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Experimental Investigation of the Fastening Parameters Influencing the Interfacial Behavior of Composite-Steel Anchored Lap Connections

by

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Outline

- Introduction
- Objectives
- Experimental Program
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INTRODUCTION

- Fiber reinforced polymers (FRP) are extensively used in **several engineering** fields due to their superior properties.
- In **Structural Engineering** applications, FRP composites have been used for **retrofitting and strengthening of** existing structures.
- A common **technique** of strengthening steel structures involves **bonding** FRP composites to targeted steel elements.
- Bonding technique is always associated with **undesirable brittle failure** of the **adhesive** at the steel-FRP interface [1,2].

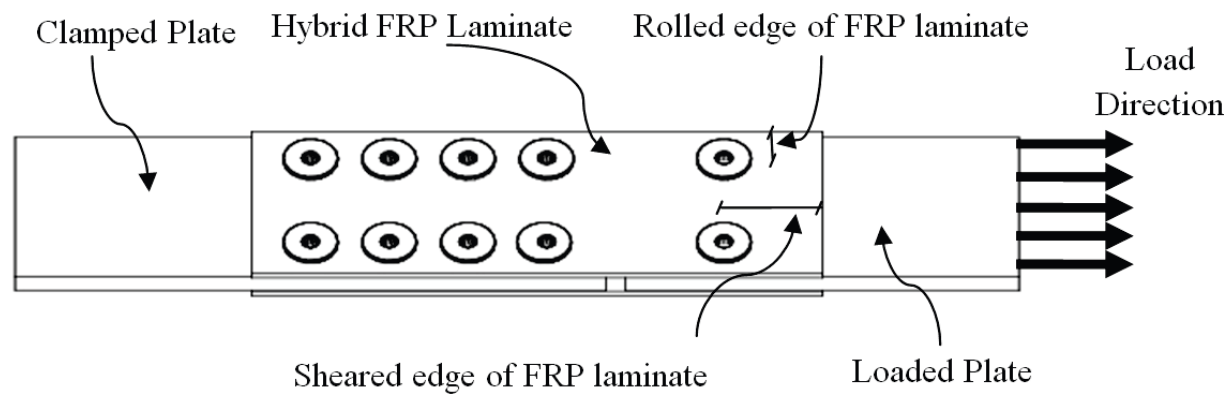


INTRODUCTION

- Recent studies were conducted at UAEU on **anchored FRP-steel connections and beams** [3,4].
- **Highlights** of the outcomes of these studies:
 - **Anchoring** technique provides **good alternative** to overcome the **unfavorable brittle** failure of **bonded** FRP composites.
 - The proposed **anchoring** technique revealed **ductile behavior** of the **FRP-steel connections**.
 - **Yield** and **ultimate** load capacities **improved** by **10%**, and **30%**, respectively.
- **Limitation** of the studies:
 - Very **narrow range** of **fastening parameters** was examined.

OBJECTIVES

- To investigate the **response of composite-steel lap connections** along with the associated **interfacial behavior** considering the following variables:
 - **Magnitude of clamping torque**
 - **Value of hole diameter**





EXPERIMENTAL PROGRAM: Materials

▪ STEEL PLATES:

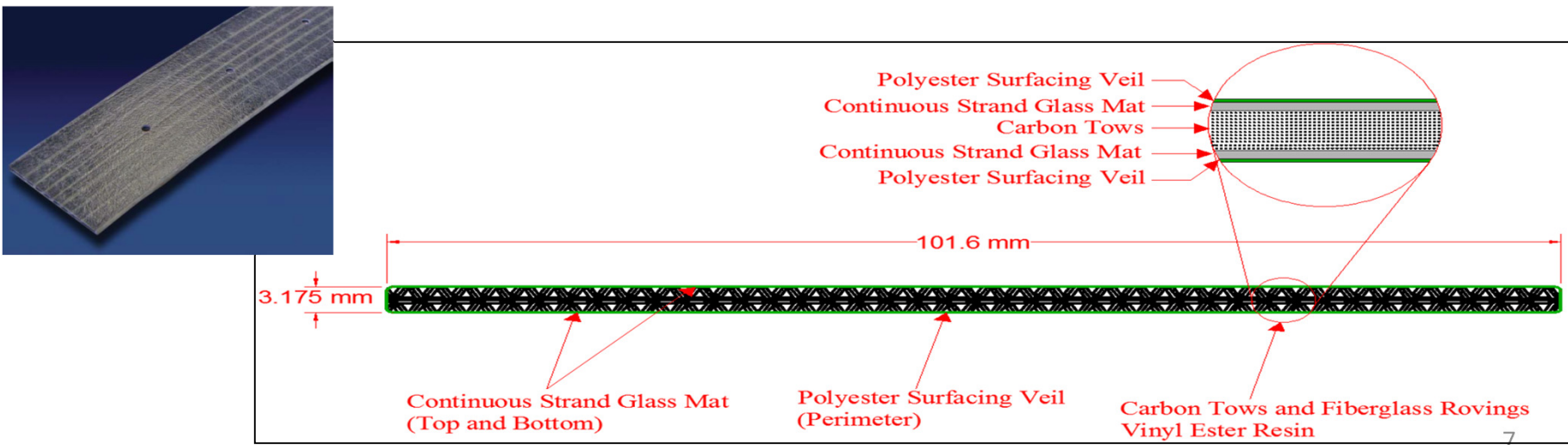
- ✓ A242 Steel ($F_y = 300$ MPa and $F_u = 460$ MPa)
- ✓ 10 mm thick
- ✓ 100 mm width
- ✓ 200 mm long at loaded side, and 300 mm long at clamped side.



