NEW SESIMIC-RESISTING CONNECTIONS FOR CONCRETE-FILLED TUBE COMPONENTS IN HIGH-SPEED RAIL SYSTEMS

Quarterly Progress Report
For the period ending September 30, 2018

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Submitted to:
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1. Background and Introduction

In seismic design of transportation structures there are several competing demands that must be met: high strength and stiffness, large ductility, damage resistance and efficient construction. Prior research at the UW demonstrates that concrete-filled tubes (CFTs) can meet these competing demands. For a given diameter, CFTs have larger strength and stiffness than an RC component. Testing of CFT connections demonstrates their ductility, with drift capacities larger than 8%. When used with precast components, CFTs facilitates ABC.

This research builds on the prior CFT research to develop connections specific for use in structural systems for high-speed rail (HSR). While the FIU study focuses on the column-to-cap connection, this study will investigate a new, untested direct column-to-pile connection. This connection is critical to the structural performance and cost of the system, but few studies have focused on it, in particular for ABC. This study will advance design and construction of pile connections for HSR.

2. Problem Statement

The research will investigate the connection and HSR system response using advanced, nonlinear analysis methods. A thorough literature review will identify types of connections and document their structural response; the UW team will work with the HSR team to identify one or more connections for further study. Using high-resolution finite element modeling, salient parameters of selected connections, including materials, geometry, and soil-structure interaction, will be studied. Those results will be used to develop spring and line-element nonlinear models of the components and connections as a function of the important connection parameters. The final research task will investigate the seismic response of a prototype HSR CFT system using these nonlinear models. Connection design details, seismic performance objectives, seismic hazard levels, and soils will be varied to study their impact. The results will provide important initial guidelines for the connection design and seismic performance which will found a future experimental research study to validate the work.

3. Research Approach and Methods

The overall goals of the proposed research are to:

- Investigate CFT connections and other column-to-pile connections through a literature review.
- Select column-to-pile connections for study in consultation with the CA HSR technical team.
- Investigate the seismic response and resilience, including damage, of selected CFT connections using high-resolution finite element analyses.
- Identify a HSR system for study, in collaboration with the CA HSR technical team.
- Report findings to the CA HSR with a proposed experimental testing program to investigate and validate the connections.

4. Description of Research Project Tasks

The following is a description of tasks. To date, none of these objecties have been achieved because the funding is not here and a graduate student has not been hired.

Task 1 – Literature Review and Agency Discussions.
A comprehensive review of past experimental research will be completed. Experimental results evaluating resistance, stiffness, and force-deflection of direct column-to-pile connections will be studied. This work is ongoing.

Task 2 –Collaboration and meeting(s) with CAHSR.
The UW research team has reached out to Parsons, the consultant on the first phase of the CAHSR. The have provided information to the PIs on the structural system and design criteria.

Task 3 – Investigation of Connection Design Parameters though FEA
Initial investigation of the CFT pile to column connection is ongoing. The PIs have selected a prototype single story bent and are focusing on a column and pile foundation geometry as shown in Figure 1a.

