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**CONFERENCE
& TRADE SHOW**

APRIL 18-20

2017

RESTON, VA

**AIR BARRIER EDUCATION TRACKS FOR
THE CONSTRUCTION INDUSTRY**

Building Enclosure Commissioning

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WJE | ENGINEERS
ARCHITECTS
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Learning Objectives

At the Conclusion of the program the participants will be able to discuss the following:

1. What is Building Enclosure Commissioning (BECx)?
2. Why Is BECx Important?
3. What is included in ASTM E2813 *Standard Practice for Building Enclosure Commissioning*?
4. What are the processes included in BECx through project phases, including Predesign, Design, Preconstruction, Construction, and Post-Occupancy
5. What functional performance testing is required for Fundamental BECx under ASTM E2813?
6. What are the “Core Competencies” for a BECx Service Provider?

Polling

<http://wje-dcii.participoll.com>

What is Building Enclosure Commissioning?

How many of you are familiar with the definition of the term Building Enclosure Commissioning (BECx)?

- A. Yes
- B. No

What is Building Enclosure Commissioning?

How many of you have worked on a project that had a BECx requirement?

- A. Yes
- B. No

What is Building Enclosure Commissioning?

“Building Enclosure Commissioning (BECx) is a holistic process that...endeavors to verify that the exterior enclosure...meets or exceeds the expectations of the Owner...”.

- Predesign
- Design
- Preconstruction
- Construction
- Post Occupancy

Is BECx more than Good Design (AOR) and Construction Practice (GC)?

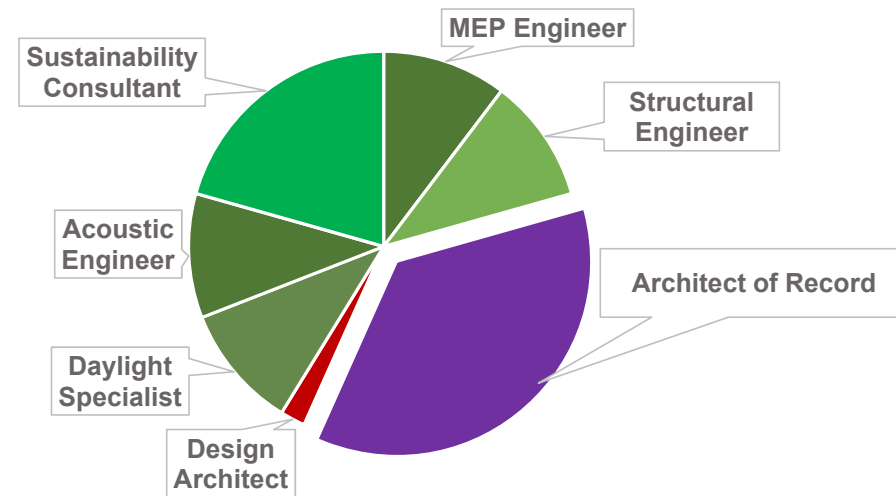
Why Do We Need It?

- **Uncontrolled rainwater penetration and condensation** are two of the most common threats to building enclosure performance.
- Together, they represent up to **80%** of all construction-related claims in the United States.
- **90%** of all water intrusion problems occur within **1%** of the total building area (**interfaces**).
- Building Sector consumes nearly **50%** of all energy produced in the United States.
- **77%** of all the electricity produced in the U.S. is used just to operate buildings.



Why Do We Need It?

- Compartmentalization of Design
- Declining Skill in the Construction Trades
- Increased expectations (Owner/User)
 - Quantifiable Building Performance (LEED?)
- A move from “Over Design” to “Efficient Design”
 - “Air leakage can hide a lot of stuff...”
 - Attic ventilation/Reflective roofs...
 - “We have been designing this way for 30 years, why are we now only seeing a problem?”



Why Do We Need It?

Which of the following do you view as most “at fault” for the need for BECx?

- A. *Inadequate Design (AOR)*
- B. *Less Forgiving Designs (Over Design-to-Efficient Design)*
- C. *Inadequate Construction Practice*
- D. *Increased/Quantifiable Expectations*
- E. *Litigation*
- F. *We don't need BECx*

Pre-Design: Owner Dilemma “101”

Owner Expectations...

- NO Uncontrolled Water Penetration (Can't Leak)
- NO Interior Finish Damage (Looks Good)
- NO Structural Damage (Can't Fall Down)
- NO “Code” Violations, *i.e. LEED (get My Plaque)*



“What’s an OPR?....”

Misaligned Expectations

Industry Expectations...

