



# Large Reinforcing Bars Spliced in UHPC

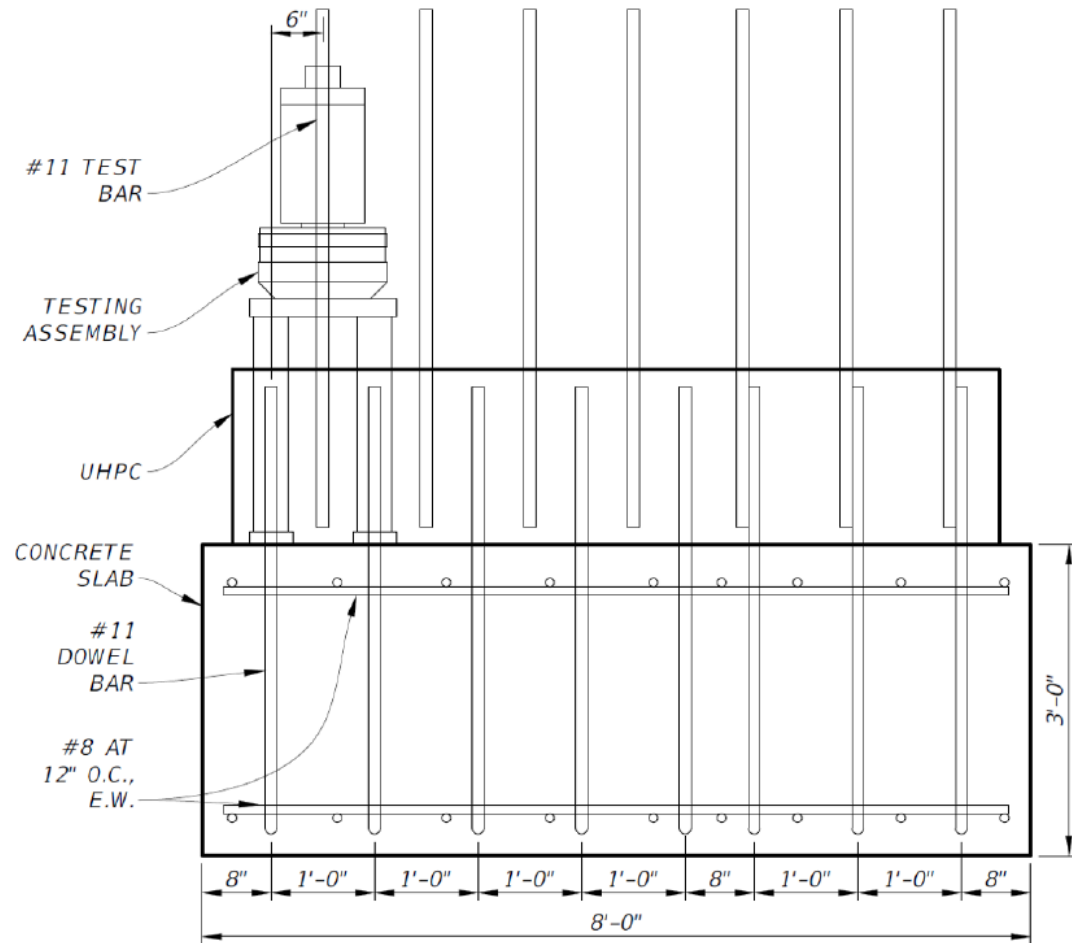


Christina Freeman  
Assistant State Structures Design Engineer  
Florida Department of Transportation



American Concrete Institute

# Test Setup



# Test Parameters

- In total, 127 tests were conducted.
- Parameters included:
  - Bar Size: #8, #9, #10, #11
  - Concrete Cover: 1.75 inch, 2.75 inch, 3.75 inch
  - Bar Spacing: contact, 6 inch (center-to-center), 8.5 inch (center-to-center)
  - Embedment Length: from 8 to 13 times the bar diameter (as required to achieve 75 ksi)
  - Splice Length: from 6 to 11 times the bar diameter (as required to achieve 75 ksi)

