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Bond-Type CFRP Anchorage System for Prestressed Concrete Applications

Yasir Saeed
Portland State University

Franz Rad
Portland State University

Salam Al-Obaidi
Portland State University

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Yasir Saeed (yasir@pdx.edu), Franz Rad (franz@pdx.edu), and Salam Al-Obaidi (salammaitham@yahoo.com)

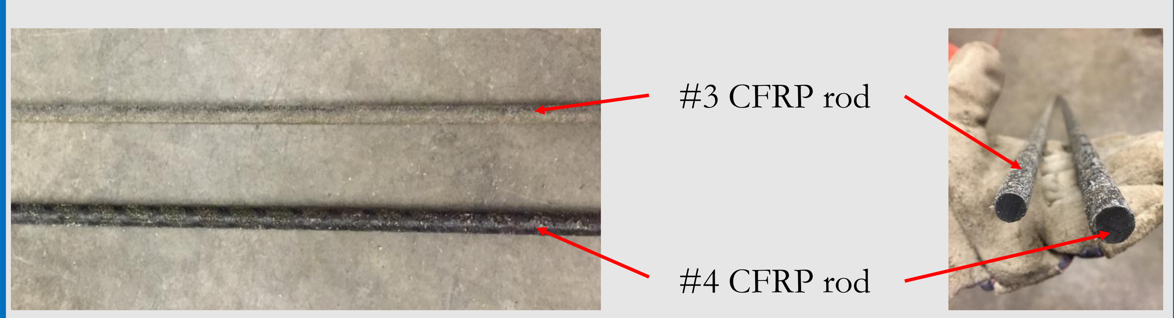
Department of Civil and Environmental Engineering, Portland State University

Abstract

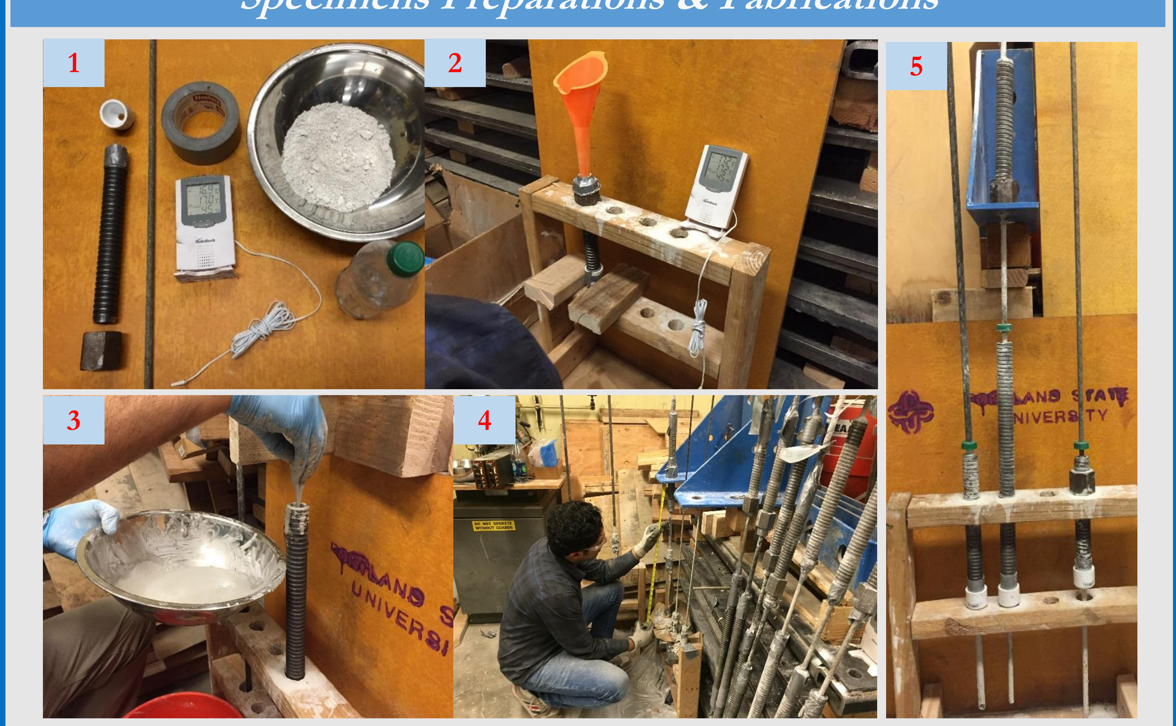
High tensile strength, adjustable and high modulus of elasticity, high strength-to-weight ratio, and non-corrosiveness are great features which have made Fiber Reinforced Polymer (FRP) very attractive to engineers. Prestressed concrete applications require high strength prestressing material that could apply and maintain effective compressive force to concrete members. Although FRPs, especially Carbon FRP (CFRP), have the desired strength, no efficient system for its anchorage to concrete has been devised yet. This paper presents an experimental evaluation on new bond-type CFRP anchors. A total of eleven samples were prepared and tested. The CFRP rods were 0.375 in. and 0.50 in. diameter. The parameters investigated were the embedded length, rod diameter, and time of curing. Using the proposed bond-type CFRP anchors, the experimental results showed that 12 in. and 15 in. were adequate embedded lengths to effectively anchor the 0.375 in. and 0.50 in. CFRP rods, respectively. The results also indicated that the anchor stiffness was directly proportional to the embedded length, and cross sectional area ratio of CFRP rods to anchor borehole affected the stiffness and bonding capacity.

