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BUILDING ENCLOSURE CONFERENCE 2023

Megapanel Mania: Prefabricated Exterior Wall Assemblies

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AIA Continuing Education Provider

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Megapanel Mania: Prefabricated Exterior Wall Assemblies

BUILDING ENCLOSURE CONFERENCE 2023

Prefabrication of exterior wall systems and assemblies is a growing trend in the construction industry. There are many terms used to describe this process (panelized, modularized, unitized, etc.) and the definition and scope of prefabrication can be as unique as the project itself. For many projects, the exterior walls are anticipated to be panelized or unitized from the start as is often the case with precast concrete panels and aluminum-frame curtain wall systems. However, sometimes modularization is proposed by the construction team after design is complete as a means of expediting the schedule, addressing site access constraints, and/or lowering project costs. The presenters will describe different types of panelized exterior wall assemblies and will present a case study regarding a 10-story, 700,000 square foot healthcare facility that utilized megapanel exterior wall construction. The change to a panelized approach occurred after the design was complete, resulting in challenges associated with continuity of air, water, and thermal control layers, particularly at the interface conditions. Perspectives and lessons learned from the building enclosure commissioning provider (BECxP) and contractor's building enclosure consultant for this project will also be offered.

Learning Objectives

1. Understand various exterior wall prefabrication techniques and several advantages and drawbacks of panelized construction.
2. Demonstrate an understanding of building science and the impacts of megapanel joinery and transitions with respect to building enclosure performance and continuity of air, water, thermal, and vapor control layers.
3. Appreciate challenges associated with integrating exterior wall and roof construction in panelized assemblies.
4. Describe building enclosure quality assurance and quality control efforts that can be performed in the prefabrication facility, for mock-ups, and at the construction site.

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BE BUILDING ENCLOSURE

Outline

- Types of Prefabricated Wall Assemblies
- Code Requirements for Prefab Walls
- Challenges and Benefits
- Story of Our Project
- Project Stakeholder Roles
- Conclusions / Lessons Learned

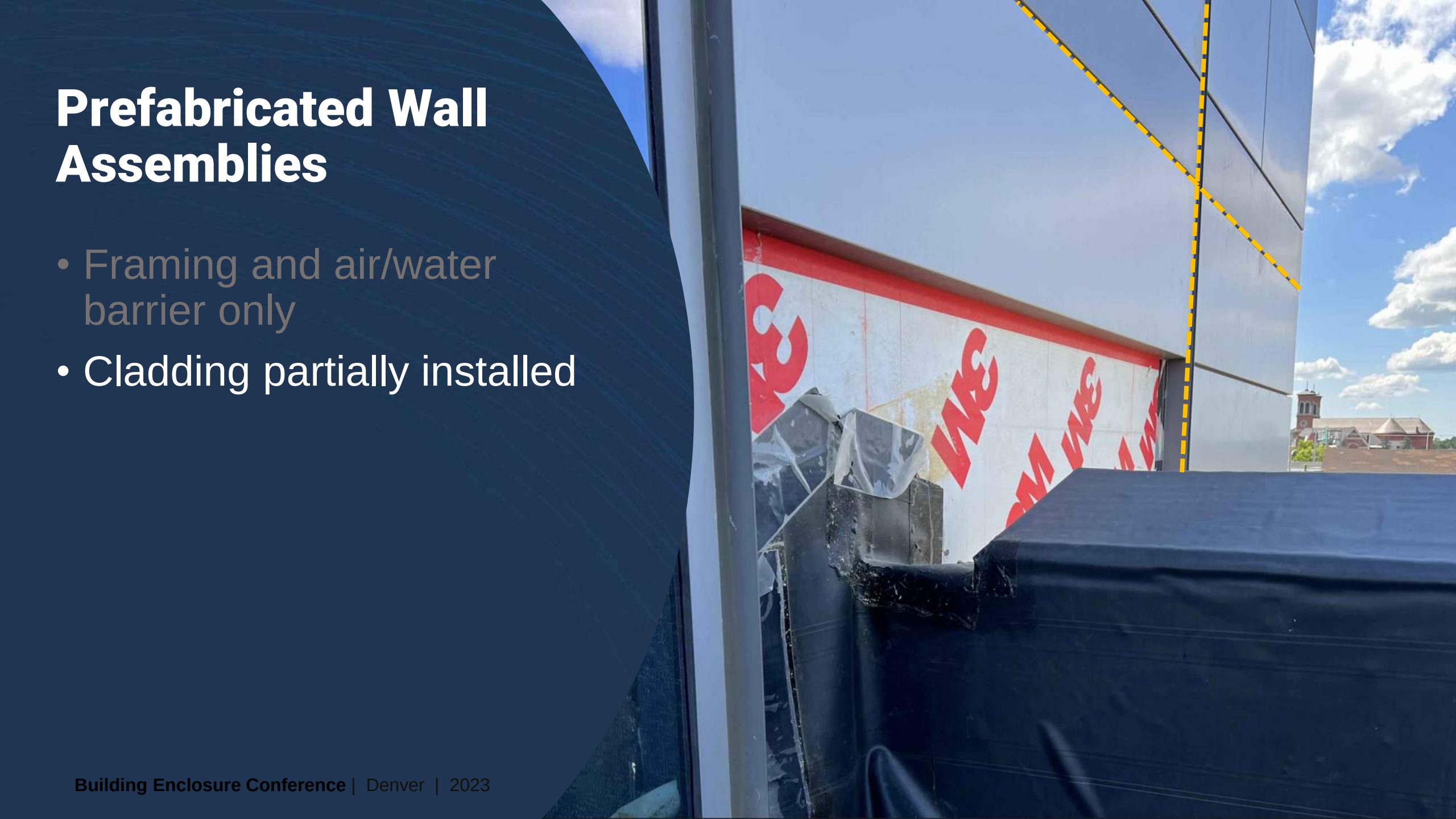
Prefabricated Wall Assemblies

Prefabricated Wall Assemblies

- Framing and air/water barrier only

Prefabricated Wall Assemblies

- Framing and air/water barrier only
- Cladding partially installed



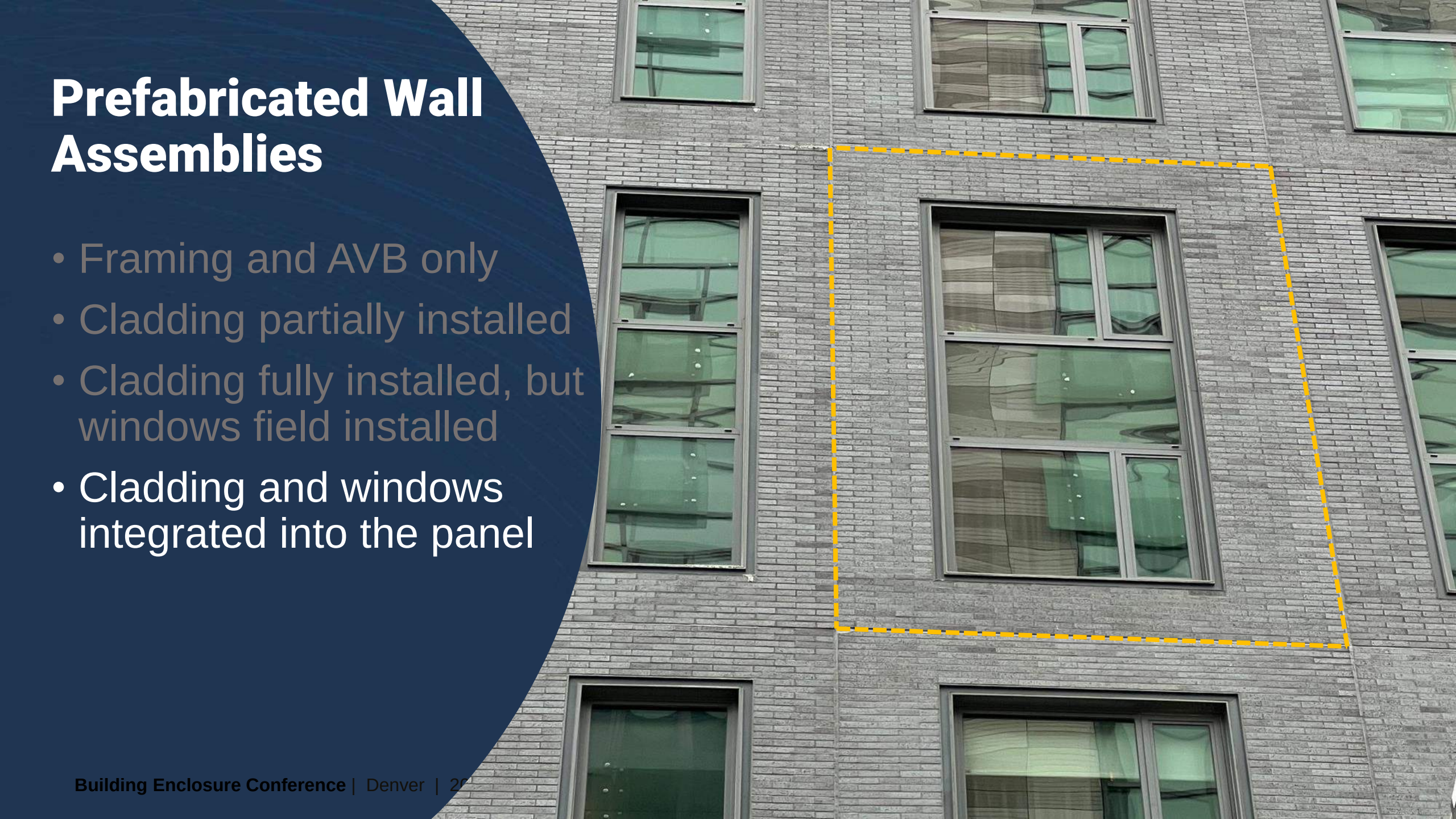
Prefabricated Wall Assemblies

- Framing and AVB only
- Cladding partially installed
- Cladding fully installed, but windows field installed

Image courtesy of atilla.co

Prefabricated Wall Assemblies

- Framing and AVB only
- Cladding partially installed
- Cladding fully installed, but windows field installed
- Cladding and windows integrated into the panel



Prefabricated Wall Assemblies

- Framing and AVB only
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- Unitized curtain wall

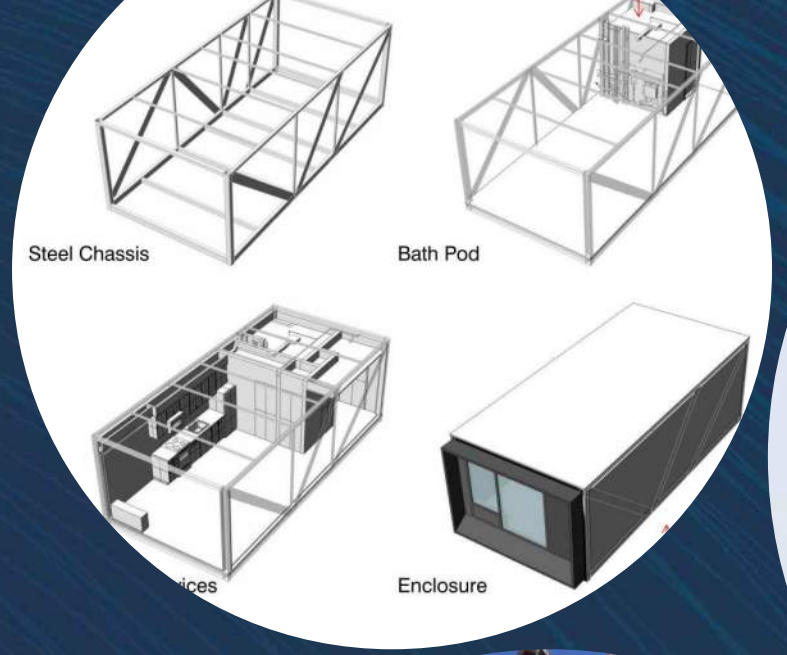
Prefabricated Wall Assemblies

- Framing and AVB only
- Cladding partially installed
- Cladding fully installed, but windows field installed
- Cladding and windows integrated into the panel
- Unitized curtain wall
- Modular
  - Residential

Images courtesy of Huntington Homes

Prefabricated Wall Assemblies

- Framing and AVB only
- Cladding partially installed
- Cladding fully installed, but windows field installed
- Cladding and windows integrated into the panel
- Unitized curtain wall
- Modular
  - Commercial

