Load Test of a Precast Concrete Tub Stadium Riser and Bond Testing of #20 Bar

Presented by

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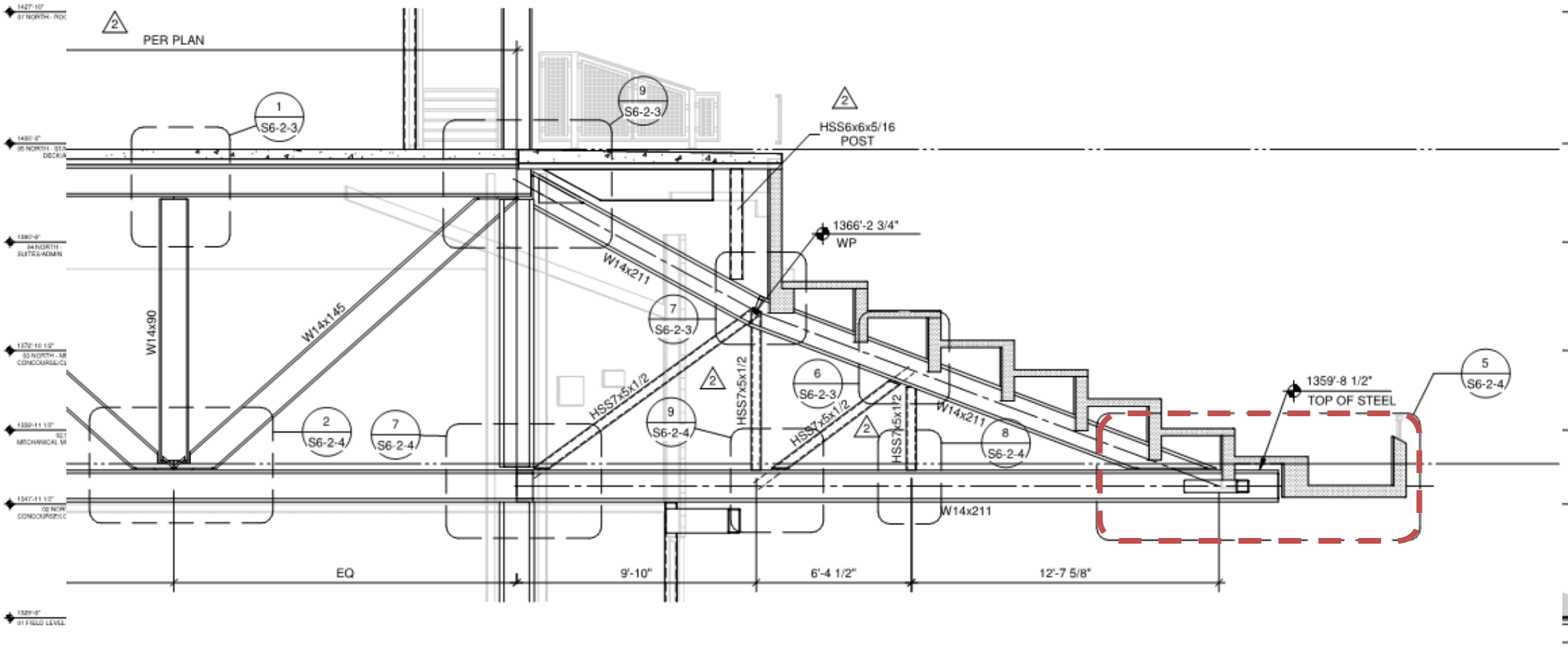
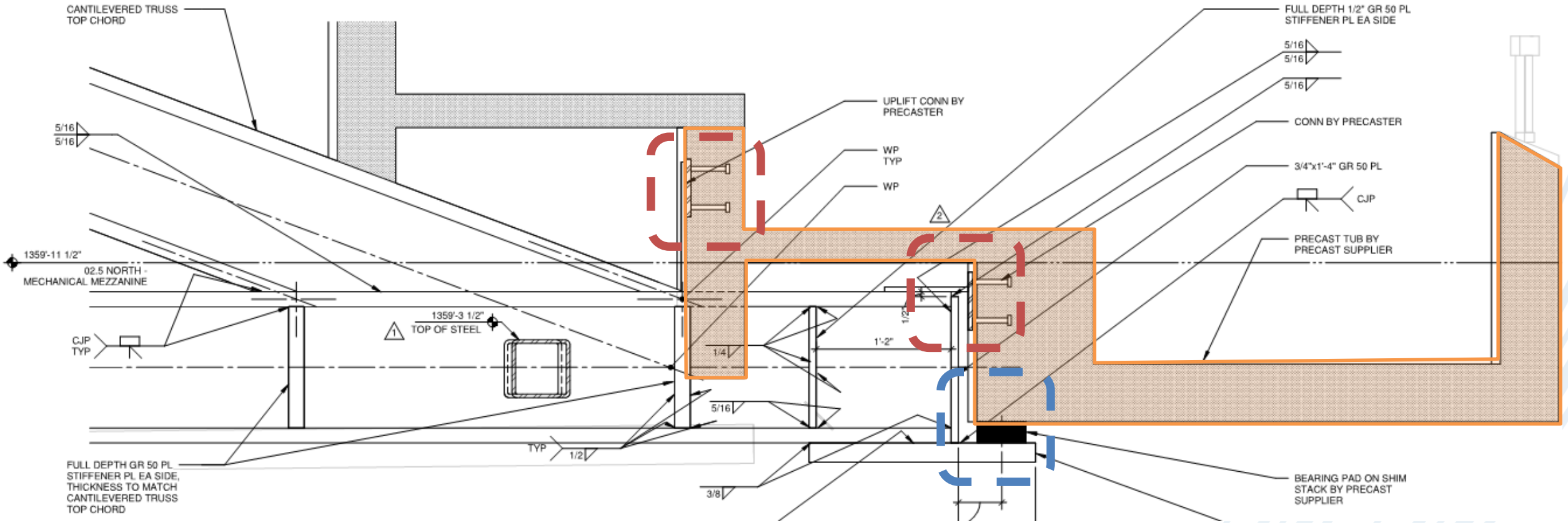
Wiss, Janney, Elstner Associates, Inc.

The Project

- Expansion at a collegiate football stadium
- Mezzanine club level in endzone
  - Cantilevering precast concrete tub riser
  - Supported by steel truss


PER PLAN
1
S6-2-3
9
S6-2-3
HSS6x6x5/16
POST
1366'-2 3/4"
WP
W14x211
7
S6-2-3
W14x90
W14x145
HSS7x5x1/2
HSS7x5x1/2
6
S6-2-3
HSS7x5x1/2
HSS7x5x1/2
W14x211
1359'-8 1/2"
TOP OF STEEL
5
S6-2-4
2
S6-2-4
7
S6-2-4
9
S6-2-4
8
S6-2-4
W14x211
EQ
9'-10"
6'-4 1/2"
12'-7 5/8"

