the current **codes and standards** related to Building Enclosure Commissioning (BECx).
2. Discuss the **building sciences** – drivers for enclosure quality and common failures.
3. Understand the linkage between **materials, systems** and whole building performance.
4. Understand how our **changing environment and construction practices** dictate modifications to traditional building enclosure quality assurance.
5. Learn how **BECx enhances** project performance.

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Program Outline

Drivers
- **Failures**
- **Safe**
- **Durable**
- **Savings**
- **"Green"**
- **Timely**
- **Expectations (OPR)**

Codes / Building Science
State of the Practice
Tomorrow's Trends

Environmental Separation

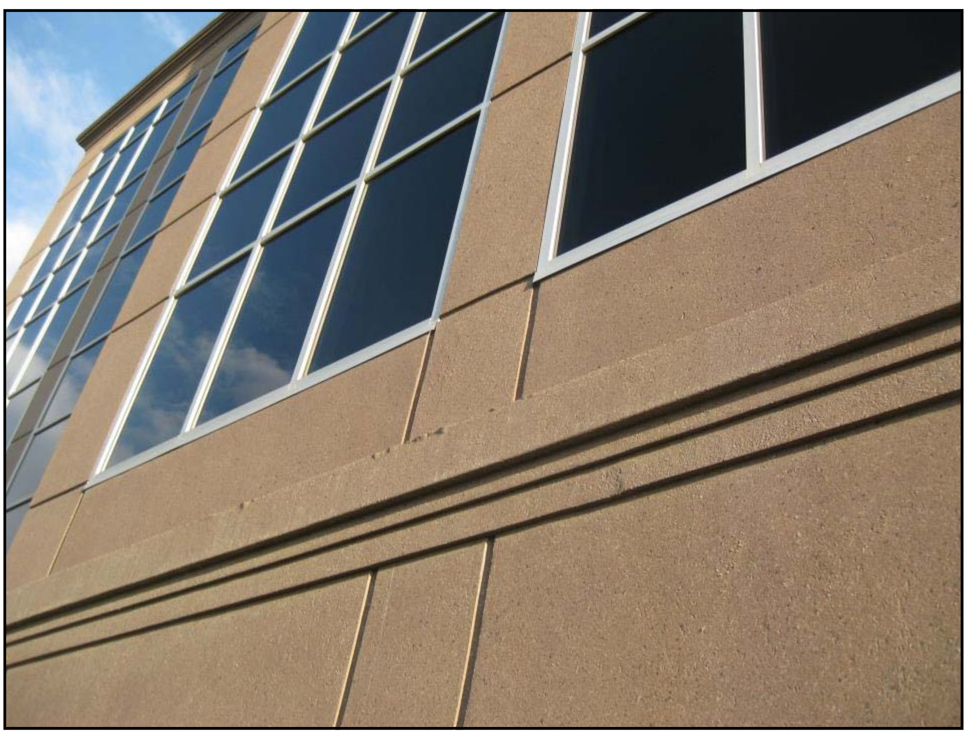
Building enclosures are designed to separate interior from exterior.

Leaks

Leaks

Air Quality / Health

Leaks



Chemical Compatibility

Durability of Materials

Sustainability Status

Program Outline

Quality Drivers
- **Failures**
- **Safe**
- **Durable**
- **Savings**
- **"Green"**
- **Timely**
- **Expectations (OPR)**

Codes / Building Science
State of the Practice
Tomorrow's Trends

Energy Conservation

Solar Heat Gain

U-Factor

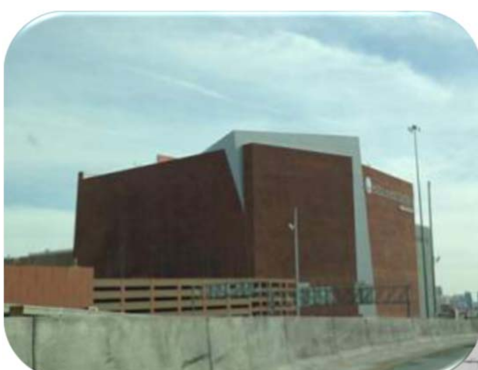
Air Leakage

Energy Conservation

Solar Heat Gain

<u>SHGC</u>
Transmittance
Reflectance
Absorptance
Emittance

Energy Conservation



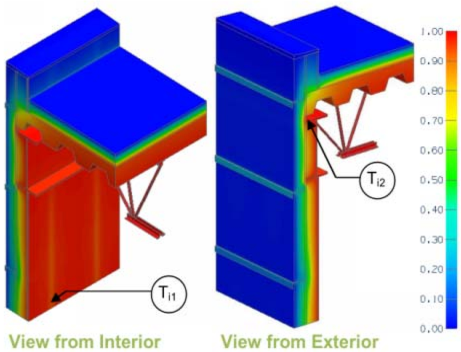
Window: Wall

Energy Conservation

Thermal Discontinuities

Energy Conservation

Energy Modeling & BECx



Thermal Performance Indicators

Assembly 1D (Nominal) R-Value	R_{1Dr}, R_{1Dw}	Two base assemblies : r = roof w = wall (Detail 11)
Transmittance / Resistance without Anomaly	U_{or} R_{or} U_{ow} R_{ow}	"clear field" U- and R-values. Separate values presented for the two base assemblies
Surface Temperature Index[1]	T_i	0 = exterior temperature 1 = interior temperature
Linear Transmittance	ψ	Incremental increase in transmittance per linear length of parapet

[1]Surface temperatures are a result of steady-state conductive heat flow with constant heat transfer coefficients. Limitations are identified in final report.

Nominal (1D) vs. Assembly Performance Indicators

Base Assembly – Wall

Wall Exterior Insulation 1D R-Value (RSI)	R_{1D} $ft^2 \cdot hr \cdot {}^oF$ / Btu (m^2 K / W)	R_{ow} $ft^2 \cdot hr \cdot {}^oF$ / Btu (m^2 K / W)	U_{ow} Btu/$ft^2 \cdot hr \cdot {}^oF$ (W/m^2 K)
R-5 (0.88)	R-19.2 (3.38)	R-13.40 (2.36)	0.075 (0.42)
R-10 (1.76)	R-24.2 (4.26)	R-16.28 (2.87)	0.061 (0.35)
R-15 (2.64)	R-29.2 (5.14)	R-18.49 (3.25)	0.054 (0.31)
R-20 (3.52)	R-34.2 (6.02)	R-20.50 (3.61)	0.049 (0.28)
R-25 (4.40)	R-39.2 (6.90)	R-22.14 (3.90)	0.045 (0.26)

Base Assembly – Roof

R_{1D} $ft^2 \cdot hr \cdot {}^oF$ / Btu (m^2 K / W)	R_{or} $ft^2 \cdot hr \cdot {}^oF$ / Btu (m^2 K / W)	U_{or} Btu/$ft^2 \cdot hr \cdot {}^oF$ (W/m^2 K)
R-21.2 (3.74)	R-21.0 (3.69)	0.048 (0.27)

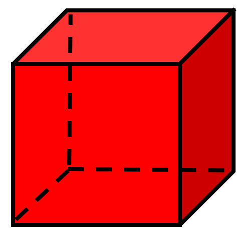
Reference ASHRAE 1365 -RP

Energy Modeling & BECx

HVAC or Envelope?

Energy Modeling & BECx

Whole building air test results (ASTM E779) are expressed as air flow through the wall, roof, and floor, not just the facade.



Case Study

Diagnostic Investigation:

- Occupants had difficulty regulating the temperature
- Windows and wall areas were cold concurrent with outside temps
- High heating costs reports by the owner

Case Study

Blower Door Testing:

Building air leakage rate @ 75PA

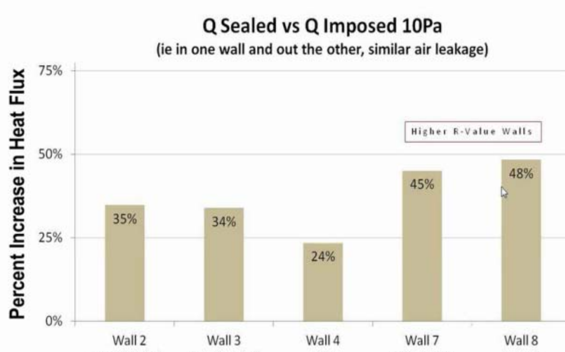
- 0.50 cfm/ft² (Positive)
- 0.61 cfm/ft² (Negative)

Diagnostic Evaluation:

- A significant amount of the air leakage occurs into the inter-story air plenums.
- Air leakage around the windows and through the window systems
- Air leakage through the wall penetrations

Oak Ridge National Lab - Study

- Test full-scale walls w/ and w/o air leakage in hot box
- Leakage limited to joints at sheathings
- Heat flux increased 25 to 50%



Case Study

	Multi-Agency State Office Building	Dixie State Holland Centennial Commons
Total Building Area (SF)	267,000 SF	177,000 SF
Total Envelope Area (SF)	227,700 SF	165,168 SF
Building envelope with Air Barrier	33,250 SF	40,000 SF
Air Barrier Type	Membrane	Fluid Applied
Total Construction Costs	$45,600,000	$31,000,000
Air Barrier Construction Costs	$292,500	$136,600
Air Barrier Cost/SF with Air Barrier	$2.50	$3.79
A/E Envelope Design Costs	0%	2.5%
Envelope Commissioning Costs	$0	$49,200
Envelope Testing Costs	$5,000	$51,700
Leakage Rate (CFM/SF @ 0.05 WC)	0.20	0.027

Oak Ridge National Lab - Study

Findings relating to energy modeling and air leakage:

Current modeling software, doesn't do a good job of accounting for energy loses due to air leakage.

- Calculations are based on conductive losses rather than losses due to air leakage.
- Current models appear to underestimate the energy loss due to air leakage.
- Past studies focus on lower R-value walls compared to the higher R-values of today.

DFCM's Case for Rigorous BECx

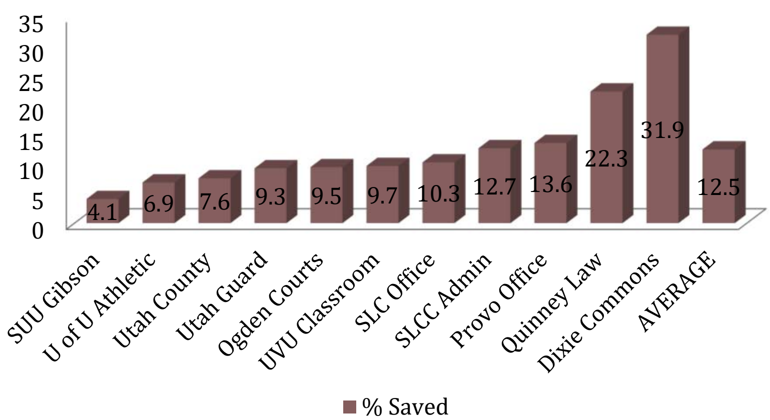
Why BECx?

DFCM Infiltration Study 2013

- Additional Implications
- Potential for smaller HVAC plant equipment (reduced first cost – issues regarding HVAC design liability?)
- Eliminate undermining of the effectiveness of insulation and high thermal performance glazing systems (why spend the money to insulate if the project's HVAC is just going to heat/cool the great outdoors?)
- Improved indoor air quality (MERV 13 vs. OSA quality)
- Improved thermal comfort (less complaints)
- Improved productivity (a comfortable occupant tends to work better)

DFCM's Case for Rigorous BECx

Modeled Yearly Energy Cost Saved (%) = [(0.8-0.1)/0.8] x 100

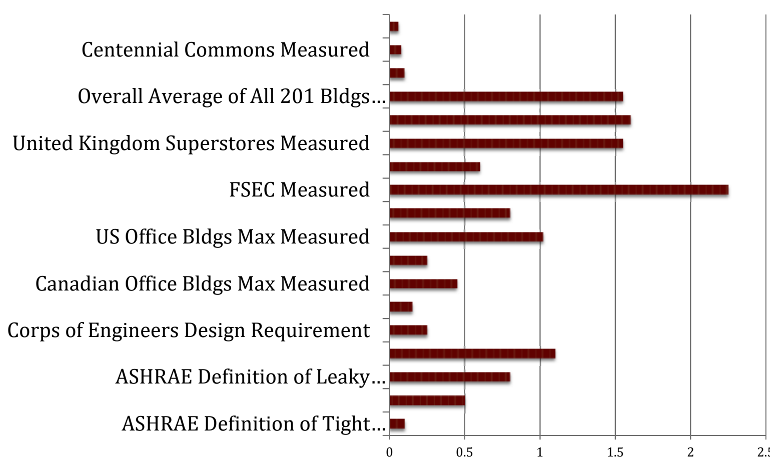


DFCM's Case for Rigorous BECx

Why the Differences?

- Type of building and type of space:
  - science vs. general classroom
  - cafeteria vs. office, etc.
- Building Shape: Square compared to irregular shape
- Long span as opposed to shorter spans
- HVAC system(s) used
- The climate zone
- The ratio of non-glazed to glazed wall
- The quality of the air barrier installation

DFCM's Case for Rigorous BECx



DFCM's Case for Rigorous BECx

AIR BARRIER SF ÷ BLDG GSF (8 OUT OF 8 PROJECTS)	33.0 %
AIR BARRIER SF ÷ BLDG ENVELOPE SF (8 OUT OF 8 PROJECTS)	28.3 %
AIR BARRIER COST ÷ PROJECT CONSTRUCTION COST (8 OUT OF 8 PROJECTS)	1.0%
AIR BARRIER COST ÷ BLDG GSF (8 OUT OF 8 PROJECTS)	$1.68/GSF
AIR BARRIER COST ÷ AIR BARRIER SF (8 OUT OF 8 PROJECTS)	$4.87/SF
COST OF AIR BARRIER COMMISSIONING & TESTING ÷ TOTAL CONSTRUCTION COST (6 OUT OF 8 PROJECTS)	0.33%
BUILDING LEAKAGE RATE (3 OUT OF 8 PROJECTS)	0.079 CFM/SF²
MOCKUP COST (7 OUT OF 8 PROJECTS)	$16,143

Metrics as of 2013.

Achieve Exceptional Energy Savings

Building Envelope Commissioning

Over the years DFCM has learned the immense value of having high performing building envelopes. Quality systems that perform as designed provide value to the building and its occupants for decades.

In an effort to quantify the value of this program, DFCM conducted an analysis utilizing a sophisticated energy modeling process to determine annual energy cost savings ranging from 4% to 32%, with a majority of buildings experiencing savings in the 10% to 15% range.

- ***John Burningham,***

Energy Development Director

Sustainability Drivers

Economy of Green

- 2013 - green building market exceeded $260b USD over 20% growth
- ECO/Green Certification $300m+ USD industry per IBIS World
- Nielson survey 55% of respondents would pay extra for socially responsible products

Saving Time

Understanding the Environment


THINK WIND BEFORE OPENING DOOR


6442


09/24/2013 14:53


08/04/2003


09/25/2013 18:28

Understanding the Owner's Expectations

Owner's Project Requirements

Program Outline

Quality Drivers

Codes / Building Science

- Code Review
- Building Science 101

State of the Practice

Tomorrow's Trends

History

2006:

NIBS Guideline 3-2006

- Exterior Enclosure Technical Requirements for the Commissioning Process
- Now part of ASTM family of documents as ASTM E2947.

History

2007:

- US Army Corps of Engineers
- Air barrier material air permeance not to exceed 0.004 cfm/ft^2 at 0.3 in. wg (1.57psf) (0.02 L/s·m^2 @ 75 Pa)
- Whole building's air leakage rate must not exceed 1.25 L/s·m^2 @ 75 Pa (0.25 cfm/ft^2 at 1.57 psf) when tested according to ASTM E779

CSA Z320-11

Building Commissioning Standards & Check Sheets

- Does not specify qualifications for BECxA
- Does not require design peer review – only input from Cx team
- Includes Pre-Construction and Functional Performance Testing
- Addresses the objectives of Part 5 – Environmental Separations of the National Building Code of Canada (NBCC) in addition to the OPR).
- Includes a comprehensive list of Functional Performance Tests

Table B.1
Architectural testing protocols
(See Clause B.3.)

