NEVADA DEPARTMENT OF TRANSPORTATION

FFY 2015 RESEARCH PROBLEM STATEMENTS

I. PROBLEM TITLE: Development of Earthquake-Resistant Precast Pier System for Accelerated Bridge Construction in Nevada

II. PROBLEM DESCRIPTION: Accelerated bridge construction (ABC) is known to address all of the key objectives of FHWA Every Day Counts (EDC) Initiative on Accelerating Technology and Innovation Deployment. Extensive use of precast members is necessary for ABC to succeed. ABC offers numerous advantages: (1) higher quality structural elements because they are fabricated in plants using good quality control, (2) more durable materials because of appropriate curing under controlled environment, (3) concurrent execution of different tasks such as site preparation while structural elements are being fabricated, (4) reduced traffic interruption and less risk to travelers and construction personnel due to shorter construction time, and (5) reduced effect on the environment due to expedited construction and the use of more efficient technologies that require less energy.

In moderate and high seismic zones, bridge connections are of primary concern because they must dissipate the earthquake energy while maintaining the structural integrity. Recent studies at UNR, University of Utah, University of Washington, and others have led to development and proof testing of several alternative earthquake resistant connections. The studies have addressed column connection to footings, column-pier cap connection, or both within the same pier system. In the studies addressing column-footing connections various types of mechanical splices such as grouted couplers, headed bar couplers, shear locks, and pipe pin connections have been studied. Figure 1 and 2 show grouted couplers and headed bar couplers at the base of a precast column, respectively. Column pier cap connection studies have focused on a variety of details: grouted ducts (Fig. 3), grouted corrugated pipes (Fig. 4), partial precast/cast-in-place cap beams (Fig. 5), grouted couplers (Fig. 6), and full precast column-cap beam connections (Fig. 7). These each have been studied to a limited extent with various advantages and disadvantages. A comprehensive comparative study of these connections is yet to be done.

Fig. 1- Column with GC

Fig.2- Headed Couplers

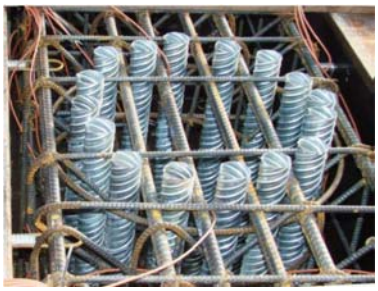
Fig. 3- Grouted Ducts

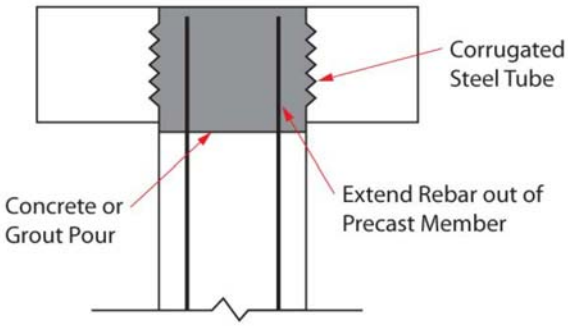

Fig. 4- Corrugate Pipe

Fig. 5- Partial Precast Cap beam

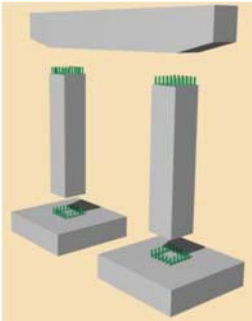

Fig. 6- Grouted Couplers

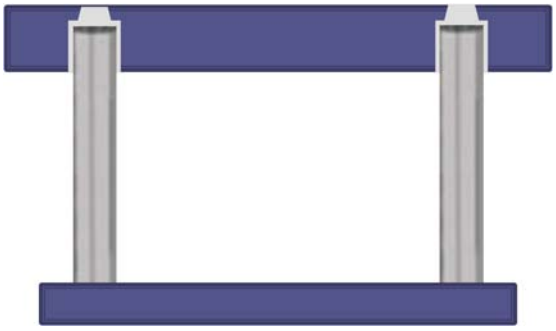

Fig. 7- Full Precast Column w/ Cap Beam Pocket

III. OBJECTIVE: The overall objective of the proposed project is to identify the most appropriate earthquake-resistant precast bridge pier system for implementation of accelerated bridge construction in Nevada. The study will be conducted through a systematic seismic evaluation of bridge piers that have been developed recently by the PI and others. Based on discussions with the NDOT Structures and Construction Divisions, a rating system will be developed with respect to seismic performance, ease and speed of construction, cost, etc. The most promising pier system will be selected, refined to suit the needs of NDOT, and proof tested through seismic loading of a large scale model.