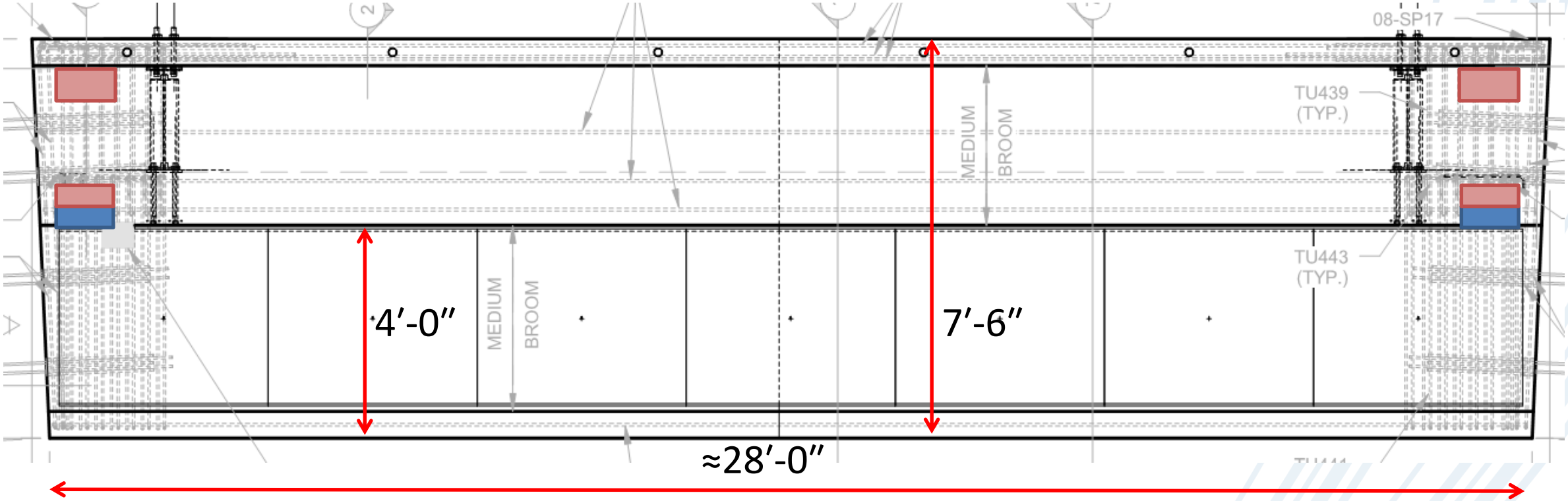
Concrete Tub Riser



Plan View

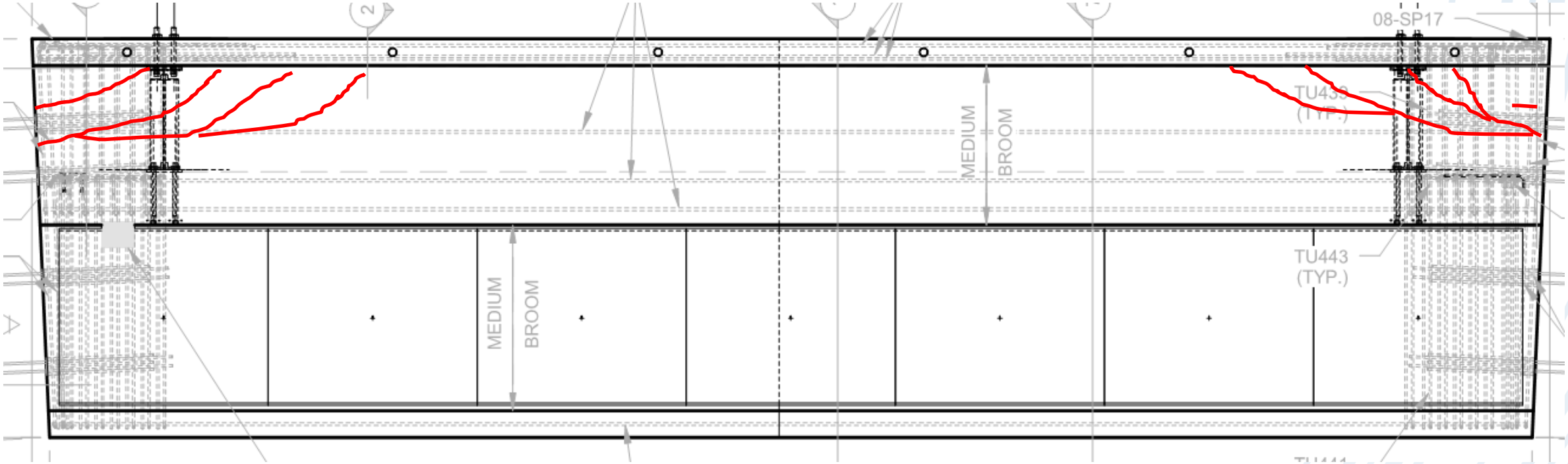
- Which direction controls?

$$\frac{l_{long}}{d} = \frac{28ft}{2ft} = 14 \qquad \frac{l_{tran}}{d} = \frac{2 \times 48in}{5.5in} = 17$$



Distress

Cracking in non-cantilever portion



- Consistent for bottom-most mezzanine concrete tub risers

Retrofit and Load Test

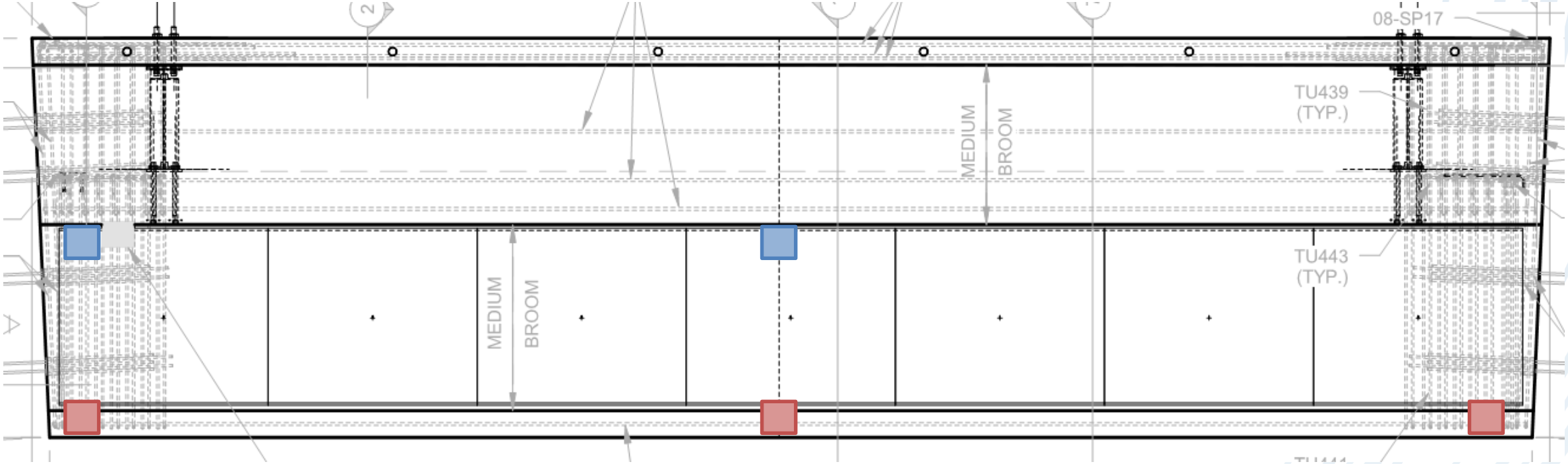
- Bending response
  - Longitudinal
  - Transverse cantilever
  - Torsional

Load Test per ACI 318-11

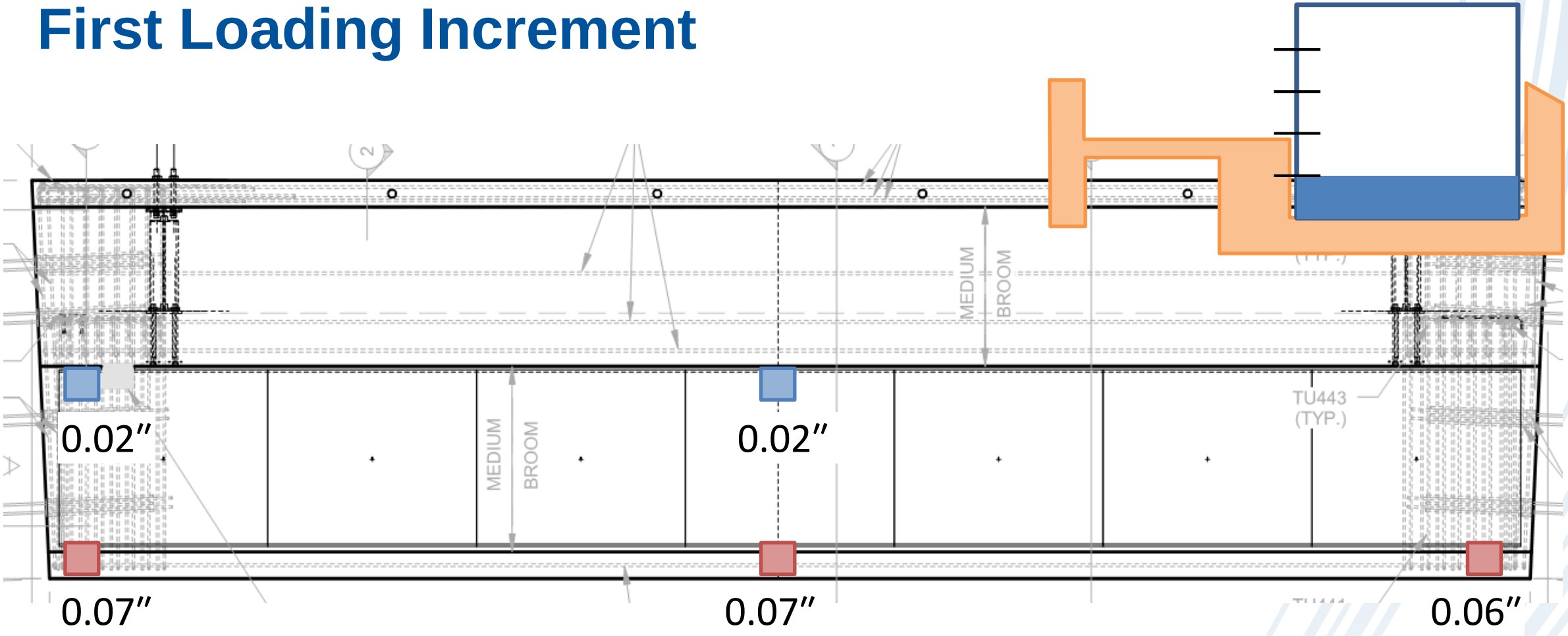
- Load cantilever portion
- Design live load = 100 psf
- Total test load = 150 psf
- Use industrial totes for loading
  - 30 inches of water

