MPC-405
January 1, 2012 – December 31,2012

Project Title:
Seismic Retrofit of Spliced Sleeve Connections for Precast Bridge Piers

University:
University of Utah

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

Research Needs:

There is a great need for research on suitable connections between precast concrete elements which will 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. This proposal aims to extend the current pool fund study project. There is a great need to be able to retrofit bridge piers that will use the spliced sleeve connections. Structural Managers at UDOT after a recent scanning tour conducted by the FHWA have recommended that such a study be conducted. The project will be carried out by performing cyclic tests to verify the capacity of the retrofitted splice sleeve connection for precast concrete elements such as columns connected to footings or bent cap beams.

Research Objectives:

The objectives of this proposal are: (1) to perform quasi-static cyclic tests of a retrofitted damaged precast concrete column to footing splice sleeved connection, and a retrofitted damaged precast concrete column to bent cap beam connection using a mechanical sleeves; the retrofits will be accomplished by using Carbon Fiber Reinforced Polymer (CFRP) jackets; and (2) to evaluate to what extend the retrofitted 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 the seismic retrofit using CFRP jackets for concrete joints using two types of connector systems. 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 evaluation of the seismic performance of the seismic retrofit of concrete joints with 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 for the seismic retrofit using CFRP jackets will be developed, including ABC Standard Drawings. The ease of application of CFRP jackets to existing reinforced concrete construction has been demonstrated by the P.I. in previous research (Pantelides et al. 1999, 2007), as well as in an actual seismic retrofit implementation for the State Street Bridge in Salt Lake City (2004).

Relevance to Strategic Goals:

The project and its outcomes are related to state of good repair. Resilience of bridges is improved and this enhances recovery efforts after a large earthquake. The State of Utah is implementing extensively ABC construction practices for bridges. Successful completion of the proposed project will ensure that there are methods to retrofit such bridges after a large earthquake.

Educational Benefits:

Several university students will be involved in the experimental portion of the project, including one MS student who will be funded from this project. This student will assist a PhD student who is working on the existing project. 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 retrofitting the columns with the sleeve connections.

Work Plan:

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

Task 1. Perform a seismic retrofit of column to footing connections (Type I)

One specimen 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. After the test, the damaged specimen will be retrofitted with CFRP jackets, as shown in Figure 2. A preliminary seismic retrofit design for the plastic hinge area of the column shows that 7 layers of CFRP composite will be required. Each layer has a thickness of 0.04 in. and the fooling design properties were assumed: An elastic modulus of 9,500 ksi, and an ultimate tensile strain of 1.0%. The seven layers will be applied for the bottom 2 ft as shown in Figure 2; to avoid stress concentration where these layers are discontinued, 3 CFRP layers will be applied for the 2 ft above the bottom layers.

Task 2. Perform a seismic retrofit of column to bent cap beam connections (Type II)

One specimen with the details shown in Figure 3 will be tested for the column to bent cap beam connection using displacement controlled quasi-static cyclic tests. After the test, the damaged specimen will be retrofitted with CFRP jackets, as shown in Figure 4. The design and details of the CFRP composite are identical to those described for Figure 2 in Task 1.

The UDOT project has started March 1, 2012 and will last 1.5 years. Task 1 will be completed in the first year, and Task 2 in the second year. The project requires the submittal of a quarterly report, and at completion the final project report. The MPC portion will last 1.5 years and will allow the MS student to generate one journal paper. 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. The budget includes provision for travel to present the findings.

Project Cost:

Total Project Costs: $44,138
MPC Funds Requested: $44,138
Matching Funds: $0

TRB Keywords: Accelerated construction; Bridge piers, CFRP composites; Grouting, Seismic retrofit, Sleeves.

