Preliminary experimental testing and parametric structural and economic analyses of semi-rigid pultruded FRP beam-column connections

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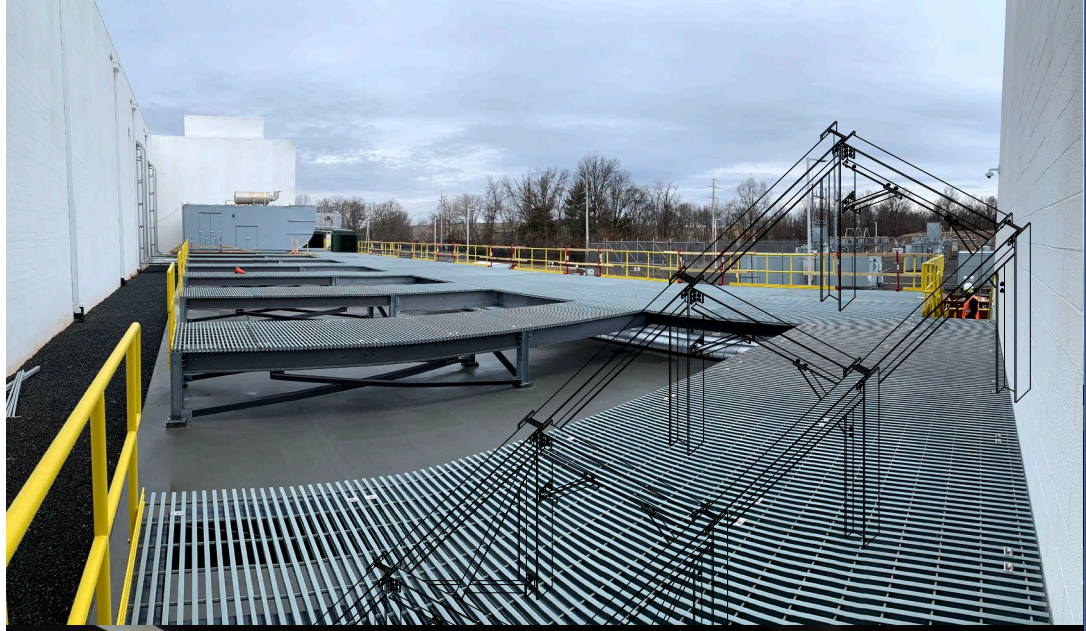
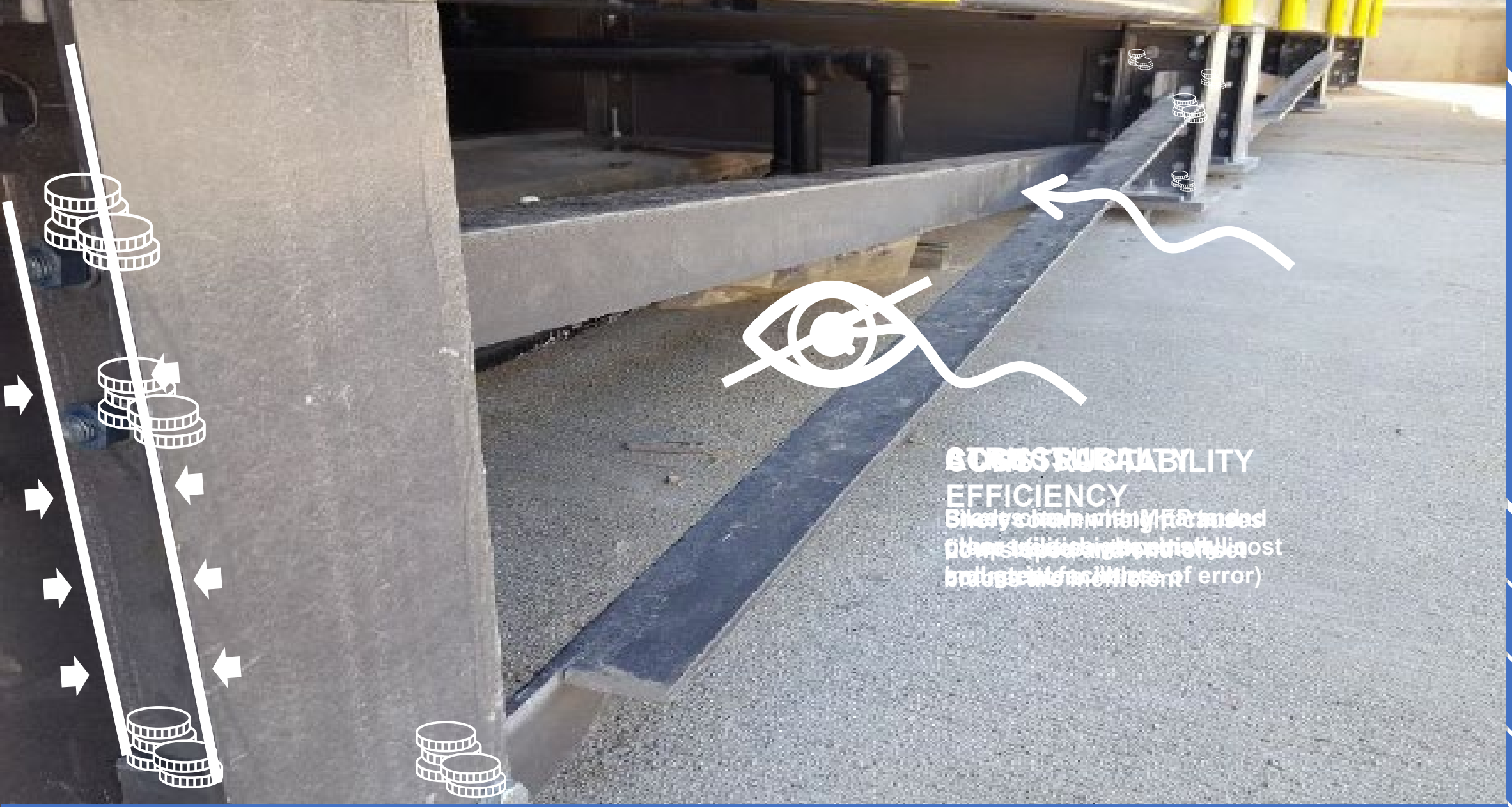
AKNOWLEDGMENT