- ASTM E1105: 3.2.3: **Penetration of water beyond a plane parallel to the glazing (the vertical plane) intersecting the innermost projection of the test specimen**, not including interior trim and hardware, under the specified conditions of air pressure difference across the specimen. For products with non-planer glazing surfaces (domes, vaults, pyramids, etc.) the plane defining water penetration is the plane defined by the innermost edges of the unit frame.
- AAMA 503-92: 4.8.1.1: ...Water contained and drained back to the exterior, or **the collection of up to one-half ounce of water in the 15-minute test period on top of an interior horizontal frame surface that does not spill onto adjacent finishes or materials is acceptable.**



Design: Why Do I Need a Peer Review?



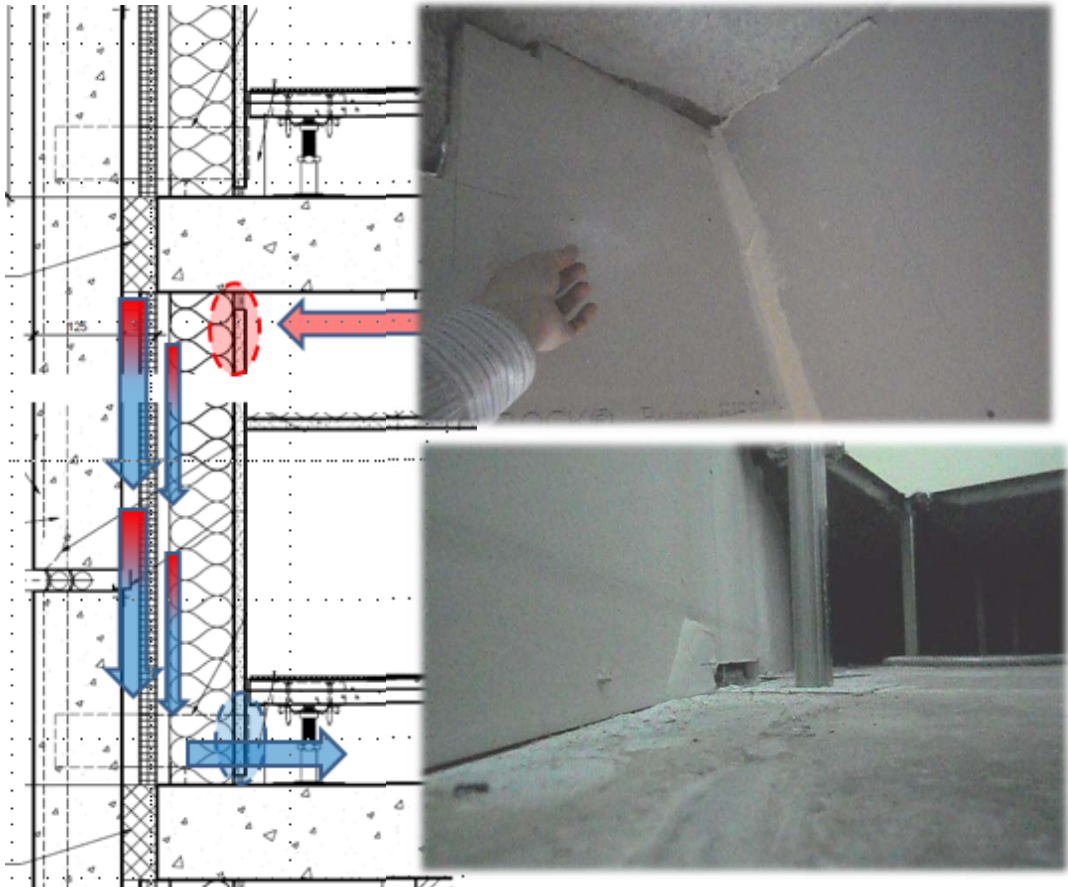
“It is not the standard of care to provide exhaustively detailed and annotated documents. If architects were expected to provide that level of detail, our fees would need to increase dramatically or we would be out of business quickly...”

- Testimony of an Architect



“What’s a BOD...?”

Why Do I Need a Peer Review?



“...we have been specifying this wall assembly for 30 years and never had a problem...”

-Architect

Standard of Care...?

