Bridge Deck Overhang Design

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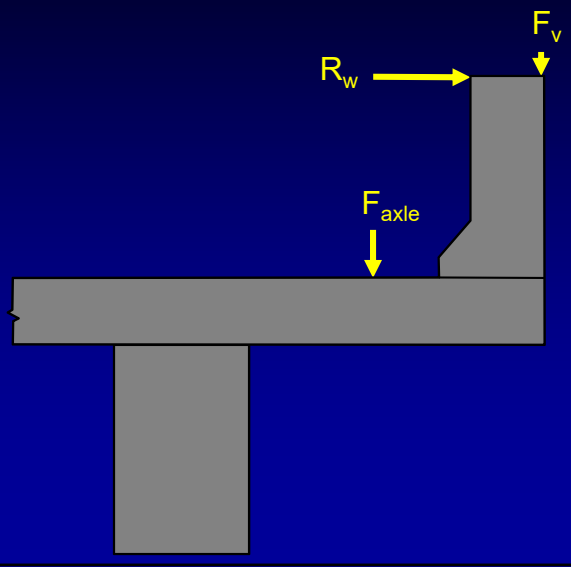
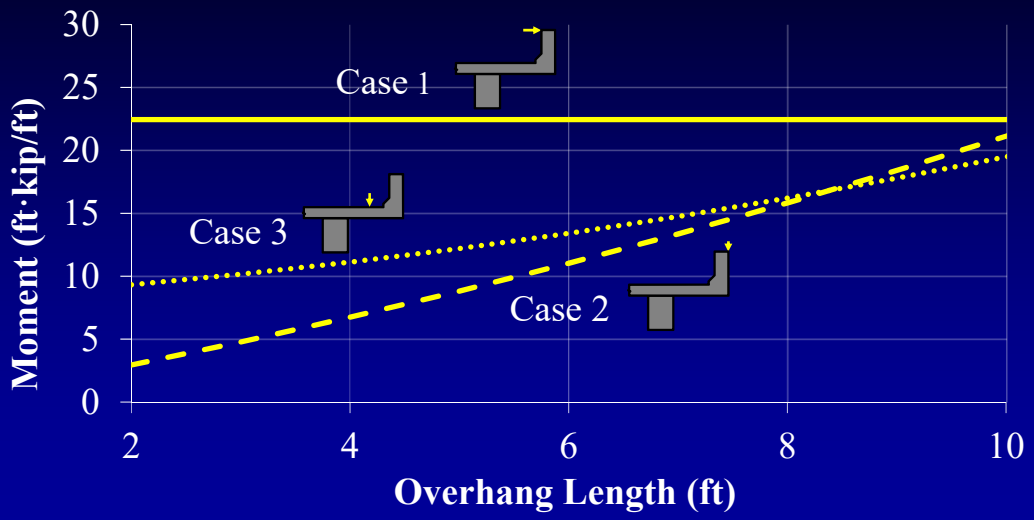
Overhang Design