- Load
  - Four equal increments with 24-hr hold
  - Measure deflection with string potentiometer
  - Measure crack width

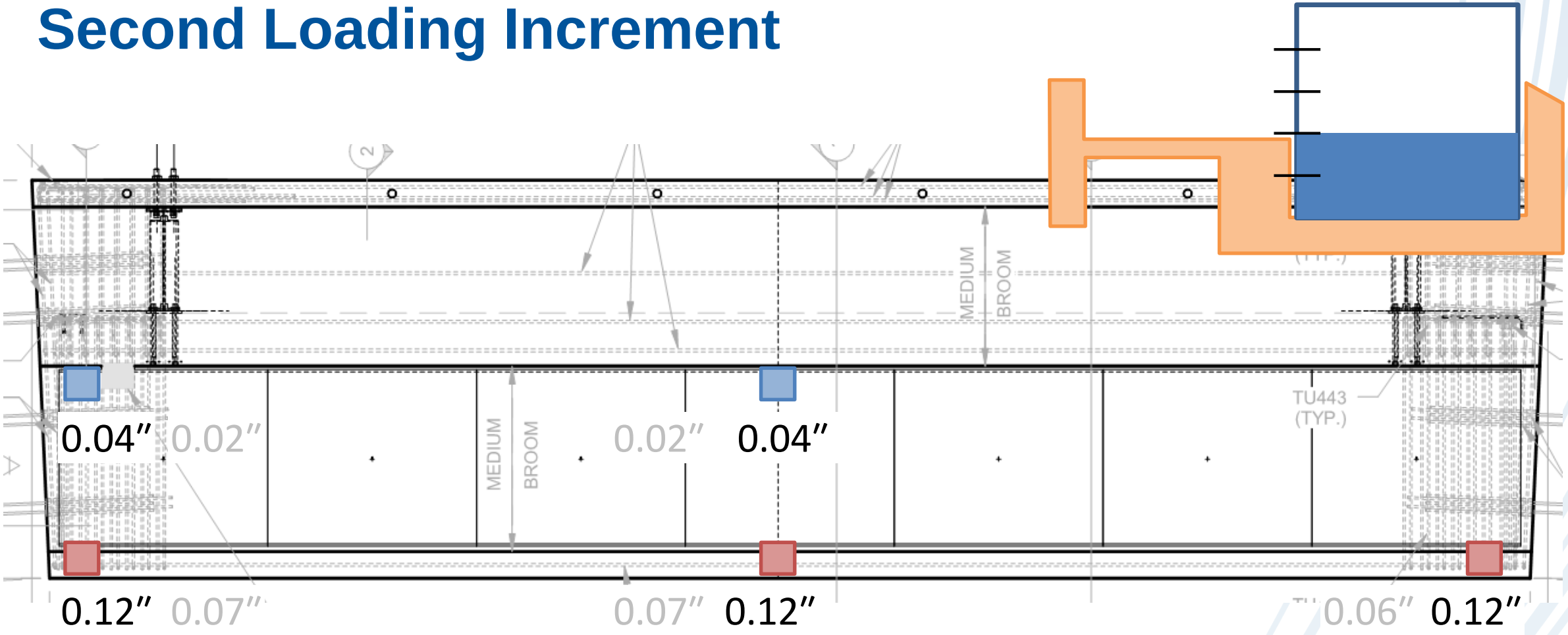
Instrumentation Locations



First Loading Increment



Second Loading Increment

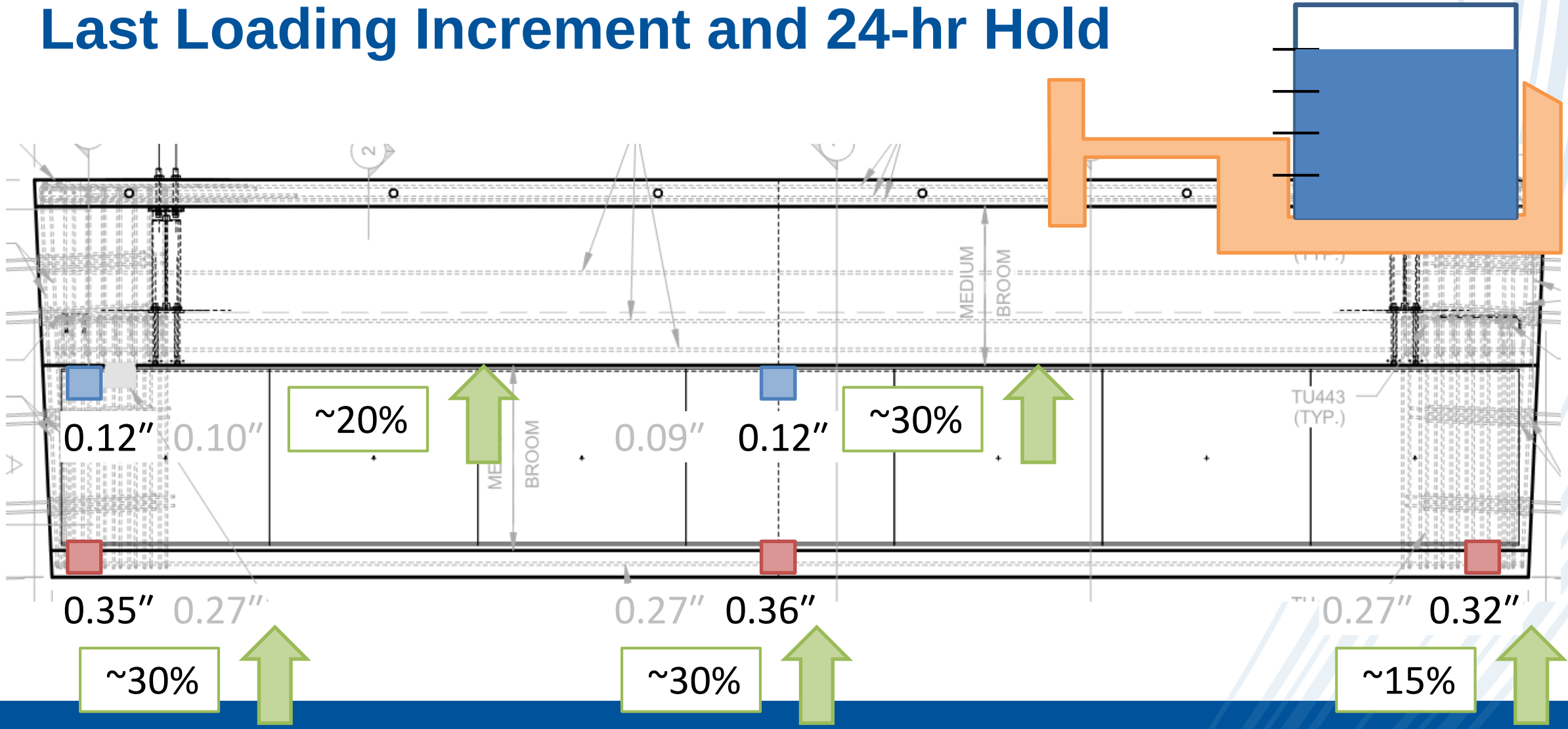


Last Loading Increment

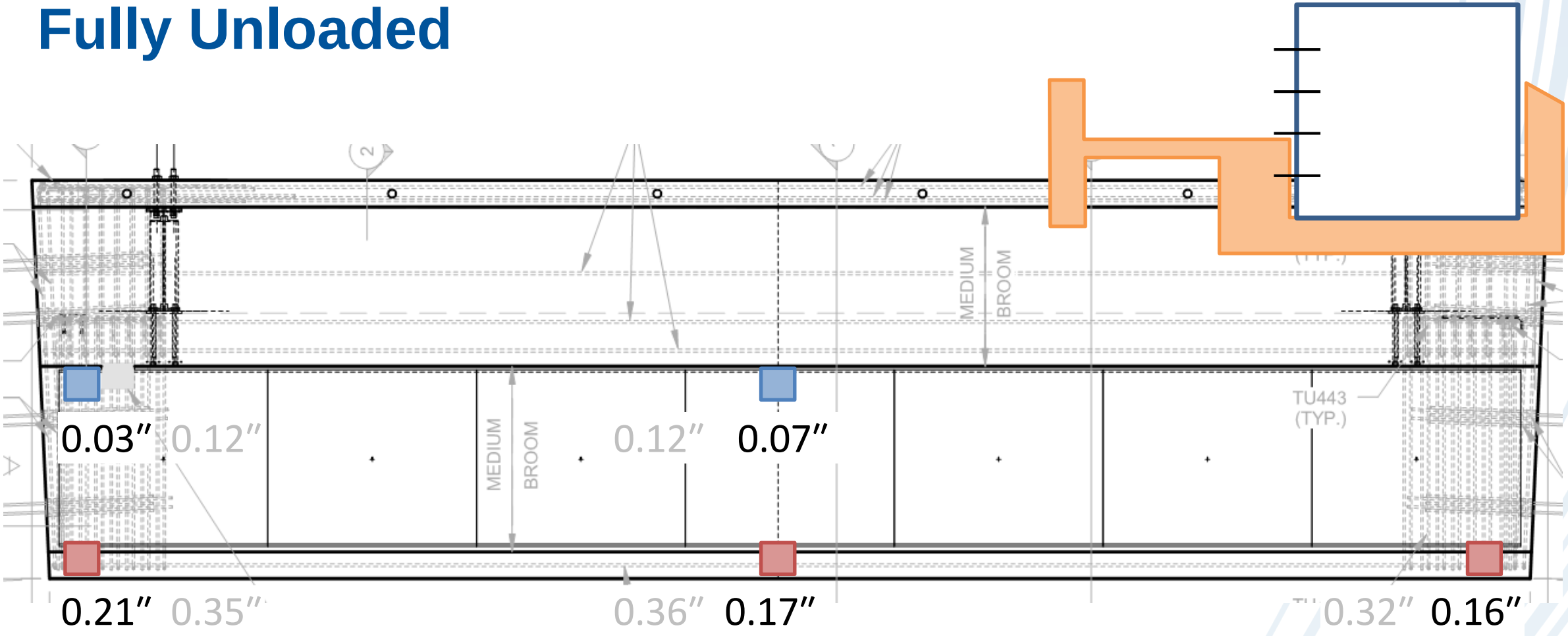
Predicted Truss Deflection:

Predicted Tub Deflection (re

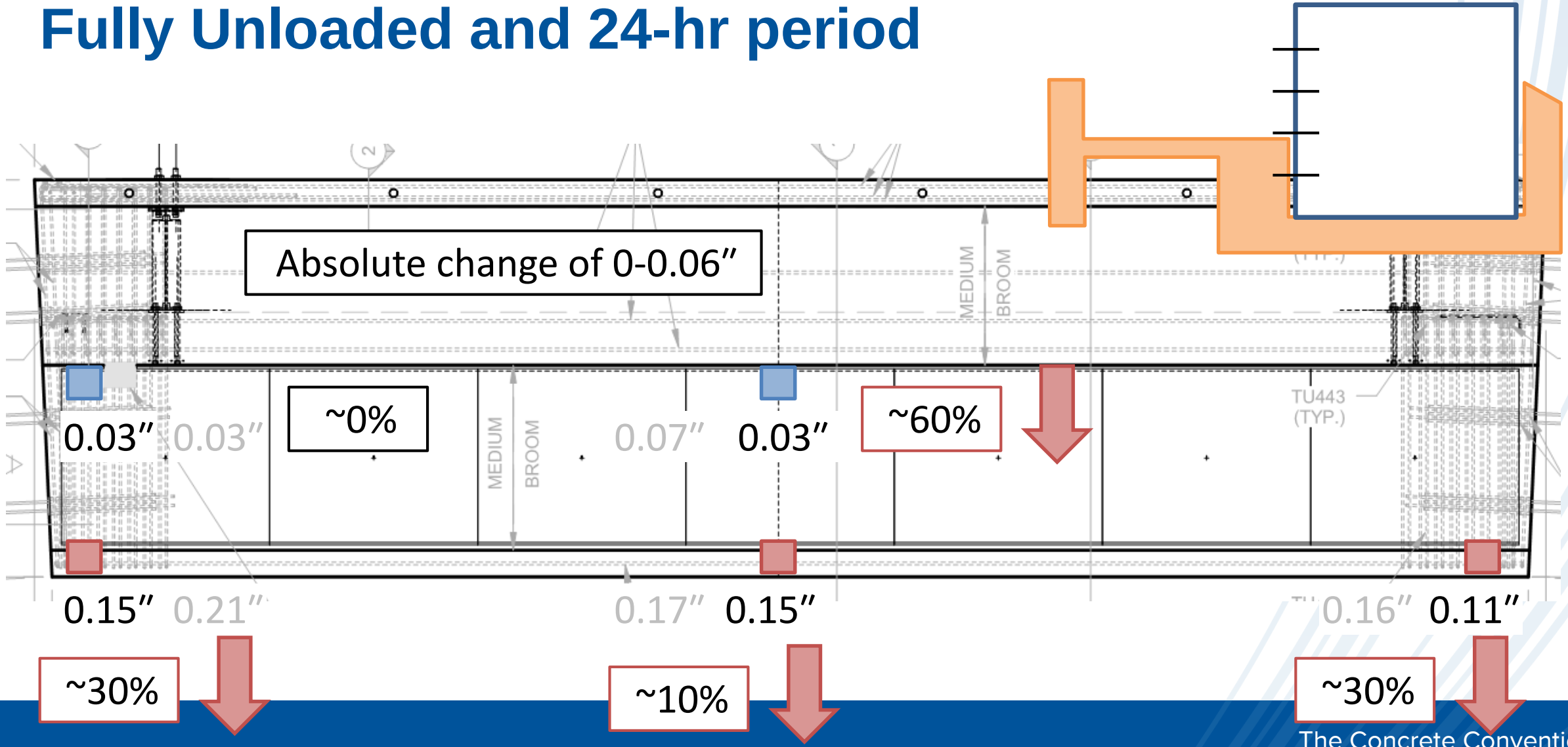
Last Loading Increment and 24-hr Hold



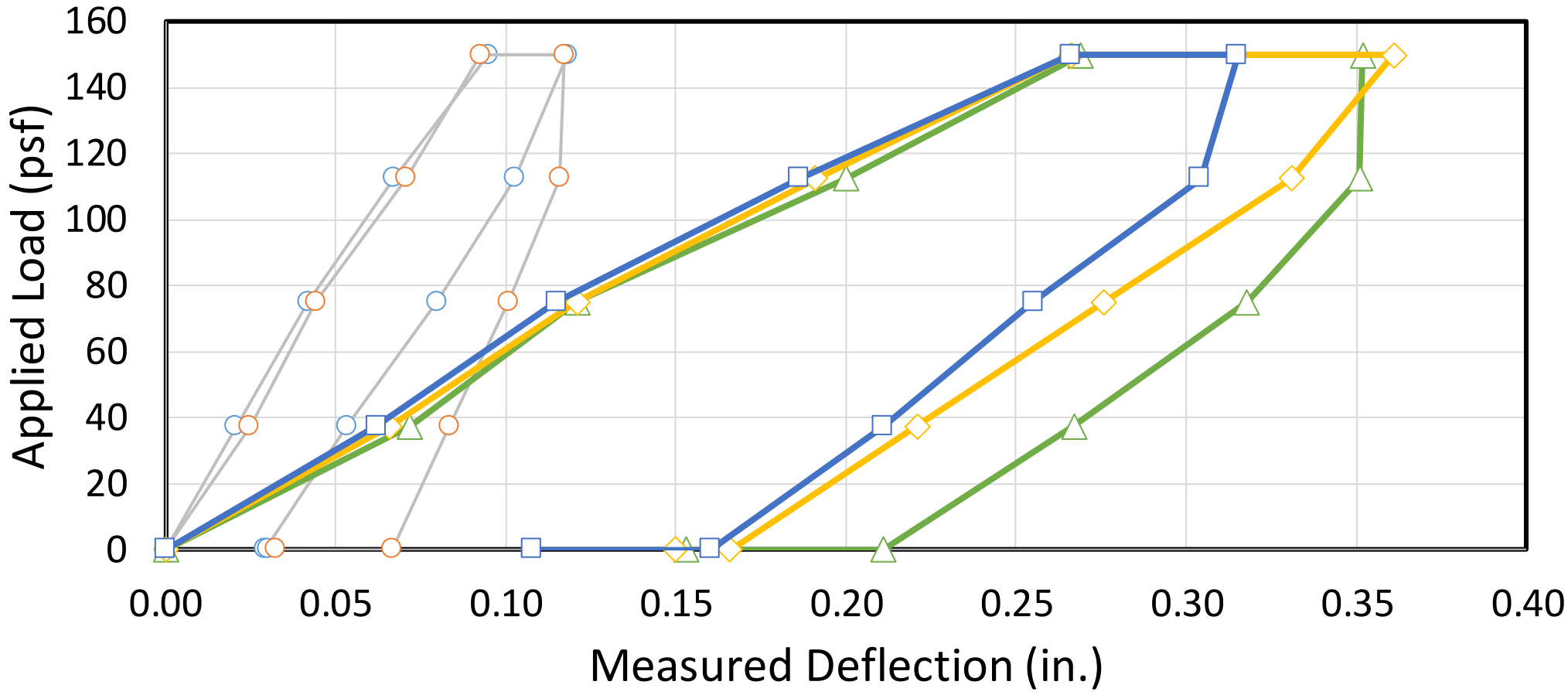
Fully Unloaded



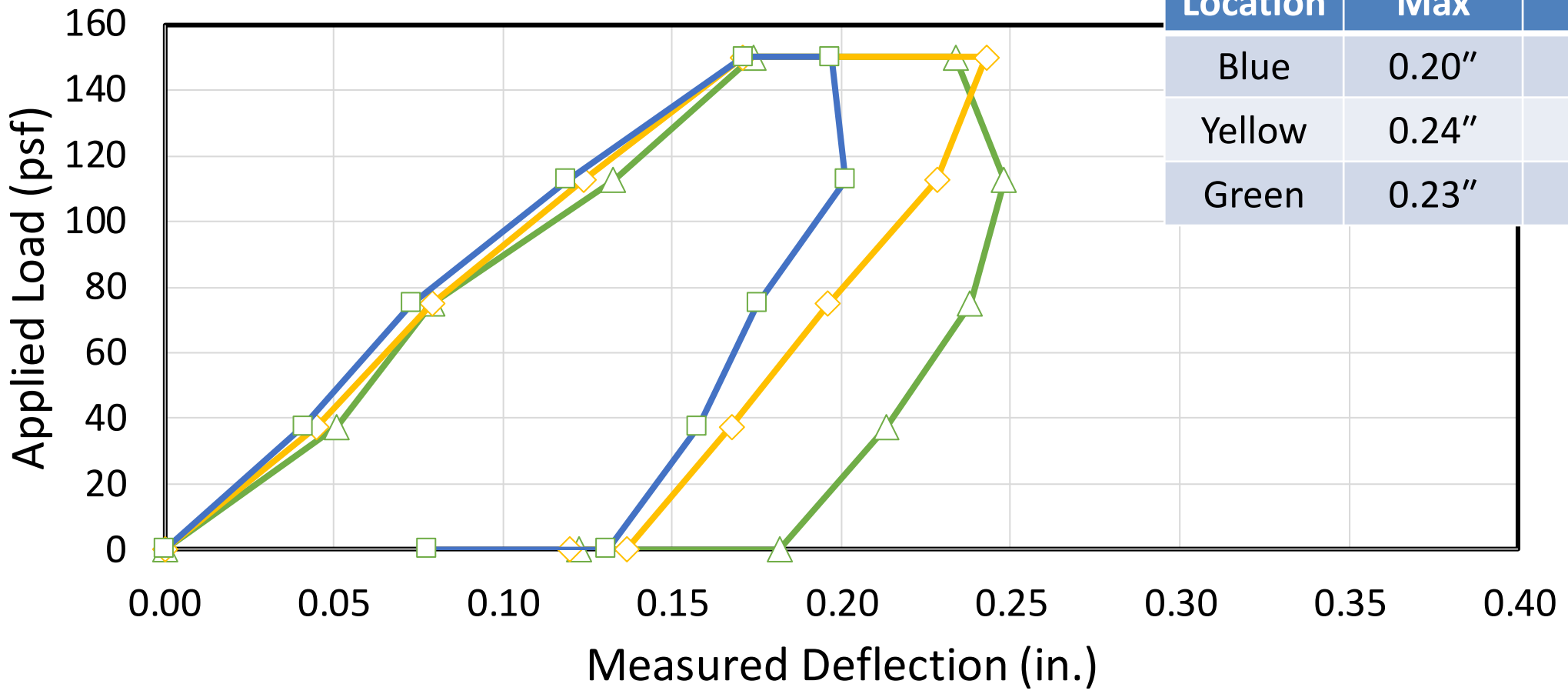
Fully Unloaded and 24-hr period



Deflections with Loading



Relative Deflection

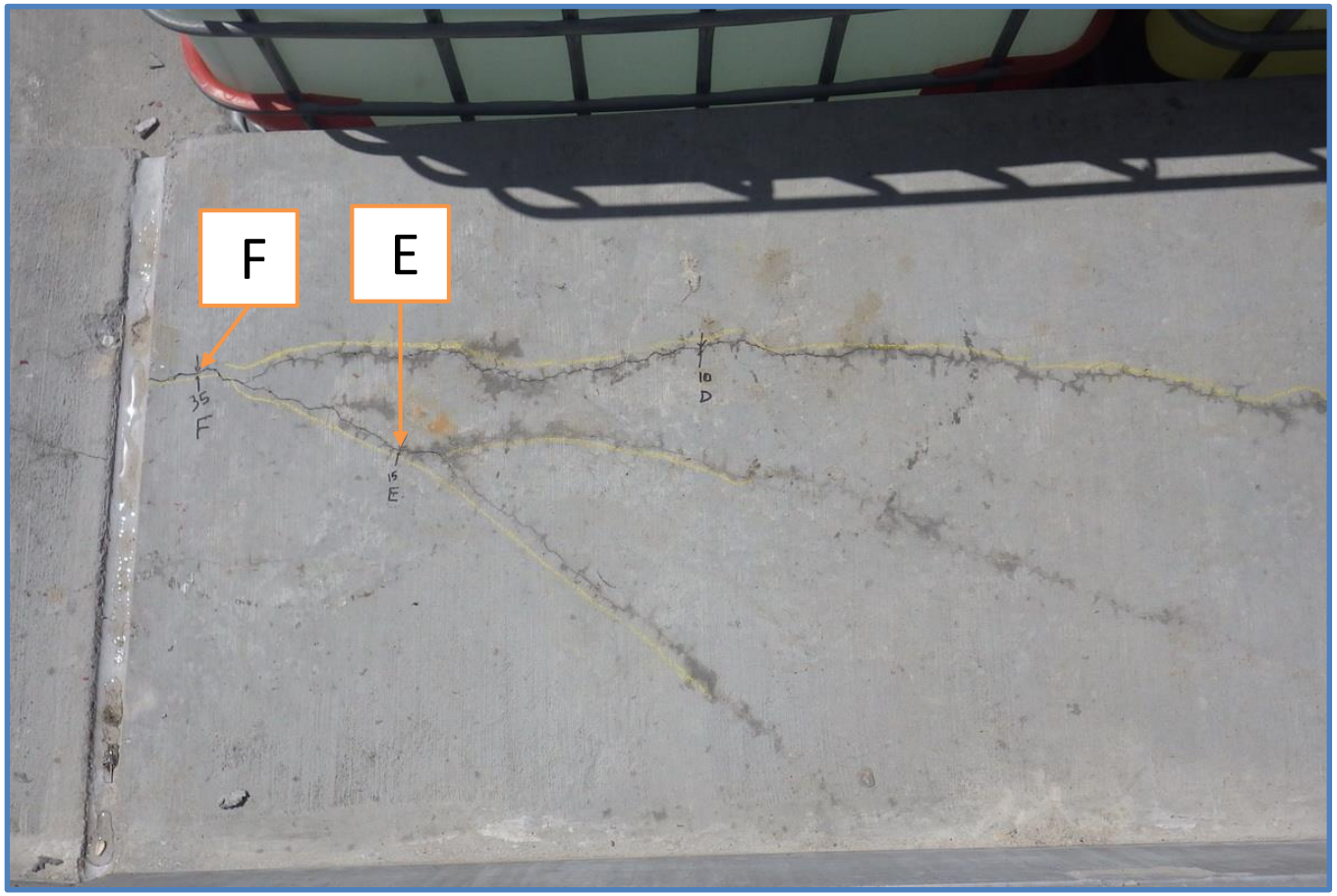


Location	Max	Final
Blue	0.20″	0.08″
Yellow	0.24″	0.12″
Green	0.23″	0.12″

Crack Width: West End

Description	A	B
Prior to test	25	25
Half Load	30	30
Full Load	35	35
Full Load + 24-hr hold	35	35
Half Load	35	35
No Load	30	30
No load + 24-hr period	30	30

Crack Width: East End



Description	E	F
Prior to test	15	35
Half Load	20	40
Full Load	20	45
Full Load + 24-hr hold	25	45
Half Load	25	45
No Load	25	40
No load + 24-hr period	20	40

Acceptance Criteria

- Maximum deflection (Eq. 20-1)