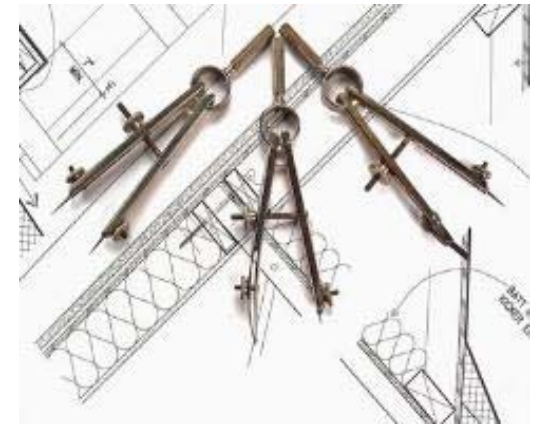
I.3 SYSTEM DESCRIPTION

- A. Description of System: Exterior wall and roof systems, complete with masonry, fiber cement board siding, EIFS (at the penthouse), stone assemblies, composite panels, storefronts, glass, glazing, precast concrete, aluminum windows, shims, sealants, and anchorage devices required to secure entire exterior envelope to building structural system and related appurtenances as necessary to provide complete and weathertight external envelope.
- B. Acceptability of masonry, fiber cement board siding, EIFS, stone assemblies, composite panels, precast concrete, storefronts, aluminum windows, is dependent upon successful test performances.
- C. General:
 - 1. Drawings are diagrammatic and do not purport to identify nor solve problems of thermal or structural movement, glazing, anchorage or moisture disposal.
 - 2. Requirements shown by details are intended to establish basic dimension of unit, sight lines and profiles of members.
 - 3. Provide concealed fastening wherever possible.
 - 4. Coordinate shop drawings and installation of exterior wall to resolve conflicts.

“Drawings are diagrammatic and do not purport to identify nor solve problems of thermal or structural movement, glazing, anchorage or moisture disposal.”

A Brief History

- It began in the 1950's...
- Death of the Master Builder ('58/'67)
- Design/Build and the Birth of the Construction Manager (1980's)
- Today?



When Did This Start...?

“Up until 1945, the liability climate within which the architect worked was fairly stable. Under the common law rule of ‘privity of contract’, the client was the only party likely to gain the court’s permission to sue...”

“The trend against the rule began in the manufacturing sector and reached the architectural profession in the 1950’s...”

- AIA Architect’s Handbook of Professional Practice

Death of the “Master Builder”

Architect as “Master Builder” Falls Victim to Risk and Liability

“Observation” vs. “Supervision” During the Construction Phase...

- Day v. National U.S. Radiator, 241 La.288, 128 So.2d 660 (1958)
- Miller v. DeWitt, 37 Ill.2d 272, 226 N.E.2d 630 (1967)

“Some viewed [this] substitution... as a retreat from the architect’s traditional role, tending to weaken the architect’s services during this crucial project phase.”

- AIA Architect’s Handbook of Professional Practice

Birth of the “Construction Manager”

“Prior to about 1980 there was no such thing as a CM. However, when interest rates ran close to 20% during the recession of that time... someone came up with the idea of speeding up the process by overlapping design and construction. That occurred at a time when architects were continuing to withdraw from the construction process. Into that void stepped the ‘CM’.”

-Outside Counsel to the AIA

Architects “Gave It Away”

“The ability to play a controlling role in the construction process was never taken away from architects – they gave it away. That [trend] continues through the most recent iteration of the [AIA] documents. Traditionally, the architect was always the initial [“arbiter”] in the case of conflicts between the contractor and owner. The documents now embrace a third party in that role.”

Why? “Architects are uncomfortable in that role...”

-Outside Counsel to the AIA on Contract Documents

Standard of Care Today

AIA B101–2007 OWNER/ARCHITECT AGREEMENT

Architects, like all professionals, must perform their duties in a given circumstance ***consistent with the degree of care and competence*** expected of a reasonably skilled member of the profession.

This standard of care applies in any professional activity an architect undertakes, regardless of whether the standard of care is stated in the contract for services.

Standard of Care Today

AIA A201 OWNER/ARCHITECT AGREEMENT

§ 4.2.2 The Architect, as a representative of the Owner, will visit the site at intervals appropriate to the stage of the Contractor's operations (1) to become **generally familiar** with and to keep the Owner informed about the progress and quality of the portion of the Work completed, (2) to **endeavor to guard** the Owner against defects and deficiencies in the Work, and (3) to **determine in general** if the Work is being performed in a manner indicating that the Work, when fully completed, will be in accordance with the Contract Documents. However, **the Architect will not be required to make exhaustive or continuous on-site inspections to check the quality or quantity of the Work.** The Architect will neither have control over or charge of, nor be responsible for, the construction means, methods, techniques, sequences or procedures, or for the safety precautions and programs in connection with the Work, since these are solely the Contractor's rights and responsibilities under the Contract Documents, except as provided in Section 3.3.1.