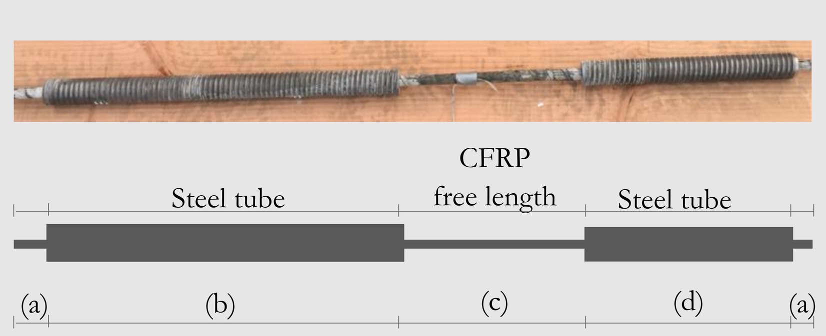
Materials and Methods

Carbon Fiber Reinforced Polymer (CFRP)



Specimens Preparations & Fabrications





(a): Free length of CFRP at the ends (5 to 10 inches)

(b): Steel tube anchor; fixed end (20 inches)

(c): Free length of CFRP at the middle (9 inches)

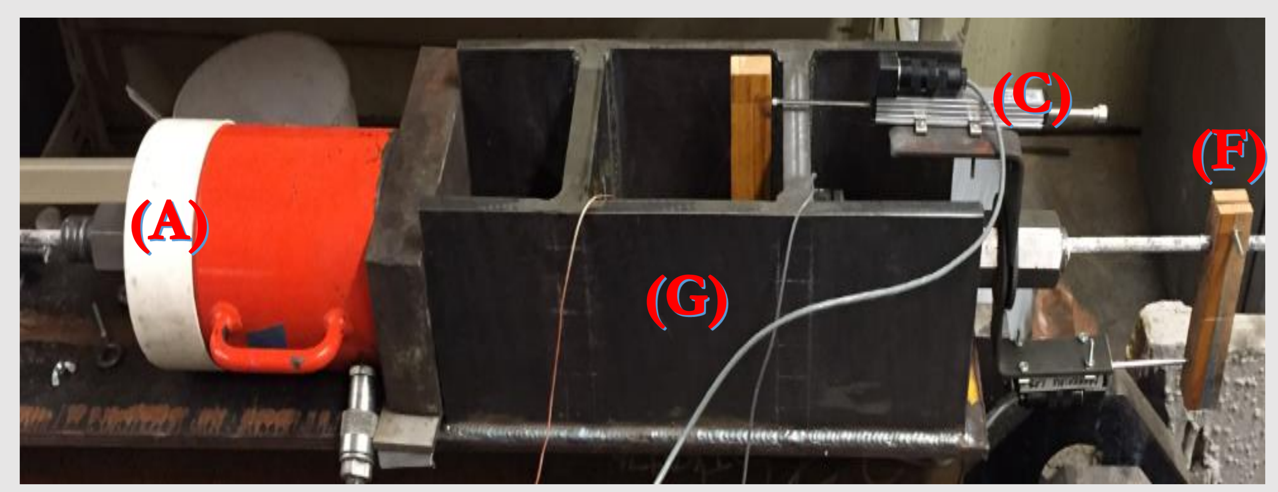
(d): Steel tube anchor; the area of interest (10, 12, and 15 inches)