Test	Property	Field review & compliance testing (static)		Functional performance	Standard	Title
		Compliance test report review (lab)	Field review (visual)	Field testing (mock-up or quality assurance)		
Acoustic performance		X	X	X	ASTM E1425	*Standard Practice for Determining the Acoustical Performance of Windows, Doors, Skylights, and Glazed Wall Systems*
		X	X	X	ASTM E569	*Standard Practice for Acoustic Emission Monitoring of Structures during Controlled Simulation*
Air leakage	Air flow	X	X	—	ASTM E2319	*Standard Test Method for Determining Air Flow through the Face and Sides of Exterior Windows, Curtain Walls and Doors under Specified Pressure Differences across the Specimen*
	Air leakage	X	X	—	ASTM E283	*Standard Test Method for Determining the Rate of Air Leakage through Exterior Windows, Curtain Walls and Doors under Specified Pressure Differences across the Specimen*
		—	X	X	ASTM E779	*Standard Test Method for Determining Air Leakage Rate by Fan Pressurization*
		—	X	X	ASTM E783	*Standard Test Method for Field Measurement of Air Leakage through Installed Exterior Windows and Doors*
		X	X	X	ASTM E1186	*Standard Practice for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems*
		—	X	X	ASTM E1258	*Standard Test Method for Airflow Calibration of Fan Pressurization Devices*
	Air permeance	X	—	—	ASTM E2178	*Standard Test Method for Air Permeance of Building Materials*

(Continued)

ASTM E2813-12

"This practice is intended to serve as a concise, authoritative, and technically sound practice for Building Enclosure Commissioning (BECx) that establishes two levels of BECx: Fundamental and Enhanced.

- Specifies qualifications for BECxA
- Specifies a "process" that has some overlap and conflict wit Guideline 0 and ASHRAE Standard 202.
- Includes questions representing the minimum range of issues and concerns that must be considered during development of the OPR.
- Requires design peer review – Fundamental at CDs, Enhanced at SD, DD and CD
- Includes Pre-Construction and Functional Performance Testing
- Includes a comprehensive list of Functional Performance Tests and outlines mandatory testing for Fundamental and Enhanced.

ASTM E2813-12

	Fundamental	Enhanced
Acoustic Performance		✓
Air Leakage	✓	✓
Thermal Performance	✓	✓
Water Penetration	✓	✓
Sealant Durability	✓	✓

Number of tests required per assembly varies

Includes combinations of Field Mockup Testing and In-Situ Field Testing

Many other optional tests

History

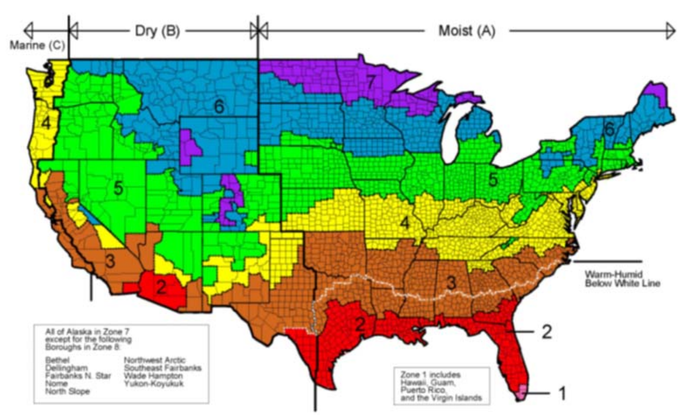
2011/2012:

- Baseline Standards:
  - IBC 2012
  - IECC 2012
  - ANSI/ASHRAE/IES 90.1 – 2010
- Enhancement Standards:
  - IGCC Version 2.0 – 2012
  - LEED 2012 – Public Version 2
  - ASHRAE 189.1 – Public Review

Vapor

Per IBC 2012

- Class I or II vapor retarders provided on interior side of frame wall in Zones 5-8 and Marine 4
- Class III permitted conditionally

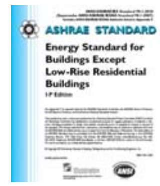


History

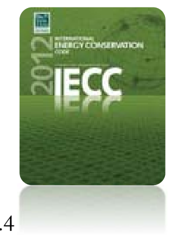
2 OPTIONS:

IBC 2012

IECC 2012



1. ASNI/ASHRAE/IESNA 90.1



2. C402.4

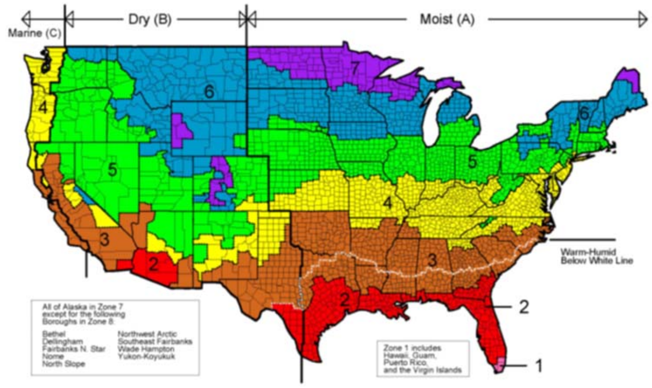
History

	IECC	ASHRAE
Continuous AB	✓	✓
Continuous AB in Zones 1-3 (Southern States)		✓
Continuous AB in Semi-heated spaces	✓	
Construction Document Requirements		✓
Materials: air permeability ≤0.004 cfm/ft^2	✓	✓
Assemblies: air permeability ≤0.04 cfm/ft^2	✓	✓
Whole Building: air permeability ≤0.4 cfm/ft^2	✓	
Joints/seams resist negative/positive pressure	✓	✓
Joints, seams, transitions, and penetrations sealed	✓	✓
Fenestration Air Leakage Requirements	✓	✓
Door Air Leakage Requirements	✓	✓
Vestibule Requirements	✓	✓

Air Leakage Requirements

Continuous Air Barrier shall be provided

- IECC: except Zones 1-3
- ASHRAE: except semi-heated spaces in Zones 1-6



Fenestration Air Requirements

TABLE C402.4.3
MAXIMUM AIR INFILTRATION RATE FOR FENESTRATION ASSEMBLIES

FENESTRATION ASSEMBLY	MAXIMUM RATE (CFM/FT²)	TEST PROCEDURE
Windows	0.20[a]	AAMA/WDMA/ CSA101/I.S.2/A440 or NFRC 400
Sliding doors	0.20[a]	
Swinging doors	0.20[a]	
Skylights – with condensation weepage openings	0.30	
Skylights – all other	0.20[a]	
Curtain walls	0.06	NFRC 400 or ASTM E 283 at 1.57 psf (75 Pa)
Storefront glazing	0.06	
Commercial glazed swinging entrance doors	1.00	
Revolving doors	1.00	
Garage doors	0.40	ANSI/DASMA 105, NFRC 400, or ASTM E 283 at 1.57 psf (75 Pa)
Rolling doors	1.00	

For SI: 1 cubic foot per minute = 0.47L/s, 1 square foot = 0.093 m².

a. The maximum rate for windows, sliding and swinging doors, and skylights is permitted to be 0.3 cfm per square foot of fenestration or door area when tested in accordance with AAMA/WDMA/CSA101/I.S.2/A440 at 6.24 psf (300 Pa).

IECC

2012

What is an Air Barrier?

What is an Air Barrier?

- Materials with air permeability ≤0.004 cfm/ft^2
- Compliant Materials
  - Plywood ≥ 3/8 in. thick
  - Oriented Strand Board ≥ 3/8 in. thick
  - Extruded Insulation Board ≥ 1/2 in. thick
  - Foil-back Insulation Board ≥ 1/2 in. thick
  - Closed-cell spray foam (min. density of 1.5 pcf and thickness ≥ 1-1/2 in.)
  - Open-cell spray foam with density 0.4-1.5 pcf and thickness ≥ 4-1/2 in.
  - Exterior or interior gypsum board ≥ 1/2 in.
  - Cement board ≥ 1/2 in.
  - Built-up roofing membrane
  - Mod-bit roofing membrane
  - Fully-adhered single-ply roofing membrane
  - Portland cement/sand parge or gypsum plaster ≥ 3/8 in. thick
  - Cast-in-place or precast concrete
  - Fully grouted concrete block masonry
  - Sheet steel or aluminum

Not All Air Barriers are Equal

Stucco: Air Vs. Flashing Requirements

Considered air barrier per C402.4.1.2.2

Must be flashed per 1405.4 IBC 2012

Weeps in assembly compromise air performance of assembly

Determining Air Infiltration

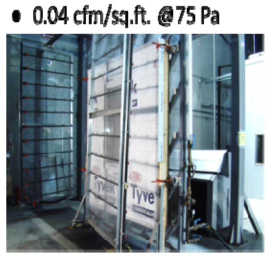
Materials

- **ASTM E2178**
- 0.004 cfm/sq.ft. @75 Pa

Testing *air barrier materials* is <u>necessary</u> but <u>not sufficient.</u>

Assemblies

- **ASTM E2357**
- 0.04 cfm/sq.ft. @75 Pa



Testing of *air barrier assemblies* is an essential step to demonstrate performance of <u>installed air barriers</u>

Whole Building

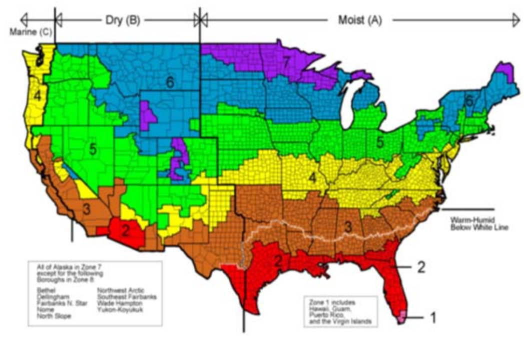
- **ASTM E779**
- 0.25-0.4 cfm/sq.ft.@75 Pa

Testing *whole building* at the end of the project may be <u>too late</u> and/or <u>too expensive to fix mistakes</u>

Vapor Control Layer

Vapor Retarders per IBC 2012:

- Class I or II vapor retarders provided on interior side of frame wall in Zones 5-8 and Marine 4
- Class III permitted conditionally



Exceptions:

1. Basement walls.
2. Below-grade portion of any wall.
3. Construction where moisture or its freezing will not damage the materials.

Applicable Standards

ASHRAE Guideline 0-2005

ASHRAE GUIDELINE

The Commissioning Process

ASTM INTERNATIONAL

E2813 – Standard Practice for Building Enclosure Commissioning

National Institute of BUILDING SCIENCES

NIBS Guideline 3-2012

Building Enclosure Commissioning Process BECx

This Guideline is for Use with ASHRAE Guideline 0-2005: The Commissioning Process

NEBB

Applicable Standards

ANSI
American National Standards Institute

INTERNATIONAL

NFRC
National Fenestration Rating Council®

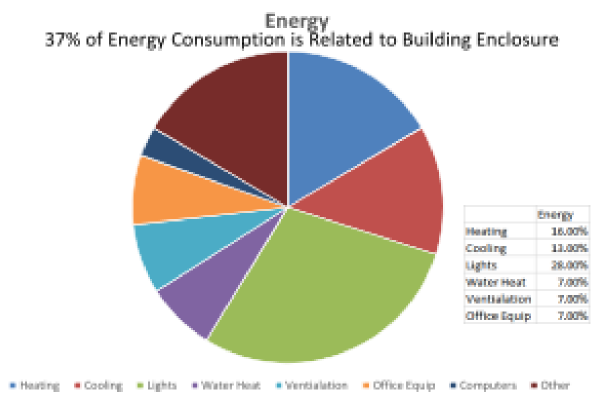
American Architectural Manufacturers Association
AAMA

ASCE®
American Society of Civil Engineers

CGSB ONGC
Canadian General Standards Board

Sustainability Programs

- LEED NC 2009
- LEED V4



LEED NC 2009

- Fundamental
- Includes Building Enclosure for OPR and BOD
- Enhanced
- Intent to begin Cx process early and include extra activities after system verification is complete.
- Design Innovation – BECx can achieve 1 point

LEED V.4

Commissioning of the thermal envelope addressing energy, water, indoor environmental quality and durability.

Energy and Atmosphere (EA):

Fundamental

- Who = Qualified member of design or construction team, not associated with the project.

Enhanced

- Who = An independent CxA
- BECx worth 2 points

LEED V4

Calls for compliance with the following standards:

ASHRAE Guideline 0-2005, 1.1 and
National Institute of Building Sciences Guideline 3-2012

These detail the roles, responsibilities and processes required as part of enclosure commissioning… but what about testing?

LEED Version 4

Fundamental Commissioning and Verification

- Inclusion in the owner's project requirements (OPR) and basis of design (BOD).
- Review of the OPR, BOD and project design.

Enhanced Commissioning Option 2

- Review contractor submittals
- Verify inclusion of systems manual requirements in CD
- Verify inclusion of operator and occupant training requirements in CD
- Verify systems manual updates and delivery
- Verify operator and occupant training delivery and effectiveness
- Verify seasonal testing
- Review building operations 10 months after substantial completion
- Develop and on-going commissioning plan.

Program Outline

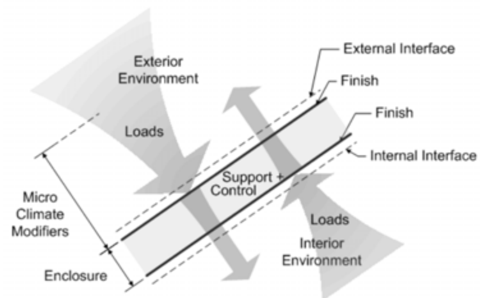
Quality Drivers

Codes / Building Science

- Code Review
- Building Science 101

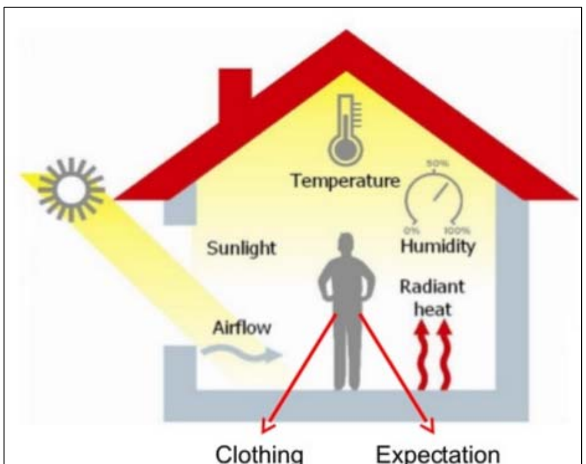
State of the Practice

Tomorrow's Trends



Occupant Comfort

- Acoustic
- Visual
- Thermal
- Physical
- Psychological
- Air Quality



Source: http://www.passive-house.co.uk/

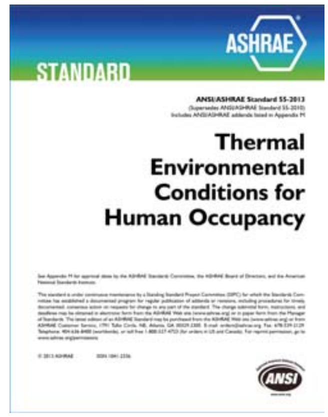
Occupant Comfort

ASHRAE 55 Defines "Comfort"

- ASHRAE 55 takes into account 10 factors to determine thermal comfort.
- Looking for an 80% approval rating
- Relative humidity between 30% and 60%
- Dry bulb temp between 19.4°C and 27.8°F

Typical Residential Environments

- 22 °C @ 30% RH
- Tdew = 4.4 °C



Interior and Exterior Loads

Causal phenomenon or loading	Specific loadings	Interior	Support	Control	Exterior
Essentially structural	Gravity – Dead (assembly, etc.)		●		
	Gravity – Live (people, snow, etc.)		●		
	Wind		●	○	
	Ground Movement (seismic, settlement, etc.)		●		
	Explosion		●		
	Rheological (creep, shrinkage, etc.)		●		○
	Impact (vehicles, missiles, people, etc.)		●		
	Fire		●		
Essentially environmental	Heat (thermal, etc.)		○	●	
	Air (pressure, movement, leakage, etc.)		○	●	
	Moisture (built-in, precipitation, etc)		○	●	○
	Smoke			●	
	Solar radiation (incident, reflected, etc.)			●	○
	Chemical attack/atmospheric (acid rain, etc.)			●	○
	Particulate matter (dust, VOC's, etc.)			●	
Essentially perceptual	People (wear & tear, etc.)	○		●	
	Insects, birds, animals, (termites, rodents, etc.)			●	
	Light (natural, incandescent, fluorescent, etc.)			●	
	Sound	○		●	○
	Visual – local	•			•
	Visual – contextual	•			•