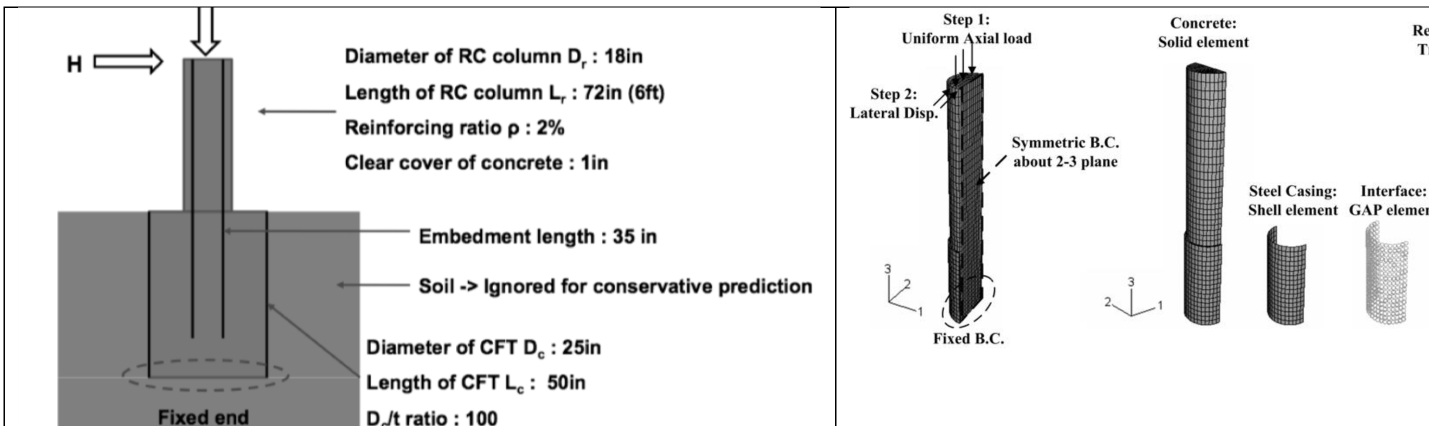

Figure 1: (a) Geometry of basis of parametric study and (b) FEA model geometry and element types

Figure 2 shows the connection gap elements used to simulate bond between the reinforcement in the colum and the pile.

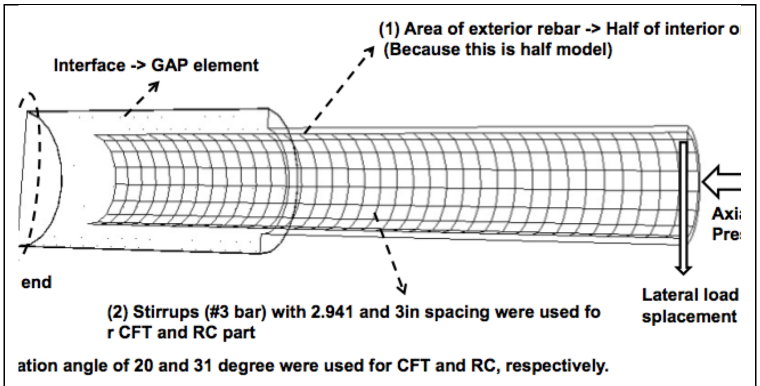

Figure 2: Model Details

The model was verified using prior test results on RC and CFT columns. As shown in Figure 6 three RC columns were modeled. The three columns had different embedment depths of the longitudinal reinforcement. These embedment depths resulted in different deformations corresponding to loss of strength and proper modeling of bond is paramount. As seen in the lower figures, the model is capable of simulating bond degradation and slip. This is an important advancement in the model since the longitudinal reinforcement will be used to transfer the shear, axial and bending forces in the proposed connection.