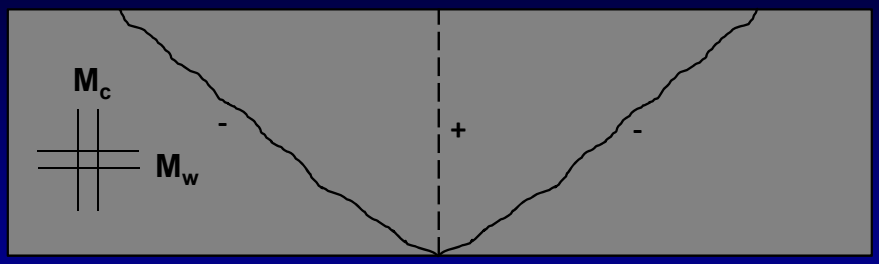


- Case 1
- Case 2
- Case 3

Overhang Design for TL-4 Barrier



Yield Line Analysis



$$W_{INT} = W_{EXT}$$

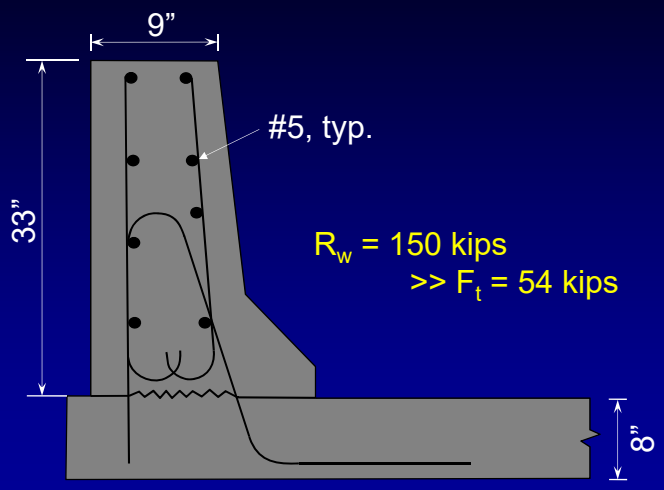
$$F \cdot \Delta = \sum M\theta$$

$F = R_w$ (nominal railing resistance)

Barrier Design Forces

Design Forces and Designations	Railing Test Levels					
	TL-1	TL-2	TL-3	TL-4	TL-5	TL-6
F_t Transverse (kips)	**13.5**	**27.0**	**54.0**	**54.0**	**124.0**	**175.0**
F_L Longitudinal (kips)	4.5	9.0	18.0	18.0	41.0	58.0
F_v Vertical (kips) Down	4.5	4.5	4.5	18.0	80.0	80.0
L_t and L_L (ft)	4.0	4.0	4.0	3.5	8.0	8.0
L_v (ft)	18.0	18.0	18.0	18.0	40.0	40.0
H_e (min) (in.)	18.0	20.0	24.0	32.0	42.0	56.0
Minimum H Height of Rail (in.)	27.0	27.0	27.0	32.0	42.0	90.0

Barrier Resistance



INDOT Type FC TL-4 Barrier

- Barrier overdesign
  - more reinforcement required in overhangs
- Overhang must resist larger moments and axial forces

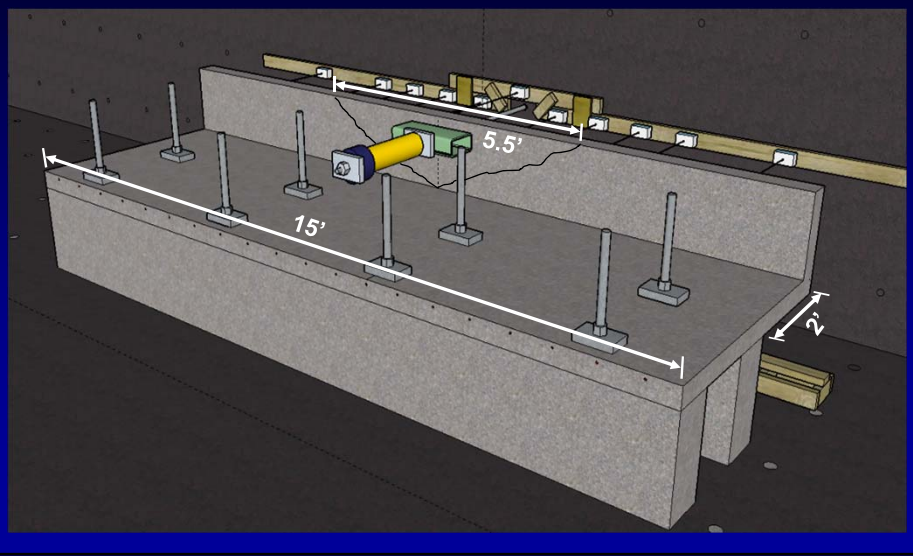
Reducing Collision Forces

- AASHTO procedure requires more reinforcement (~3 x F_t)
  - Design for barrier capacity
- Past practice required less reinforcement
  - Lower design forces
- INDOT and other states reduce collision force (1.25 x F_t)
  - Design for transverse force
- What is the appropriate design procedure?