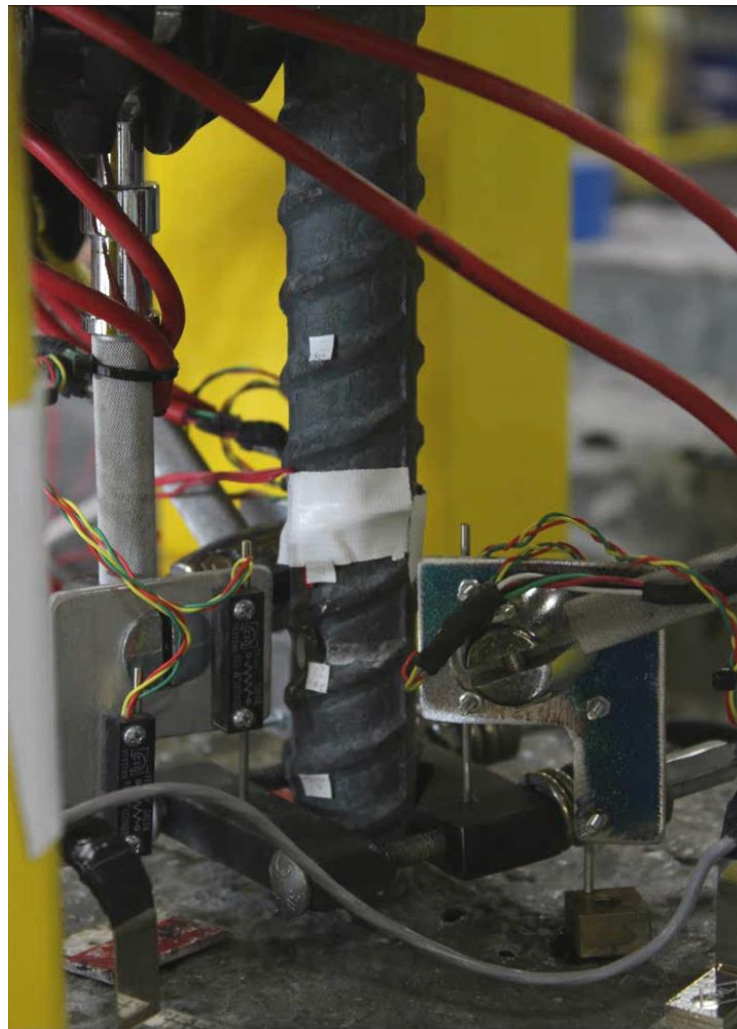


# UHPC Placement

THE WORLD'S GATHERING PLACE FOR ADVANCING CONCRETE

aci CONCRETE  
CONVENTION



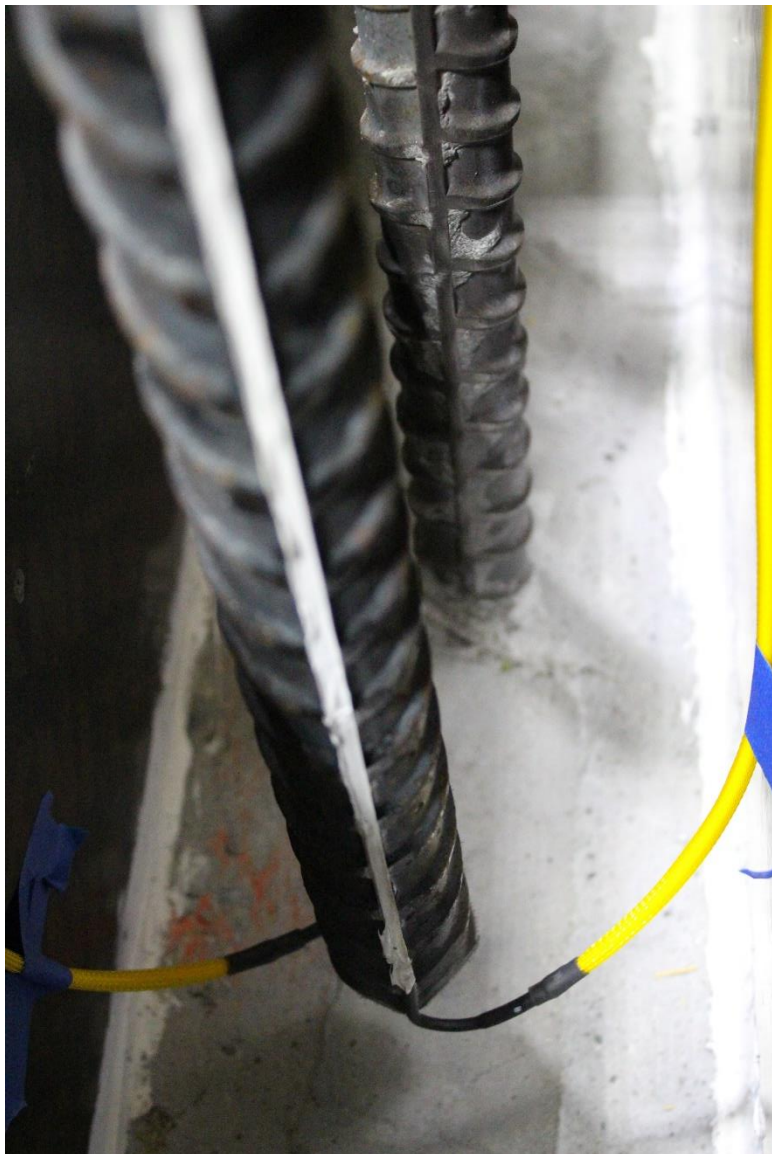


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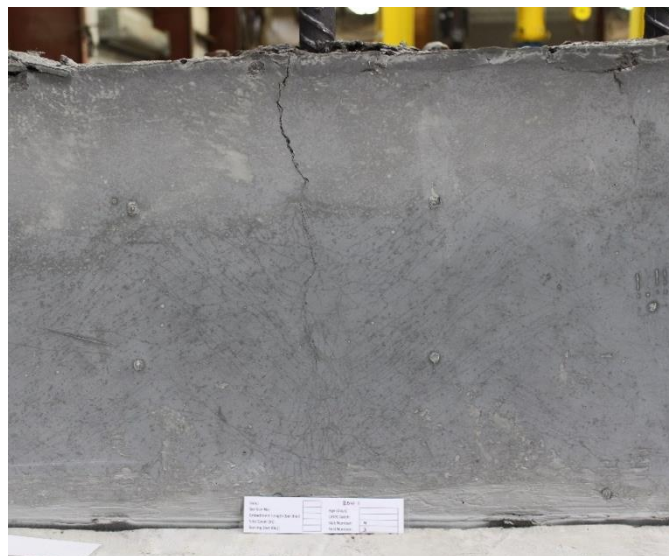
# Fiber Optic Sensing

- Strain can be measured at 0.25-inch increments along the length of the bar, including the portion embedded in UHPC.