Design Intent “101”



The construction documents must:

- Carry enough information to convey design intent and the importance of a fully-integrated Building Enclosure...
- Convey how those materials and systems will be reconciled at the **interfaces**...

A failure to provide this information prior to bidding effectively shifts the burden of designing these details “downstream” to the submittal review and shop drawing phase...

“Finishing the Design”



GC/CM Role And Responsibility

“A general contractor is responsible for the means and methods to be used in the construction execution of the project in accordance with the contract documents...”.

- **“Means and Methods” is often broadly defined by many architects...**
- **Contractors will argue (pejoratively) that it is “Finishing the Design”...**
- **Shop Drawing Review is “Finishing the Design”**
 - **Interface Detailing (Architect)**
 - **Sequencing and Coordination of Trades (Contractor)**

Shifting The Burden Downstream



“...The appellate court agreed, stating that a subcontractor has a general duty to perform his or her work in a good and workmanlike manner regardless of the terms of the subcontract. For this reason, the owner of a project ordinarily has a cause of action against a subcontractor even though there is no privity of contract between them. The Court of Appeal relied on Kuitems v. Covell (1951) 104 Cal.App.2d 482, which held that “accompanying every contract is a common-law duty to perform with care, skill, reasonable expedience, and faithfulness the thing agreed to be done, and a negligent failure to observe any of these conditions is a tort as well as a breach of the contract.” (Id. at 485.)

Regardless of privity, the subcontractor may be liable to the Owner...

Construction Phase: Design Assist, Some Can Handle It...

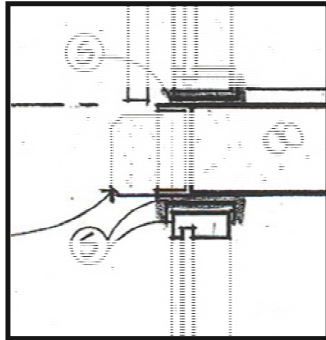
Specialty Subcontractors

Proprietary Pre-Fabricated,
Structurally-Glazed Unitized Curtain
Wall

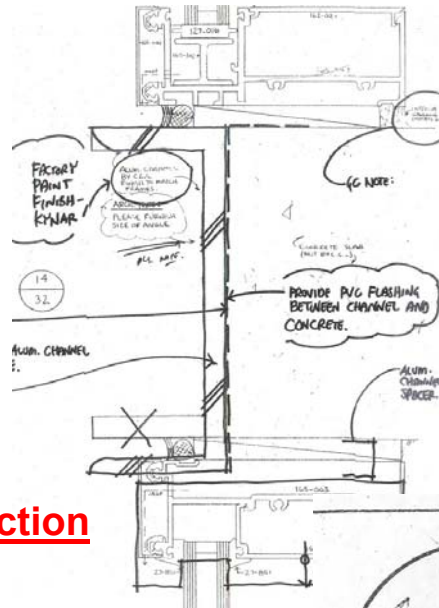
- Level of complexity often beyond the capability of the A/E to detail
- Design responsibility pushed “downstream”
- GC/CM assigns responsibility for QA/QC to the specialty subcontractor



Others Cannot...



From Architect...



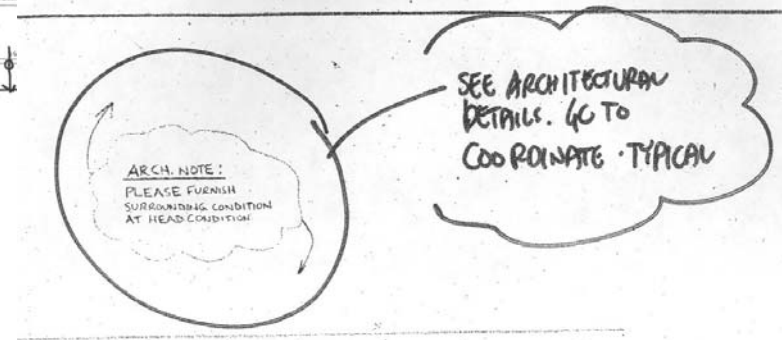
...to Dispute...