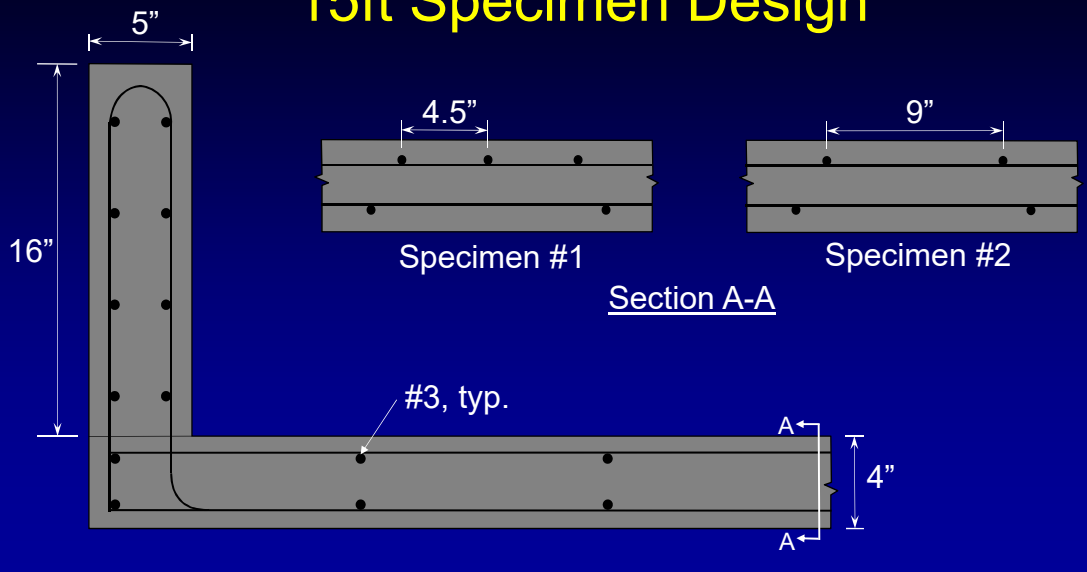
Research Objective

- Investigate appropriate design procedure
- Determine failure mechanism in overhang specimens
- Improve design assumptions