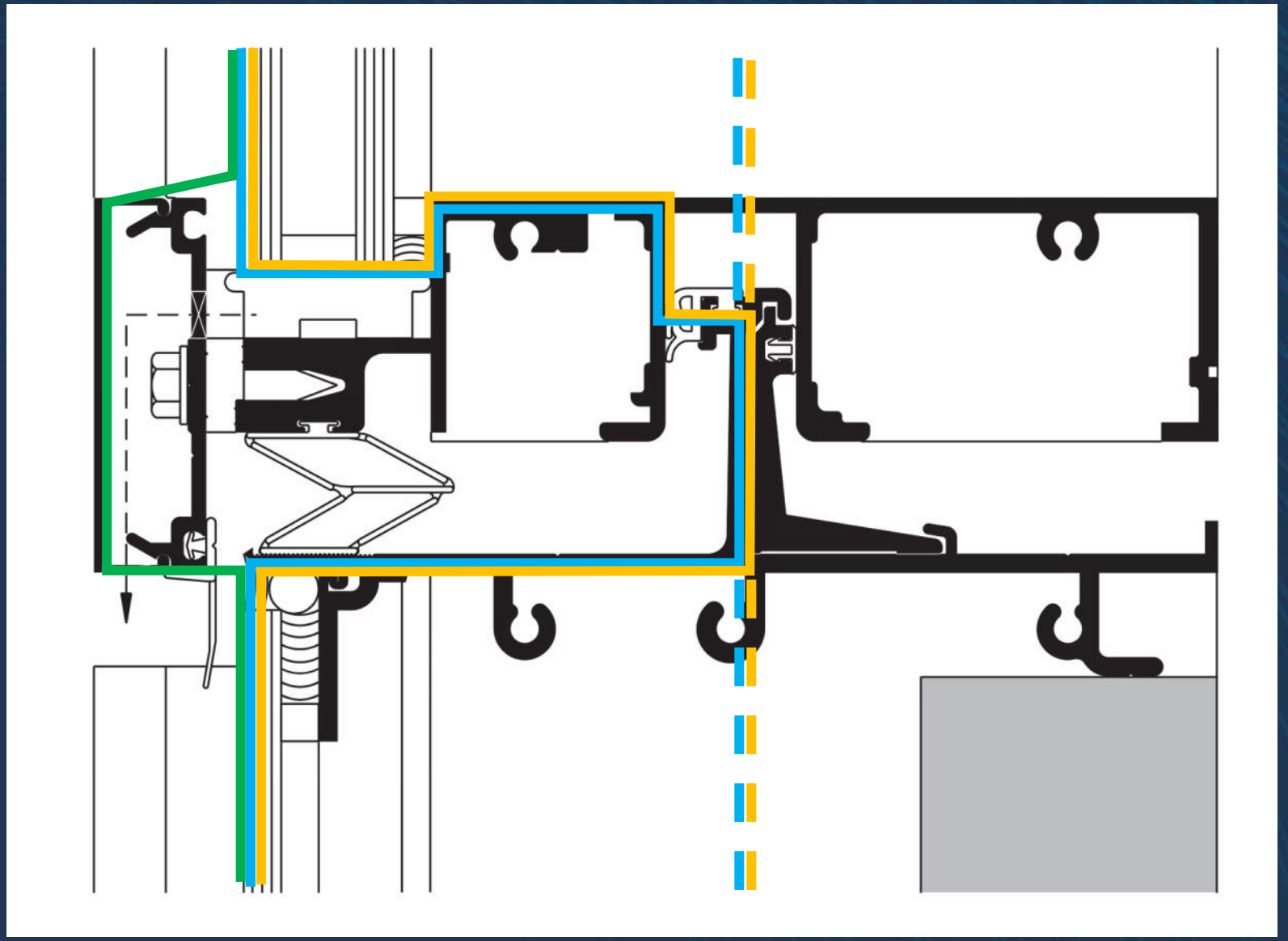


Images courtesy of Forest City Modular

Joinery Between Modules

EXTERIOR

INTERIOR



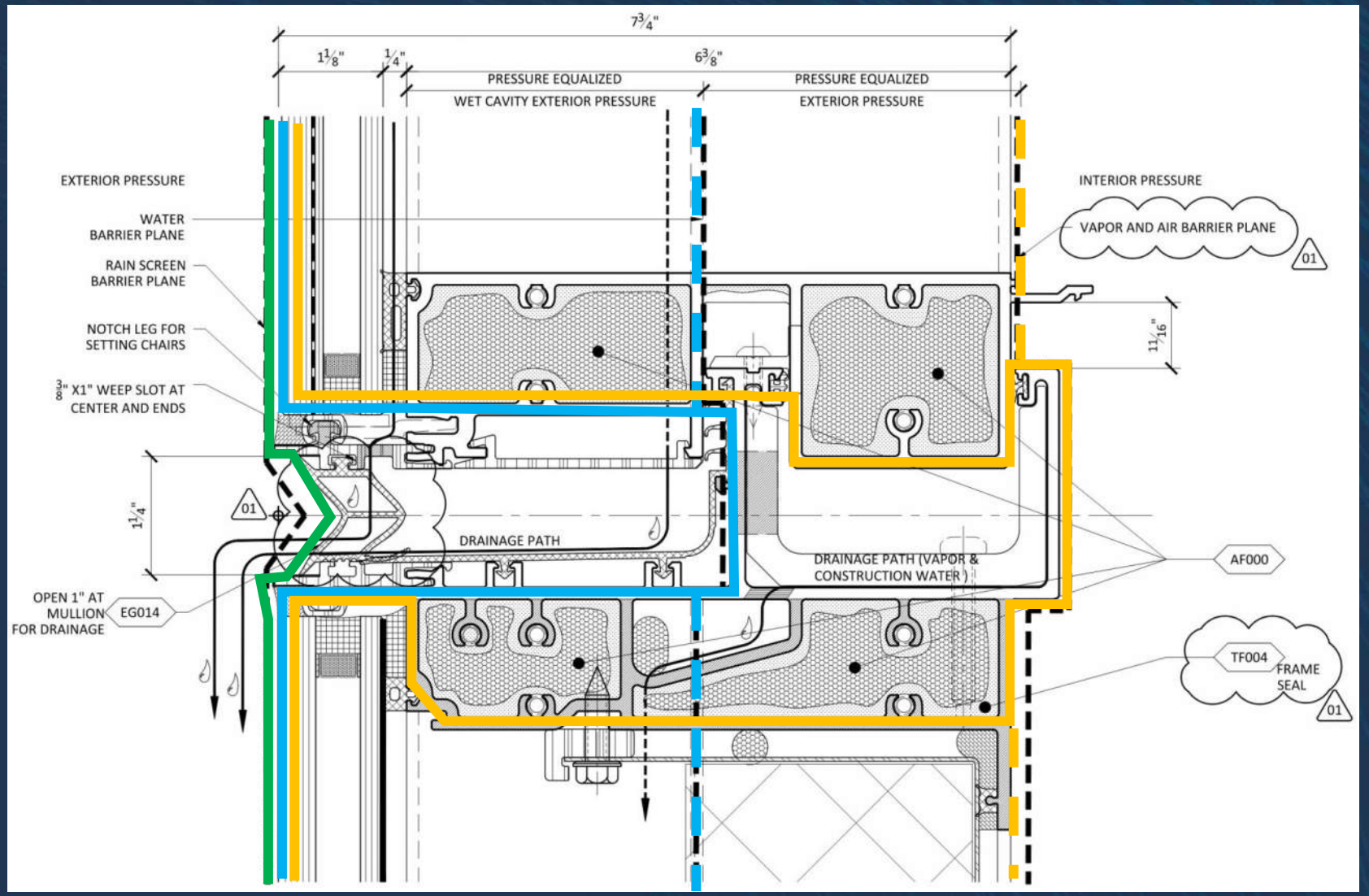
Rainscreen

Water control

Air control

EXTERIOR

INTERIOR



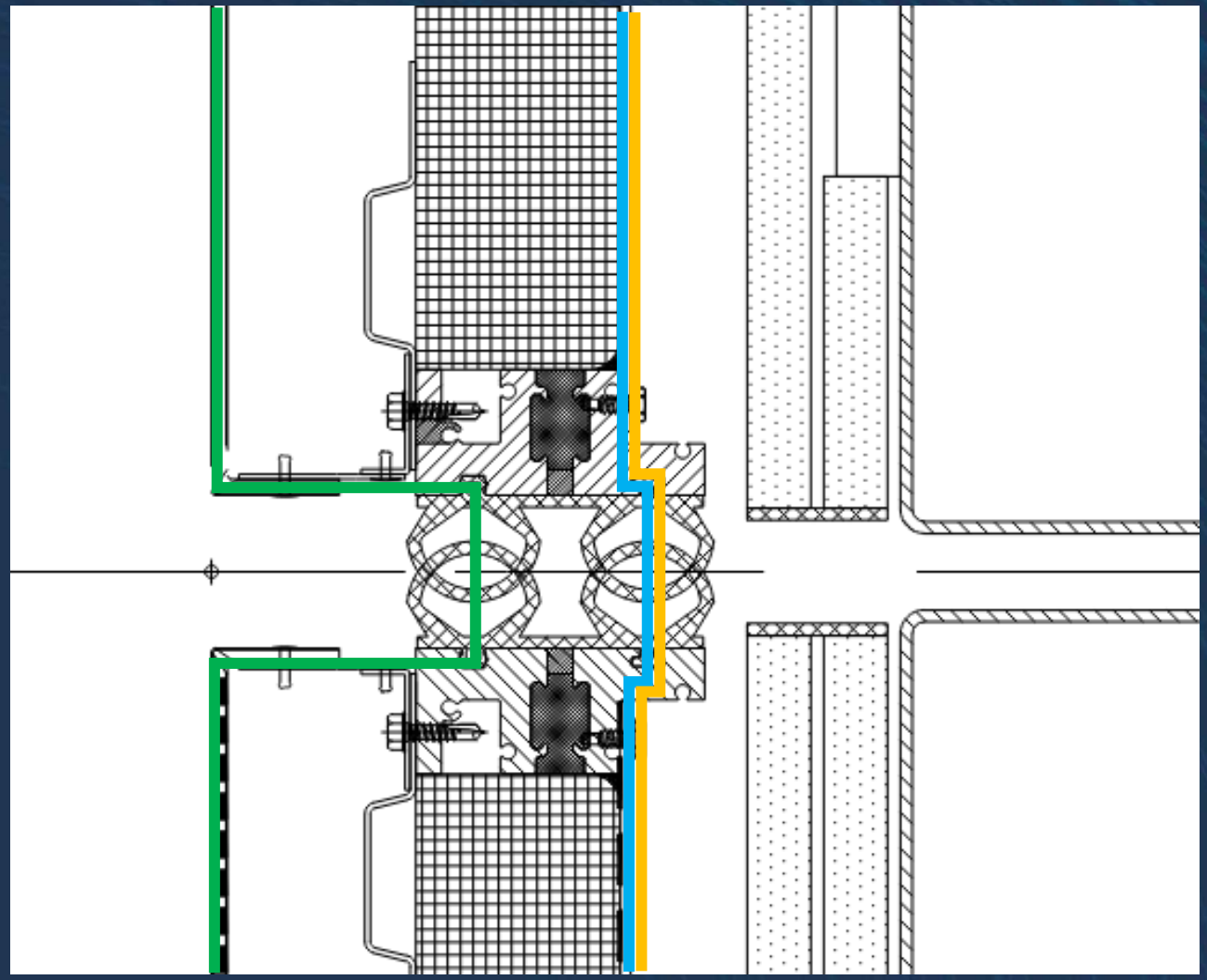
Rainscreen

Water control

Air control

EXTERIOR

INTERIOR



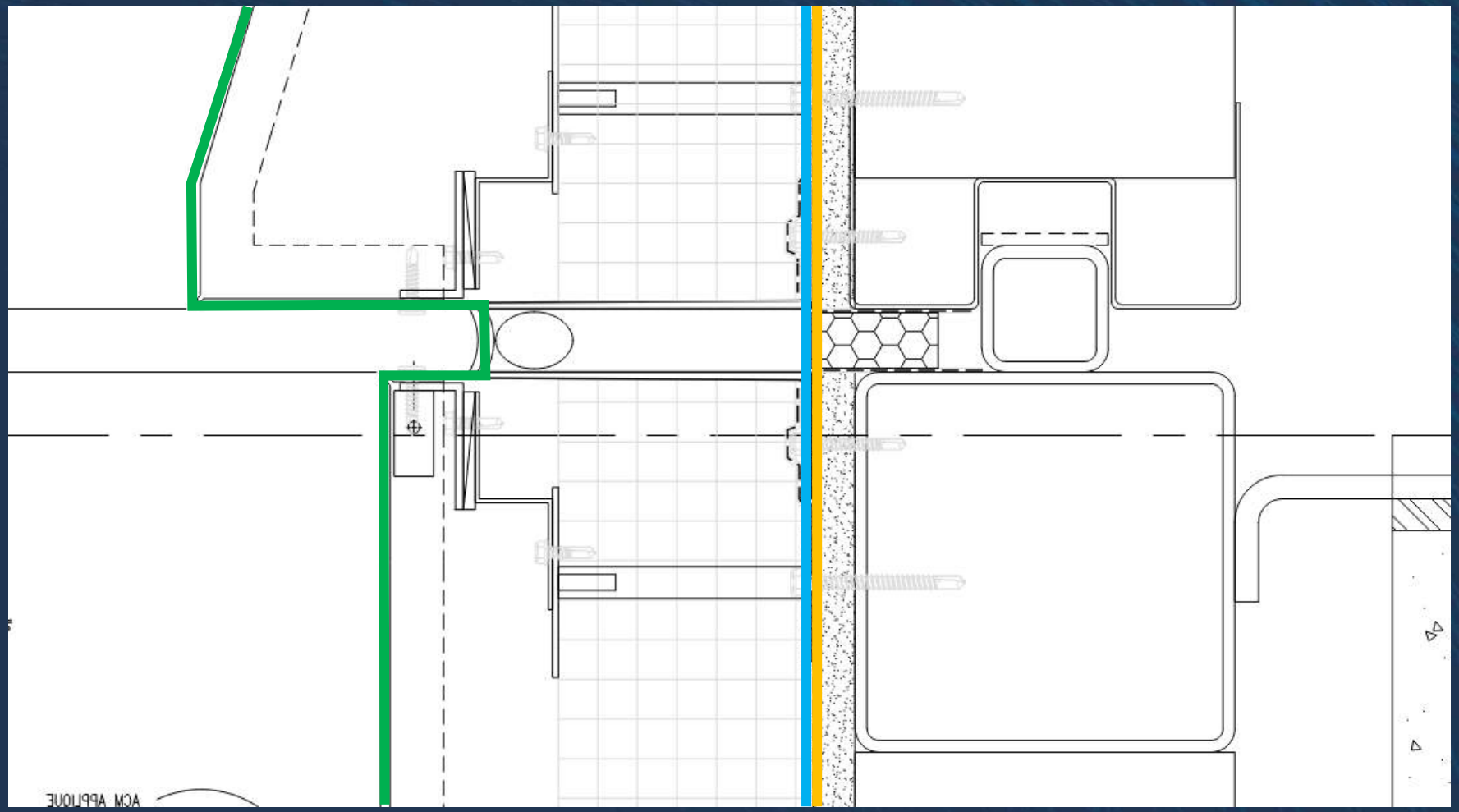
Rainscreen

Water control

Air control

EXTERIOR

INTERIOR



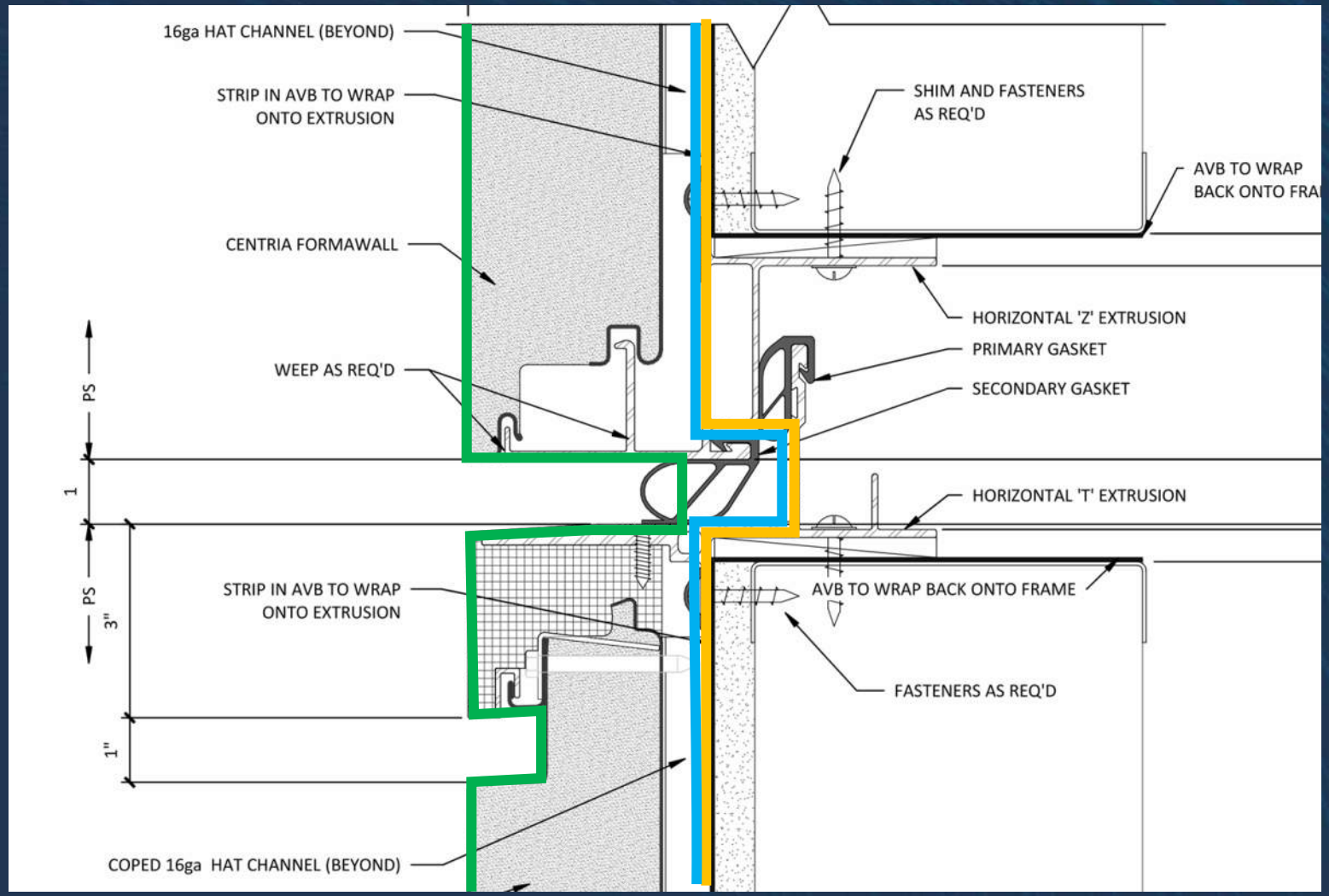
Rainscreen

Water control

Air control

EXTERIOR

INTERIOR



Rainscreen

Water control

Air control

Challenges and Benefits

Benefits

- Speed of erection
- Controlled weather during fabrication (typically)
- Shop quality control
- Minimizes site material storage needs

Challenges

- Less flexible to field changes
- Requires upfront coordination
- May limit/dictate cladding selection/design (weight and shipping to be considered)
- Interface conditions

⟵ Schedule & Cost ⟶

Code Requirements

Largely no different than any exterior wall assembly…

But, we test unitized curtain walls in a laboratory setting…

What about mega panel wall assemblies?

Code Requirements

- The building code requires laboratory testing of windows and doors per ASTM E330 (structural testing) (§1709.5 – IBC 2021)
  - Glazed curtain walls fall into this definition.
  - Opaque walls of similar framing type would not.

1709.5.1 Exterior Windows and Doors

Exterior windows and sliding doors shall be tested and *labeled* as conforming to AAMA/WDMA/CSA101/I.S.2/A440. The *label* shall state the name of the manufacturer, the *approved* labeling agency and the product designation as specified in AAMA/WDMA/CSA101/I.S.2/A440. Exterior side-hinged doors shall be tested and *labeled* as conforming to AAMA/WDMA/CSA101/I.S.2/A440 or comply with Section 1709.5.2. Products tested and *labeled* as conforming to AAMA/WDMA/CSA 101/I.S.2/A440 shall not be subject to the requirements of Sections 2403.2 and 2403.3.

1709.5.2 Exterior Windows and Door Assemblies Not Provided for in Section 1709.5.1

Exterior window and door assemblies shall be tested in accordance with E330. Exterior window and door assemblies containing glass shall comply with Section 2403. The design pressure for testing shall be calculated in accordance with Chapter 16. Each assembly shall be tested for 10 seconds at a load equal to 1.5 times the design pressure.

Code Requirements

- The energy code requires laboratory testing of air barrier assemblies (§C402.5.1.4 - IECC 2021).

C402.5.1.4 Assemblies

Assemblies of materials and components with an average air leakage not greater than 0.04 cfm/ft^2(0.2 L/s × m^2) under a pressure differential of 0.3 inch of water gauge (w.g.)(75 Pa) when tested in accordance with ASTM E2357, ASTM E1677 , ASTM D8052 or ASTM E283 shall comply with this section. Assemblies listed in Items 1 through 3 shall be deemed to comply, provided that joints are sealed and the requirements of Section C402.5.1.1 are met.

1. Concrete masonry walls coated with either one application of block filler or two applications of a paint or sealer coating.
2. Masonry walls constructed of clay or shale masonry units with a nominal width of 4 inches (102 mm) or more.
3. A Portland cement/sand parge, stucco or plaster not less than $^1/_2$ inch (12.7 mm) in thickness.

Code Requirements

- **E2357 –** Standard Test Method for Determining Air Leakage Rate of Air Barrier Assemblies
- **E1677 –** Standard Specification for Air Barrier (AB) Material or Assemblies for Low-Rise Framed Building Walls
- **D8052 –** Standard Test Method For Quantification Of Air Leakage In Low-Sloped Membrane Roof Assemblies
- **E283 –** Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen

C402.5.1.4 Assemblies

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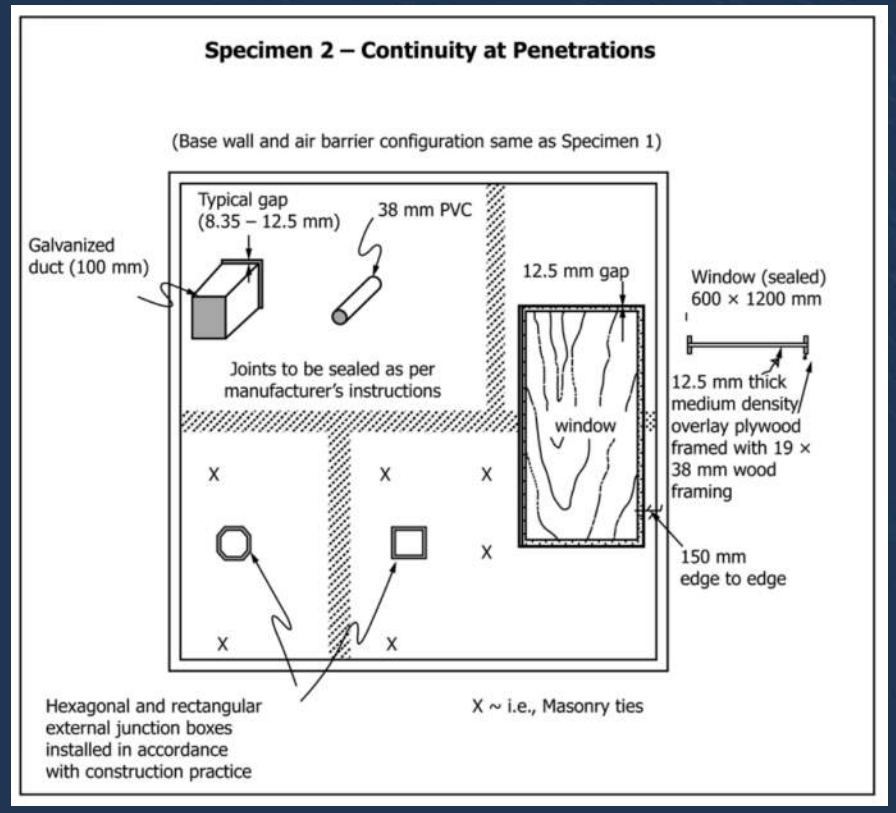
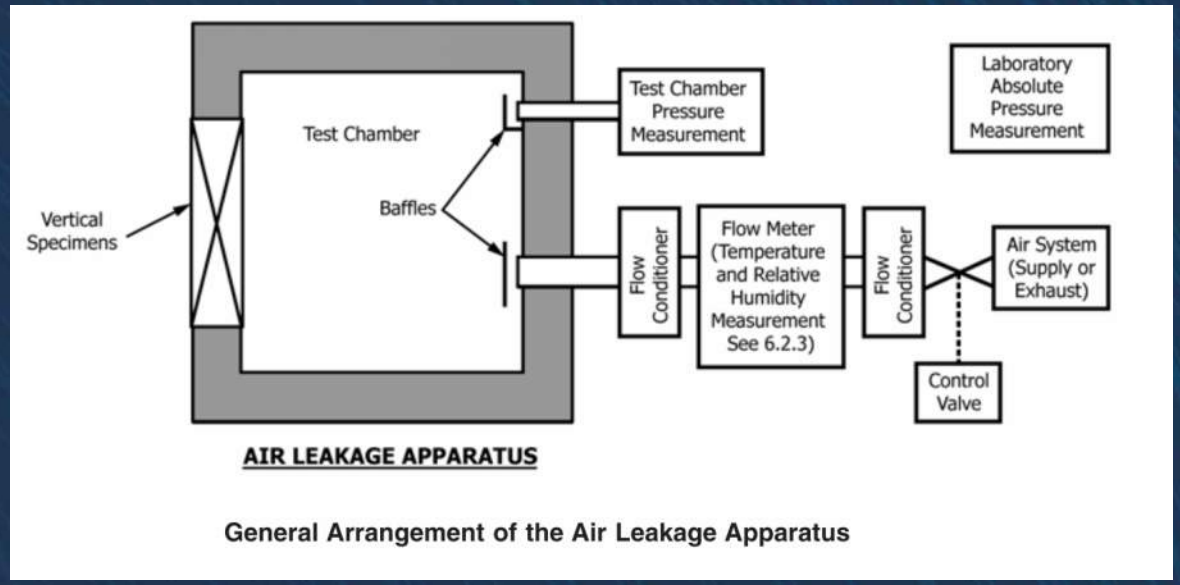


- **E283** - Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen.



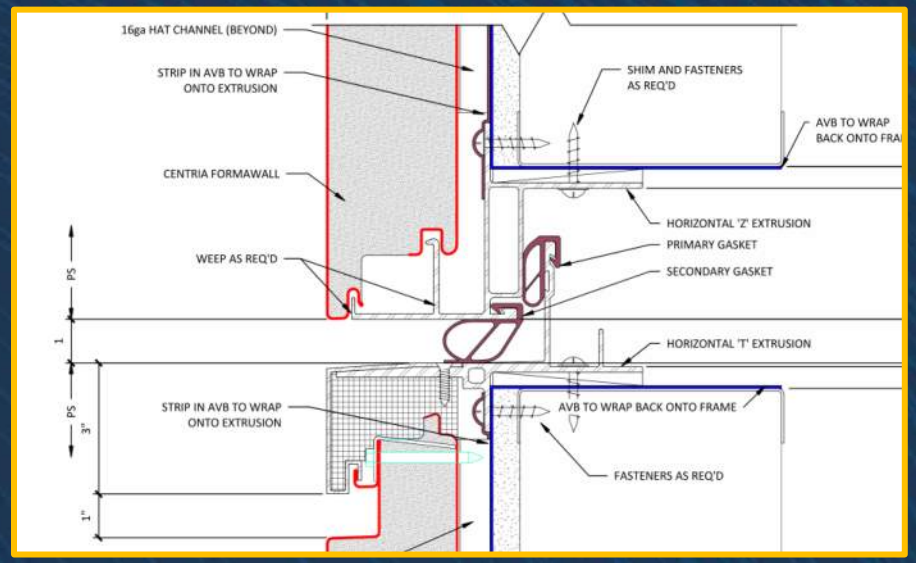
General Arrangement of the Air Leakage Apparatus

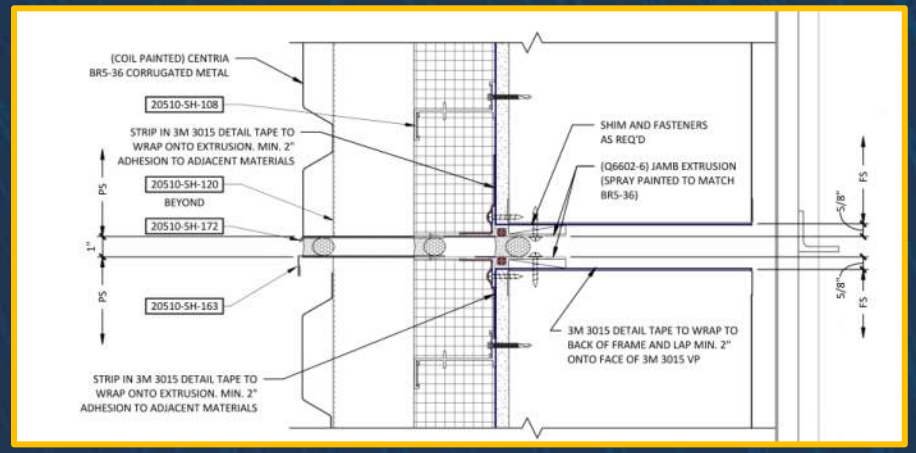
Code Requirements

- Should the joint in the megapanel wall assembly be considered part of the “assembly” and subject to testing?

