Exterior Enclosure Commissioning During Design

BEST 3 Conference
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Presented by
Wagdy Anis, FAIA, LEED AP
• Fred Wajcs, P.E.
  – “The Building Enclosure is a part of the mechanical system”.

• Wagdy Anis, LEED ap, FAIA :
  – “If your building enclosure doesn’t work, your HVAC system may not work as designed (even after fine-tuning it until you’re blue in the face).”
“the over-all function of an exterior wall, in conjunction with floors and roofs, is to provide a barrier between indoor and outdoor environments, so that the indoor environment can be adjusted and maintained within acceptable limits”

Hutcheon, N. CBD 48, 1963
Control heat flow;
Control air flow;
Control water vapour flow;
Control rain penetration;
Control light, solar and other radiation;
Control noise;
Control fire;
Provide strength and rigidity;
Be durable;
Be aesthetically pleasing;
Be economical.

Hutcheon, N. CBD 48 1963
Be Sustainable; Be Maintainable
Provide Connection to Place; Phototropism and Biophilism
Control Particulates and Pollutants
Protect against Projectiles
Protect against Insects, Animals, People
Provide Security and Blast Resistance
Be Disposable

Other requirements
When?
COMMISSIONING = 

COMMUNICATION

+ 

COMMITMENT

The design

What specs identified

What the code manual required

How the contractor built it

What the client wanted

How it was resolved
risk management

The process of analyzing exposure to risk and determining how to best handle such exposure.
Not a “one size fits all”
Building Enclosure Commissioning (BECx)

- Quality-oriented process for achieving, verifying, and documenting that the performance of facilities, systems, and assemblies meets defined objectives and criteria.
- Assumes that owners, programmers, designers, contractors, and operations and maintenance entities are fully accountable for the quality of their work.
- Achieve the Owner’s Project Requirements throughout the delivery of the project.
- Begins at project inception (during the Pre-Design Phase) and continues for the life of the project.

Owner Project Requirements

The OPR may be developed by an experienced Owner, a commissioning provider, architect or construction manager,

- **Owner’s Vision.** Owner’s vision for the building exterior enclosure building’s function, image, service life, expansion strategy, etc.

- **Project budget and schedule.** A description of the Owner’s approach to allocating resources for the building exterior enclosure systems.
  - Durability expectations and service life of systems and components,
  - Capital investment, life of systems, operating costs, maintenance costs, and use of life cycle costing for selection of systems.
  - Schedule, design, construction, startup, testing, and operational/seasonal tuning of building exterior enclosure systems.

- **Owner directives** – What exterior enclosure systems, materials, and components will be required.
  - “Brick to fit within campus”, or “shiny crystal-like curtain wall”
OPR – Examples of objectives and functional requirements of building exterior enclosure systems to be included:

• Occupant requirements
• Thermal comfort
• Energy efficiency
• **Visual comfort** (views to the outside, access to daylight, luminance of surfaces in the space, control of glare, etc.)
• Indoor air quality, Acoustics, Special indoor environmental requirements (museums, archival facilities, rare book libraries, hospitals, laboratories, research facilities, etc.), Level of occupant control (operable windows, etc), Access, Life safety.
• **System Performance requirements** – impact of the building exterior enclosure all related systems.
• **Site information** – Topographical survey, below-grade utilities, geotechnical, pollutants
• Training requirements
• Warranty requirements
• Quality requirements of systems, materials and construction

“The Basis of Design (BOD) is a narrative and analytical documentation prepared by the design A-E along with design submissions to explain how the Owner's Project Requirements (OPR) are met by the proposed design... An OPR is developed for an owner/user audience while the BOD is typically developed in more technical terms.”

www.wbdg.org/project/perform_req.php
PEN TEST
Continuity of barriers
Liquid Moisture
Mass Transfer by Pressure Differentials
Mass Transfer by Diffusion

Water in its Two Forms
Heat Transfer

Conduction
Convection
Radiation
The Three Air Pressures
Air Pressure Control Strategies
Continuous Air Barriers

Infiltration Control
Water Vapor Control

Diffusion
Vapor Pressure
Vapor Barriers (Retarders)
Rain Wets Top and Projections First
Rain Wets Top and Projections First
Efflorescence, Biological Growth

Rain
Figure 1
Layering materials to shed water applies to whole building.
**Barrier: 100% of Pressure on Sealant**

**Cavity Wall: Pressure-Moderated**

*Barrier vs. Rainscreen*
Barrier vs. Rainscreen
Figure 2: Shows need for correct positioning and sizing of backer rod and correct shaping of sealant.
High Performance

