APPENDIX J 2012 RESEARCH PROBLEM STATEMENT

2012 RESEARCH PROBLEM STATEMENT

I. PROBLEM NUMBER

(To be assigned by TRB)

II. RESEARCH NEEDS TITLE

Advancement of Accelerated Bridge Construction (ABC) in Moderate-to-High Seismic Regions

III. BACKGROUND

This research problem statement defines a proposed Program of work that is needed to advance Accelerated Bridge Construction (ABC) in regions of the United States that are subject to moderate-to-high seismic hazards. The Federal Highway Administration (FHWA) and many state Departments of Transportation (DOT) are actively promoting accelerated bridge construction to minimize construction-related impacts to the traveling public and to improve work zone safety. ABC techniques have been applied on many projects, primarily in regions of low seismic activity. However, their utilization in moderate-to-high seismic regions of the country has been limited, because the conventional, linear, precast elements used with ABC cause the connections to be located at the intersections of framing elements, and those are typically the regions expected to experience the highest demands under earthquake loading. Accordingly, significant work is needed to ensure that ABC connections can meet the required seismic performance, in addition to having the necessary non-seismic properties of constructability, cost effectiveness, durability, and inspectability.

A national seismic ABC initiative, sponsored by the Transportation Research Board (TRB) and FHWA, was recently initiated to develop a program of research to address the issues related to ABC in seismic regions. Part of that effort included the FY 2011 National Cooperative Highway Research Program (NCHRP) synthesis project 12-88 to evaluate the current status and future needs of ABC techniques for use in moderate-to-high seismic regions (abbreviated as SABC). The NCHRP Project 12-88 is still being completed at the time of writing of this Problem Statement. Thus, the recommendations made herein may change slightly as the 12-88 synthesis report is finalized. It is therefore expected that, if funding is awarded for this project, the Request for Proposal (RFP) for the work would take into account the final recommendations of the synthesis project.

A key factor in successful implementation of the SABC initiative is the connection technology used with prefabricated elements. Providing reliable connections to ensure ductile performance is essential to developing designs capable of performing to the exacting requirements for earthquake-prone areas.

IV. OBJECTIVE

The objective of this research is to address immediate needs for use of ABC in moderate to high seismic regions. The NCHRP 12-88 project has identified and prioritized these needs, and those that will provide the most value have been selected for the work proposed by this Problem Statement.

The proposed work will provide substantiation of seismic performance and develop design and construction recommendations for:

- Bar coupler systems. (Note that some of these have already been deployed in high seismic regions),
- Connections for a complete pier system, inclusive of top and bottom column connections using:
    - either grouted ducts or pocket-type connections at the top, and
    - socket-type connections for the bottom.

V. POTENTIAL BENEFITS

This research addresses Grand Challenge 3, *Accelerating Bridge Construction*, from the 2005 AASHTO Highway Subcommittee on Bridges and Structures "Grand Challenges: A Strategic Plan for Bridge Engineering." Specific activities from the AASHTO Grand Challenges report covered through the proposed work include:

- Further development and implementation of rapidly assembled connection details and joints that are constructible, durable and repairable.
- Development of prefabricated seismically resistant systems, including substructures.
- Development of more efficient modular sections.

The challenge of ABC construction in seismic regions affects at least 36 of 50 states, a number based on the AASHTO seismic design methodology, which is a function of site soil conditions. For sites with the poorest soils, 36 states could have bridges that fall into the moderate to higher seismic areas (Seismic Zone 2 or higher and Seismic Design Category of B or higher). Therefore this is a national issue. The systems developed in this research will, of course, be usable in all 50 states. If the connections' constructability properties are outstanding, their use may be economically attractive, even if no advantage is taken of the benefits of the seismic resistance. The use of ABC is a national initiative and expansion of the use of ABC with regard to seismic zone is necessary to provide the benefits of ABC for all highway users.

An ancillary benefit of development work on SABC systems is that such systems may address other extreme events, such as vessel impact, blast, or other loadings that may load a bridge beyond its elastic limits in ways not addressed by design for gravity load alone. The design principles used for seismic loading require continuity of load path, reserve inelastic strength, and a high level of structural integrity, and such attributes directly benefit the structure for other extreme events with strong lateral effects.

VI. RELATIONSHIP TO THE EXISTING BODY OF KNOWLEDGE

Previous NCHRP and state DOT-funded research to develop workable solutions to meet seismic performance requirements for ABC applications has produced a good start, and the proposed work represents the next logical step on a longer journey.

The review of existing technologies undertaken in the NCHRP 12-88 project led to the identification of four connections types that were recommended for this Problem Statement, which are listed below. For each of the types of connection, the available information is insufficient to justify implementation as an ABC system in the field without further investigation.

1. Bar couplers: Their primary shortcoming is that a comprehensive test series on grouted-bar couplers is lacking. Partial information is available (tests on couplers in air under high strain rates, isolated tests on members connected using particular couplers, e.g. in Japan and Italy, etc.), but tests covering the full range of behaviors under seismic loading have not been conducted.
2. Grouted ducts: A number of test programs have demonstrated the high anchorage capacity of grouted ducts under monotonic loading, but only a few tests have been conducted using inelastic cyclic loading. Other areas where more information is needed include the effects of the size of duct, the type of duct (particularly the nature and roughness of the corrugations), the location of the bar in the duct (eccentric or otherwise), group pullout, and transfer of the load from the duct wall through the concrete to neighboring reinforcement.
3. Pocket Connections: The system provides considerable promise, but mechanics-based design procedures are needed for the joint region, and more extensive testing is needed to advance their development. The joint region includes not only the confined pocket itself, but also the surrounding region in the cap beam. The dimensions of that region are limited by the width of the cap beam and the size of the pocket, so it may be quite small and therefore highly stressed. In particular, the required quantity of tie and other confining reinforcement, and procedures for computing it, need to be established.
4. Socket Connections: Some cyclic testing has been conducted on both precast concrete and steel columns embedded in footings that are typical of bridge construction. Other studies have investigated footings suitable for buildings, but those results appear to translate poorly to bridge construction. A more extensive study is needed to define the relationships between the embedded length of the column, the column diameter, surface roughness and confining reinforcement. Clear, mechanics-based design guidelines are needed for the design of the critical connection region.

VII. FOLLOW-ON AND IMPLEMENTATION ACTIVITIES

The work performed under this problem statement will produce design and construction information that should be stewarded through the process of adoption into the AASHTO family of specifications, both design and construction.

VIII. ESTIMATED FUNDING REQUIREMENTS AND DURATION

Recommended Funding:

It is estimated that the cost to complete the research envisioned herein will be approximately $750,000.

Research Period:

The estimated time needed to complete the research described herein is approximately 36 months.

IX. PERSONS DEVELOPING THE PROBLEM STATEMENT

M. Lee Marsh, PhD, PE
Senior Project Manager
BergerABAM
33301 Ninth Ave. South
Federal Way, WA 98003
206-431-2340

lee.marsh@abam.com

John F. Stanton, PhD, PE
Professor
Dept. of Civil and Environmental Engr.
University of Washington
233 More Hall
Seattle, WA 98195

stanton@u.washingon.edu

Marc O. Eberhard, PhD, PE
Professor
Dept. of Civil and Environmental Engr.
University of Washington
233 More Hall
Seattle, WA 98195

eberhard@u.washingon.edu

X. PROBLEM MONITOR

To be determined by TRB

XI. DATE AND SUBMITTED BY

December 15, 2010