Code Requirements

- Does your opinion change if the panel joint is gasketed vs. sealed with sealant?





Code Requirements (our conclusion)

- The IBC does not definitively require laboratory testing of “megapanels” so long as components can be designed via AHJ approved engineering analysis.
- If sealant joints are employed at panel joinery, they are likely already part of a “tested” air barrier assembly.
- If gasketed panel joints are employed, they may not be part of a pre-tested assembly and assembly testing may be warranted.

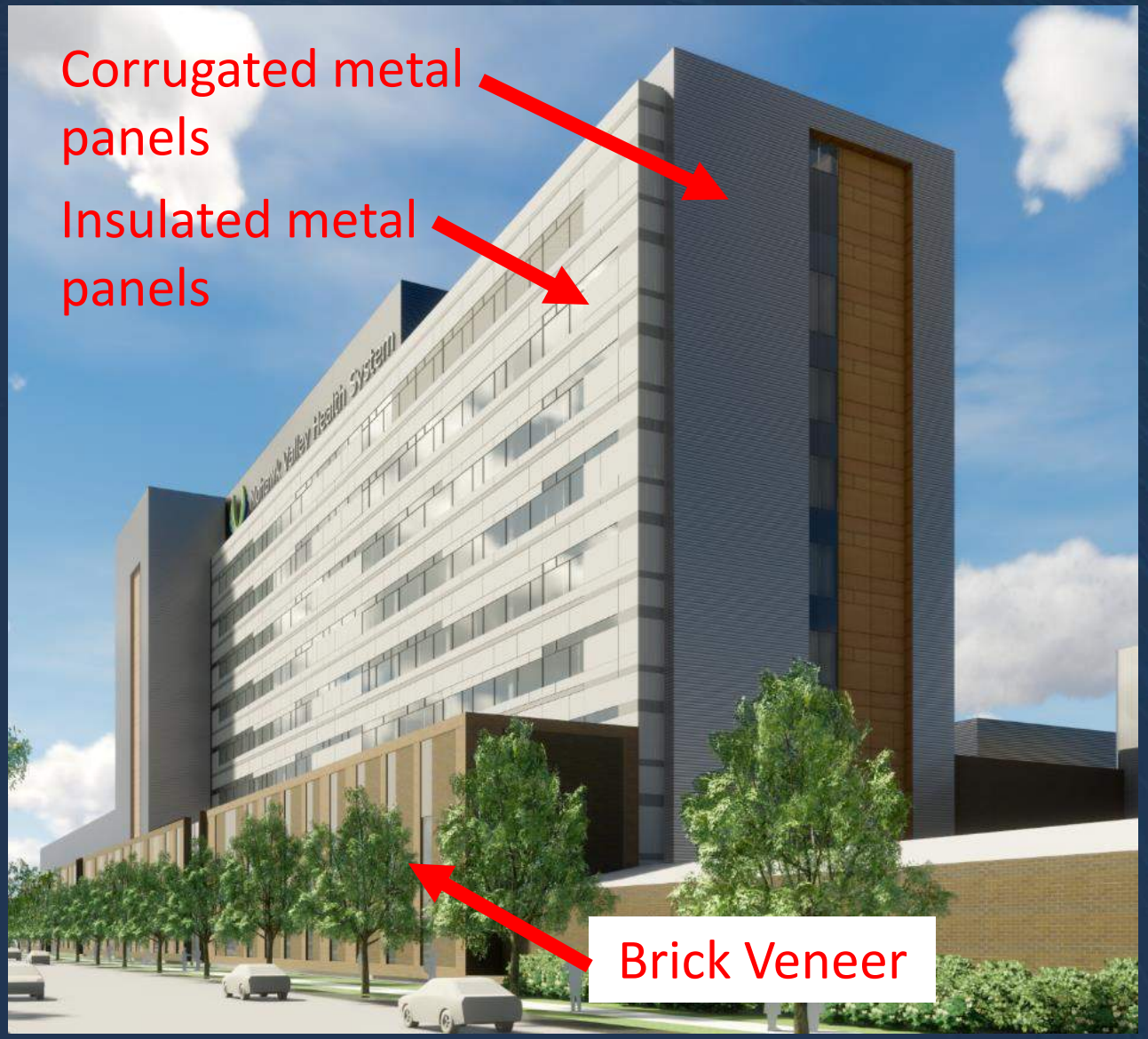
Questions to Ask Early

- Track-record: project examples and details
- Previous laboratory performance testing ?
- Previous field performance testing ?
- Who is responsible for integration/transition detailing?
- Structural coordination for loads imposed on structure.
- Are U-factor and condensation resistance requirements met – particularly at joinery?
- What, if any, components need to be field installed from the exterior?

Case Study

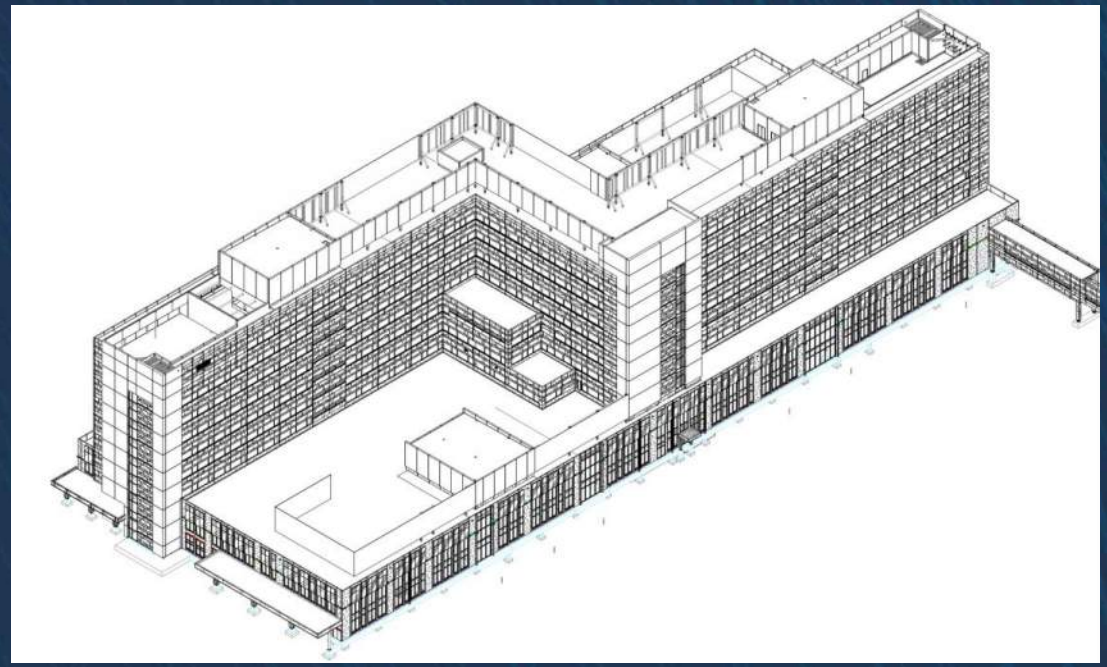
Megapanels

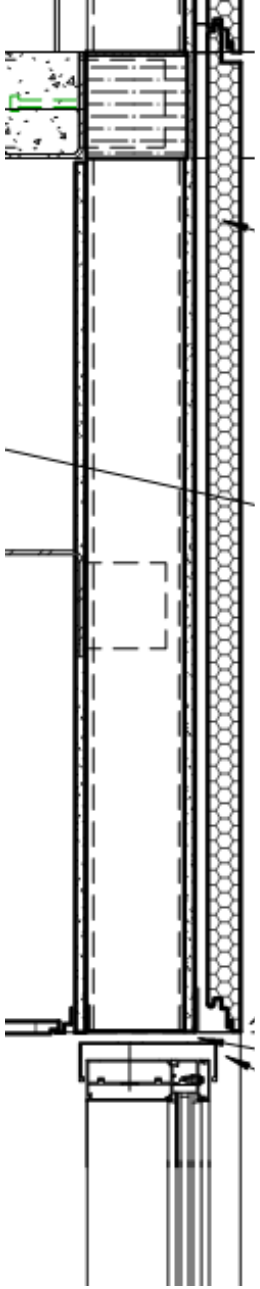
Tower



Podium

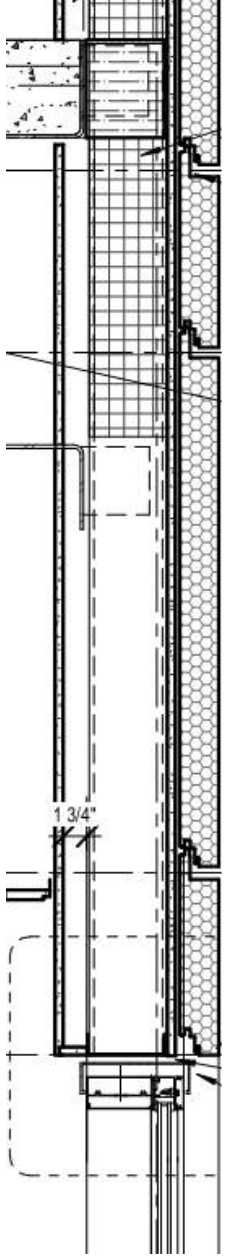
- 10-story, 690,000 square foot healthcare facility, 373 beds
- Location: Upstate New York
- Steel structural system
- Exterior walls: cold-formed steel stud back-up walls





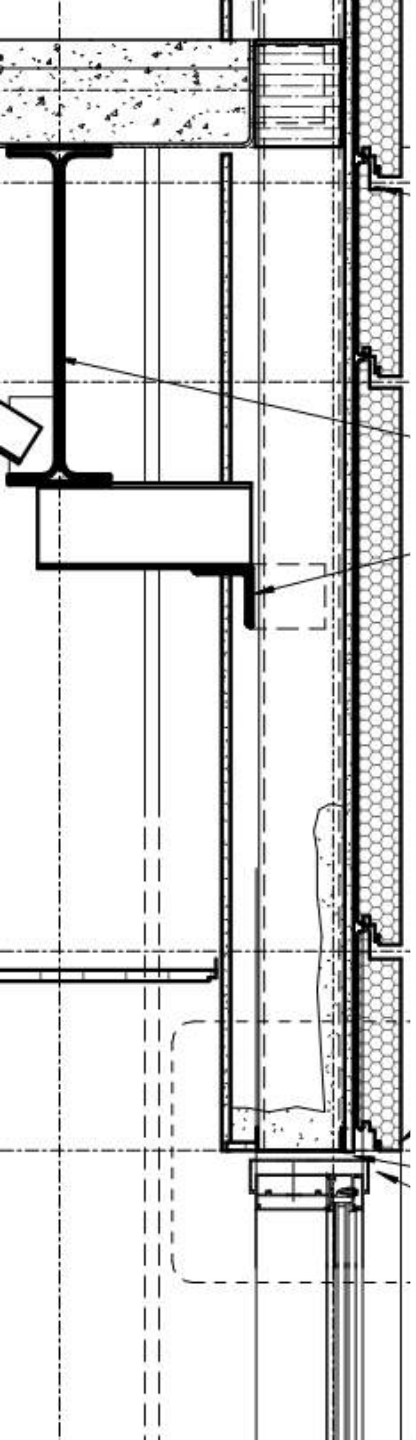
SD May 2018

No Exterior
Sheathing or AWB
(Barrier Wall)



DD March 2019

Exterior Sheathing and AWB
(Cavity Wall w/ Drainage Plane)

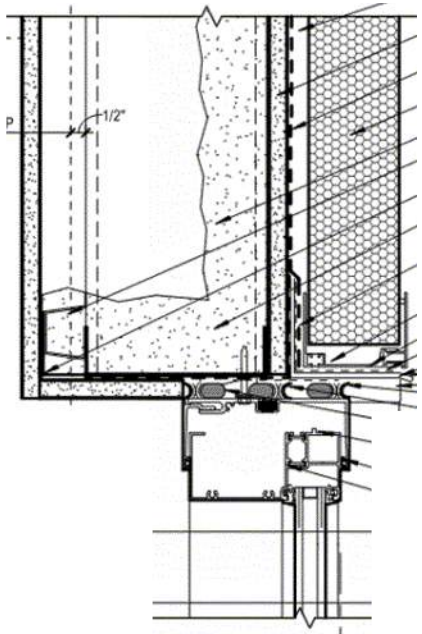


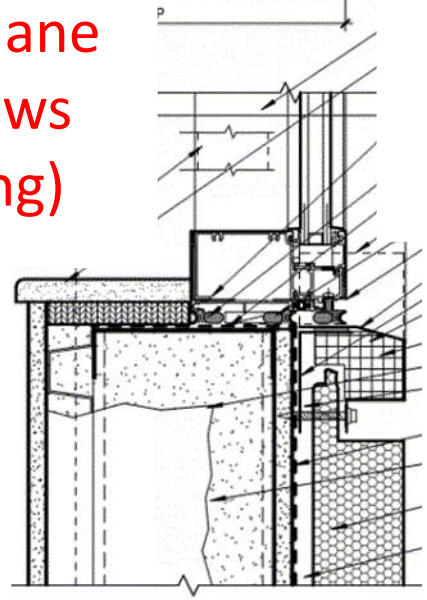
IFC April 2020

Exterior Sheathing and AWB

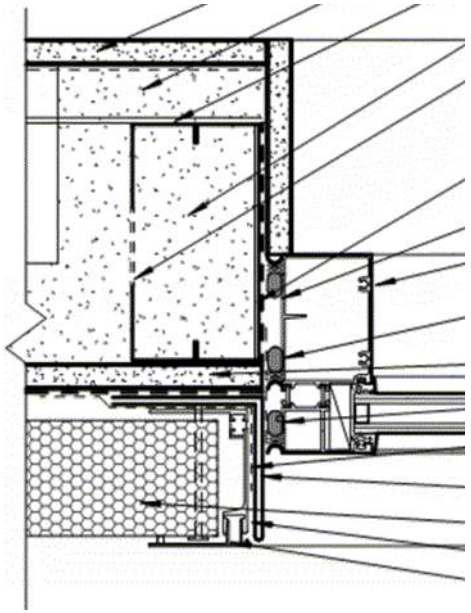
- Cavity Wall w/ Drainage Plane
- Interior SPF around windows (based on THERM modeling)

Window Wall Head

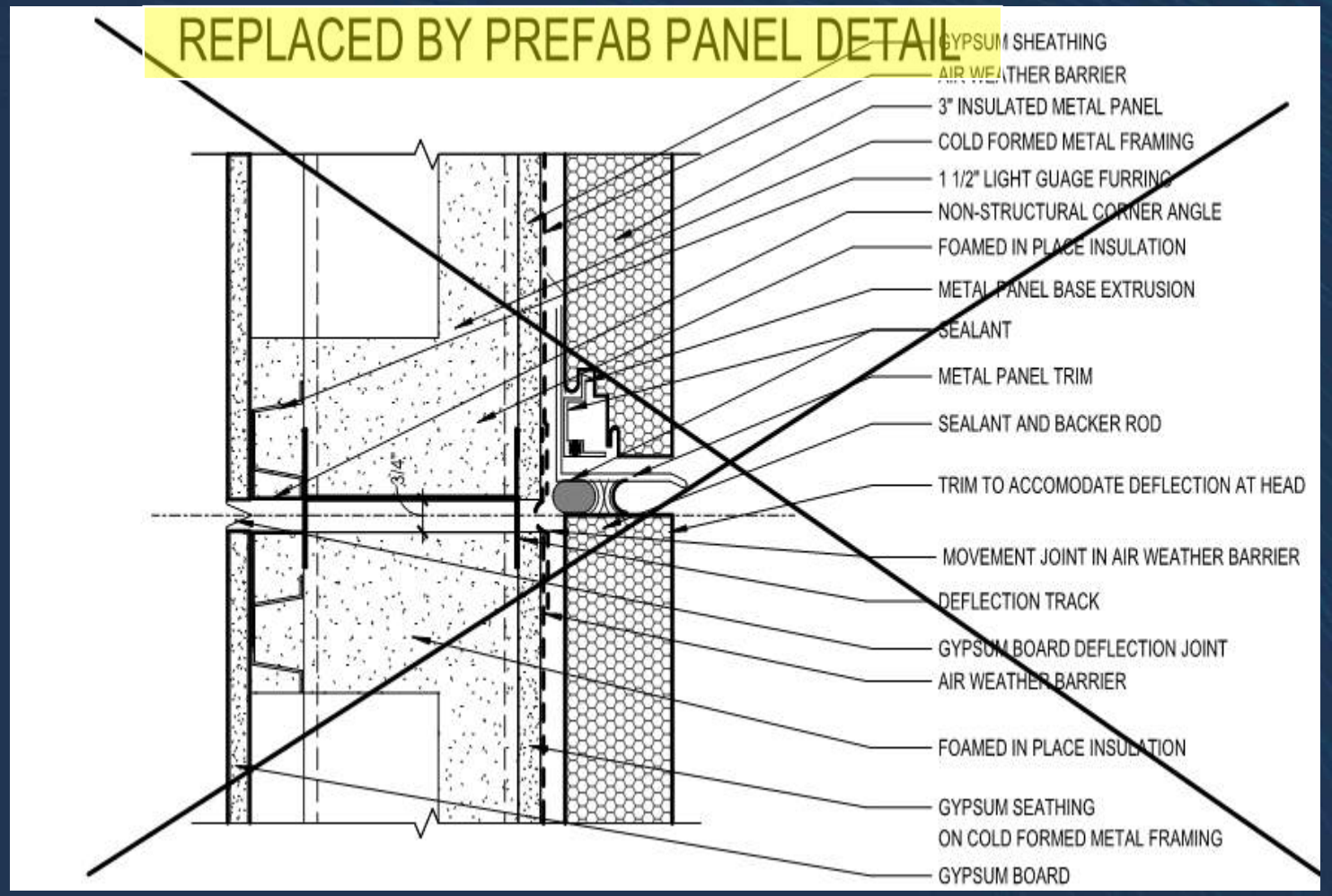


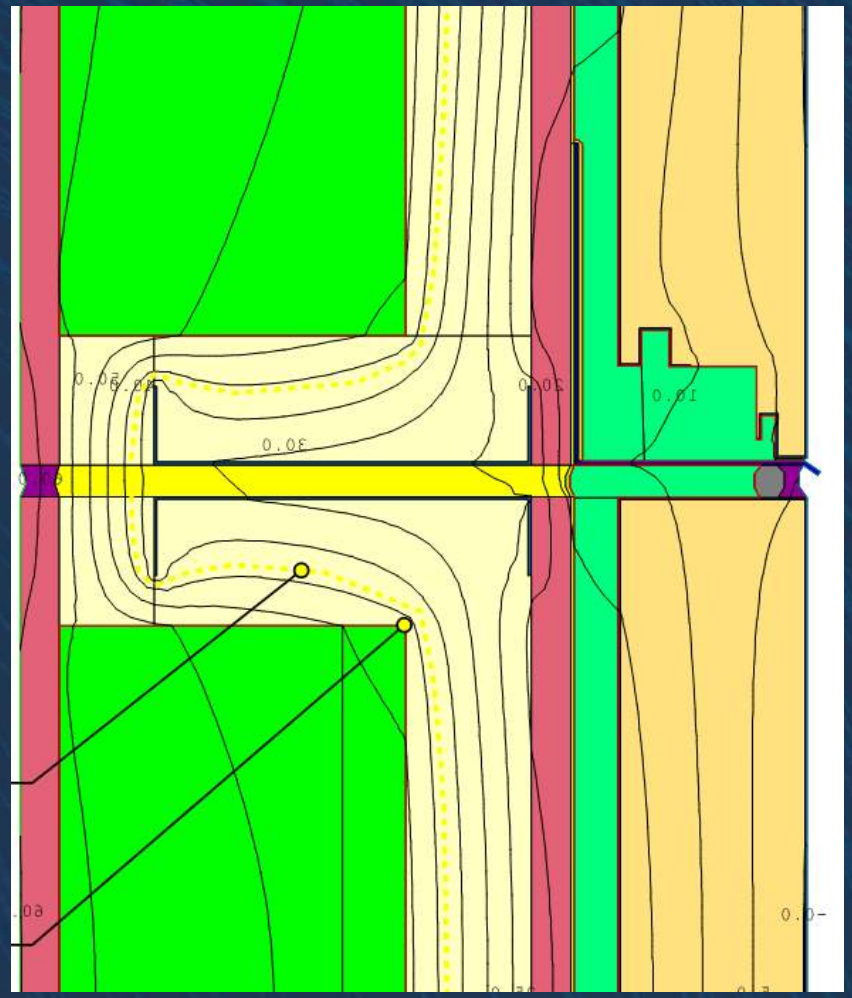


Window Wall Sill



Window Wall Jamb





“Mega Panels” April 2020

Project Schedule At-a-Glance

2018-2019

- May 2018: A/E issues SD documents
- Sept 2018: RRJ retained as BECxP
- Nov 2018: OPR discussions and preliminary THERM models
- Mar 2019: A/E issues DD documents
- July 2019: GC change near end of pre-construction phase
- Dec 2019: A/E issues 90% CD's, break ground