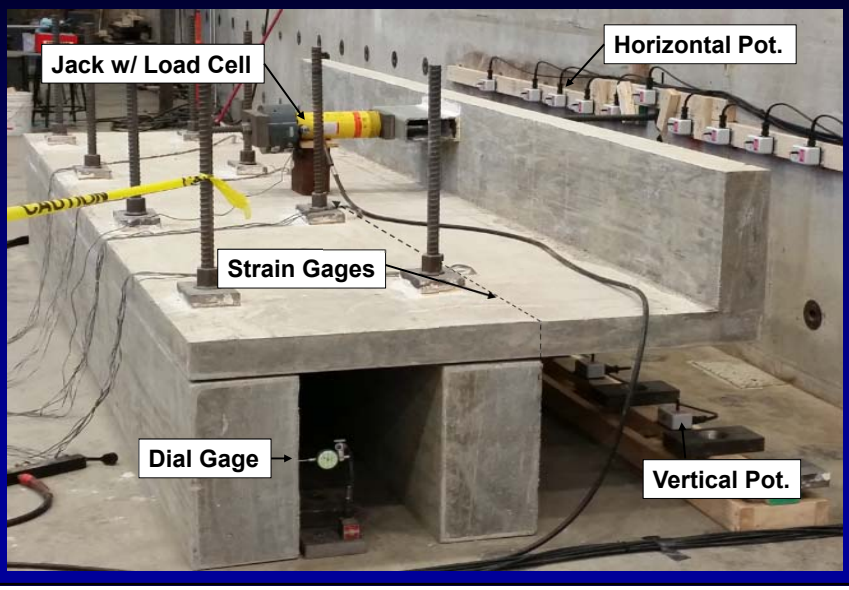
Schematic Design



15ft Specimen Design



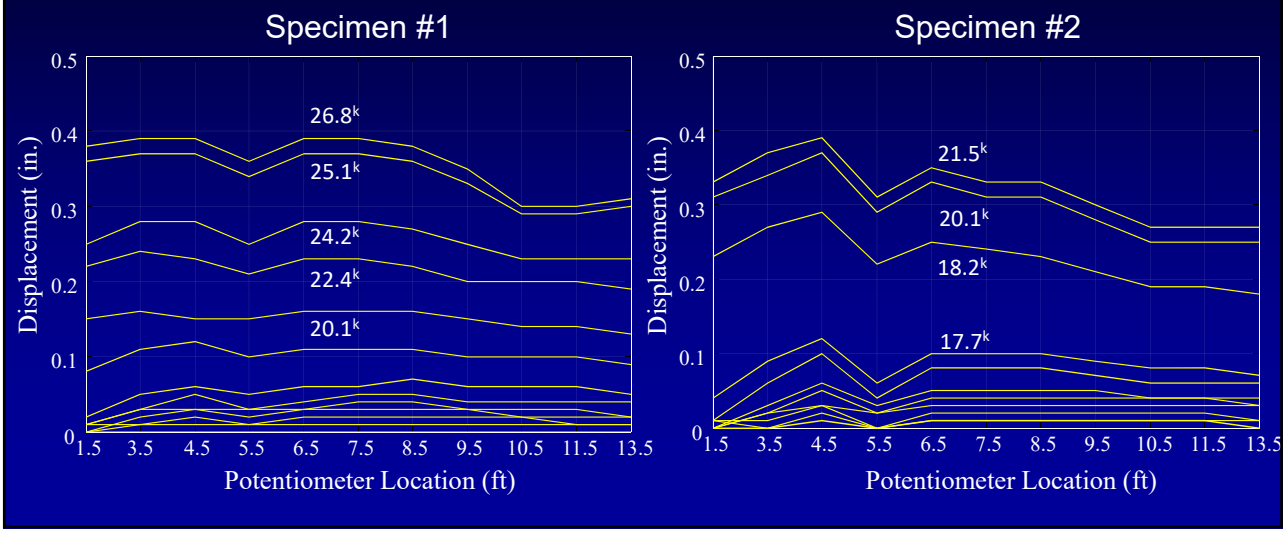
Experimental Setup



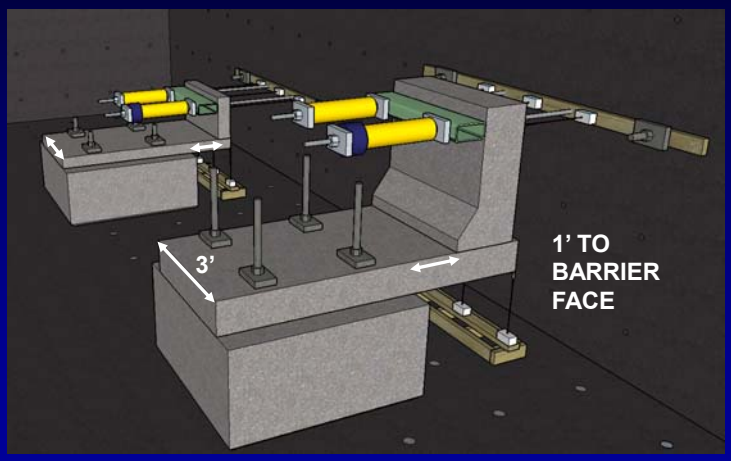
Specimen #1 Cracking

Specimen #2 Cracking

Vertical Displacement

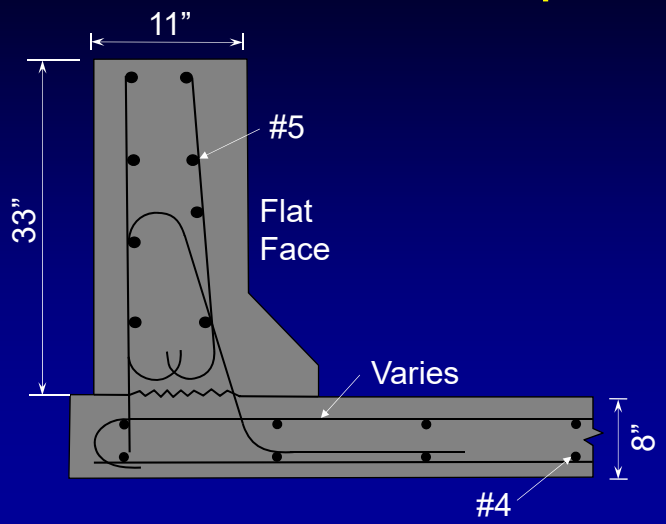


3’ Strip Specimens