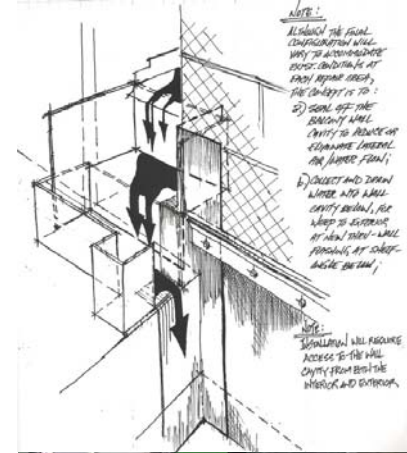
\$12M Original Construction Cost

\$6M Lawsuit...

\$1.2M +/- in Masonry Repairs...

...to Subcontractor...





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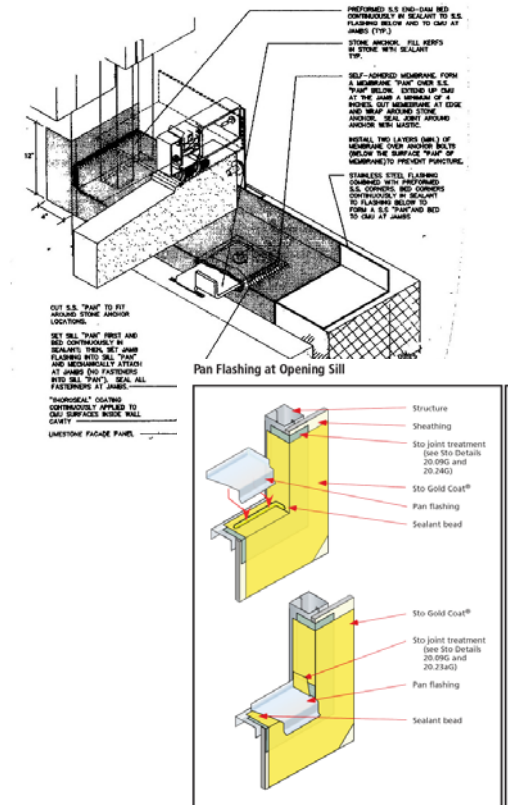
What Does the Code Say...?

Model Code Requirements – 2012 IBC

107.2.4 Exterior wall envelope.

Construction documents for all buildings shall describe the exterior wall envelope in sufficient detail to determine compliance with this code.

The construction documents shall provide details of the exterior wall envelope as required, including flashing, intersections with dissimilar materials, corners, end details, control joints, intersections at roof, eaves or parapets, means of drainage, water-resistive membrane and details around openings.



Courtesy of STO Building Systems

“Does ICC Establish Code...?”

How Do We Address These Issues?

Building Enclosure Commissioning (BECx)

A Return to Basics

- Building Performance begins “Pre-Design”
- Building Performance is a Team Effort
- **“Trust but Verify”**

The Building Enclosure Commissioning (BECx) process establishes appropriate and **quantifiable metrics** for performance testing and verification that demand accountability at every stage of the design and construction process.



The BECx Process

“Building Enclosure Commissioning (BECx) is a holistic process that...endeavors to ensure that the exterior enclosure...meets or exceeds the expectations of the Owner...”.

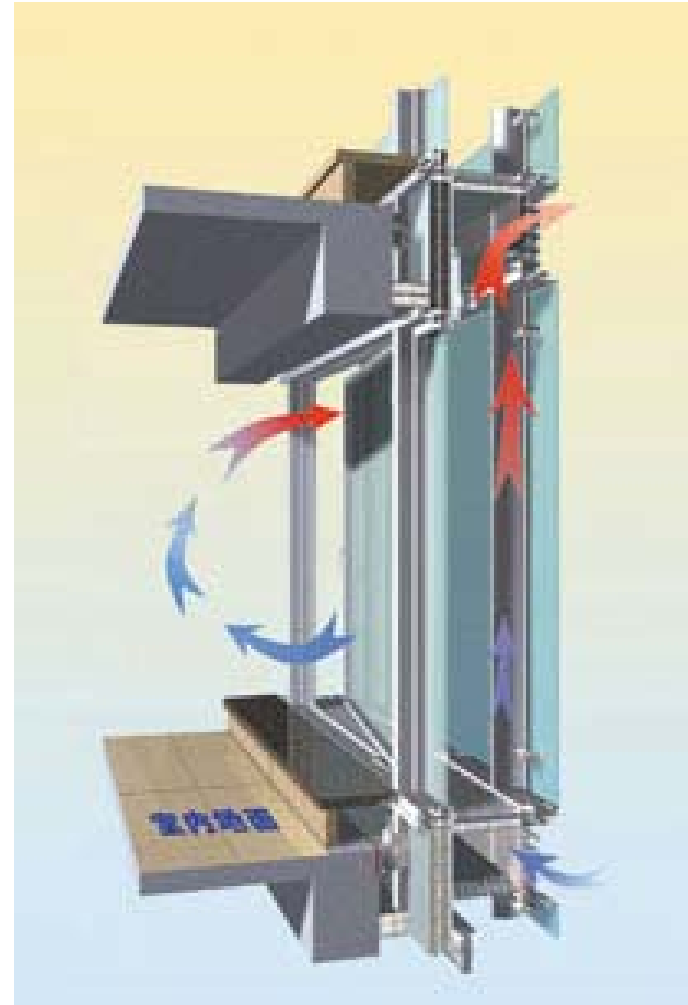
- Predesign
- Design
- Preconstruction
- Construction
- Post-Occupancy

