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The Mark – Curtain Wall Design Challenges and Solutions

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Harmon
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seattle building enclosure council

seabec

Provider Number: 40107205

The Mark: Exterior Curtain Wall Challenges and Solutions

2018 04 19

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April 4, 2018

CONTINUING EDUCATION AIA

Credit(s) earned on completion of this course will be reported to AIA CES for AIA members. Certificates of Completion for both AIA members and non-AIA members are available upon request.

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Course Description

Exterior Curtain Wall challenges and solutions for one of Seattle's newest towers, The Mark will be discussed. The Presentation will provide information and learning as it relates to specific building design features of the diagonal brace cover, and the challenging geometry. We will also learn about the specific system features that were utilized to meet the thermal requirements of the project, and discuss installations sequencing, and weathering quality control challenges between the brace and the curtain wall.

Learning Objectives

At the end of the this course, participants will be able to:

1. Knowledge of the design of the diagonal stainless steel brace cover which runs the entire height of the project
2. Learn about the unique geometry that includes outward sloping, inward sloping and variable horizontal angles to create different facets.
3. The different strategies used to meet the Stringent U-Factor requirements including high performance glass
4. Unique weatherization detailing of the brace member joints which required consistent quality control.

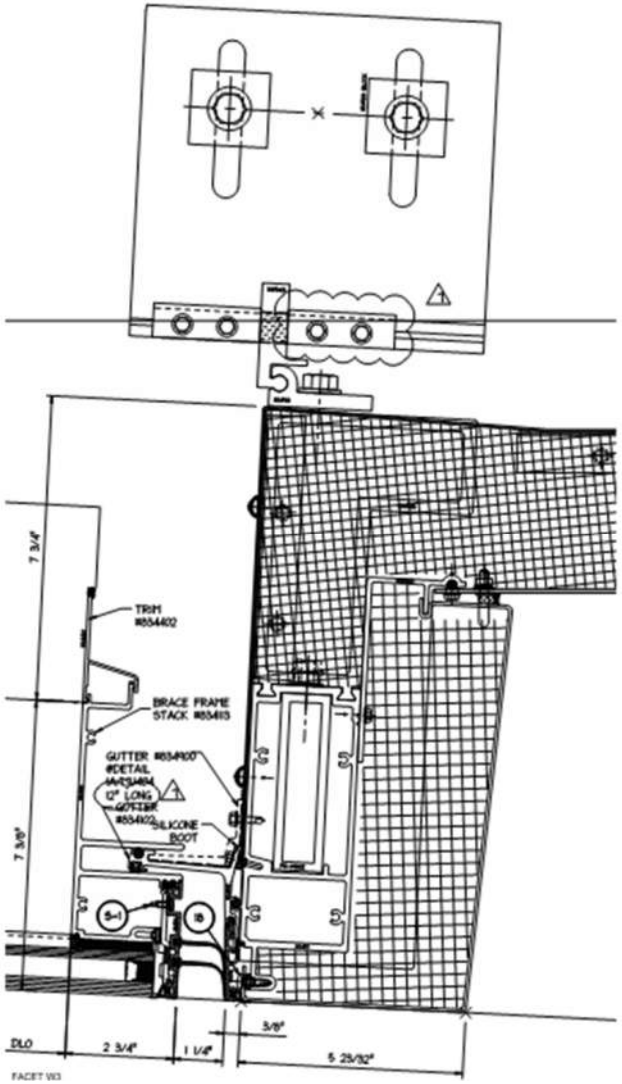
Challenges

Topics

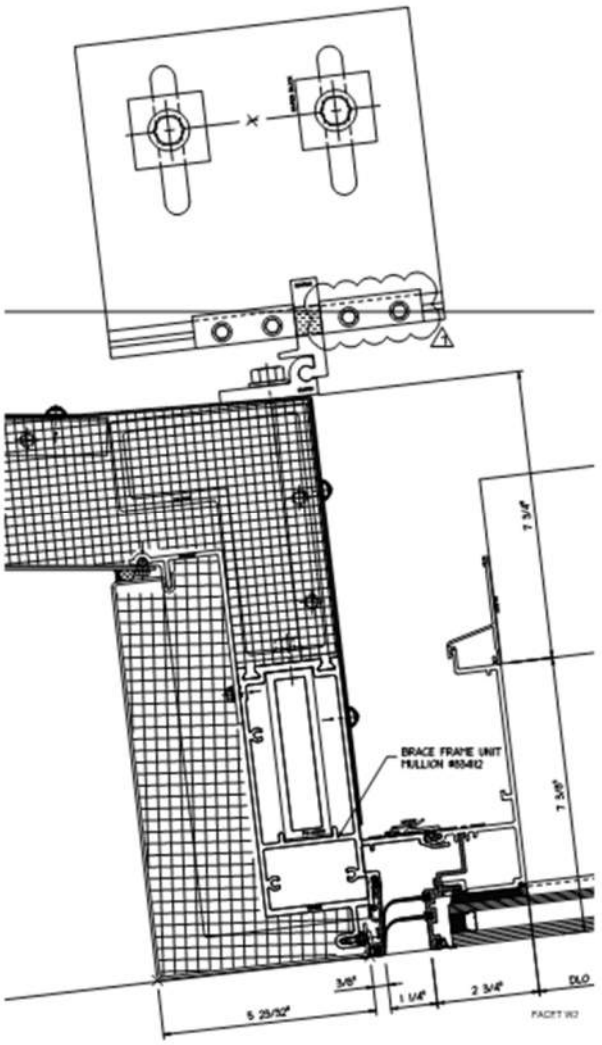
- **Building Design – The Diagonal Brace Cover**
- **Building Design – Geometry**
- **Thermal - U-Factor Requirements**
- **Installation – Unit Sequencing**
- **Installation – Weathering at the Brace**

Building Design – Diagonal Brace Cover

Building Design – Diagonal Brace Cover

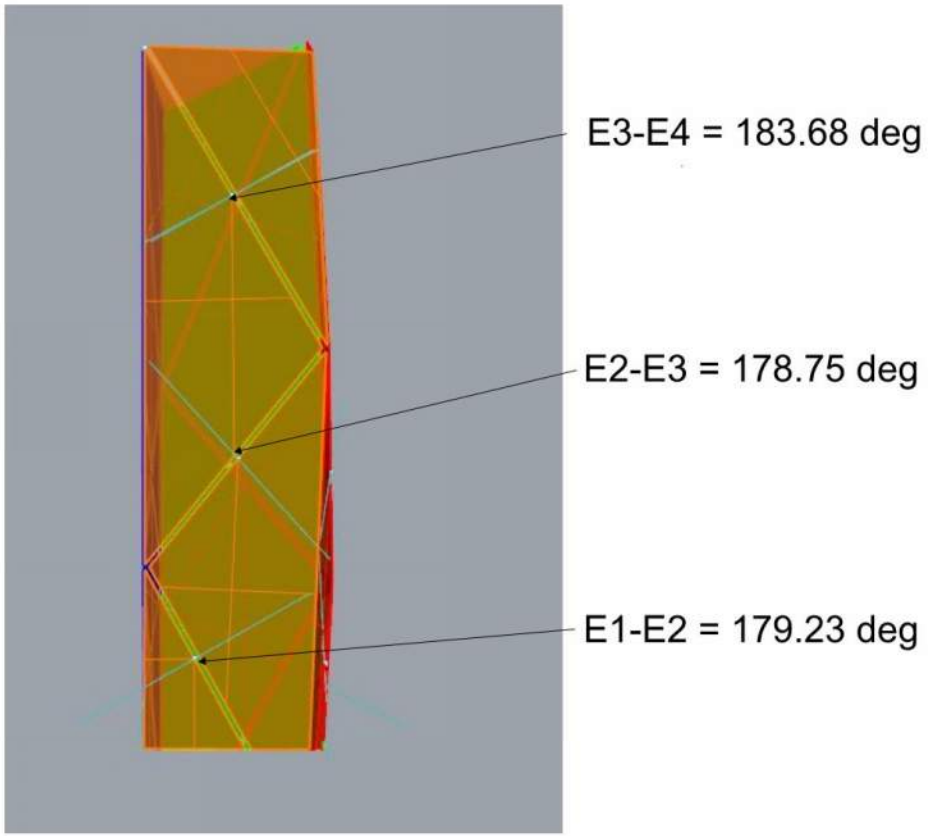


Upper Side Stack Joint

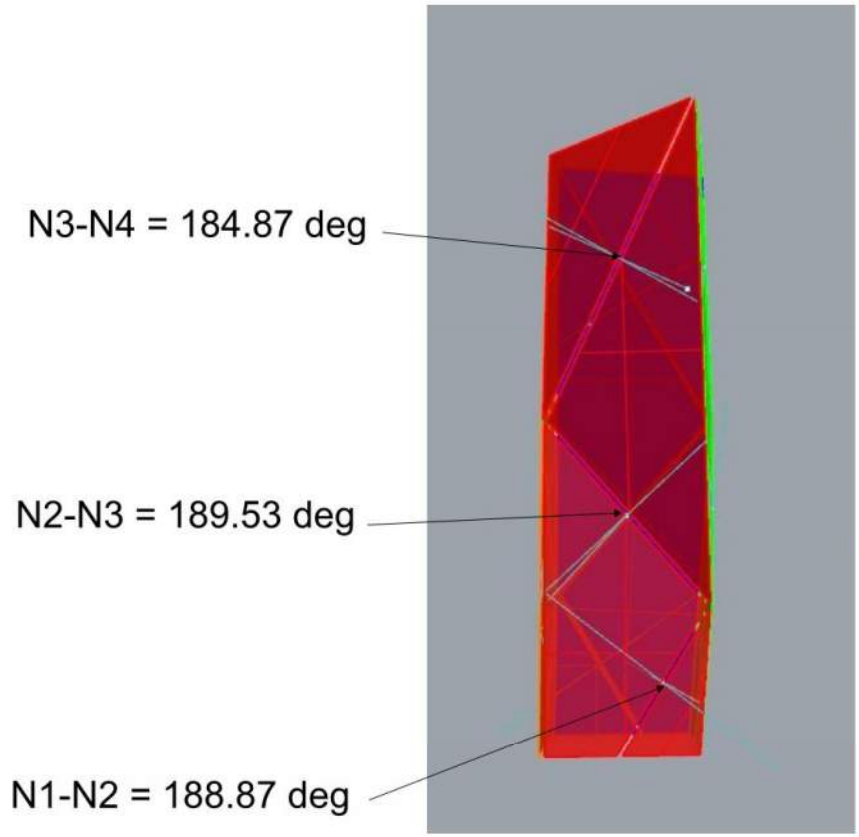


Lower Side Male/Female

Building Design – Geometry



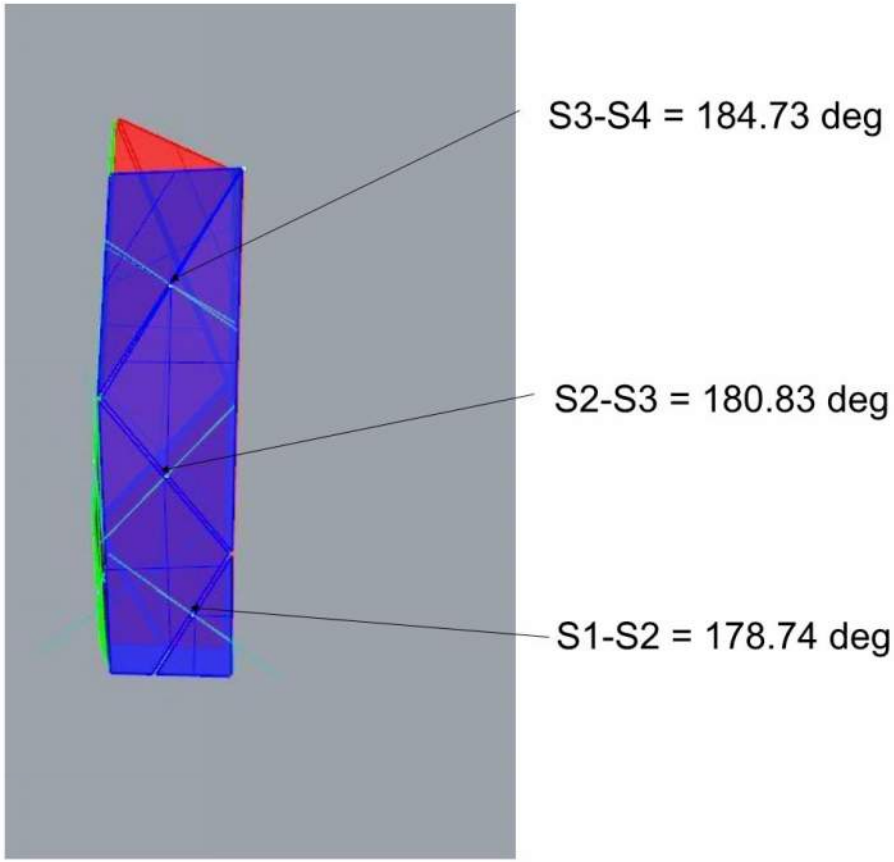
EAST ELEVATION



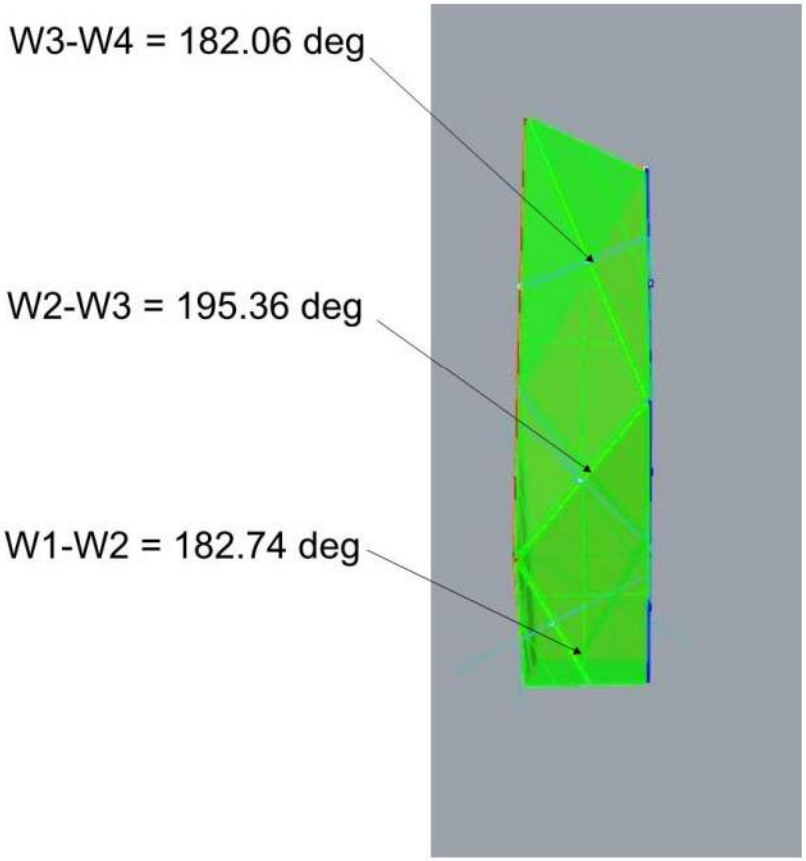
NORTH ELEVATION

5th & COLUMBIA FACET ANGLES

Building Design – Geometry



SOUTH ELEVATION



WEST ELEVATION

5th & COLUMBIA FACET ANGLES

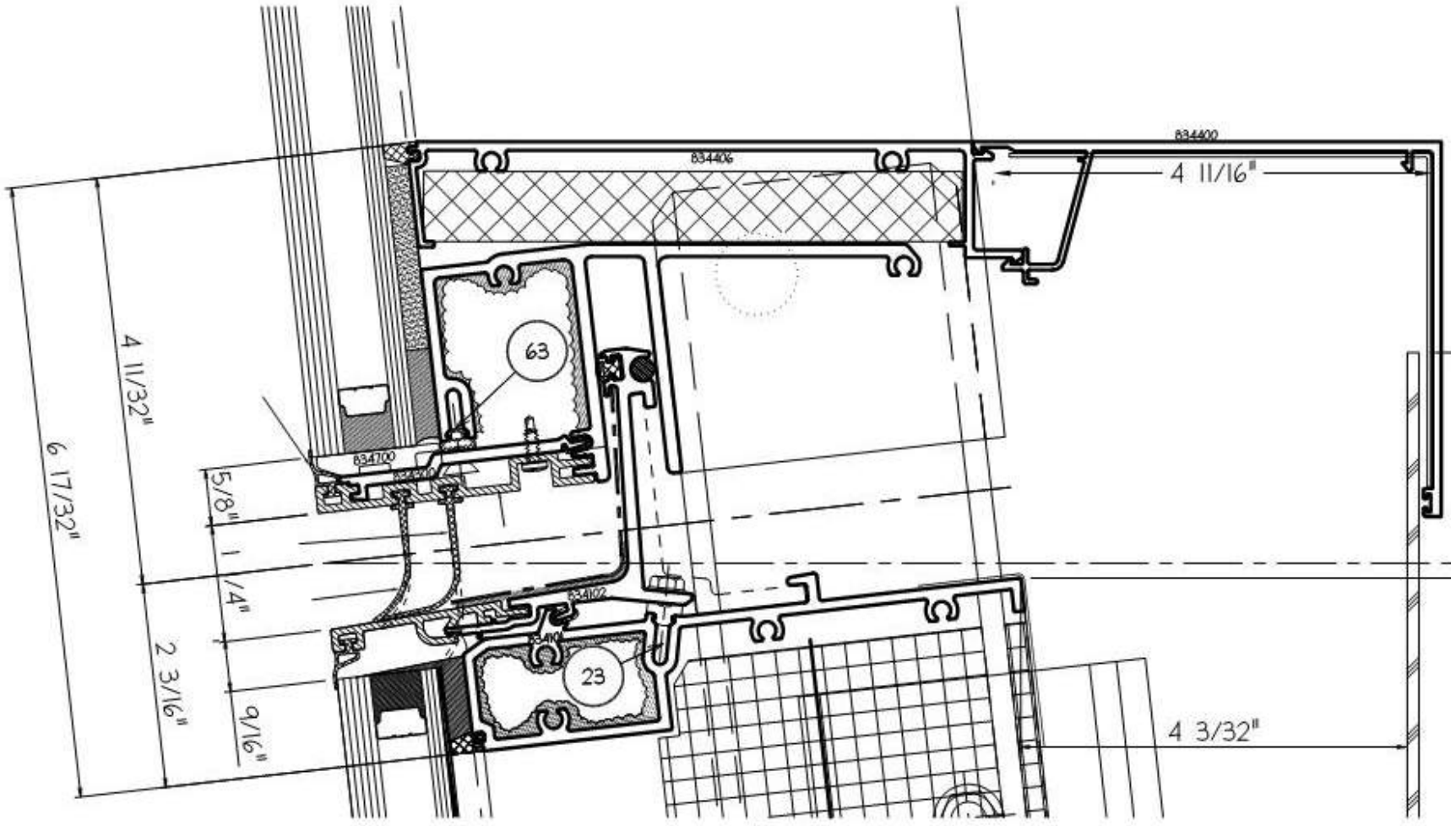
Building Design – Geomtery - Stack Sill

- **Facets – Angle from Vertical,**
- **+ leaning out, - leaning in**

Elev.	Detail	Angle	Elev.	Detail	Angle
E1	403	-1.5558	W1	401	+6.6893
E2	404	-0.7568	W2	405	+3.9901
E3	415	-0.0000	W3	417	-1.9493
E4	419	-1.4314	W4	421	-2.3256
N1	401	+6.3403	S1	402	-0.0000
N2	405	+3.8141	S2	406	+0.4865
N3	416	-1.8500	S3	415	-0.0000
N4	419	-2.0840	S4	418	-1.4378

