American Concrete Institute

Tensile Performance of GFRP Bars Connected with FRP Couplers

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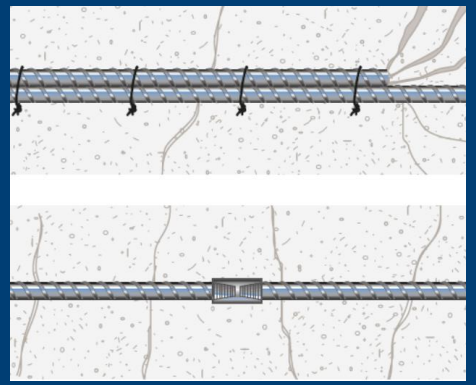
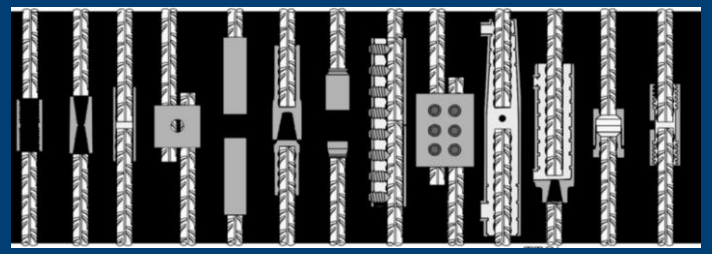
Reinforcing Bars in Concrete Structures

- Used to increase concrete strength in tension
  - Often steel material
  - Corrodes over time

- Mechanical couplers to connect spans
  - More efficient than splicing
  - Reduces congestion
  - Varying connection options





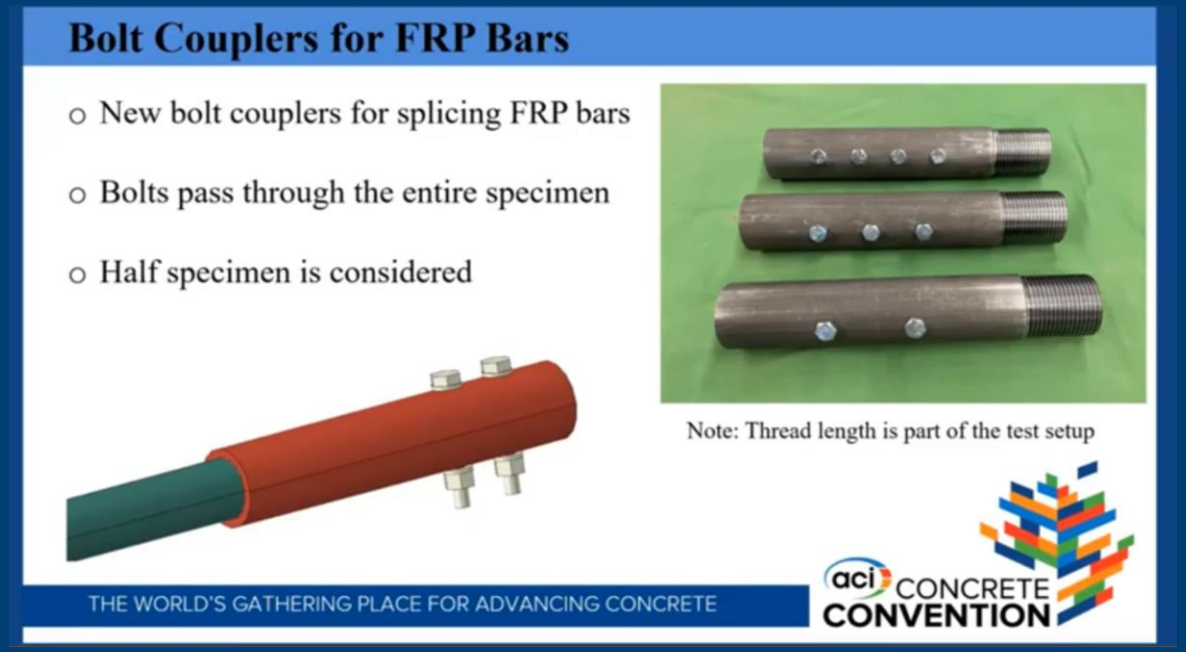
GFRP Reinforcing Bars and Couplers

- Glass fiber reinforced polymer (GFRP) reinforcing bars
  - Corrosion resistant
  - Lightweight
  - Brittle

- FRP mechanical couplers to bars
  - Limited research on best connection options or products
  - ACI Center of Excellence for Nonmetallic Building Materials (NEx)
    - RFP for testing and acceptance criteria