Use of Pultruded FRP in construction:

- Increasingly competitive lead times versus steel
- Resistance against weathering and corrosion
- Lightweight (less overhead equipment)
- Low specialization required for typical construction scenarios
- Rapidity of assembly
- Braced frame configuration most common based on designer comfort and available design tools for FRP





DEFICIENCIES

DRAWBACKS OF BRACING LOW-RISE PLATFORMS

From BRACED FRAMES to SEMI-RIGID FRAMES

- The structural system does not rely on vertical braces anymore and they can be removed, therefore, the possible of clashing with MEP and utilities is avoided;

- The connections have to resist mainly moment and shear instead tension/compression and shear; and

- The connections have to grant enough stiffness to prevent large lateral displacements.

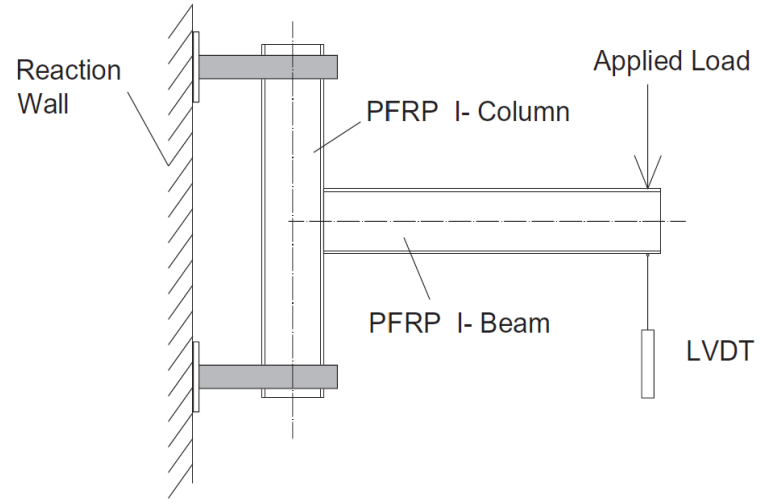
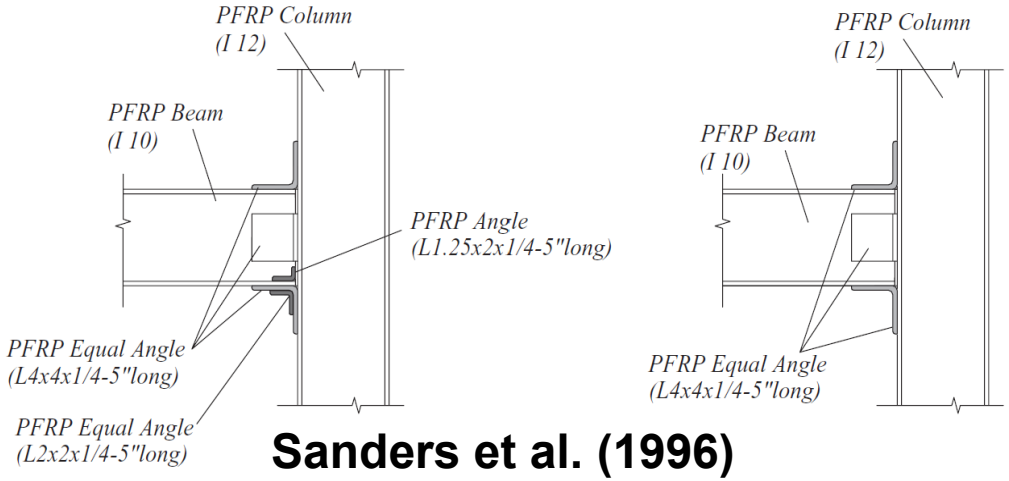


Figure 7-100. Exterior PFRP beam-to-column bonded connection setup.
Source: Sanders et al. (1996).



Sanders et al. (1996)

Figure 7-101. Beam-to-column bonded specimens details.
Source: Sanders et al. (1996).

Mosallam et al. (1993)