- 5 full scale INDOT Type FC specimens
- 2 half scale specimens

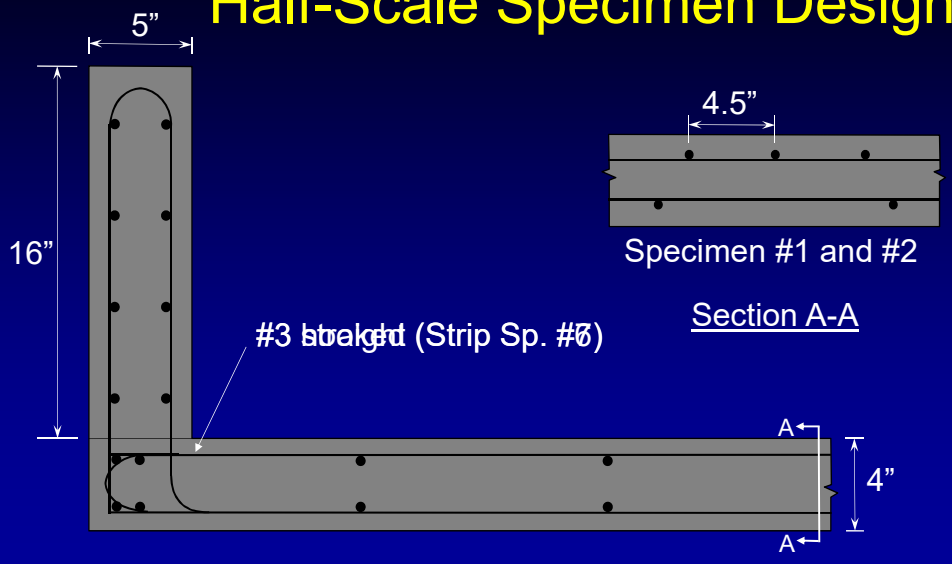
Full-Scale Specimen Design



Test Variables:

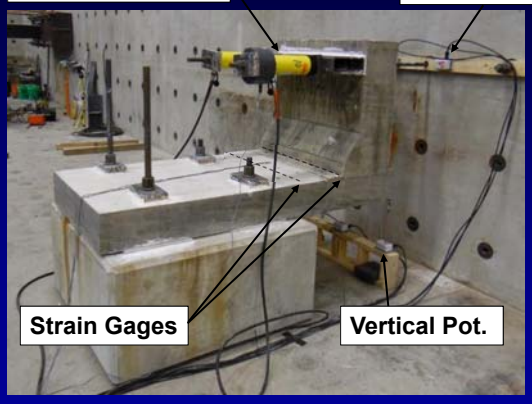
- Top Transverse Bar Size
  - #5 and #6
- End Condition
  - Straight and Hook
- Bar Coating
  - Epoxy coat and black