Previous Research

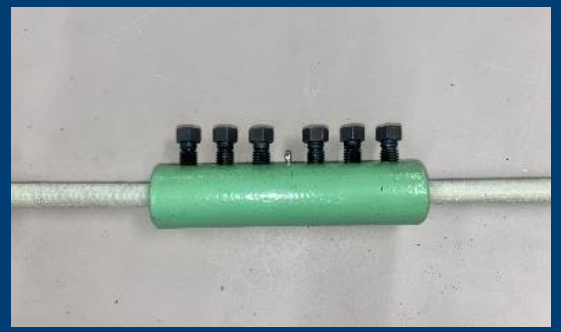
- "Shear Bolt Couplers for Splicing FRP Bars" [1]
  - Supported the viability of GFRP bars in substructure applications
  - Coupler failure at 60% guaranteed tensile strength of GFRP bar



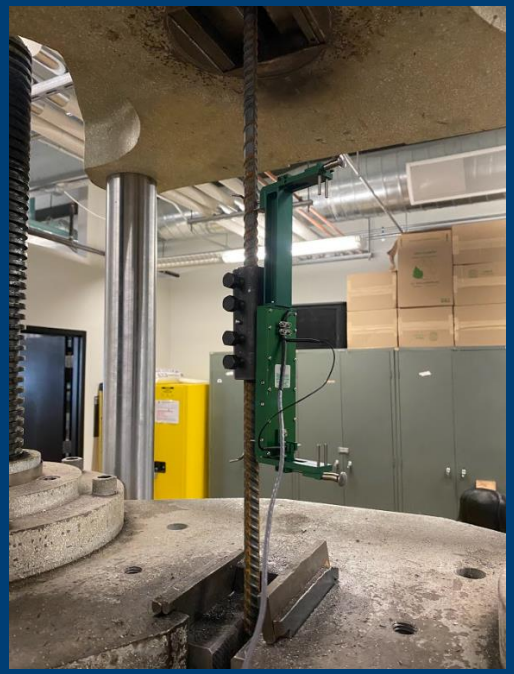
[1] N. Kiani and A. Nanni, "Shear Bolt Couplers for Splicing FRP Bars," American Concrete Institute Concrete Convention, Orlando, 2022.

Project Objectives

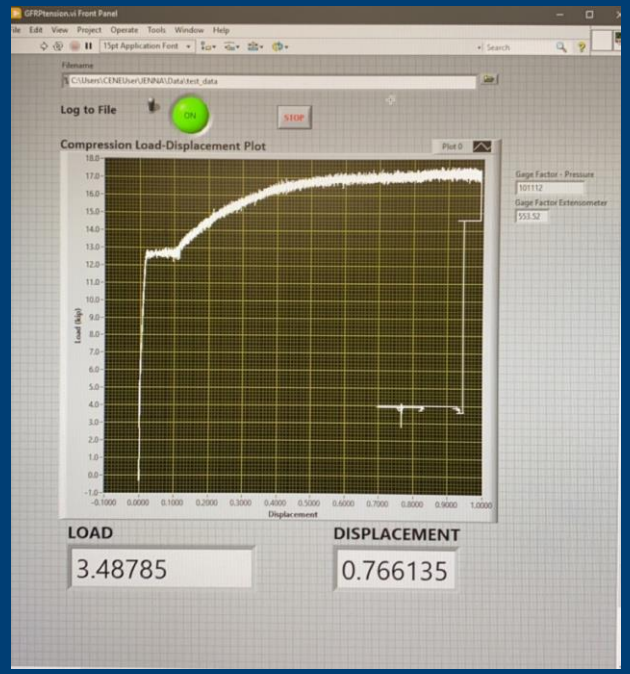
- Investigate performance of reinforcing bar-and-coupler connections

Bars:	Steel	GFRP	GFRP	GFRP
Coupler:	Steel	Epoxy-Coated	FRP	FRP
Bolts:	Steel	Steel	Fiberglass	Stainless Steel
				