PRELIMINARY TESTING

TESTED SPECIMENS

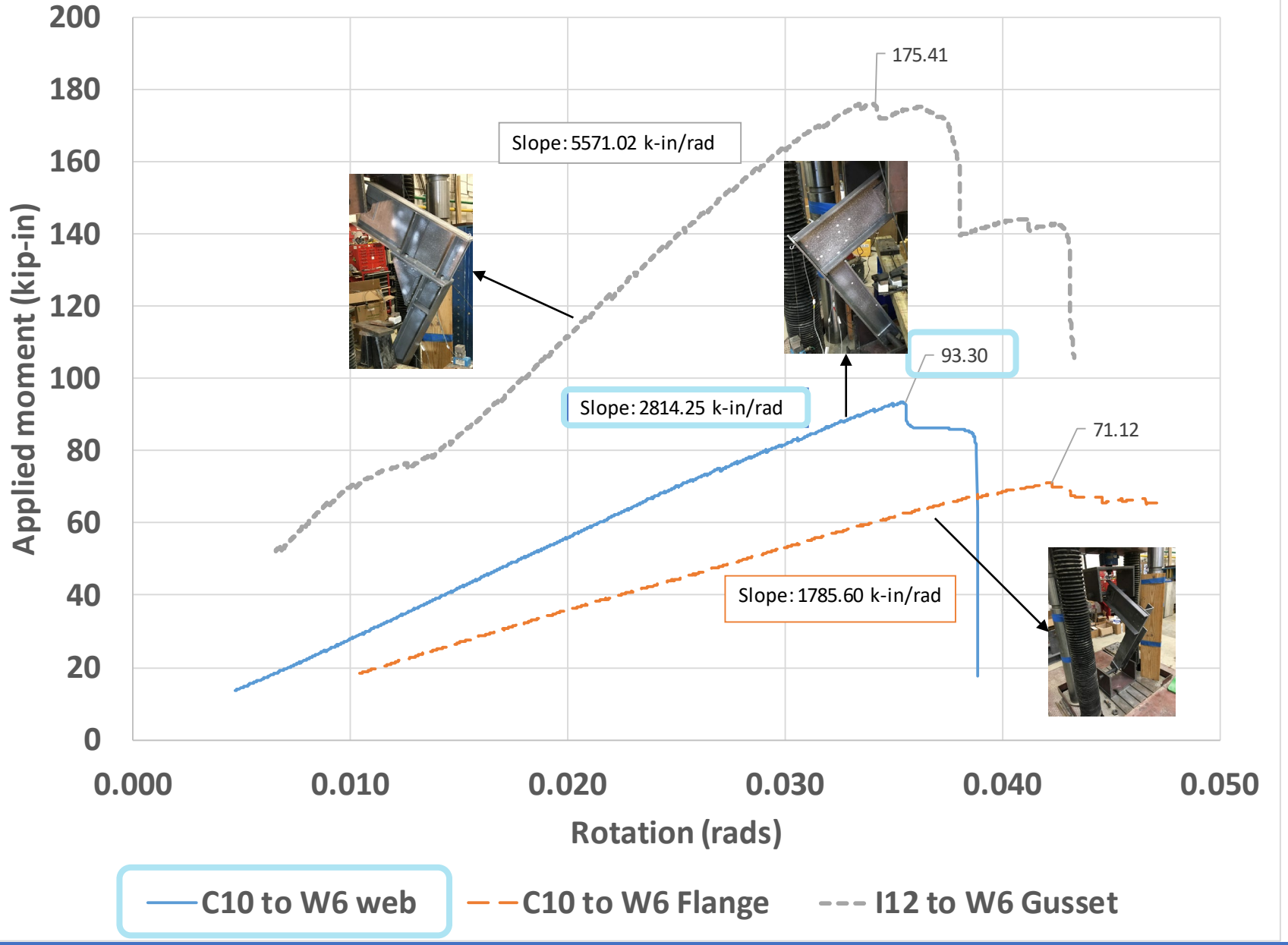
C10 to W6 flange
(Lapped and adhered)

C10 to W6 web
(Lapped and adhered)

I12 to W6 gusset
(Bolted and stiffened)