EXPERIMENTAL PROGRAM: Materials

- **Composite FRP Laminates:**

- ✓ Supplied by STRONGWELL® manufacturer in rolls of length 30 m, width 101.6 mm and thickness 3.175 mm [5].





EXPERIMENTAL PROGRAM: Materials

- **STEEL BOLTS:**

- **Material:** Hexagonal galvanized zinc coated steel bolts (Hilti).
- **Bolt designation:** M6x40



- **STEEL NUTS:** 5 mm thick hexagon zinc coated nut (Hilti).



- **STEEL WASHERS:** 2 mm thick flat washers, 8.4/28 mm inner/outer diameters.

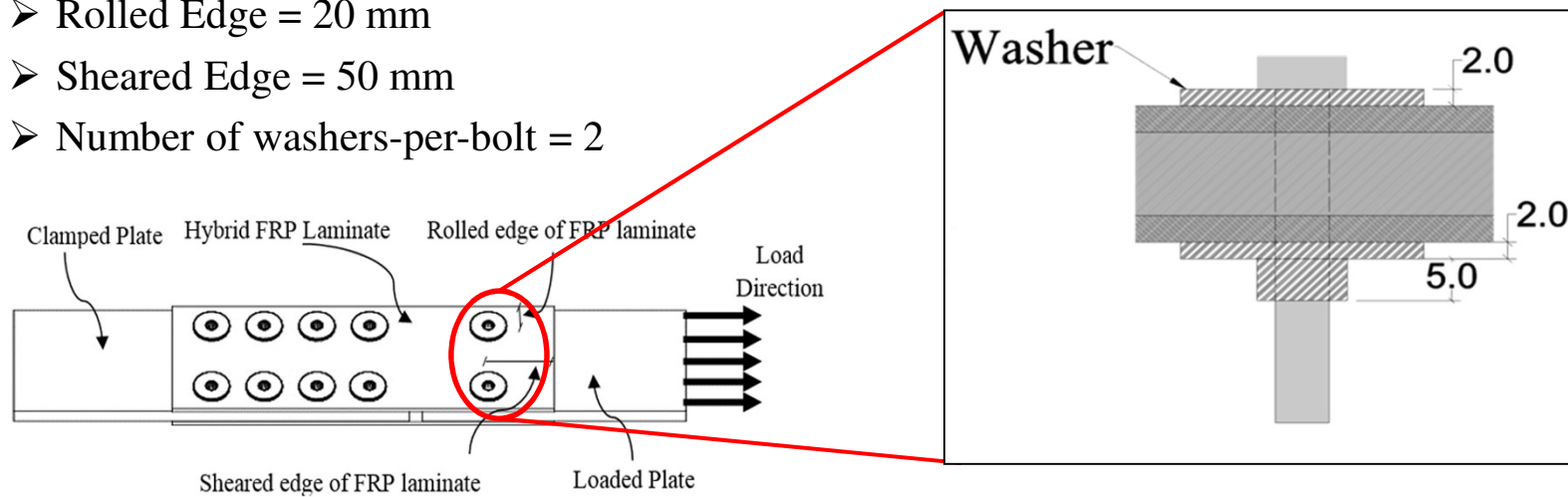




EXPERIMENTAL PROGRAM: Connection Design

■ Specimens' Details:

- Rolled Edge = 20 mm
- Sheared Edge = 50 mm
- Number of washers-per-bolt = 2





EXPERIMENTAL PROGRAM: Test Configurations

“Clamping Torque”

- **Four** different configurations are used to examine the effect of **clamping torque** on the behavior of FRP-steel lap connections.