2020

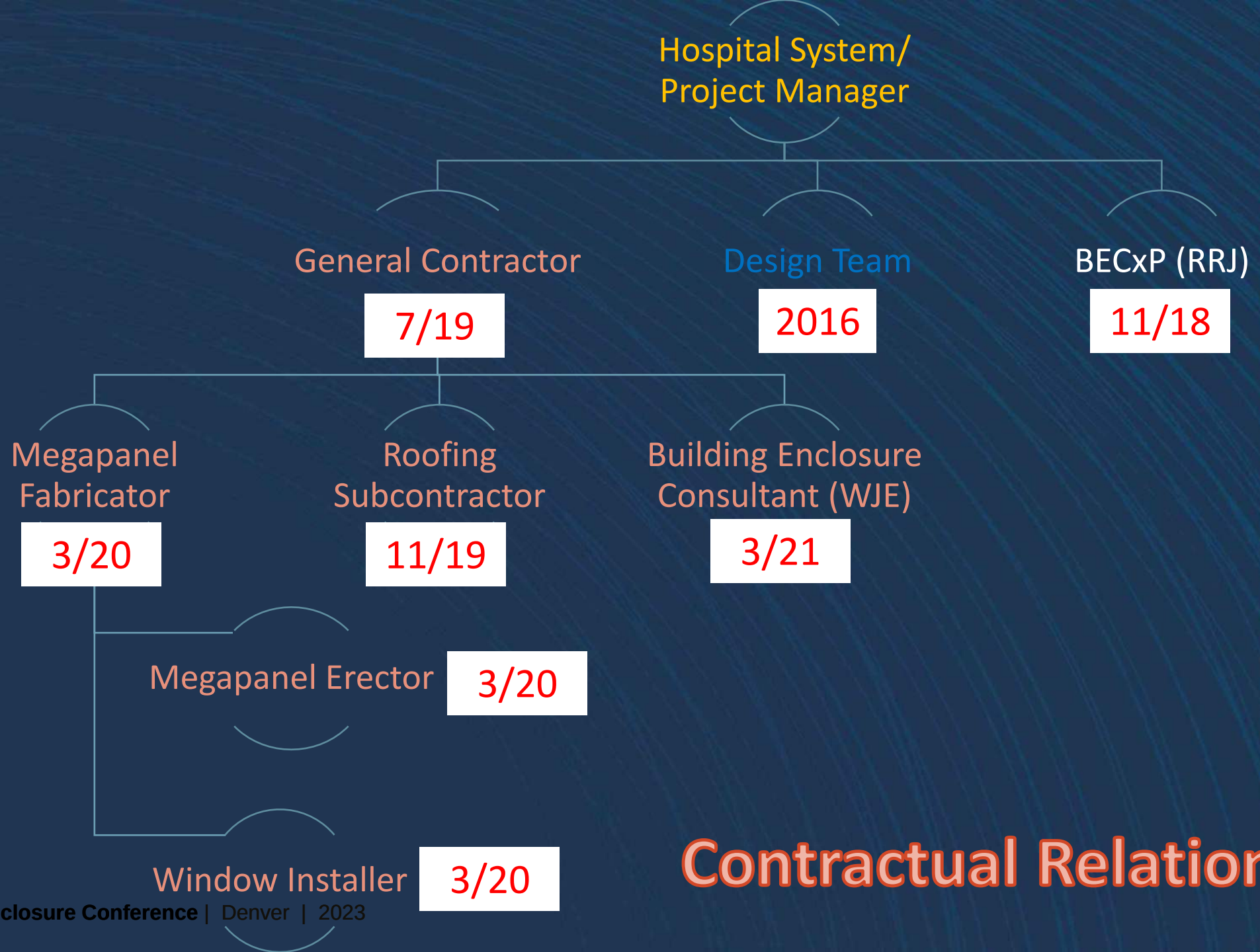
- Mar: Megapanel contractor selected by GC
- March: Covid-19!!!
- Apr: A/E issues IFC set (including BECx specifications)
- May: Preliminary megapanel drawings provided
- Aug: Initial mock-up shop drawings provided
- Nov: Site visit to mega panel fabrication facility, AWB testing

2021

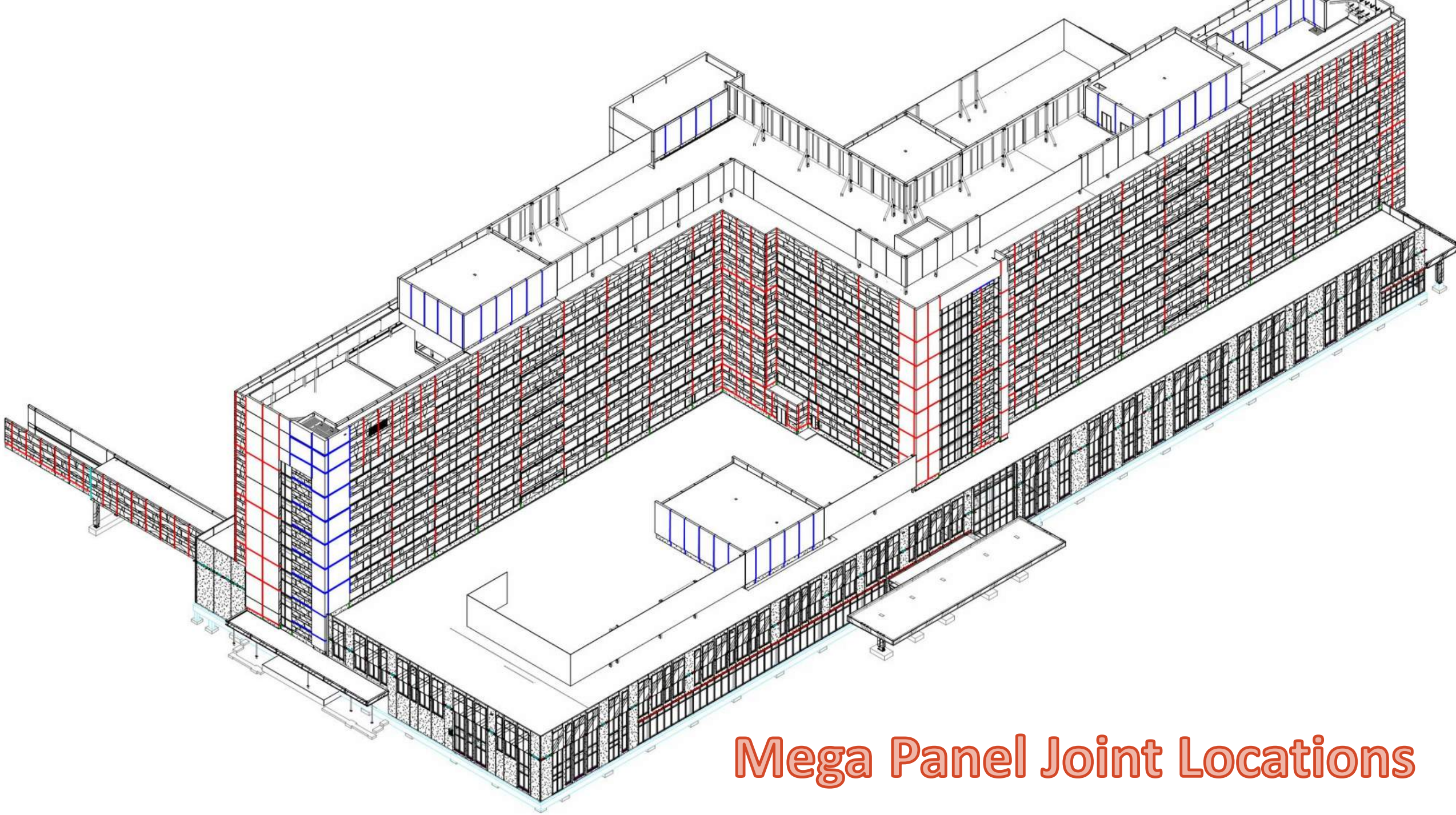
- Mar: WJE retained as consultant for GC
- Mar: Megapanel shop drawings issued
- Apr: BECx mock-up testing (part 1)
- May: BECx mock-up testing (part 2)
- July: Megapanel erection at Tower commences
- Aug: BECx testing at podium commences
- Oct: BECx testing at tower commences

2022-2023

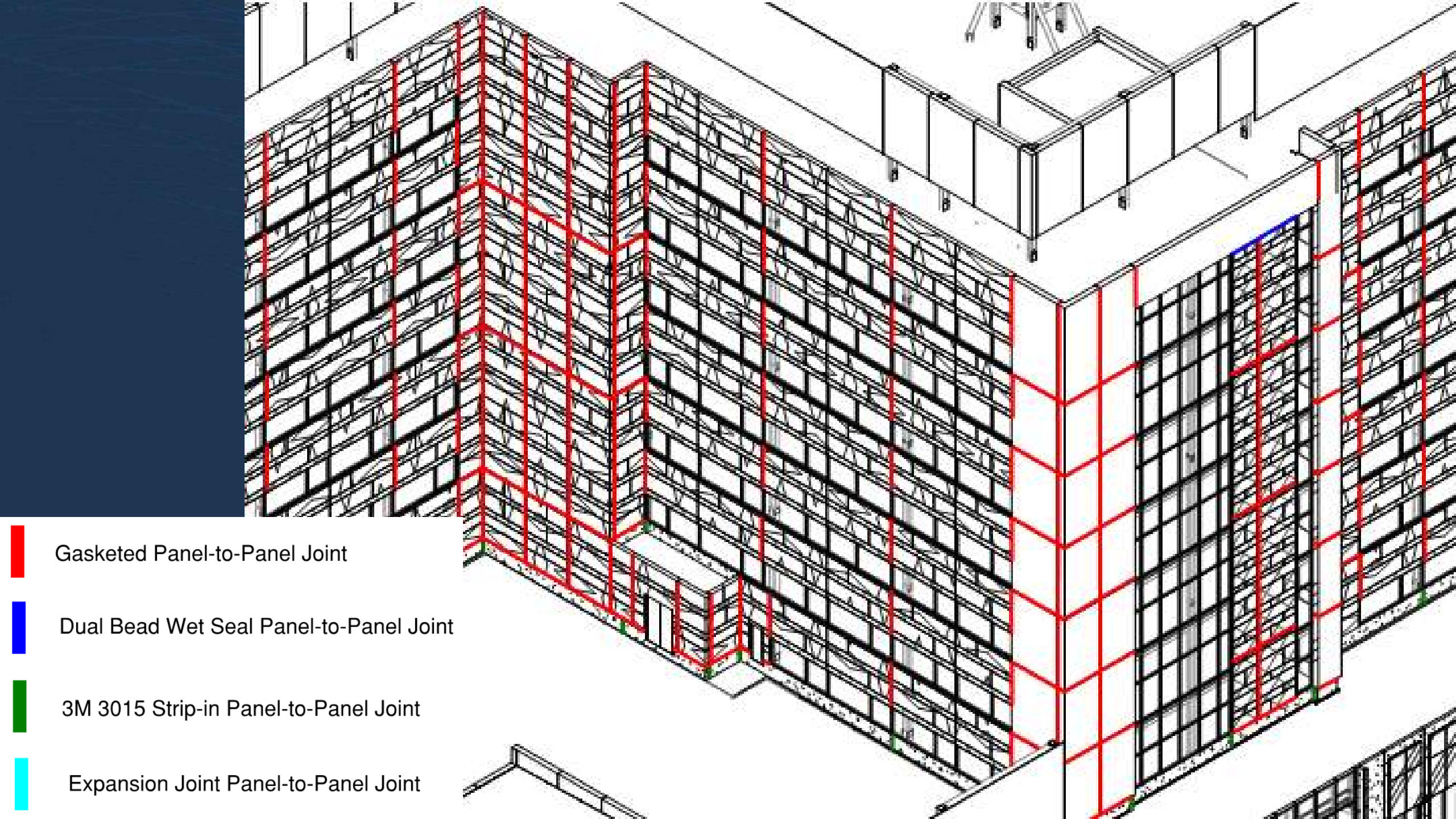
- Apr 2022: Tower Megapanel install substantially complete
- May 2022: WJE issues initial sketches to address interface conditions
- June 2022: WJE, RRJ and project team first site visit to review interface conditions
- April 2023: Most recent BECxP site visit
- August 2023: Substantial Completion



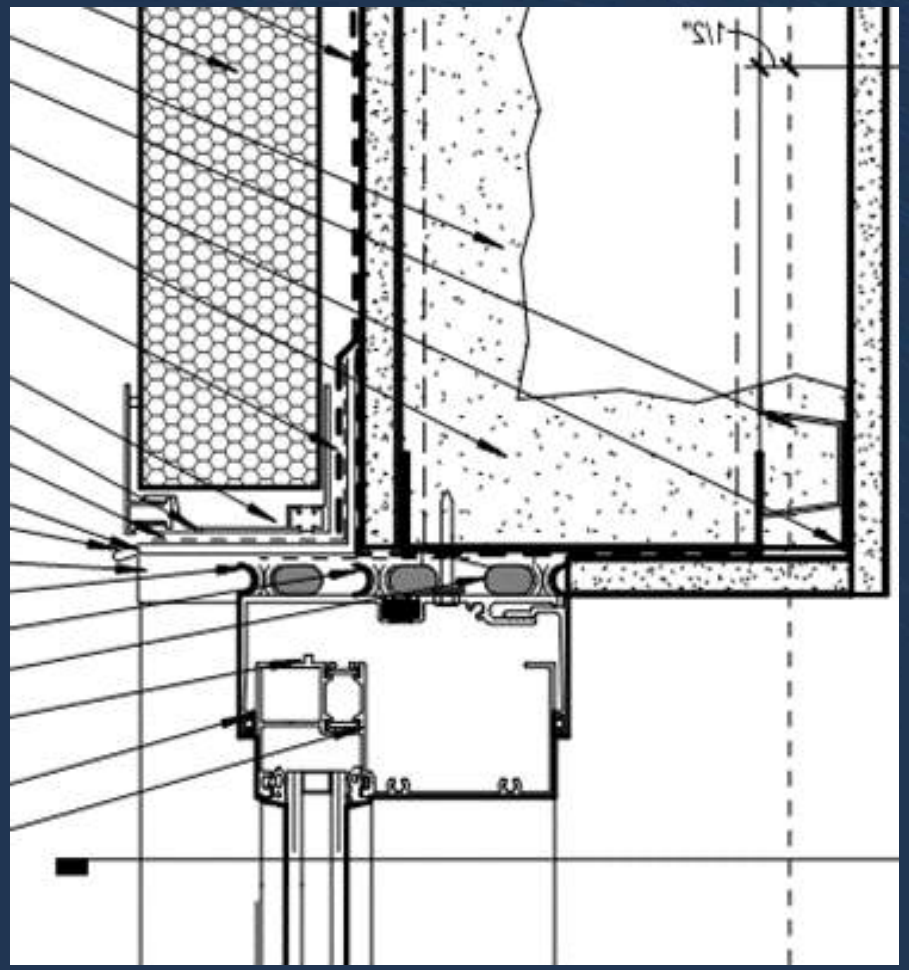
Contractual Relationships

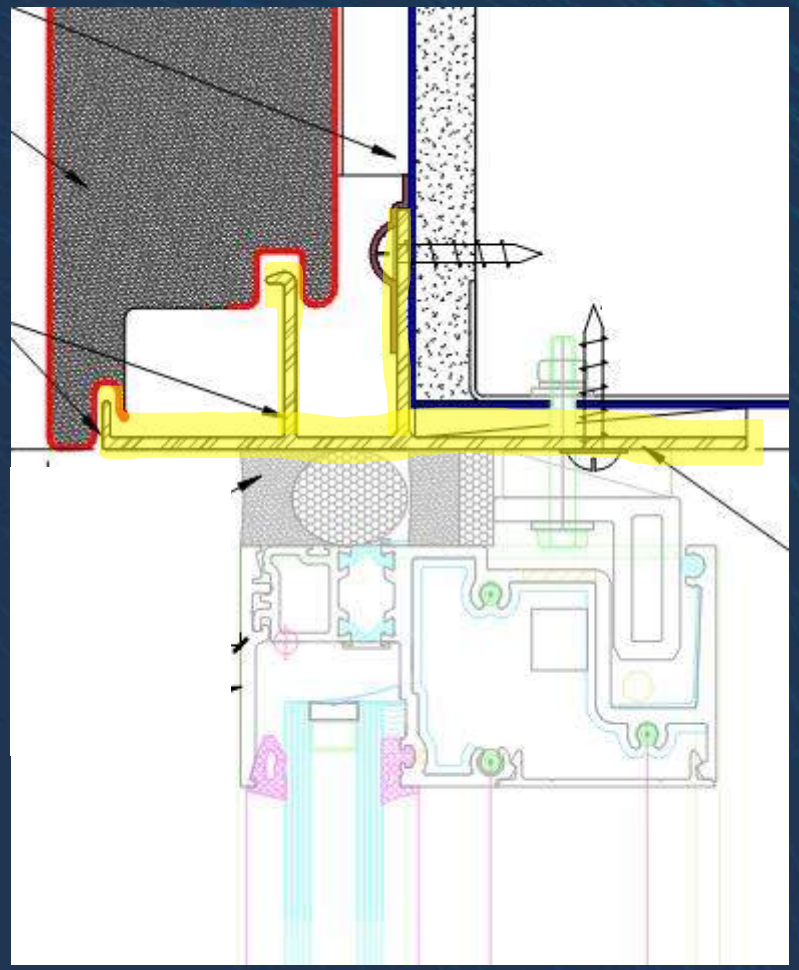


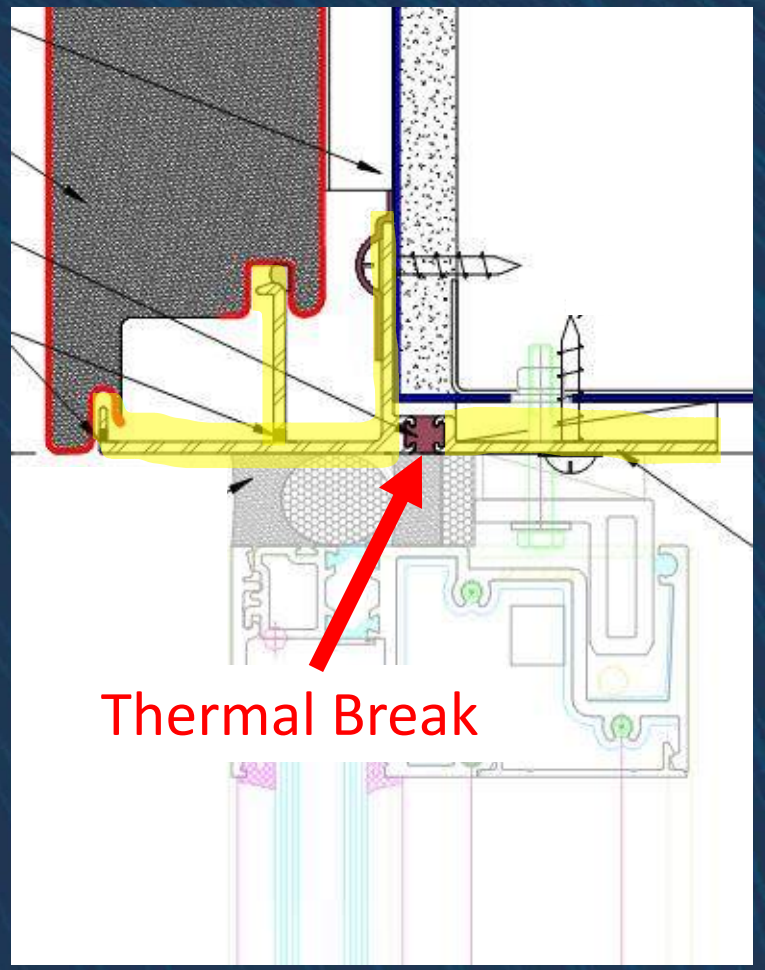
Mega Panel Joint Locations


Gasketed Panel-to-Panel Joint
Dual Bead Wet Seal Panel-to-Panel Joint
3M 3015 Strip-in Panel-to-Panel Joint
Expansion Joint Panel-to-Panel Joint