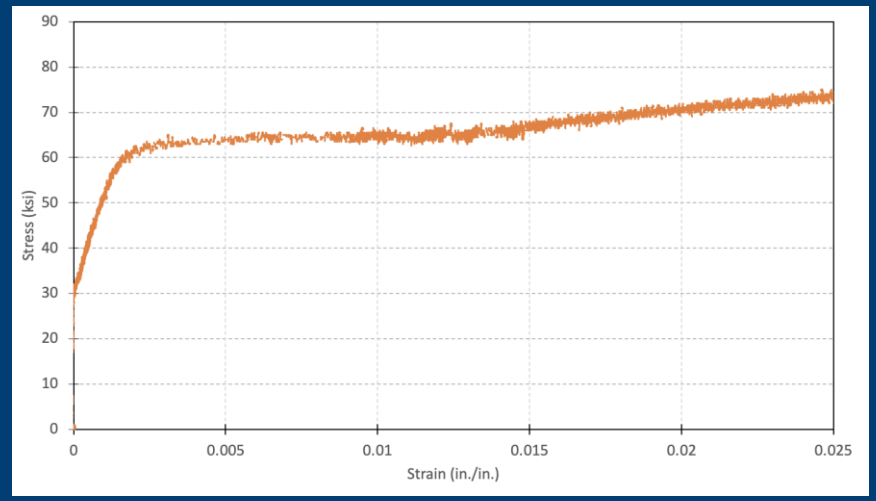
Methods: Overview



Tension Testing

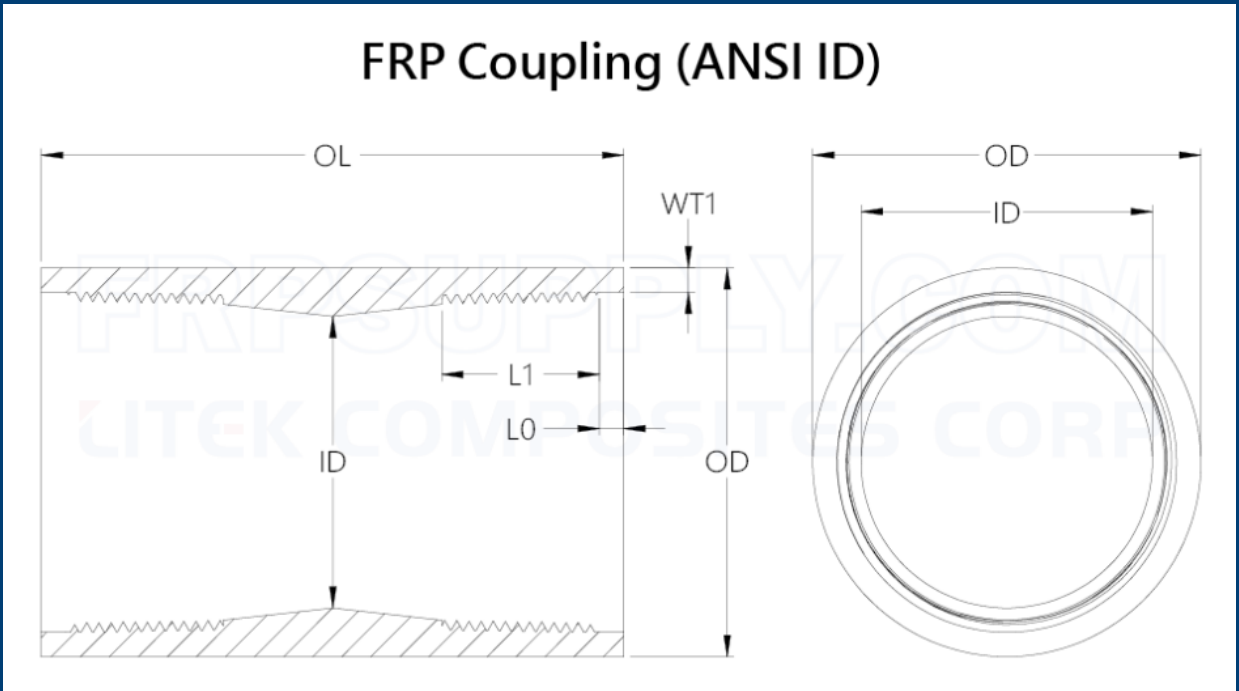


Load vs. Displacement



Stress vs. Strain

Methods: FRP Coupler



Methods: GFRP Coupler Fabrication

- GFRP bars, fiberglass coupler, fiberglass bolts

Methods: GFRP Coupler Fabrication

- GFRP bars, fiberglass coupler, stainless steel through-bolts

Results: Overview

- Investigate performance of reinforcing bar-and-coupler connections
  - Corrosion-resistant coupled bars vs. steel coupled bars