Half-Scale Specimen Design



Slab Cast

Experimental Setup



Full Scale

Half Scale

Full-Scale Cracking Behavior

#5 Epoxy @ 3.5” Straight
14 kips

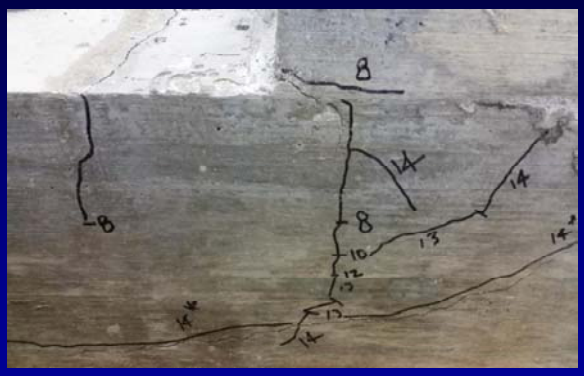
#6 Epoxy @ 4.75” Straight
14 kips

Full-Scale Cracking Behavior

#5 Epoxy @ 3.5” Hooked
15 kips

#5 Black @ 3.5” Straight
15 kips

Full-Scale Cracking Behavior



#6 Black @ 4.75” Straight
14 kips

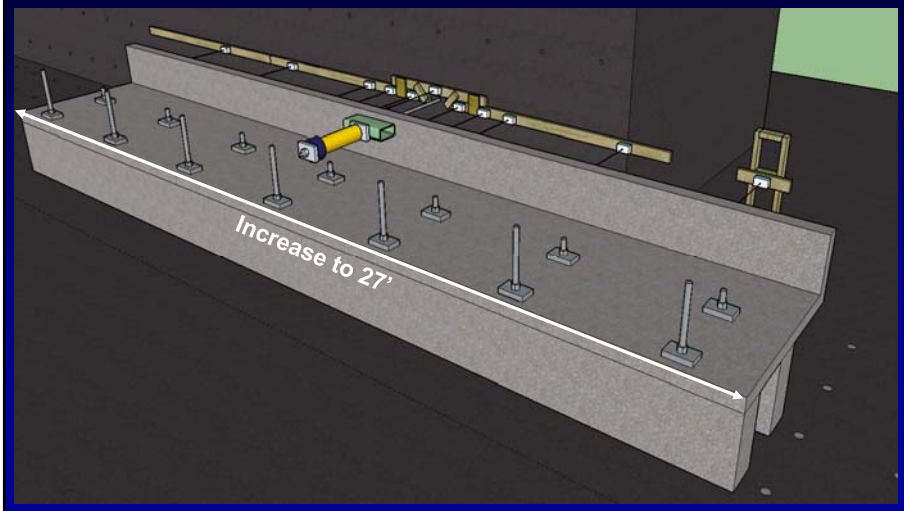
Typical Specimen Failure Plane

Half-Scale Cracking Behavior

#3 @4.5” Hooked
8 kips

#3 @ 4.5” Straight
6 kips

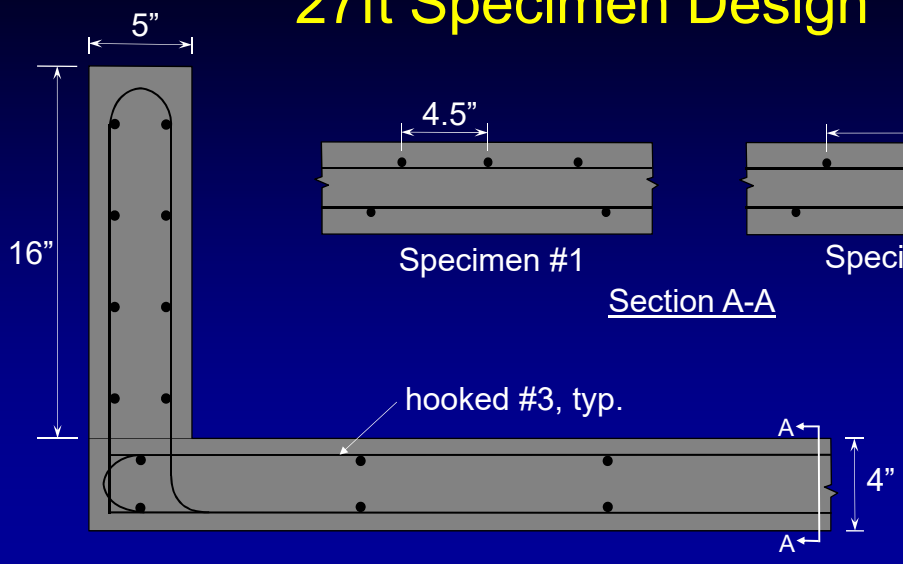
27ft Specimens



Objectives

- Form Barrier Mechanism
- Refine Distribution Length

27ft Specimen Design



Experimental Setup

Specimen #1L Loading

Specimen #2L Loading

Behavior at Ultimate Load

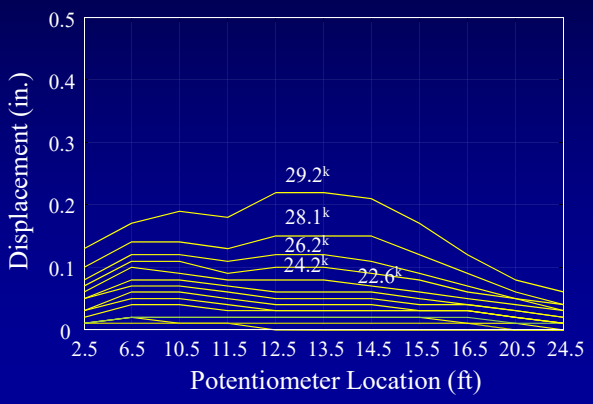
Specimen #1L at 29.2 kips

Behavior at Ultimate Load

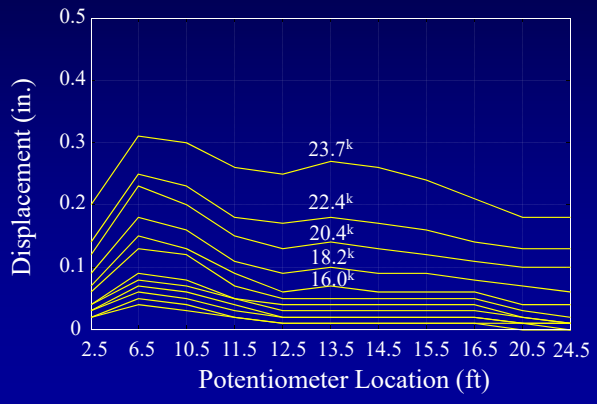
Specimen #2L at 23.7 kips

