

MPC-392

January 1, 2012 - December 31, 2013

Project Title:

Evaluation of Spliced Sleeve Connections for Precast Reinforced Concrete Bridge Piers

University:

University of Utah

Principal Investigator:

Chris P. Pantelides, Professor, c.pantelides@utha.edu, (801) 585-3991

Co-Principal Investigator:

Lawrence D. Reaveley, Professor, reaveley@civil.utah.edu, (801) 581-6118

Research Needs:

Connections between precast concrete elements must be able to withstand significant stresses and deformations in earthquakes. The splice sleeve connection is being considered for connecting such elements in Accelerated Bridge Construction (ABC). There is limited data for use of this connection in bridges located in moderate to high seismic regions. The proposal aims at performing cyclic tests to verify the capacity of the splice sleeve connection for precast concrete elements such as columns connected to footings or bent cap beams. A recent study has developed a different connection than the one proposed for bent cap systems in seismic regions (Restrepo et al. 2011). A recent state-of-the art review has determined that there is an urgent need for research that would provide substantiation of the design, construction, and seismic performance of bar coupler systems such as grouted sleeves (Marsh et al. 2011).

Research Objectives:

The objectives of this proposal are: (1) to perform quasi-static cyclic tests of precast concrete column to footing connections using a splice sleeve connection, and precast concrete column to bent cap beam connections using a mechanical sleeve connection, and (2) to evaluate to what extent the sleeve connections behave in a manner consistent with the earthquake resisting elements that would be expected with traditional construction methods, as described in the AASHTO Guide Specification for LRFD Seismic Bridge Design (AASHTO 2011).

Research Methods:

The proposed research will evaluate the seismic performance of two types of connector systems for ABC construction of bridges. Specifically the NMB Splice Sleeve System and the Lenton Interlock System will be evaluated for column to footing and column to bent cap beam connections using precast concrete elements. In addition, design recommendations will be developed, including ABC Standard Drawings.

Expected Outcomes:

The expected outcomes of the proposed research will include the seismic performance of two types of connector systems for ABC construction of bridges. Specifically the NMB Splice Sleeve and the Lenton Interlock will be evaluated for column to footing and column to cap beam connections using precast concrete elements. Design recommendations will be developed,

including ABC Standard Drawings. The ease of construction and the performance in terms of plastic rotation capacity, displacement ductility, and energy absorption will be measured. The tests will evaluate to what extent the splice sleeve connections behave in a manner consistent with the earthquake resisting elements that would be expected with traditional construction methods, as described in the AASHTO Guide Specification for LRFD Seismic Bridge Design.

Relevance to Strategic Goals:

The project and its outcomes are related to environmental sustainability, and livable communities. The State of Utah is implementing extensively ABC construction practices for bridges. Successful completion of the proposed project will enhance ABC methods in areas of moderate to high seismic activity. Well known benefits of ABC methods include significant reduction of construction time by using precast elements. Moreover, ABC eliminates traffic congestion, and reduces energy use and associated greenhouse gas emissions for passenger travel and freight movement. The reduction of the time spent in onsite construction fosters the quality of life of the public for bridges in urban settings, and the protection of critical watersheds and ecosystems. Moreover, the resilience of bridges is improved and this enhances recovery efforts after a large earthquake.

Educational Benefits:

Several university students will be involved in the experimental portion of the project, including an MS student and a PhD student. At the local level, the technology transfer activity will involve high school students through an Annual Exploring Engineering Camp, during which small-scale models will be built to illustrate the details of the sleeve connections.

Work Plan:

The proposed research will require the execution of the following tasks:

Task 1. Review existing experimental results for splice sleeve connections.

Work in this area is very limited. However, every effort will be made to identify any work related to this issue and will be reviewed with the purpose of adding value to the proposed tests. The experimental program will not be finalized until Task 1 is complete and any findings are evaluated for incorporation.

Task 2. Build precast columns, footings and cap beams.

The tests envisioned are designed to be approximately half-scale compared to typical bridge dimensions. The column and footing details for the column to footing connection are shown in Figure 1. Note that Type I connections will utilize the NMB splice sleeve system. The column and cap beam details for the column to bent cap beam connection are shown in Figure 2. Type II connections will utilize the Lenton Interlock mechanical splice system.

Task 3. Test column to footing connections (Type I)

Three specimens with the details shown in Figure 1 will be tested for the column to footing connection using displacement controlled quasi-static cyclic tests. The tests will be carried out at the University of Utah Structures Laboratory.

Task 4. Test column to bent cap beam connections (Type II)

Three specimens with the details shown in Figure 2 will be tested for the column to bent cap beam connection using displacement controlled quasi-static cyclic tests.

