Research Project Highlight

Seismic Evaluation of the California High Speed Rail System

Project # 11-48 - NCTRHN

Principal Investigator
John Stanton, Professor of Civil Engineering, University of Washington

Research Team
Marc Eberhard, Professor of Civil Engineering, University of Washington.
Michelle Chang, Graduate Research Assistant, University of Washington.

Start-End Dates:
1/18/2019 - 1/18/2021

Abstract

The work originally proposed for this project concerned the evaluation of different structural systems for use in the California High Speed Rail (CAHSR) system. After the project was awarded, the funding for the CAHSR was indefinitely postponed, so the research was re-directed, with agreement from PEER, to investigate structural systems that would be of use in either the HSR system or in highway bridges. Those systems concerned bridge substructures, because the superstructures for HSR and highway bridges differ in both their requirements and their typical configurations.

Deep foundations, and primarily drilled shafts, are being used for transportation infrastructure with increasing frequency today, and the transition region from the shaft to the column is a critical region for which behavioral models and design details have not yet been fully developed. "Type 2" shafts are larger in diameter than the columns that they support, and they are widely used because they allow some tolerance in the column location after the body of the shaft has been cast. However, they necessarily depend on non-contact splices between the shaft and column bars. If the development length provisions from the AASHTO LRFD Specifications for such splices are used without modification, the transition region becomes long, the splices become expensive, and the construction crew members face additional safety hazards working at depth. The purpose of this project is to develop, by physical experiment and structural analysis, models for the behavior of the non-contact splice in the transition region that will allow transition regions to be designed that are more compact, more economical and safer to build.

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Deliverables

A PEER report, several conference and journal papers, and presentations that describe the previous work in the area, the test design and results, and the subsequent modeling.

Research Impact

Highway bridges in California constitute one of the most important components of the transportation system. When construction of the High Speed Rail system resumes, it is expected to play a similar role. The capital cost of that infrastructure is much too high to accept the need for replacement after a severe earthquake, so the components, and especially those in locations that are hard to access and repair, must be designed to be both reliable and economical. This can only be achieved by developing a full understanding of the structural properties and behavior of those components. In reinforced concrete, "Disturbed Regions" such as connections and non-contact splices, are some of the least well understood elements. The research described here is expected to have a significant impact on the safety and reliability of drilled shafts and the associated columns.

Progress to date – January 2021

A literature review revealed relatively little work in the area. One of the most relevant studies was the work of Murcia-Delso et al (2014), who investigated the problem in detail, but treated it exclusively as a bond problem. None of their specimens failed in the transition region, showing that the bond in the transition was adequate, but the study provided no critical information about the mechanics of the load transfer in the region. Work by Tran (2015) did lead to a failure in the transition region, but his specimens used precast columns in cast-in-place shafts. Based on those test specimens, a new configuration was developed, and a test specimen was constructed and tested. Images are shown below.

The failure mode was unexpected and provides some real insights into the behavior. The individual column bars did not pull out by anchorage failure, but rather the column rotated as a rigid body and caused failure in the shaft spiral by prying action. Tran had seen this behavior with one of his precast columns but the mechanism was not expected in this specimen, which was all cast-in-place and contained more shaft spiral. The result shows that an additional failure mode, beyond the traditionally considered ones of anchorage failure of the column bars and flexural failure of the column, must be

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taken into account. The test data is now being analyzed and evaluated. When that process is complete, we will begin modeling efforts.

Murcia-Delso, J., Liu, Y., and Shing, P. B. "Development of Bridge Column Longitudinal Reinforcement in Oversized Pile Shafts," Journal of Structural Engineering, V. 142, No. 11, 2016, p. 04016114.

Tran, H. V., Stanton, J. F., and Eberhard, M. O. "Precast Bent System for High Seismic Regions: Laboratory Tests of Column-to-Drilled Shaft Socket Connections," Federal Highway Administration, 2013.

Project Images

Fig. 1. Specimen construction

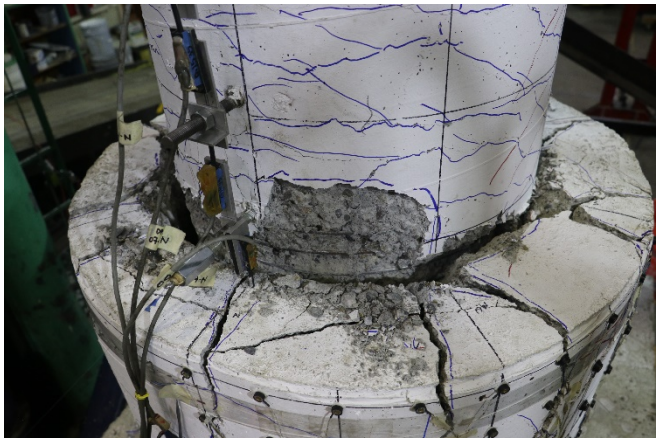

Fig 2. After testing. (Note the separation between column and shaft)

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