  - $\Delta \leq \frac{l_t^2}{20{,}000h} = \frac{(2\times 48in)^2}{20{,}000(5.5in)} = 0.084in$
- Residual deflection (Eq. 20-2)
  - $\Delta_r \leq \frac{\Delta_1}{4}$

Location	Max
Blue	
Yellow	
Green	

Location	Max/4	Final
Blue	0.05″	
Yellow	0.06″	
Green	0.06″	

Criteria not satisfied

Discussion

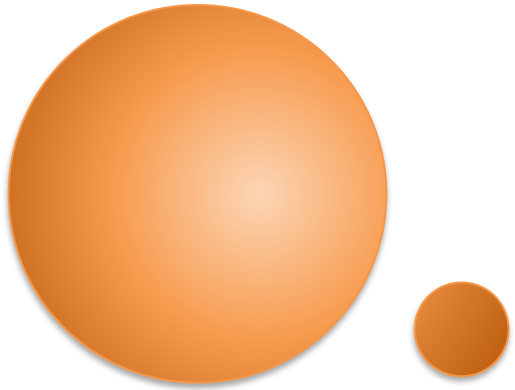
- Dominated by cantilever bending
- Next steps
  - Retest?
  - Perform cyclic test?
  - Detailed analysis?
  - Retrofit?
- Other influences
  - Temperature on ≈20′ cable

Corpus Christi Harbor Bridge Project

Main span: 1,661 ft (longest in US)

Confirm Development Length

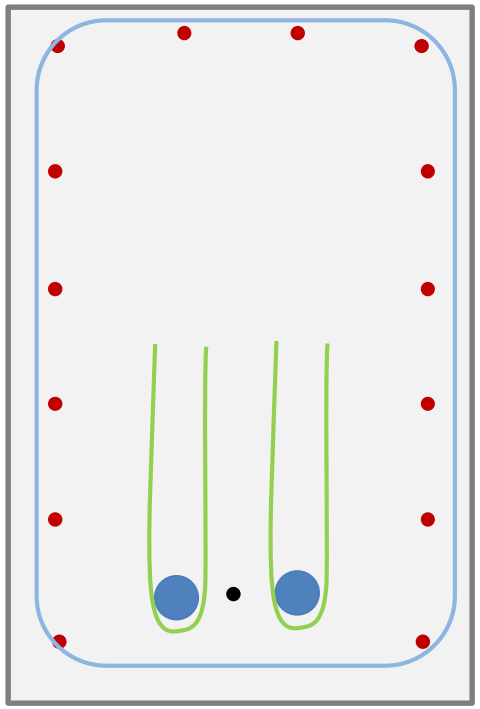
- Develop yield strength of #20 (grade 75)
  - Diameter = 2.5″
  - Min. yield strength = 368 kips
- Supplied by Williams Form Engineering
  - All-thread bars
  - Threaded terminator
- Footings