The project is expected to start on March 1, 2012 and last two years. Task 1 will be completed in three months, Task 2 in six months, Task 3 in nine months and Task 4 in twelve months. The project requires the submittal of a quarterly report, and at completion the final project report.

The UDOT portion will last one year; the MPC portion will last two years to allow the MS and PhD students to generate journal papers. The technology transfer plan includes presentations of the findings at the TRB AFF50-Seismic Design and Performance of Bridges Committee meeting, and at the ACI 341- Earthquake-Resistant Concrete Bridges Committee meeting.

Project Cost:

Total Project Costs: \$179,148
 MPC Funds Requested: \$70,355
 Matching Funds: \$ 108,793
 UDOT, TxDOT, and NYSDOT

Source of Matching Funds: Pooled fund study from

TRB Keywords: Accelerated construction; Bridge piers, Grouting, Seismic design, Sleeves.

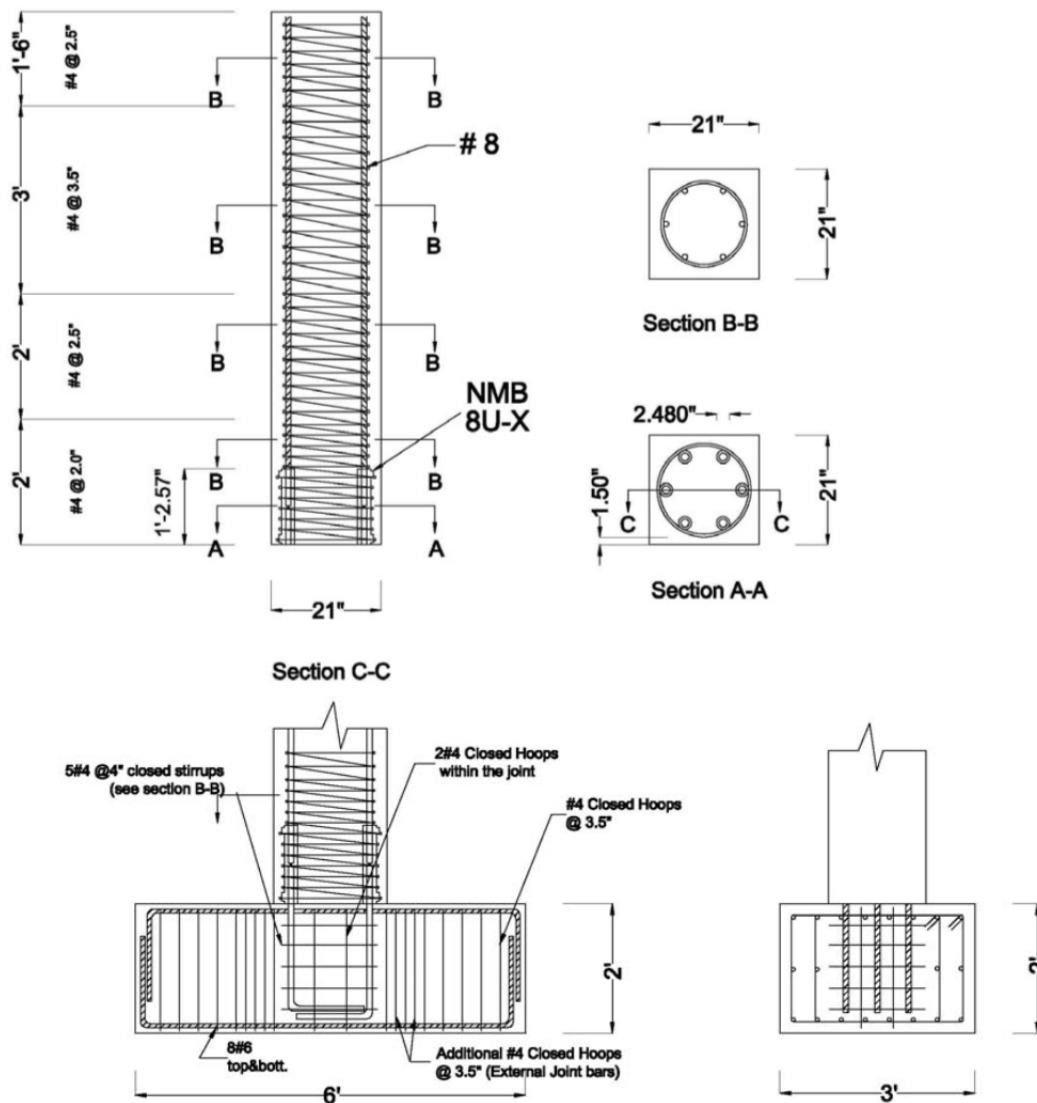


Figure 1. Column and footing details for the column to footing tests using NMB splice sleeves.