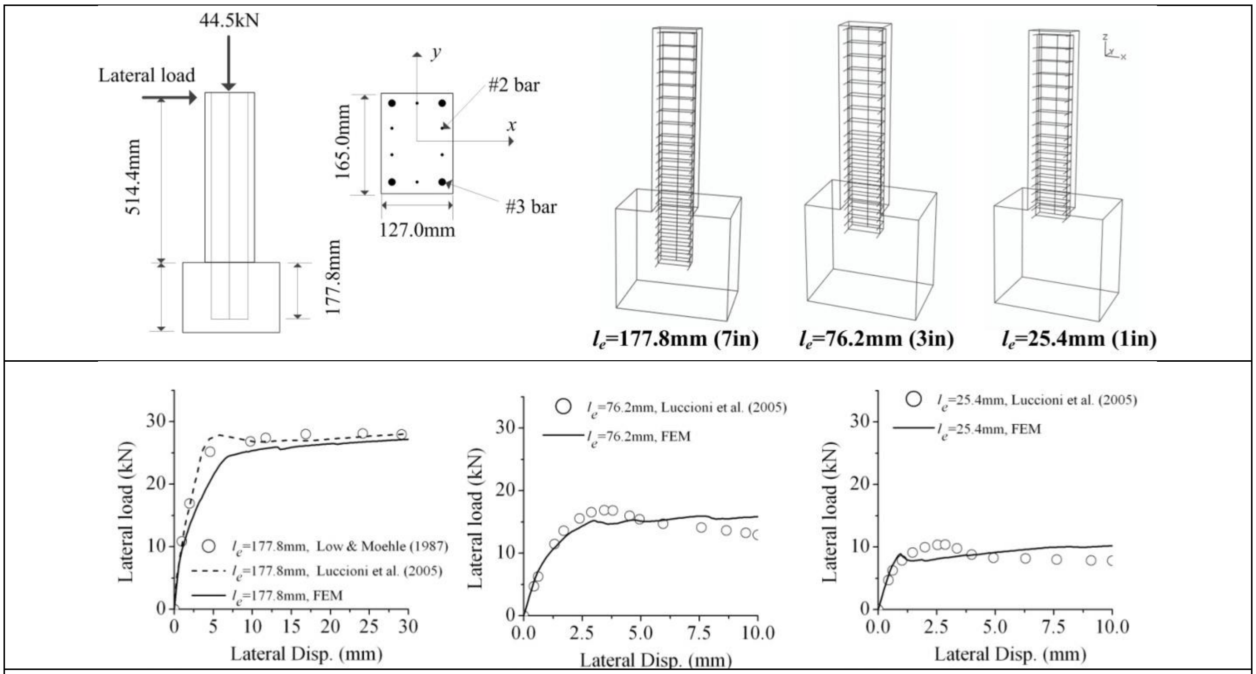

Figure 3: Model Verification of RC behavior for difffernt embedment lengths using data by Low and Moehle (1987)

Task 4 – Performance Evaluation of System Presently Under Consideration.
Working with the CAHSR team, the UW team will identify an HSR system for structural investigation using nonlinear analysis methods. This work has not been initiated and with the

time constraints is unlikely to be completed. The PIs propose removing this task from the present research project.

Task 5 – Final Report.
A Final Report will be written that summarizes the methods used and the findings reached during the project. This work has not been initiated.

5. Expected Results and Specific Deliverables

Tentative ABC-UTC Guidelines for Design and Behavior of Column-to-Pile Connections.
Initial guidelines will be developed for the connection designs. These designs are conceptual and expected to be followed by experimental testing; this testing is critical to investigate the salient design methods and parameters as well as to validate the modeling approaches. To the extent possible will take into account the conditions in which the HSR is to be built (e.g. seismic vs. non-seismic, soil-structure interaction for different soil conditions, etc.) Seismic conditions will be a primary design constraint given the focus on the California HSR route.

A five-minute Video Summarizing the Project

A five-minute video will be produced that summarizes the project in collaboration with FIU.

Conceptual designs for a representative CA-HSR bridge.

Conceptual designs, based on the prototype system, will be prepared. Descriptions, calculations and drawings prepared for those systems will enable CAHSR to evaluate both the structural performance and the likely construction time and cost

6. Schedule

Quarter 1 is going to be in Fall 2018 after a student is hired and a visiting student joins the project team.

Task Number and Description		Y1 Q1	Y1 Q2	Y1 Q3	Y1 Q4
Task 1	Literature Review	Deliverable: Summary and Excel Database			
Task 2	CAHSR Collaboration	Deliverable: Interim Report			
Task 3	FEA Analyses	Deliverable: Connection Behavior and Initial Designs			
Task 4	NLA of Prototype System	Deliverable: NLA recommendations and results			
Task 5	Reporting	Deliverable: Final Report			
Coordination: Virtual and in-person meetings with CAHSR		Virtual	In Person	Virtual	in Person