LEED 2012 Enclosure Fundamental and Enhanced Commissioning
Icicles due to Air Leaks

Water Vapor Control

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Air Leakage

Efflorescence, Spalling due to Air Leaks
air spaces must be filled
Condensation on Cold Surfaces in Plenums
Air Leakage

Air Barrier Continuity
Vapor Control

WUFI Pro 5.0

8760 Hour Calculations

Transient Hygrothermal Analysis

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EFCO 590 REPLICATION WINDOW
Polyamide thermal break
Wind Load Study
Wind Load Study
Practice for Enclosure Commissioning, is now approved as E2813-2012
Figure GL3-B1: Key Envelope Commissioning Milestones by Phase (Overview)

Pre-Design

Design

Schematic Design

Design Development

Construction Documents

Construction

Occupancy and Operations

**KEY**
- Define Expectations
- Assess Results
- Document
- Owners Project Requirements
- Basis of Design
- Test
- Update
- Milestones
Pre-Design

• Expectations: Owner’s project requirements (OPR)
• Site, air and groundwater analysis
• Interior Environment Tolerances
• Corporate, institutional, social or environmental statement.
• Total project commissioning plan
• Budget
• Document
Identify and address problems before they occur:

- Perform comprehensive technical review and analysis
  - including all influencing factors impacting the performance, durability and maintenance of the building enclosure.
- Perform computer based thermal modeling to predict performance of wall assembly.
- Ensure owner / user satisfaction

Confirm constructability of details:

- Provide recommendations to Owner / A/E for consideration regarding details impacting performance.
- Determine schedule / sequencing impacts early
• Perform peer review checking at SD, DD, 50% and at 90% CD’s
• Develop/refine details for envelope systems
• Perform moisture/thermal analyses
• Review interactions between systems
• Refine energy code analysis
• QA Review envelope details and specifications
• Refine / Finalize project commissioning plan
• Review estimate and budget
• Draft / Finalize EECx specification
• Document
Project Team Meetings

- Charette style
- Detail development / refinement
- Owner / Design / construction team input

- Schedule
- Timing
Exterior Enclosure Cx Specification

- Exterior Enclosure Commissioning specification
- Coordinate all BECx relationships and aspects of the project.

- The BECx specification should clarify the field testing and shall be included in the Project Manual, Section 1, in coordination with specifications addressing:
  - Contractor Quality Assurance and Control
  - Moisture Prevention Procedures during Construction
  - Building Enclosure Performance Requirements (inclusive of the Air Barrier)
  - Testing and Inspection Services
  - Project specific Substitution Request Form for building enclosure components.
SECTION 01  91 13
BUILDING ENCLOSURE COMMISSIONING
GENERAL

1.1 WORK INCLUDED
• Commissioning requirements common to all Building Enclosure-Related Sections.
• Validation of proper and thorough installation of Building Enclosure components.
• Documentation of tests, procedures, and installations.
• Coordination and requirements for field mock-up, trial installation and Functional Performance Testing events.

1.2 GENERAL DESCRIPTION

A. Statement of Exterior Enclosure Design Intent (EEDI):

B. Exterior Enclosure Commissioning (EECx) is the process of ensuring that all building enclosure components are installed and perform collectively according to the EEDI and that the installation is adequately tested and that the specified performance is verified and documented.

It serves as a tool to identify deficiencies in the building enclosure during the preconstruction and construction phases in an effort to advance the building enclosure components from mock-up installations, through installation of the separate components on the structure, to a fully integrated, weather-tight assembly prior to occupancy, thereby reducing impact on the building end user.

C. The Exterior Enclosure Commissioning Coordinator (EECxC)
... focus is on quality assurance...

- BECx Design Phase Services

- BECx Pre-Construction Phase Services
  - Task A: Mock-Up Shop Drawing and Submittal Review Assistance
  - Task B: Observation of Mock-up and Performance Testing
  - Task C: Preconstruction Mock-up Performance Testing
  - Task D: Shop Drawing and Submittal Review Assistance
  - Task E: Pre-Construction Commissioning Meeting
  - Task F: Building Enclosure Trade Coordination/Pre-Construction Mtgs

- BECx Construction Phase Services

- BECx Post Construction Phase Services
Mock-up Performance Testing


Typical test sequence:

- Static Air Infiltration Test (ASTM E283)
- Static Water Test (ASTM E331)
- Dynamic Water Test (AAMA 501.1-83)
- Uniform Load Test (ASTM E330)
- Static Water Test (ASTM E331)
- Interstory Drift / Lateral and Vertical Movement (AAMA 501.4-200)
- Static Water Test (ASTM E331)
- Thermal Cycle (AAMA 501.5)
- Dynamic Water Test (AAMA 501.1-83)
- Structural Overload Test
- Thermal Resistance Test (AAMA 1503)
CONSTITUTION CENTER MOCK-UP - ACTION ITEMS

Item No: 1:
The lifting lugs / "knife plates" inhibited the placement of units at the head of the first floor rack. The steel plates, designed as a component of the blast resistance system, were required to be cut off approximately 2-3 inches to facilitate installation of units.