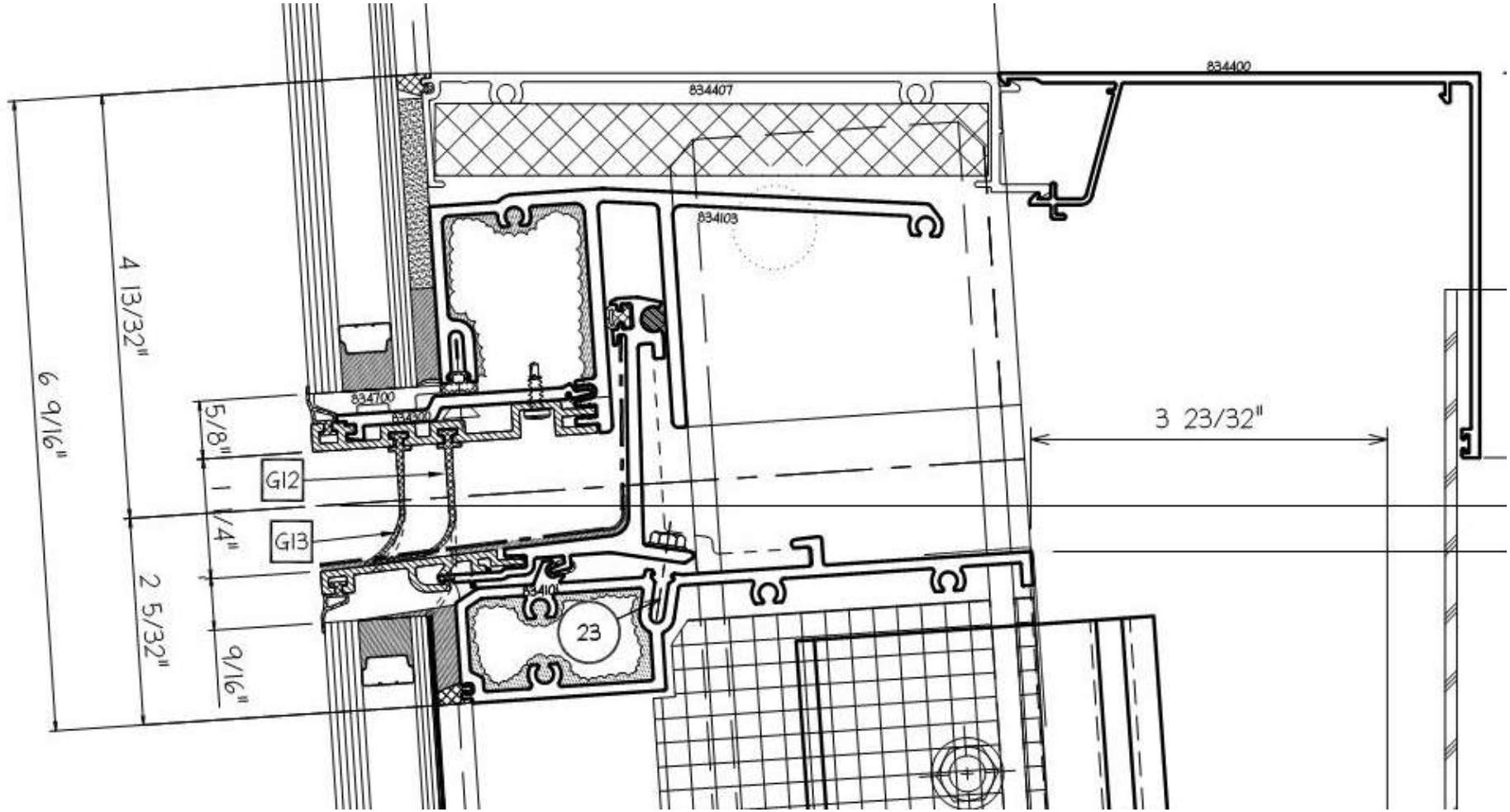
14 different angles, 3 sets of dies

Building Design – Geometry - Stack Sill



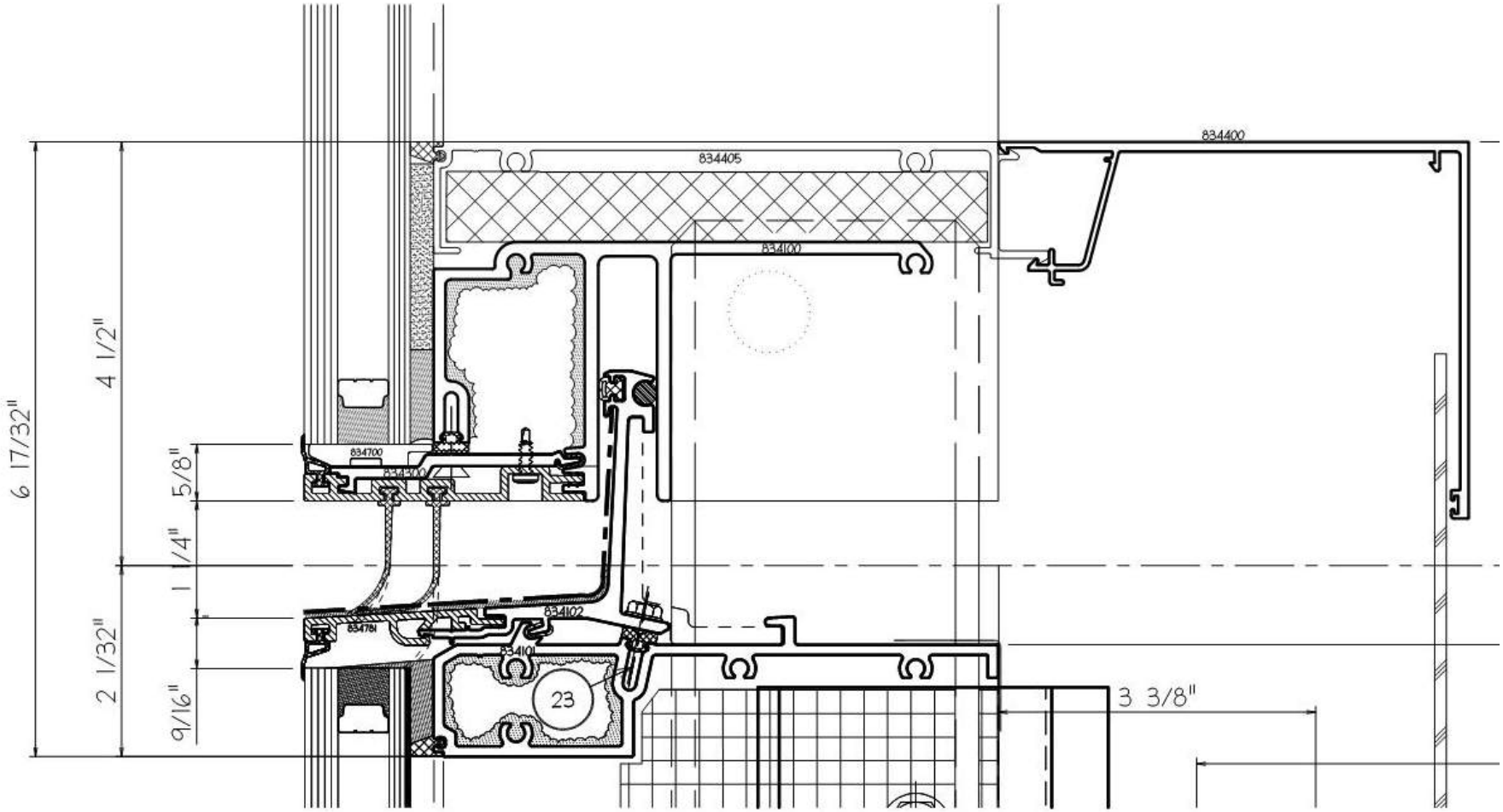
Facets N1 and W1; Detail 401; Angle +6.3403 to +6.6893;
Dies 834406, and 834110

Building Design – Geometry – Stack Sill



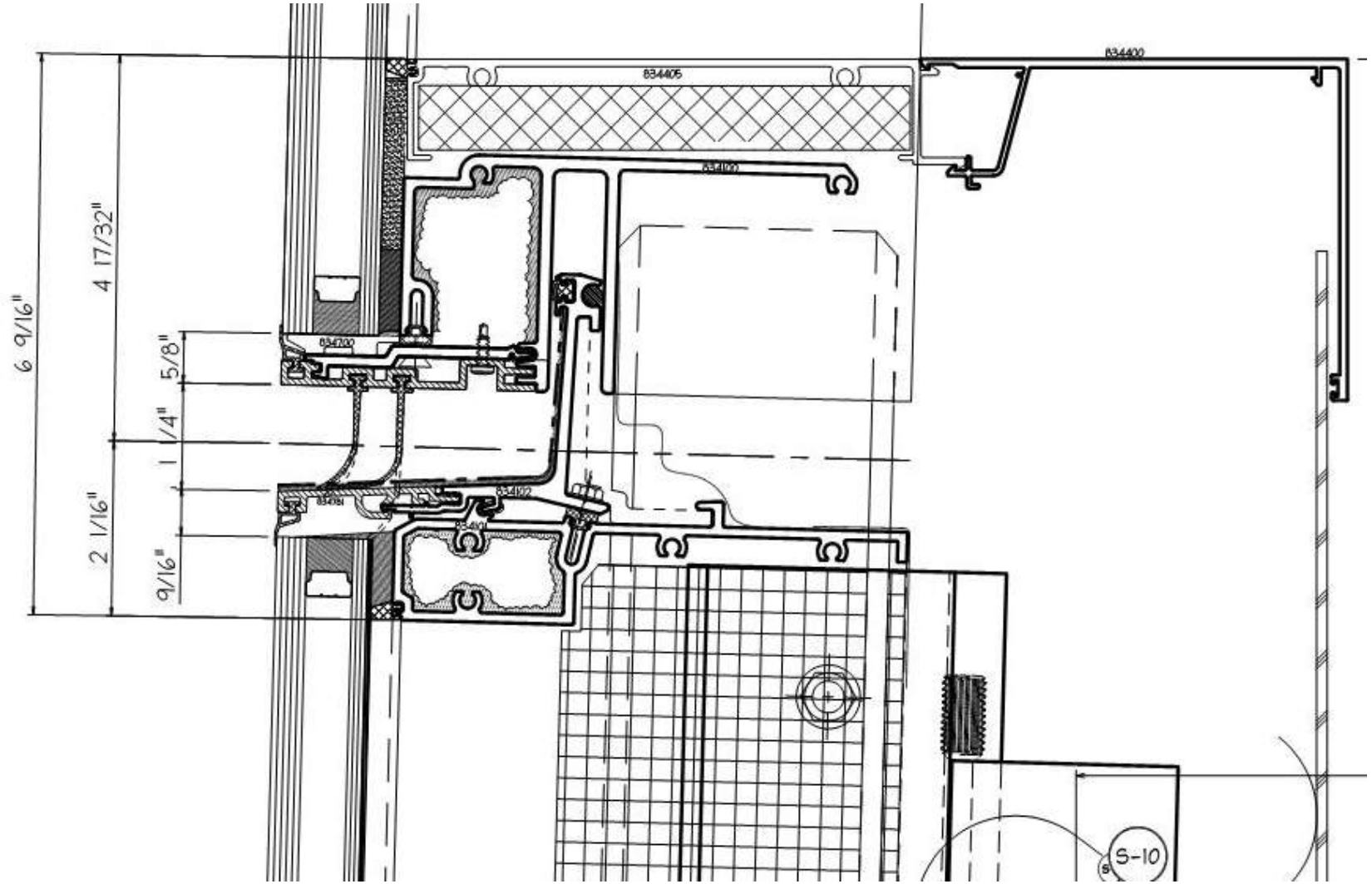
Facets N3 and W2; Details 405, and 416; Angles +3.8141, and +3.9901;
Dies 884407, and 834103

Building Design – Geometry – Stack Sill



Facets E3, S1, S3; Details 402, and 415; Angle; 0.0000;
Dies 834405, and 834100

Building Design – Geometry – Stack Sill



Facets E1, E2, E4, N3, N4, W3, W4, S2, and S4; Details 403, 404, 406, 416 to 421; Angles +0.4865 to -2.3256; Dies 884405, and 834100

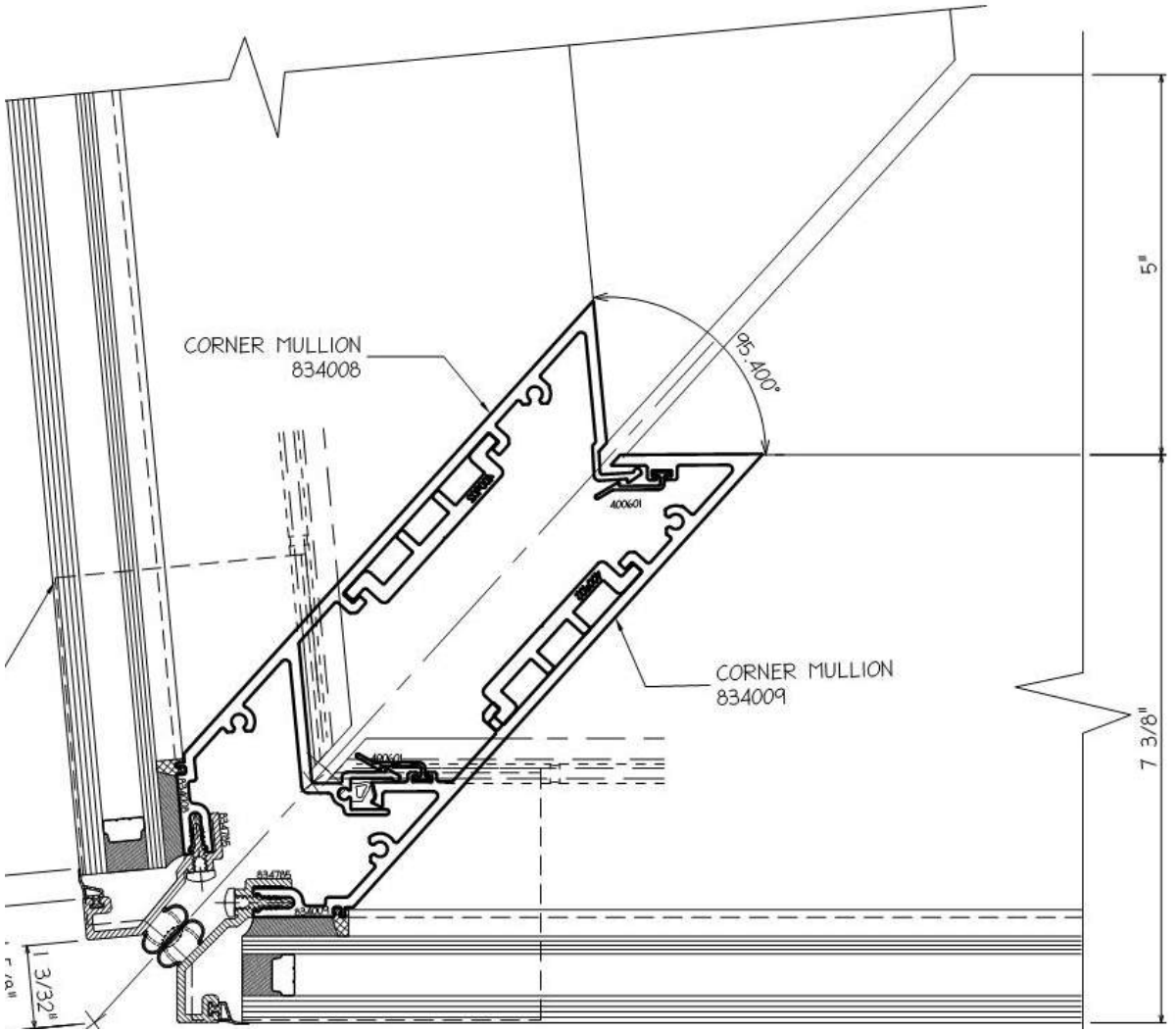
Building Design – Geometry – Corner Mullion

- **Facets – Horizontal angle between Facets**

Column	Facets	Angle	Dies
H-1	W2, S2	95.40	834008, 834009
H-9	S1, E1	88.60	834001, 834002
A-9	N2,E2	93.00	834006, 834007
A-1	W1, N1	90.50	834004, 834005
H-1	W4, S4	91.15	834004, 834005
H-9	S3, E3	90.50	834004, 834005
A-9	N4, E4	90.47	834004, 834005
A-1	W3, N3	94.33	834008, 834009

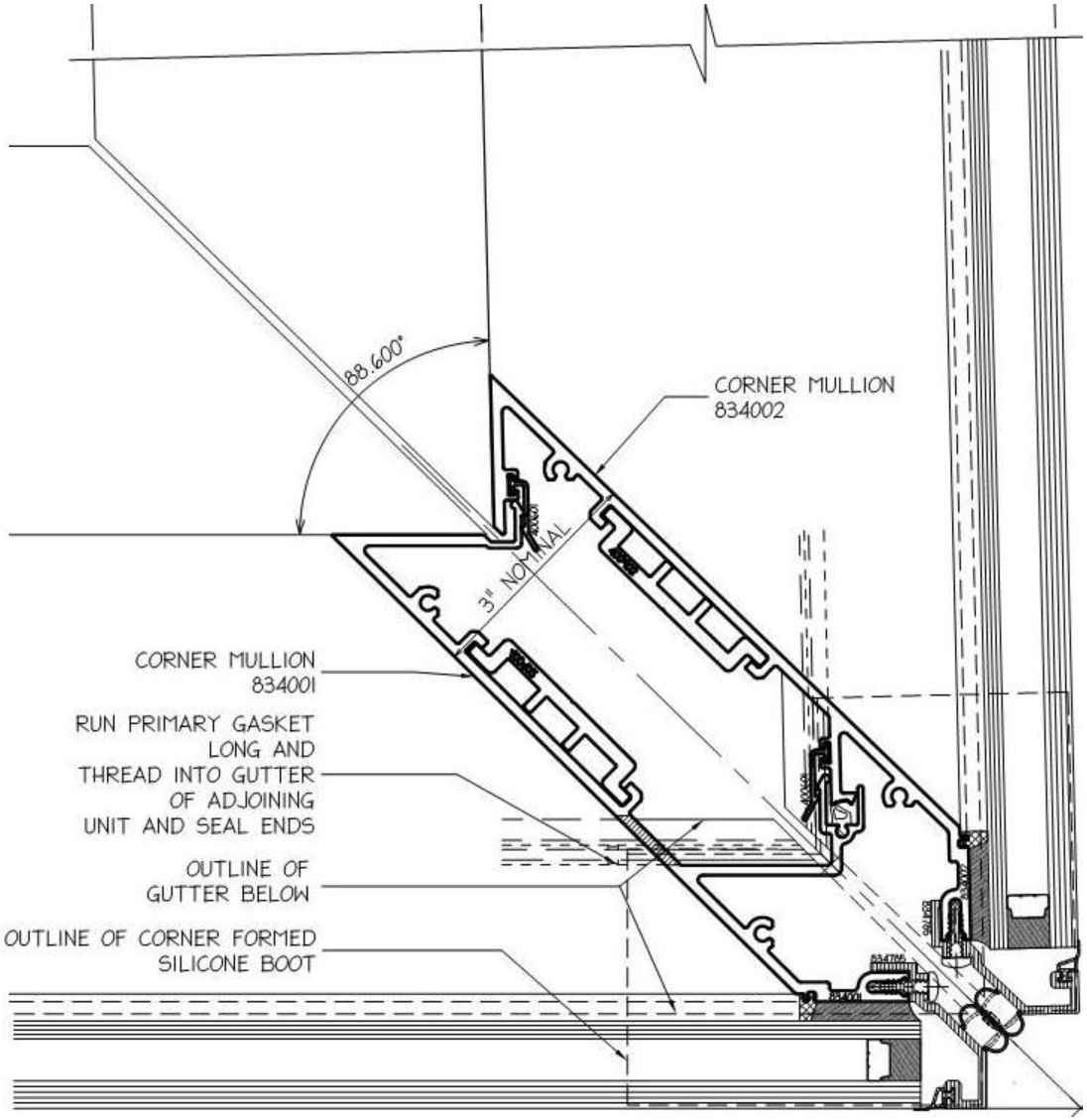
7 different angles, 4 sets of dies, Rule of thumb is 1.5 degrees

Building Design – Geometry – Corner Mullion



Column H-1; Facets W2, S2; Angle 95.40; Dies 834009, 834008

Building Design – Geometry – Corner Mullion



Column H-9; Facets S1, E1; Angle 88.60; Dies 834002, 834001

Thermal - U-Factor Requirements

Thermal Features

- **Insulated Sill Cover**
- **High Performance Glass**
- **L Shaped Head Horizontal**
- **Synthetic Fins**

Performance Challenges

- U value of .32
  - Seattle Energy Code requires U = 0.32 for glazed areas.
  - Requires thermal simulations of standard size and a physical test of standard size sample to validate simulations to obtain NFRC Label Certificate.
- NFRC Label Certificate
  - Seattle building department requires NFRC Label Certificate submittal prior to beginning installation.