PRELIMINARY TESTING

TESTED SPECIMENS



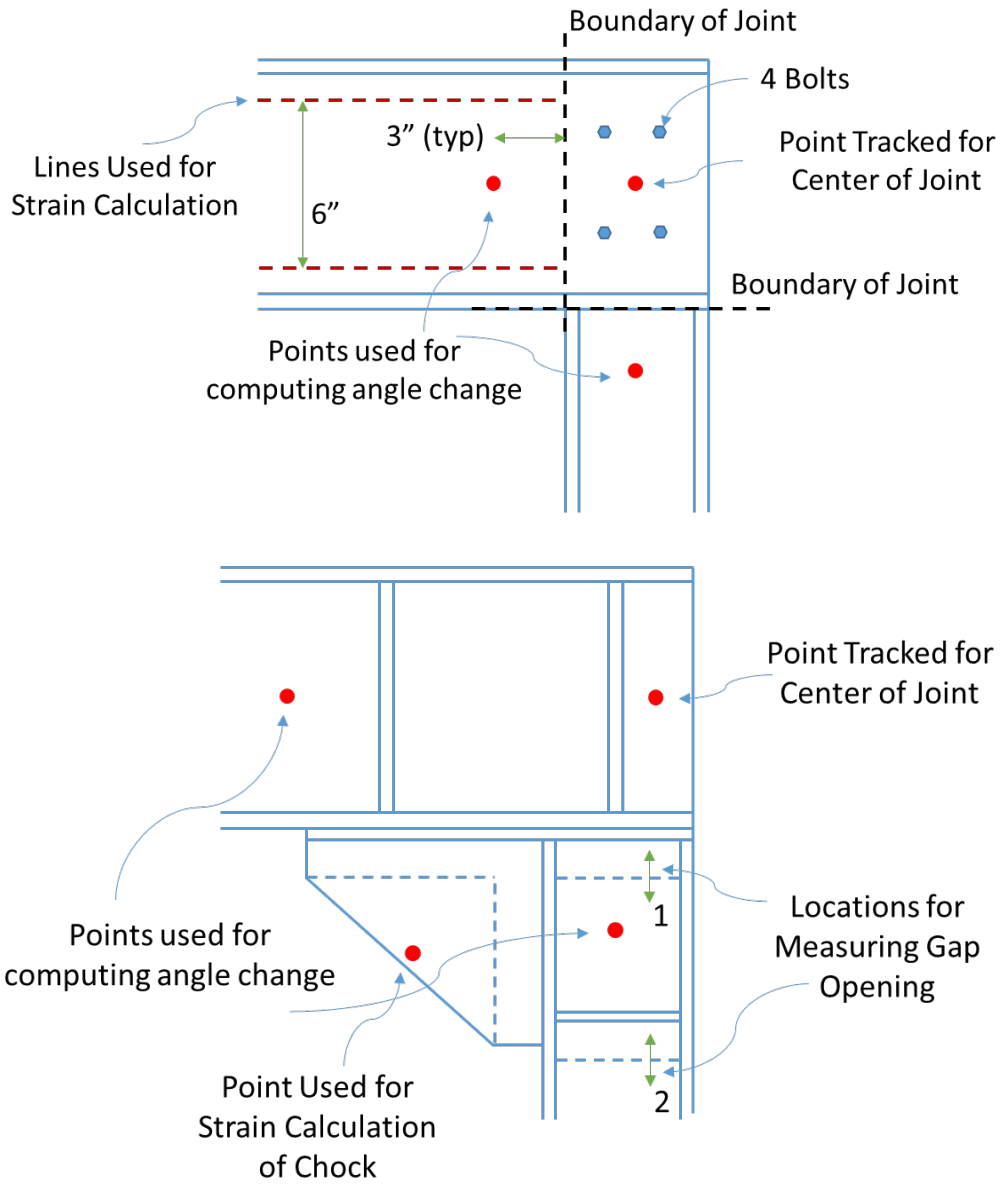
PRELIMINARY TESTING

PRELIMINARY RESULTS

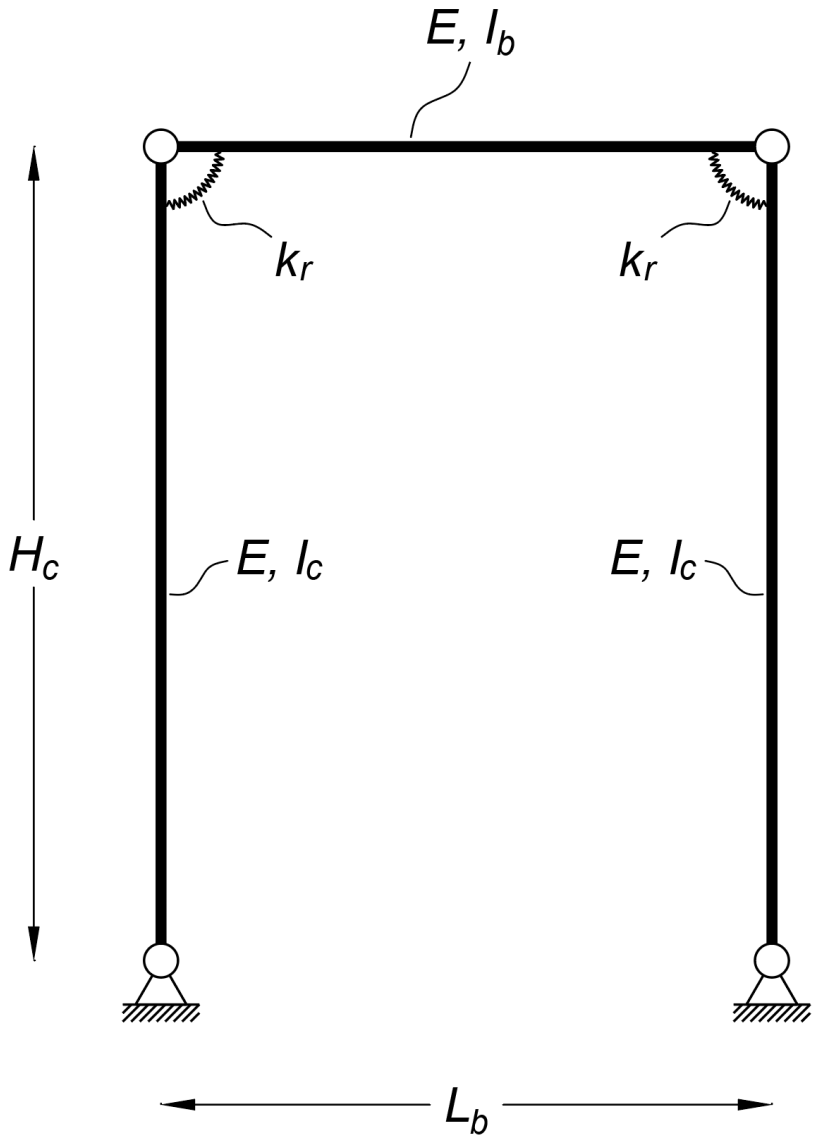
Note that the points used for computing the angle change are placed at a non-negligible