NEVADA DEPARTMENT OF TRANSPORTATION

FFY 2015 RESEARCH PROBLEM STATEMENTS

I. PROBLEM TITLE: Toward Successful Implementation of Prefabricated Deck Panels to Accelerate the Bridge Construction Process

II. PROBLEM DESCRIPTION: The development of accelerated bridge construction (ABC) techniques and connection details has become a national research focus. Several states have successfully standardized the ABC approach with high rates of public satisfaction. Compared to other ABC techniques, the technologies for pre-fabricated bridge decks are relatively mature. For instance, full depth precast concrete deck panels have been in use for over 20 years [1]. Due to aging of the national bridge inventory, many of the bridges in the United States have significant deterioration, often centered on the bridge superstructure. Therefore, concrete deck replacement projects are becoming increasingly common, and can be expedited efficiently with minimal disruption to traffic using ABC.

Nevada is interested in the application of partial-depth and full-depth concrete deck panels. Partial-depth precast concrete deck panels are lifted into place and make up the bottom portion of the structural deck (Fig. 1). Once placed, a top layer of conventional reinforcing is placed over the panels and a partial-depth concrete layer is cast to finish the composite deck. Partial-depth precast concrete deck panels are extensively used in some states; for example, this forming method is applied to 85 percent of all bridges built in Texas [2]. Full-depth precast concrete deck panels are fully prefabricated units that are lifted into place and generally inter-connected by way of a longitudinal post-tensioning system (Fig. 2), although a connection without post-tensioning is also viable [3]. The deck is designed as a one-way slab between supporting beams using either mild reinforcement or prestressing. Several northeast states, working through a PCI committee, published design and detailing standards for this system [4].

Fig. 1. Partial-depth precast deck panels placed on bulb tee beams. (Source: [1])

Fig. 2. Full-depth precast panels, with leveling bolt systems and longitudinal post-tensioning ducts. (Source: [1])

Issues that need to be addressed for successful application of prefabricated bridge decks in the state of Nevada include:

- maintaining high quality control with on-site casting from local non-PCI certified contractors;
- adequate sealing of the joints between the deck panels to prevent leakage that might lead to deck cracking;
- identifying climate conditions suitable for application of partial-depth and full-depth deck panels, or best practices to overcome the negative impacts of the freeze-thaw cycles imposed in harsher climates;

- identifying the range of bridge geometries suitable for application of partial-depth and full-depth deck panels, or best practices to successfully apply precast deck panels to bridges with high skew or curvature.

III. OBJECTIVE: The objective of the proposed project is to determine appropriate applications of prefabricated bridge decks in Nevada through literature review and analysis. The application potential will consider climate effects, bridge girder system, and bridge geometries and dimensions. The project deliverables will include: 1) recommended suitable applications for prefabricated deck panels based on system characteristics, 2) selection of standard details from among existing options, and 3) design and construction guidelines based on lessons learned in other states.

IV. CURRENT PRACTICE and RELATED RESEARCH: The state of Nevada has limited experience with the application of precast deck panels. Partial-depth precast panels that were implemented in a bridge in Mesquite had performance issues, and a polymer overlay was applied to repair the bridge. However, extensive research has been conducted on the national level to develop and test design and connection details for partial-depth and full-depth precast deck panels [e.g. 3-5]. In addition, several states have significant experience in the application of these deck panels, and have documented lessons learned and made recommendations for best practices. For example, Utah has learned that bridges with welded tie connections between the full-depth precast panels are susceptible to joint leakage, even when a polymer overlay is added. However, the more recently adopted standard detail with mandatory longitudinal post-tensioning is performing much better [6]. Iowa DOT has successfully applied NUDECK panels with longitudinal post-tensioning and a central cast-on-site closure joint that forms the roadway crown [7].