The BECx Process

Pre-Design

Development of OPR
(Owner Performance Requirements)

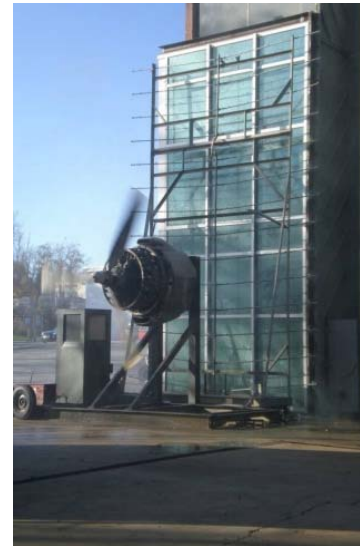
- Energy
- Environment
- Safety
- Security
- Durability
- Sustainability
- Operation
- Other...



The BECx Process

Design

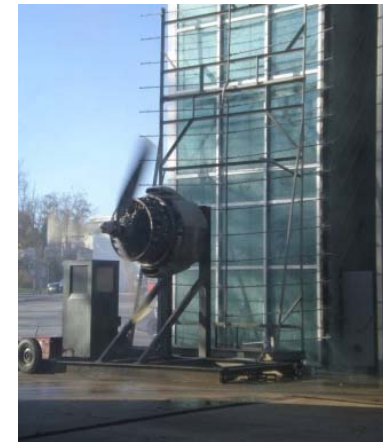
- Peer review of all applicable systems at various stages of design
 - Schematic Design
 - Design Development
 - Construction Document
- Establishment of mock-up requirements & testing scope
 - Air Leakage, Water Leakage, etc.
- Assisting project team with “value engineering” decisions
- Hygrothermal and Thermal Analysis (THERM, WUFI, etc.?)



The BECx Process

Pre-Construction

- Submittal Review
 - Shop Drawing/Product Data Review
 - Coordination between Systems
- Observation of laboratory or 'off-wall' site mock-up testing
- Quality assurance and performance testing plan development
- Building Envelope Coordination Meetings



The BECx Process

Construction

- Observation of In-Situ Field Testing
- Construction Observation
- Fabrication plant visits
- Preparatory Meetings
- Quality Assurance Team Meetings
- RFI Review Assistance



The BECx Process

Post-Occupancy

- Building Envelope Operation and Maintenance Manuals
- Observation of Post-Occupancy Testing



ASTM E2813



Standard Practice for BECx

Minimum Enforceable Levels of BECx...

Fundamental BECx

Architecture or engineering-related technical services, or both, performed on behalf of the Owner by the Building Enclosure Commissioning Agent or Authority (BECxA), including:

- BECxA Engagement During the Design Phase
- Retro-Active Development and Documentation of the OPR
- Minimum of One (1) Independent, Third-Party Design Review of the Construction Document Drawings and Specifications
- Minimum One “On-Building, First Installation” Mock-Up
- Minimum Level of Performance Testing as Required in Annex A2 for “Fundamental” BECx

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Standard Practice for BECx

Minimum Enforceable Levels of BECx...

Enhanced BECx

Architecture or engineering-related technical services, or both, performed on behalf of the Owner by the Building Enclosure Commissioning Agent or Authority (BECxA), including:

- BECxA Engagement During the Pre-Design Phase
- Development and Documentation of the OPR
- Minimum of Three (3) Independent, Third-Party Design Review of the Construction Document Drawings and Specifications
- Minimum One “Off-Building”, On-Site Mock-Up
- Minimum Level of Performance Testing as Required in Annex A2 for “Enhanced” BECx