NFRC Label Certificate

NATIONAL FENESTRATION RATING COUNCIL
LABEL CERTIFICATE

PROJECT INFORMATION

LABEL CERTIFICATE ID: ***2015-09-14.001*** **Issuance Date:** 09/14/15

This is to be completed by an NFRC Approved Calculation Entity (ACE), based on information provided by the Specifying Authority and calculated in accordance with NFRC procedures.

PROJECT LOCATION:

Address: 801 5th Ave
City: Seattle, **State,** WA, **Zip code:** 98101
Contact person: John Little, **Title:**
Phone: 763-525-2332, **Facsimile:**, **Email:** jlittle@harmoninc.com
Project name (optional): 5th & Columbia, **Designer (optional):**

IDENTIFICATION OF SPECIFYING AUTHORITY:

Company name: Harmon, Inc, **ID:** HAR
Address: 7900 Xerxes Ave South Suite 1800
City: Bloomington, **State,** MN, **Zip code:** 55431-1159
Contact person: John Little, **Title:**
Phone: 763-525-2332, **Facsimile:**, **Email:** jlittle@harmoninc.com

IDENTIFICATION NAME OF APPROVED CALCULATION ENTITY (ACE):

Company name: Quast Consulting & Testing, **ID:** QCT
Address: 1055 Indianhead Drive
City: Mosinee, **State,** WI, **Zip code:** 54455
Contact person: Brian Sasman, **Title:**
Phone: 715-693-8378, **Facsimile:**, **Email:** bsasman@qct-usa.com

IDENTIFICATION NAME OF INSPECTION AGENCY (IA):

Company name: N/A, **ID:**
Address:
City:, **State,**, **Zip code:**
Contact person:, **Title:**
Phone:, **Facsimile:**, **Email:**

Number of individual products listed on this label certificate: 1

NATIONAL FENESTRATION RATING COUNCIL
LABEL CERTIFICATE

PRODUCT LISTING

FOR CODE COMPLIANCE

LABEL CERTIFICATE ID: ***2015-09-14.001*** **Issuance Date:** 09/14/15

NFRC CERTIFIED PRODUCT RATING INFORMATION:*

The NFRC Certified Product Rating Information listed here is to be used to verify that the ratings meet applicable energy code requirements.

PRODUCT LISTING:

						CERTIFIED Performance Rating at NFRC Standard Size		
CPD ID	Product Name	Framing Ref	Glazing Ref	Spacer Ref	Total Area	U-factor**	SHGC**	VT**
					ft²	hr•ft²•°F	-	-
Metal Framing Products - Curtain Wall/Storefront:								
P-HAR-40267	UCW8000 TI	FA-HAR-50842	GA-VIR-10960	SA-NFC-3715	43.06	0.31	0.30	0.42

FRAME, GLAZING and SPACER ASSEMBLIES:

FRAMING LISTING:

Framing Ref	Supplier ID	Product Type	Frame Material	Description
FA-HAR-50842	HAR	GWCW	Aluminum Alloy	UCW8000 TI Standard Product Rating

GLAZING LISTING:

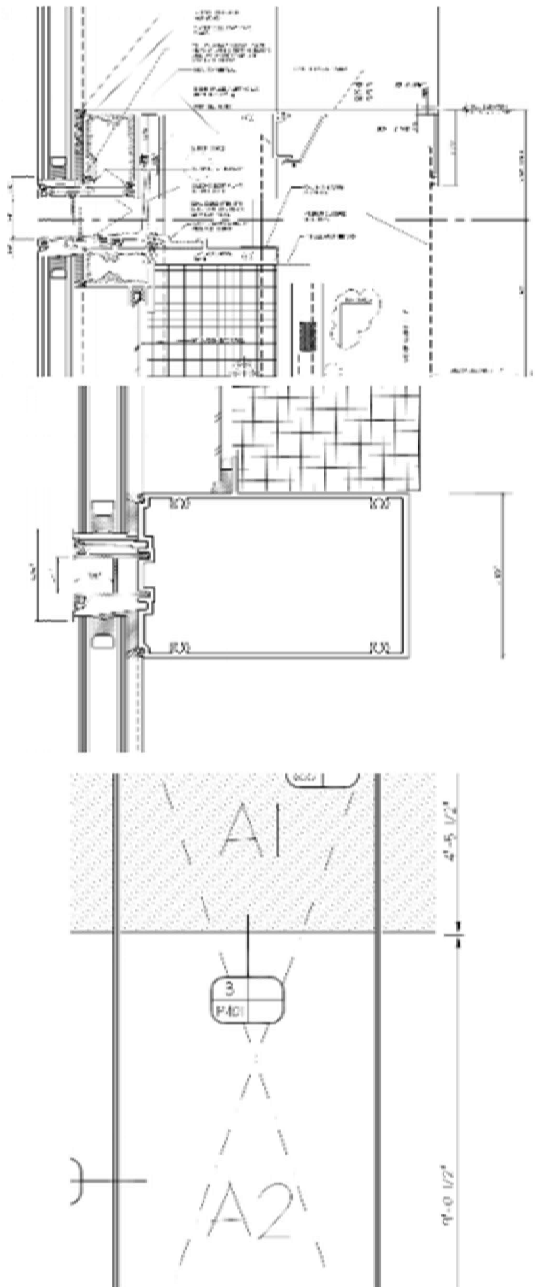
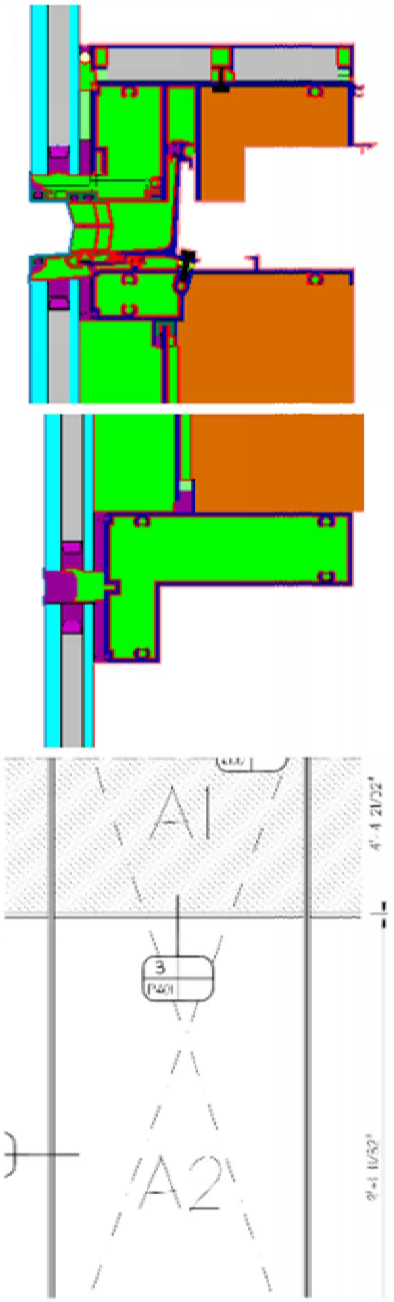
Glazing Ref	Supplier ID	# Layers	Low-e	Gap Fill	Description
GA-VIR-10960	VIR	2	Y	Argon	3/8" VRE 1-54 #2, ½" Argon, ¼" Clr HS

SPACER LISTING:

Spacer Ref	Supplier ID	Sealant Config.	Spacer Material	Description
SA-NFR-3715	NFR	PIB Prim, Silicone Secondary	Stainless Steel	

Note: For NFRC-approved frame, glazing and spacer component performance information see the NFRC Approved Component Library Database: www.nfrc.org/CMAST

PROPOSED FEATURES FOR CURRENT DESIGN

CURRENT DESIGN	PROPOSED DESIGN FEATURES
Enlarged Thermal Bulb Gasket @ Vision Sill **Insulation @ Vision Sill** **Trim with XPS @ Vision Sill** **"Cutout" Profile & ¾" Joint @ Vision Head** **Increase Vision Height & Decrease Spandrel Height by Trim thickness**	
	
$A_{COG} = 5090\ in^2$ $A_{EOG} = 774\ in^2$ $A_{VisionFrame} = 616\ in^2$	$u_{COG} = 0.248$ (per WINDOW) $u_{EOG} = 0.289$ $u_{VisionFrame} = 1.308$
$U_{VISION} = 0.35$	
$A_{COG} = 5115.5\ in^2$ $A_{EOG} = 776.9\ in^2$ $A_{VisionFrame} = 668.3\ in^2$	$u_{COG} = 0.248$ (per WINDOW) $u_{EOG} = 0.279$ $u_{VisionFrame} = 0.880$
$U_{VISION} = 0.316$	

5th and Columbia (R1.3)
U - FACTOR CALCULATIONS
SUMMARY OF RESULTS

Climatic Conditions:

Interior Ambient Temp.	T_i =	69.8 °F
Interior Dewpoint Temp.	T_{dp} =	
Exterior Ambient Temp.	T_o =	-0.4 °F
Interior Relative Humidity	RH =	
Exterior Wind Speed	v =	12.3 mph

Typical Unit:

Overall U-Factor

$U_{overall}$ =	0.31	$\frac{BTU}{hr*ft^{2}*^{o}F}$	$U_{overall}$ =	1.77	$\frac{W}{m^{2}*^{o}C}$

Vision U-Factor
(for vision infill and framing ONLY)

U_{vision} =	0.31	$\frac{BTU}{hr*ft^{2}*^{o}F}$	U_{vision} =	1.77	$\frac{W}{m^{2}*^{o}C}$

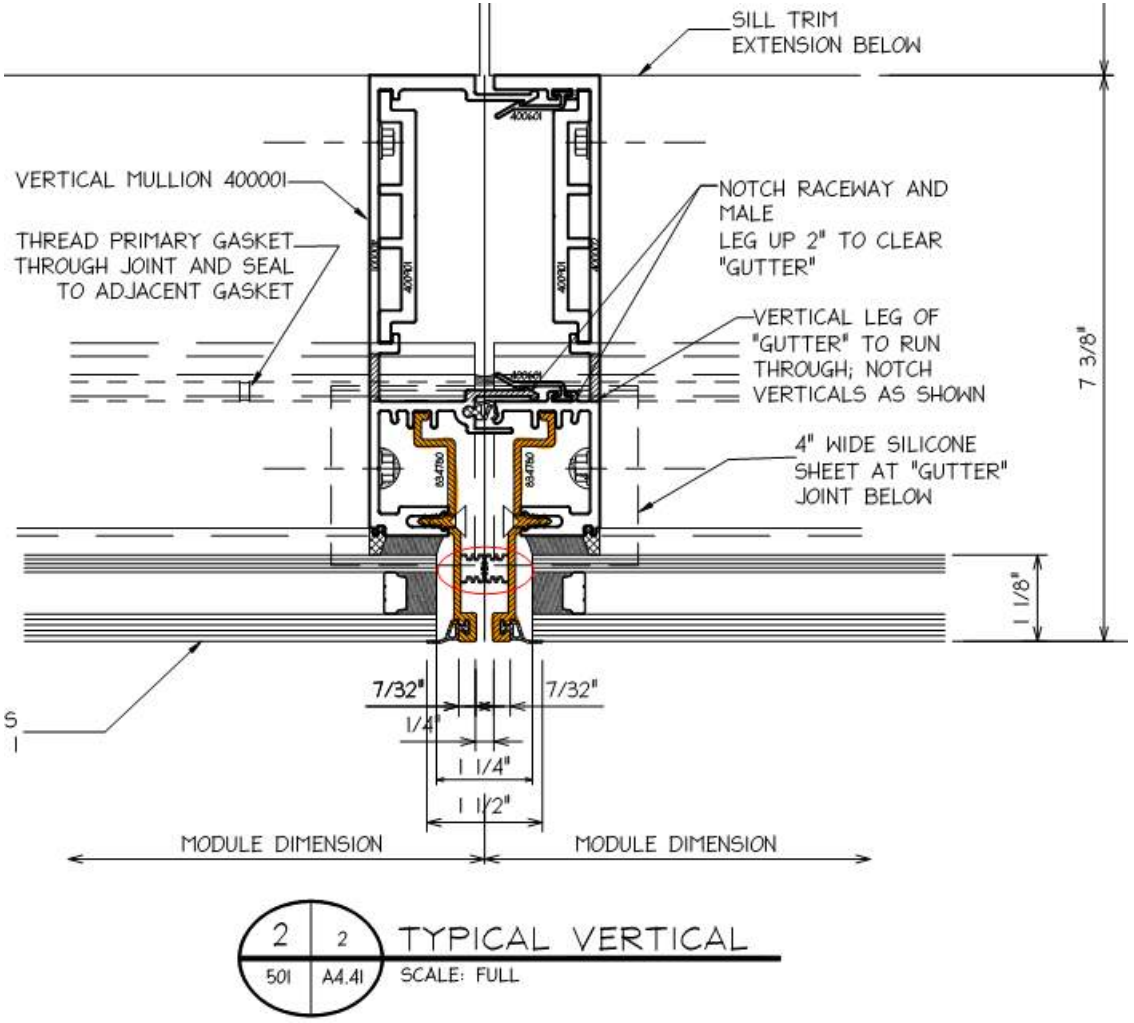
Spandrel U-Factor
(for spandrel infill and framing ONLY)

$U_{spandrel}$ =	$\frac{BTU}{hr*ft^{2}*^{o}F}$	$U_{spandrel}$ =	$\frac{W}{m^{2}*^{o}C}$

Thermoplastic Trim

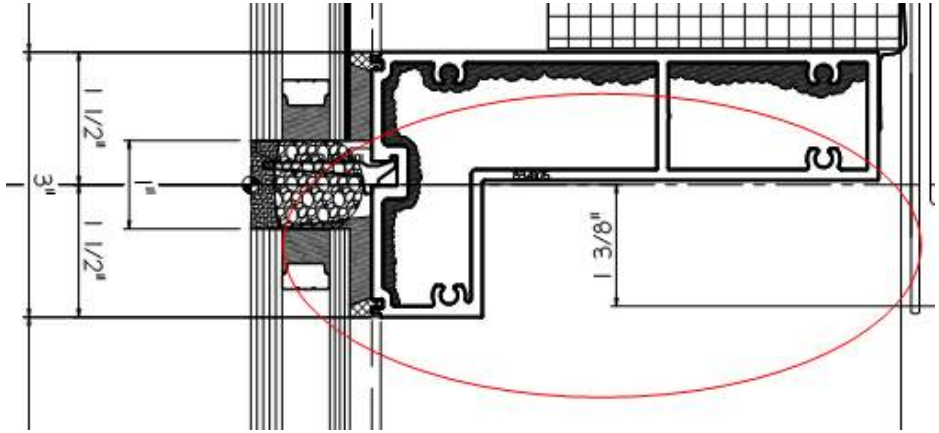
THERMO PLASTIC SCHEDULE

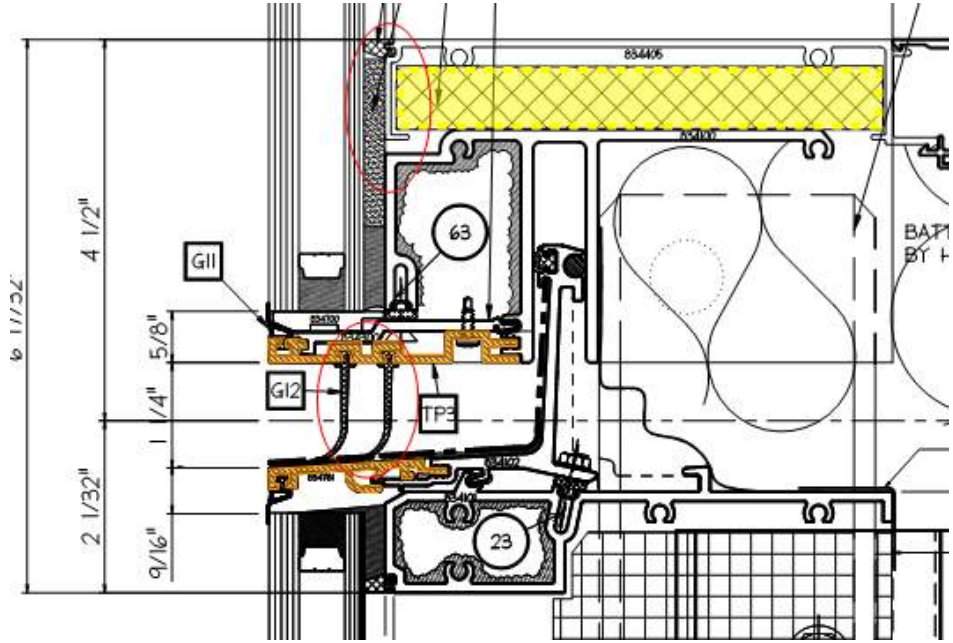
GASKET NO	PROFILE	DESCRIPTION
TP	834780	THERMO PLASTIC EXTRUSION-WITH FLEX. ALCRYN BARBS & BULB WITH ASTRO SLIP AND GEON CAP STOCK GEON 6935, COLOR 2880 BLACK
TP2	834781 STACK HORIZONTAL	UNIT HEAD THERMO PLASTIC EXTRUSION-WITH FLEX. ALCRYN BARBS & BULB AND GEON CAP STOCK GEON 6935, COLOR 2880 BLACK
TP3	834782 STACK HORIZONTAL	UNIT SILL THERMO PLASTIC EXTRUSION-WITH FLEX. ALCRYN BARBS AND GEON CAP STOCK GEON 6935, COLOR 2880 BLACK
TP4	834783 BRACE STACK	CURTAIN WALL UNIT UNDERSIDE BRACE, THERMO PLASTIC EXTRUSION-WITH FLEX. ALCRYN BARBS AND GEON CAP STOCK GEON 6935, COLOR 2880 BLACK