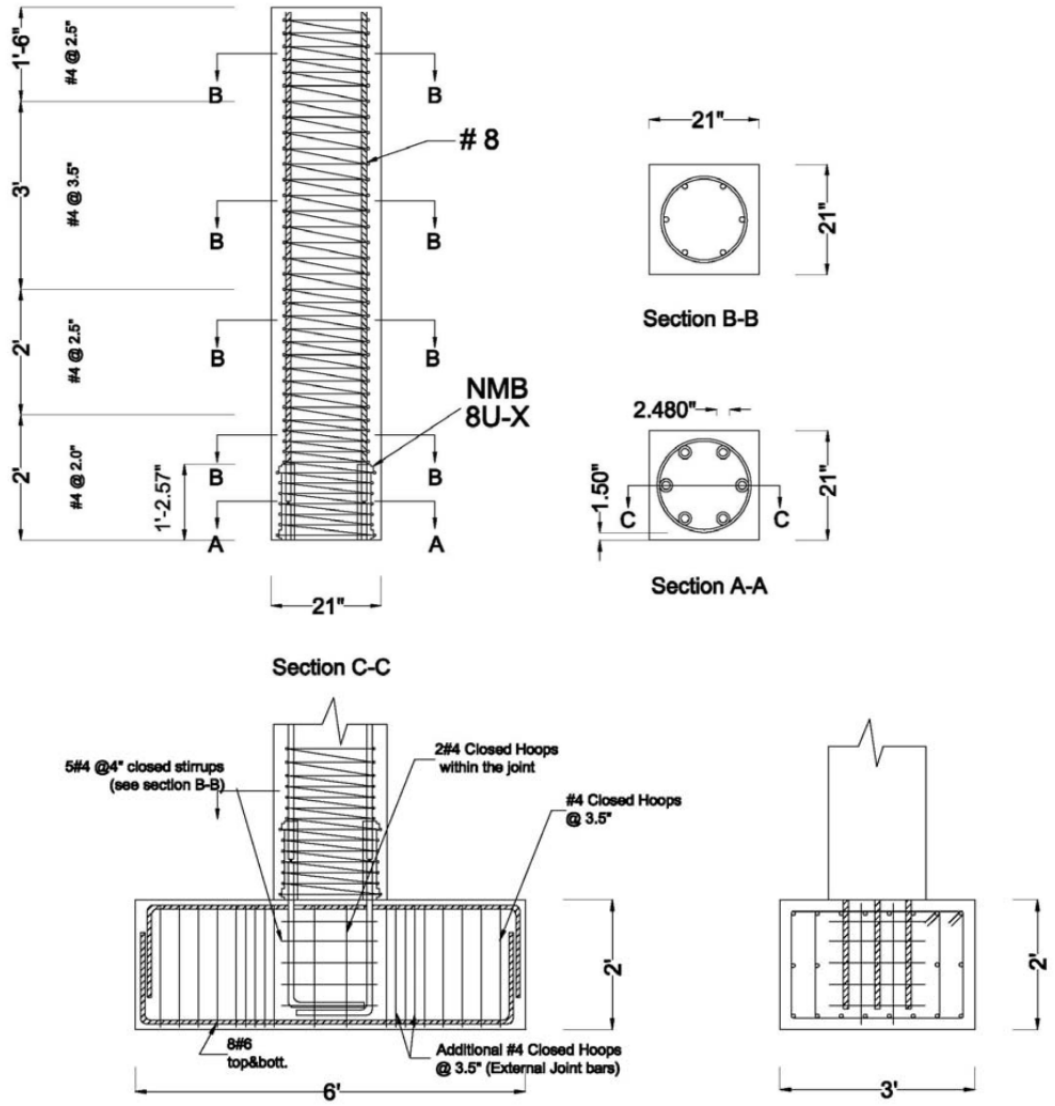

Figure 1. Column and footing details for the column to footing tests using NMB splice sleeves.