**Cone**



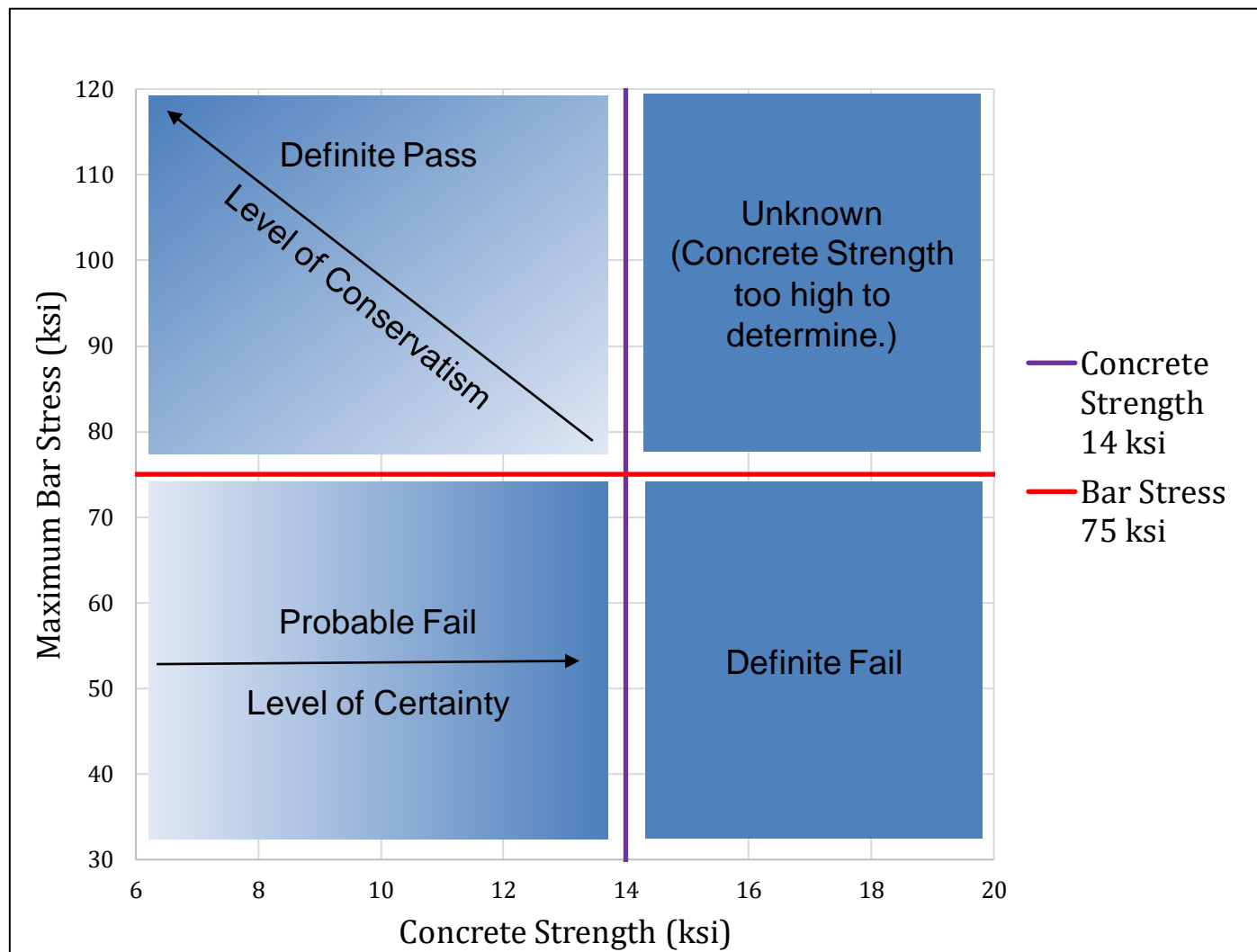
**Splitting**



**Combination**

# UHPC Modes of Failure





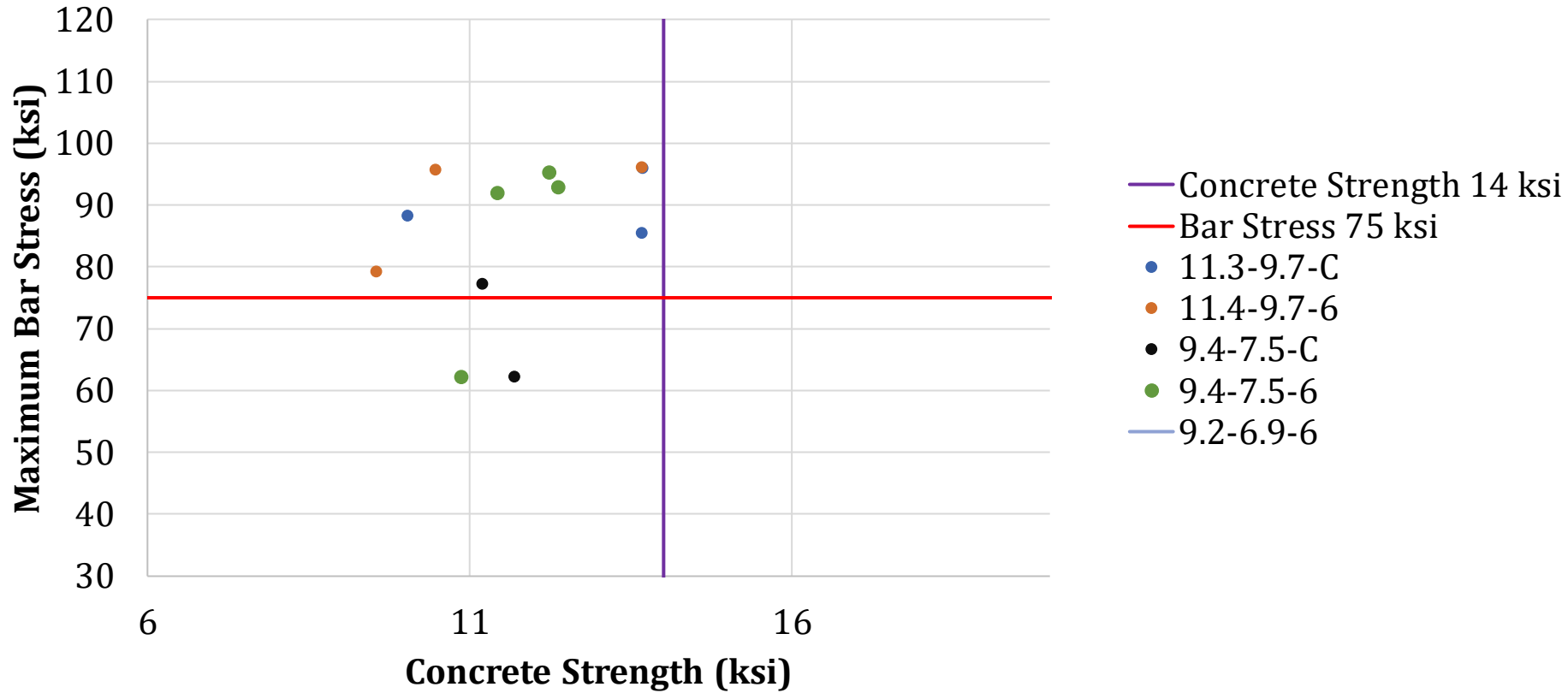
— Concrete Strength  
14 ksi

— Bar Stress  
75 ksi



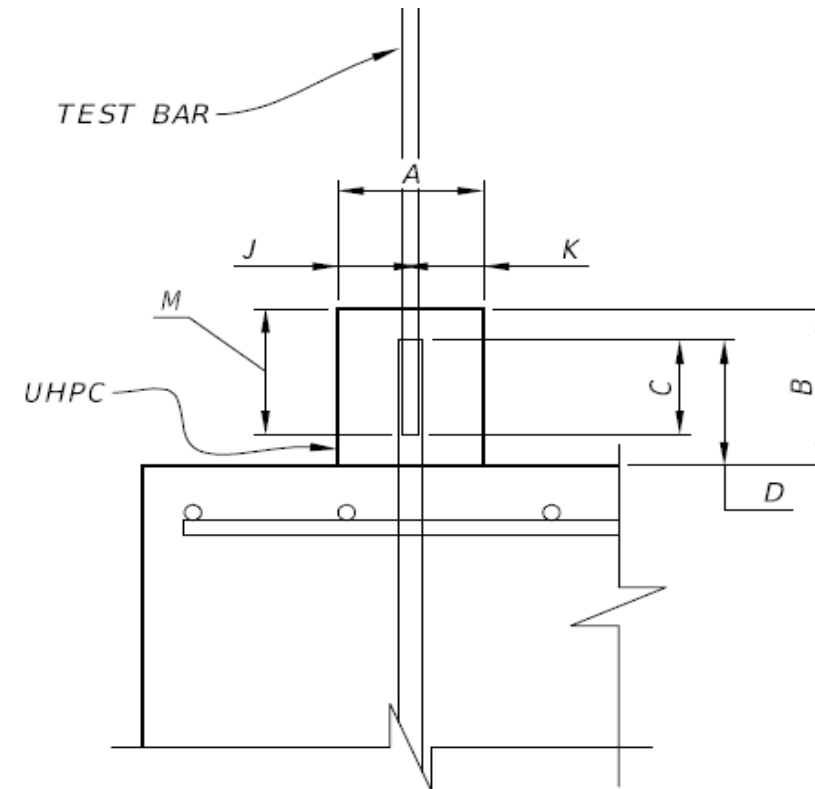


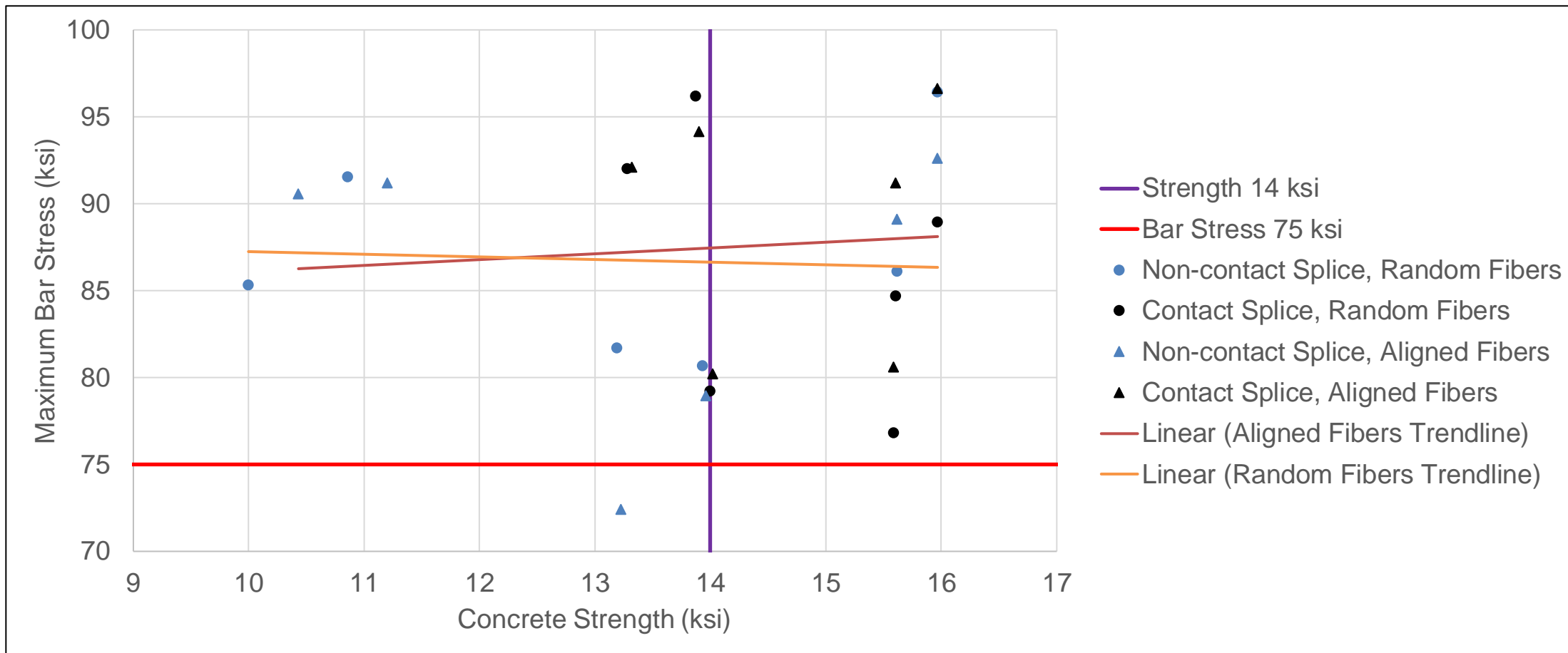
### Bar Size #11 Side Cover 2.75"