Thermal Component Solutions

- Intermediate Horizontal
- Insulation and Trim Sill
- Thermoplastic Trim





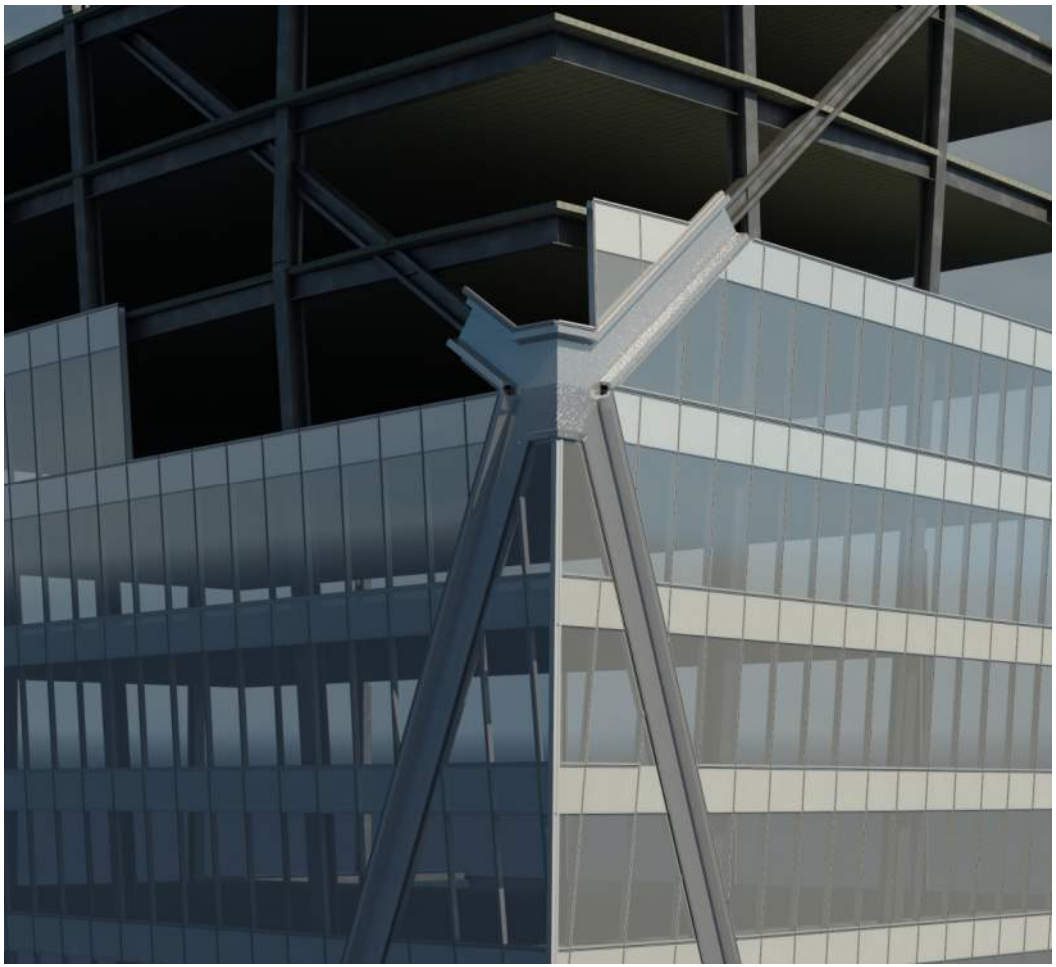
Installation Unit Sequencing

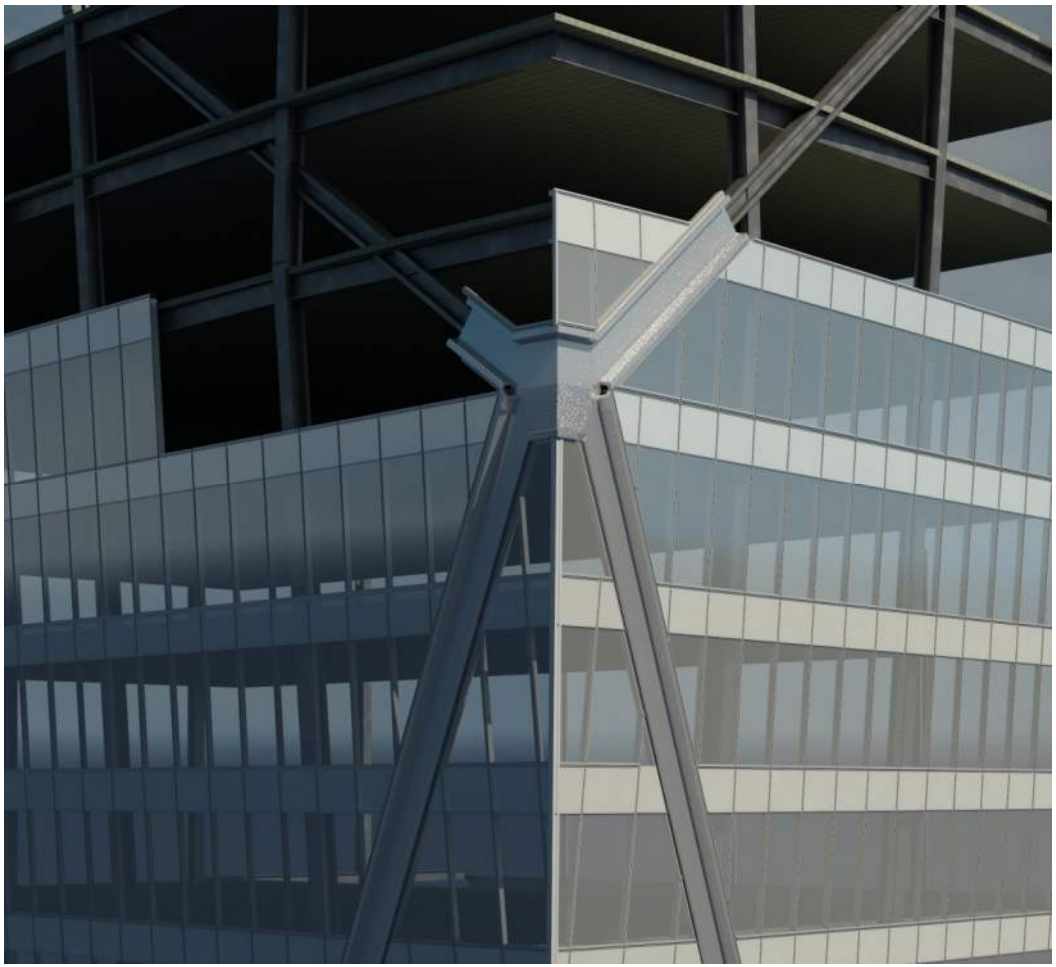
Unit Sequencing Approaches

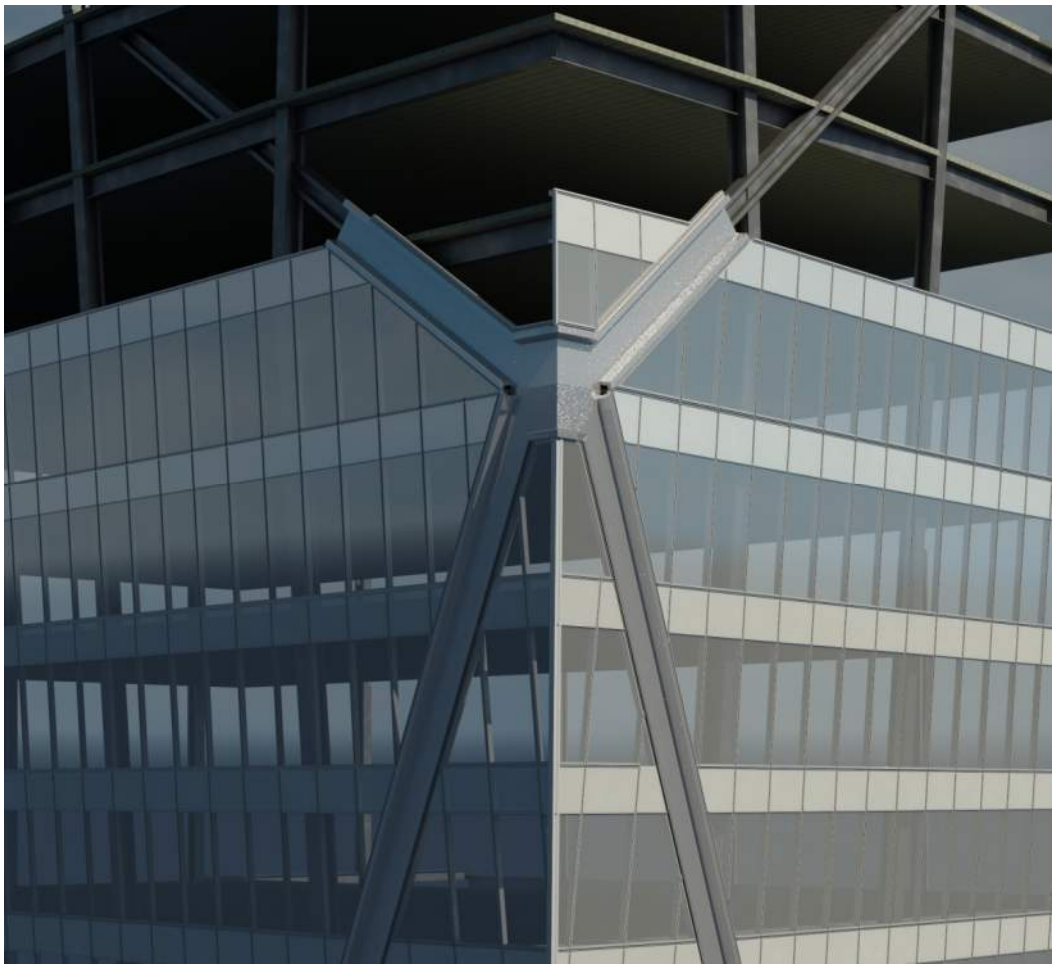
- **Preconstruction**
  - **Begin Installation from corners progressing towards the brace**
- **Mock Up**
  - **Support of units under the brace**
- **Construction**
  - **Able to set in both directions**

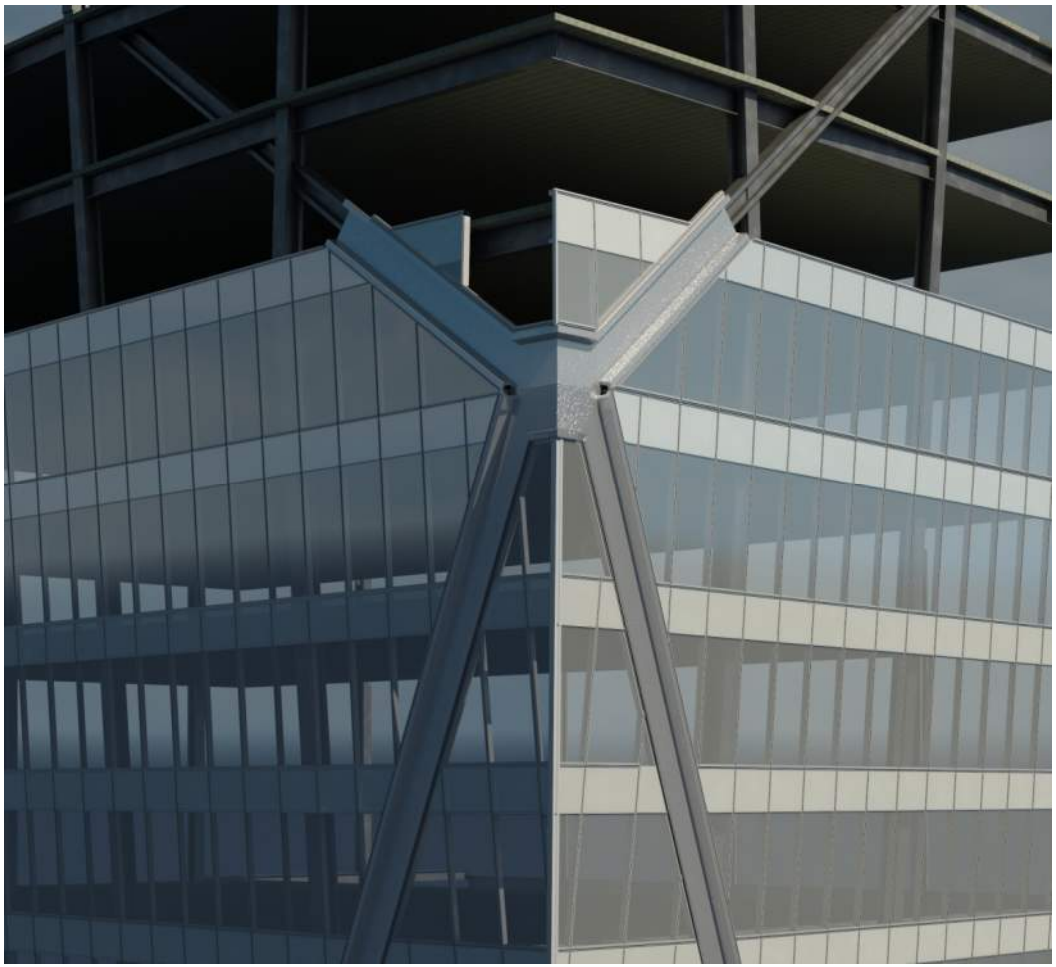
Project Overview/Stats

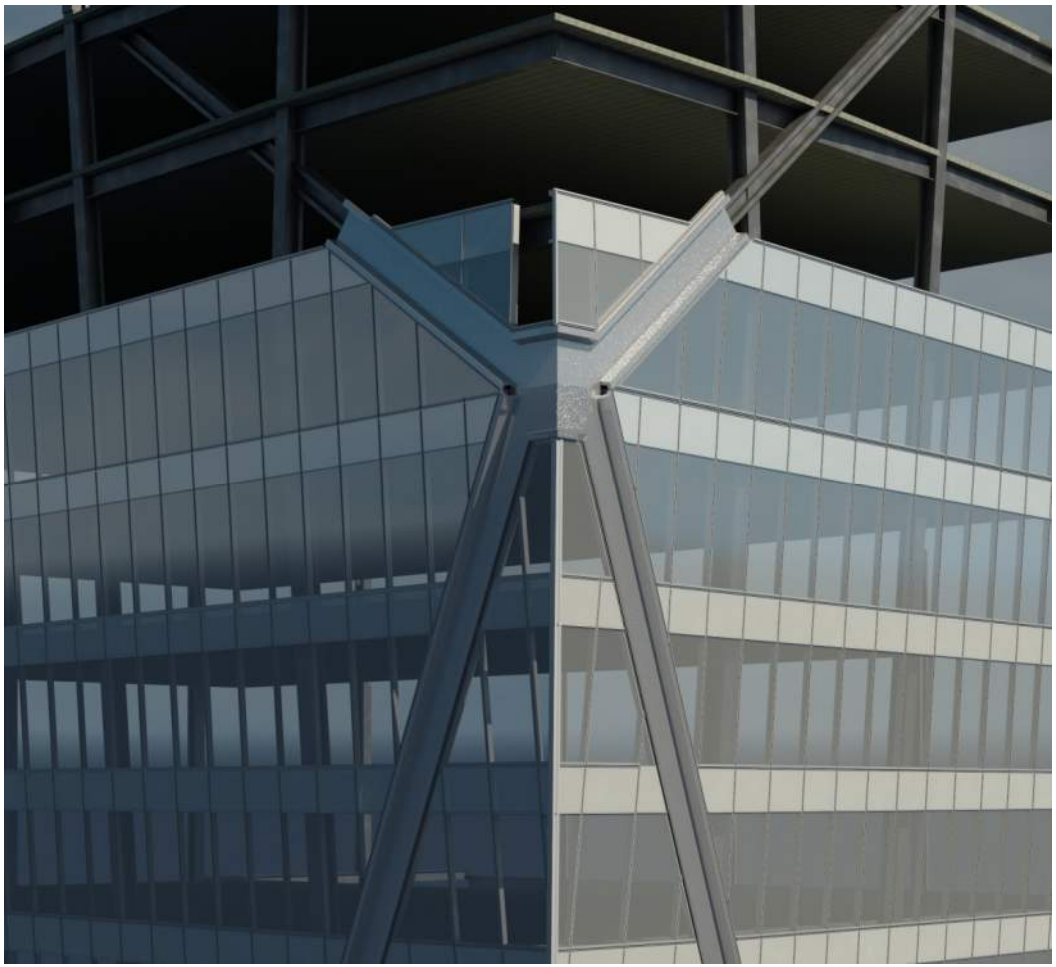
- 44 story/660’ office/hotel
- 334,000 sf Enclosure Scope
- 5,700 CW Units
- 10,454 Glass Lites
- 4,600 Shadowbox Panels
- 1,400 SST Panel Units
- 390 Louver Panels
- 50,000 MH Site Labor

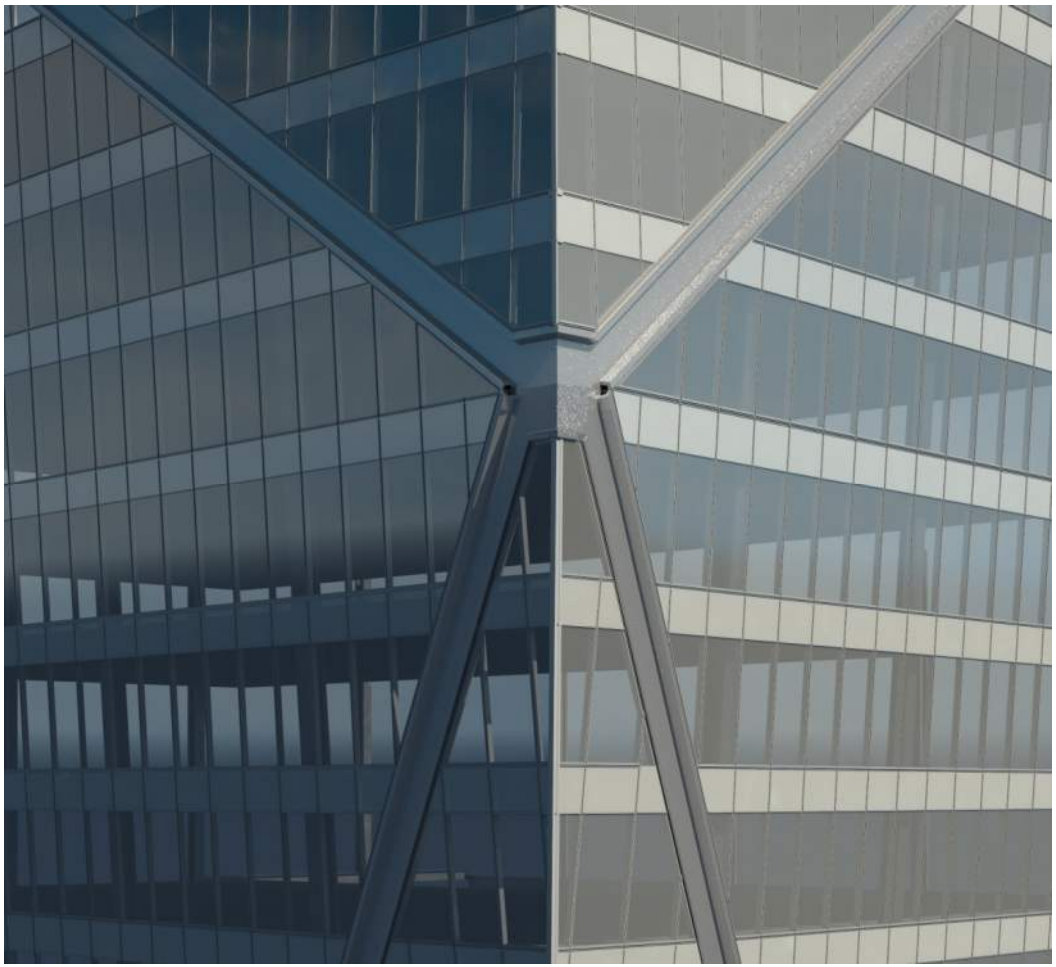












Complex By Design

- Diagonal seismic brace frame system expressed on skin
- Façade segmented on diagonals
- Geometry cuts each elevation into 4 separate facets
- 16 unique angles and slopes
- CW unit dimensions vary with each angle