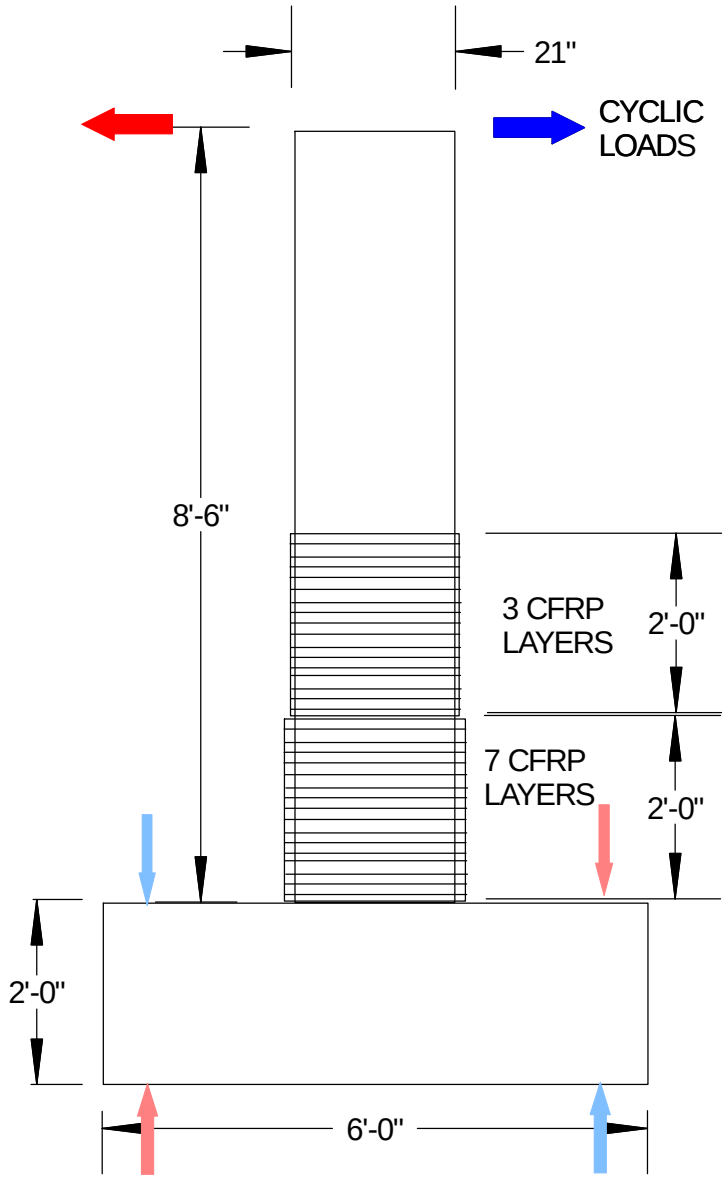

Figure 2. Seismic Retrofit of the column to footing joint using NMB splice sleeves.

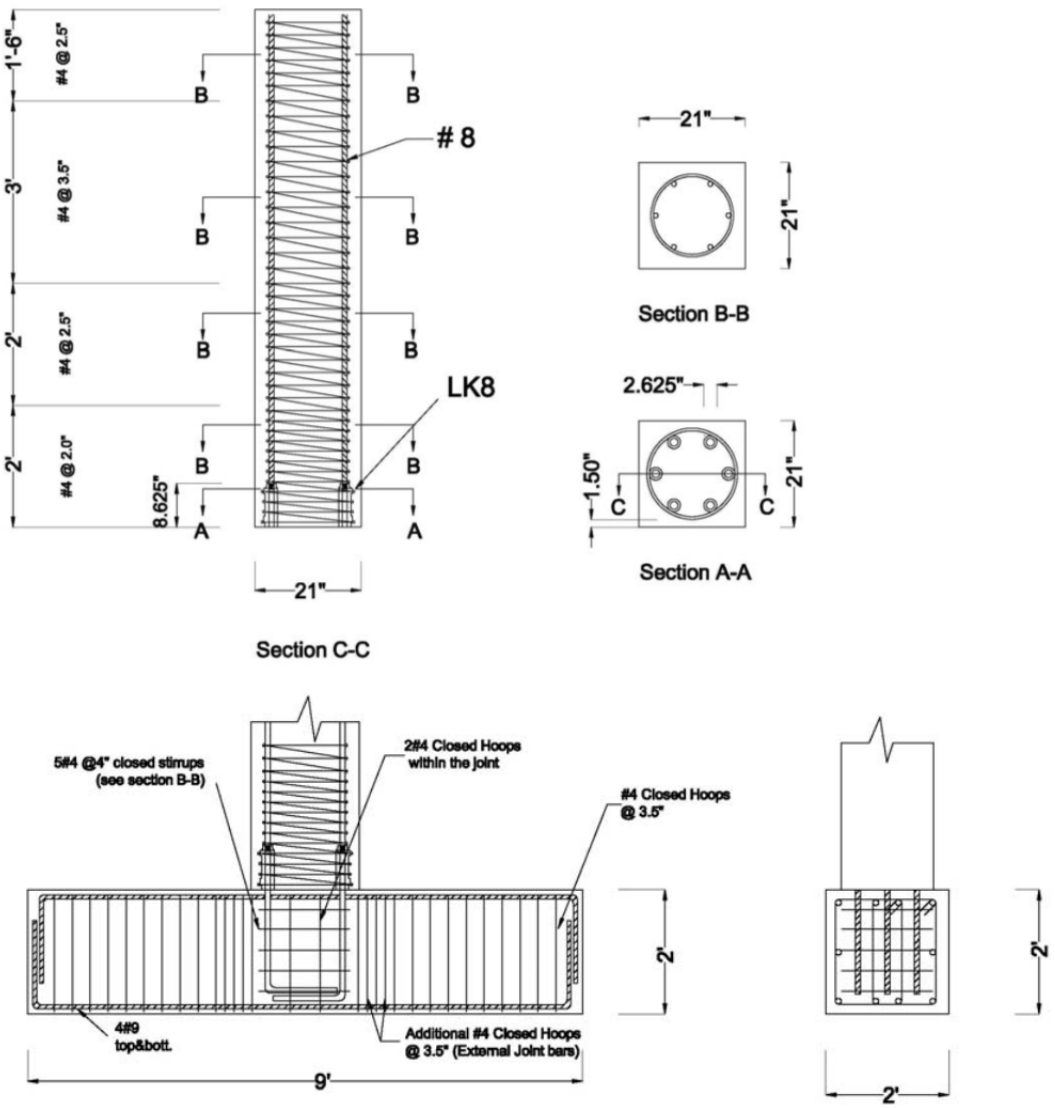

Figure 3. Column and cap beam details for the column to cap beam tests using Lenton Interlock