Designation	Torque (N.m)	Torque/Snug-tight
T1	11.0	1.0
T2	13.2	1.2
T3	16.5	1.5
T4	20.0	1.8

- **Sensitivity** of the **breaking-type torque wrench: 0.1 N.m.**
- **Typical hole-diameter: 8 mm**
- **Number of replicates: 3**





EXPERIMENTAL PROGRAM: Test Configurations “Hole Diameter”

- **Three** different values of **hole-diameter** are used to investigate the effect of **clearance** on the behavior of FRP-steel lap connections.

Designation	Hole Diameter (mm)	Clearance (mm)
D6	6.0	0.0
D8	8.0	2.0
D10	10.0	4.0

- Applied **clamping torque**: **11 N.m.**
- Number of **replicates**: **3**



EXPERIMENTAL PROGRAM: Test Setup

MTS Universal Testing Machine:

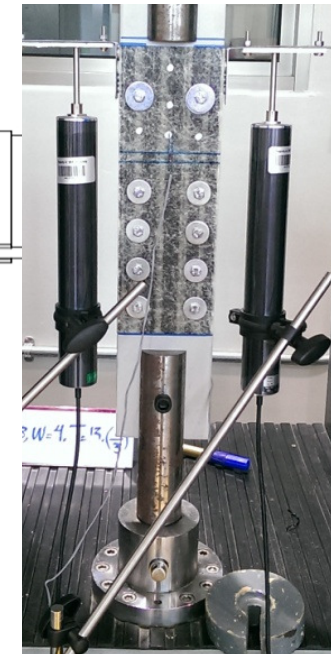
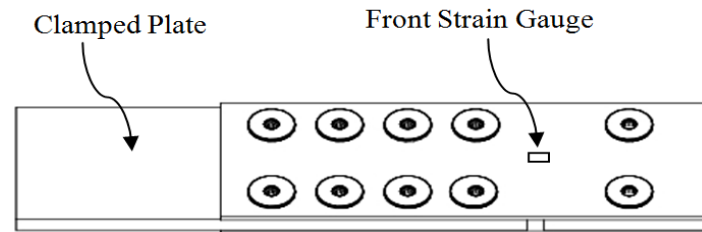
- Machine capacity : 100kN
- Cross-head speed: 1mm/min

Strain Gauges:

- 3 mm longitudinal strain gauges.

LVDTs:

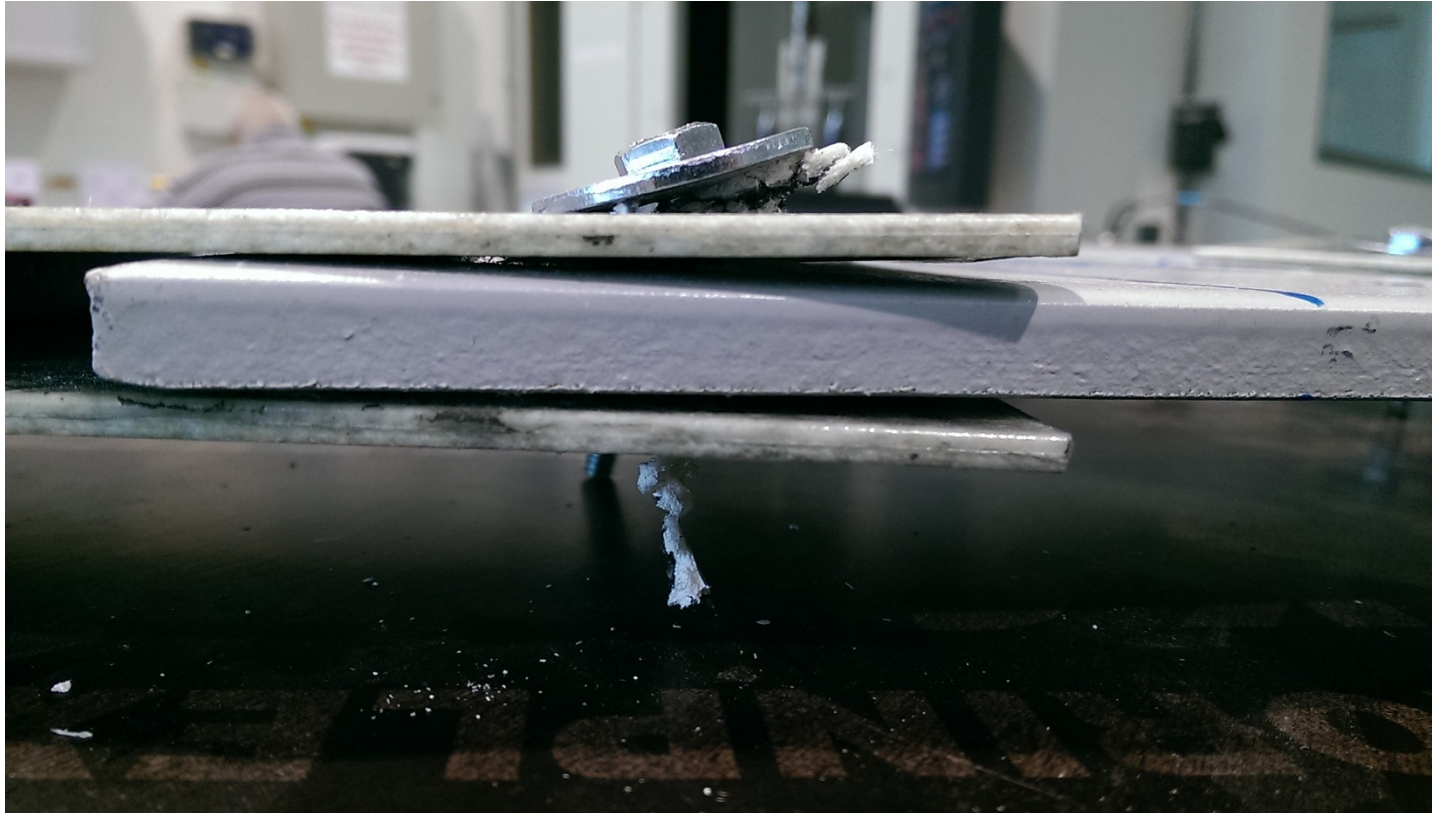
- 100 mm LVDTs are used to measure the longitudinal displacement of the specimen during loading.