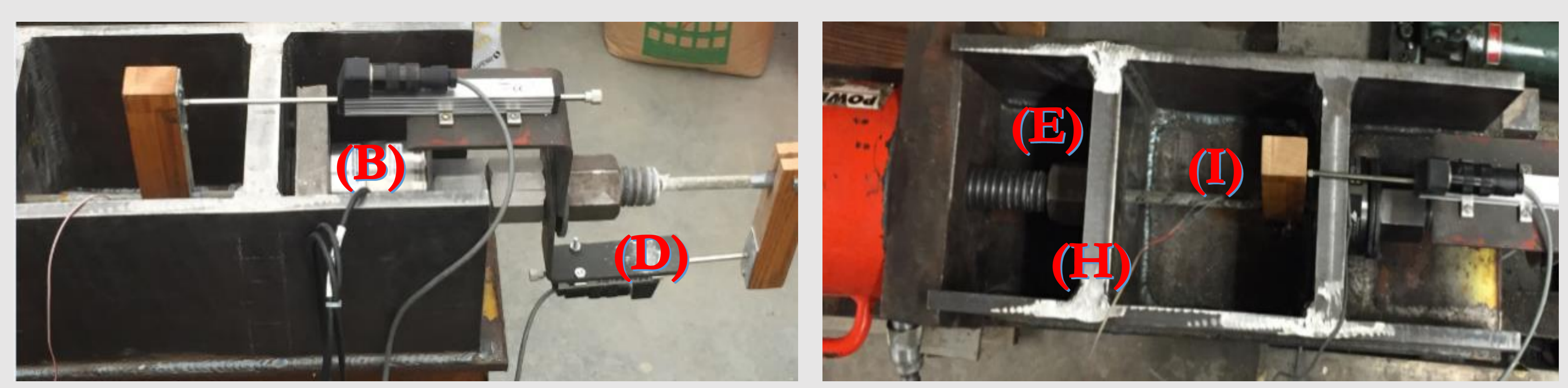
Specimens Design

Sample #	Bond length* (in.)	CFRP diameter (in.)	Rod/tube area ratio	Curing time
3-1	10	0.375	22.7 %	1 week
3-2	10	0.375	22.7 %	1 week
3-3	12	0.375	22.7 %	4 weeks
3-4	12	0.375	22.7 %	4 weeks
3-5	12	0.375	22.7 %	4 weeks
3-6	10	0.375	22.7 %	4 weeks
4-1	12	0.500	40.4 %	4 weeks
4-2	12	0.500	40.4 %	4 weeks
4-3	15	0.500	40.4 %	4 weeks
4-4	12	0.500	40.4 %	4 weeks
4-5	15	0.500	40.4 %	4 weeks

