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

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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.

- 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, the team is working on Tasks 1 and 3 and have initiated Task 2, in collaboration with FIU and other rsearchers at UW.

**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
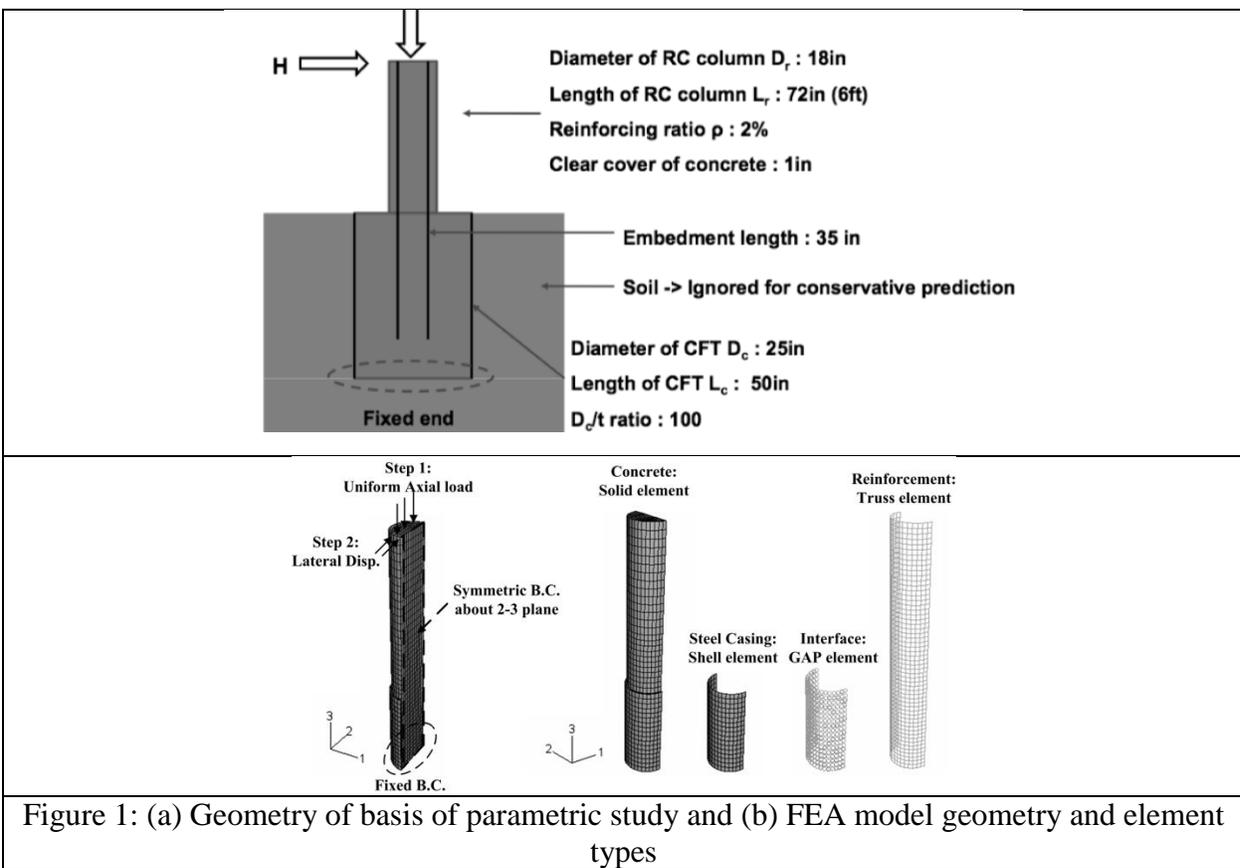
Initial analyses were conducte in Abaqus. However, the concrete damage plasticity model dissipates energy in tension and therefore is not appropriate for simulation of damaging and non-ductile response modesl. Instead, the PIs are migrating the analysis to LS Dyna. To date the team has:

    (1) Validated the new concrete damage plasticity model in LSDyan with concrete material testing, as shown in Figure 2.

(2) Validation of the modeling approach using prior CFT column tests, as shown in Figure 3.

The next steps will be to conduct a parametric study. However the student who will be conducting these studies is not joining the team until March and therefore it is expected that limited advancement will take place over the next reporting period.