Category of functions: Interior, Support, Control, Exterior

Primary significance ●

Secondary significance ○

Tertiary significance •

Source: Building Science Corporation

Interior and Exterior Loads

Causal phenomenon or loading	Specific loadings	Interior	Support	Control	Exterior
		Category of functions			
Essentially structural	Gravity – Dead (assembly, etc.)		●		
Essentially structural	Gravity – Live (people, snow, etc.)		●		
Essentially structural	Wind		●	○	
Essentially structural	Ground Movement (seismic, settlement, etc.)		●		
Essentially structural	Explosion		●		
Essentially structural	Rheological (creep, shrinkage, etc.)		●		○
Essentially structural	Impact (vehicles, missiles, people, etc.)		●		
Essentially structural	Fire		●		
Essentially environmental	Heat (thermal, etc.)		○	●	
Essentially environmental	Air (pressure, movement, leakage, etc.)		○	●	
Essentially environmental	Moisture (built-in, precipitation, etc)		○	●	○
Essentially environmental	Smoke			●	
Essentially environmental	Solar radiation (incident, reflected, etc.)			●	○
Essentially environmental	Chemical attack/atmospheric (acid rain, etc.)			●	○
Essentially environmental	Particulate matter (dust, VOC's, etc.)			●	
Essentially environmental	People (wear & tear, etc.)	○		●	
Essentially environmental	Insects, birds, animals, (termites, rodents, etc.)			●	
Essentially environmental	Light (natural, incandescent, fluorescent, etc.)			●	
Essentially perceptual	Sound	○		●	○
Essentially perceptual	Visual – local	•			•
Essentially perceptual	Visual – contextual	•			•

Primary significance ●

Secondary significance ○

Tertiary significance •

Source: Building Science Corporation

Interior and Exterior Loads

Heat

HOT → COLD

Air

HIGH PRESSURE → LOW PRESSURE

Moisture

PATH OF LEAST RESISTANCE

Vapour

HIGH PRESSURE → LOW PRESSURE

Interior and Exterior Loads

Heat

HOT → COLD

Air

HIGH PRESSURE → LOW PRESSURE

Moisture

PATH OF LEAST RESISTANCE

Vapour

HIGH PRESSURE → LOW PRESSURE

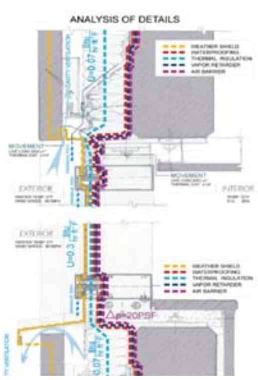
CONTROL

Control Layers

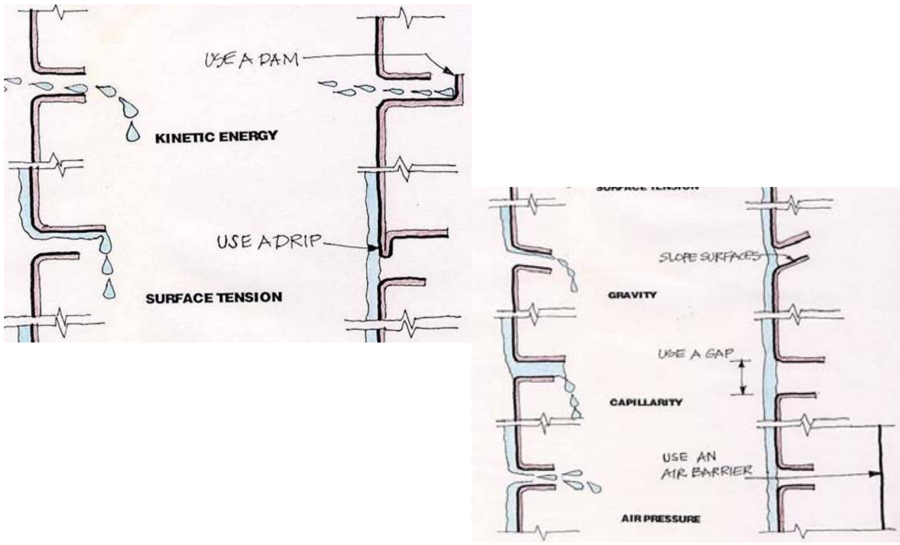
Building enclosures are designed to control multiple loadings.

Control layers include:

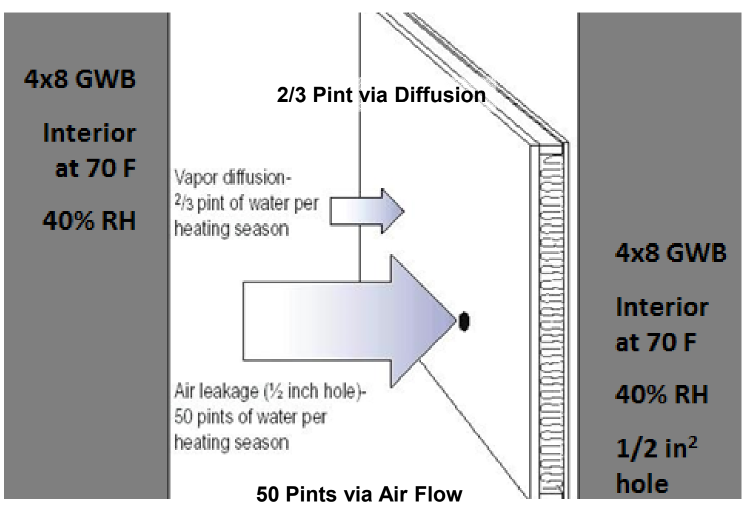
1. Water control layer
2. Air control layer
3. Vapor control layer
4. Thermal control layer

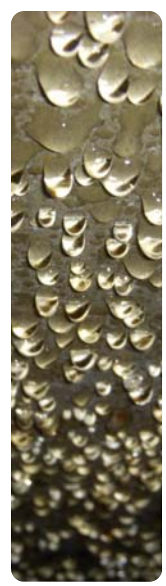


Modes of Bulk Water Transport



Moisture Transport





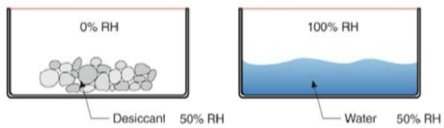
Vapor Retarder Class (IBC)

VAPOR RETARDER CLASS. A measure of a material or assembly's ability to limit the amount of moisture that passes through that material or assembly. Vapor retarder class shall be defined using the desiccant method of ASTM E 96 as follows:

Class I: 0.1 perm or less.

Class II: 0.1 < perm ≤ 1.0 perm.

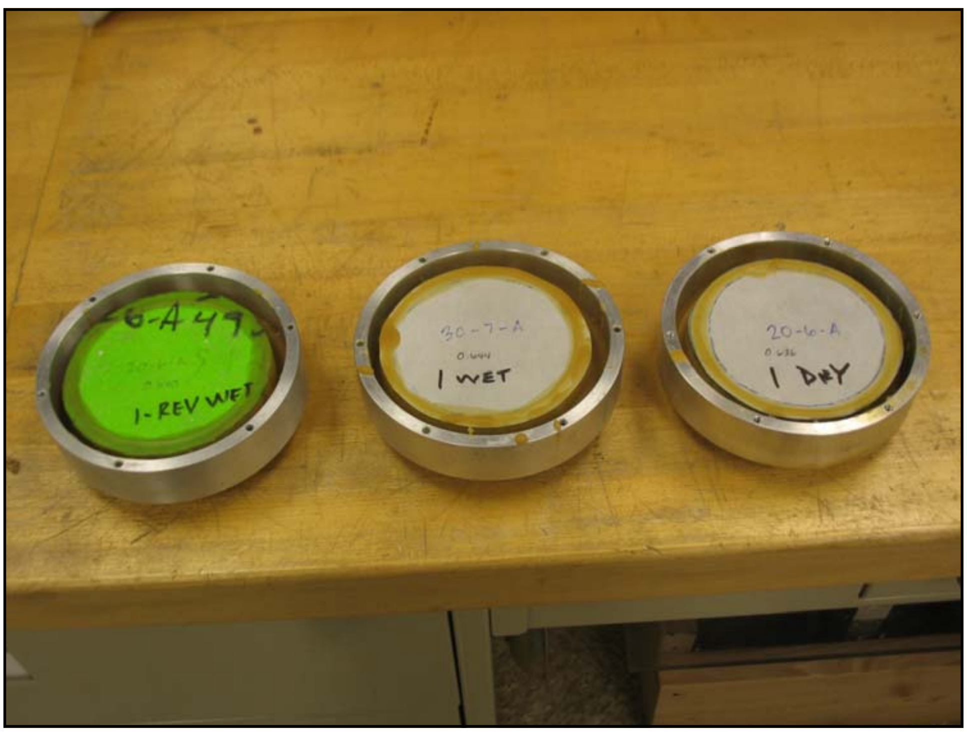
Class III: 1.0 < perm ≤ 10 perm.



ASTM E96

Wet Cup

Dry Cup



Air/Vapour Barriers

Vapour Permeable: >10 Perms

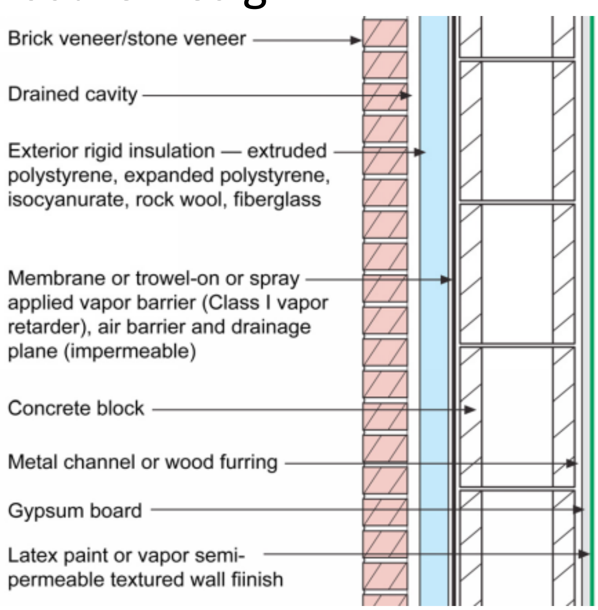
- The higher the perms, the higher the vapour permeance and the higher the diffusion.

Vapour Retarders: < 10 Perms

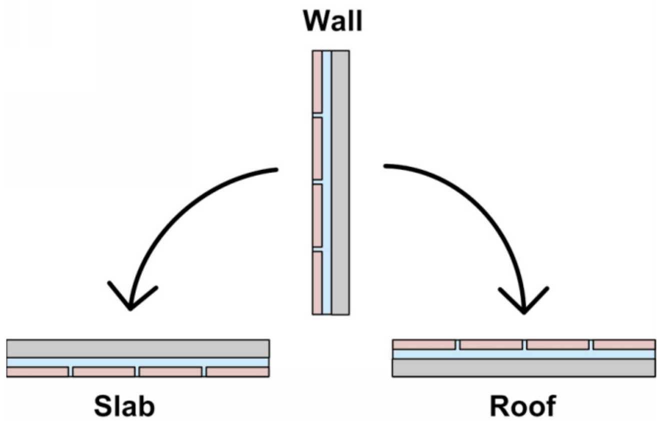
- Class I: 0.1 Perms or less
- Class II: 0.1 < Perms < 1.0
- Class III: 1.0 < Perms < 10

Possible Unintended Vapour Barrier

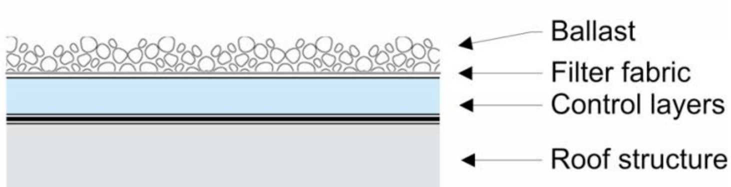
Enclosure Design



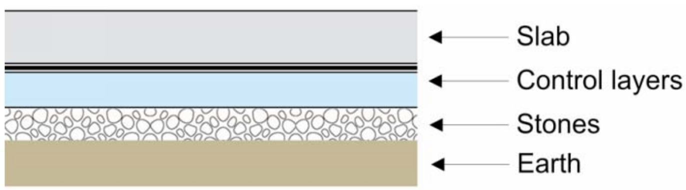
Enclosure Design



Enclosure Design



Enclosure Design



Enclosure Design

DATE: 2-D
FILE: P:\ sc
PROJECT: SU
SUBJECT: W
LOCATION: Ce
WALL: W

Inside Temperature (T_{inside}):	72	°F
Outside Temperature ($T_{outside}$):	0	°F
Relative Humidity (Φ):	38	%
Total Wall R-Value (R_{tot}) =	23.869	h-ft²-°F/Btu
Total Wall U-Value (U_{tot}) =	0.04	Btu/h-ft²-°F
Heat Flow (Q) =	3.02	Btu/h-ft²
Dew Point Temperature (T_{dp}) =	44.99	°F

Wall Sections

Description	R-Value	T_o (°F)	T_i (°F)	Φ_{max} (%)
Outside Air Film	0.17	0.0	0.5	5.8
1/2" UHPC panel	0.104	0.5	0.8	5.9
Air Space	1.2	0.8	4.4	7.0
2" mineral wool insulated sheathing	7.875	4.4	28.2	19.6
Vapor Barrier	0	0.8	28.2	19.6
7/16" OSB	0.62	28.2	30.1	[illegible]
10" mtl studs w/2" cell spray-on	12.66	30.1	68.3	88.0
5/8" gyp board	0.56	68.3	69.9	93.3
Inside Air Film	0.68	69.9	72.0	100.0

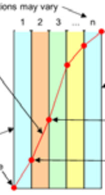
Notes

1. Φ_{max} is the relative humidity at which condensation may occur on the inside surface of the wall section.
2. The Φ_{max} value appears red if it is lower than the room humidity and there is no "Vapor Barrier" between the section inside surface and the inside of the room. This indicates there may be condensation in the wall on that surface.

Cell Color Legend

Information that must be input by the user.
Typical values that may be changed if needed.
Values that are calculated automatically.

Typical Wall Section



Formulas

$$Q = U_{tot}(T_{inside} - T_{outside}) \qquad U_{tot} = \frac{1}{R_{tot}}$$

$$R_{tot} = \sum R_{section}$$

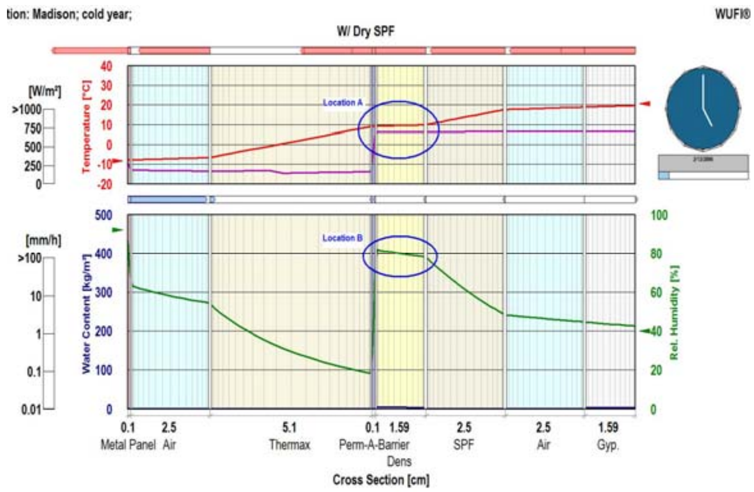
All the temperatures in the following equations are in °C and are converted to/from °F as needed in this spreadsheet.

