Proposal No. UW-2016-4-2

IMPACT OF CONSTRUCTION ECCENTRICITY ON DIRECT PIER-TO-PILE CONNECTIONS FOR PERMANENTLY CASED SHAFT (CFST) PILES

Quarterly Progress Report
For the period ending November 30, 2021

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1. Background and Introduction

2. Problem Statement

For seismic design of transportation structures, there are competing demands including: economy, strength, stiffness, inelastic deformation capacity, and seismic resilience. Prior research at the University of Washington (UW) demonstrates that concrete-filled steel tubes (CFSTs) can meet these competing demands. This proposed research builds on the prior CFST research to develop direct pier-to-pile connections specific for use in wide range of transportation systems including bridges, high speed rail (HSR), and port structures.

Initially finite element analyses (FEA) were conducted to develop the connection and experimental test matrix. Specific study parameters include embedment depth and the addition of a ring to enhance mechanical bond. This initial study resulted in an initial test matrix that is currently being conducted, to study these aspects of the connections. However, there is an important, yet unstudied parameter, which is the placement of the reinforcing steel cage. In construction, it is likely that the pier will not be placed at the exact center of the pile, but instead will be placed with some eccentricity relative to the center of the pile. This eccentricity is likely to be very important but is not possible to study analytically.

Here, it is proposed to investigate the impact of load history and supplemental mechanical bond to investigate if these parameters will exacerbate or inhibit the impacts of eccentricity on the transfer mechanism and damage using large-scale experimental specimens. Two tests will be conducted which will be complementary with and extend current research that is being sponsored by Pacific Earthquake Engineering Research (PEER) center (referred to as PEER herein). The results will be used to determine design methods and nonlinear analytical models for these new connections.

3. Objectives and Research Approach

The overall goals of the proposed research are to:

- Investigate impact of supplemental mechanical connections on the response of direct pier-to-CFST pile connections.
- Investigate the seismic response and resilience, including damage, of selected CFST connections using large-scale testing.
- Build on prior experimental study and validated FEA models to investigate unstudied parameters including load history.
- Develop, in collaboration with WSDOT and Caltrans as well as other interested transportation agencies, new design methods for these connections.

4. Description of Research Project Tasks

The following research tasks are proposed to achieve these objectives.

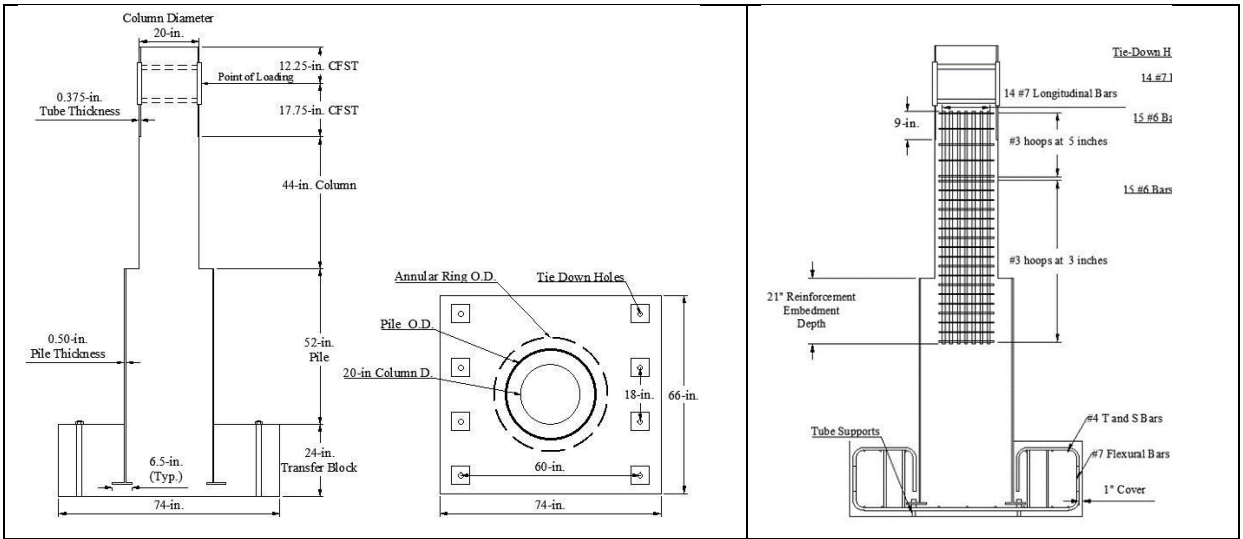
Task 1 – Presentation to and Discussion with Transportation Agencies.

The researchers will develop a one-hour course module summarizing the current research on the direct connection. This will include: (1) current state of practice for direct connections (this connection is used by WSDOT and likely other agencies), (2) analytical investigation of fundamental response parameters, (i.e., load-displacement response and damage) for salient design parameters, and (3) initial test results of concentric connections with different pile diameters with and without supplemental ribs. This will be followed by a discussion with these agencies, to provide feedback on the completed and proposed research. This will become another module in the CFST course. In addition, the research team will send out a survey to relevant DOTs to quantify the acceptable eccentricity for cage placement. The majority of Task 1 will be completed within the first two months, with additional time needed to determine the allowable eccentricity for each DOT (starting with WSDOT, ODOT and Caltrans).

This task has been initiated. WSDOT engineers attending a recent research presentation on this topic. It is expected that the team will work with FIU leadership to find a time to present the research approach, findings and implications for design.

Task 2 – Select and Design Test Matrix.

The research team selected two specimens for testing. Unfortunately, the team did not have sufficient funding to directly induce the eccentricity because it would have required a different set up. Instead, the team looked into using the supplemental rib to eliminate all slip and therefore solve issues related to eccentricity. Figure 1 shows the geometry and reinforcement of the two specimens. The first was built without a supplemental rib. The second had a supplemental rib. Both specimens used Specimen 30-21 (Cycle 3 work) as their reference specimen.



(a) Geometry (b) Reinforcement

Figure 1. Specimen Geometry and Reinforcement

Task 3 – Testing of Specimens.

Underway. It is expected that two tests will be conducted this quarter.

Task 4 – Development of Design and Analytical Tools.

Using the FEA and experimental results, the team will develop both design methods.

Underway

Task 5 – Interim and Final Reporting.

The team will submit quarterly reports and present annually at the Research Days meeting. A final paper will be written that summarizes the methods used and the findings reached during the project. In addition, the results will be incorporated into the CFST course module, as indicated in Task 1.

5. Expected Results and Specific Deliverables

- Design expressions for the connections.
- A webinar that summarizes the project in collaboration with FIU.
- Addition of these findings to the CFST module.
- Final report and relevant journal publications
- Video of presentation on the work

6. Schedule

Progress on tasks in this project is shown in the tables below.

Item	% Completed
Percentage of Completion of this project to Date	50%

Research Tasks	Q1	Q2	Q3	Q4
Task 1. Presentation and Discussions with DOT	C			
Task 2. Design & Construction of Test Specimens	C			
Task 3. Experimental Testing of 2 Specimens with Different Cage Eccentricities.		O	O	
Task 4. Development of Design and Analysis Tools			F	F
Task 5. Reporting	O			

C = complete
O = ongoing
F = future