Required Embedment Length (M, D) in Terms of Bar Diameters					
		Bar Size			
		No. 8 (Per FHWA)	No. 9	No. 10	No. 11
Cover	1.75 inch	8	9.8	11.7	12.9
	2.75 inch	-	-	-	11.3
	3.75 inch	8	6.9	8.4	9.3

Required Splice Length (C) in Terms of Bar Diameters					
		Bar Size			
		No. 8 (Per FHWA)	No. 9	No. 10	No. 11
Cover	1.75 inch	6	7.3	9.7	11.1
	2.75 inch	-	-	-	9.7
	3.75 inch	6	5	6.6	7.3

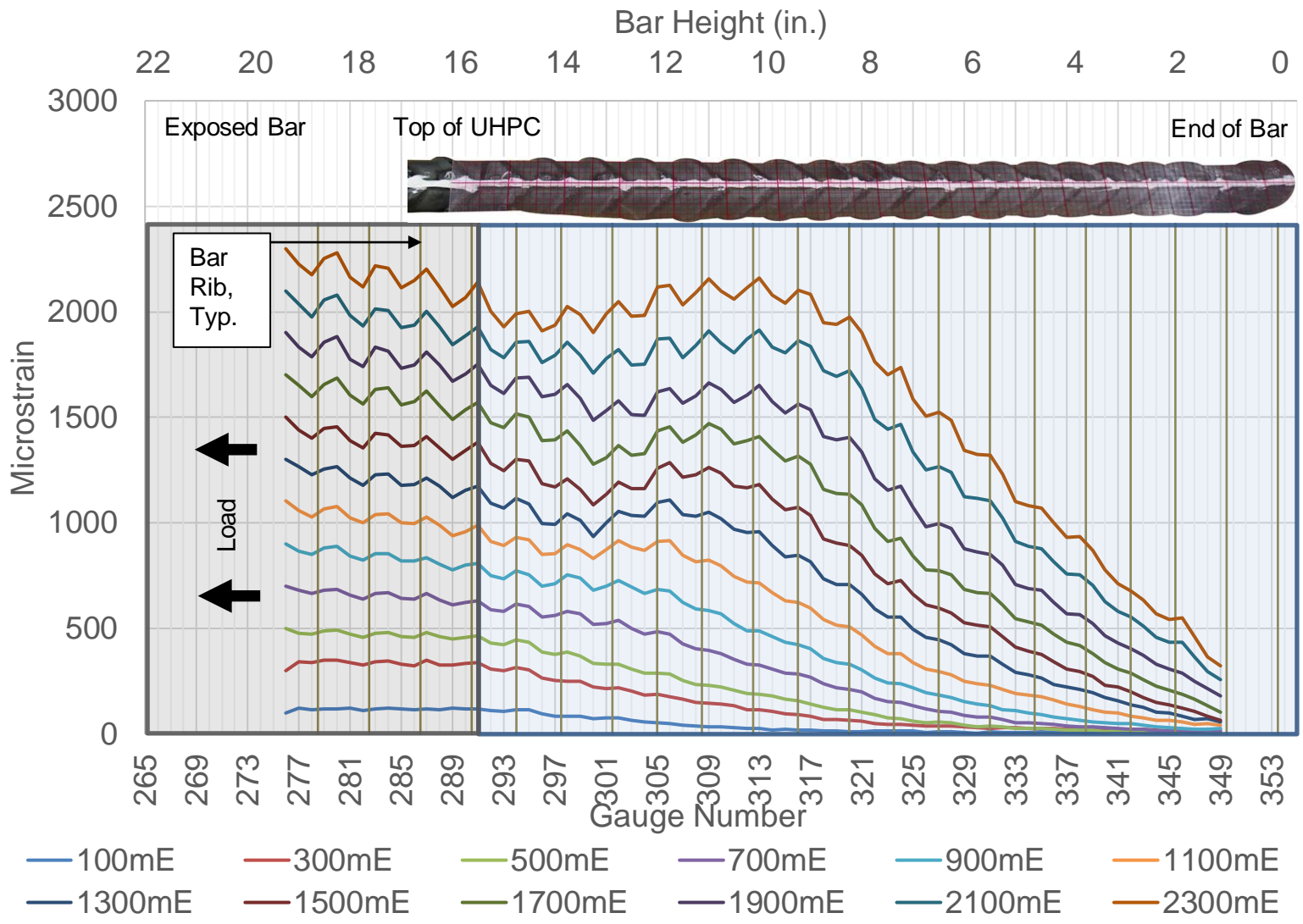




# Random vs. Oriented Fibers

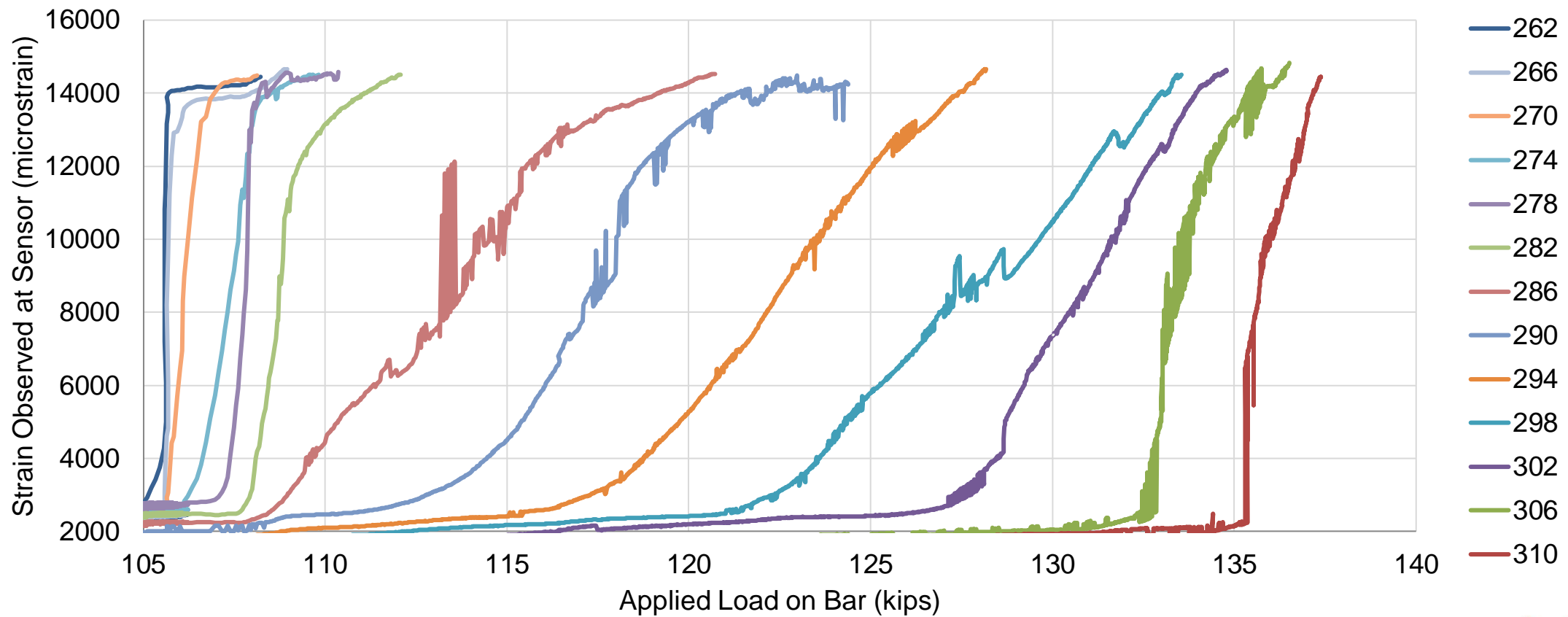
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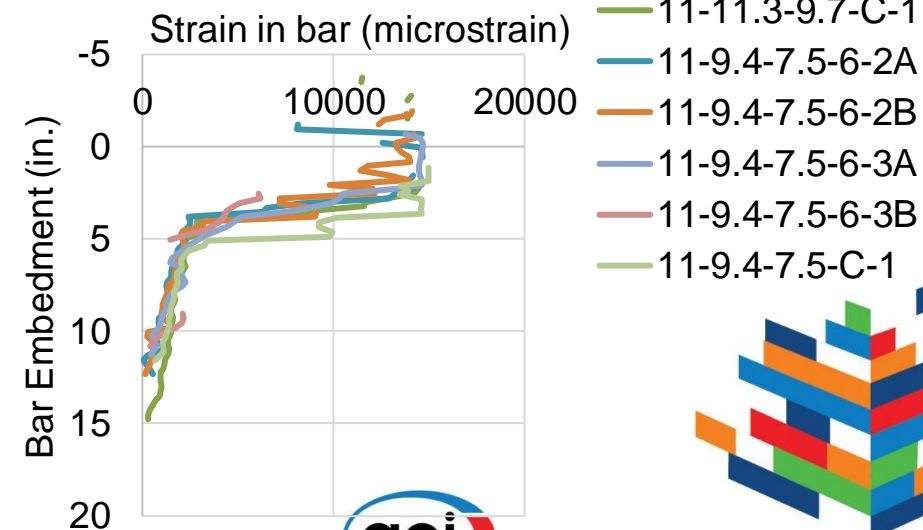
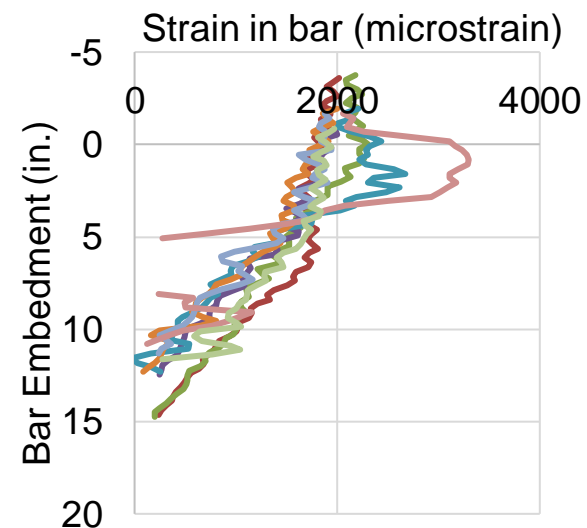
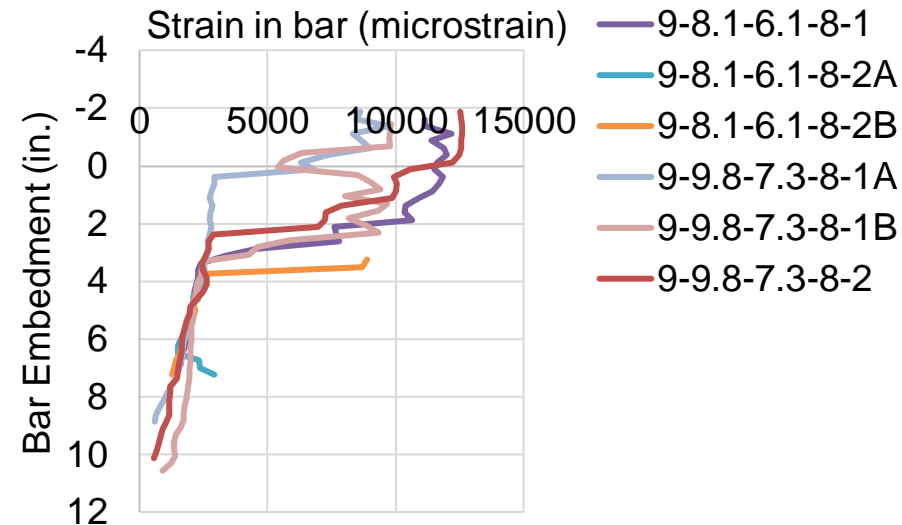
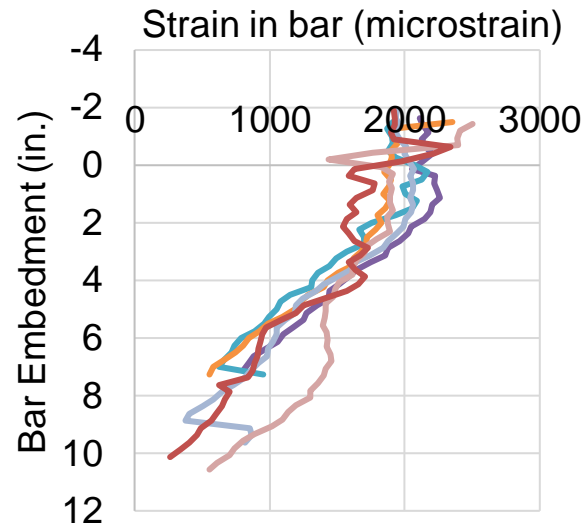
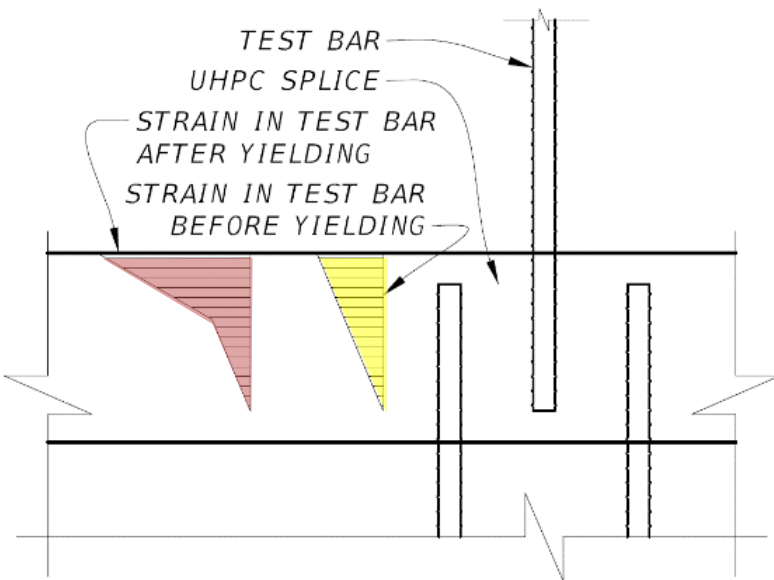