distance from the center of the connection, therefore:

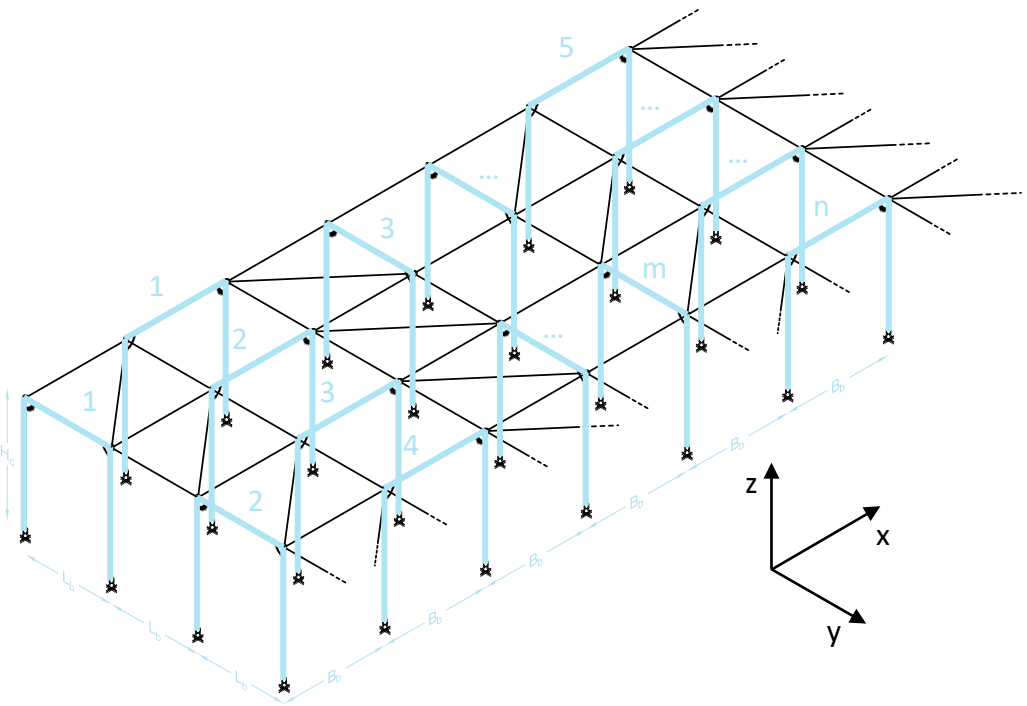
- Bending stiffness of the column/beam system is included in the analysis;
- The computed rotational stiffness is slightly smaller than the actual one.