ASTM E2813

Standard Practice for BECx



ASTM E2813 – 12

TABLE A2.1 *Continued*

Property	Standard Designation	Title	Lab System Testing	Enhanced		Fundamental	
				Field Mockup Testing ^A	In-Situ Field Testing	Field Mockup Testing	In-Situ Field Testing
	ANSI S12.8	Methods for Determination of Insertion Loss of Outdoor Noise Barriers	...	(OF)	(OF)	(OF)	(OF)
	ANSI S12.60	Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools	OL	...	...	...	...
Air Infiltration							
Air flow	ASTM E2319	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	OL	...	...	...	...
Air leakage	ASTM E283	Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen	L (M)	...	...	...	...
	ASTM E779	Test Method for Determining Air Leakage Rate by Fan Pressurization	...	...	✓ (1X)	...	(OF)
	ASTM E1827	Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door	...	...	✓ (1X)	...	(OF)
	ASTM E783 ^B <i>Opaque Walls</i>	Test Method for Field Measurement of Air Leakage Through Installed Exterior Windows and Doors	...	✓ (1X)	✓ (1X)	✓ (1X)	✓ (1X)
	ASTM E783 <i>Windows</i>	Test Method for Field Measurement of Air Leakage Through Installed Exterior Windows and Doors	...	✓ (1X)	✓ (2X)	✓ (1X)	✓ (1X)

Typical Field Testing Standards

- 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
- ASTM C1601 – Standard Test Method for Field Determination of Water Penetration of Masonry Wall Surfaces
- AAMA 501.1 – Standard Test Method for Water Penetration of Windows, Curtain Walls and Doors Using Dynamic Pressure
- AAMA 501.2 – Quality Assurance and Diagnostic Water Leakage Field Check of Installed Storefronts, Curtain Walls, and Sloped Glazing Systems
- AAMA 502 – Voluntary Specification for Field Testing of Newly Installed Fenestration Products
- AAMA 503 – Voluntary Specification for Field Testing of Newly Installed Storefronts, Curtain Walls and Sloped Glazing Systems
- AAMA 511 – Voluntary Guideline for Forensic Water Penetration Testing of Fenestration Products

Typical Field Testing Standards



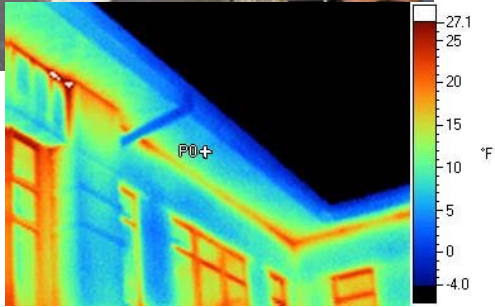
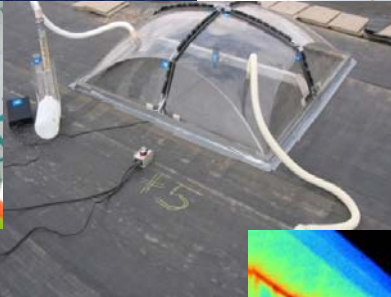
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Typical Field Testing Standards



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Typical Field Testing Standards



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Who Is the Service Provider?



Industry Terms (*Under Development*):

- Certified BECx Technologist (BECxT)
Certifications in specialized testing
- Certified BECx Specialist (BECxS)
Enclosure Assembly/System Expert(s)
- Certified BECx Authority (BECxA)
Coordinator and Document Technologist of BECx Activities

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Standard Practice for BECx



Minimum Core Competencies of the BECx Service-Provider

- Building and Materials Science,
- Procurement and Project Delivery,
- Contract Documents and Construction Administration,
- Performance Test Standards and Methodology

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Standard Practice for BECx



Building and Materials Science

- Principles associated with heat transfer via conduction, convection, radiation, and air infiltration/exfiltration;
- Principles associated with moisture storage and transport via gravity, diffusion, convection, capillary action, absorbed flow, and osmosis; and
- Characteristics and behavior of enclosure-related materials, components, systems, and assemblies when specified for a given application, geographic region, location, exposure, or climate, and corresponding influence on workability, durability, serviceability, performance, and anticipated service-life.

ASTM E2813

Standard Practice for BECx



Procurement and Project Delivery

- Influence of the project delivery method selected by the Owner on the scope, adaptation, implementation, and cost of the BECx process as defined in this practice;
- Influence of the number and type of contracts established between the Owner and the design and construction teams on the role and responsibilities of the BECxA and individual members of the BECx team;
- Influence of design and construction scheduling, phasing, and sequencing of the work on the scope, adaptation, implementation, and cost of the BECx process as defined in this practice;
- Influence of the experience, qualifications, technical depth, and commitment of the design and construction teams to the BECx process on the role and responsibilities of the BECxA, the range and technical depth required of the BECx team, and the anticipated scope and cost of the BECx process.