“HUB” Connections

Unitized SST clad brace frame panels wrap around building, intersect at corners creating custom “hubs”

Architect’s Vision

Built Reality

Ugly Truth

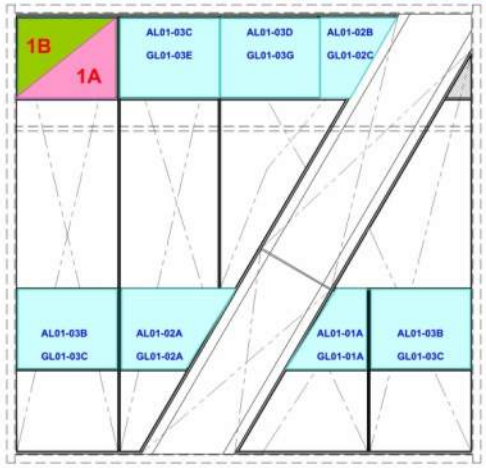
Flying Visual Mock-Up

- Viewed at 60’ to simulate actual placement
- Reconfigurable system for quick panel swap
- Finalize material selection
- Delete unnecessary materials/components

VMU Viewing Configurations

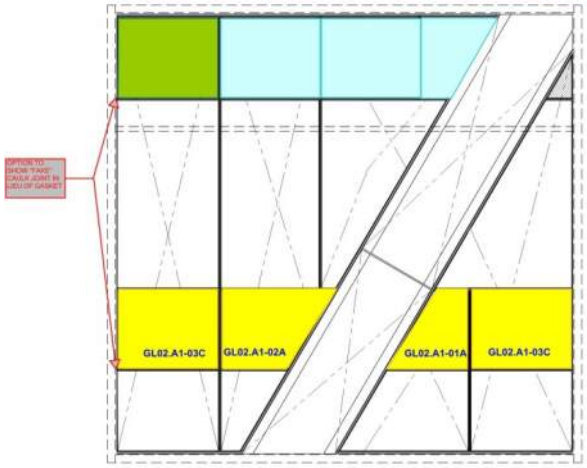
Sequence #1A & 1B

#1A = Louver and picture frame set flush w/ F.O.G.
#1B = Move louver flush to back of mullion w/o picture frame and install perf



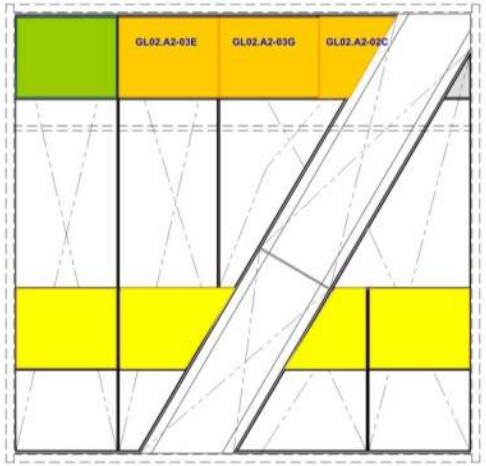
Sequence #2

#2 = Remove GL01 and Shadow Box Panel and install Spandrel (GL02 Alt. 1)



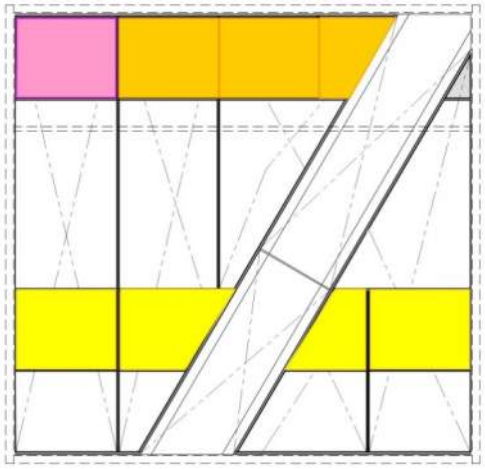
Sequence #3

#3 = Remove GL01 and Shadow Box Panel and install Spandrel (GL02 Alt. 2)

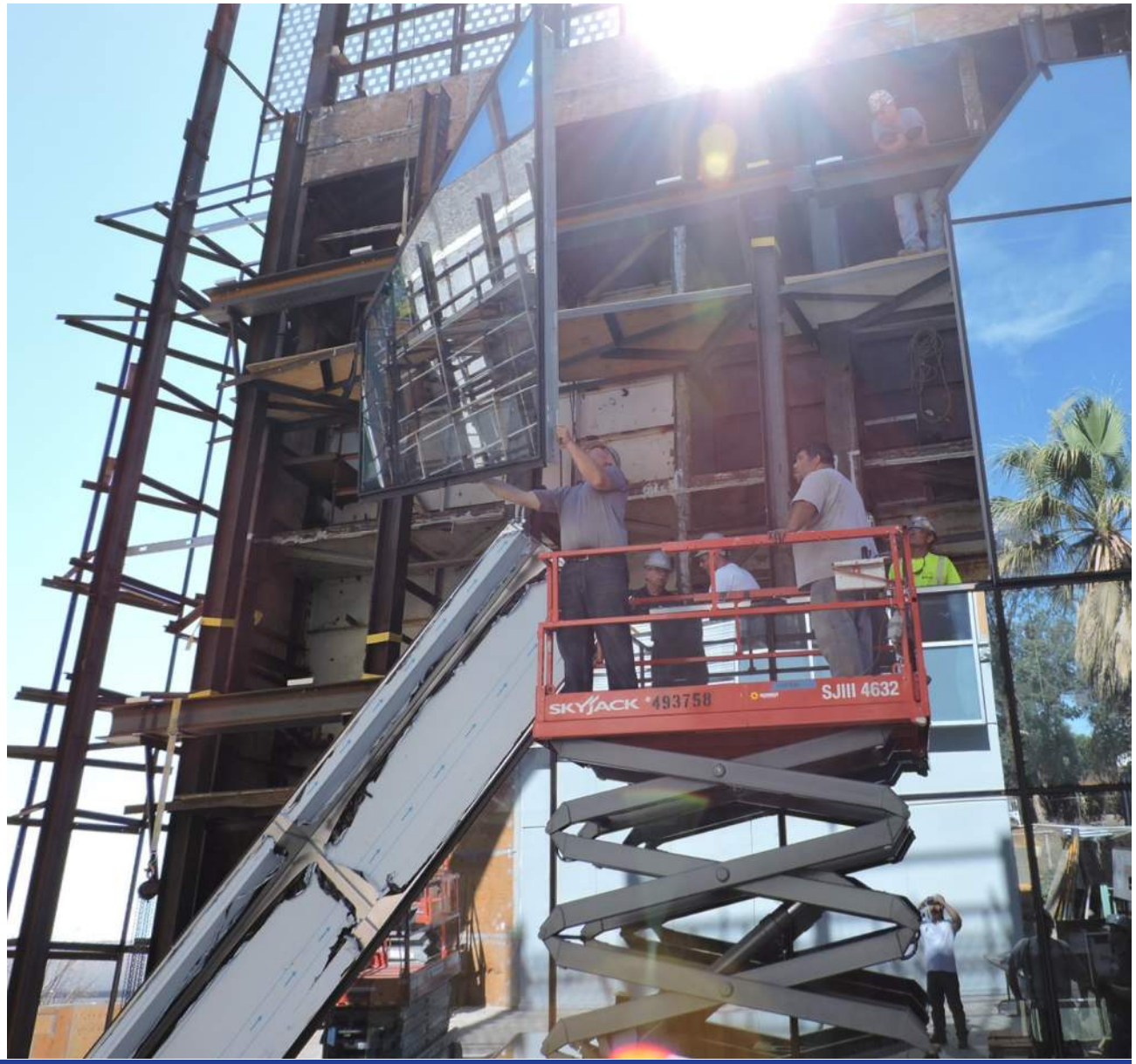


Sequence #4

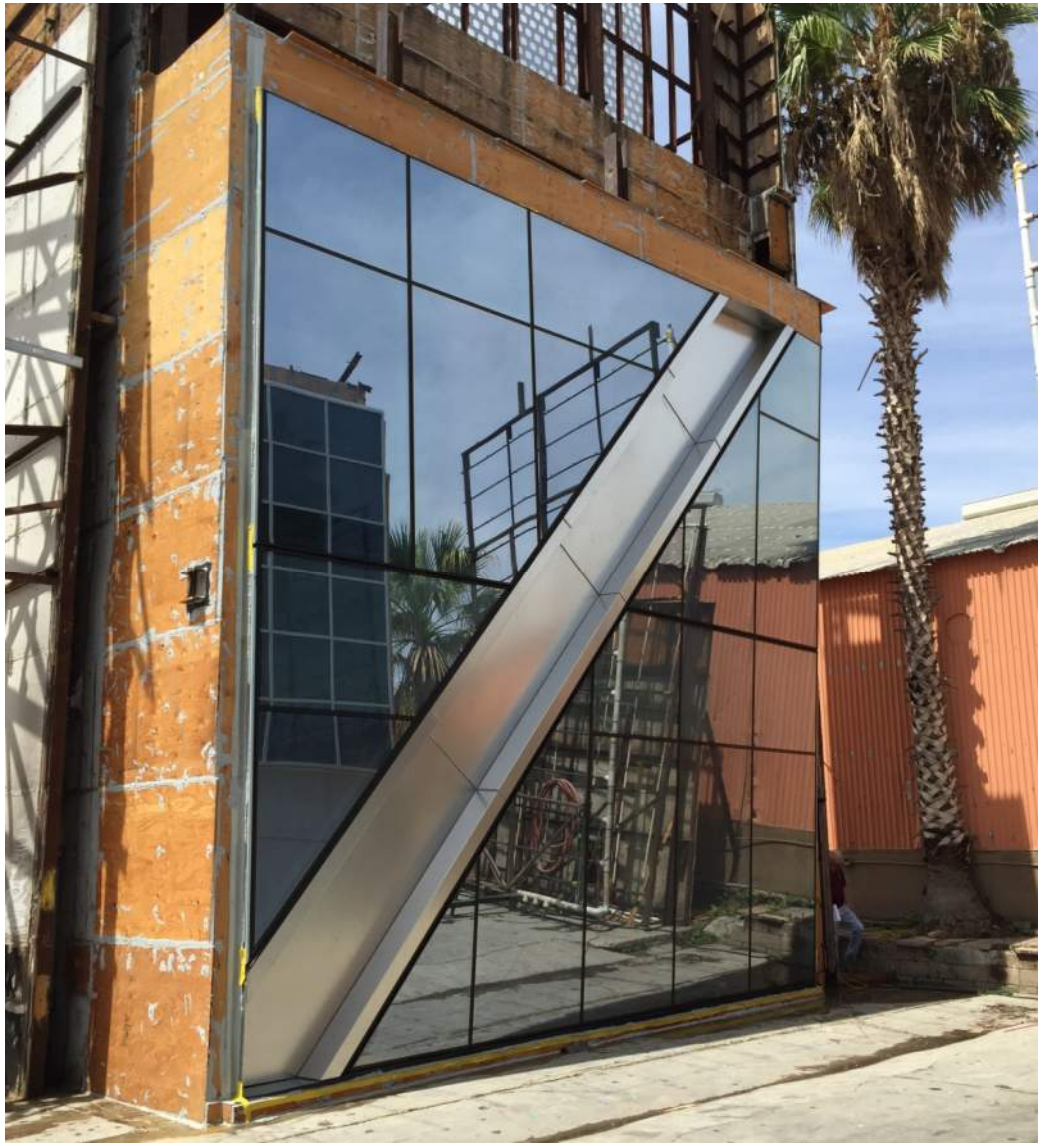
#4 = Remove Perforated Panel and install Louver w/ Picture Frame flush w / F.O.