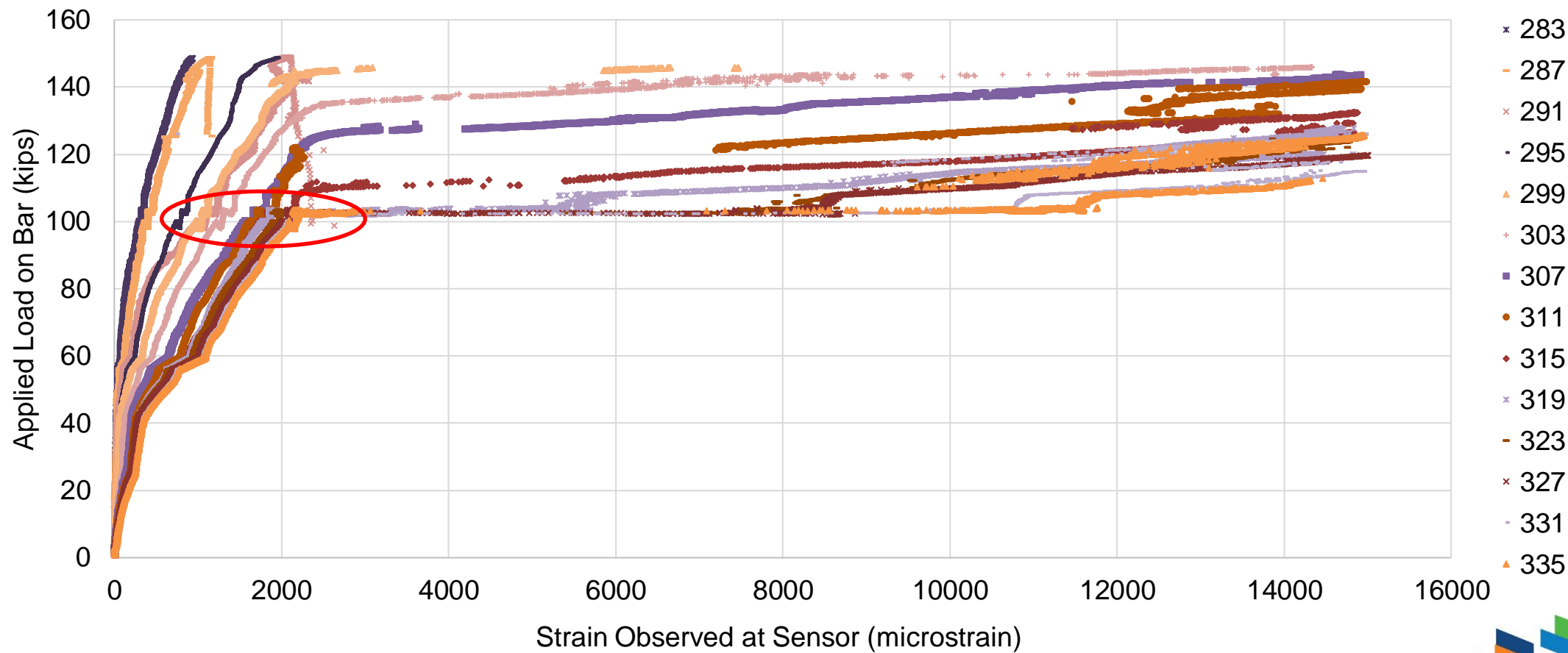


# Strain Along Bar







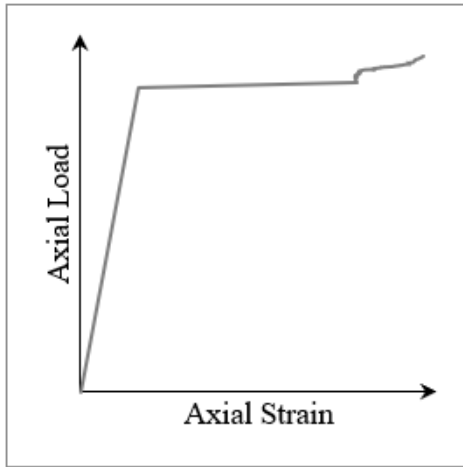


## Load vs. Strain at 1-inch Increments Along Bar

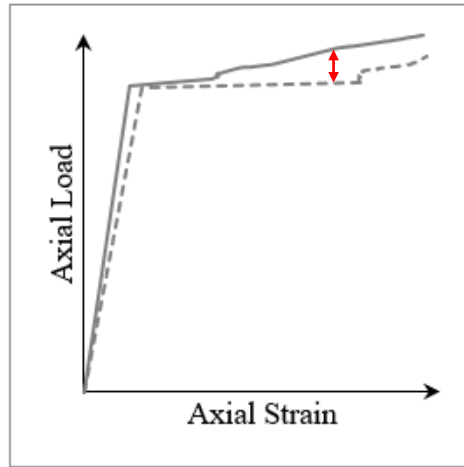
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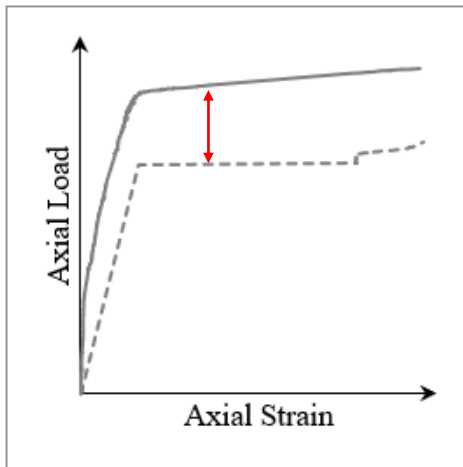
# Load vs. Strain for Reinforcing Bar at Multiple Embedment Depths



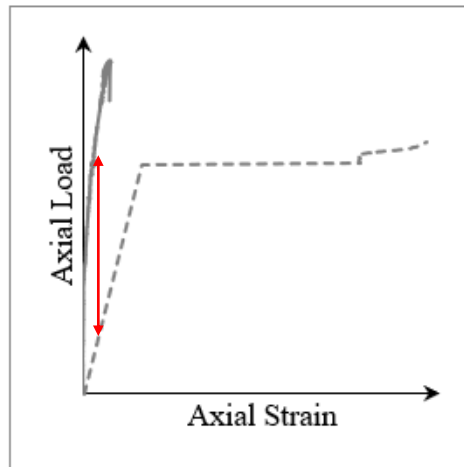
(a)



(b)