Window Wall Head



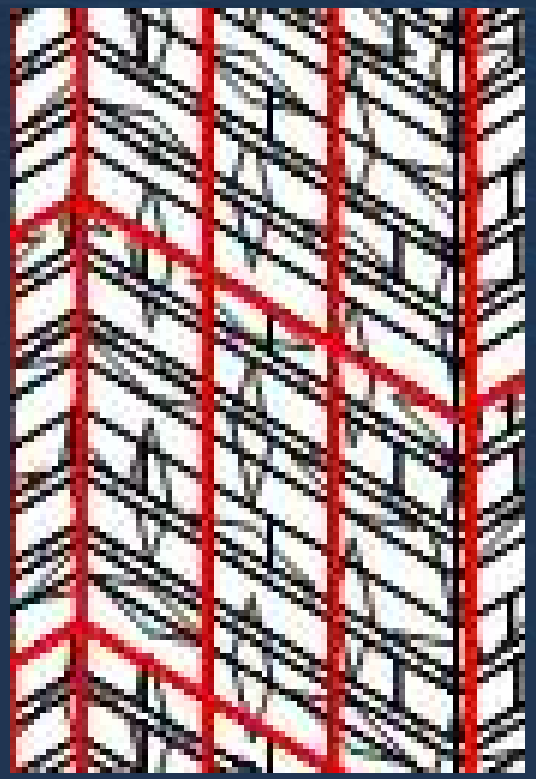




IFC April 2020

May 2020

August 2020



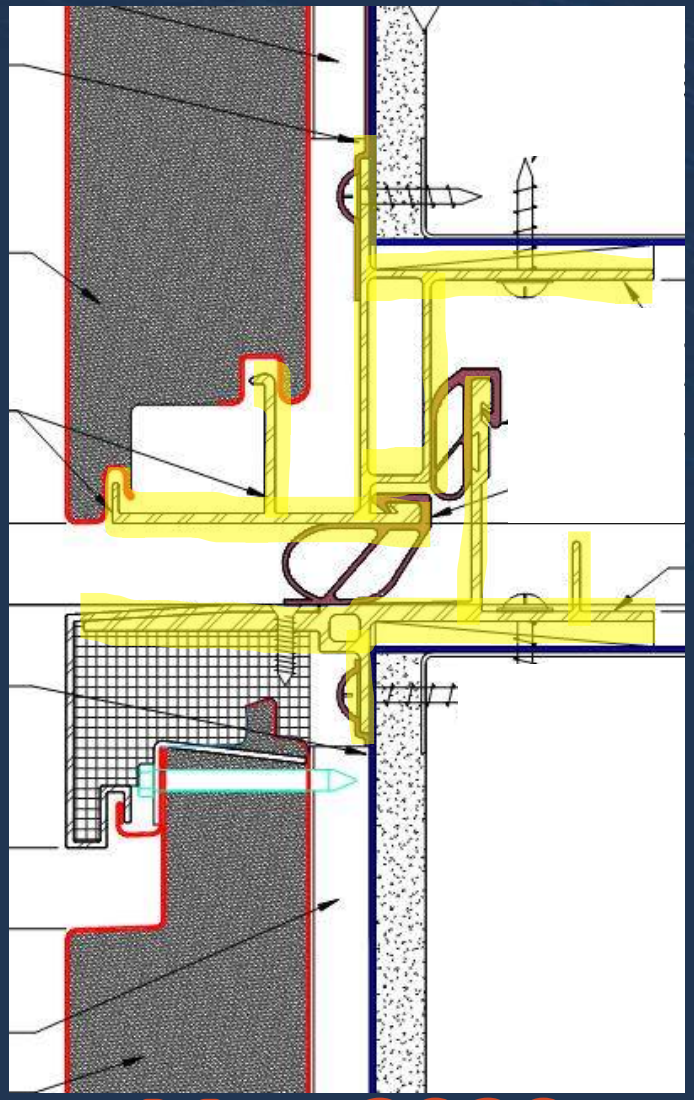
Gasketed Panel-to-Panel Joint

Dual Bead Wet Seal Panel-to-Panel Joint

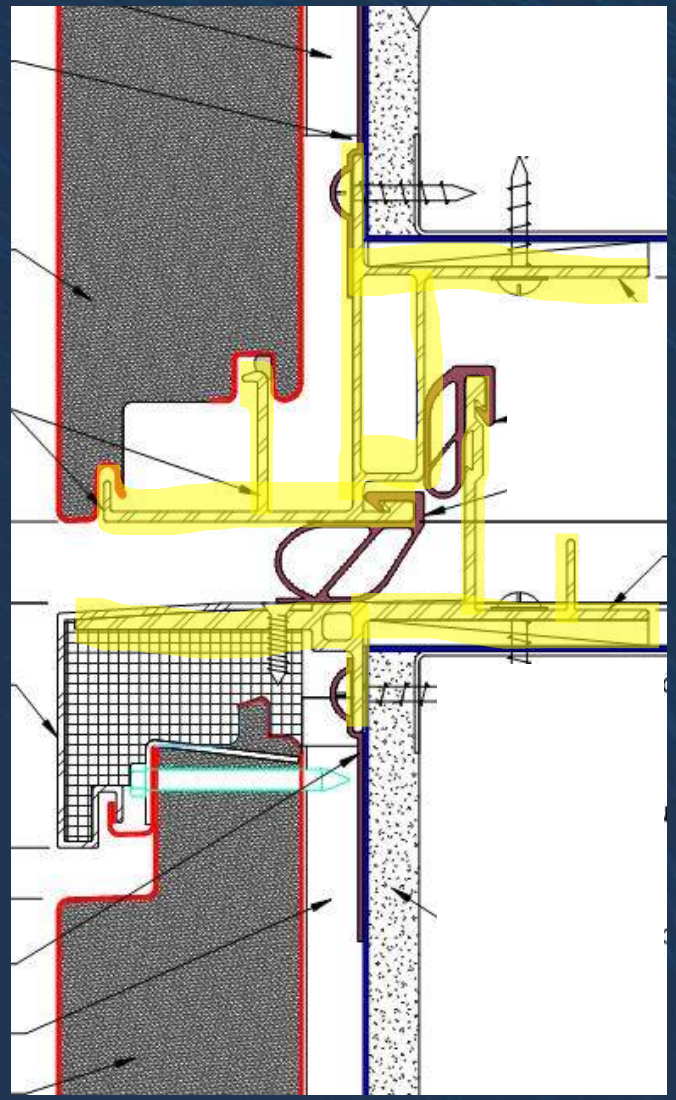
3M 3015 Strip-in Panel-to-Panel Joint

Expansion Joint Panel-to-Panel Joint

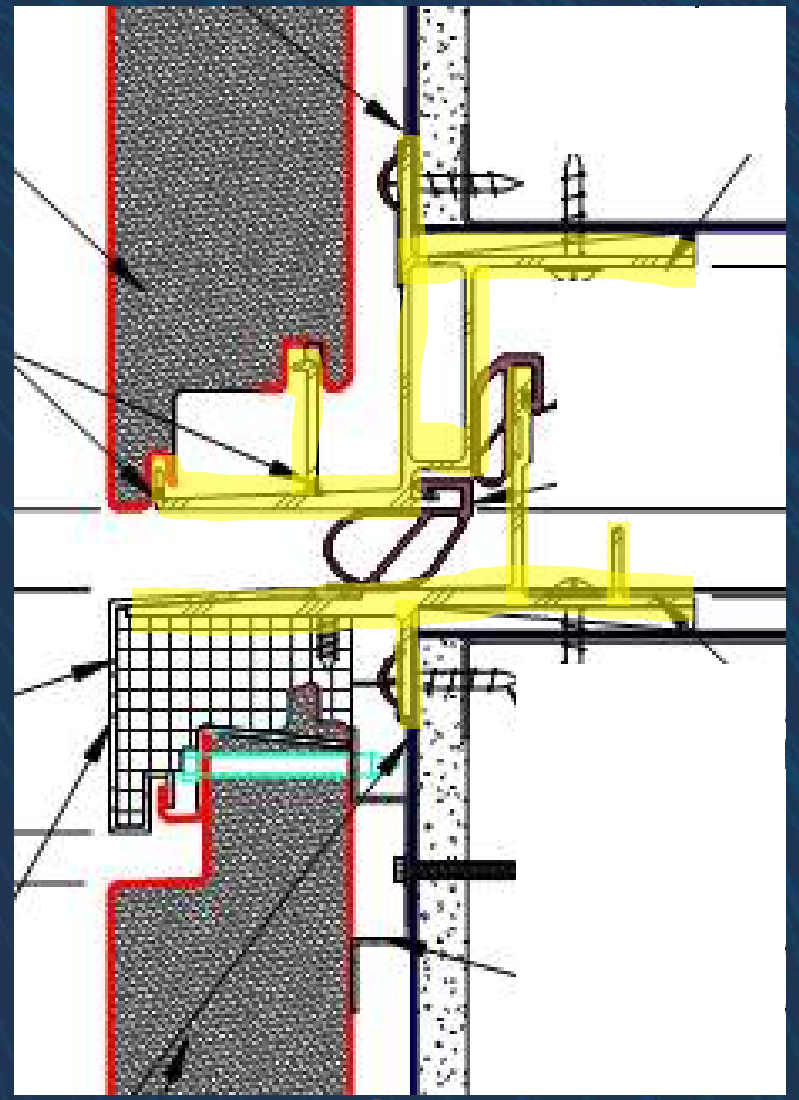
Mega Panel Horizontal (Stack) Joint



May 2020



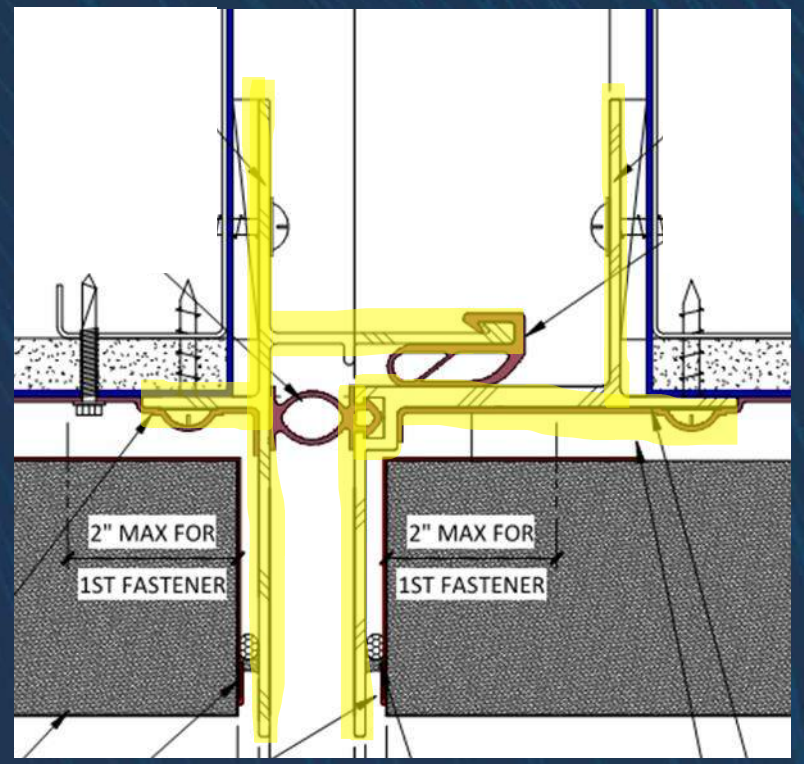
August 2020



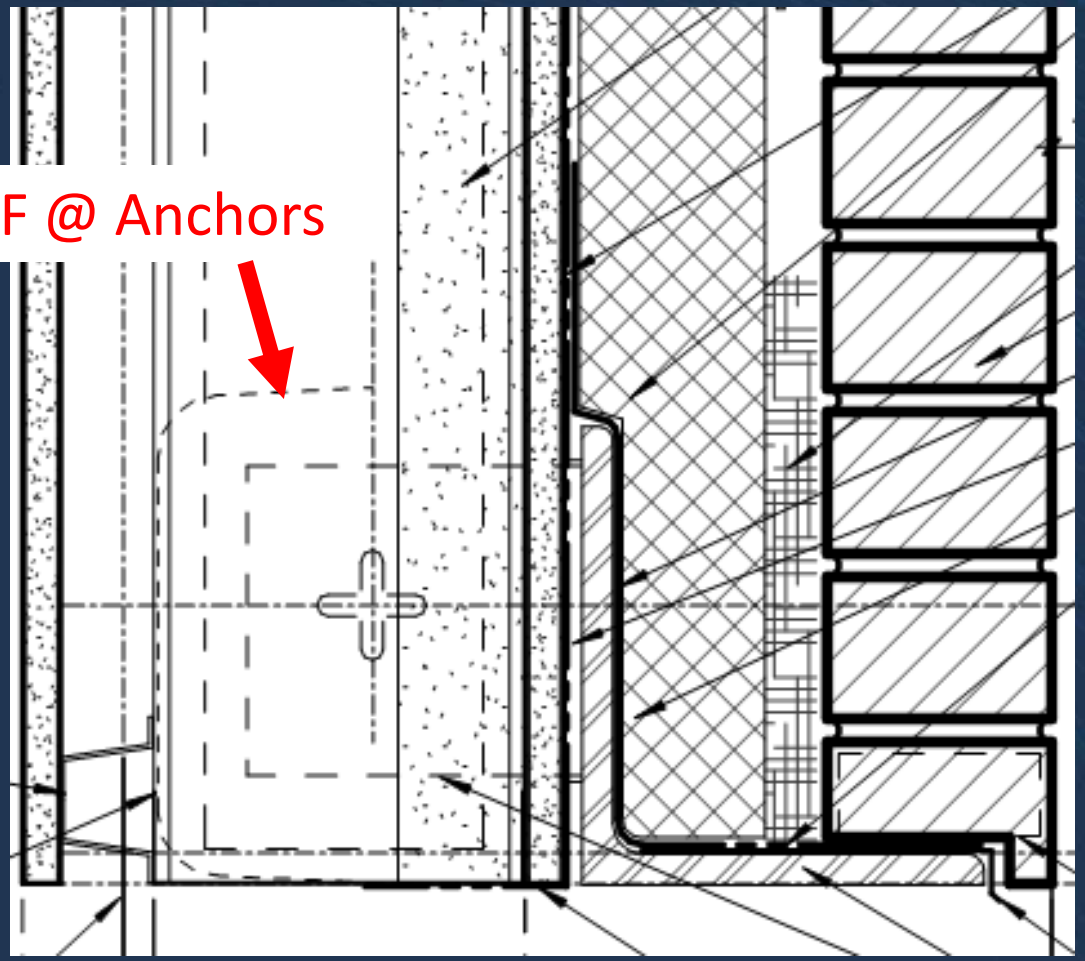
March 2021

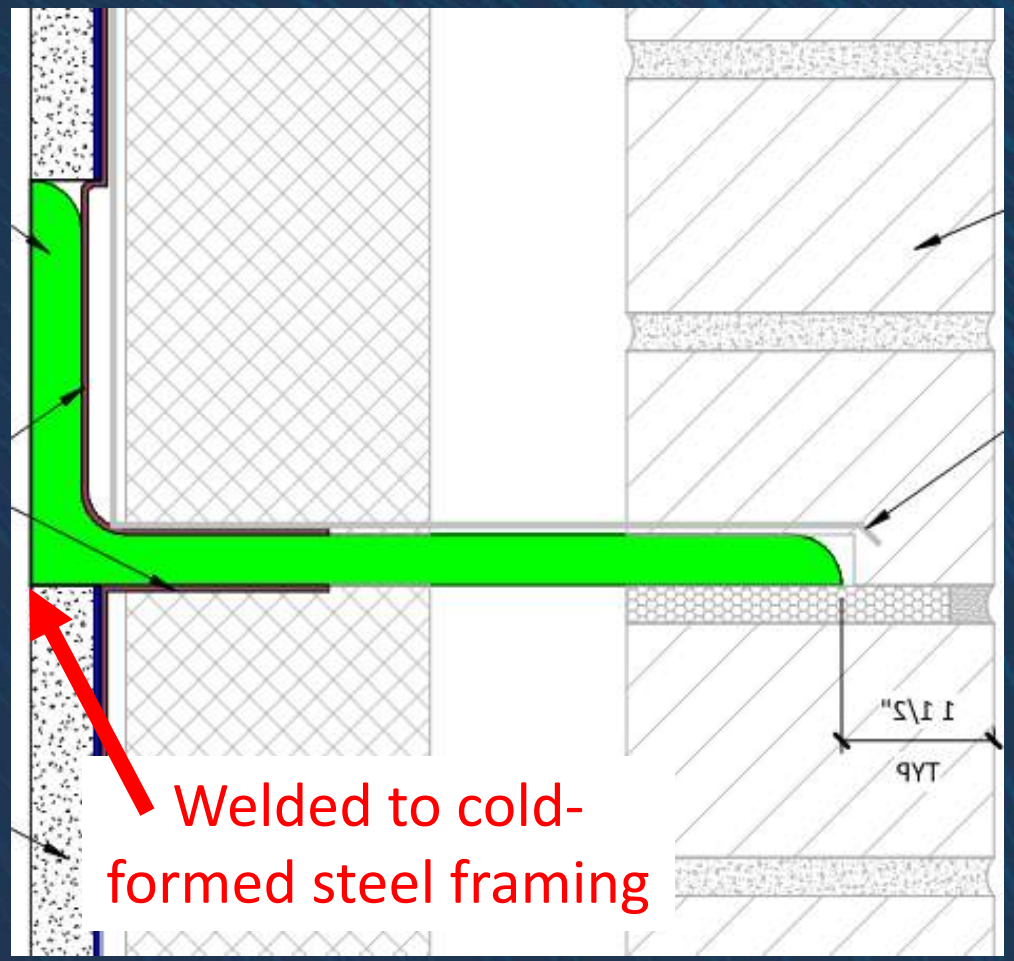
Vertical Joint

Stack Joint



Lintels/Shelf Angles at Podium





IFC April 2020

August 2020

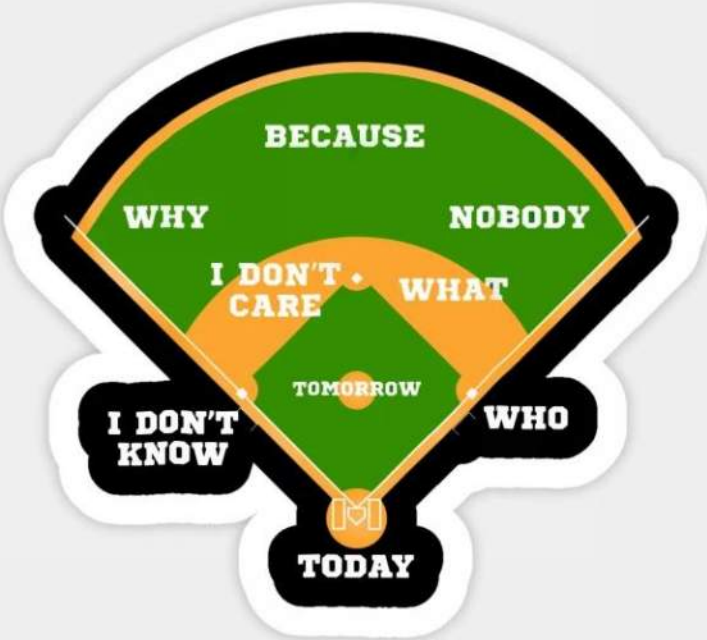
Lintels/Shelf Angles at Podium

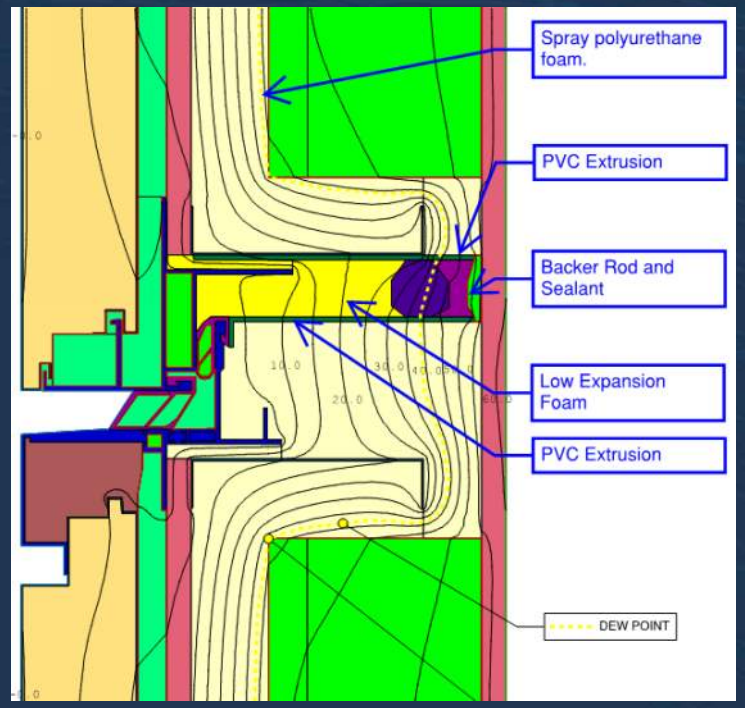
Coordination | Design Responsibility

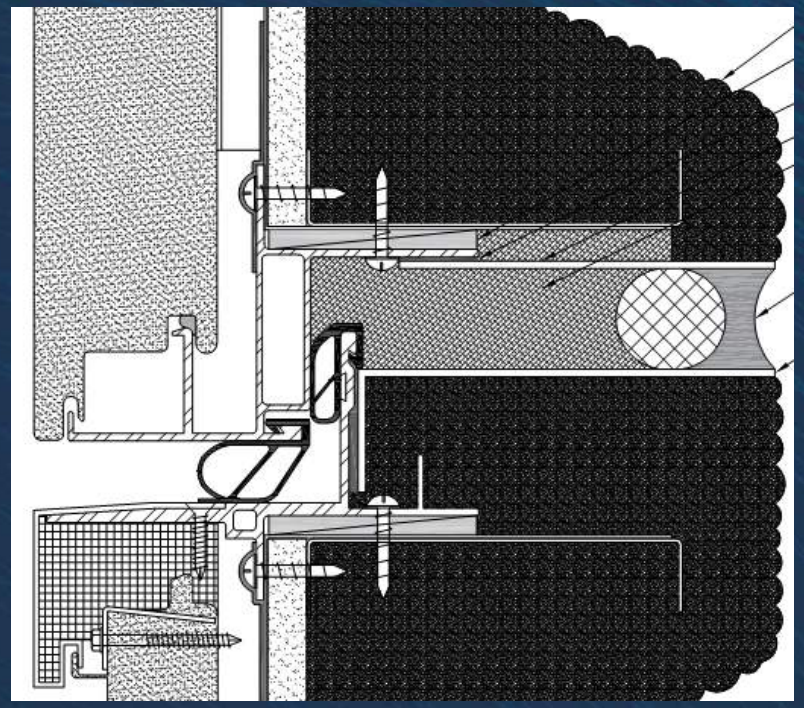
Who is responsible for coordination and interface details with multiple delegated design materials/systems?

- General Contractor
- Designer of Record
- Subcontractors
- Manufacturers
- ~~Enclosure Consultant~~
- BECx Provider
- Owner
- Specialty Design Professional
- CAD Operator

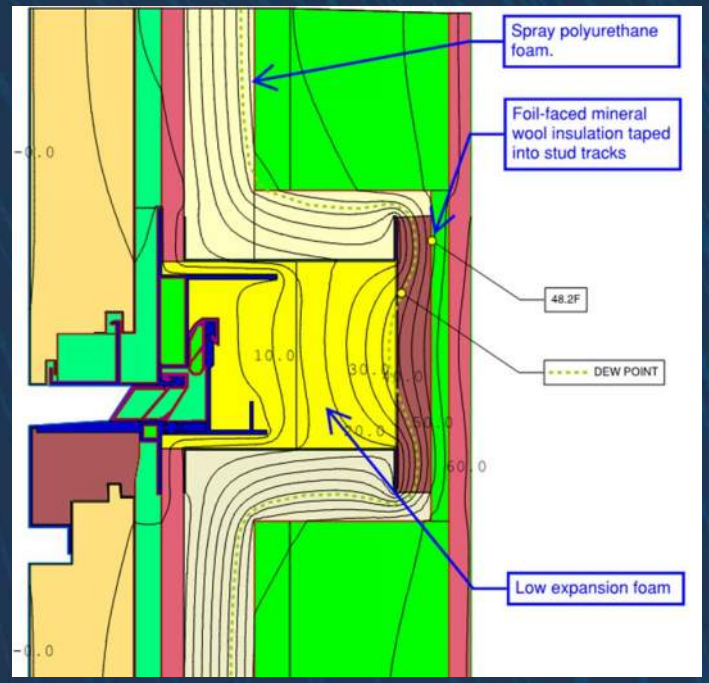
27




Spray polyurethane foam.
PVC Extrusion
Backer Rod and Sealant
Low Expansion Foam
PVC Extrusion
DEW POINT



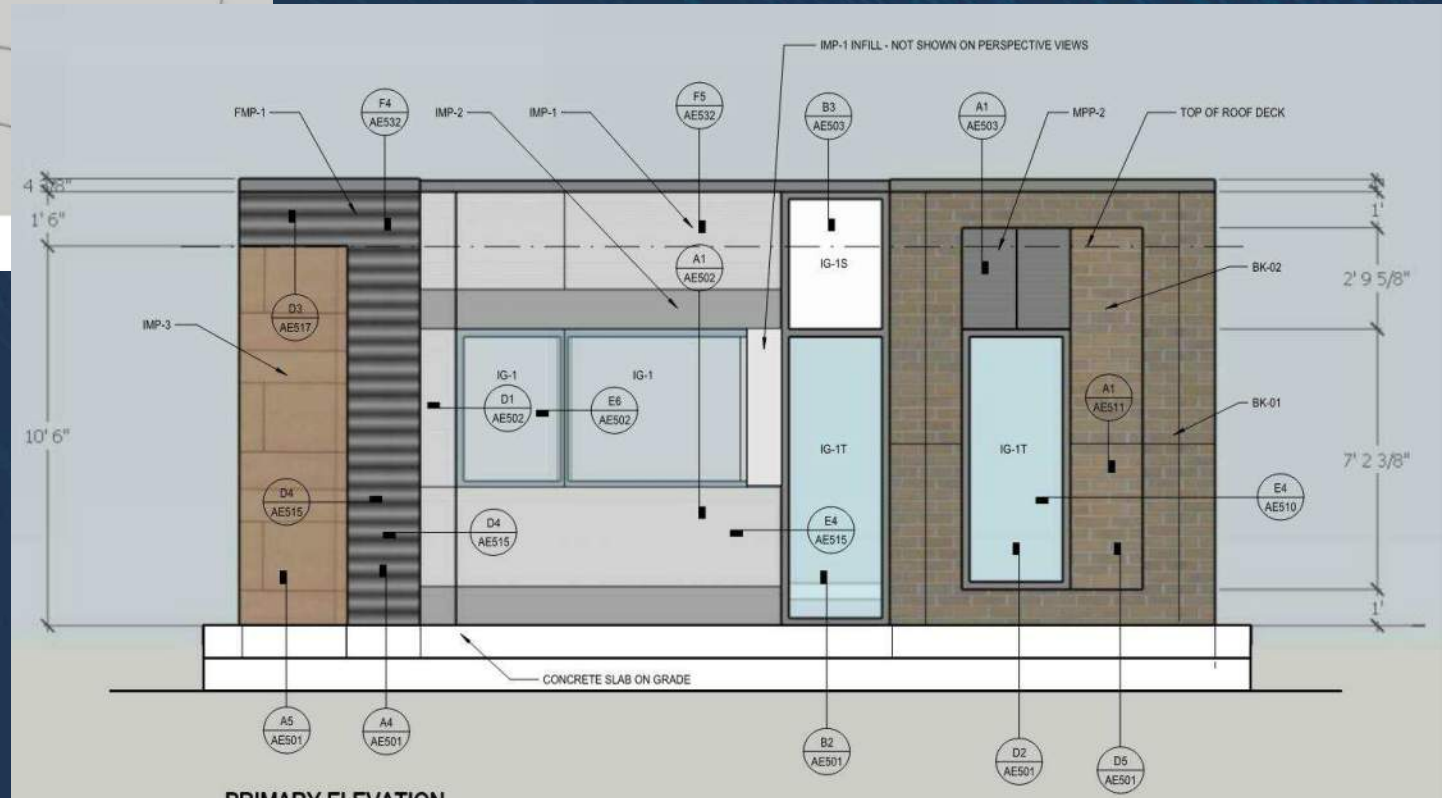
Stack Joint


Spray polyurethane foam.
Foil-faced mineral wool insulation taped into stud tracks
48.2F
DEW POINT
Low expansion foam

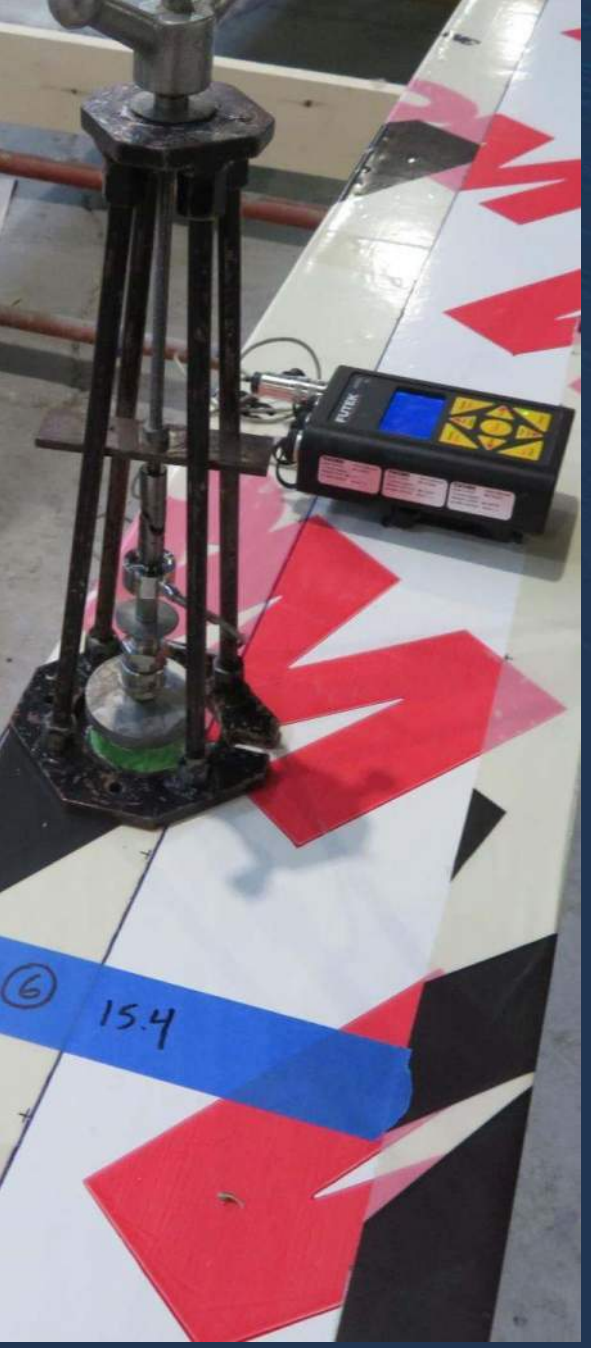
PERSPECTIVE VIEW

IFC April 2020

DATE	04/30/20
SHEET NAME	ENCLOSURE MOCKUP



PRIMARY ELEVATION



BECx Specification

Specification Section	Specification Title	RRJ Recommended Field QC Testing Requirements	Number of Tests	Responsible Party for Tests