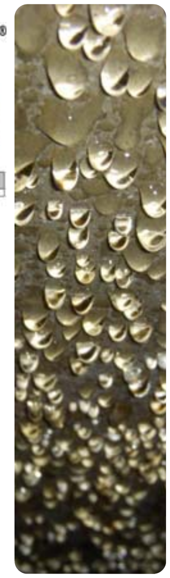
$$T_{dp} = \frac{237.7 \log\left(\frac{P_s \phi}{611}\right)}{7.5 - \log\left(\frac{P_s \phi}{611}\right)} \qquad \phi_{max} = \frac{P}{P_s} 100$$

$$P_s = 6.11 \times 10^{\frac{7.5 T_{inside}}{237.7 + T_{inside}}}$$ Saturated Vapor Pressure

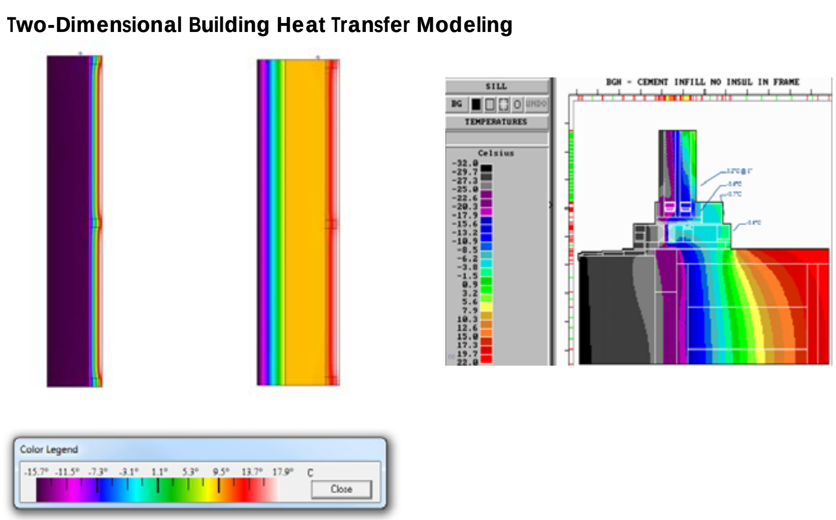
$$P = 6.11 \times 10^{\frac{7.5 T_i}{237.7 + T_i}}$$ Actual Vapor Pressure

Enclosure Design





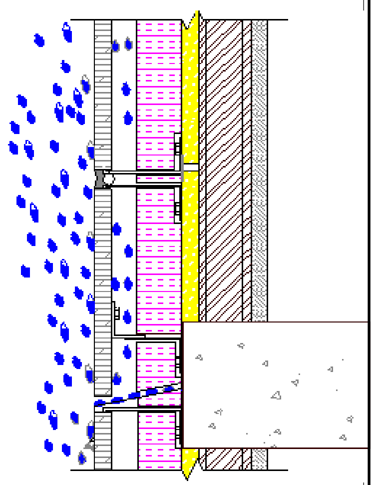
Heat Transfer Simulation



Conceptual Assemblies

Cavity wall

- Masonry
- Metal panels
- Drained EIFS/Stucco



Source: NIBS www.wbdg.org

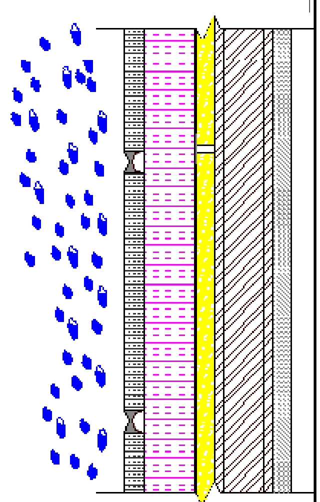
Conceptual Assemblies

Cavity wall

- Masonry
- Metal panels
- Drained EIFS/Stucco

Barrier wall

- Barrier metal wall panels
- Barrier EIFS/Stucco



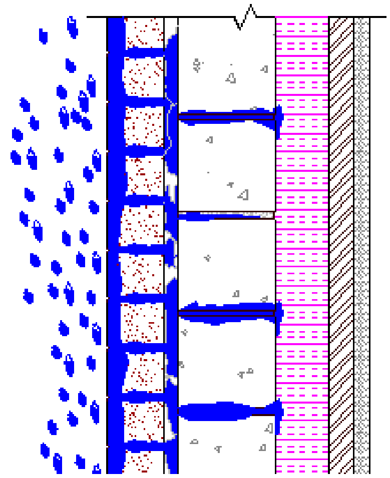
Source: NIBS www.wbdg.org

Conceptual Assemblies

Cavity wall

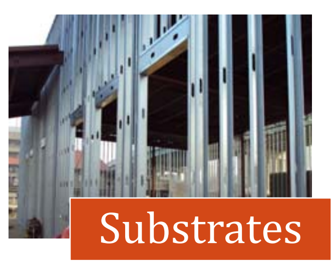
- Masonry
- Metal panels
- Drained EIFS/Stucco

Mass wall



Source: NIBS www.wbdg.org

Common Elements



Sources: NIBS www.wbdg.org; nexusfocus.com; www.greenbuildingadvisor.com; www.wbdg.org; www.huggettbetten.com

Fluid-Applied

- Asphalt
- Acrylic
- STPE
- Silicone

Self-Adhered Sheet

May include:
- Rubberized asphalt
- Cross-laminated HDPE film
- Polypropylene
- Other polymers

Other

- Board
- Spray polyurethane foam
- Insulated metal wall panels

Insulation Types

- Foam plastics
  - Spray polyurethane foam (SPF)
  - Extruded polystyrene (XPS)
    - Open cell
    - Closed cell
  - Expanded polystyrene (EPS)
  - Polyisocyanurate
- Mineral wool
- Fiberglass

Insulation Types

Exterior Wall

Cladding Types:

- Masonry/stone
- Precast concrete
- Panelized metal
- Exterior insulation and finish system (EIFS)
- Stucco/adhered masonry

Source: www.globalstonesupplier.com; img.archiexpo.com; www.masoncontractors.org

Exterior Wall

Attachment:

- "Continuous insulation"
- Thermally improved clips
- Corrosion resistance

Source: construction.com; www.sabmagazine.com

14th Annual Building Enclosure Event

CSI Chicago Chapter

10 Minute Break

Sponsor Tabletops are Open

DuPont™ Tyvek®

distributed by Parksite

ROXUL® The Better Insulation™

Oldcastle BuildingEnvelope®

Program Outline

Quality Drivers

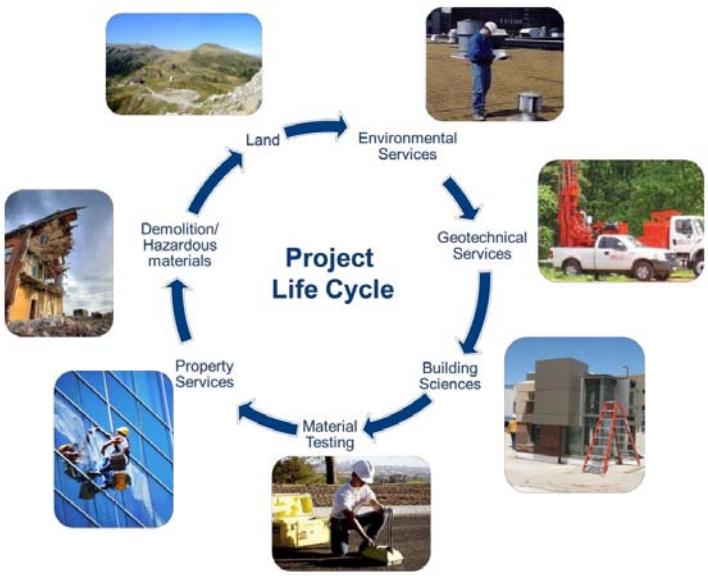
Codes / Building Science

State of the Practice

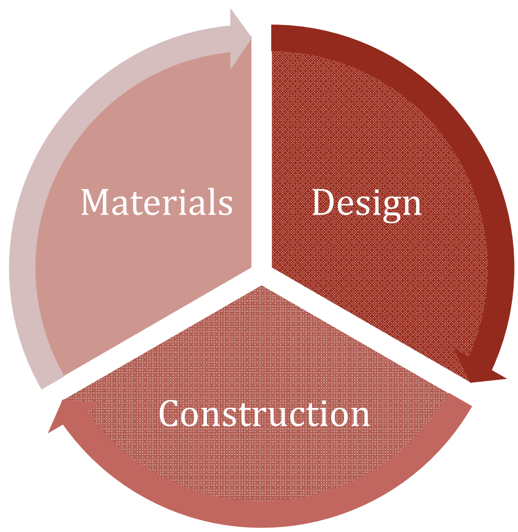
- Materials
- Consulting / Design
- BECx
- Field Testing
- Inspections

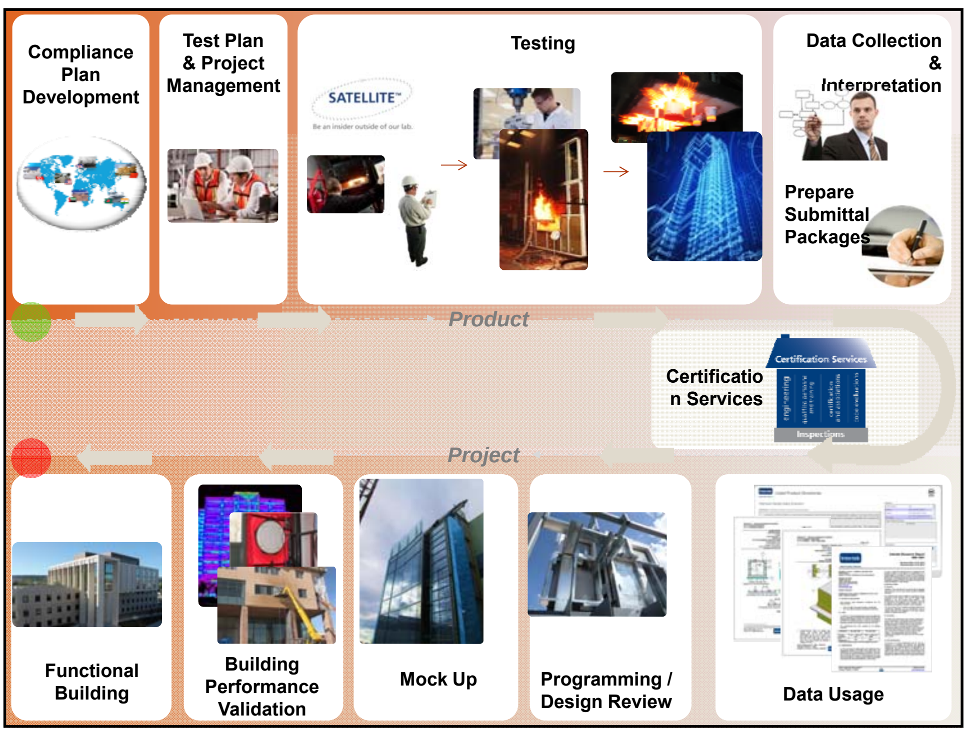
Tomorrow's Trends

Project Life Cycle



Common Forms of QA





Arena Blast Testing

Hail Impact Testing


ASTM F 588
ASTM F 842
AAMA 1304

Forced Entry Resistance

Structural Testing

Program Outline

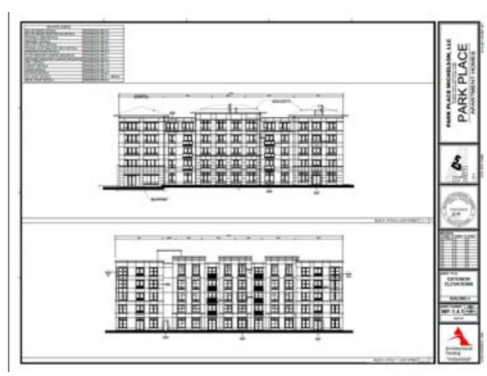
Quality Drivers

Codes / Building Science

State of the Practice

- Materials
- Consulting / Design
- BECx
- Field Testing
- Inspections

Tomorrow's Trends



Code / Special Inspections

Comprehensive Enclosure QA

Field QA Inspection

- Field verification of contract design requirements for building enclosure systems

ATI OBSERVATION LOG

Project Name: Park Place
Weather: Cloudy 70's
Time On-Site: 7:30 AM Off-Site: 1:30 PM
Reported By: Tiffan S. Pattan - ATI
Reported To: Tom Sestak - The Irvine Company

Log No.: 28
Date: 6/5/2013
Hours On-Site: 6
Present: Tiffan S. Pattan - ATI
Art Nava - Courtney Waterproofing
Crew of 3 - Courtney Waterproofing

N/A	Checked	Elevator Pits ***
X		1. Waterproofing sheets installed with 4" laps at edges, end laps staggered minimum 12" per manufacturer's recommendations.
X		2. All laps fastened with staples per manufacturer's recommendations.
X		3. Trowel grade below grade mastic applied around elevator plunger sleeve.
X		4. Water stop applied around elevator plunger cylinder, set in a bead of Cetseal and secured with tie wire.
X		5. Water stop applied around top of perimeter of elevator pit walls below topping slab, roll ends butted tightly together.

Work in Progress
Backfilling at the south perimeter wall.

Item No.	Substrate	Contractor	Observation	Bldg.	Elevation	Floor	Photo No.	Class.
257	Perimeter CMU wall	Courtney Waterproofing	Item 213 of Log 22 was revisited. Core 58 of segment 58 was observed with dirt around the column adjacent to the elevator pit. The dirt was observed removed and the previously installed voltex was observed damaged. The area was observed free and clear of dirt and debris and voltex is to be re-installed. **Notify ATI when repairs are to be conducted so they are able to be inspected prior to backfilling.**	B5-B	East	Below Grade	IMG_2134 IMG_2136 IMG_2139 IMG_2178 IMG_2181	In Progress

Additional Notes
Items marked as N/A on the check list above do not apply at the time of the inspection or are not applicable to the system being installed for this project. For Segment B5-A, a follow up is required.

Comprehensive Enclosure QA

Field QA Inspection

- Electronic Field Reports

Centerpointe 01/14/2015 Log 337

Exterior Doors Flashing		
1. Self-adhered membrane installed at door jambs.	Checked	
2. Door Pan flashings fabricated with a 1/2" vertical dam.	Checked	
3. Door pan flashings installed tightly into rough opening.	N/A	
4. Door threshold substrate slope reviewed prior to pan installation.	N/A	
5. All fasteners flush.	Checked	
6. Door back dams are protected.	Checked	
Windows Flashing		
1. Rough opening clean and framing ready for flexible flashing application.	N/A	
2. All fasteners are flush.	Checked	
3. Self-adhered membrane primer installed.	N/A	
4. Self-adhered membrane shingled where required.	Checked	
5. Self-adhered membrane/flexible flashing laps reviewed.	Checked	
6. Self-adhered membrane paper backing removed where required.	Checked	
Exterior Door Installation		
1. Review flexible flashing at 2-Hour firewall conditions.	N/A	
2. If drywall is required for fire, flexible flashing is to be installed over the drywall.	N/A	
3. If the jamb is metal, J-mold is required along the jambs and a min. of 1/4" between the door trim and J-mold is required to allow for backer rod.	N/A	
4. Head flashing installed over the door jamb/flexible flashing wrapping into opening.	N/A	
5. Door jambs notched around the back jamb.	N/A	
Window Installation		
1. Review sealant type used at flexible flashings.	Checked	
2. Window installed with sealant oozing from the	Checked	

2015-01-14 Centerpointe_Pre Lath, WD Flashing, WD Install, Railings

3

Consulting/Design QA

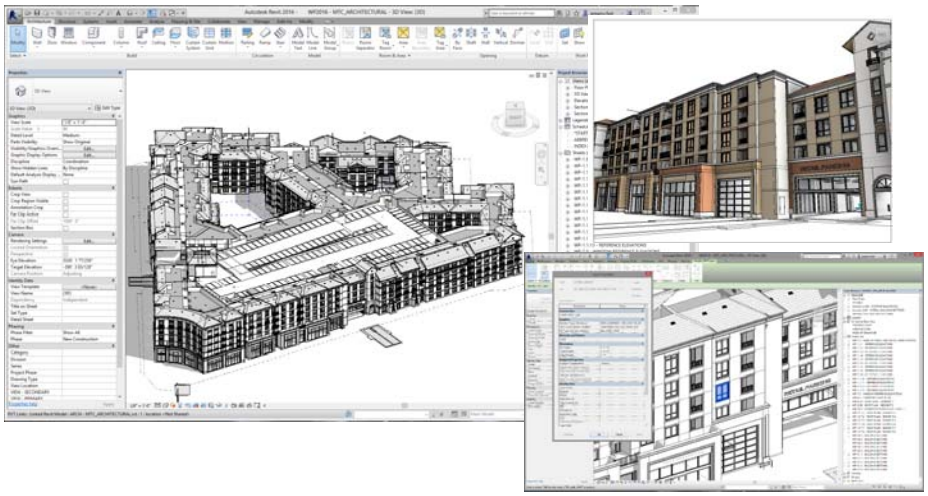
Design
- OPR (Owner's Project Requirements)
- BIM (Revit)
- Standalone building enclosure detail packages

