Fiberglass Reinforced Polymer (FRP) Pile to Thermoplastic Wale Connection Creep Evaluation

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Introduction

Department of Transportation specifications currently call out bolt torque requirements of 150 lb-ft when connecting solid **polymeric piles** to polymeric wale sections. Prior history has shown that excessive bolt torques can cause hollow FRP sections to egg shape when a through section connection is being made.

In addition, excessive bolt torque can cause adjacent bolts to loosen as the, in proximity, second bolt is tightened.

Investigation

Creative Pultrusions purchased several Barforce 10"x10" polymeric wale sections made by Bedford Technology, LLC. The 24" long, 10"x10" wale sections were attached to Creative Pultrusion’s TU460 16” dia. Superpile pipe pile section that measured 48” in length. A 1” diameter 8 UNC threaded rod was inserted through two 1.0625” dia. holes that were drilled through the **FRP pile**. The threaded rod connected the polymeric wale section to the **FRP pile**. The connection detail mimicked a typical connection currently called out in DOT Specifications.

![Photo depicts the polymeric wale bolted to the FRP pile](image)

Two wale sections were attached to the **FRP pile**. The bottom wale was bolted 6” from the bottom of the FRP pile. The second wale was bolted in the middle of the 48” **FRP pile** section. A torque of 150 lb-ft was applied to the middle wale. No sign of cracking was detected, however the pile “egg shaped” slightly. The
bottom bolt was tightened to 150 lb-ft. It was observed that the pile deformed by \( \frac{1}{2} " \). The middle wale section became loose due to the pile deformation.

Based on the experiment it was determined that 150 lb-ft of torque is excessive for the SuperPile section. The same experiment was conducted at a torque load of 50 lb-ft. It was determined that the pile deformed by 1/8". A third test at 25 lb-ft showed no sign of deformation. Therefore, a torque specification of 25 lb-ft needs to be utilized for the FRP pile to wale connection.

**Hypothesis**

It was hypothesized that the thermoplastic wale section could be susceptible to creep. Therefore, an initial torque load of 150 lb-ft would decrease over time. The extent and rate was the unknown. Therefore, an experiment was conducted on a typical polymeric wale to FRP pile connection in order to evaluate creep deformation on bolt torque.

**Experiment**

A Barforce 10"x10"x24" long polymeric wale section was attached to a 16" diameter, ½" thick FRP pile section. The connection was made with a 1" dia 8 UNC alloy steel all thread rod. The rod was recessed into the wale section 1.5" deep in order to mimic a typical wale to pile connection.

Two through holes were drilled into the polymeric pile parallel to the threaded rod adjacent to the thermoplastic wale. One though hole was drilled into the polymeric pile perpendicular to the threaded rod adjacent to the threaded rod. The holes were used to measure and record the dimensional change in the pile over time.

![Creep Test Set Up](image-url)
A torque load of 150 lb-ft was applied to the nut with a calibrated torque wrench. Dimensional measurements of the FRP pile were taken prior and after the torque load was applied. Torque and dimensional readings were taken nine times over a five month period.

**Observations and Results**

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<th>Time</th>
<th>Torque Reading (ft-lbs)</th>
<th>Diameter Measurements (in)</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Holes #1 and #2</td>
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<td>150</td>
<td>15 5/8</td>
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<td>108</td>
<td>15 11/16</td>
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</table>

**Torque and Dimensional Recordings**

The initial deflection or “egg shape” of the pile, parallel to the bolt, was 15 5/8” as indicated by the diameter measurements taken at holes one and two. The hole three measurement, 16 ¼” represents the outside diameter measured parallel to the wale section.

![Torque Creep: Initial Torque 150ft-lb](image)

**Torque Creep: Initial Torque 150ft-lb**

Torque measurements were taken nine times beginning on 6-4-2012 and ending 10-8-2012.
Conclusions

The torque readings decreased from 150 lb-ft to 95 lb-ft within the first seven days. The dimensional measurements leveled out to 15-3/4" and 16 3/16" within the first seven days, noting that the preload outside diameter was 16" both perpendicular and parallel to the wale section. After a period of 30 days, the torque readings leveled off to approximately 81.3 lb-ft. This indicates that creep relaxation of the thermoplastic wale section had stopped.

The same experiment was conducted with an initial torque load of 50 lb-ft applied to the threaded rod. Torque and dimensional measurements were conducted for a period of 60 days. The results indicated that no significant creep or relaxation was observed over a period of two months.

![Graph showing torque creep over time](image)

Concluding points

- Bolt torque affects the rate and magnitude of creep relaxation.
- A 150 lb-ft torque requirement appears to be excessive.
- Less creep relaxation is observed with a 50 lb-ft bolt torque.
- Evidence suggests that a torque requirement of less than 50 lb-ft will cause limited creep relaxation over time. A torque of 25 lb-ft is recommended.
- Lower bolt torque loads will reduce the loss of pile section resulting from distortion of the pile at higher torque values.