More precise rotational analysis based on photogrammetry is currently developing, although the results could not be used yet.



PRELIMINARY TESTING





PRELIMINARY TESTING

APPLICATION FOR A 3D FRAME

Seismicity Limit

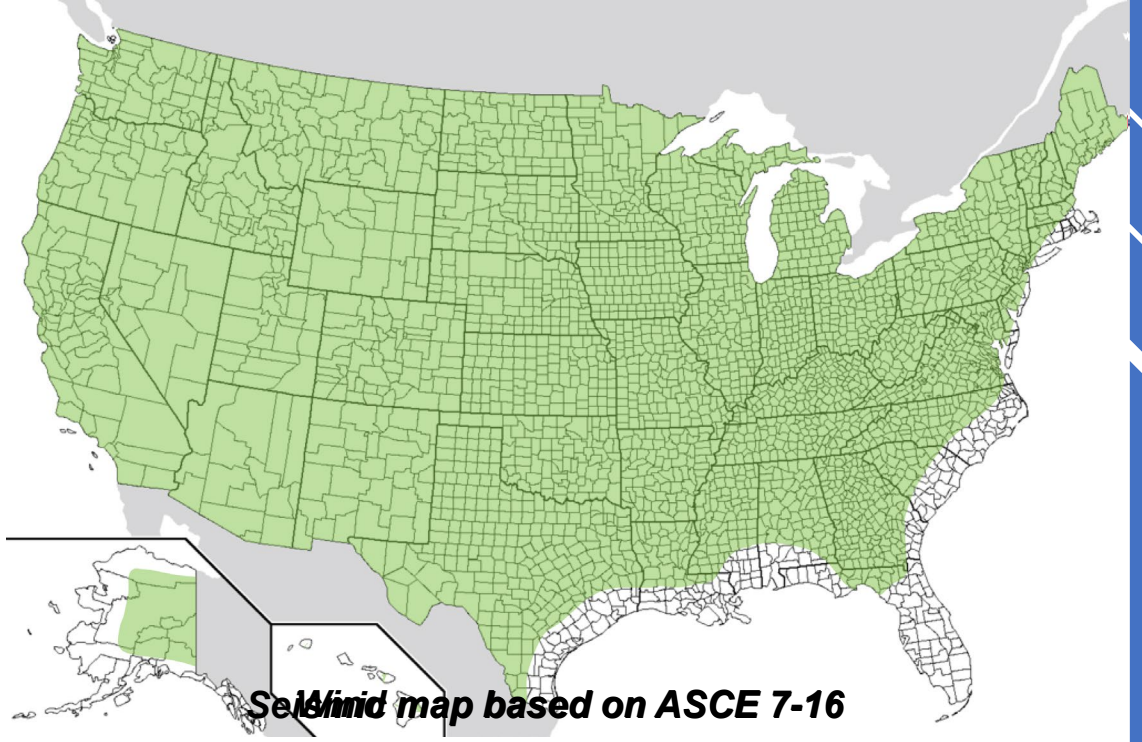
Building Category: **II**

Soil Category: **D**

$S_{DS} \leq 0.50g \longrightarrow S_S \leq 0.55g$

$S_{D1} \leq 0.20g \longrightarrow S_1 \leq 0.13g$

$T_L \leq 12s$



Seismic map based on ASCE 7-16

Wind Limit

Risk Category: **II**

Exposure Category: **C**

Topographic Factor, K_{zt}: **1.0**

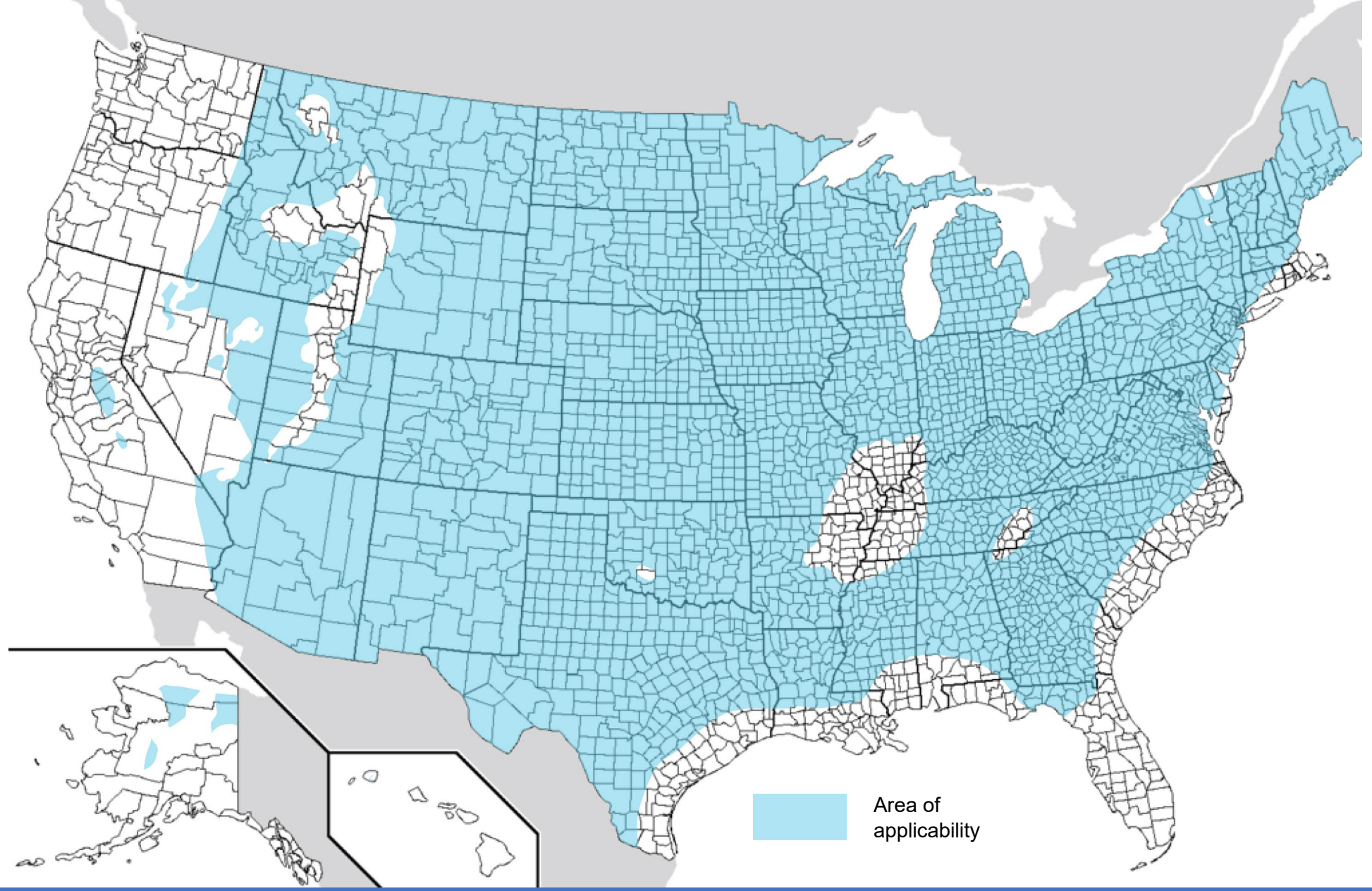
Wind Speed, v_w: **≤ 120 mph**