Construction
- Submittal reviews
- Mock-up and pre-construction meetings
- Field inspections
- Field testing

Post-Construction
- Final verifications
- Maintenance training
- Lessons learned for future projects
- 1 year walk

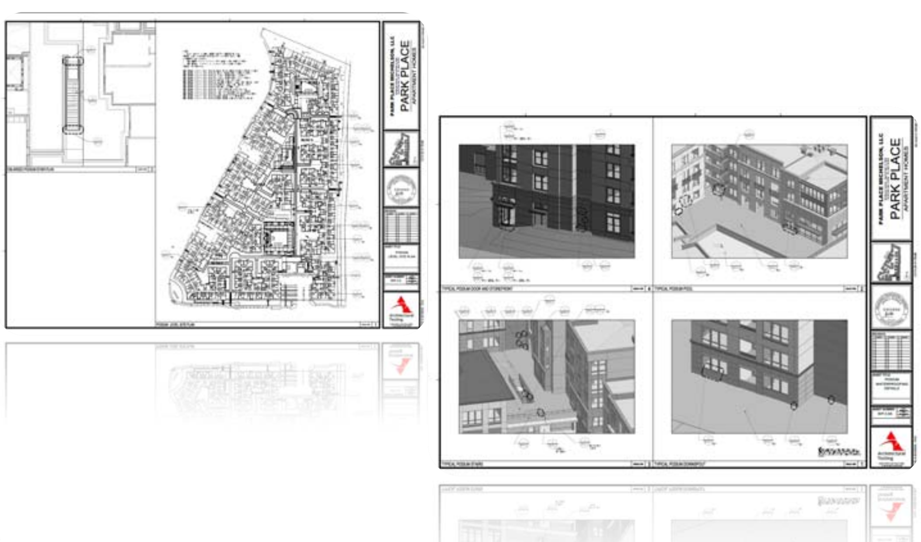
Consulting/Design QA

Revit Model



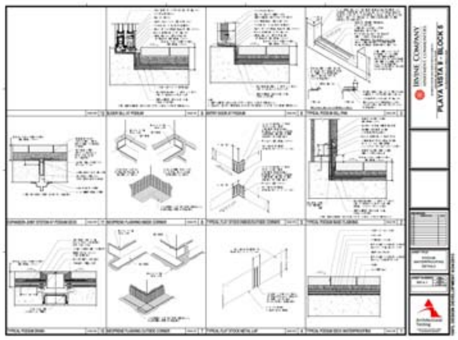
Consulting/Design QA

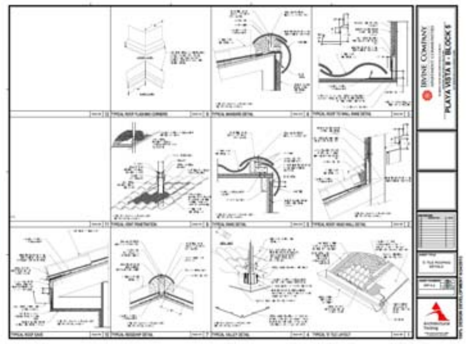
Building Enclosure Details Set



Consulting/Design QA

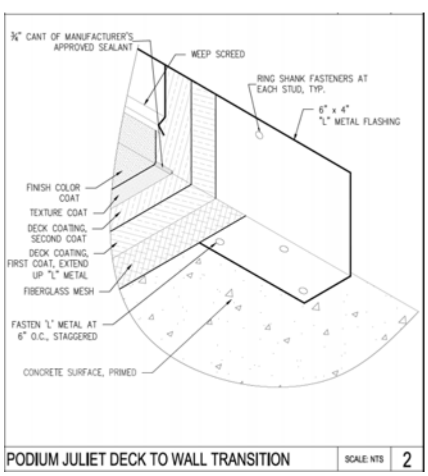
Building Enclosure Details Set

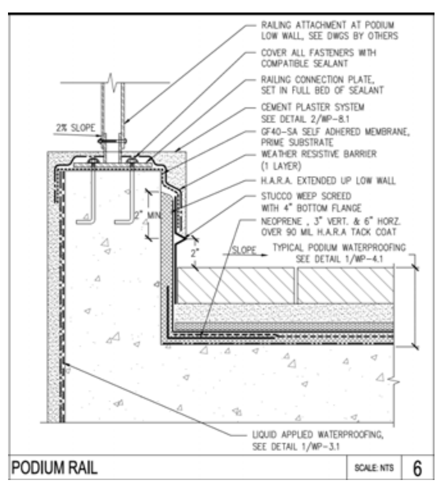




Consulting/Design QA

Building Envelope Details Set





Definition

Process that verifies enclosure performance against the Owner's Project Requirements (OPR) and Basis of Design (BOD)

BECx: -VS-
- Formal Process (start/end)
- Based on performance
- More accountability
- Based on real world cond.

Enclosure Consulting:
- Could be only one task
- Based on reducing liability
- Less accountability
- Based on standards

Program Outline

Quality Drivers

Codes / Building Science

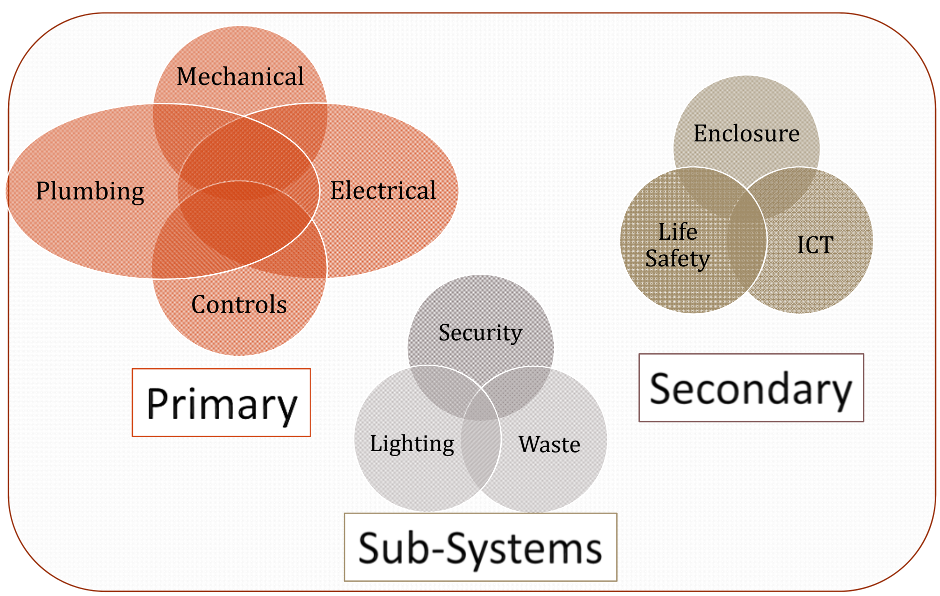
State of the Practice

- Materials
- Consulting / Design
- BECx
- Field Testing
- Inspections

Tomorrow's Trends

Discipline Specific Cx

Whole Building Commissioning



Commissioning Twin Track

Systems to be Cx

- Mechanical
- Electrical
- Plumbing
- Life Safety
- ICT
- Building Enclosure

Performance (OPR)

- Energy

Commissioning Twin Track

Systems to be Cx

- Mechanical
- Electrical
- Plumbing
- Life Safety
- ICT
- Building Enclosure

Performance (OPR)

- Energy
- Acoustical
- Fire
- Air Quality

Commissioning Twin Track

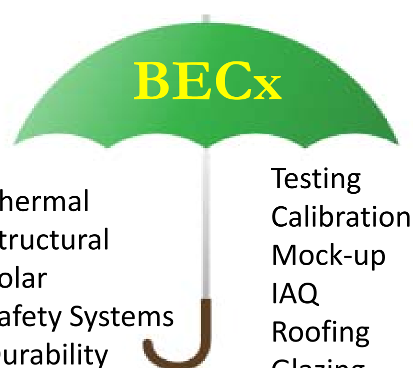
Systems to be Cx

- Mechanical
- Electrical
- Plumbing
- Life Safety
- ICT
- Building Enclosure

Performance (OPR)

- Energy
- Acoustical
- Air Quality

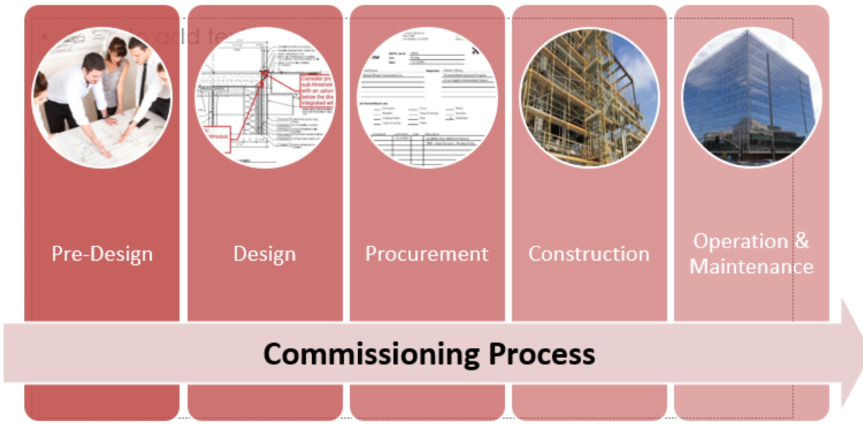
Sub-Discipline Specific Cx



Thermal
Structural
Solar
Safety Systems
Durability
Fire
Acoustics
Blast
Water / Air

Testing
Calibration
Mock-up
IAQ
Roofing
Glazing
Façade
Waterproofing
Material
Properties

BECx Process



Pre-Design

Project Planning Conference
- Introduce BECx process
  - Objectives
  - Tasks and milestones
  - Responsibilities

BECx Plan
- Roles and responsibilities
- Communication protocols
- Format for reporting

Owner's Project Requirements (OPR)
- Establish enclosure performance criteria

Pre-Design/Design Development

OWNER'S PROJECT REQUIREMENTS (OPR)

- Durability/Service Life
- Air Leakage
- Water Leakage
- Thermal Performance
- Fire Resistance
- Acoustic Performance
- Testing Requirements

See NIBS Annex J

BASIS OF DESIGN (BOD)

- Proposed system(s)
- Assemblies and Materials
- Illustrate Compliance with OPR

See NIBS Annex K

Pre-Design/Design Development

BUILDING ENCLOSURE COMMISSIONING PLAN

- Organization
- Schedule
- Allocation of Resources
- Roles and Responsibilities
- Documentation Requirements

See NIBS Annex G

TABLE OF CONTENTS

Pre-Design/Design Development

Annex F: Roles and Responsibilities Matrix — **NIBS Guideline 3-2006**

Phase & GL-3 Section number	Document	Owner	CxA	Design Team						ExEncl		Contractors					Specialists								Bldg Ops			Notes
		Owner, or Owner's Representative	Commissioning Authority	Architect	Structural Engineer	Mechanical Engineer	Electrical Design Engineer	Lighting Design professional	Interior Systems Design Prof.	Exterior Enclosure Consultant	Ext. Enclosure Manufacturers	Construction Manager	General contractor	Exterior Enclosure Contractors	Testing contractor	Electrical Contractor	Indoor Air Quality Specialist	Acoustic specialist	Vibration specialist	Moisture/mildew specialist	Measurement/verification specialist	Information technology specialist	Physical security specialist	Blast (and Chem-bio) Security	Facilities management	Facilities engineer (O&M)	Occupants	
Pre-Design																												
5.2.2	Owner's Project Requirements	A	R	I	I	I	I	I	I	I		P													I	I	I	Design Team not hired yet?
5.2.3	Allocation	P/A	U	U	U	U	U	U	U			P													I	I		Design Team not hired yet?
5.2.4	Commissioning Plan	A	P	I	I	I	I	I		I															I	I	I	Design Team not hired yet?
5.2.4.4	Issues Log & Report	R	P	U	U	U	U	U		I	U	U	U	U	U	U									I	I		Design Team not hired yet?
5.3.1	Acceptance & Commissioning Process Report	R	P	U	U	U	U	U		U	U	U	U	U	U										U	U		Close of Phase report
Design																												
6.1.1	Owner's Project Requirements (OPR) Update	A	P	I	I	I	I	I		I		I					I			I					I	I	I	
6.1.1.1	OPR - Schematic Design Phase	A	P	I	I	I	I	I		I		I					I	I	I	I	I	I	I	I	I	I	I	
6.1.1.2	OPR - Design Development Phase	A	P	I	I	I	I	I		I		I					I			I					I	I	I	
6.1.1.3	OPR - Construction Document Phase	A	P	I	I	I	I	I		I		I					I			I					I	I	I	
6.2.2	Basis of Design	A	R	P	I	I	I	I		I							I			I					I	I	I	
6.2.2.1	BOD - Schematic Design Phase	A	R	P	I	I	I	I		I							I	I	I	I	I	I	I	I	I	I	I	
6.2.2.2	BOD - Design Development Phase	A	R	P	I	I	I	I		I							I			I					I	I	I	
6.2.2.3	BOD - Construction Document Phase	A	R	P	I	I	I	I		I							I			I					I	I	I	
6.2.3	Commissioning Plan - Update	R	P	U						U	U	U													I	I		
6.2.4	Construction Specifications for Commissioning	R	P	U						I	I	R													I	I		May also be provided by Owner's Rep
6.2.4	Construction Checklists	R	A	R						R	I	R													I	I		Contractor may not be hired yet
6.2.5	Systems Manual Outline -	A	P	I	I	I	I	I		I		R													U	U		Contractor may not be hired yet
6.2.6	Specifications	A	R							I		R						I		I					I	I		
6.2.7	Commissioning -Focused Design Reviews	A	P	U	U	U	U	U		I		U						I		I					I	I	I	
	Issues Log & Report	A	P	U	U	U	U	U		I		U						I		I					I	I		
6.3, 6.4	Acceptance & Commissioning Process Report	A	P	U	U	U	U	U		I		I						I		I					I	I	I	Close of Phase report

Key

- P — Provided by
- A — Approved by
- R — Reviewed by
- R/A — Reviewed/Approved by
- I — Input from
- U — Used by

Construction Documents

Design Review(s)

- At multiple phases: SD, DD, CD
- Review drawings and specifications
- Comment on water, air, thermal, and vapor control
- Review for compliance with OPR (Owner's Project Requirements) and the Basis of Design (BOD)

Construction Documents

- Incorporate BECx requirements into the CDs:
  - Building Enclosure Commissioning (BECx) specification
  - Functional Performance Test (FPT) specification
- Update BECx and FPT specifications each design phase

Other BECx Activities

- Update the OPR
- Update the BECx Plan
- Building enclosure systems maintenance manual

Design Phase

BECx Specification:

SECTION 019115
BUILDING ENCLOSURE COMMISSIONING REQUIREMENTS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. The work under this Section is subject to requirements of the Contract Documents, including the Owner's General Conditions and articles of the Construction Manager's General Conditions.

B. This section includes the commissioning requirements for the Building Enclosure systems. Refer to Section 019117 for Building Enclosure Functional Performance Testing.

1. The commissioning requirements for the Building Enclosure systems given in this section are entirely separate from, and in addition to, the General Commissioning Requirements for this project. The General Contractor (GC), Subcontractors, and Suppliers are required to participate in both commissioning processes as required and any supplemental General Commissioning requirements.

1.02 DESCRIPTION

A. Building Enclosure Commissioning (BECx) is a systematic process of ensuring all building enclosure systems responsible for environmental separation perform interactively according

Design Phase

FPT Specification:

SECTION 019117
BUILDING ENCLOSURE FUNCTIONAL PERFORMANCE TESTING REQUIREMENTS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. This section includes the functional performance testing requirements for the Building Enclosure systems. Refer to Section 019115 for Building Enclosure Commissioning Requirements

1.02 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section. Divisions 03, 04, 07, 08 and 09 Specification Sections also apply to this section. Where conflicts arise regarding building enclosure testing, this Section shall supersede other Sections where contradictions occur.