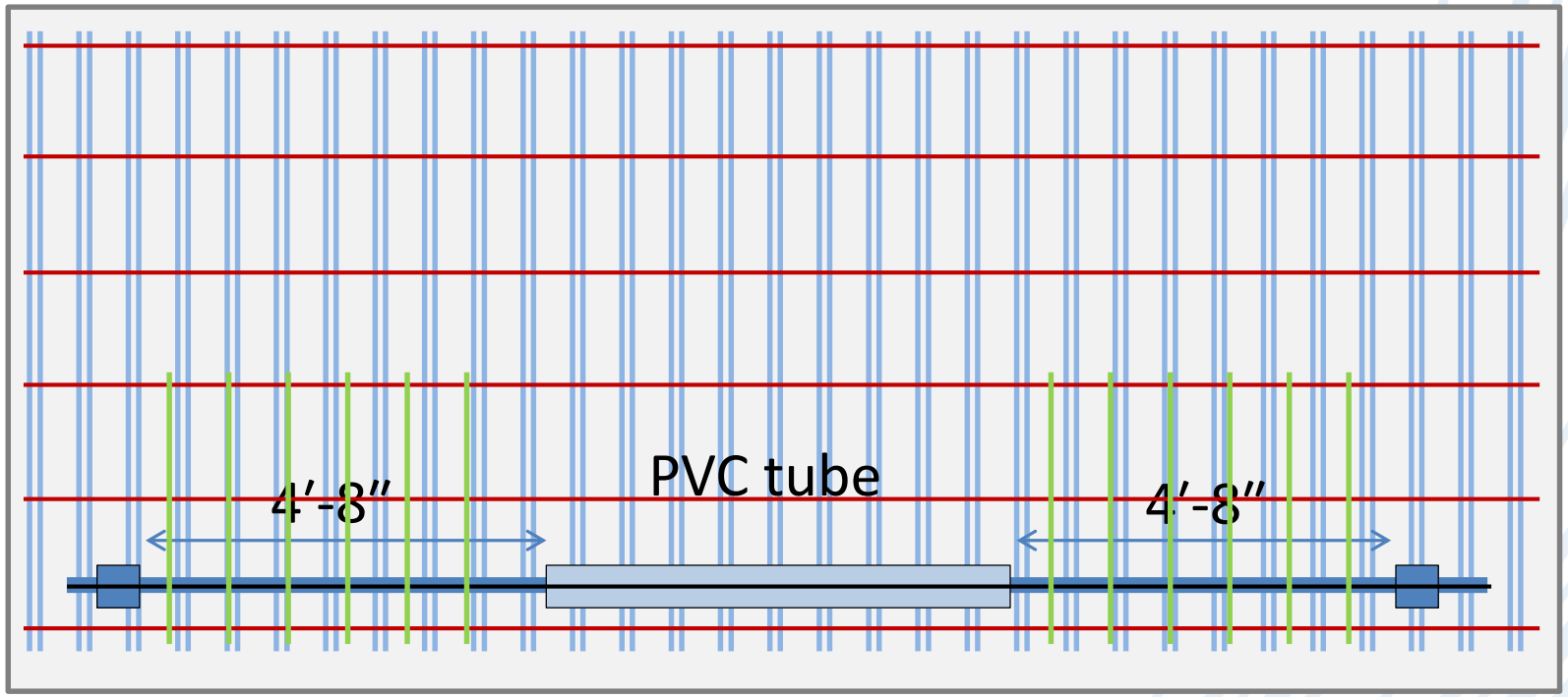


#20 ~ 16#5s

Fabricated Beams

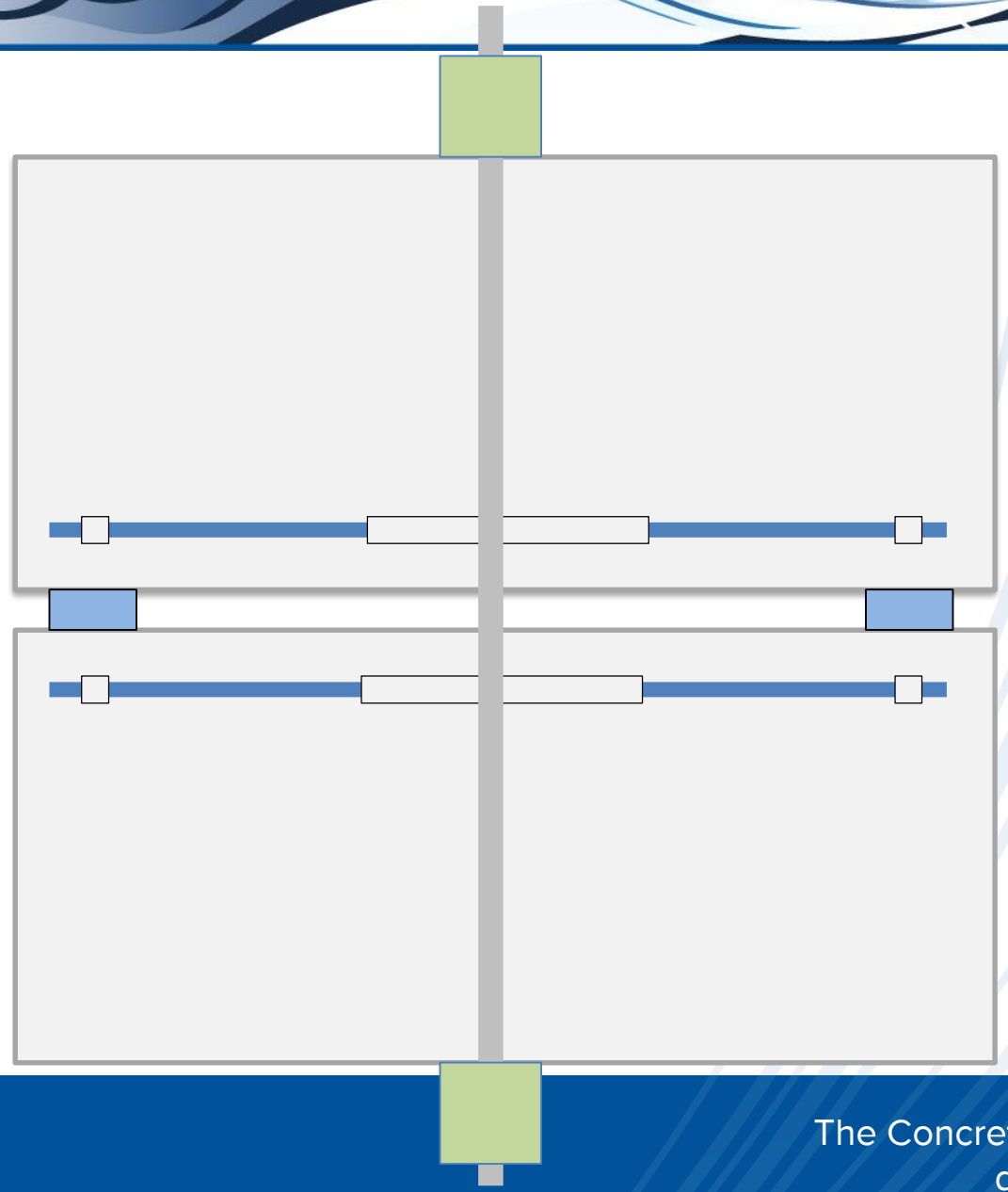
- 6′-0″ deep, 4′-0″ wide, 15′-6.5″ long
- Development length: 4′-8″





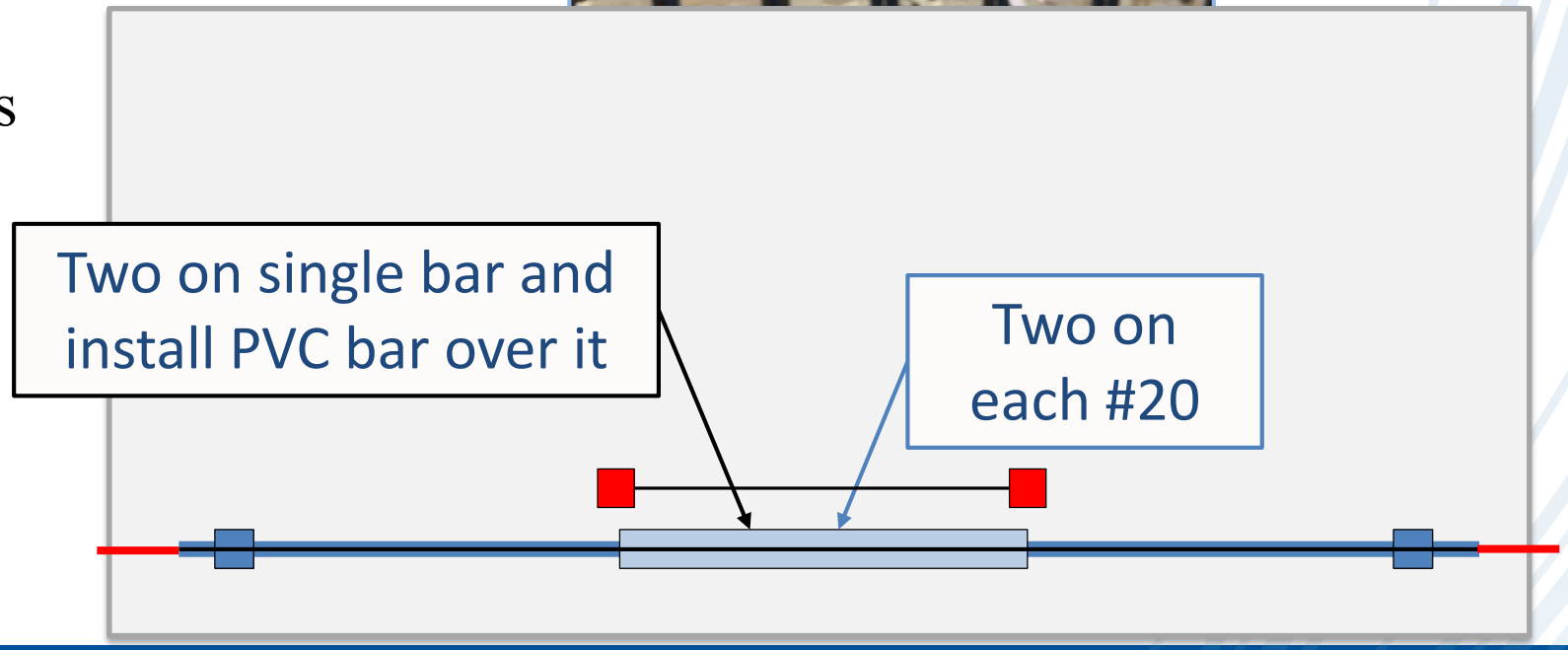
2#20s | 1#5 (Grade 100) | 14#5 | 2#6 @ 6″ O.C. | #4 @ 9″ O.C.

Two Tests at Once



Instrumentation Plan

- Internal strain gages
  - Vibrating wire gages (#5 bar)
  - Foil strain gages (#20 bar)
- External strain gages
- Slip at ends of #20 bars
- Deflection
- Pressure



Acceptance Criteria

- Reach 75 ksi in #20 bars
  - (2800 microstrain)
- Slip < 0.04″
- No evidence of bond failure