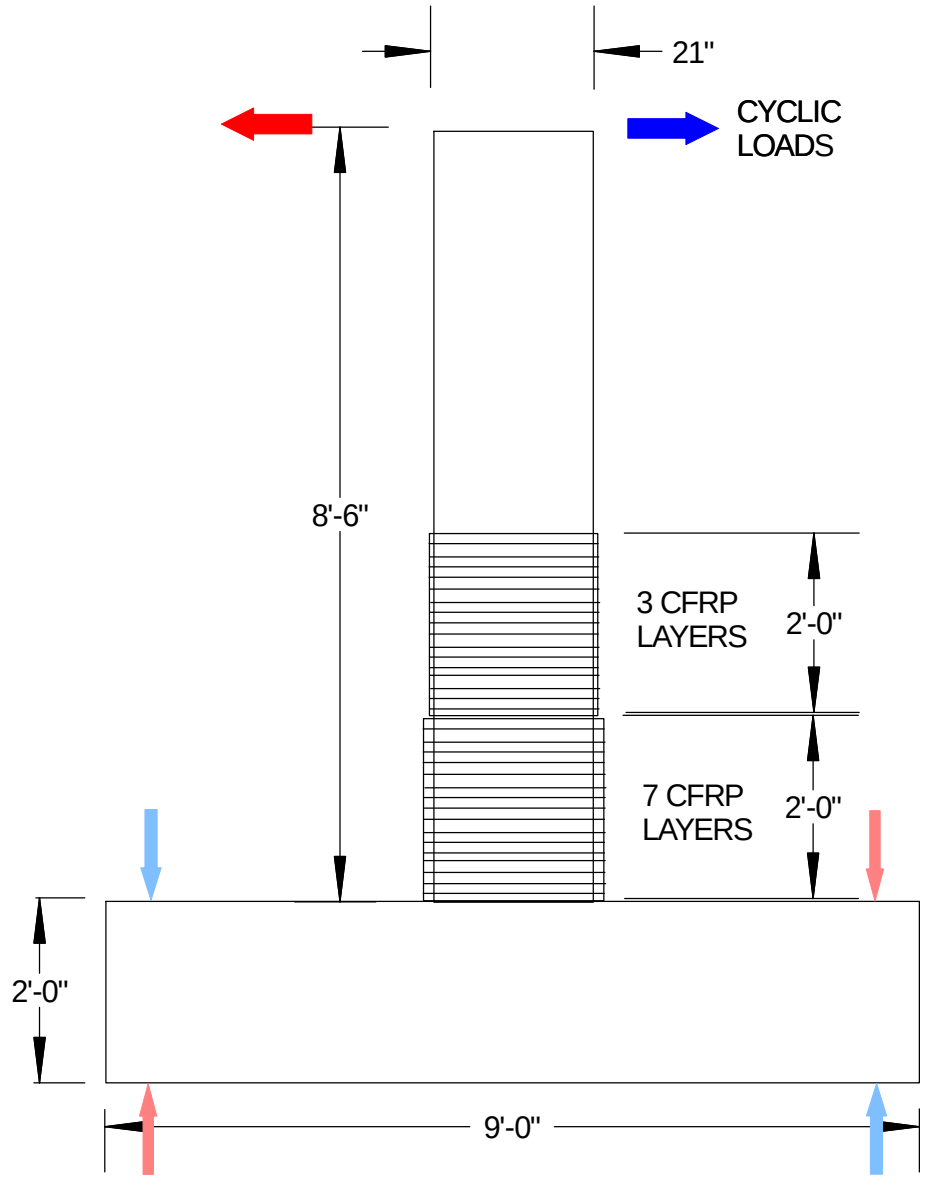

Figure 4. Seismic Retrofit of the column to cap beam joint using Lenton Interlock

References:

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

Pantelides, C.P., Gergely, J., Reaveley, L.D., and Volnyy, V.A., 1999. Retrofit of RC bridge pier with CFRP advanced composites, *J. Structural Eng.*, ASCE, **125** (10), 1094-1099.

Pantelides, C.P., Alameddine, F., Sardo, T., and Imbsen, R., 2004. Seismic retrofit of State Street Bridge on Interstate 80, *J. Bridge Eng.*, ASCE, **9** (4), 333-342.

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