Setting Sequence – Testing Assumptions

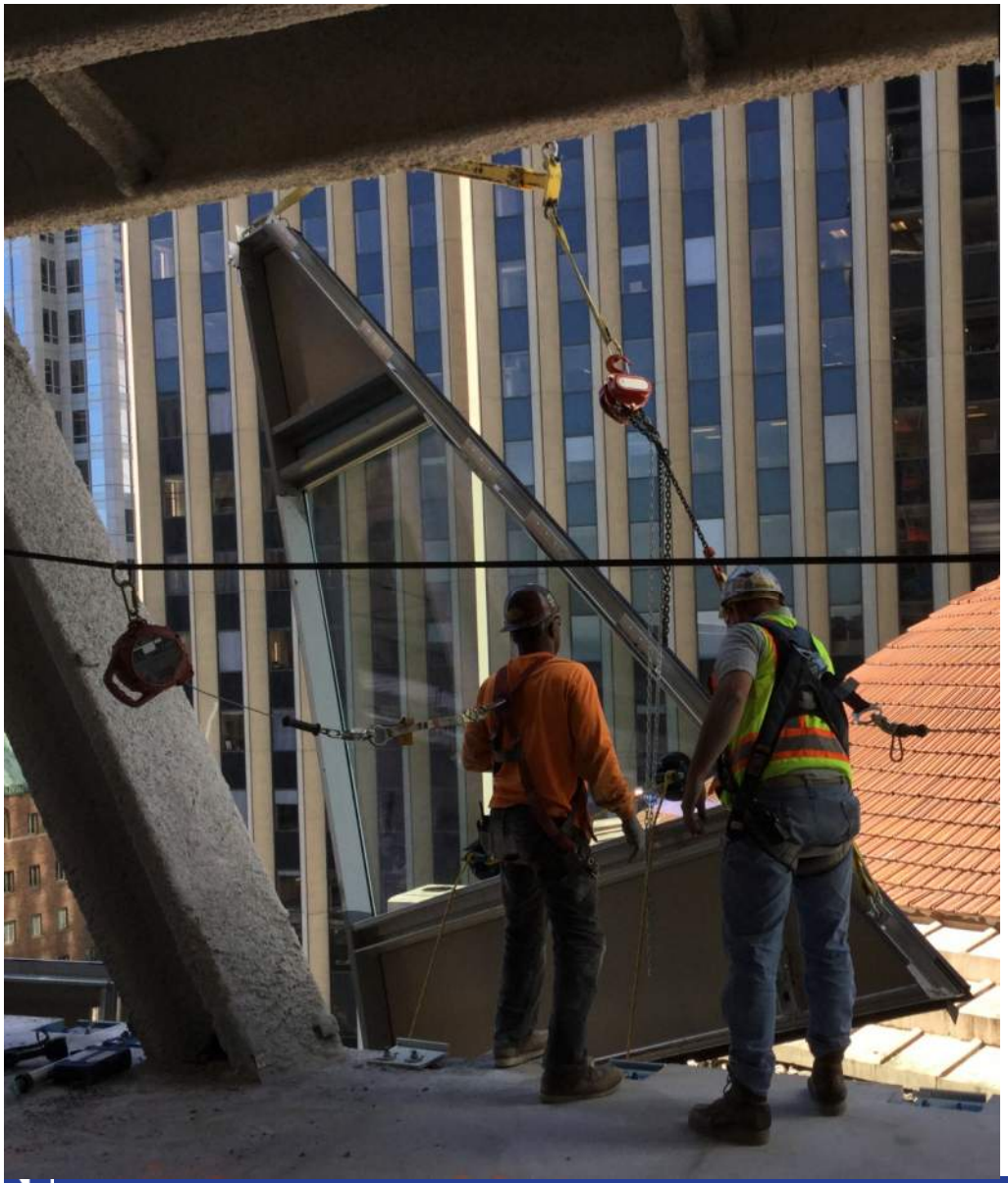


Performance Mock-Up



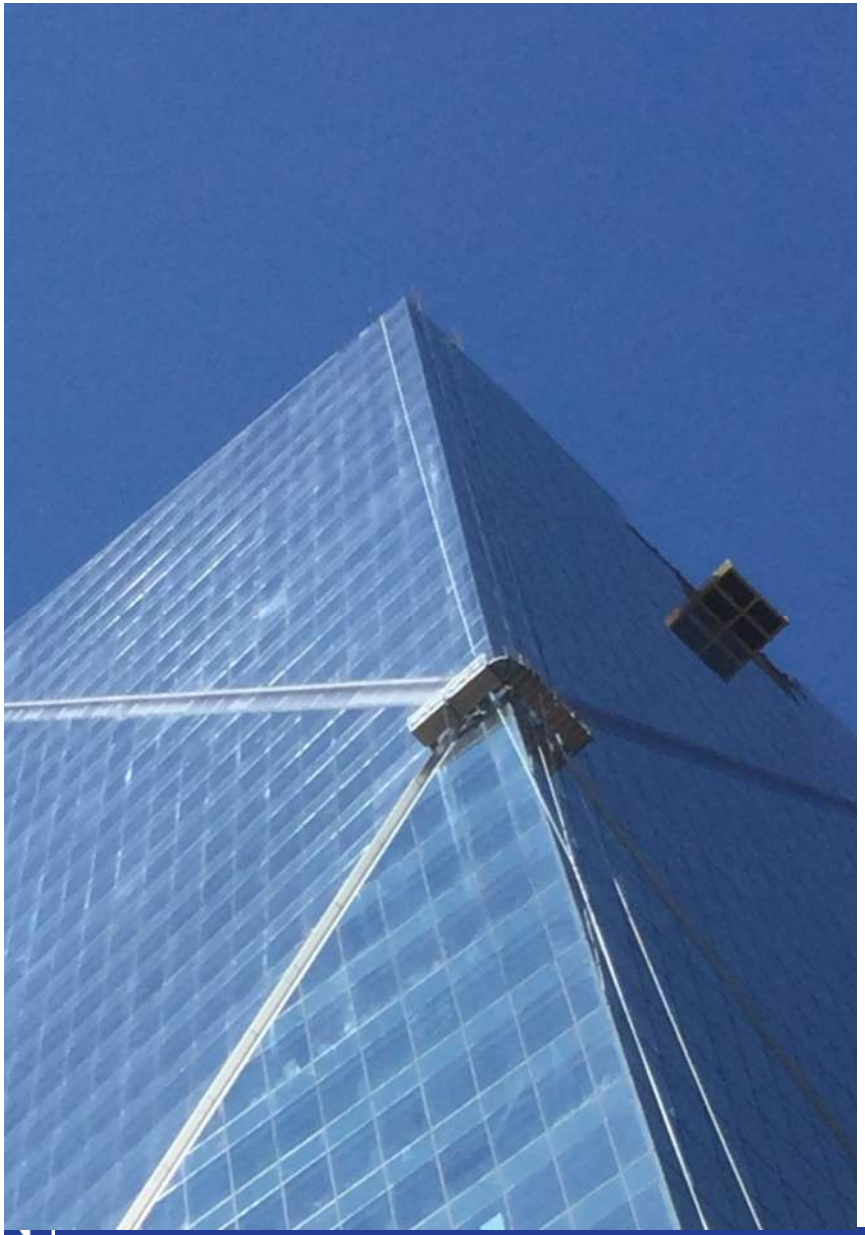
Dynamic Testing

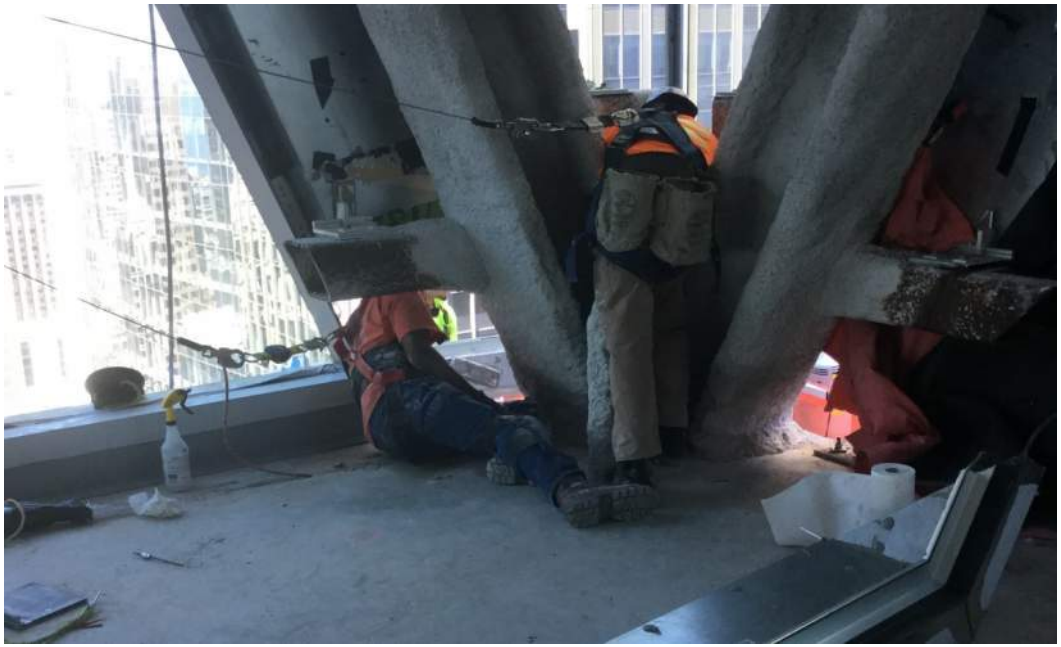
Setting Pattern Units



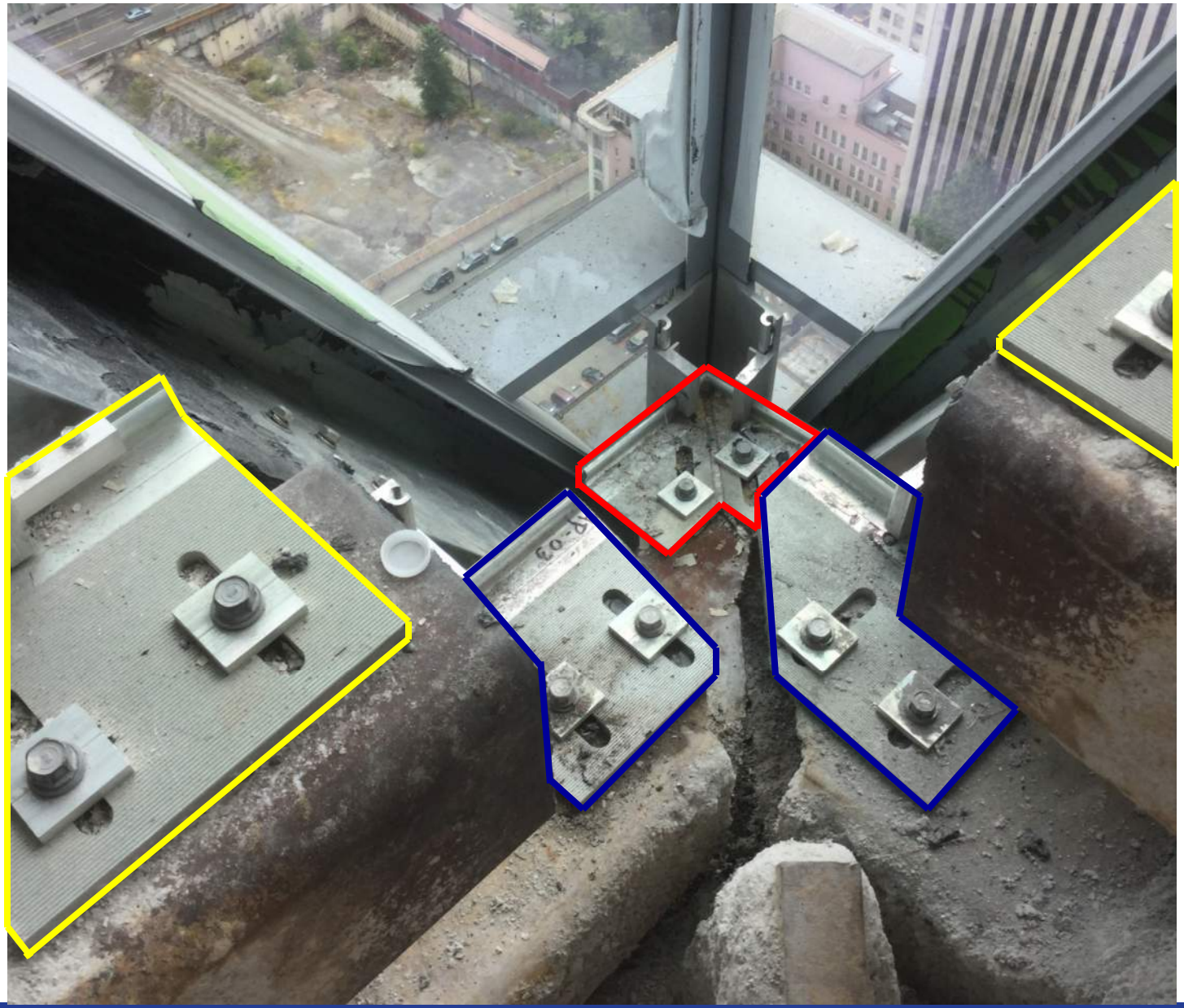
- Complex rigging for balance
- Detailed tagging plans, patterns vs. typical units
- Total Station layout & anchor setting

Setting “Hub” Units

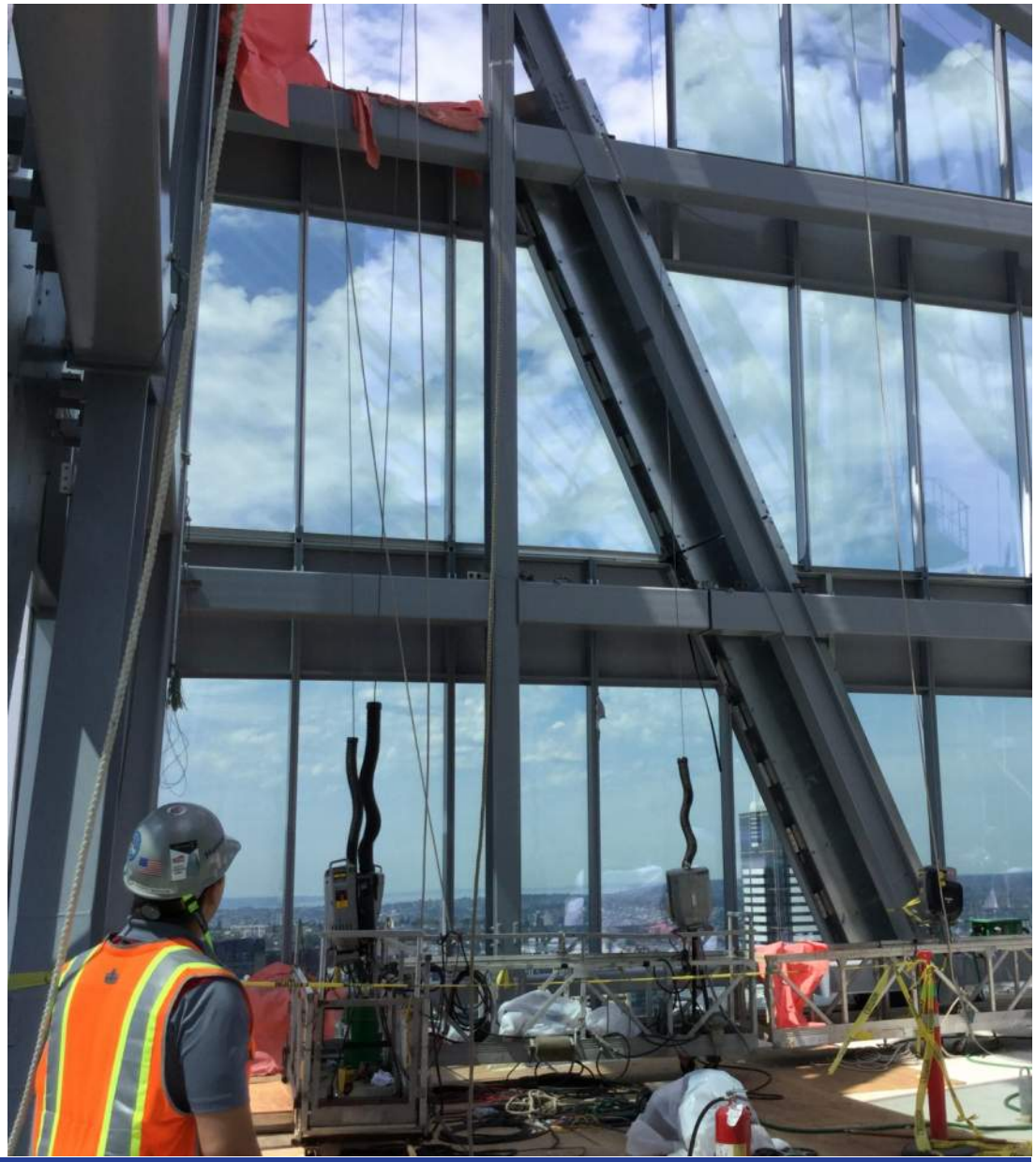




“Hub” Anchor Install



Wind Bracing at Top of House



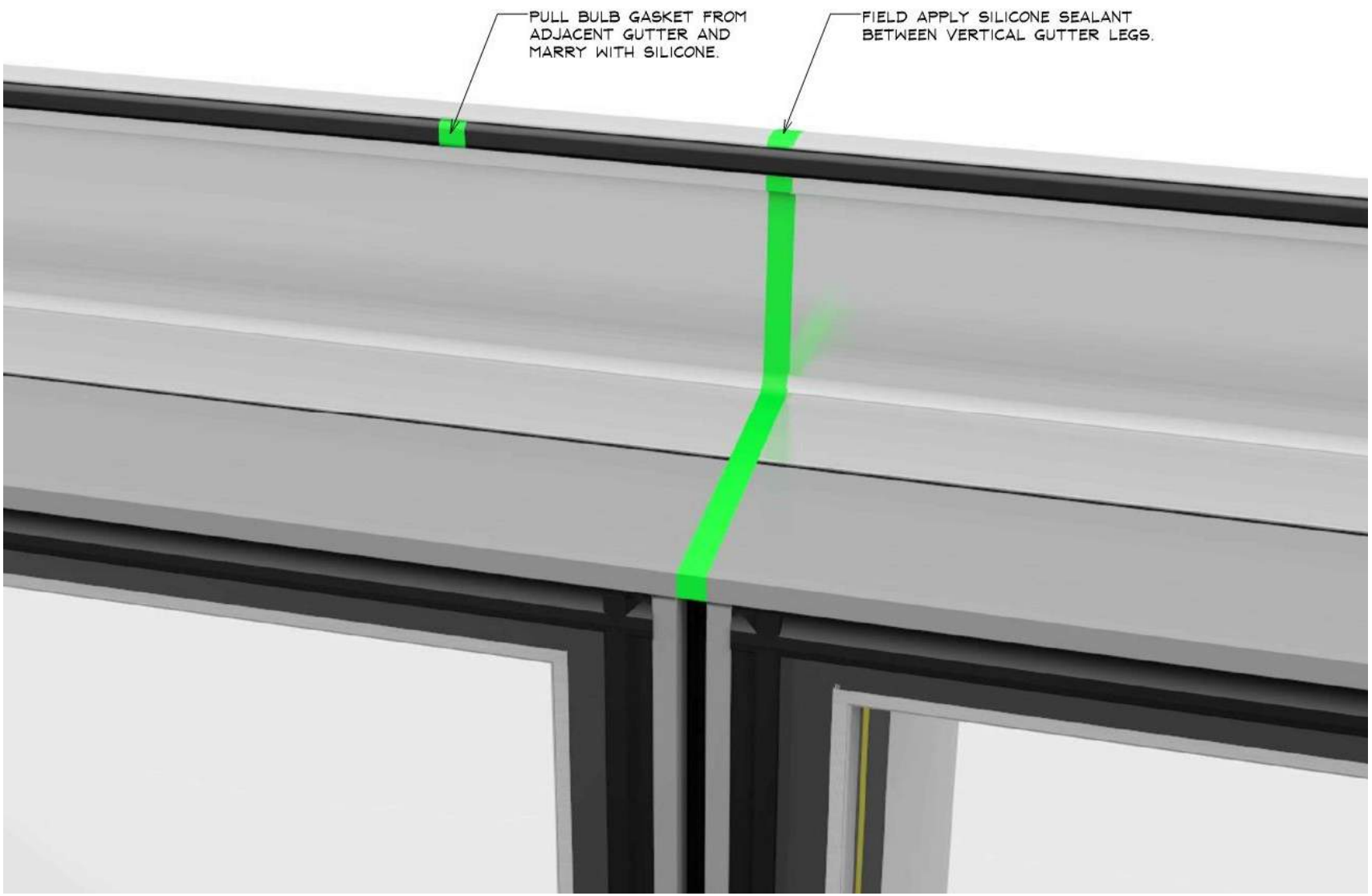
Top of House Waterproofing & Steel Substructure

- Waterline above roof deck
- Wind girts for deflection
- Roofing/coping coordination

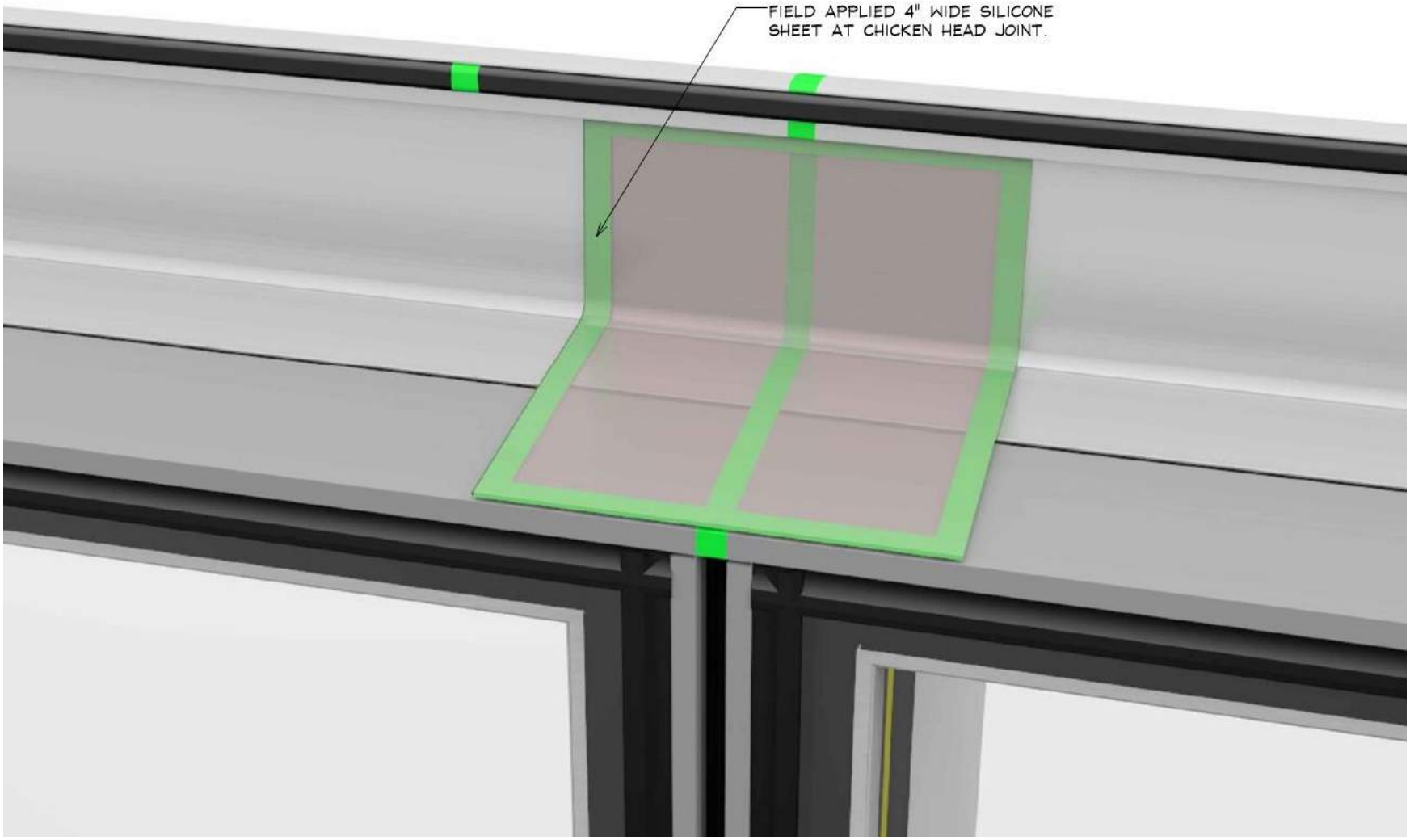
Coping at Top of House

- Unitized for interface with CW units
- Complex shape for transition to structure
- Set with building maintenance crane

