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

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Outline

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- Objectives
- Experimental Program
- Results and Discussion
- Conclusions
- References
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.

<table>
<thead>
<tr>
<th>Designation</th>
<th>Torque (N.m)</th>
<th>Torque/Snug-tight</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>11.0</td>
<td>1.0</td>
</tr>
<tr>
<td>T2</td>
<td>13.2</td>
<td>1.2</td>
</tr>
<tr>
<td>T3</td>
<td>16.5</td>
<td>1.5</td>
</tr>
<tr>
<td>T4</td>
<td>20.0</td>
<td>1.8</td>
</tr>
</tbody>
</table>

- **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.

<table>
<thead>
<tr>
<th>Designation</th>
<th>Hole Diameter (mm)</th>
<th>Clearance (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D6</td>
<td>6.0</td>
<td>0.0</td>
</tr>
<tr>
<td>D8</td>
<td>8.0</td>
<td>2.0</td>
</tr>
<tr>
<td>D10</td>
<td>10.0</td>
<td>4.0</td>
</tr>
</tbody>
</table>

- 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.
REFERENCES


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Questions