019119	Building Enclosure Commissioning (Mock-up)	Phase 0, Pre-fabrication Plant: ABAA 0002 pull-off adhesion testing of air barrier	Minimum 6 tests of air barrier (2 sets of 3)	Owner | RRJ
		Phase 1, Prior to Brick Veneer and SPF Installation: ASTM E1186 theatrical fog testing	Minimum of 50 % of joints, shelf angles, and interfaces	Owner | RRJ
		Phase 1, Prior to Brick Veneer and SPF Installation: ASTM E1186 bubble gun testing	Minimum of 6 masonry veneer ties	Owner | RRJ
		Phase 1, Prior to Brick Veneer and SPF Installation: ASTM E1105 water penetration testing (without differential pressure)	Appx. 200 square feet test area, including areas containing masonry veneer ties, fenestration, metal panels, primary sealant joints, and through-wall flashing	Owner | RRJ
		Phase 1, Prior to Brick Veneer and SPF Installation: AAMA 501.2 calibrated spray nozzle testing	Minimum of 100 linear feet of internal glazing joints, perimeter sealant joints, transitions, roof system base flashing, and metal panel interface joints	Owner | RRJ
		Phase 1, Prior to Brick Veneer and SPF Installation: ASTM E1105 water penetration testing at a static-air-pressure difference not less than 10 psf	One test encompassing the size of the test chamber agreed to for testing	Owner | RRJ
		Phase 2, Upon Completion: ASTM C1715 masonry wall drainage system testng	Minimum 1 test near base of wall and 1 test above steel lintel to test through-wall flashing	Owner | RRJ
		Phase 2, Upon Completion: ASTM C1521 sealant adhesion testing	Minimum of 5 tests inccorporating all substrate conditions	Owner | RRJ
		Phase 2, Upon Completion: ABAA 0002 pull-off adhesion testing of spray polyurethane foam.	Minimum 6 tests of spray polyurethane foam (SPF)	Owner | RRJ