Vertical Displacement

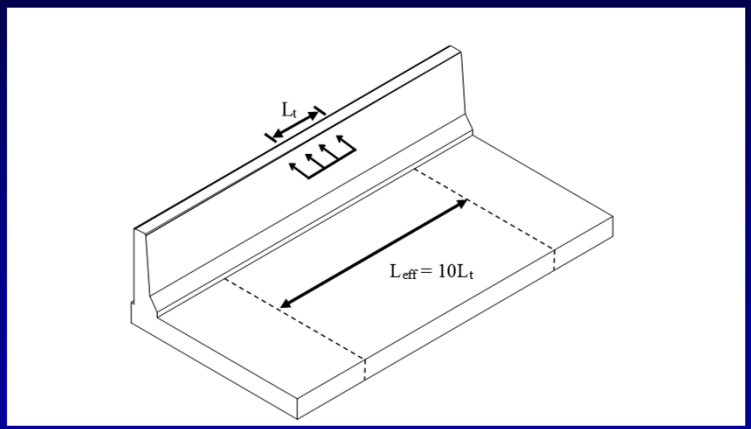
Specimen #1L



Specimen #2L



Distribution Length



Lower Punching Shear

Upper Punching Shear

Nonsymmetrical Failure

Conclusions

- Diagonal tension joint failure (15ft and 3ft strip specimens)
  - Concrete failure rather than reinforcement anchorage in overhang
  - Only applicable for short bridge lengths (< 30 ft)
- Punching shear failure (27ft specimens)
  - Punching controls prior to forming barrier mechanism (110 kips vs 150 kips)
  - Consistent with actual failures
- Research suggests overhang reinforcement not critical
  - Punching shear governs design
  - Large distribution length ($10L_t$)
  - Reinforcement can be reduced in overhang

Recommendations

- Design overhang for vertical loads (Case 2 and 3)
- If lateral force considered:
  - Design for lesser of:
    - Punching Shear Strength
    - Yield Line Strength
  - Consider distribution length as $10L_t$

Questions?