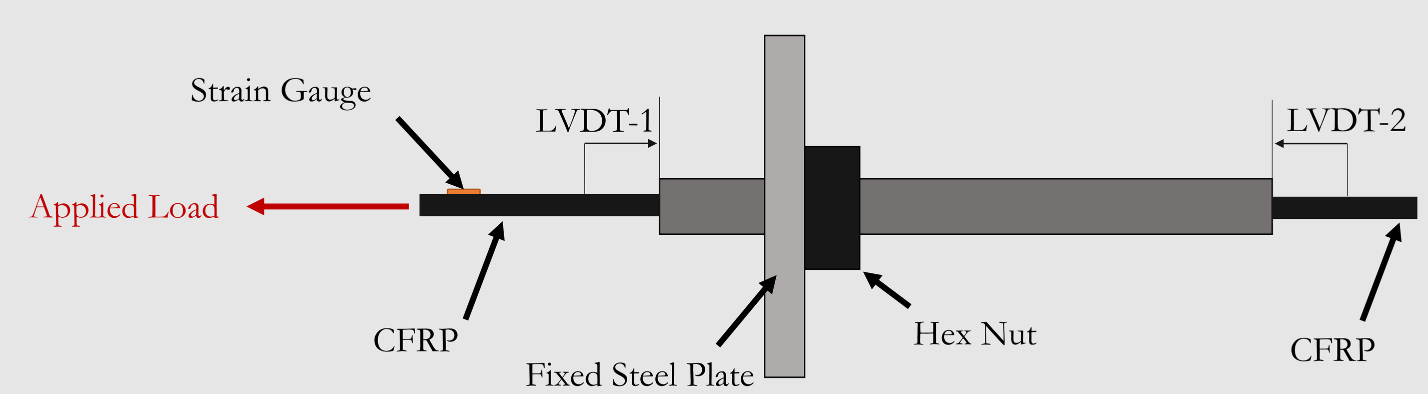
** Bond length is equal to the length of steel tube*

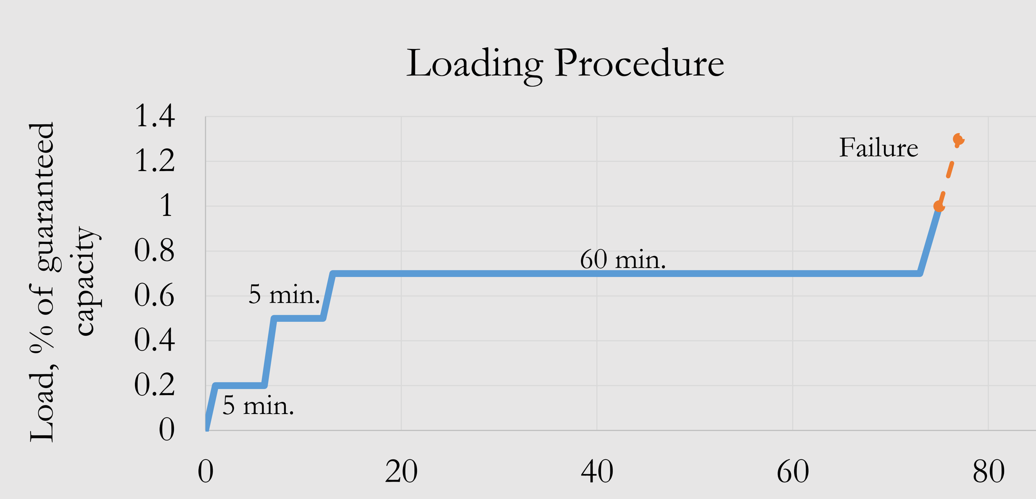
Testing Set-up and Procedure





(A): Hollow-core ram
(B): Load cell
(C): LVDT-1
(D): LVDT-2
(E): Hex nut
(F): Piece of hard wood transferring the movements of the CFRP to the LVDTs.
(G): Longitudinal steel plate; 20 x 7 x ½ in.
(H): Transverse steel plate; 7 x 6 x 1 in.
(I): Strain Gauge