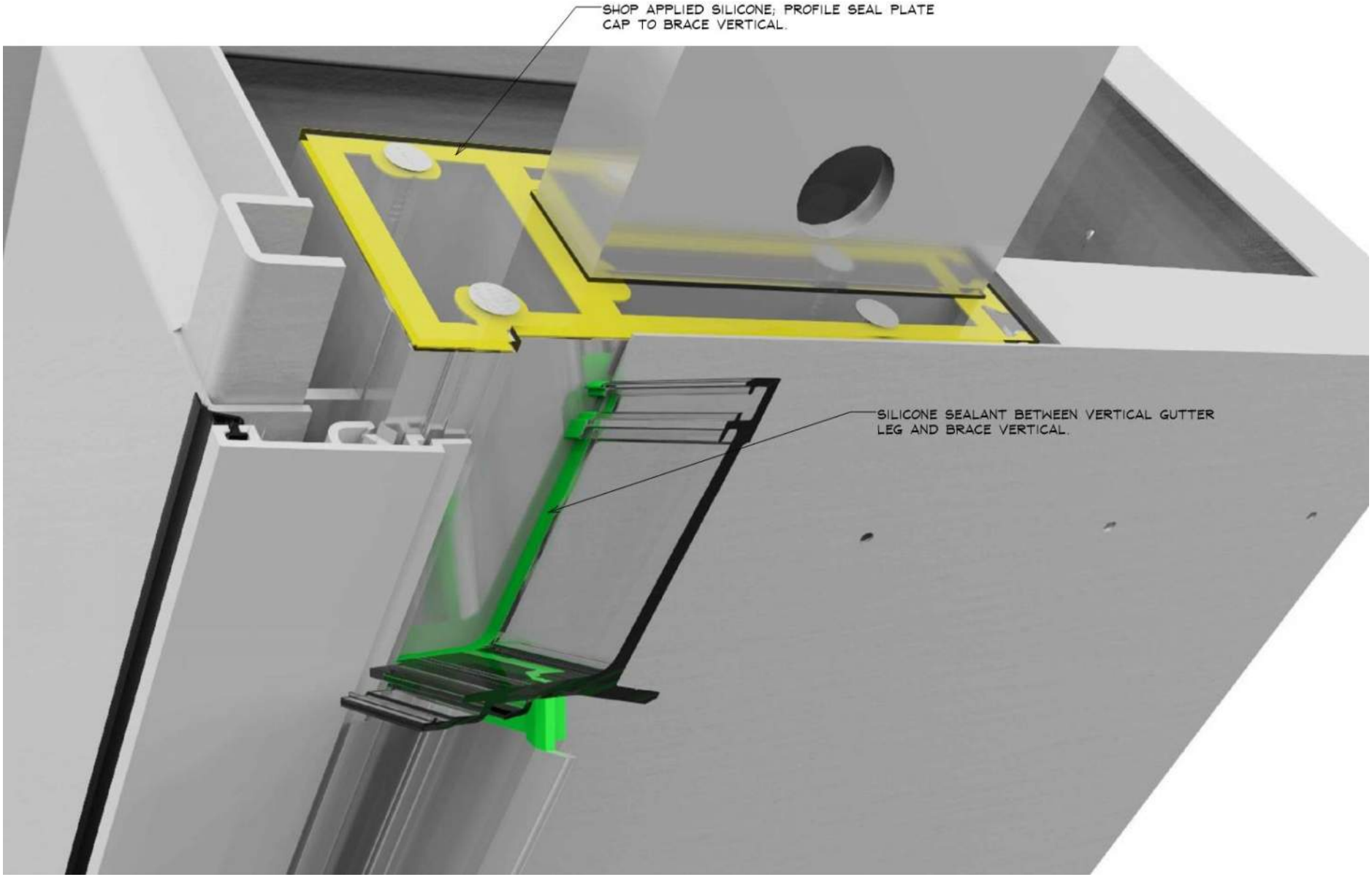
Installation – Weathering at Braces



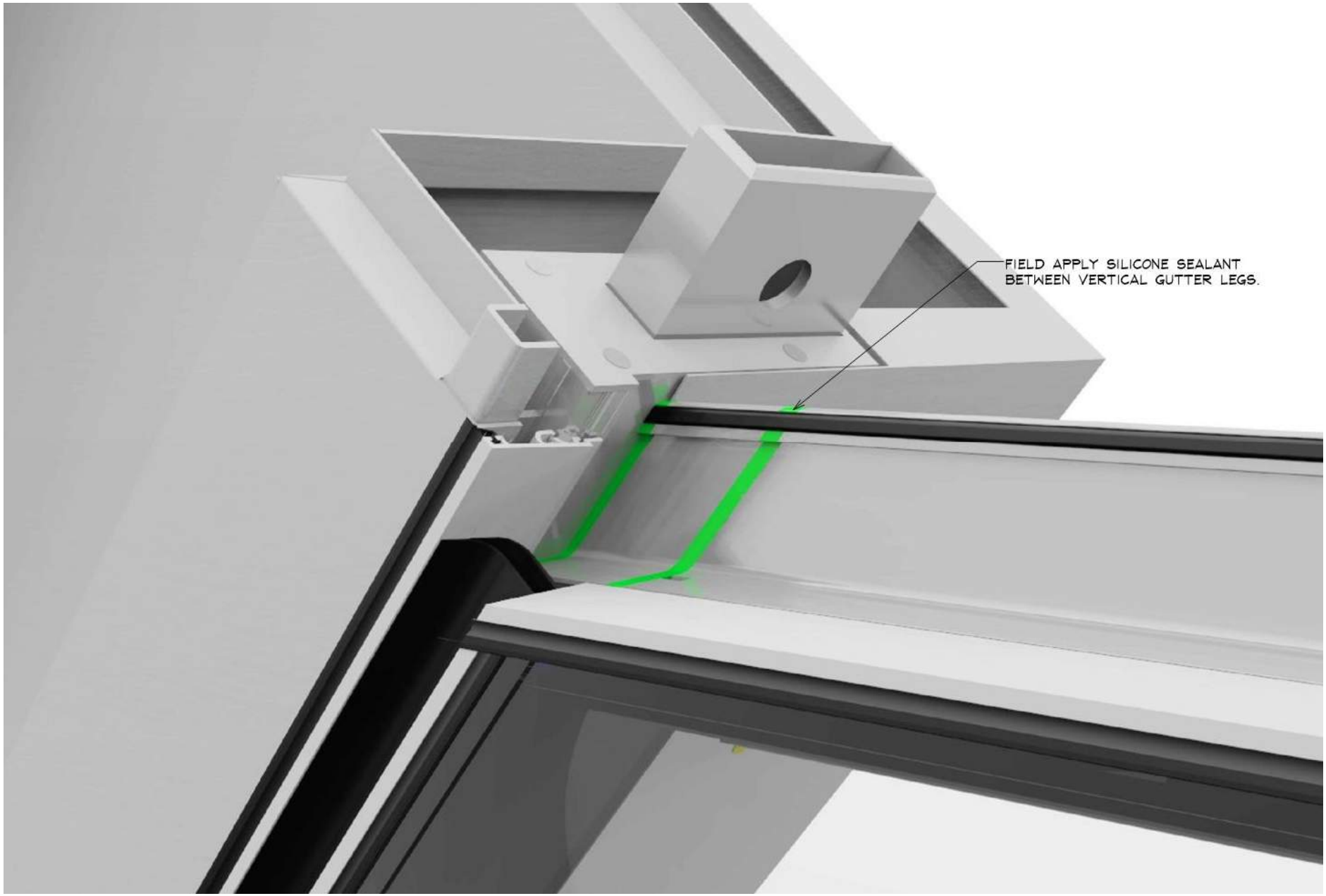
Installation – Weathering at Braces



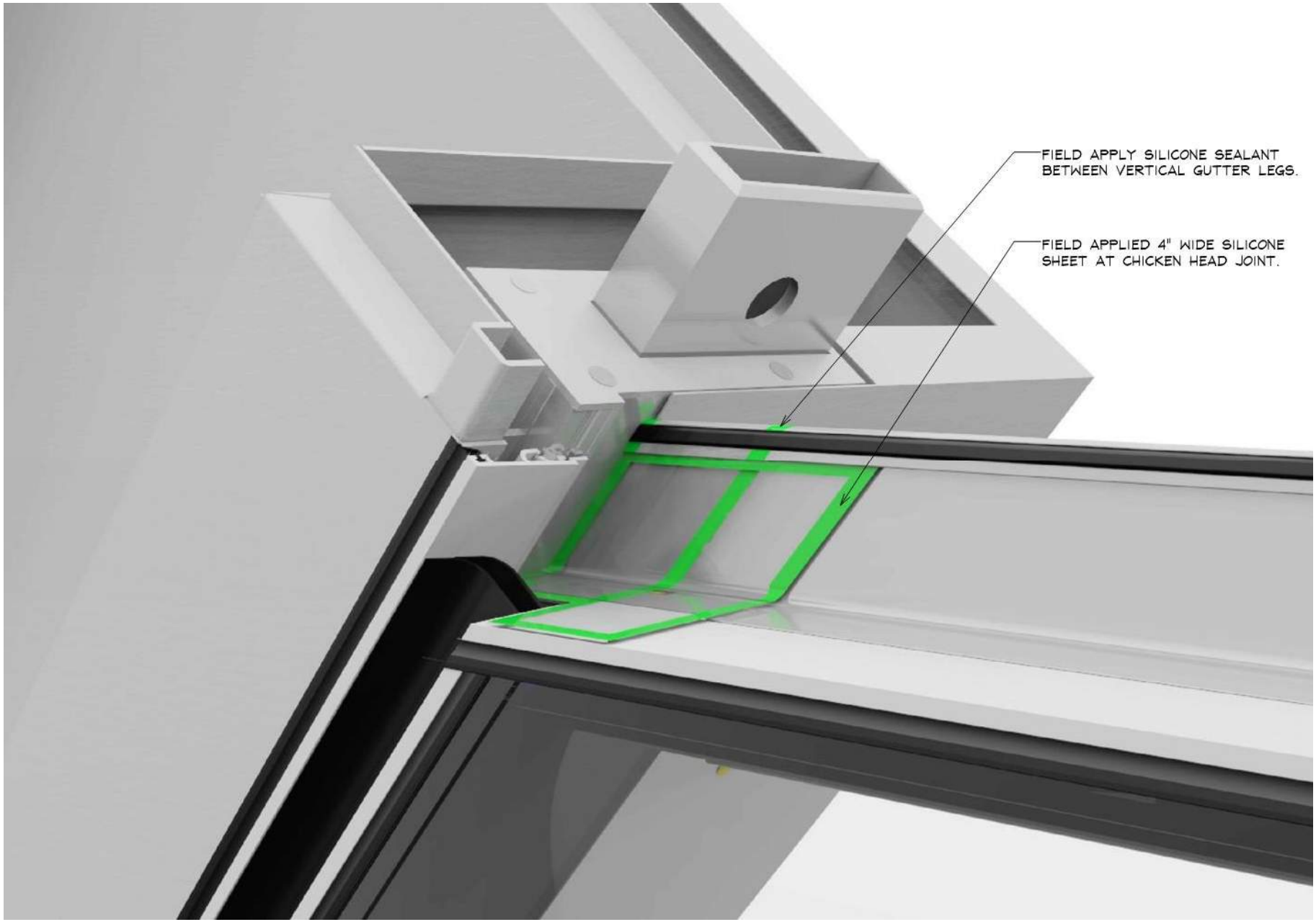
Installation – Weathering at Braces



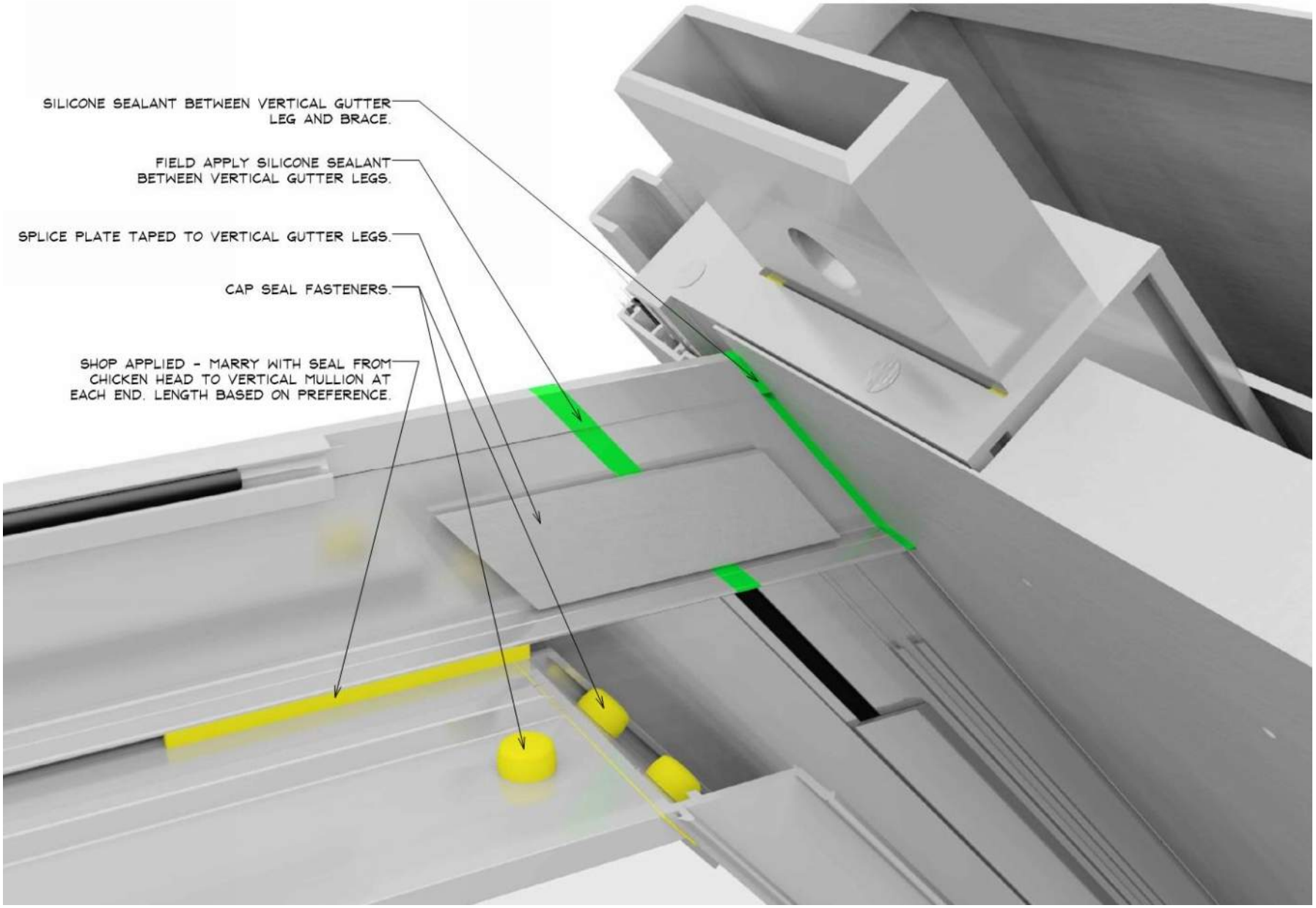
Installation – Weathering at Braces



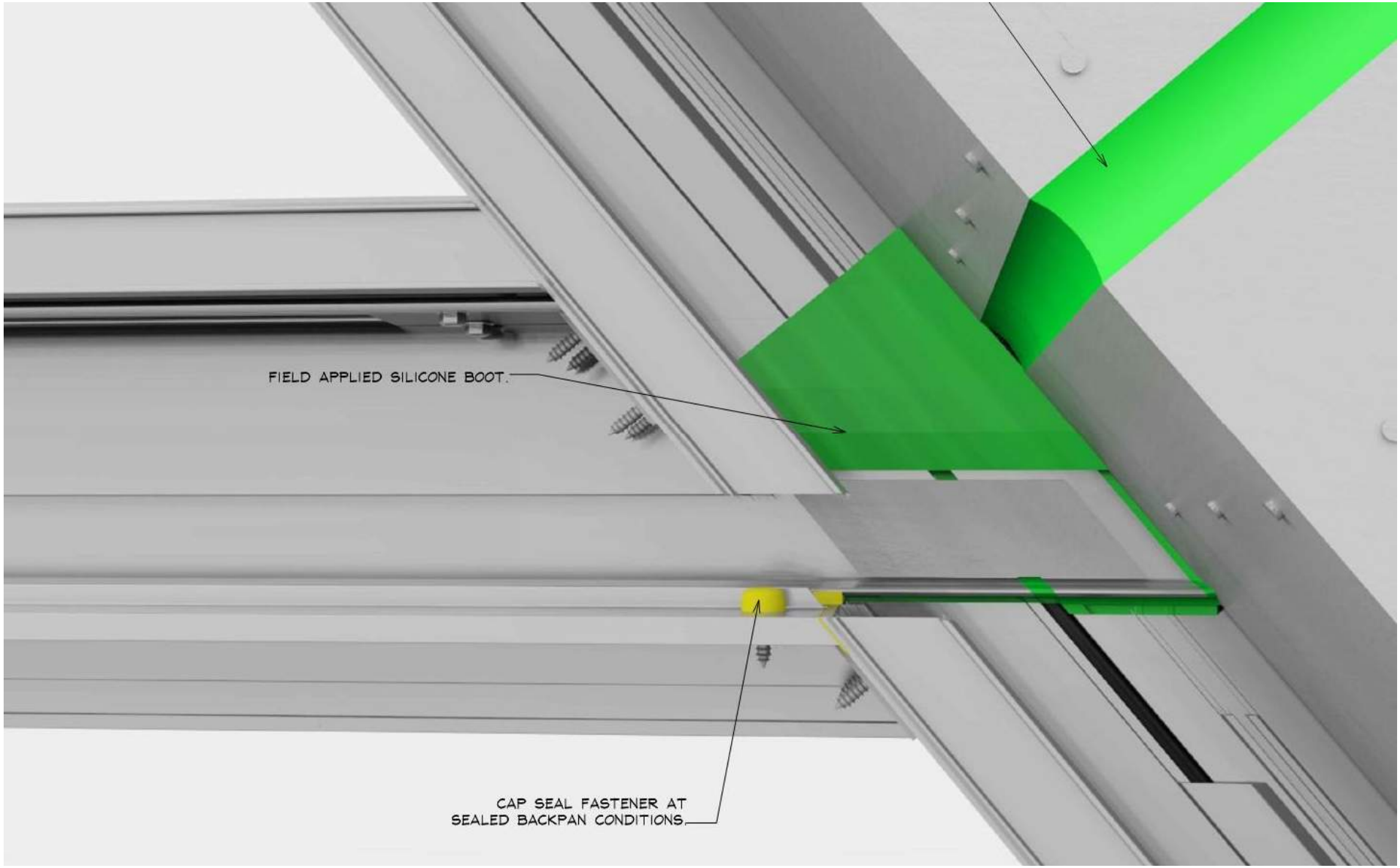
Installation – Weathering at Braces



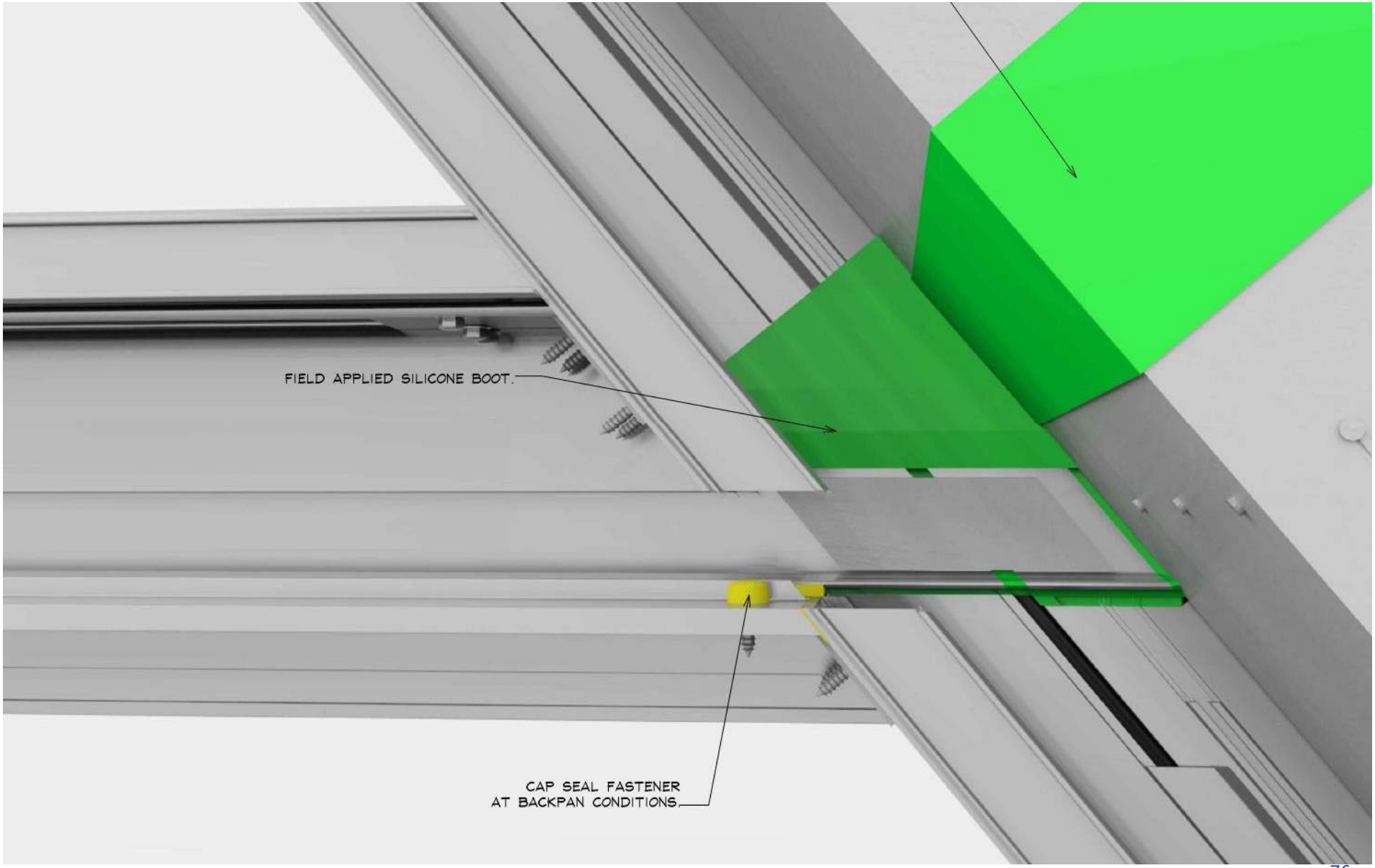
Installation – Weathering at Braces



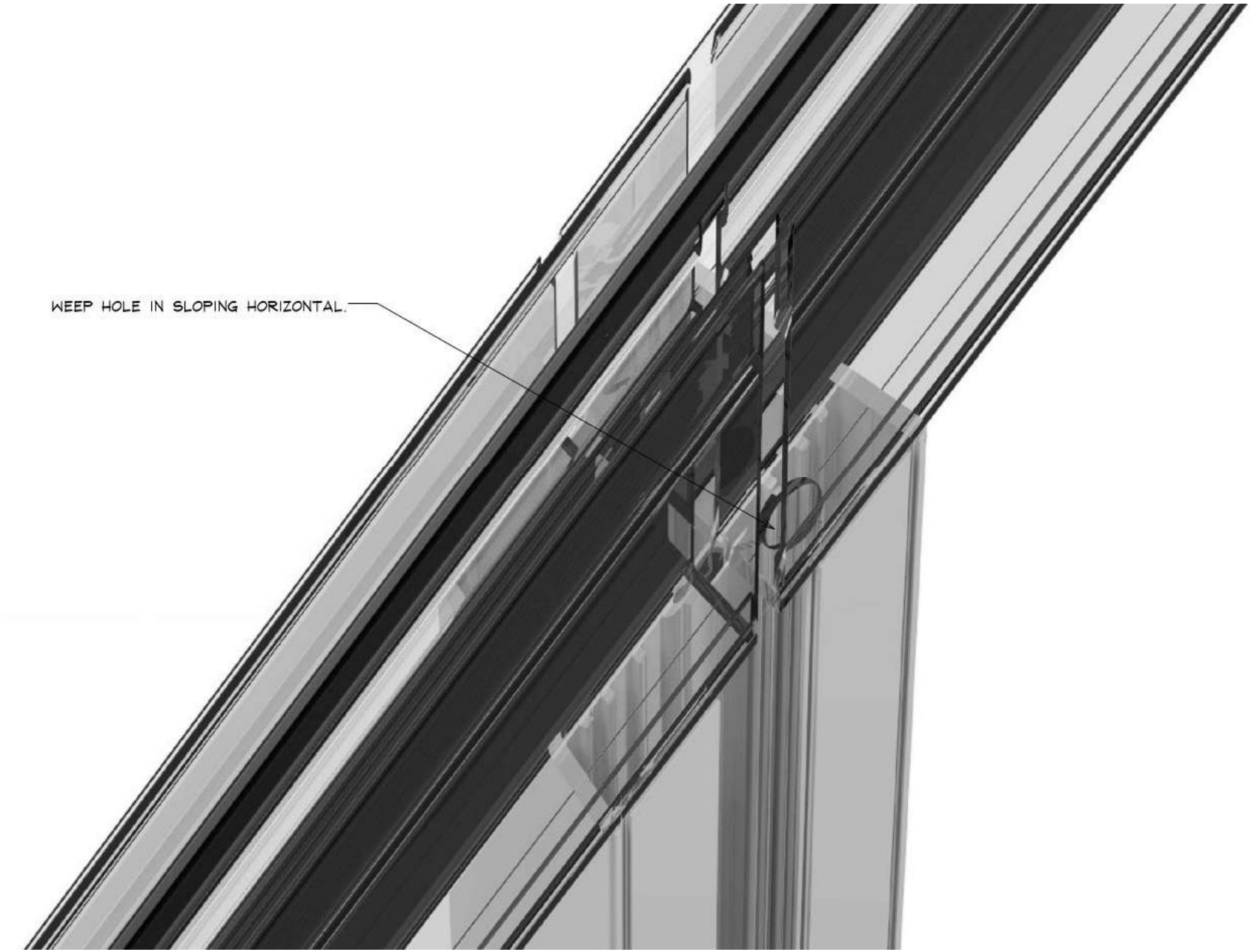