Gravity and Notional Load Limit

Dead load, D: **≤ 15 psf**

Live Load, L: **≤ 60 psf**

Notional Load, N: **0.05 (D + L)**



AREA OF APPLICABILTY BASED ON SEISMIC AND WIND

Number of Bays

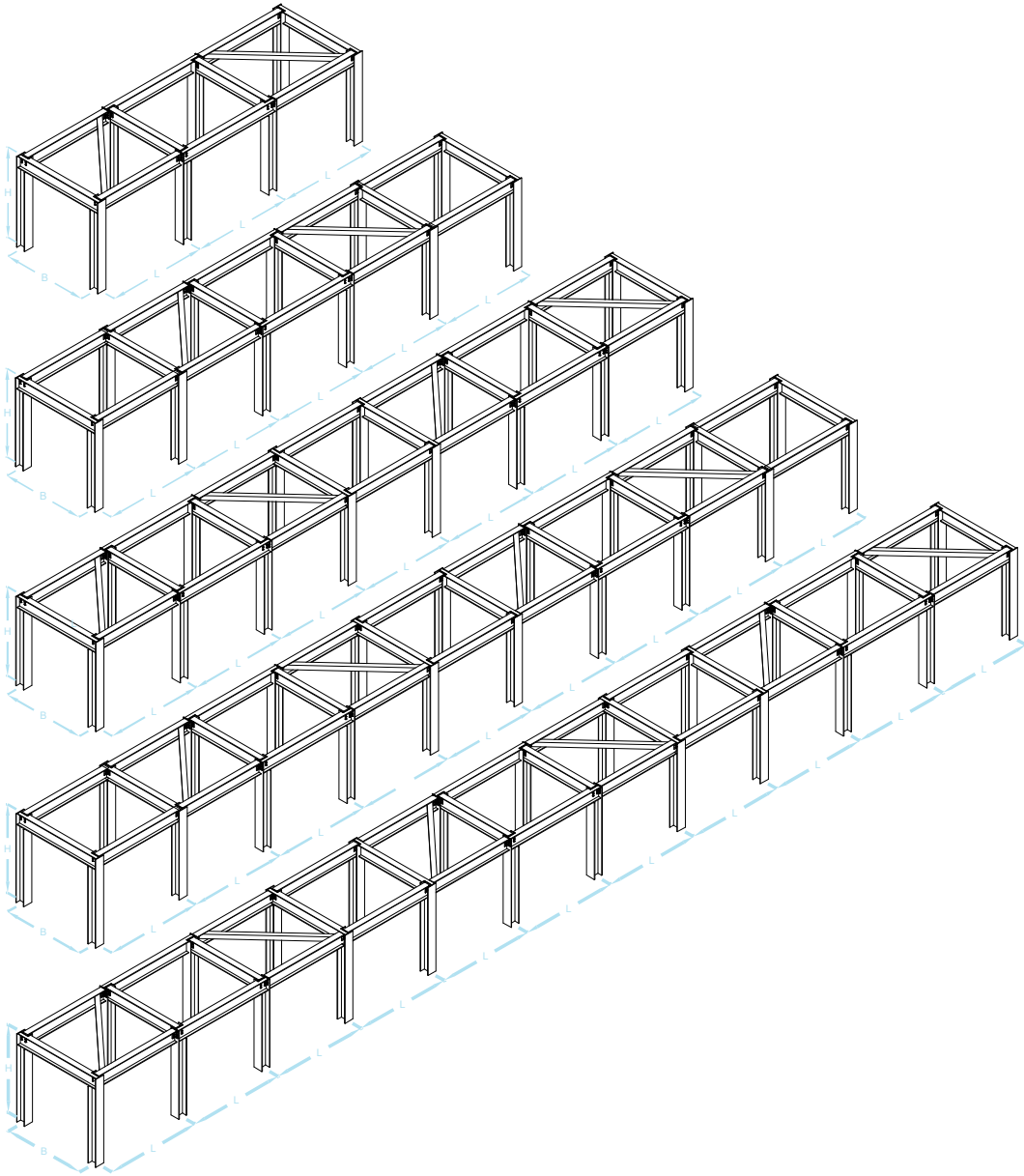
1 Transversal 3 Longitudinal

1 Transversal 5 Longitudinal

1 Transversal 7 Longitudinal

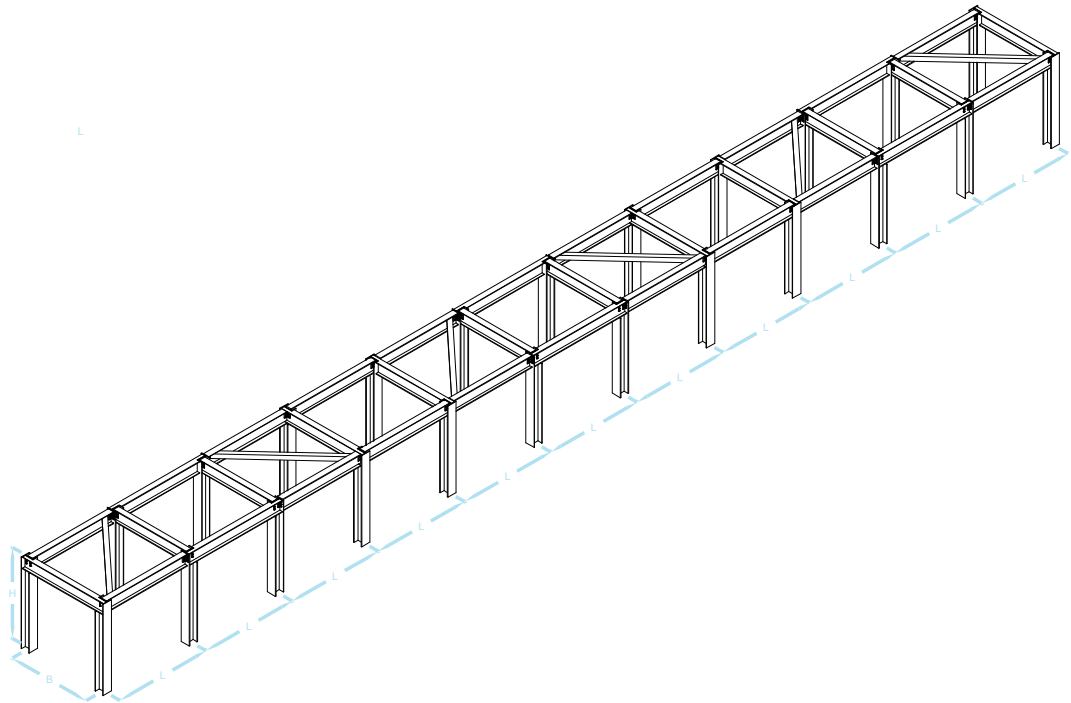
1 Transversal 9 Longitudinal

1 Transversal 11 Longitudinal



VIABLE GEOMETRIC DIMENSIONS

# Bays: 11 Height: 2 ft	Length of longitudinal bays, *L* (ft)						
Width of transversal bay, *B* (ft)	6	7	8	9	10	11	12
6							
7							
8							
9							
10							
11							
12							