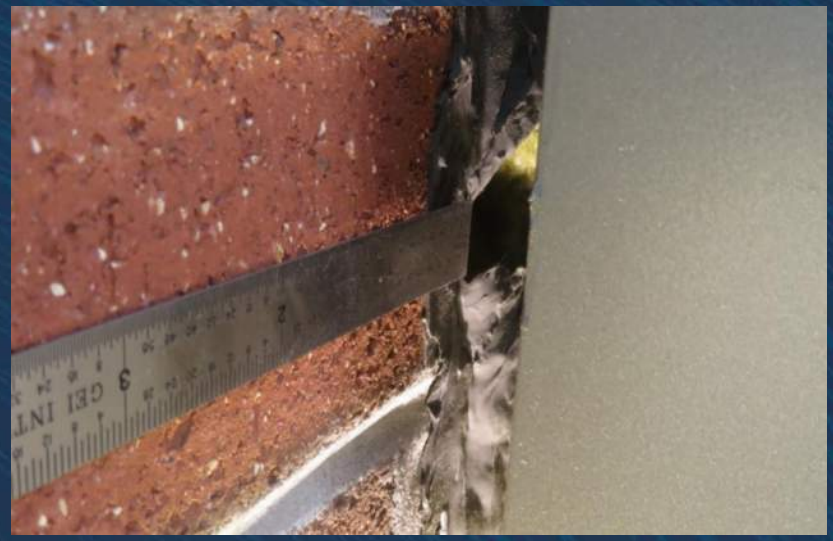
Mock-Up


CARLISLE
705FR-A


LOUISVILLE

Building Enclosure Conference | Denver | 2023


FUTEK
IHH500

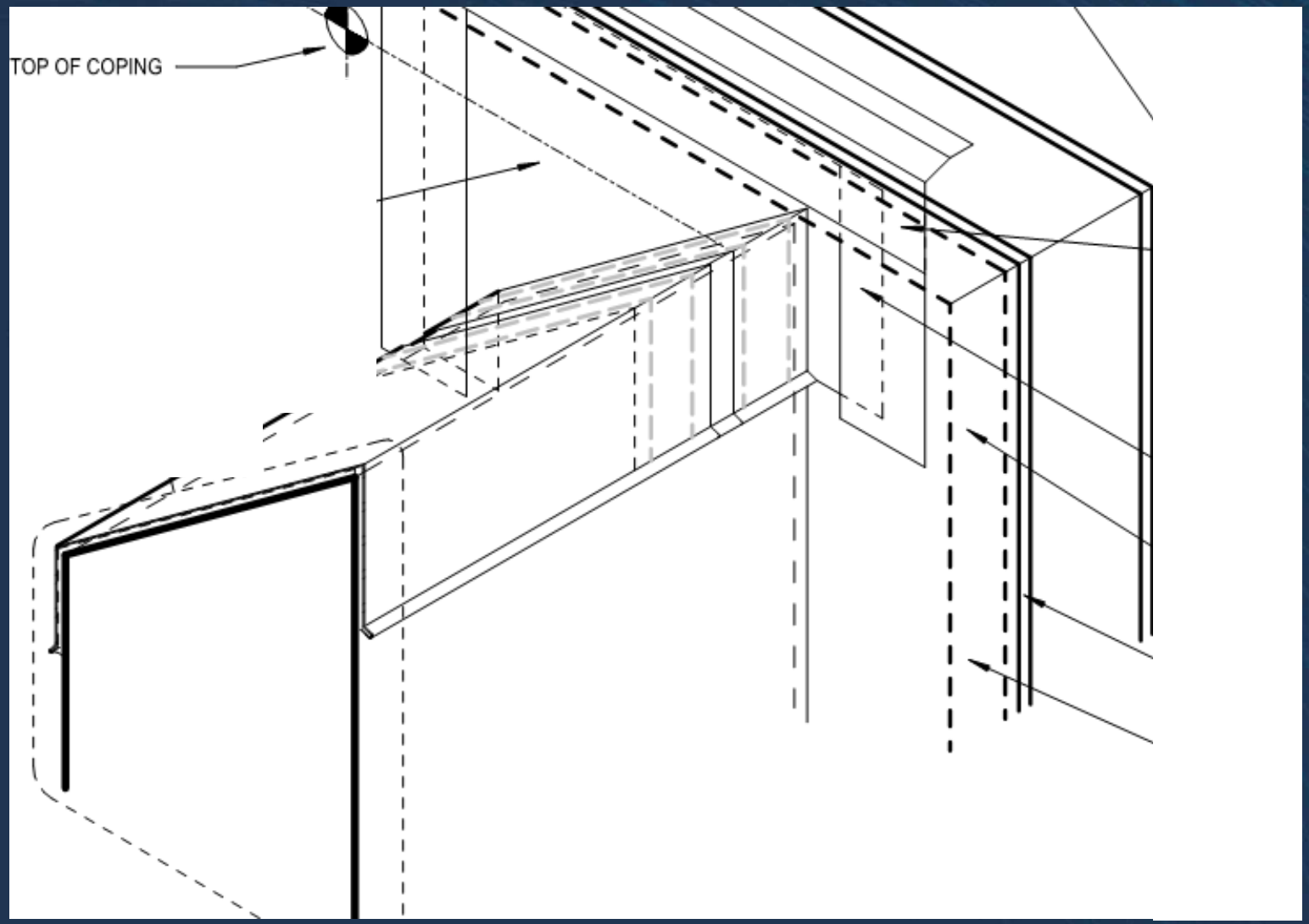


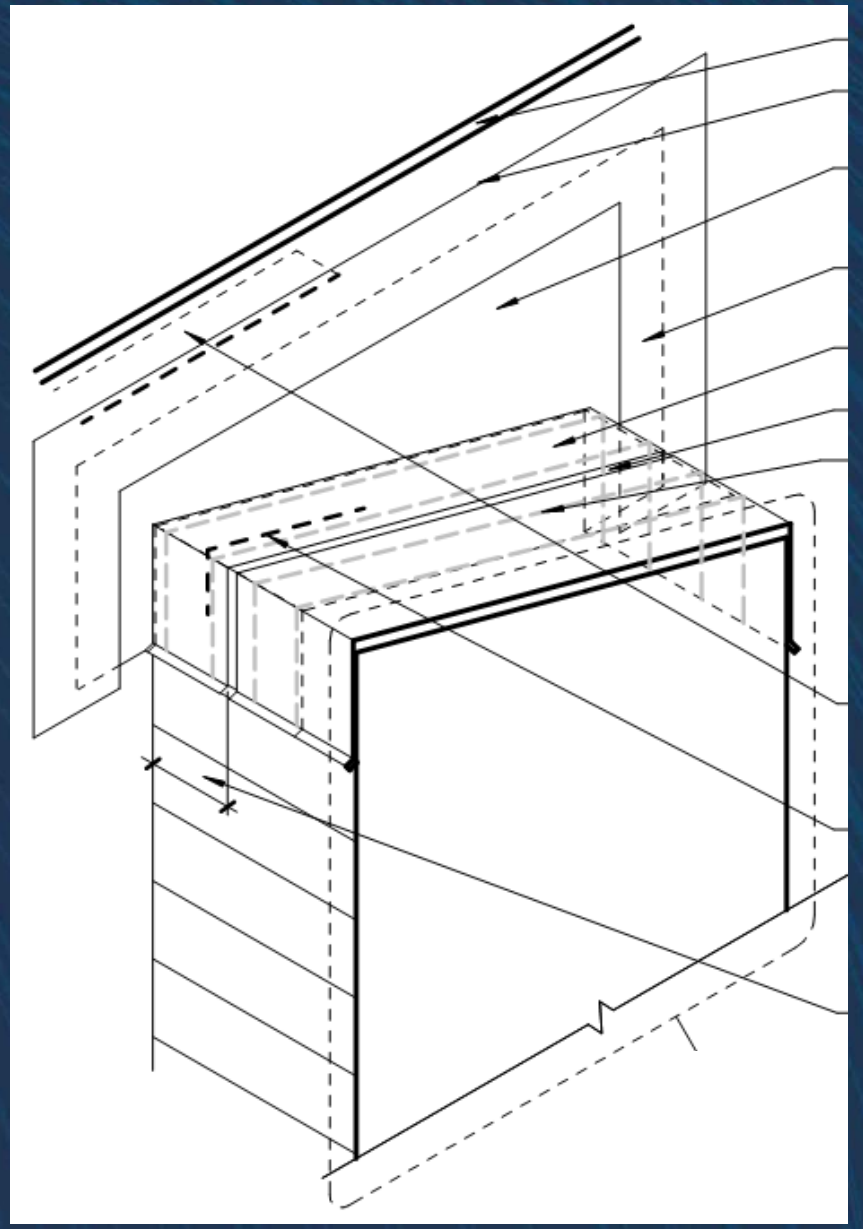
Mock-up

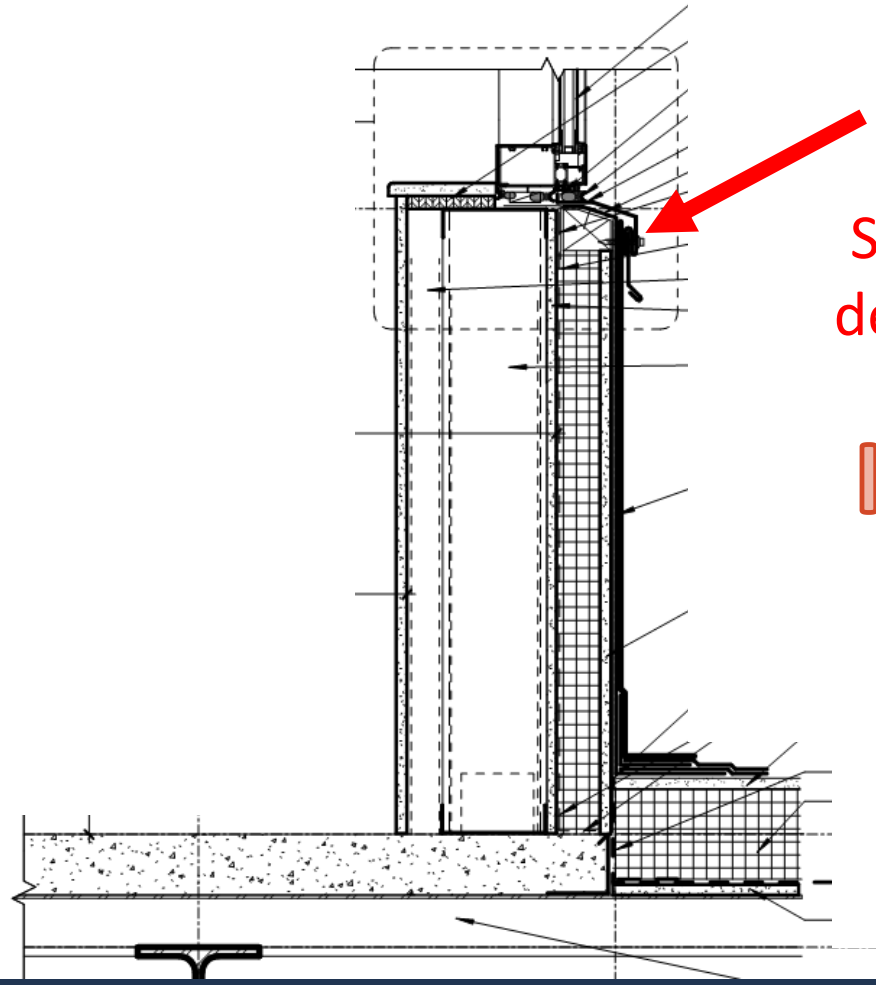
"The performance mock-up can be built and tested in various configurations and at different cost levels. The most crucial part is that they account for the high-risk areas of a building (foundation to wall, wall to window, wall to roof, expansion joints, penetrations, etc.) and are tested - for water leakage, air leakage, thermal concerns, and durability".

Also, ensure the people installing the materials on the mock-up will be working on the actual building. What good does it do the project if the knowledge gained by the mock-up is not available for the actual construction of the project?

Interface Conditions







Same transition flashing detail for both conditions

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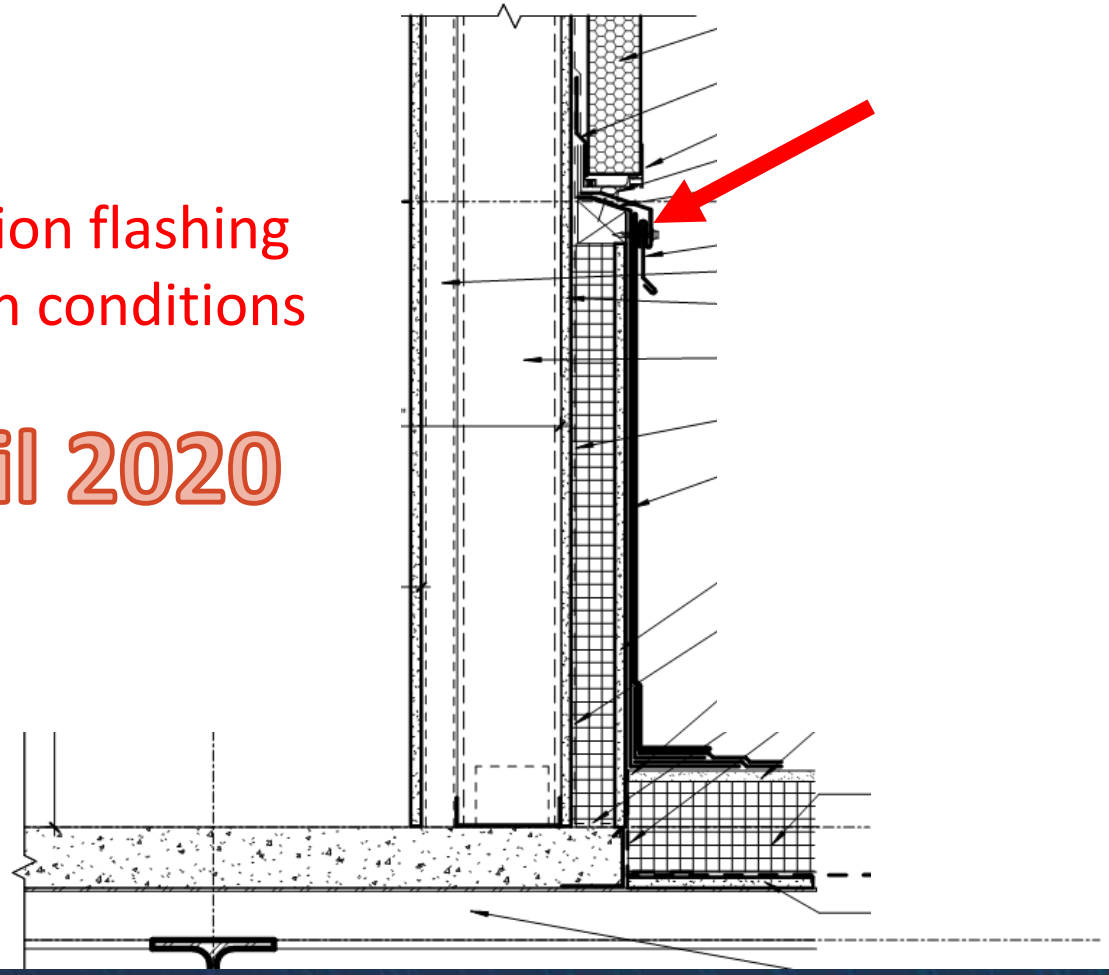

Window Wall

Insulated Metal Panel

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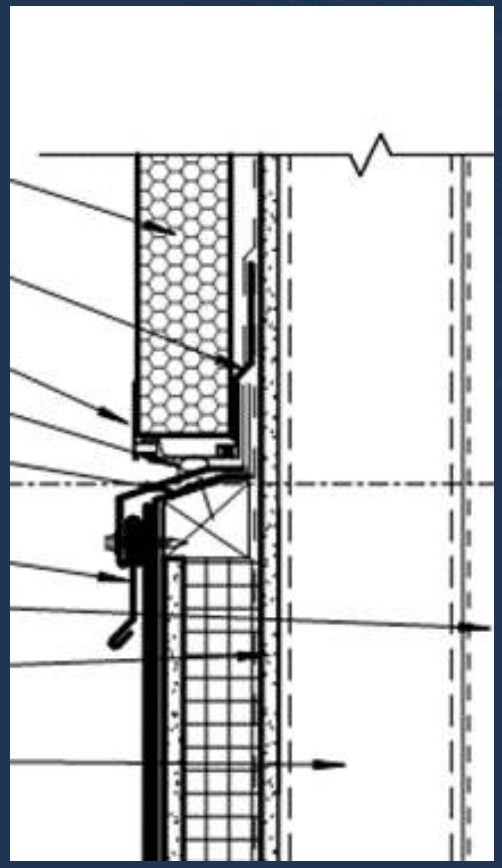
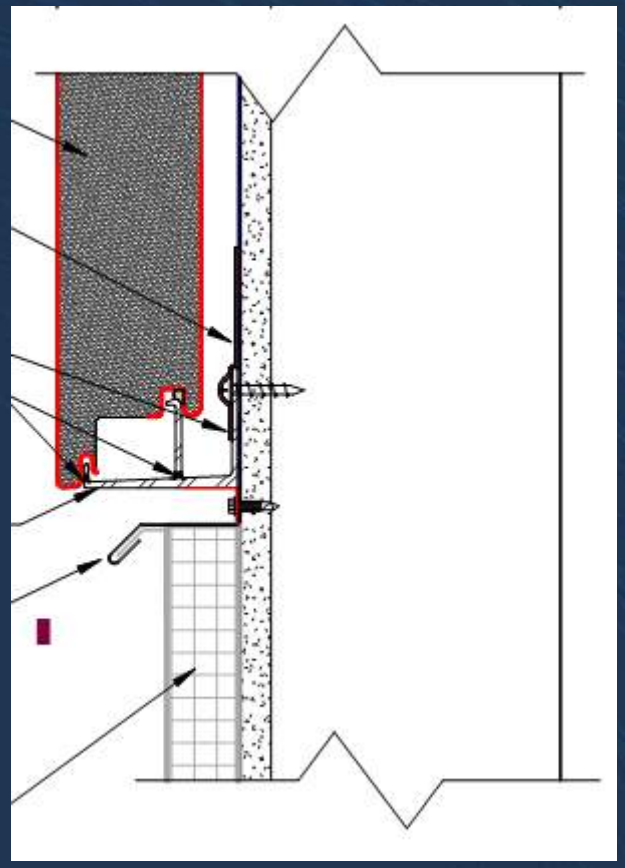
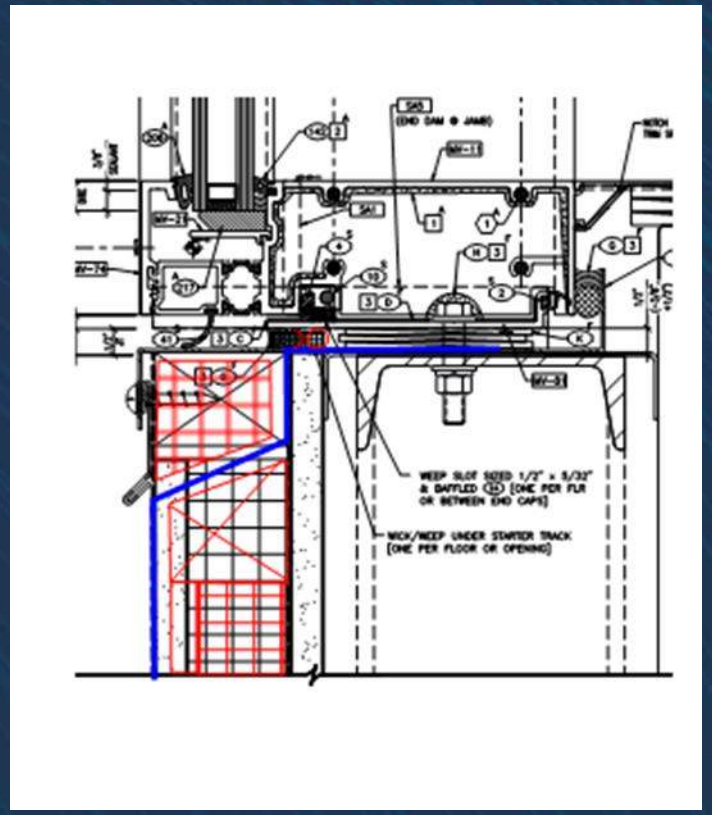
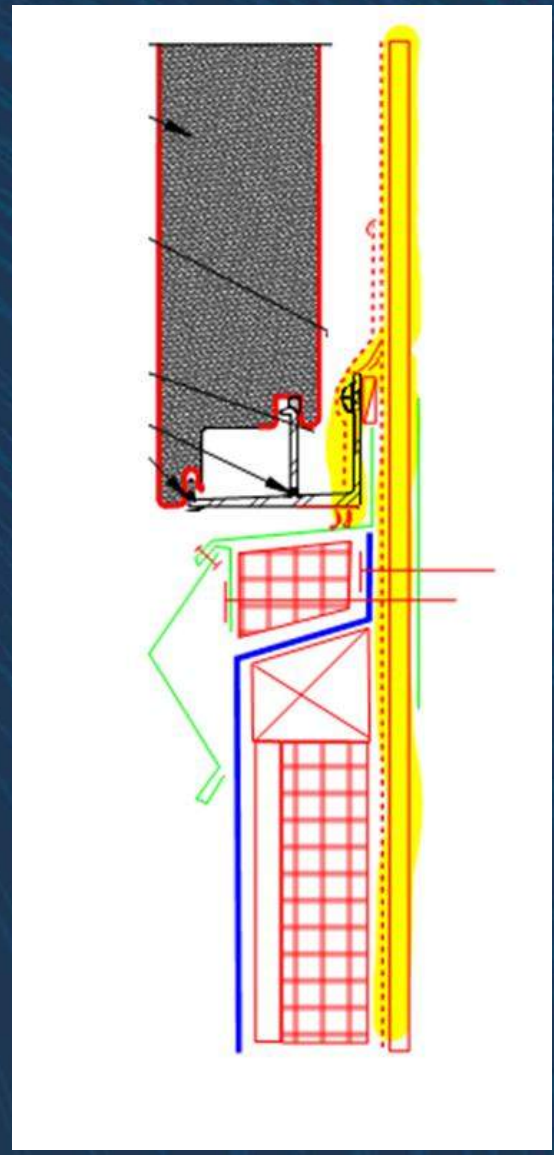




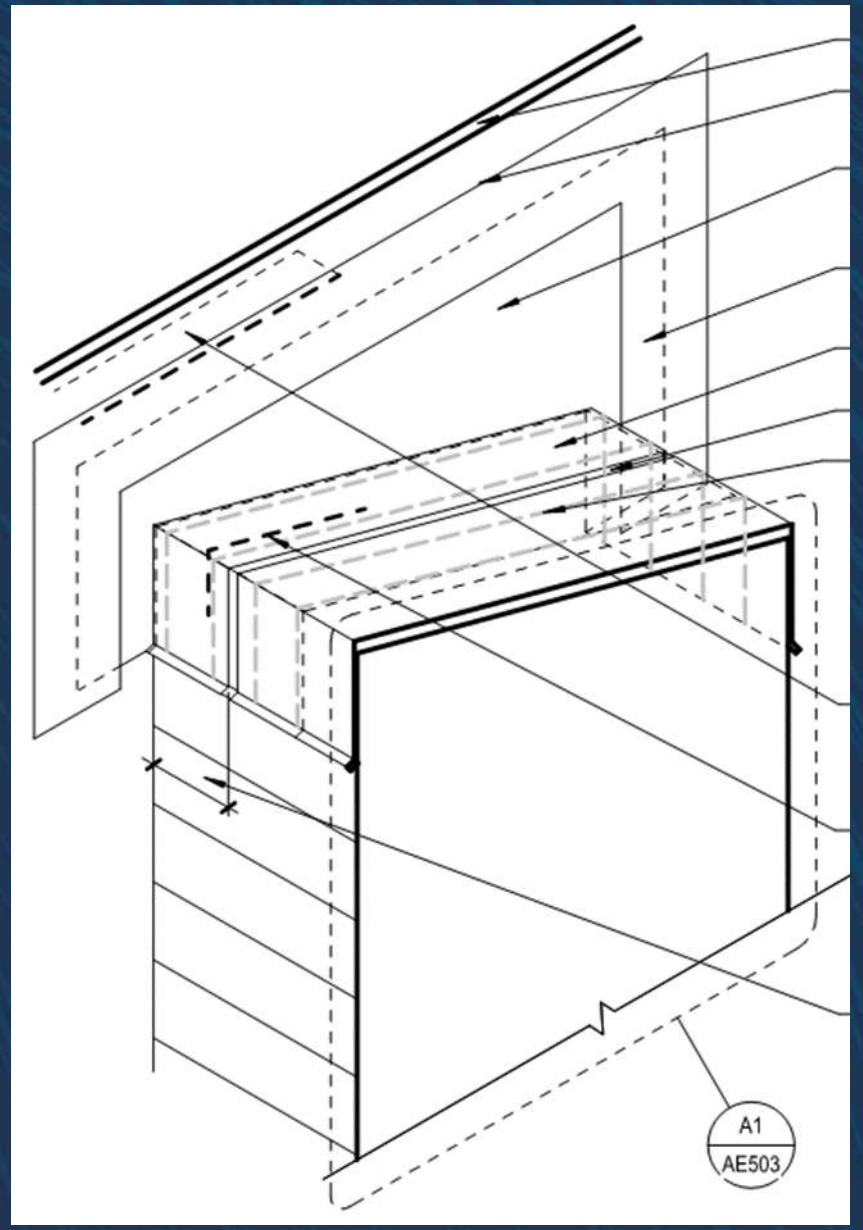
March 2021

April 2021





May 2021


A1
AE503

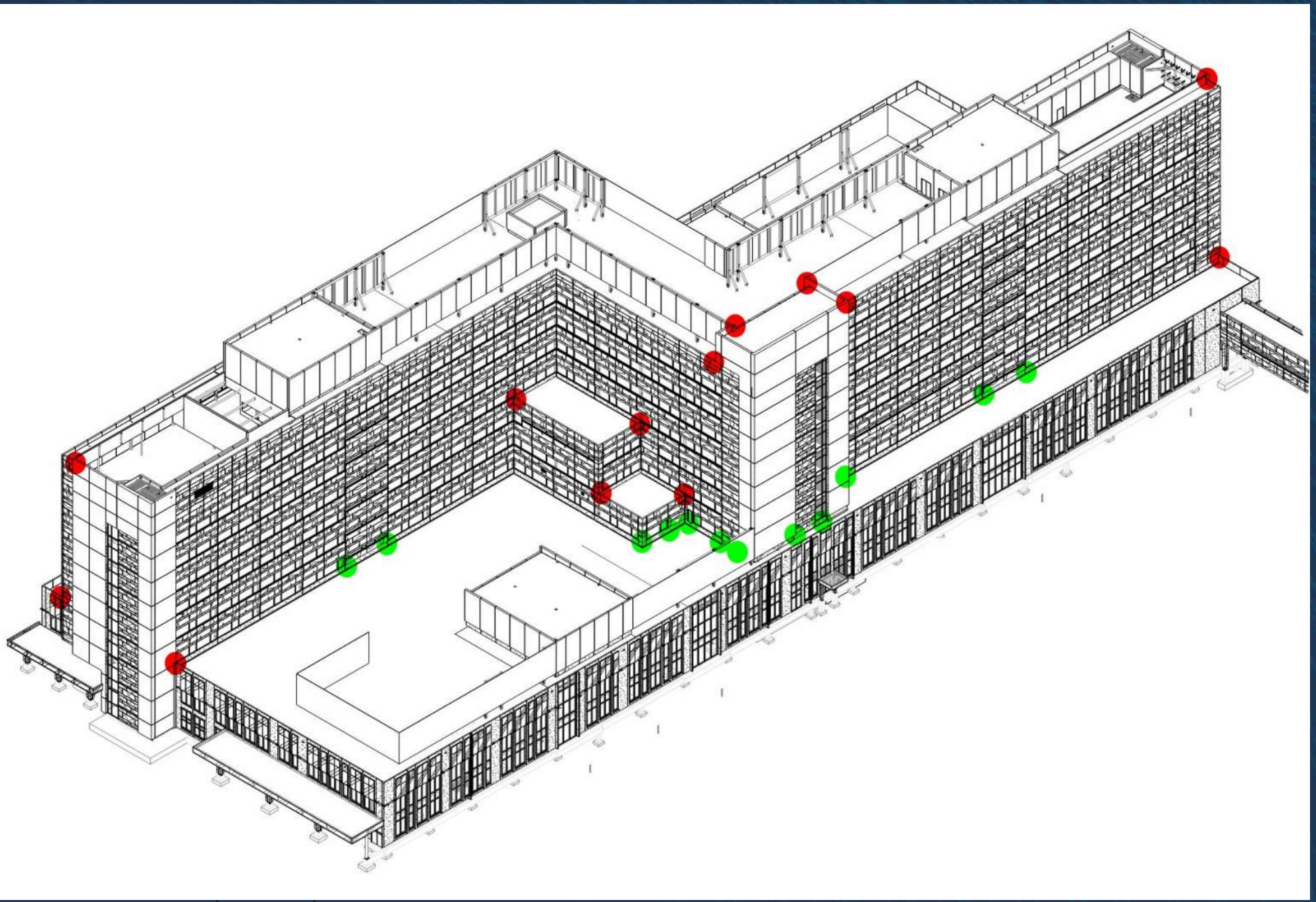
MegaPanels: Would You Do It Again?