IV. CURRENT PRACTICE and RELATED RESEARCH: The FHWA EDC initiative has identified ABC as a means to substantially improve service to the travelling public, improve construction quality, and minimize impact of bridge construction on the environment. States in high seismic zones have not been able to embrace ABC because of insufficient data on the seismic performance on ABC connections. Studies are being funded by Caltrans and DOTs in Utah, Washington State, and S. Carolina on ABC connections that suit the needs of those states. The PI has served as a "Subject Matter Expert" on an AASHTO scan team focused on ABC connections under seismic and other extreme loads and has firsthand knowledge of the current state of practice in different states.

V. RESEARCH METHODOLOGY:

Task 1- Update Literature Search and Develop Project Website: New research data that becomes available between now and start of the project will be reviewed. The existing and new data will be evaluated and results will be presented to NDOT. A dedicated website will be developed providing updates about the study after NDOT review and approval of the content.

Task 2- Comprehensive Evaluation of Existing Pier Systems: The available data on seismic performance of different connections at column base and at pier caps will be

thoroughly evaluated and a rating system will be developed to take into account constructability, speed of construction, seismic performance of different pier components (columns, pier caps, and joints), cost, and feasibility for use in Nevada bridges. Results will be presented to NDOT. Based on discussions with NDOT, the most promising and appropriate pier system for Nevada will be selected. Given that all past studies have been of limited scope, knowledge gaps are expected to exist even for the selected system, thus requiring limited additional experimental and analytical studies.

Task 3- Design a Pier System Test Models and Test under Seismic Loading: A large-scale test model will be designed to address the knowledge gaps identified under Task 2. The model will be discussed with NDOT Structures and Construction Divisions and refined as necessary. Both shake table testing and quasi-static cyclic testing will be considered. Final selection will be made based on discussions with NDOT.

Task 4- Analyze the Test Model Response to Address the Knowledge Gaps: The models will be analyzed and the new information will be incorporated in the details of the selected system. The pier system will be finalized accordingly, and design guidelines with illustrative examples will be developed.

Task 5- Prepare the Final Report: The draft final report of the project will include an executive summary presenting the study, results, recommendations, and a design example. The draft report will be submitted to NDOT for review and revised as necessary.

VI. IMPLEMENTATION POTENTIAL: The project is a Stage I-II project that will prepare the technology for pilot implementation or deployment (Stage IV-V). This project will be of direct use by NDOT in future ABC in Nevada. Similar to other states, it is anticipated that the connections and details recommended as a result of this study will be made available online for bridge designers within and outside NDOT. A similar effort by Utah DOT in posting of standard preferred ABC details has helped expand the use of ABC in Utah.

VII. URGENCY AND PAYOFF POTENTIAL: Many states have expanded their ABC program to better serve travelers by reducing bridge construction time and traffic delays and to improve work zone safety. States in moderate and high seismic zones have been slow to adopt ABC because of uncertainties in seismic performance of ABC connections. Nevada has its own constraints with respect to adopting ABC. The proposed research could enable NDOT to customize ABC to its needs and to expand its ABC program as appropriate.

VIII. ESTIMATED BUDGET: The estimated budget for this project is $100,000 per year. The study will be conducted over a two-year period at a total estimated budget of $200,000.

IX. DATE AND SUBMITTED BY: This problem statement was developed and submitted by Prof. M. Saiid Saiidi in collaboration with Dr. Keri Ryan on May 20, 2014. Prof. Saiidi's contact information is as follows:

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X. NDOT CHAMPION, COORDINATION AND INVOLVEMENT: The PI and Co-PI held a meeting with NDOT Structures Division in May 2014 discussing implementation of ABC and the constraints in Nevada. The primary NDOT champions for this project are the Structures Division in collaboration with the Construction Division. The Structures Division plans to coordinate the effort with the Construction Division.