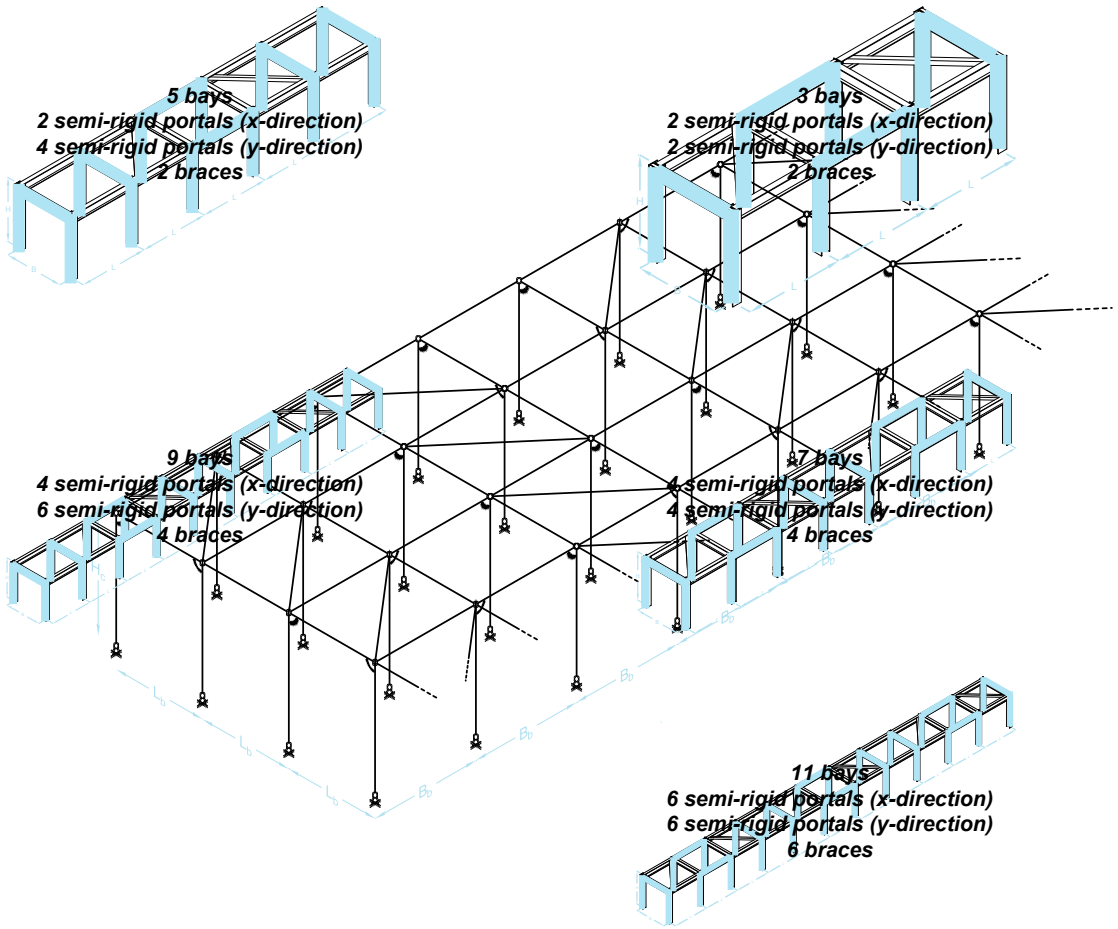


# Bays: 11 Height: 4 ft	Length of longitudinal bays, *L* (ft)						
Width of transversal bay, *B* (ft)	6	7	8	9	10	11	12
6							
7							
8							
9							
10							
11							
12							

# Bays: 11 Height: 6 ft	Length of longitudinal bays, *L* (ft)						
Width of transversal bay, *B* (ft)	6	7	8	9	10	11	12
6							
7							
8							
9							
10							
11							
12							

# Bays: 11 Height: 8 ft	Length of longitudinal bays, *L* (ft)						
Width of transversal bay, *B* (ft)	6	7	8	9	10	11	12
6							
7							
8							
9							
10							
11							
12							

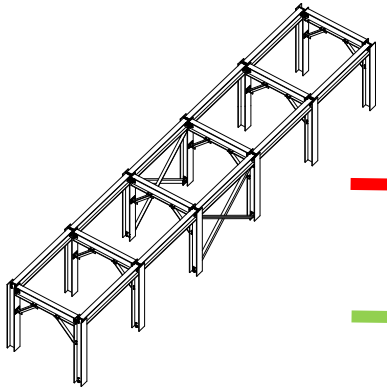
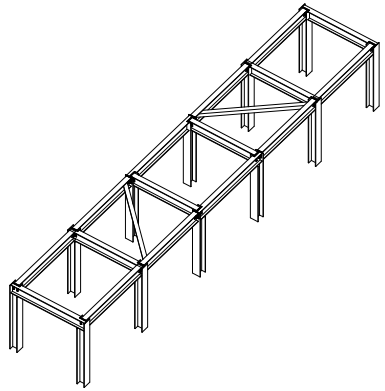
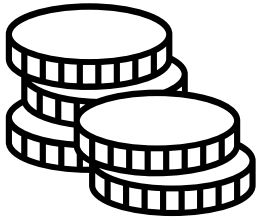
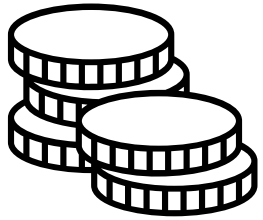
# Bays: 11 Height: 9 ft	Length of longitudinal bays, *L* (ft)						
Width of transversal bay, *B* (ft)	6	7	8	9	10	11	12
6							
7							
8							
9							
10							
11							
12							



# Bays: 11 Height: 6 ft		Length of longitudinal bays, *L* (ft)						
		6	7	8	9	10	11	12
Width of transversal bay, *B* (ft)	6							
	7							
	8							
	9							
	10							
	11							
	12							

The geometric ranges are meant for the framing itself. Span limitations of the decking system must be included before applying the results.

NO. OF BAYS INFLUENCE ON VIABLE GEOMETRIC RANGE

	Braced Frame		Semi-Rigid Frame
Volume of FRP		+43% →	
Clip connectors		-37% →	
WT connectors		-100% →	
Plates		-50% →	
Adhered area	*Fabrication & Material*	+39% ≈	*Fabrication & Material*
Coping cuts		+50% →	
	Installation	>	*Installation*

COST-EFFICIENCY COMPARISON

PROS:

- Quicker and higher quality field installation due to prefabrication of semi-rigid bents;
- Fewer bolt holes in members increases strength and reduces error; and
- Fewer clashes with MEP and other utilities.

CONS:

- Larger members may increase material cost; and
- More prefabrication increases fabrication lead times prior to delivery on site.

***Additional testing will lead to higher confidence in results and thus*:**

- Larger rotational stiffness, resulting in smaller displacements and applicability in a larger variety of applicable scenarios;
- Larger rotational strength, resulting in longer feasible spans;
- Less conservative safety factors;
- Development of predictive equations for rotational strength and stiffness; and
- Overall larger range of applicability.

THANK YOU
FOR YOUR ATTENTION

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