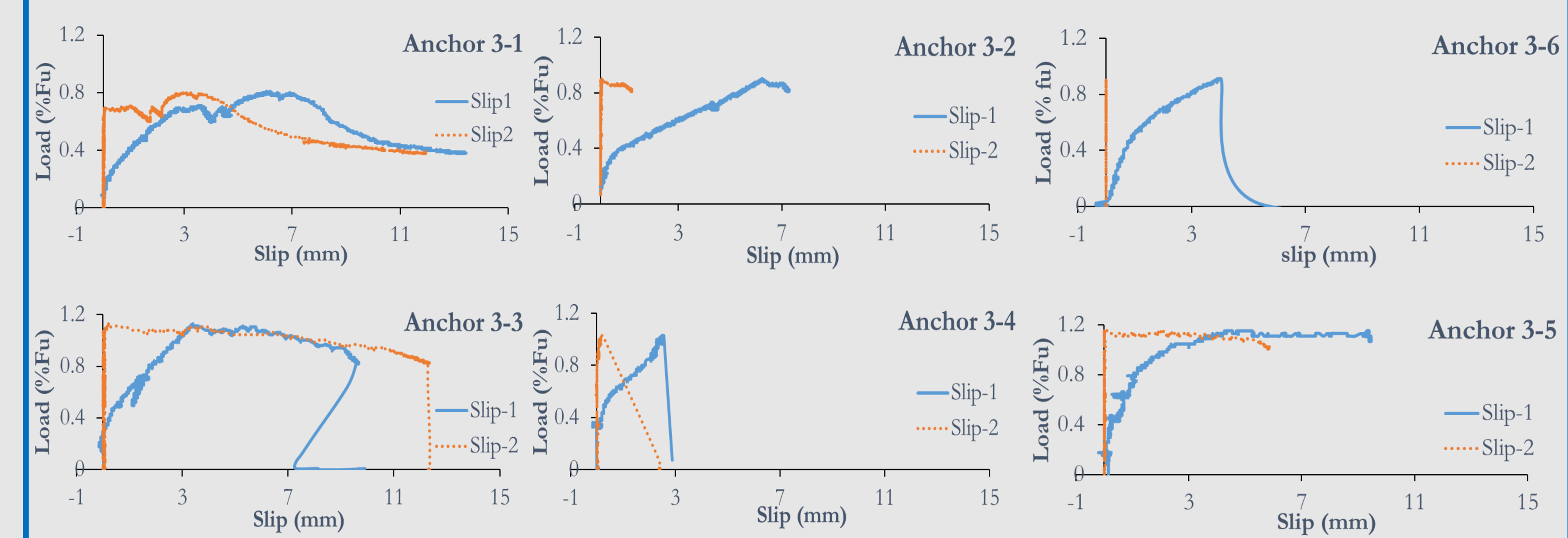




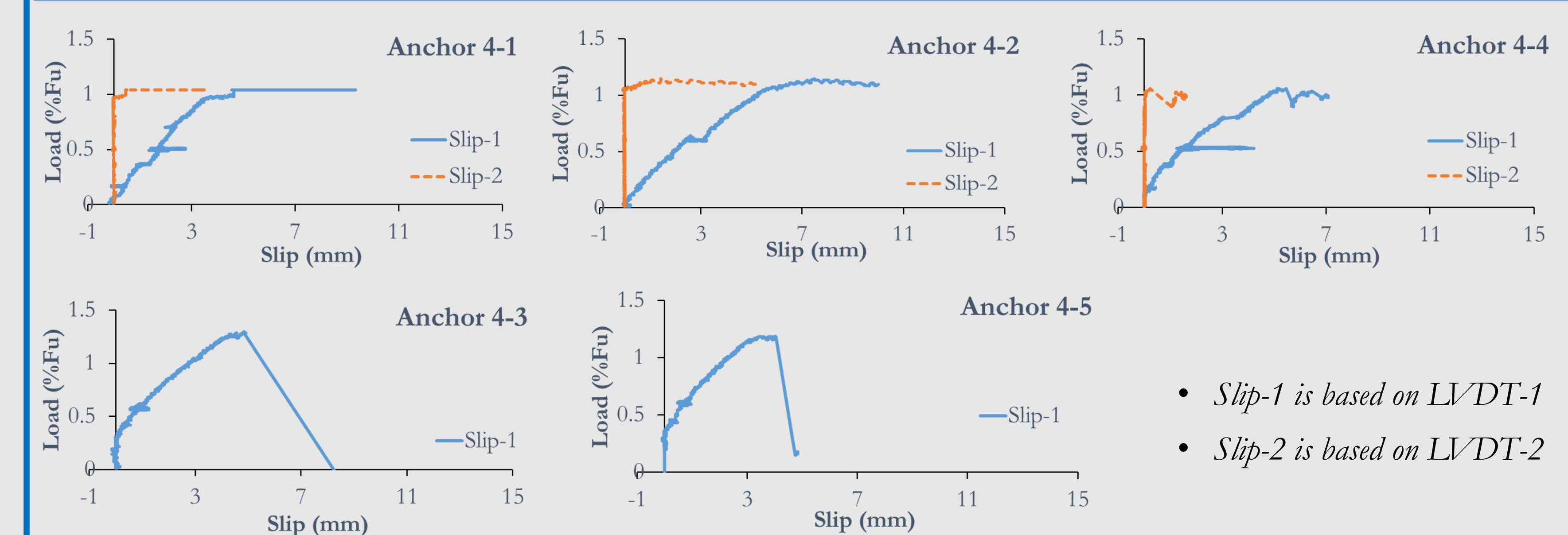
This testing procedure was adopted from Schmidt et al. (2010).

Experimental Results

Load vs. slip for #3 specimens