Installation – Weathering at Braces



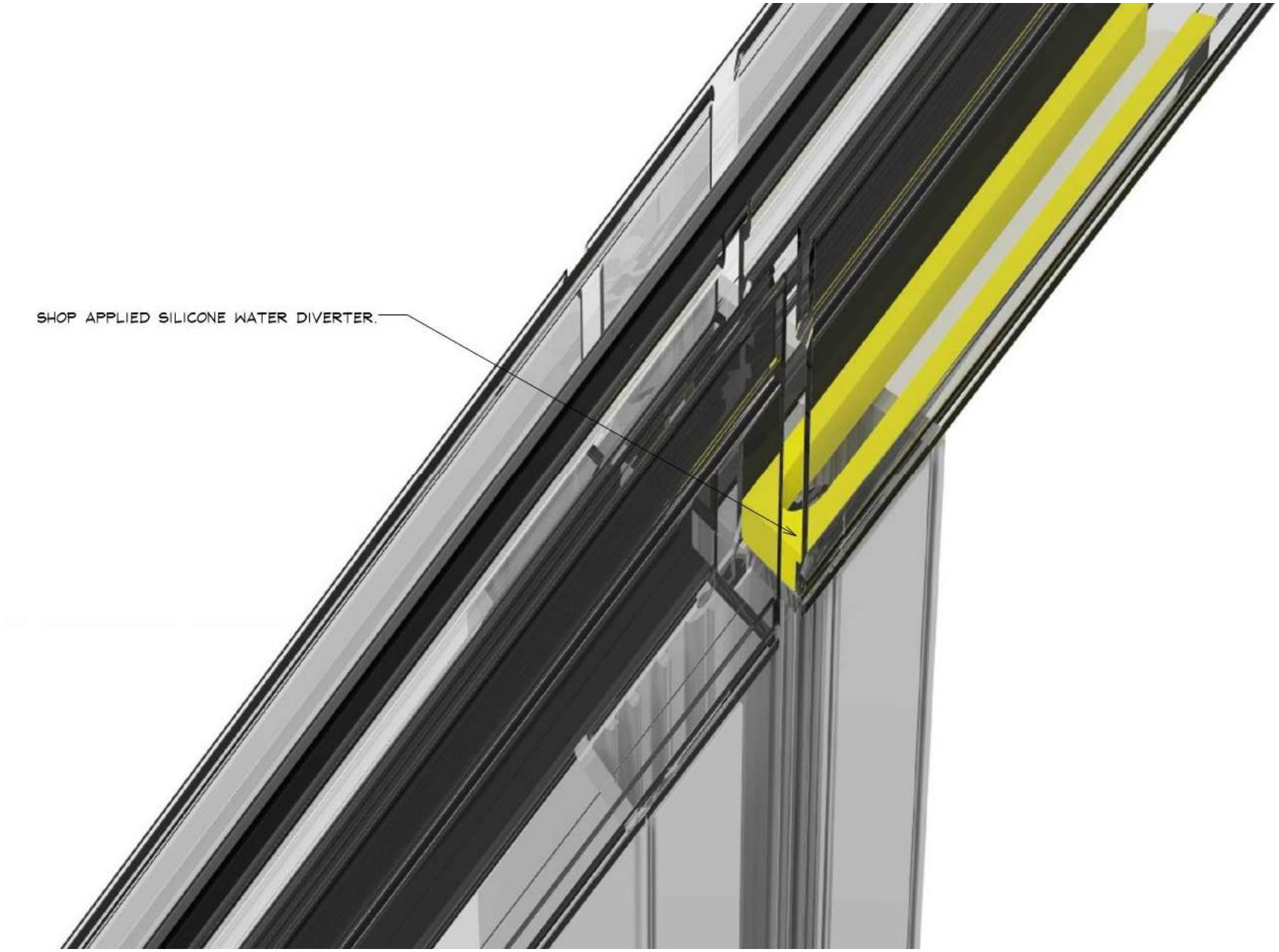
Installation – Weathering at Braces



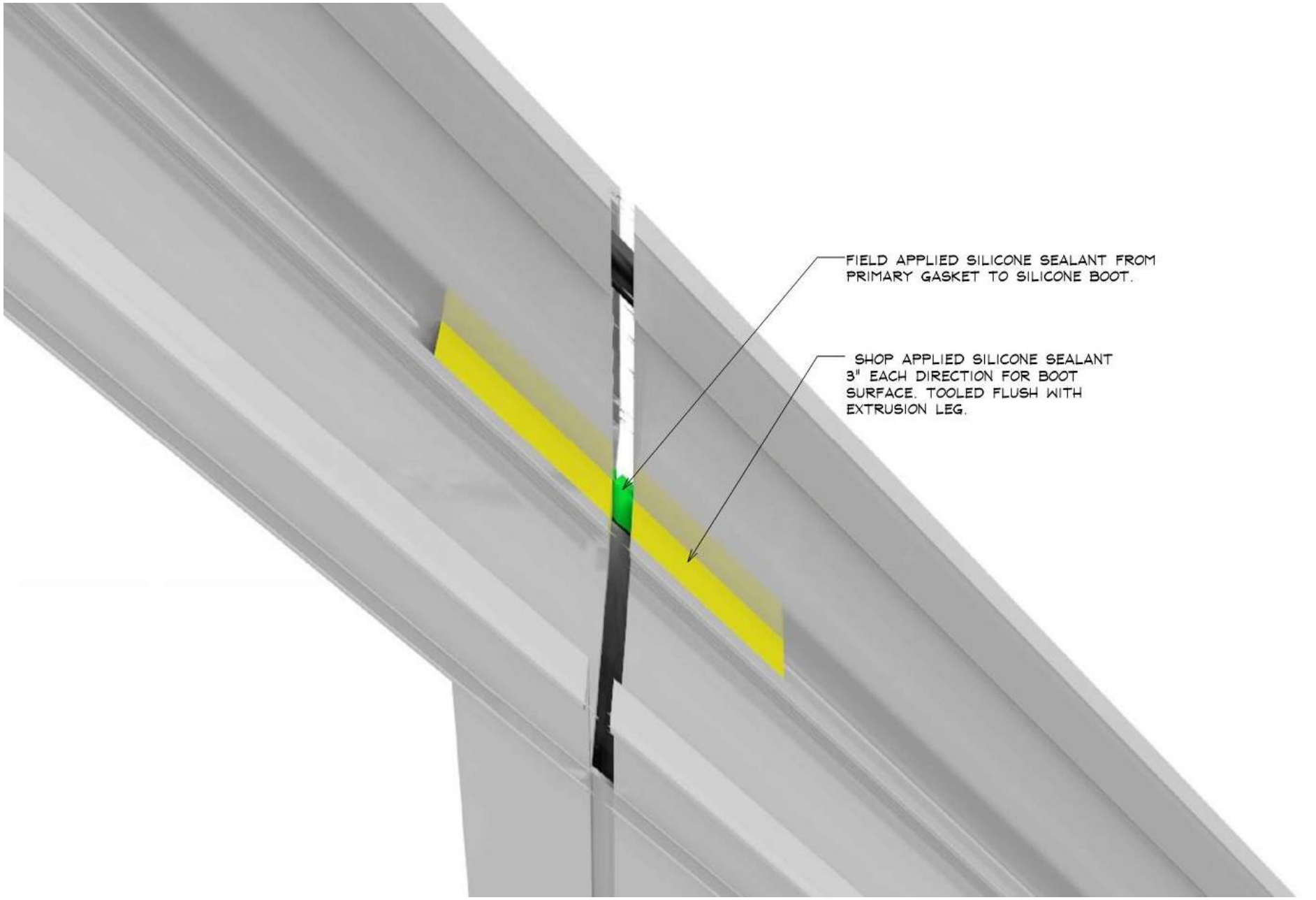
Installation – Weathering at Braces



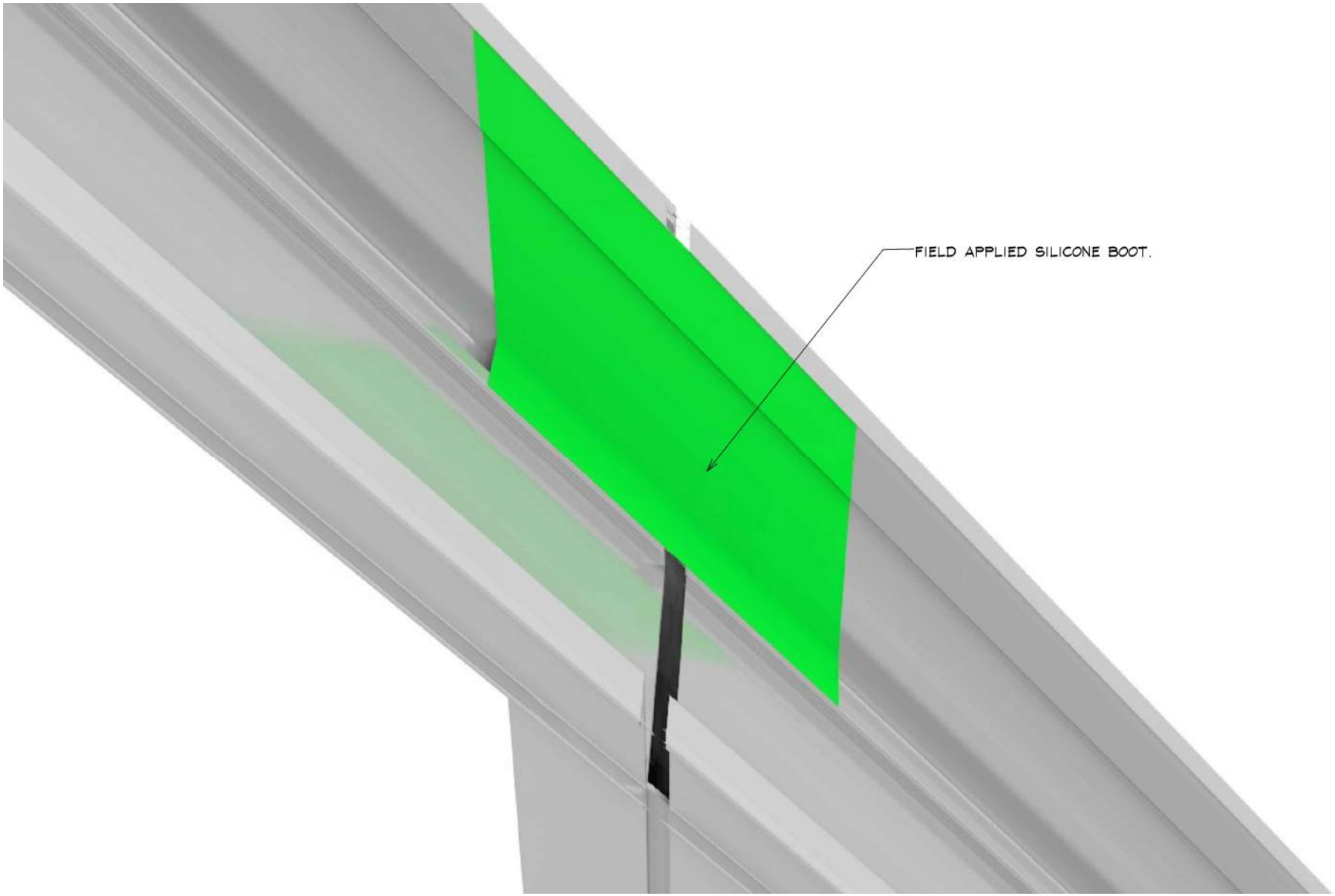
Installation – Weathering at Braces



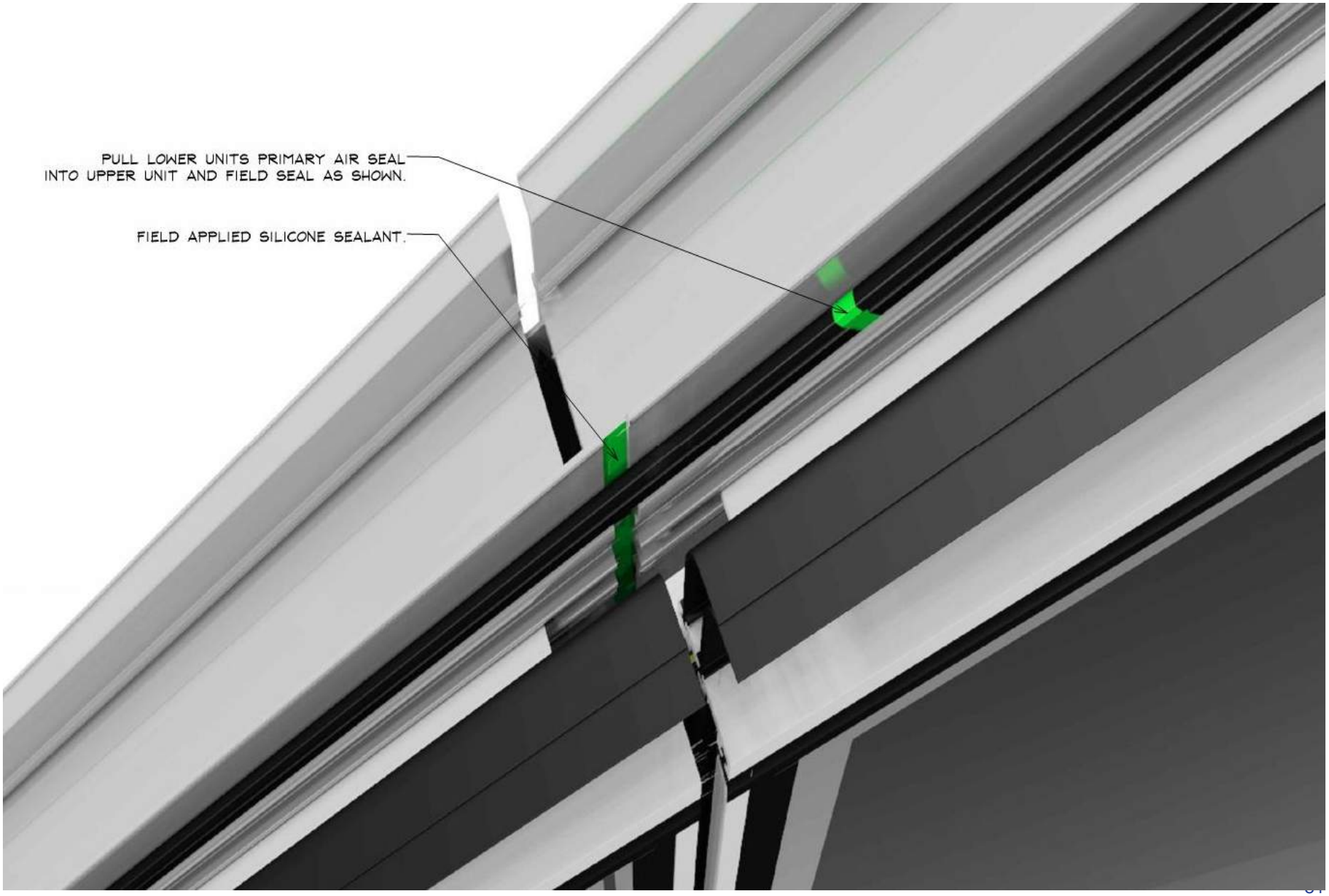
Installation – Weathering at Braces



Installation – Weathering at Braces



Installation – Weathering at Braces



5th & Columbia

A New Icon on the Seattle Skyline

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