1.03 TESTING AGENCY

A. The Owner will retain a Building Enclosure Testing Agent (BETA), which may be the same entity as the Building Enclosure Commissioning Agent (BECA). In such cases, the BECA

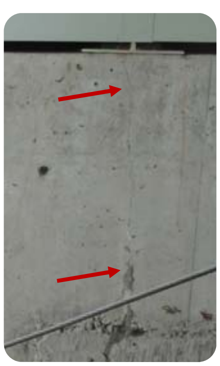
Functional Performance Testing

Procedure for a Failed Test:

- Determine cause of failure
  - Isolated issue
  - Systemic problem
- Remediation
- Re-test failed specimen
- Additional testing of similar systems

Functional Performance Testing

Typical Failures:



Concrete cracks

Z-girt fasteners

Brick ties

Functional Performance Testing

Typical Failures:

Curtain wall gaskets

Perimeter seal

Functional Performance Testing

Typical Failures:

Stem wall connection

Mullion intersection

Functional Performance Testing

Typical Failures:

Unsealed holes

Roof-to-wall interface

Design Phase: FPT Specification

Fenestration Systems Performance

Air	Water
ASTM E 1186 (4.2.7) – No major air leaks. A major leak is defined as air and smoke are visible and easily detectable by hand within one inch of the leak location(s)	AAMA 501.1/ ASTM E 1105 - No uncontrolled water leakage when tested under a pressure difference equivalent to the greater of 20% of the maximum positive pressure in zone 5 of the ASCE 07 wind load calculations or 20% of the positive wind tunnel recorded pressure but not less than 6.24 psf
ASTM E 783 – Maximum air leakage of 0.09 cfm/ft at an air pressure differential of 6.24 psf	

Functional Performance Testing

Performance Requirements:

Water Leakage Definition

- Requirements are different than ASTM E1105 or AAMA 501.1

Water leakage is only acceptable if ALL of the following conditions are satisfied:

- Water is contained and drained to the exterior.
- There is no wetting of a surface that is visible to the building occupants.
- There is no staining or other damage to the completed building or finishes.

Design Phase: FPT Specification

Air Barrier Performance

Air	Water
ASTM E 1186 (4.2.6) – Pass/fail criteria shall be no bubbles observed in the leak detection liquid.	AAMA 501.1/ ASTM E 1105 - No uncontrolled water leakage when tested under a pressure as defined in fenestrations above, but not less than 6.24 psf.
ASTM E 783 – Maximum air leakage of 0.04 cfm/ft at an air pressure differential of 1.57 psf	
ASTM E 1186 (4.2.7) – No major air leaks. A major leak is defined as air and smoke are visible and easily detectable by hand within one inch of the leak location(s)	

Design Phase: FPT Specification

Roofing System Performance

Air	Water
ASTM E 1186 (4.2.6) – Pass/fail criteria shall be no bubbles observed in the leak detection liquid.	ASTM D5957 – No leaks through membrane/roof deck after 48 hours of 2.5” ponded water or. Electronic Leak Detection (ELD) may be provided in lieu of flood testing in the field and details of the membrane; supplemental flood testing may be required at drain bodies and other penetrations that are difficult to test with ELD.

Functional Performance Testing

Performance Requirements

- Building Enclosure Functional Performance Testing Specification Section
- This Section shall supersede other Sections where contradictions occur

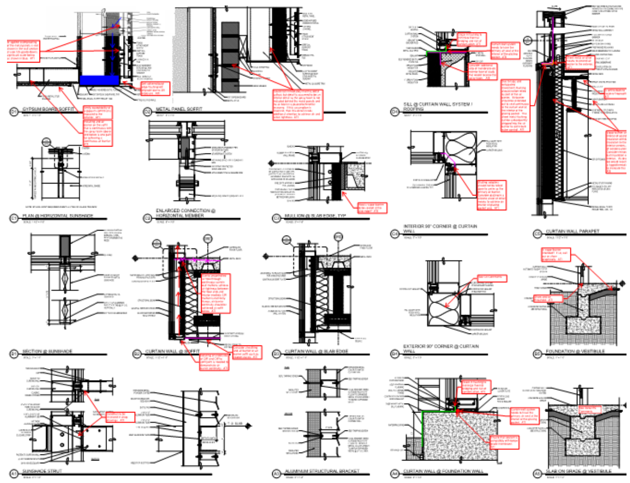
Component	Performance Criteria	
	Air	Water
Curtain Wall/ Fenestrations/ Skylights	ASTM E 1186 (4.2.7) – No major air leaks. A major leak is defined as air and smoke are visible and easily detectable by hand within one inch of the leak location(s)	AAMA 501.1/ ASTM E 1105 - No uncontrolled water leakage when tested under a pressure difference of 8.0 lbf/sq. ft
	ASTM E 783 – Maximum air leakage of .09 cfm/ft at an air pressure differential of 6.24 psf	
Air Barrier Assemblies	ASTM E 1186 (4.2.6) – Pass/fail criteria shall be no bubbles observed in the leak detection liquid.	AAMA 501.1/ ASTM E 1105 - No uncontrolled water leakage when tested under a pressure difference of 8.0 lbf/sq. ft
	ASTM E 783 – Maximum air leakage of .04 cfm/ft at an air pressure differential of 1.57 psf	
	ASTM E 1186 (4.2.7) – No major air leaks. A major leak is defined as air and smoke are visible and easily detectable by hand within one inch of the leak location(s)	
Roofing Systems	ASTM E 1186 (4.2.6) – Pass/fail criteria shall be no bubbles observed in the leak detection liquid.	ASTM D5957 – No leaks through membrane/roof deck after 48 hours of 2.5" ponded water.

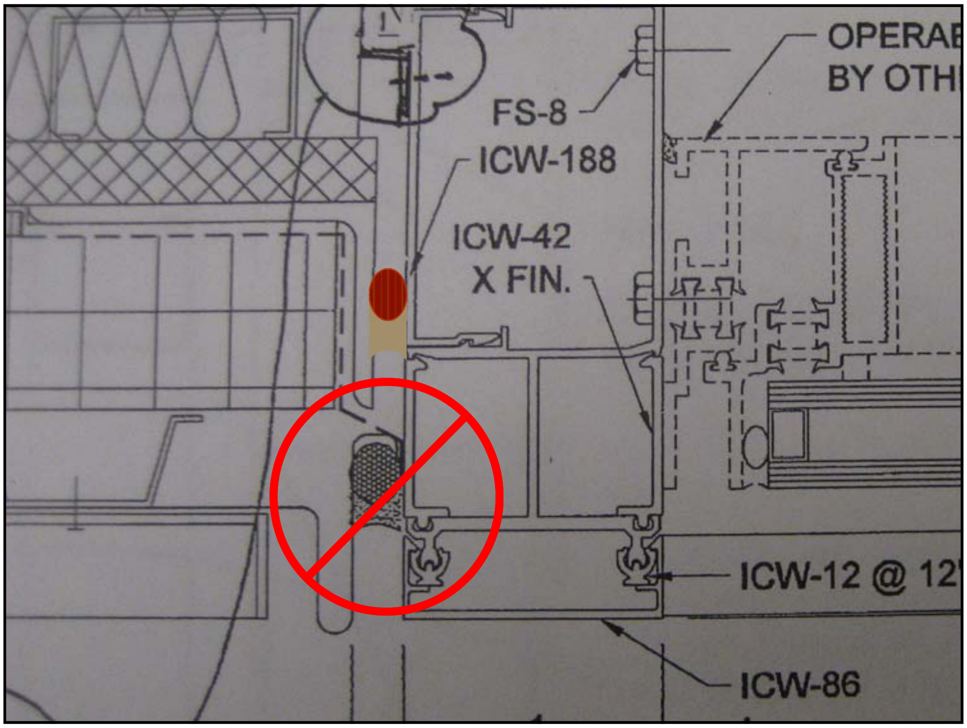
C. Water leakage is only acceptable if ALL of the following conditions are satisfied:

1. Water is contained and drained to the exterior.
2. There is no wetting of a surface that is visible to the building occupants.
3. There is would be no staining or other damage to the completed building or finishes.

Design Phase

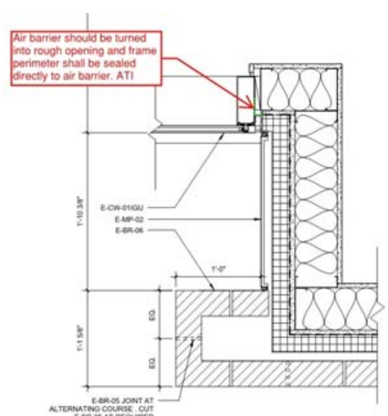
Design Reviews:

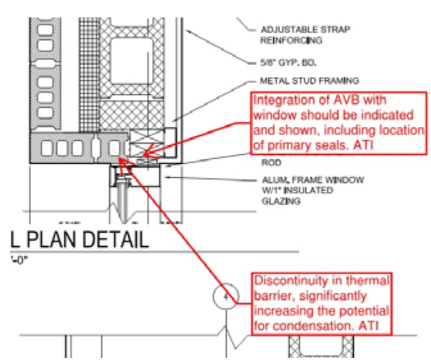




Design Phase

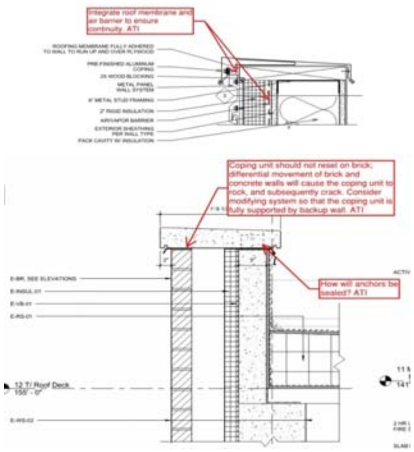
Design Review Examples:

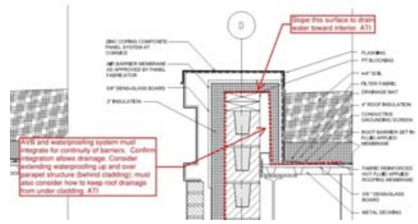




Design Phase

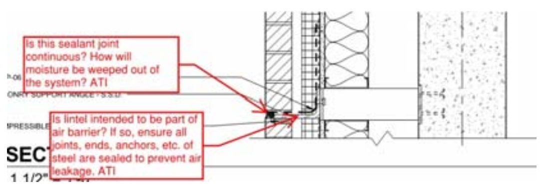
Design Review Examples:

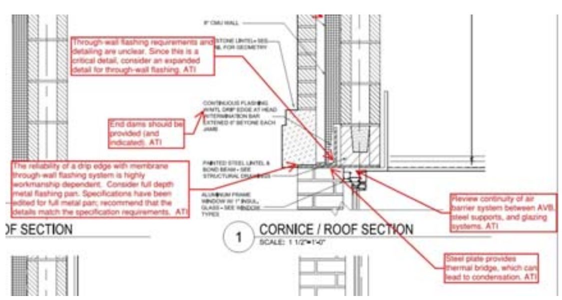




Design Phase

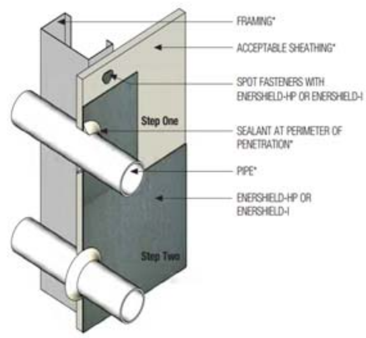
Design Review Examples:



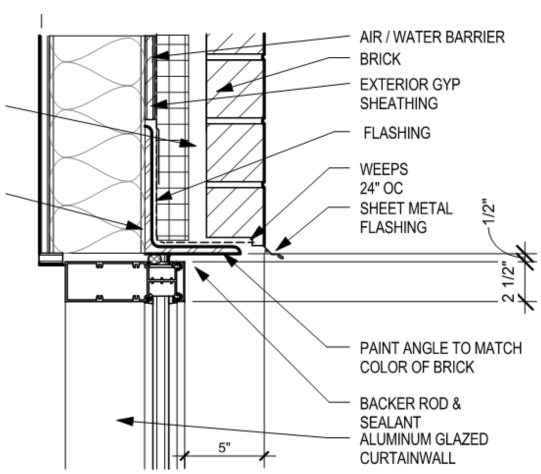


Typical Interface Concerns

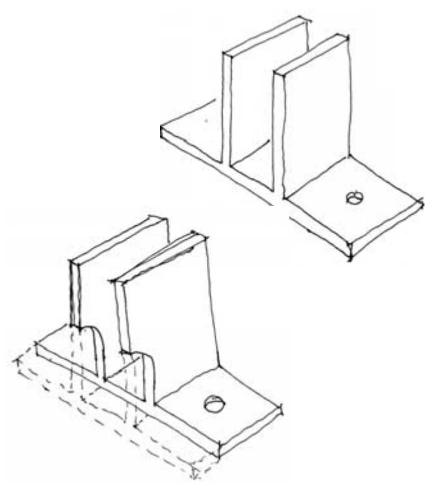
Penetrations:



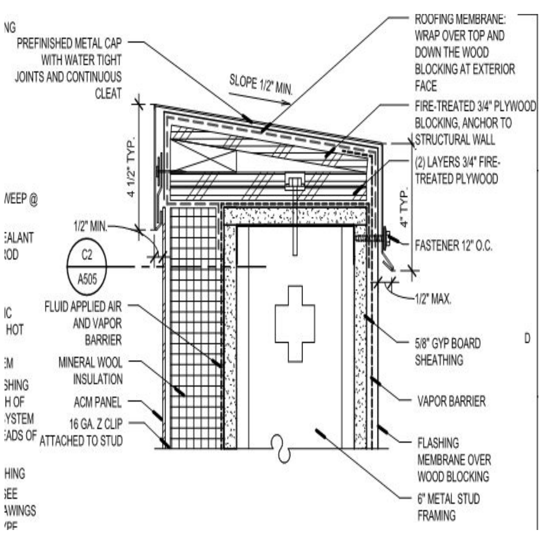
Head Detail



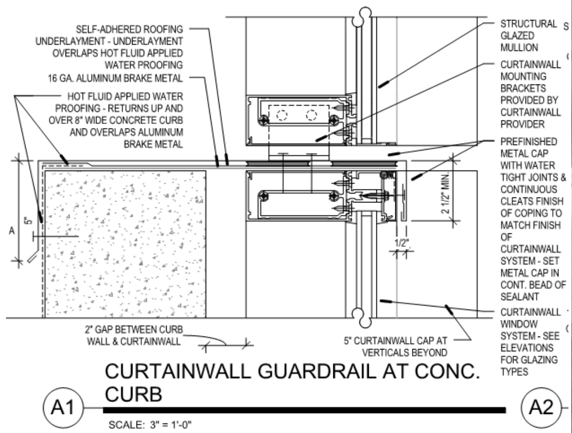
Typical Interface Concerns



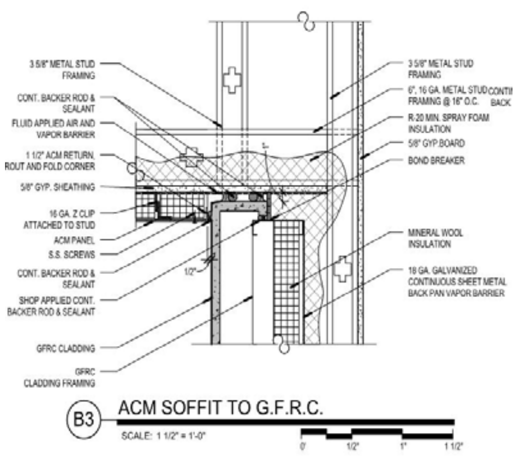
Parapet Cap



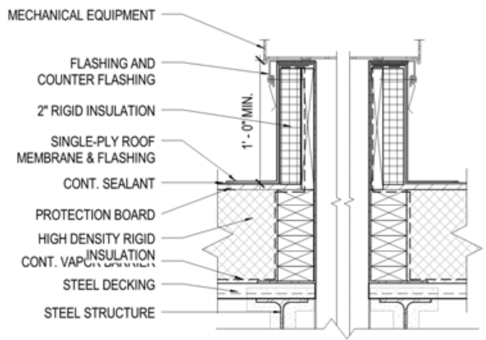
Extended Curtain Wall



Soffits



Mechanical Equipment

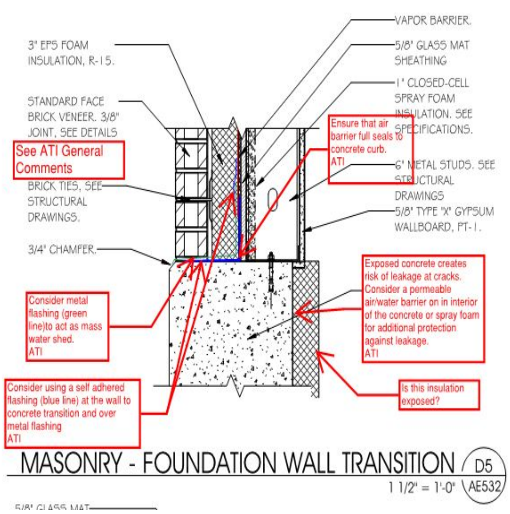


Wall to Wall

Typical Interface Concerns

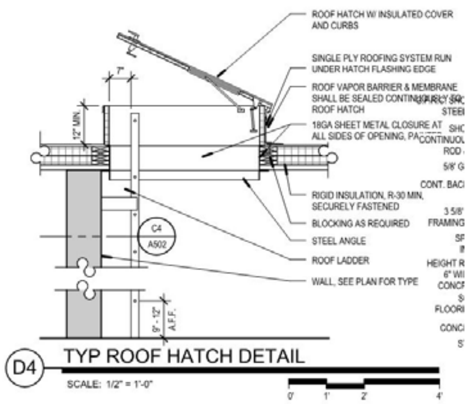
Penetrations:

Wall to Foundation



Typical Interface Concerns

Special Condition:



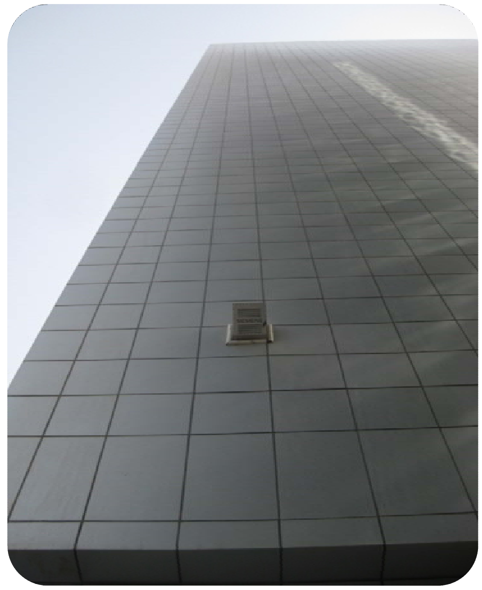
Successful Design

- Achieve environment separation
- Meet durability/sustainability
- Fulfills desired use
- Simple
- Redundant
- Constructible

How Important are Aesthetics?

Successful Design

- Achieve environment separation
- Meet durability/sustainability
- Fulfills desired use
- Simple
- Redundant
- Constructible



Successful Design

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Successful Design

- Achieve environment separation
- Meet durability/sustainability
- Fulfills desired use
- Simple
- Redundant
- Constructible

Pre-Construction Phase

Meetings
- BECx kickoff meeting
- Preconstruction meetings

Review for Compliance with the OPR and Contract Documents
- Submittals
- RFI, ASI, CCD
- Change Order
- Substitution Request
- Value Engineering

Mockup
- Construction
- Observation
- Testing

Pre-Construction Phase

Pre-Construction Trade Orientation Meeting

- Review the BECx process and purpose
- Review plans and specifications
- Review of shop drawings
- Construction schedule and sequencing
- Material selections and compatibility
- Field observation report process
- Functional performance testing

Pre-Construction Phase

Value of Mock-ups:

- Verify the performance of the systems
- Set construction standards
- Establish sequencing of work
- Verify material selection


ASTM E283

Pre-Construction Phase

Mock-ups should include:

- Complete waterproofing system
- Interface of wall to roof condition
- Typical wall and roof penetrations
- A sample of cladding anchorage
- Typical fenestration assemblies
- Constructed to be air tight to facilitate testing

Pre-Construction Phase

Types of Mock-ups:

- Freestanding fully enclosed
- Freestanding partially enclosed
- In-situ

Pre-Construction Phase

Mock-up Testing:

Who should witness?

- Contractor
- Air barrier subcontractor
- Glazing subcontractor
- Roofing subcontractor

Pre-Construction Phase

Mock-up Testing:

When failures occur

- Contractor to investigate cause(s) and propose solutions
- A/E and BECxA review and comment on approach
- Repair or remedial work documented by BECxA

Pre-Construction Phase

Other Pre-Construction Items:

- RFI, ASI, PR
- Change order
- Substitution request
- Value engineering

Construction

Field Observations
- Quality assurance tool
- Verifying compliance with:
  - Contract documents
  - Submittals and shop drawings
  - Product installation instructions
  - Industry standards

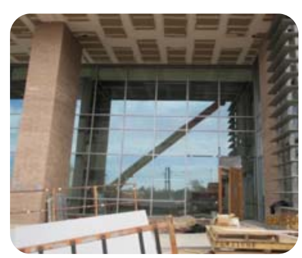
Functional Performance Verification
- Verify the performance of the systems (including interfaces)
- Verify installation methods
- Avoid late stage (expensive) problems with early detection.

Other BECx Activities
- BECx meetings to review building enclosure schedule, testing, and Issues
- Update OPR and BECx plan
- Review contractor checklists
- Construction phase BECx report

Functional Performance Testing

Typical Testing:
- Standalone Mock-up Testing
- In-Situ (First Installation) Testing
- Continuing Quality Assurance Testing





Program Outline

Quality Drivers

Codes / Building Science

State of the Practice

- Materials
- Consulting / Design
- BECx
- Field Testing
- Inspections

Tomorrow's Trends

Functional Performance Testing

Common Challenges:

Site

- Capable water source
- Clear access to test location
- Loose building materials/debris
- Lift and operator
- Site work (landscaping/concrete)
- Weather

Functional Performance Testing

Common Challenges:

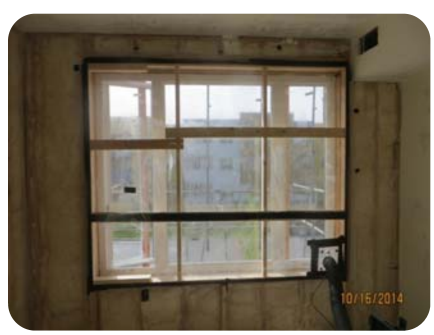
Installation

- Uncured sealant
- Incomplete systems
- Temporary systems
- Rain screens/sunshades
- Interior seals
- Interior insulation/gypsum

Functional Performance Testing

ASTM E783

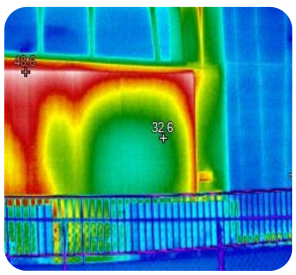
- Field Measurement of Air Leakage Through Installed Exterior Windows and Doors
- Quantitative Air Infiltration Test

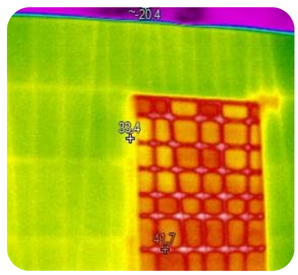
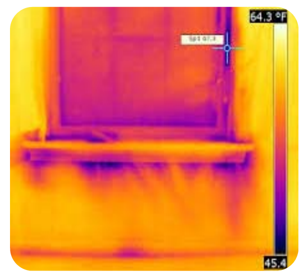


Functional Performance Testing

ASTM E1186, Practice 4.2.1

- Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems - Building Depressurization (or Pressurization) with Infrared Scanning Techniques
- Qualitative Air Infiltration/Exfiltration Test



Functional Performance Testing

ASTM E1186, Practice 4.2.6

- Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems – Chamber Pressurization or Depressurization in Conjunction With Smoke Tracers
- Qualitative Air Infiltration/Exfiltration Test



Functional Performance Testing

ASTM E1186, Practice 4.2.6

Functional Performance Testing

ASTM E1186, Practice 4.2.7

- Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems – Chamber Depressurization in Conjunction With Leak Detection Liquid
- Qualitative Air Infiltration/Exfiltration Test

Functional Performance Testing

ASTM E1186, Practice 4.2.7

Functional Performance Testing

ASTM E779 (Whole Building Air Test)

- Standard Test Method for Determining Air Leakage Rate by Fan Pressurization
- Quantitative Whole Building Air Leakage Test

Functional Performance Testing

ASTM E1105

- 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
- Water Penetration Test

Functional Performance Testing

AAMA 501.1

- Standard Test Method for Water Penetration of Windows, Curtain Walls, and Doors using Dynamic Pressure
- Water Penetration Test

Functional Performance Testing

AAMA 501.1

Functional Performance Testing

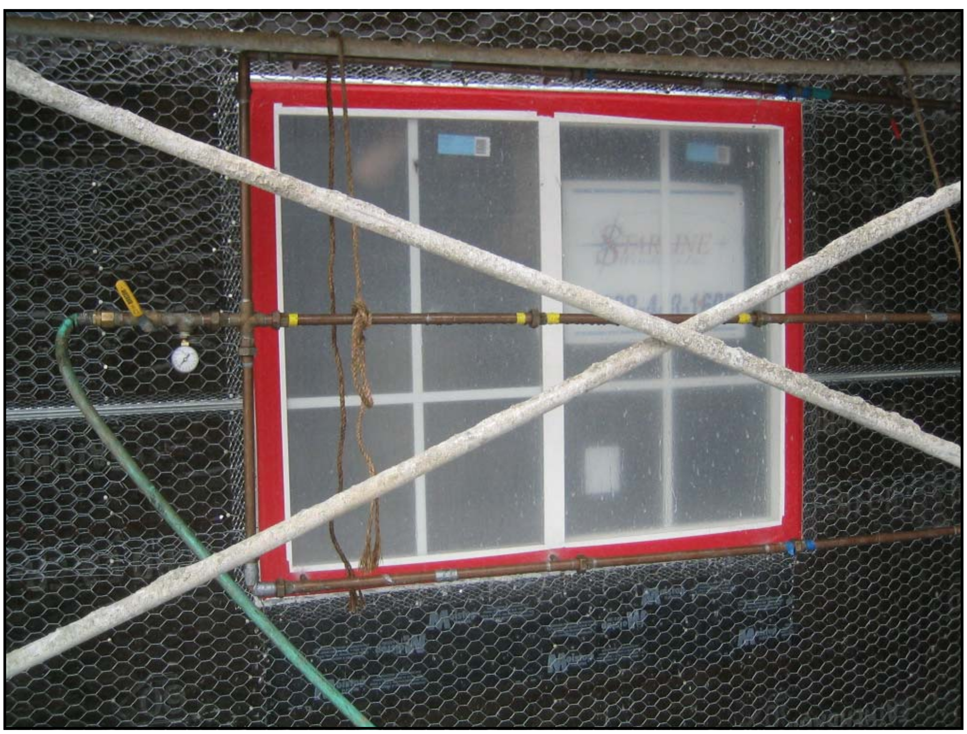
AAMA 501.2

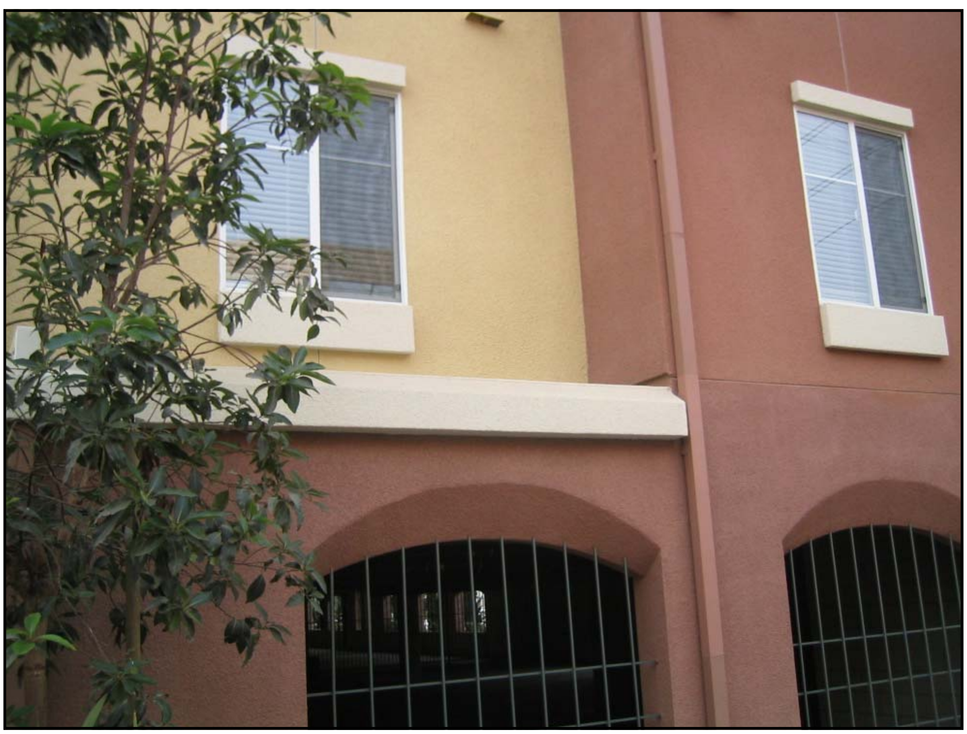
- Quality Assurance and Diagnostic Water Leakage Field Check of Installed Storefronts, Curtain Walls and Sloped Glazing Systems
- Water Penetration Test

Functional Performance Testing

ASTM D4541

- Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers
- Quantitative Adhesion Test






ENERPAC


Henry
BlueskinVP


Henry
BlueskinVP
Blueskin

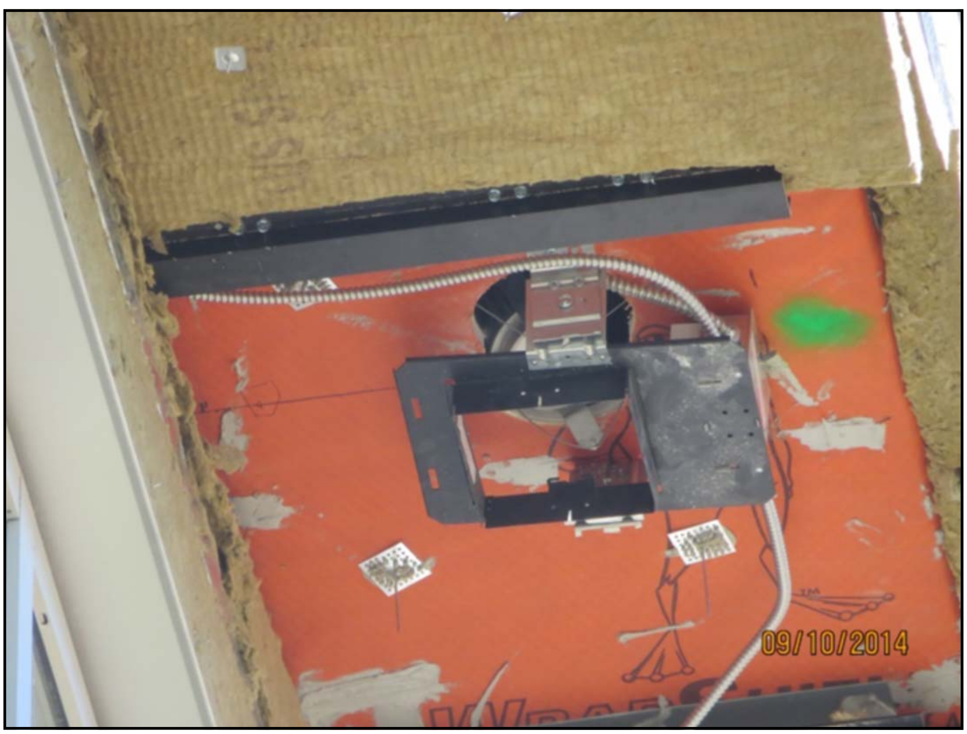

Henry
BlueskinVP
Blueskin

Quantitative Field Air Testing

Surface Preparation


GP
DensGlass
Sheathing


Genie S-40
4x4
08/14/2014


09/10/2014

Field Observations

Typical Observations:

Curtain wall fasteners

Unadhered flashing

Field Observations

Typical Observations:

Thin air/vapor barrier

Missed fasteners

Field Observations

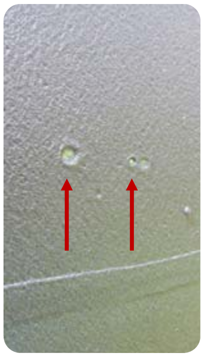
Typical Observations:

Insufficient spray foam

Unsealed electrical box

Field Observations

Typical Observations:



Air/Vapor Barrier

Unsealed holes

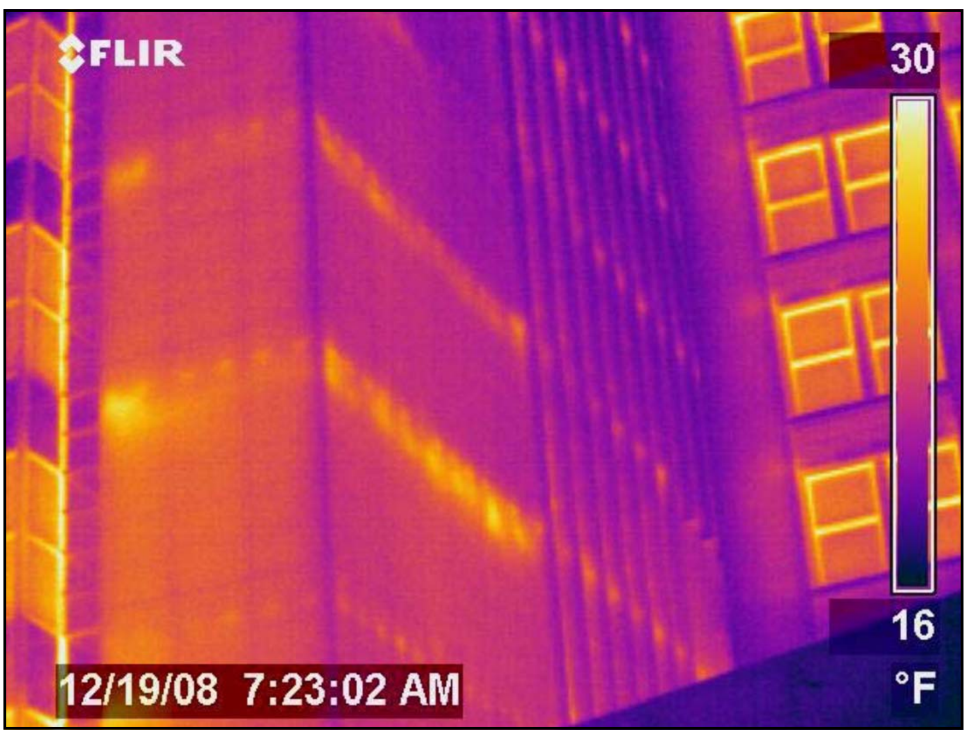
Holes in flashing

Field Observations

O & M Phase

- EVALUATE IMPACT OF NON-CONFORMANCE ITEMS
- ORGANIZE ALL COMMISSIONING DOCUMENTATION
- END OF WARRANTY PERFORMANCE REVIEWS
- OPERATIONS AND MAINTENANCE TRAINING
- PERIODIC PERFORMANCE REVIEWS
- VERIFICATION OF SEASONAL PERFORMANCE LEVELS

FINAL PROJECT COMMISSIONING REPORT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12/19/08 7:23:02 AM

Program Outline

Quality Drivers

Codes / Building Science

State of the Practice

Tomorrow's Trends

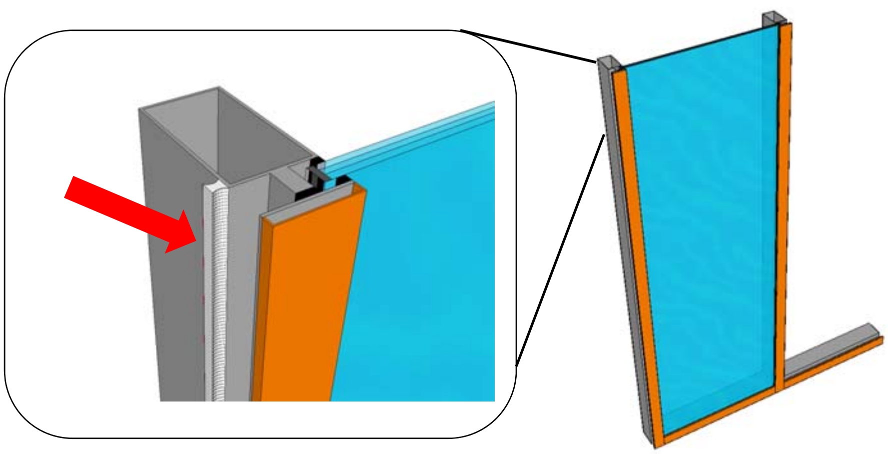
- One world
- Tighter Schedules
- Ambiguity in Qualifications
- Robust energy models
- Desire for green

Geographical Expansion

- The recognition of building enclosure commissioning has expanded beyond US
- International labor force
- Increase in foreign fabrication /materials

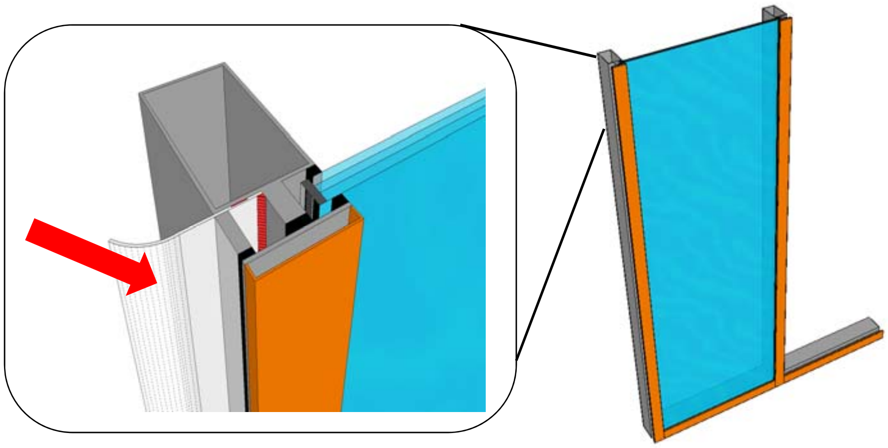
Primary Air and Water Seal

Sealant



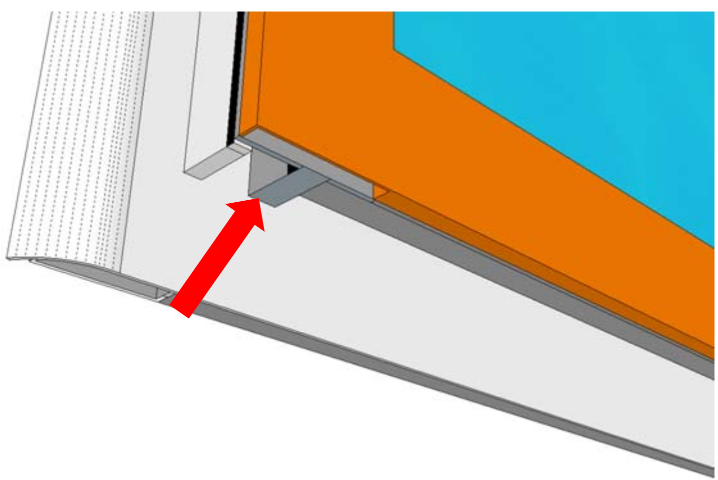
Primary Air and Water Seal

Silicone Sheet



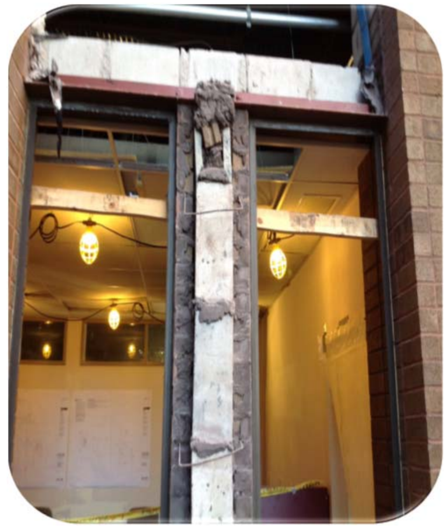
Primary Air and Water Seal

Silicone Sheet



Case Study 1- Philadelphia

- Built in 1980’s
- Active water and air leakage
- Client is upgrading building to increase commercial leasing value/solve problems.

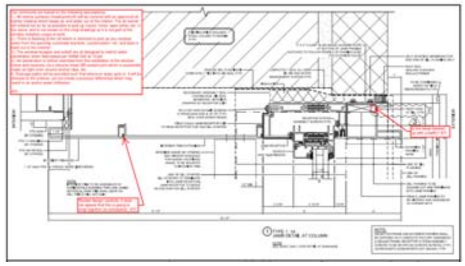


Case Study 1 - Philadelphia

- Existing BECx starts with an investigation
- Mock-ups were key to verifying repair scope
- New windows, insulation, air barrier, roof, existing cladding to remain
- Air leakage performance increase by 10x

Case Study 2 – New York City

- Built in 1940’s
- 14 stories, 460,000 sf
- Concrete encased steel frame
- Client is upgrading building to change use from manf. to education
- Client looking to greatly increase energy performance
- Minor façade repairs

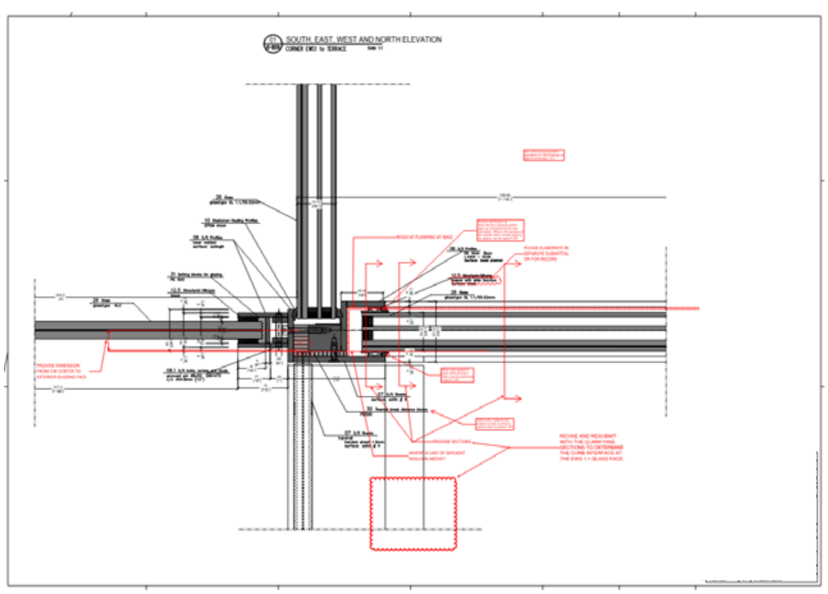


Case Study 2 – New York City

- Existing BECx starts with an investigation
- Mock-ups were key to verifying repair scope
- New windows, insulation, air barrier, roof, existing cladding to remain
- Air leakage performance increase by 10x

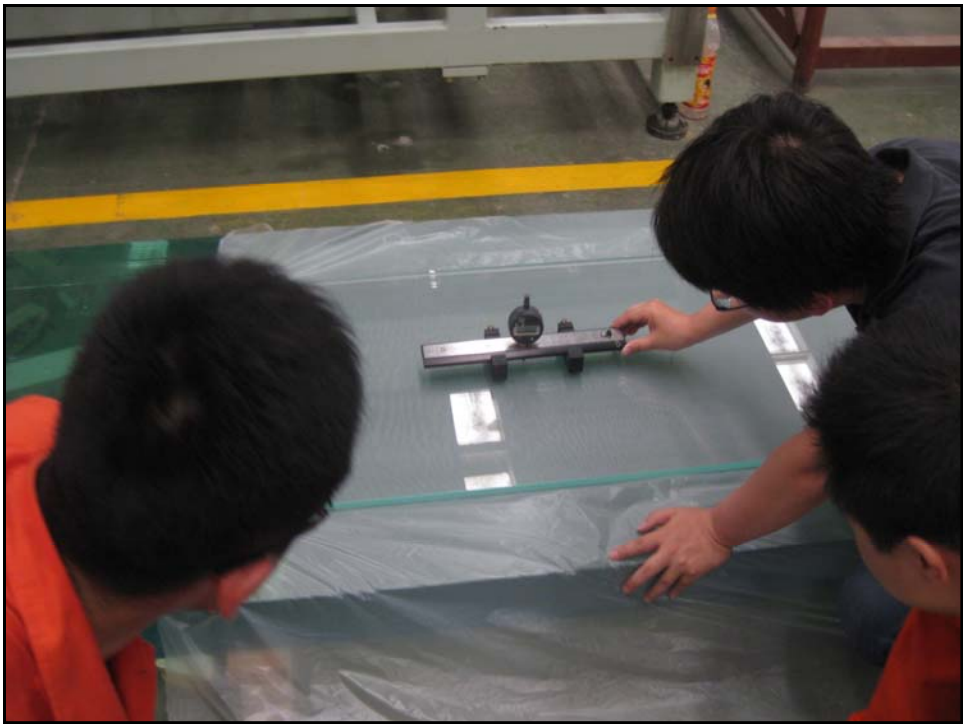
Case Study 3 – New Jersey

Case Study 3 – New Jersey



Case Study 3 – New Jersey

Defining BECx | Energy Usage | Design | Construction | Operations | Case Study



Case Study 3 – New Jersey

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Case Study 3 – New Jersey

ATI OBSERVATION REPORT

Project N
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Reporte
Reporte

Areas Observed: General below grade, roofing and curtain wall observations from grade, roof and the interior of the building.

Work in Progress: Fin installation on the South elevation, center. Glazing on the West elevation, south end.

Field Observation Report No.: 3
Site Visit Date: 9-5-12

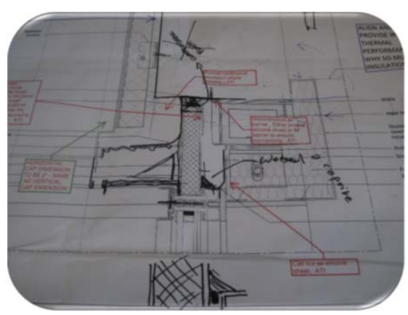
Item:	Observation:	Floor:	Elev.:	Location:	Photo No.:	Classification
20	Damaged below grade membrane with unadhered laps. **Fully inspect and repair membrane in accordance with W.R. Grace's recommendation prior to concealment.**	Grade	Typical condition		912, 913	Deficiency
21	The liquid membrane at the below grade laps is crazed and shows signs of weathering/UV exposure. **Ensure that the below grade membrane system including lap sealant is not exposed to UV longer than recommended by W.R. Grace. Repair any locations at have exceeded exposure times in accordance with W.R. Grace's recommendations.**	Grade	Typical condition		914	Deficiency
22	Repeat of Condition 11 - Gaps of up to 3/4 inch wide exist in the rigid insulation board joints. **Fill all gaps to provide continuous insulation.**	Grade	North	Column 2-3	915	Deficiency

Case Study 4 – New York City

- Built in 1930's
- 7 stories
- Client is upgrading building to change use from manf. to residences
- Modest façade repairs
- Desire energy savings

Case Study 4 – New York City

- Existing BECx starts with an investigation
- Mock-ups were key to verifying window performance
- New windows, roof and exterior coating / air barrier



Vapor Control Layer

Variable Permeance Materials

MemBrain™, The SMART Vapor Retarder & Air Barrier Film

PRODUCT DESCRIPTION

Basic Use: CertainTeed MemBrain Smart Vapor Retarder is a vapor retarder sheeting intended for use with unfaced, vapor permeable mass insulation (fiber glass and mineral wool) in wall and ceiling cavities.

Benefits: MemBrain Smart Vapor Retarder is a polyamide film that changes its permeability with ambient humidity conditions. The product's permeance is 1 perm or less when tested in accordance with ASTM E 96, dry cup method, and increases to greater than 10 perms using the wet cup method. This process allows closed building envelope systems to increase their drying potential with seasonal climatic changes. With a high

Energy Modeling & BECx

Trends:

- Model accuracy is increasing
- Model comparison with actual performance is increasing
- Most projects have modeling requirements
- Modeling is dictating some design decisions

14th Annual Building Enclosure Event

Questions?

This concludes The American Institute of Architects Continuing Education Systems Program.

AIA/CES Sign-in Forms and Certificates of Completion available at the registration table.