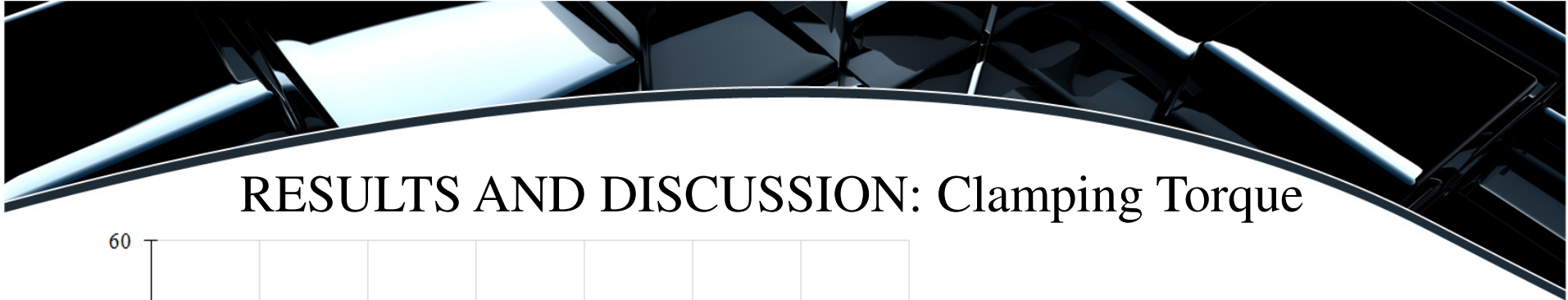


Typical behavior of connections under T1

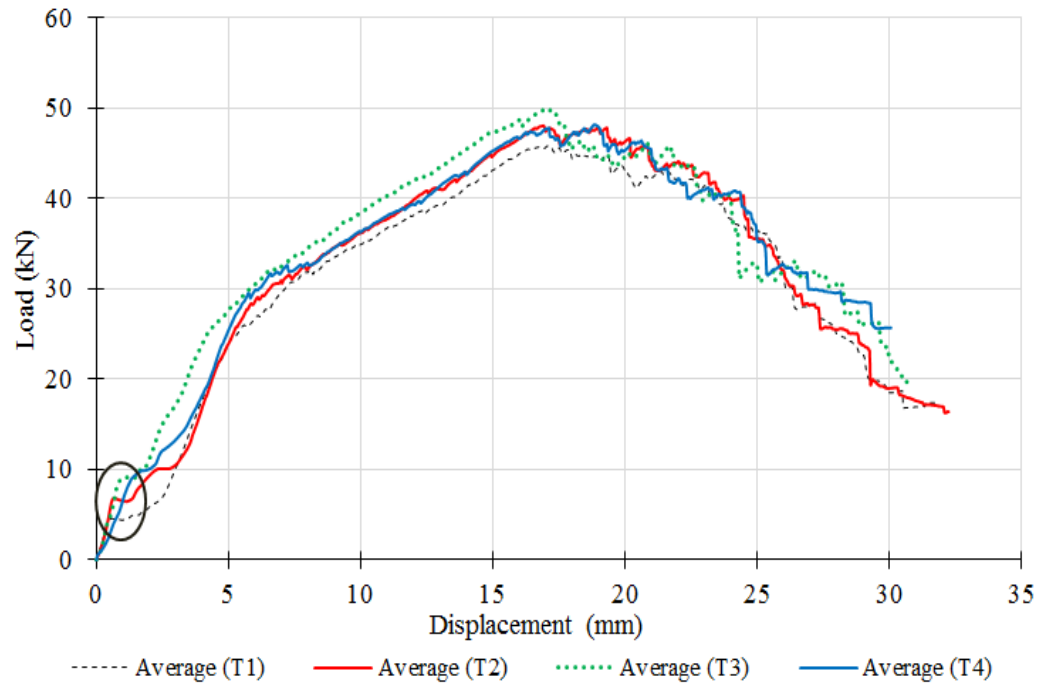


Typical behavior of “D6” connections





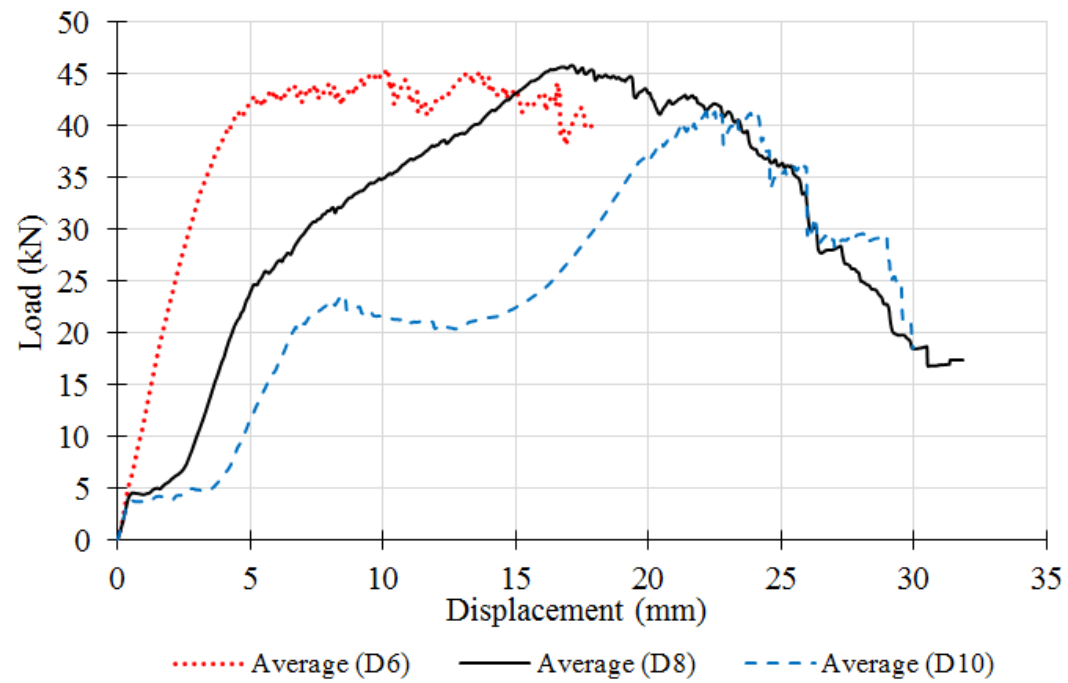
RESULTS AND DISCUSSION: Clamping Torque



- Failure modes.
- Relative slippage.
- Peak loads.



RESULTS AND DISCUSSION: Hole Diameter



- Failure modes.
- Peak loads.



CONCLUSION

- An **experimental** study is conducted to examine the **behavior of composite FRP-steel anchored connections** subjected to **axial tensile loading** with **variable values of clamping torque, and bolt hole**.
- Experimental findings highlight the **insignificant effect of torque** on both **failure mechanisms**, and **peak loads** of this special type of connections.
- **Bolt hole** was proven to **affect the failure modes** of the connection **without** influencing its **load carrying capacity**.
- The study recommends to **snug-tight** the bolts after placing them in **standard hole-diameter** for **optimum** behavior of similar composite connections.



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Questions