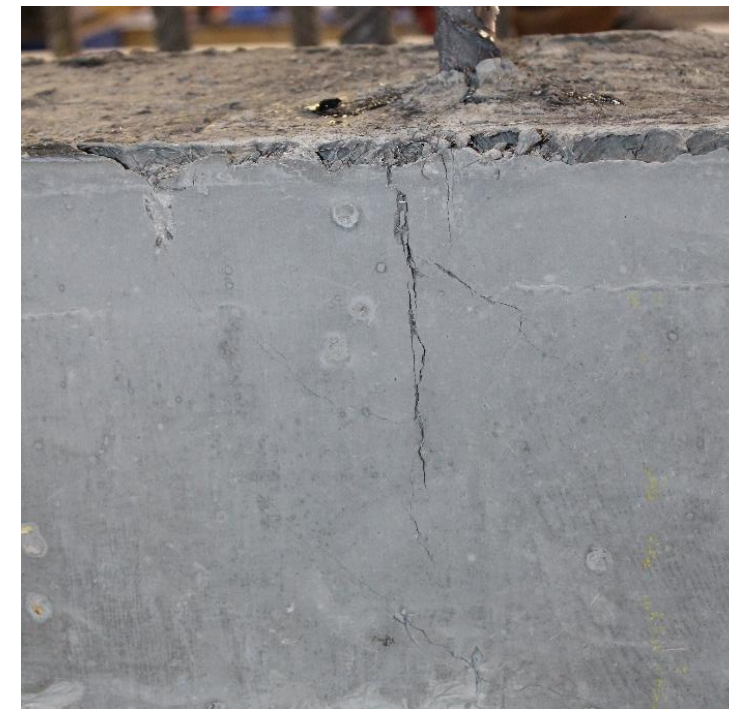
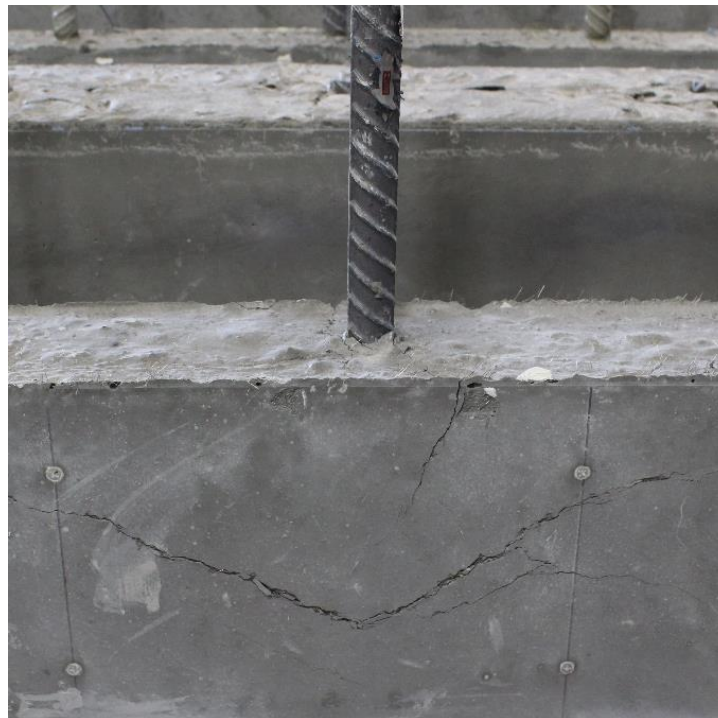
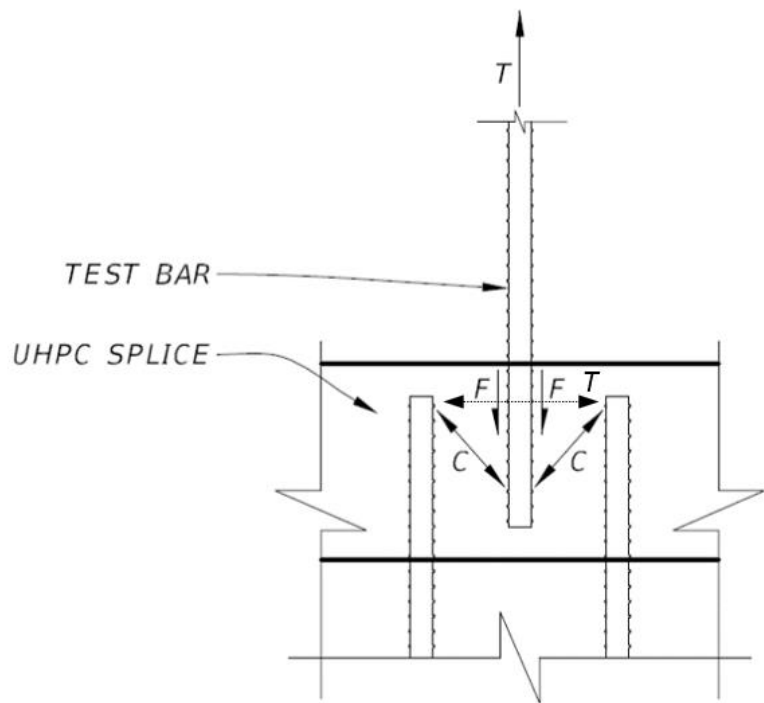


(c)



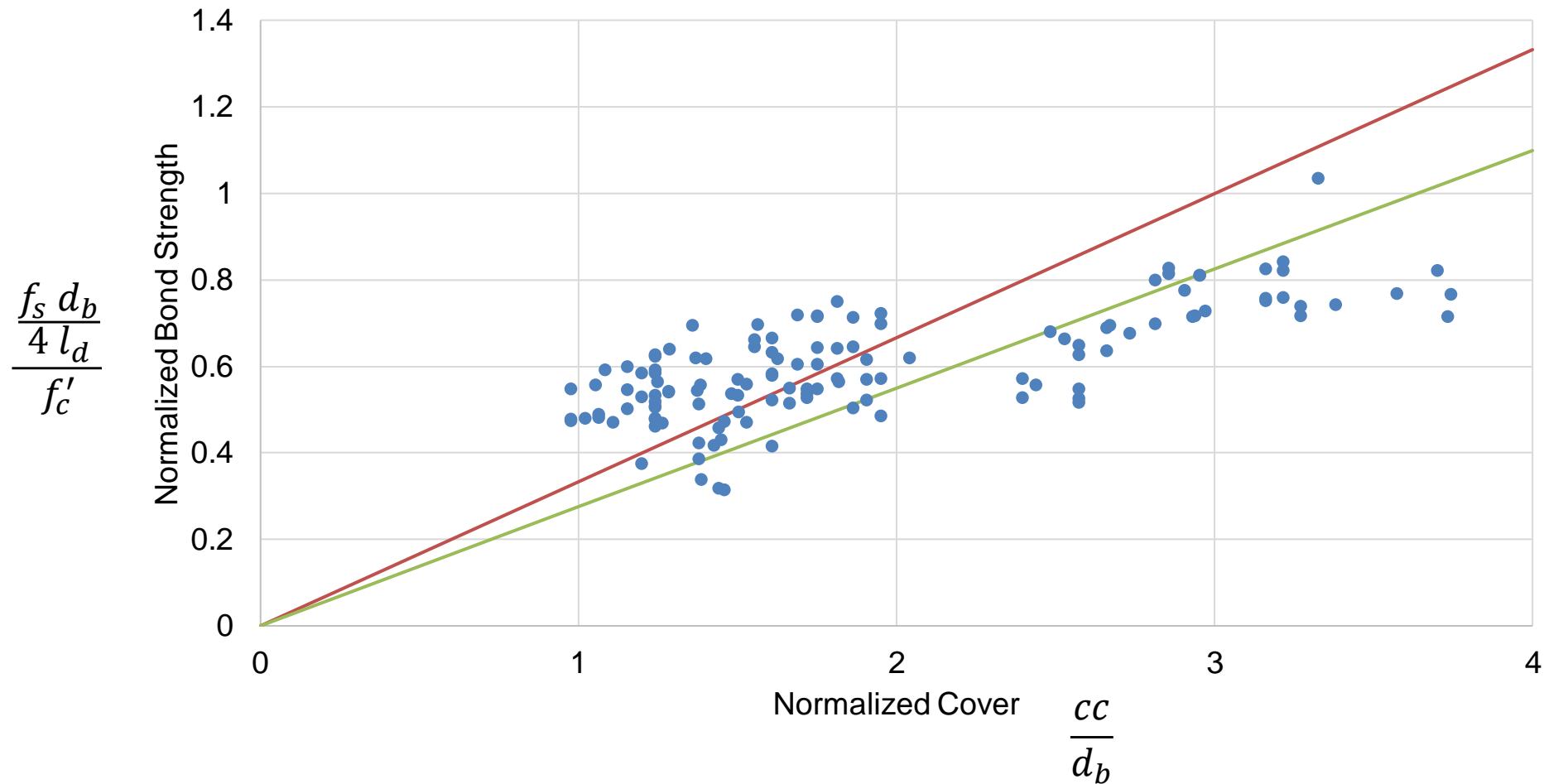
(d)