Figure 2 Validation of CDPM in LSDyna

Figure 3 Validation of Modeling Approach Using CFT Column Tests
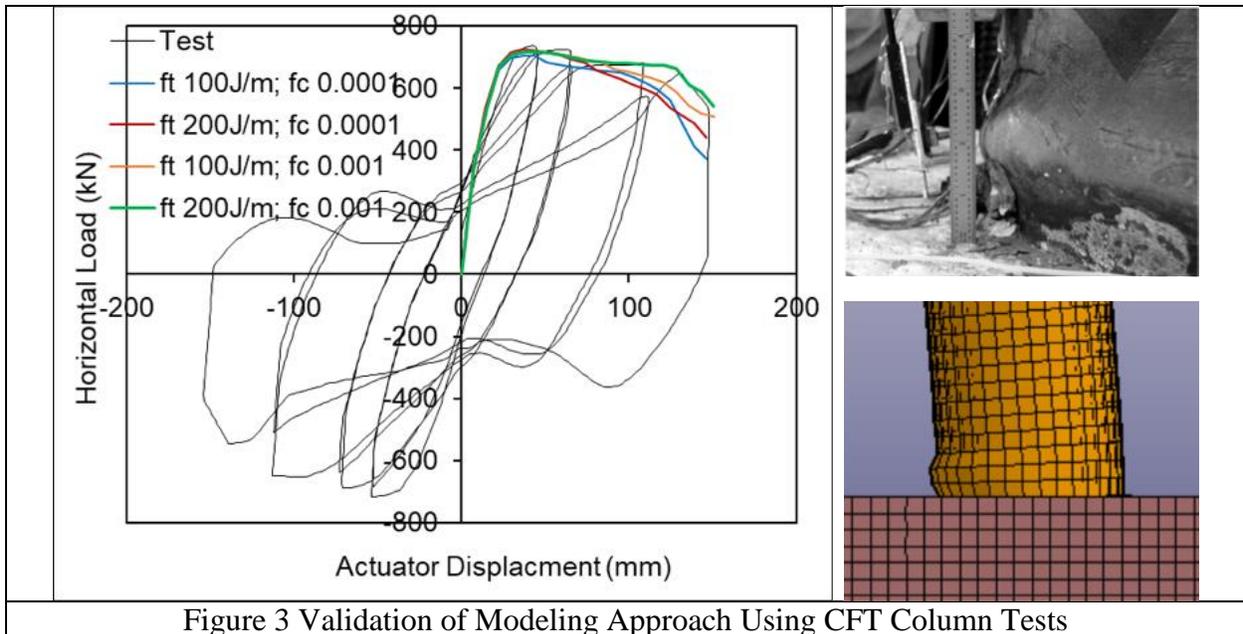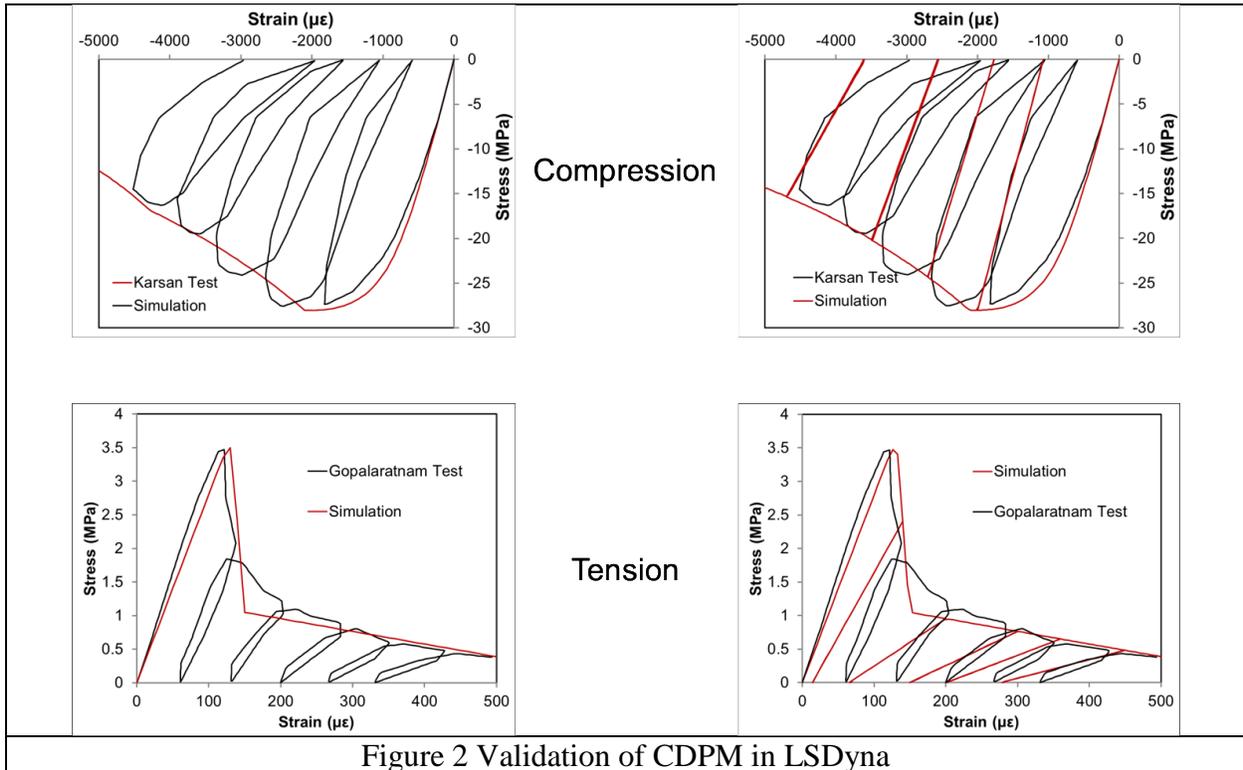
Task 4 – Performance Evaluation of System Presently Under Consideration.
Removed from the project because of insufficient time.

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.

6. Schedule

The following is a revised schedule with Task 4 removed.

Task Number and Description		Y1 Q1	Y1 Q2	Y1 Q3	Y1 Q4
Task 1	Literature Review				
		▓			
Task 2	Meeting with CA HSR				
			▓		
Task 3	Parametric Study				
			▓	▓	▓
Task 4	Removed				
Task 5	Report				
					▓