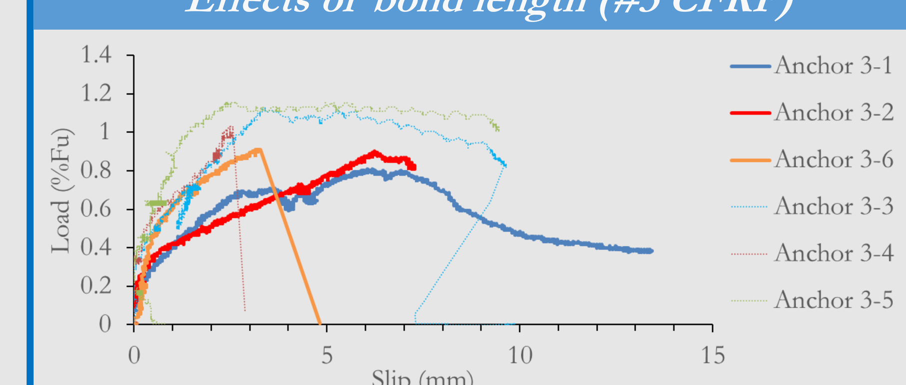


Load vs. slip for #4 specimens



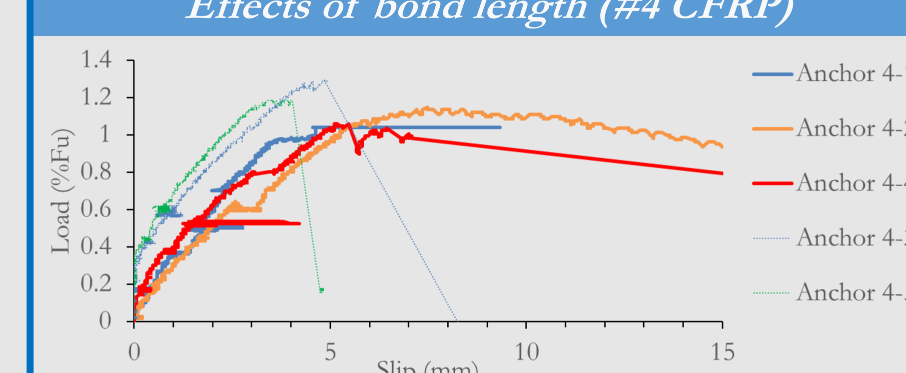
- *Slip-1 is based on LVDT-1*
- *Slip-2 is based on LVDT-2*