Action Required:
Davis/Enclos to resolve height of "knife" plates above the top of the unit to allow for ease of unit installation.

Item No: 2:
The silicone sheet seal between the head of the units and the base of the building was to be installed. Access behind the column was obtained by Enclos to facilitate the job. Brake metal angle transitioning between the head of the unit and the bridging of the unsupported membrane was not installed.

Action Required:
Davis/Enclos to confirm details and accessibility to install silicone seal.

Item No: 3:
Inside corner at head of metal panel column cover was fabricated with additional length of the piece creating a skewed corner. The piece was not cut to the correct size.

Action Required:
Davis/Enclos to determine if the error was human or dimensional. V ensure non-repeat of item (unless human error).

Item No: 4:
The SFF application at head of curtain wall was held back to facilitate a deterioration resulting from structural loading tests.

Action Required:
Davis/Enclos to submit report detailing the air barrier stop drawn head of the curtain wall.

Item No: 5:
The application of a continuous plane of SFF without air voids behind c nozzle distribution was too wide for the 1/2" inch cavity below the glass panel, and the grout of form did not penetrate back far enough, allowing multiple passes of SFF to build up sufficient depth without proper attention.

Action Required:
Davis/Enclos to review application with AABA & Demelco and use achieve design detail.

SmithGroup/WJE is to develop alternate detail utilizing mineral wool insulation for the fire-stop assembly related to alternate detail.

Item No: 6:
A missing piece of silicone sheet behind the splice joint in metal panel resulted in leakage at the pre-test.

Action Required:
Davis/Enclos to verify QA/QC process at metal panel fabrication.

Item No: 7:
The starter track at the base of the vertical metal panels included water joints to accommodate the recessed metal panels. This condition is specific to the mock-up and does not represent job built conditions. Refer to Encluss detail 1/325 for the job specific conditions at this interface. As a result of the molded starter tracks, water infiltration was observed at the interior during mock-up testing.

Action Required:
All parties agreed to an additional field chamber test (ASTM E-1105) to test the performance and identify potential issues with the continuous starter track condition not included in the mock-up.

Item No: 8:
A galvanite was observed at the seal beneath the metal panel sill plate at the stack joint transition.

Action Required:
Davis/Enclos to verify all seals are continuous and free of pinholes at recessed metal panel stack joint transition.

Item No: 9:
A field applied sealant was found to be missing at a gutter leg / "chicken-lead" to primary vertical seal interface. WJE noticed at this interface during dynamic water penetration testing (AAMA 501.1). Enclos installed their proposed field repair for this condition. This repair consists of a fillet seal applied to the backs of the gutter leg / "chicken-lead" to primary vertical seal interface applied from the interior.

Action Required:
All parties agreed to test the Enclos proposed field repair for this deficiency. The additional dynamic water penetration test (AAMA 501.1) is to occur between steps 14 and 15 of the approved mock-up test procedures. WJE also recommends that an installation procedure for all field installed sealants be submitted by Enclos for review and approval by Smith Group. Davis/Enclos to verify QA/QC process at test seal installation.

Note: Irrigated test procedures to be discussed between WJE and SD. Additional technical requirements will be determined pending SCA/EIE discussions.

Item No: 10:
The "condensation gutter" located directly behind the gutter leg is drained to the exterior. The slop includes a rerouted downspout. During testing, water leakage was noted to be captured within the condensation gutter and flow to the exterior.

Action Required:
The gutter is located behind the defined air intrusion seal. The function of this detail and definition of leakage should be clarified. Details which allow drainage of the "condensation gutter" behind the line of air intrusion seal are recommended to be reviewed carefully for potential compromise to adjacent wall cladding components.
Submittal Reviews

- Technically-focused review of the building enclosure submittals
- Meet performance objective?

- Interface with design and construction team
  - Performance and constructability of details
  - Impacts to schedule and cost
  - Durability
  - Compatibility / Adhesion
  - Coordination between submittals
Questions?