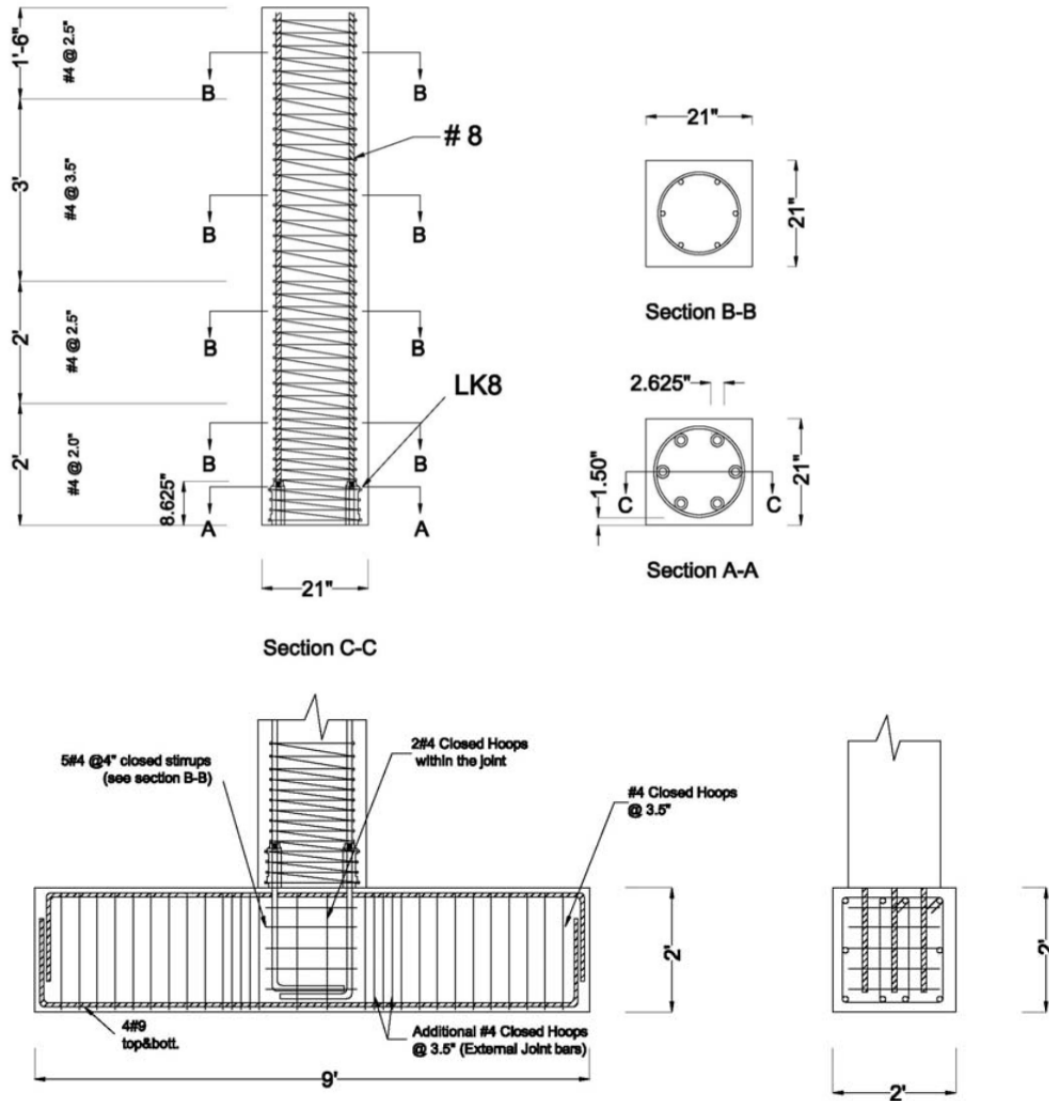


Figure 2. Column and cap beam details for the column to cap beam tests using Lenton Interlock

References:

American Association of State Highway Transportation Officials (2011). *AASHTO Guide Specifications for LRFD Seismic Bridge Design*. 2nd ed., Washington, DC.

Marsh, M.L., Wernli, M., Garrett, B.E., Stanton, J.F., Eberhard, M.O., and Weinert, M.D. (2011). *NCHRP Report 698: Application of Accelerated Bridge Construction Connections in Moderate-to-High Seismic Regions*. Transportation Research Board of the National Academies, Washington, DC.

Restrepo, J., Matsumoto, E., and Tobolski, M. (2011). *NCHRP Report 681: Development of Precast Bent Cap Systems for Seismic Regions*. Transportation Research Board of the National Academies, Washington, DC.