Delegated Design

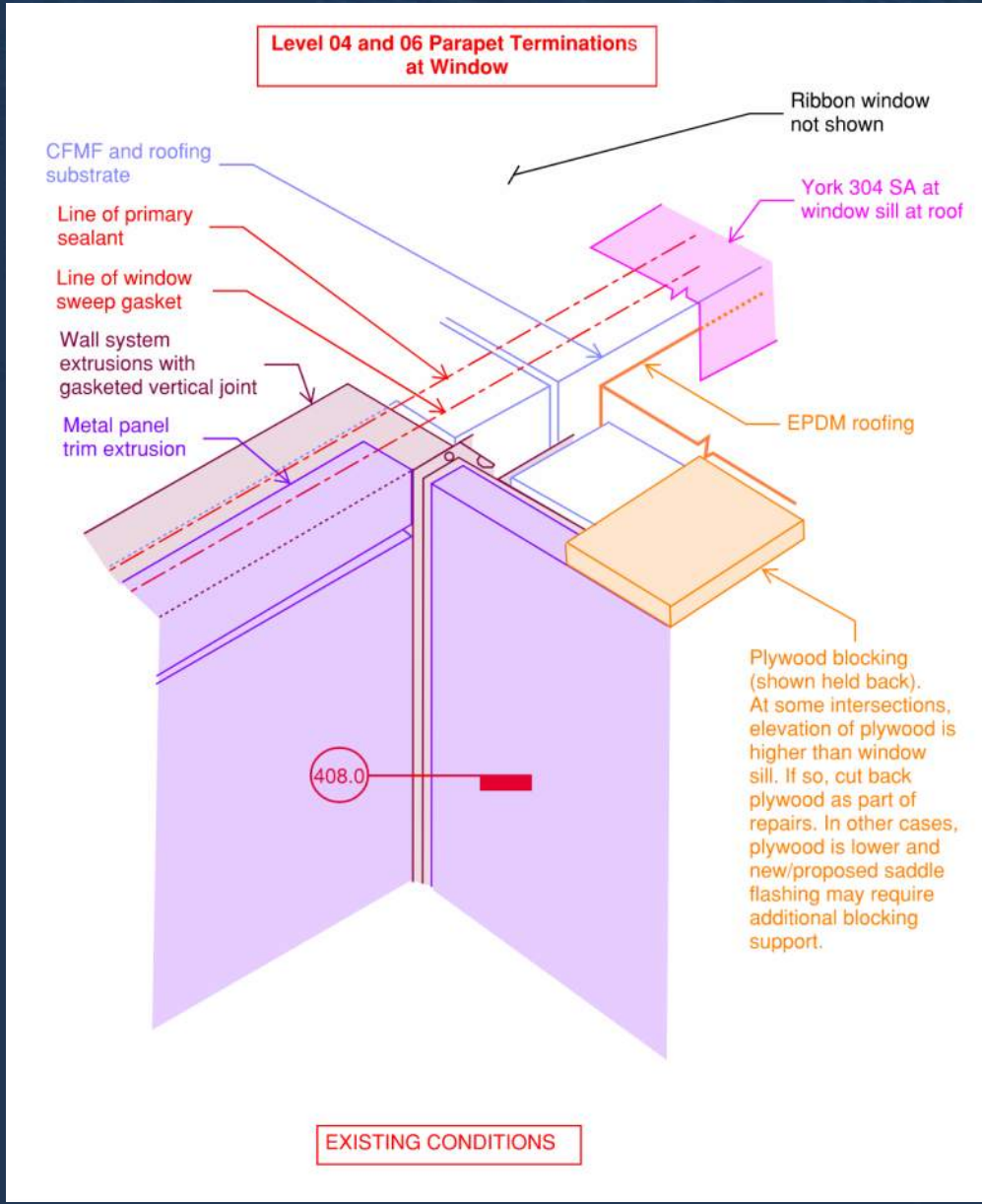
- Contractors are ceded more responsibility and project control as a larger percentage of projects are being implemented by delegated design.

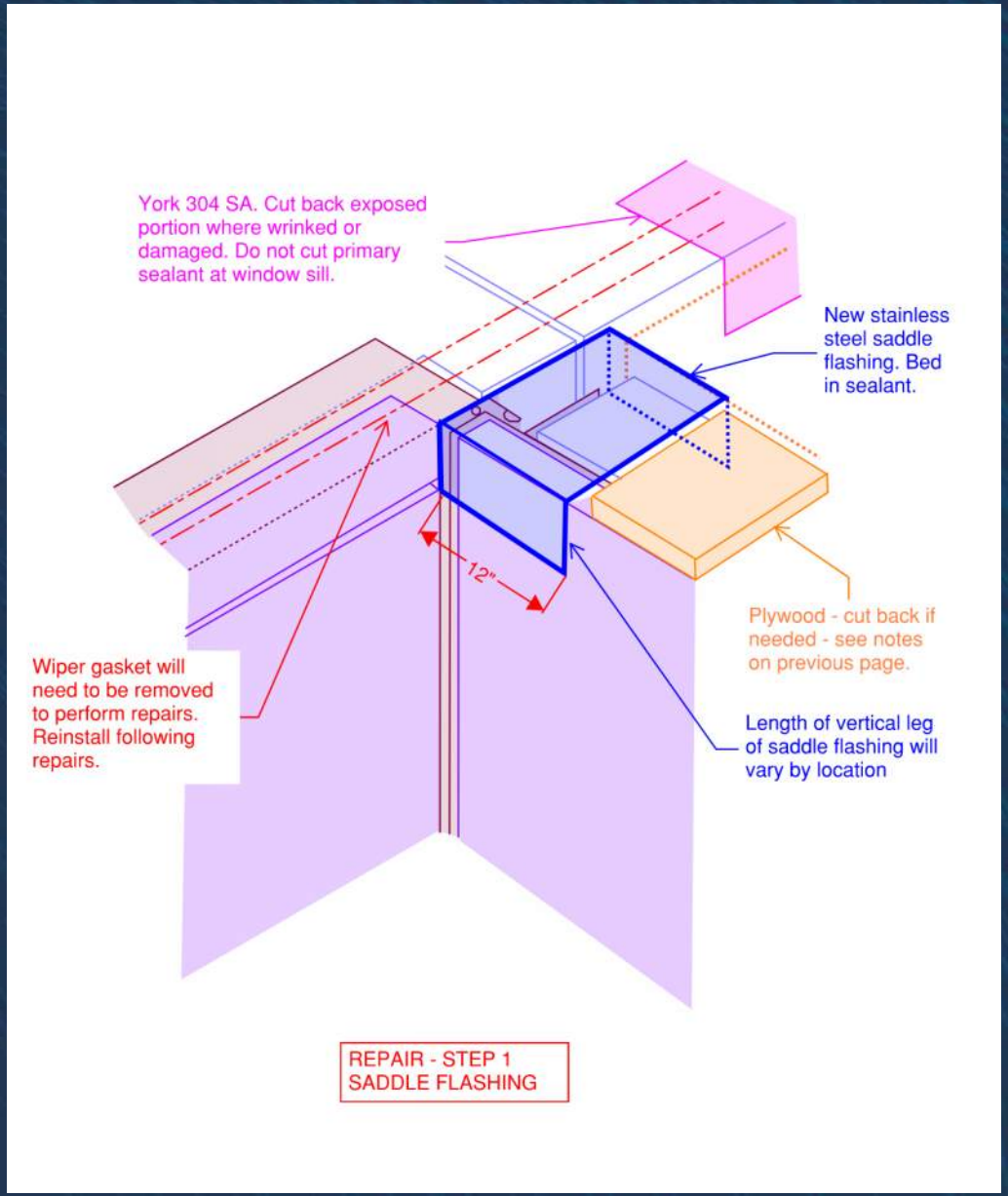
Roles

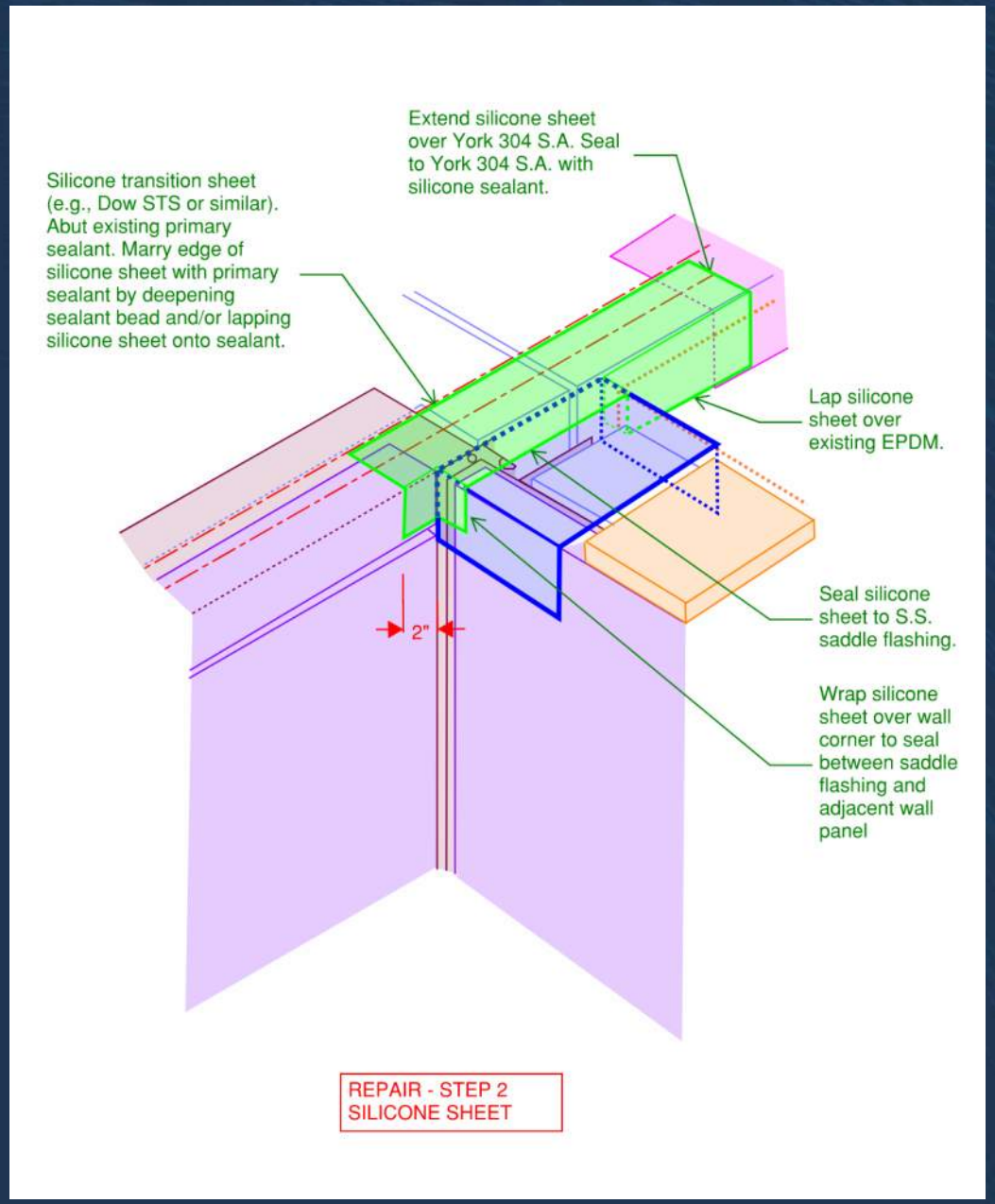
- Architect
- Envelope Consultant for Architect?
- Contractor and Subcontractors
- Envelope Consultant for Contractor/CM?
- BECxP?



Building


Level 04 and 06 Parapet Terminations at Window
Ribbon window not shown
CFMF and roofing substrate
York 304 SA at window sill at roof
Line of primary sealant
Line of window sweep gasket
Wall system extrusions with gasketed vertical joint
Metal panel trim extrusion
EPDM roofing
Plywood blocking (shown held back). At some intersections, elevation of plywood is higher than window sill. If so, cut back plywood as part of repairs. In other cases, plywood is lower and new/proposed saddle flashing may require additional blocking support.
408.0
EXISTING CONDITIONS


York 304 SA. Cut back exposed portion where wrinked or damaged. Do not cut primary sealant at window sill.
New stainless steel saddle flashing. Bed in sealant.
12"
Plywood - cut back if needed - see notes on previous page.
Wiper gasket will need to be removed to perform repairs. Reinstall following repairs.
Length of vertical leg of saddle flashing will vary by location
REPAIR - STEP 1
SADDLE FLASHING


Extend silicone sheet over York 304 S.A. Seal to York 304 S.A. with silicone sealant.
Silicone transition sheet (e.g., Dow STS or similar). Abut existing primary sealant. Marry edge of silicone sheet with primary sealant by deepening sealant bead and/or lapping silicone sheet onto sealant.
Lap silicone sheet over existing EPDM.
Seal silicone sheet to S.S. saddle flashing.
Wrap silicone sheet over wall corner to seal between saddle flashing and adjacent wall panel
2"
REPAIR - STEP 2
SILICONE SHEET

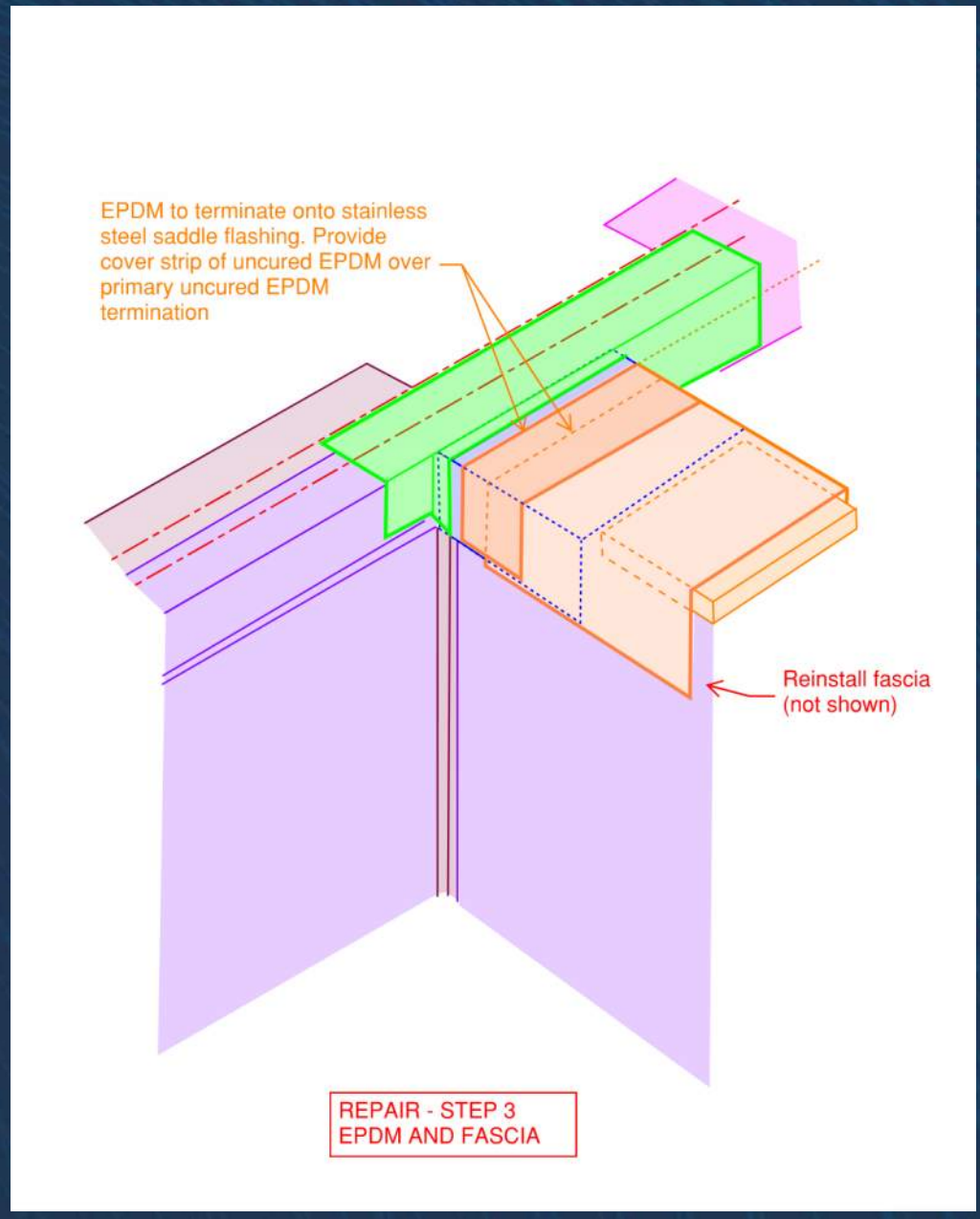

EPDM to terminate onto stainless steel saddle flashing. Provide cover strip of uncured EPDM over primary uncured EPDM termination
Reinstall fascia (not shown)
REPAIR - STEP 3
EPDM AND FASCIA

Figure 9.1a – Parapet to building wall transition. Red arrow points to York flashing, which laps over EPDM at vertical wall.

Figure 9.1b – Stainless steel saddle flashing installed at parapet.

Figure 9.1c – Stainless steel saddle flashing installed at parapet.

Figure 9.1d – Uncured EPDM used to transition from existing EPDM at parapet onto stainless steel saddle.

Figure 9.1e – Silicone transition sheet (boot) installed from stainless steel saddle flashing to primary sealant below window. Silicone extends only 1/2" onto exisitng metal panel (red arrow), in order to be concealed by parapet facia.

Figure 9.1f – Silicone transition sheet (boot) installed. Existing counterflashing identified to be cutback (red arrow) so as not to damage silicone boot when installed.

Conclusions

- Track-record
  - Consider not just similarity in megapanel assembly, but also in complexity of transitions.
  - Contractor to vet the installer, not just the fabricator.
- Performance testing:
  - Previous laboratory performance testing?
  - Previous field performance testing?
  - Owner’s willingness to budget for mock-up and field testing?
  - Air barrier testing may need to be performed at fabrication facility.

Conclusions

- Performance Requirements:
  - Is the project specification applicable to prefabricated assemblies?
  - Is it clear that performance (structural, air, water, thermal) applies to the panel itself *and* the joinery.
- Ensure architect's or consultant's services include QA/QC visits to the fabrication facility.

Conclusions

- Transition Details:
  - Who is responsible for integration/transition detailing?
  - Will coordinated shop drawings be provided? Or separate sets?
  - Ideally, megapanel will be included in the original design and transition detailing can begin there.
- Teamwork! Including between consultants!

Questions?

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Thank You!!

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