References:

1.) Culmo, M.P. "Accelerated Bridge Construction - Experience in Design, Fabrication and Erection of Prefabricated Bridge Elements and Systems", FHWA-HI-12-013, Federal Highway Administration, 2011.
2.) Merrill, B.D. *"Texas' Use of Precast Concrete Stay-in-Place Forms for Bridge Decks",* TxDOT Concrete Bridge Conference, Fort Worth, Texas, 2002.
3.) Badie, S.S. and Tadros, M.K. *"Full Depth Precast Concrete Bridge Deck Panel Systems"* Report Number 584, National Cooperative Highway Research Program, Transportation Research Board, 2008.
4.) *"Full Depth Precast Concrete Deck Slabs",* PCINER-02-FDPCDS, Precast Prestressed Concrete Institute, Northeast Bridge Technical Committee, June 2002.
5.) Issa, M.A., Yousif, A.A., Issa, M.A., Kaspar, I.I. and Khayyat, S.Y.. *"Analysis of Full Depth Precast Concrete Bridge Deck Panels,"* PCI Journal, 43(1):74-85, 1998.
6.) Utah Department of Transportation. *"Performance of Accelerated Bridge Construction Projects in Utah as of June 2010: Lessons Learned Report"*, 2010. http://www.udot.utah.gov/main//uconowner.gf?n=4762119634528636 [Accessed 5/ 2014].
7.) Abu-Hawash, A., McDonald, N.L., Nelson, J.S., Nielsen, S., Samuelson, A. "*Accelerated Construction in Iowa",* National Bridge Conference, 2007.

V. RESEARCH METHODOLOGY: The following research tasks will be performed.

Task 1 – State-of-the-Art Literature Review on Precast Deck Panels: A plethora of information on the use of precast deck panels is available, including numerous research studies conducted for at least 20 years, as well as the experiences and lessons learned from states that have been early implementers. The intent of this task is to comprehensively review this body of information,

extract the useful information, and summarize in a form that is relevant for application in Nevada. Emphasis will be placed on identifying details and construction practices that have proven to work well in climatic conditions that are similar to those of Nevada, and to explain why other details have not turned out favorably.

Task 2 – Interim Guidelines for Application of Precast Deck Panels: Based on Task 1 findings, interim design guidelines for partial and full-depth precast panels will be developed by selecting details that would work well in Nevada, taking into account bridge geometric characteristics and climatic conditions. Detailing and construction guidelines with appropriate tolerances and illustrative numerical examples will be developed as part of this task.

Task 3 – Finite Element Analysis of Superstructures with Precast Deck Panels: Based on the interim guidelines developed, a series of superstructure configurations will be selected for further investigation using finite element analysis. The configurations will include varying degrees of skew and/or curvature. The focus of the analysis will be to assess the ability of the combined precast deck panel-girder system to provide composite bending action for both steel girders and concrete girders. The system may also be modeled with and without longitudinal post-tensioning to assess the degree of joint closure that can be provided. The analysis is expected to provide information beyond the literature review to support refinement of the guidelines.

Task 4 – Updated Design Guidelines and Final Report: The guidelines will be updated based on the results of the finite element analysis. A final report will be prepared that reports the finite element results and explains all design recommendations and guidelines.

VI. IMPLEMENTATION POTENTIAL: The nature of this research makes it a concept (Stage I) project; however, because of the extensive information available, it is anticipated that upon the conclusion of this project the technology will be ready for pilot implementation (Stage IV) or full deployment (Stage V). If necessary, follow-up laboratory tests could be conducted to examine issues identified in the research. One barrier to implementation is the lack of PCI-certified contractors in the state; however, the submitters have learned that Jensen Precast is expanding their operations in both northern and southern Nevada. Furthermore, site casting could present a viable option as well.

VII. URGENCY AND PAYOFF POTENTIAL: The project is a top priority for implementation because it will support rapid bridge deck replacement projects that can save the state time and money, as well as avoid significant inconvenience to the public. The payoff potential is high, since the project is low risk and low cost, and could support a relatively short transition to standard implementation of prefabricated bridge decks.

VIII. ESTIMATED BUDGET: This project can be conducted over an 18-month period with an estimated budget of $140,000.

IX. DATE AND SUBMITTED BY: The project statement was jointly developed by: Keri Ryan, Associate Professor (Phone: 775-784-6928, E-mail: klryan@unr.edu) and M. Saiid Saiidi, Professor (Phone: 775-784-4839, Email: saiidi@unr.edu), Dept. of Civil and Environmental Engineering, University of Nevada, Reno, MS 248, Dept. Fax: 775-784-1185. Submitted May 2014.

X. NDOT CHAMPION, COORDINATION AND INVOLVEMENT: The submitters consulted with Mark Elicegui and Troy Martin of the Structures Division to develop this problem statement. The primary NDOT champion for this project is the Structures Division. In addition, the NDOT Construction Division is a major stakeholder in this project.