vs


  - Coupled bars vs. plain steel reinforcing bar



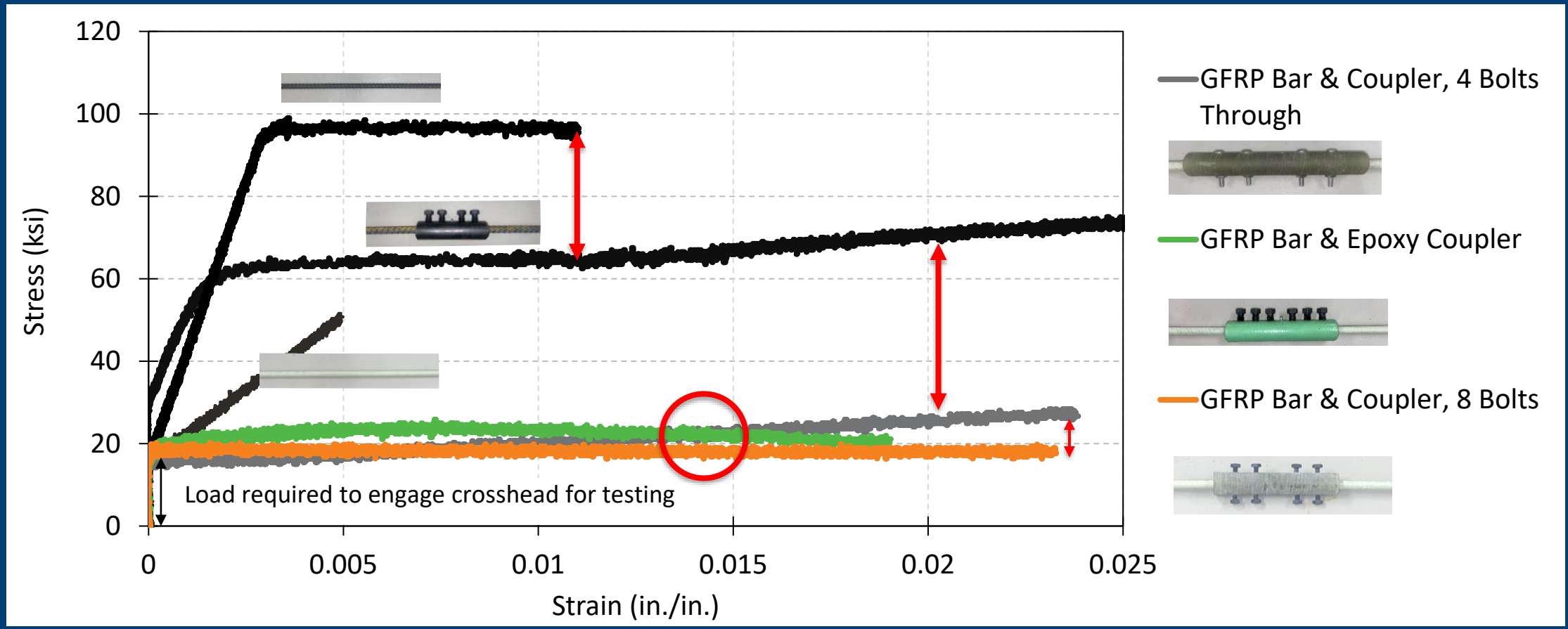

vs


  - Steel: coupled strength >1.25 of bar yield strength (ACI 318)

25.5.7 *Mechanical and welded splices of deformed bars in tension or compression*

25.5.7.1 A mechanical or welded splice shall develop in tension or compression, as required, at least $1.25f_y$ of the bar.

Results: Stress-Strain



Results: Bar-and-Coupler Connections

Steel Bar	Steel Bar and Steel Coupler	GFRP Bar and Epoxy Coupler
		
Load: 19.5 kips **Stress:** 97.5 ksi **Failure:** N/A	16.5 kips 82.5 ksi Bar	6.0 kips 25.8 ksi Connection

Results: Bar-and-Coupler Connections

GFRP Bar	GFRP Bar & FRP Coupler 8 Bolts	GFRP Bar & FRP Coupler 4 Bolts Through
		
Load: 33.7 kips*	4.7 kips	6.6 kips
Stress: 145 ksi *	20.2 ksi	28.4 ksi
Failure: Grips	Connection	Bolts

*Tensile strength reported from manufacturer due to testing failure at grips

Summary & Future Research

- Coupler strength performance results
  - Steel bar **>** coupled steel bars
  - Coupled steel bars **>** coupled corrosion-resistant systems
  - FRP coupler with bolts through **>** epoxy coupled bars, FRP coupler with 8 bolts
  - Low strength of corrosion-resistant coupler systems

- Using mechanical couplers to connect spans
  - Finalize coupler-to-GFRP bar connection options
  - Industry standards for testing and acceptance
  - Availability → off-the-shelf nonmetallic couplers

Thank you

- Jenna Hays, Undergraduate Researcher
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