Effects of bond length (#3 CFRP)

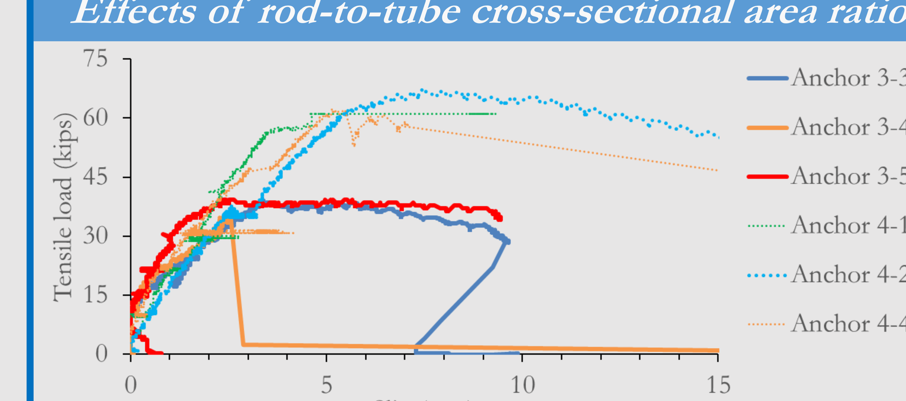


Modes of failure

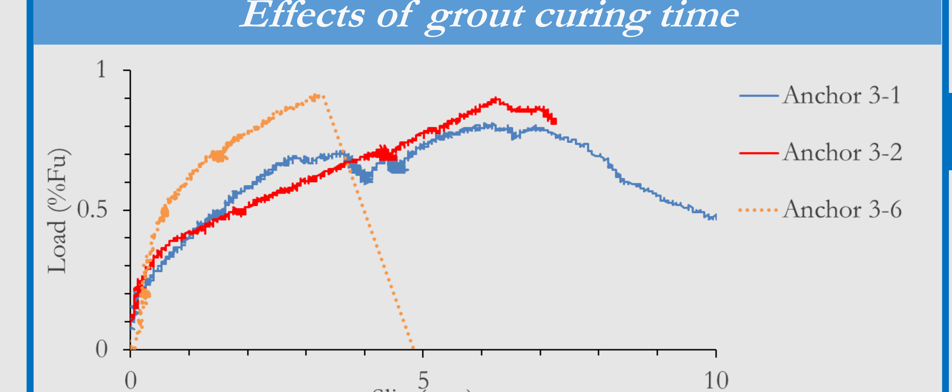
Effects of bond length (#4 CFRP)



Effects of rod-to-tube cross-sectional area ratio



Effects of grout curing time



Discussion & Conclusions

- A minimum bond length of 12 in. is required to achieve the maximum tensile capacity of #3 and #4 CFRP rods.
- The maximum bonding stresses before failure in order to develop the guaranteed capacity of CFRP for #3 and #4 are 2.5 ksi and 3.0 ksi, respectively.
- The anchor stiffness is directly proportional to the bonded length.
- Although the anchor stiffness is higher when using lower rod-to-tube cross-sectional area ratio, the anchor can handle more stress when the ratio is higher.
- The time for grout (expansive cement) curing significantly affect the anchorage stiffness for #3 CFRP anchors. A minimum of four weeks of curing is recommended. The effects of curing time on anchors with #4 CFRP rods have not been investigated.

Acknowledgements

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References

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