# Theory of Splice Mechanism

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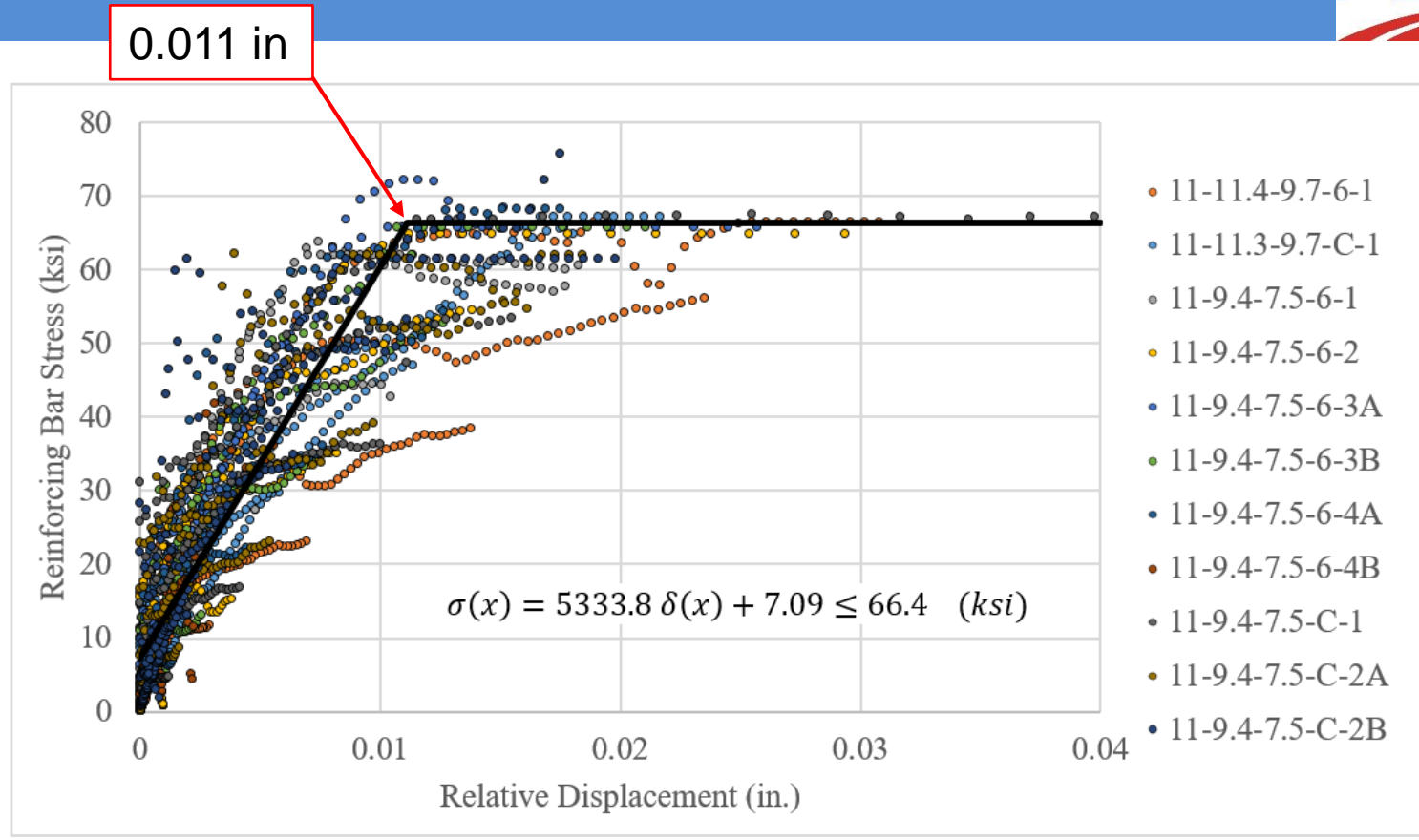
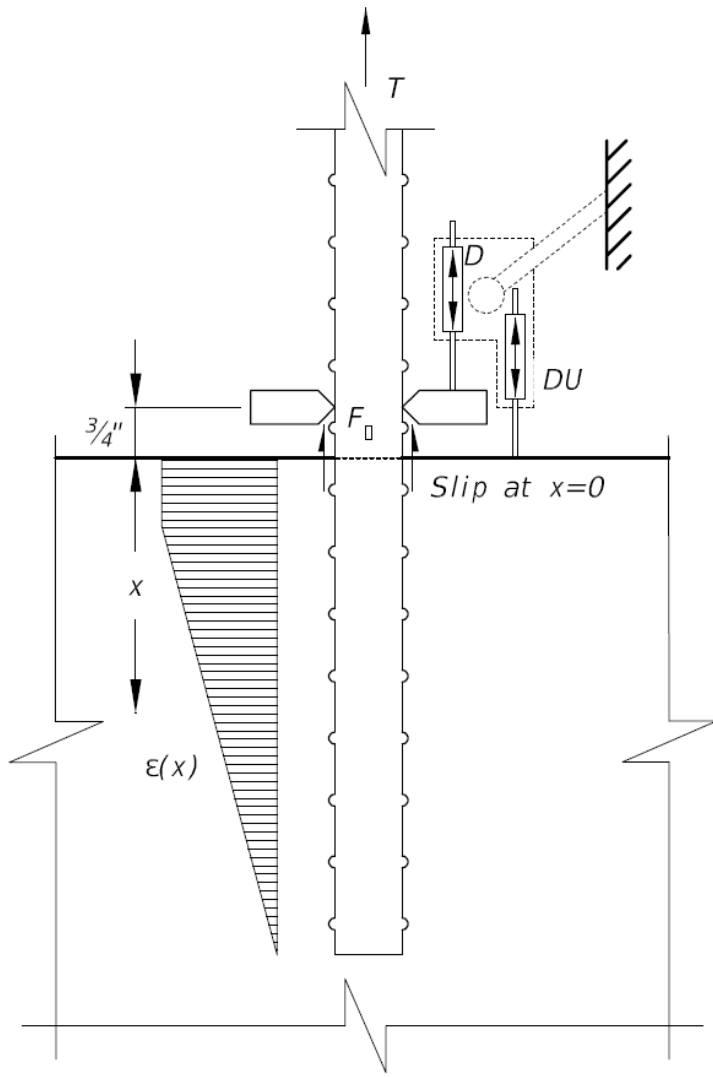
$$\frac{\tau_{max}}{\sqrt{f'_c}} = 0.275 \frac{c}{\phi}$$

- Marchand et al. Curve
- Experimental Results
- 95% Confidence

# Normalized Bond Strength vs. Normalized Cover

THE WORLD'S GATHERING PLACE FOR ADVANCING CONCRETE





# Reinforcing Bar Stress vs. Relative Displacement





## Any Questions?



Christina Freeman

Assistant State Structures Design Engineer

Florida Department of Transportation

[Christina.Freeman@dot.state.fl.us](mailto:Christina.Freeman@dot.state.fl.us)

(850) 921-7111



American Concrete Institute