- 50′ safety buffer

Strain in #20 Bars

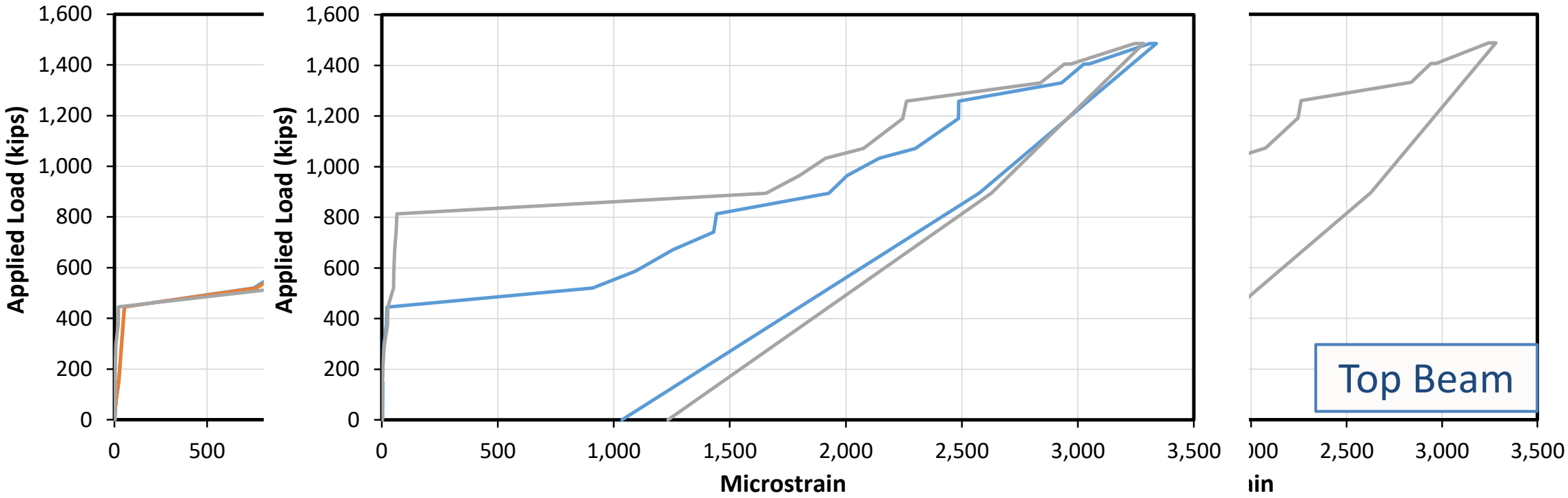
Start loading

Loud bang

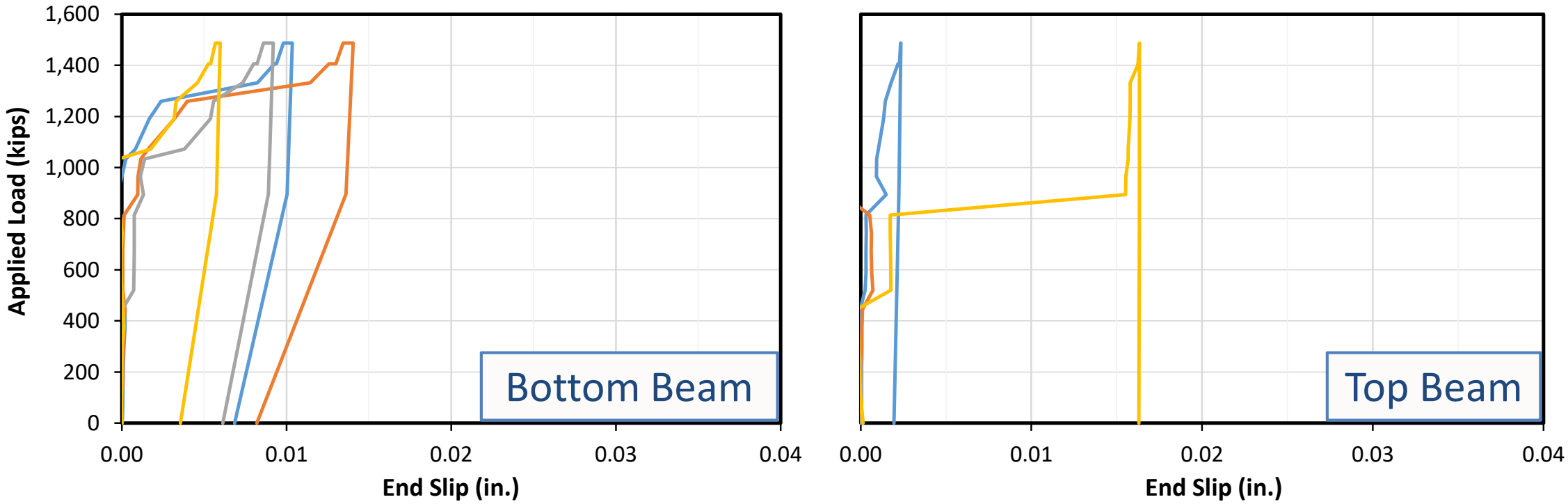
Continue loading, another bang

Continue loading

Unload



Slip at Ends


1,600
1,400
1,200
1,000
800
600
400
200
0
Applied Load (kips)
0.00
0.01
0.02
0.03
0.04
End Slip (in.)
Bottom Beam
0.00
0.01
0.02
0.03
0.04
End Slip (in.)
Top Beam

Condition of Beam

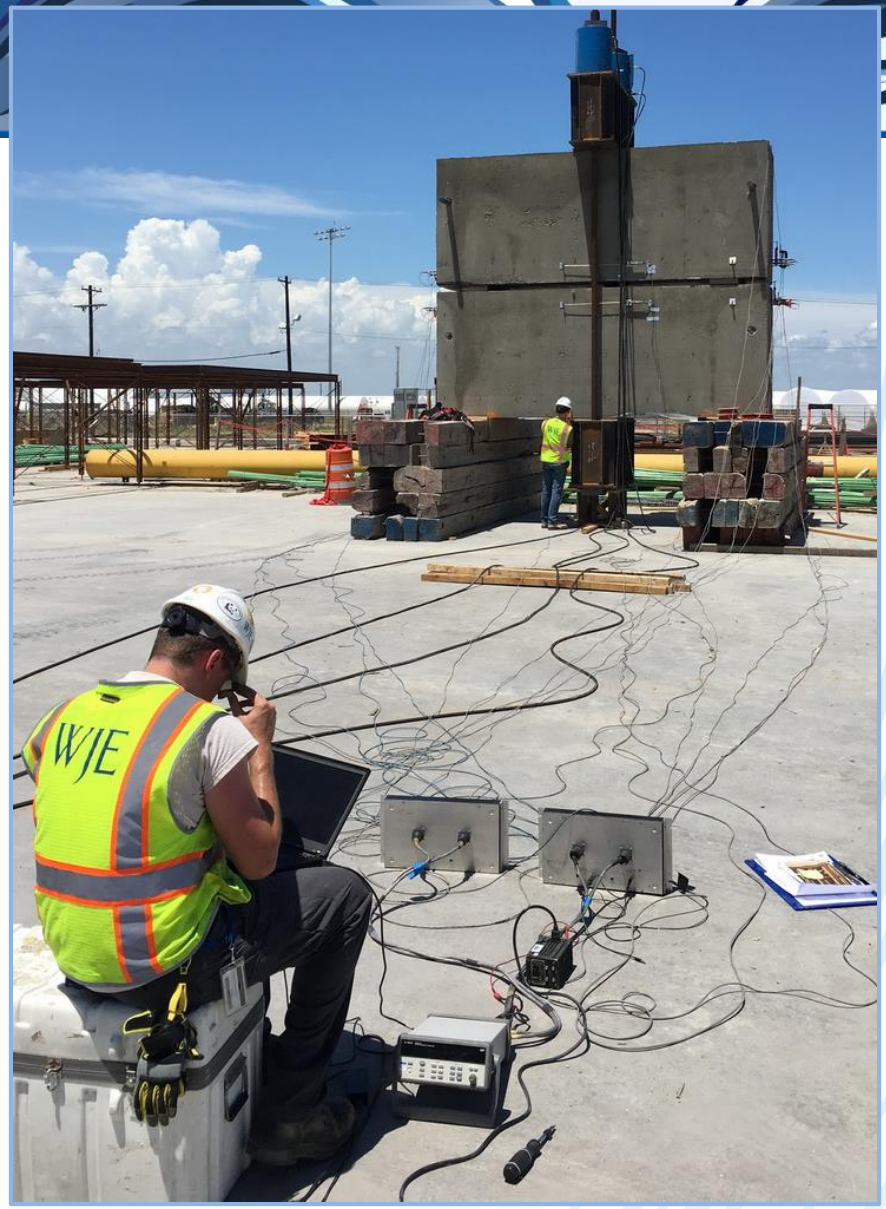
Residual Strain (external): 1,000 με
0.04" crack / 38" gage = 1,052 με

Residual Strain (external): 1,200 με
0.05" crack / 38.125" gage = 1,300 με

Discussion

- Met acceptance criteria
- Idealized behavior

- Important to measure right component
- Redundancy
  - Gages
  - Equipment



Questions?