ASTM E2813

Standard Practice for BECx

Contract Documents and Construction Administration



- Interrelationship and commonly understood hierarchy that exists between Procurement Documents, Contract Documents, Contract Drawings and Specifications and other legally binding documents issued during the Pre-Construction and Construction Phases...
- Influence of enclosure-related design, detailing, and integration on total building performance...
- Influence of product selection, allowable construction tolerances, and dimensional requirements on detailing at building enclosure interface conditions, and the corresponding influence on sequencing, phasing, and coordination of trades during the Construction Phase...
- Importance of material compatibility and continuity of primary heat, air, and moisture control layers throughout the building enclosure on total building performance...
- Importance of the timely preparation and distribution of subject-direct, technically sound, and actionable documentation...

ASTM E2813

Standard Practice for BECx

Performance Test Standards and Methodology



- Pre-construction laboratory and field-applied test standards and methodology
- Importance of establishing appropriate and quantifiable thresholds of performance and clear and unambiguous definitions of failure
- Influence of modifications to the intended use and application of test standards and methodology on the appropriate interpretation of test results and their relevance to the requirements of the contract documents;
- Importance of ensuring the timely, clear, and unambiguous translation of all modifications to the design arising from pre-construction laboratory testing to the field...
- Importance of recognizing the distinction between errors and omissions in architectural or product design, or both, versus defective installation or workmanship when interpreting field test results...
- Potential conflicts between voluntary guide specifications and standards developed by the industry and individual test standards included within those documents and its impact on the enforcement of the contract documents...

Case Study

Case Study

Mid-Rise multi-family residential building

Punched window

Punched window with spandrel

Window wall

Storefront

Precast

Clay brick masonry cavity wall

HFA IRMA roof



How Much Does BECx Cost?

As a percentage of overall construction costs (*assume a multi-family mid-rise +/- 43 Million*)?

- A. <0.5%
- B. 0.5%-1%
- C. 1%-3%
- D. 3%-5%
- E. >5%

Case Study

Unique conditions....



Case Study

1. Punched windows w/
Spandrel/Precast
2. Punched
windows/Brick
3. Window wall/Precast
4. Window wall/Brick
5. Window wall/fin detail
6. Window wall/metal
panel clad roof
7. Storefront/Precast



Case Study												
	\$ 45,000,000.00	Total Building Cost										
	\$ 2,700,000.00	Design Fees (6% total)										
	\$ 6,750,000.00	Façade Cost (15% total)										
		Fundamental		Project		Number of unique conditions	estimated cost \$					
		mock up	field	mock up	field							
Acoustic												
ASTME1503		0	1 as req.	1	0	1	3,000			adjacent to highway		
Air												
E783-opaque		1	1	1	2	2	6,000			test on Tyvek on mock-up and once on building; test precast with window opening by masking..use same chamber for WRB as window		
E783-fenestration		1	1	1	1	7	35,000					
ASTME1186 air leakage, infrared, fog		0	1	0	1	1	10,000			1 scan of the building; coordinate fog (if needed) with air/ water testing; units testing at 4 locations		
Thermal												
C1153 infrared		0	1 as req	0	0	n/a	n/a			IRMA roof		
Water												
D5357 - flood test		0	1	0	0	1	15,000			ELD in lieu of flood testing (no vapor barrier)		
E1105 (chamber test)				1	1	7	0			Performed in conjunction with E783...		
aama 501.2				1	1	7	5,000			Nozzle test at perimeter joints, non operable (separate from E1105)		
aama 501.1		0	0	0	0		4,000			consider dynamic test at lower interface condition/ box bay/window		
Durability												
D4541-coating adhesion test		0	0		n/a							
E488-anchor pull test		0	0		n/a							
E2353-EIFS pull test		0	0		n/a							
C734 sealant peel adhesion		1	1	1	1	5	3,000			metal/brick; metal/metal; precast/precast; precast metal; manuf may provide at no cost		
							\$ 81,000.00			for mandatory testing		
							\$ 60,000.00			cost of mock-up to include section of window wall and punched window in brick (note an off-building on site mock-up was constructed)		
							\$ 50,000.00			BECC Team site visits (enclosure construction 16 weeks)		
							\$ 30,000.00			Submittal Review/RFI/Correspondence		
							\$ 30,000.00			Design Peer Review (includes DPR and BOD participation)		
							\$ 251,000.00					
							0.6%			% of construction costs		

Case Study



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...0.1%

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Thank You!

