MPC-395
Time Duration 2012-2013

Project Title:
Accelerated Bridge Construction in South Dakota: Pilot Study for Implementation Strategy

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South Dakota State University

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Research Needs:
Accelerated bridge construction (ABC) is a construction philosophy that seeks to minimize traffic interruption through reduced construction time, primarily through the use of prefabricated elements. The concept is gaining the momentum to become a recommended practice for bridge work on existing routes especially for bridges on heavily travelled corridors. Several research and implementation initiatives have been set in action around the U.S. including multiple projects in Utah [1,2], Washington [3-6], California [7], etc. An ABC research center has been established recently at Florida International University [8]. All these demonstrative projects on critical bridge sites had been very successful in minimizing traffic interruption to a level that is not possible with traditional construction methods (e.g. removal and replacement of a major bridge in a week [1]). A number of ABC applications are documented in Connection Details for Prefabricated Elements and Systems [9], published by FHWA in 2009. A summary of current ABC applications and experiences was presented in an "ABC Manual" [10] published recently by FHWA. The ABC methodology is quite general and can also be applied to relatively small scale projects and very typical high way bridge systems, as it was demonstrated in an Iowa DOT project (bridge over Keg Creek near Council Bluffs, Iowa) as part of The second Strategic Highway Research Program (SHRP 2). In order to achieve the time savings, implementation of ABC will involve pre-manufacture of modular bridge components [11] and need additional resources and special planning considerations during construction (such as special equipment [12, 13] and site management plan). These requirements tend to drive up the cost of the project when compared to traditional construction. Thus ABC is most beneficial when the potential

traffic volume affected by the project is high. It is hypothesized in this study that given the project condition and current viable ABC techniques, there exist a threshold traffic volume and composition that must be exceeded in order to reap benefit from ABC implementation. This threshold value will depend on the nature of the traffic, significance of the road corridors, and the availability of immediate detour options. For most areas in South Dakota, it is very likely that this threshold traffic will not be exceeded. Thus the implementation of ABC in South Dakota must be planned carefully to ensure cost efficiency. Currently there have been guidelines used by other DOT's to assess the necessity of ABC (e.g. ABC rating system used by Utah DOT). But the effectiveness of these procedures has not been fully investigated. A quantitative approach to support decision making on ABC implementation in South Dakota has not been developed.

Research Objectives:

1. Identify a quantified benefit indicator to represent ABC implementation cost-benefit ratio considering project constraints such as traffic volume and site condition.
2. Develop a procedure that can be followed to evaluate ABC implementation benefit indicator for candidate bridges on the South Dakota highway system.
3. Using the proposed procedure to develop recommendations for representative sites (identified by SD Dot) in South Dakota for ABC implementation.

Research Methods:

The research methods that will be employed to achieve the project objectives include three main components:

1. *Literature review and in state survey:* The existing literature and examples on successful ABC projects will be reviewed systematically in two steps. The first step will include general review on overall ABC methods and techniques. The 2nd step will be focused on the techniques that can be practically implemented at the potential SD sites. Surveys to major contractors in South Dakota will be conducted to further confirm the availability of resources needed to implement ABC. The cost associated with ABC will be an important part of the survey; costs associated with traditional methods will also be investigated.

2. *Traffic interruption impact evaluation:* Network analysis functions in GIS programs will be used to analyze possible detours that can be created given the closure of the bridges. The potential costs associated with the closure and delay will also be evaluated. Traffic data for the bridge site will be combined with network analysis results to generate the potential cost to the public.

3. *Decision making support:* As the potential costs and savings of ABC will not be deterministic, probabilistic decision theory will be implemented to develop cost-benefit indicator as random variable conditioned on traffic and site conditions. It is expected that the cost-benefit indicator will be calculated relative to compared to cost associated with the option of traditional replacement procedures, then be compared to a threshold value in order to generate statistics that can guide the decision making on ABC implementation for a given site.

Expected Outcomes:

A systematic analysis procedure will be developed to evaluate the cost-benefit ratio of implementing ABC given traffic information and project details. This procedure will incorporate end-user costs into decision making process of bridge replacement or construction project quantitatively. The procedure will be applicable to a variety of traffic and span conditions and will be applied to selected sites in South Dakota to evaluate their ABC feasibility.

At the end of the study, a comprehensive report will be published to document the research procedures and results. A guidebook will be developed to summarize the decision making procedures on ABC implementation so that the research results can benefit the practice. Recommendations on implementing ABC for potential major sites (identified by SD DOT) in SD will be developed. If ABC is found to be desirable for a given site, suggested ABC techniques will also be presented. The guidelines will also be presented to decision makers and engineers in form of a power point presentation.

Relevance to Strategic Goals:

1. State of good repair
2. Economic competitiveness

Educational Benefits:

The research will involve one full time graduate student who will acquire valuable research experience in the area of ABC. By the end of this research project, it is expected that a guest lecture for transportation engineering classes will be developed focusing on introducing the ABC concepts and techniques to undergraduate students as well.

Work Plan:

The proposed research objectives will be accomplished through following tasks

Task 1: General literature review

Comprehensive literature review on ABC techniques and implementation examples will be reviewed. Research reports will be the focus of this review process in order to gain a solid understanding of the current state-of-the-art for ABC. Successful projects in other state DOTs will also be reviewed.

Task 2: Research meeting with SD DOT to identify potential sites

A research meeting with SD DOT engineers will be held. Potential sites for future bridge construction and replacement work in South Dakota will be identified. The research team will work with the SD Dot bridge design office to identify a group of major bridge sites that may benefit from ABC in the next 10 years. Available traffic data at these sites will also be collected for later use.

Task 3: Specific literature review

With the potential bridge sites given in Task 2, the design and construction practices for ABC that has the potential to be applied to these sites will be identified. The review materials for this step may include journal and conference publications, research reports, online resources, and surveys. It will be ideal to find existing ABC projects that are similar to the sites on interest.

Task 4: ABC implementation cost evaluation
A series of surveys will be conducted with major contractors, designers, and pre-fabricators in South Dakota to evaluate the feasibility of the ABC options identified in Task 3. The survey will be focused on system availability and costs. An alternative traditional construction method will also be included in the survey in order to benchmark the additional cost for ABC.

Task 5: GIS network analysis
Network analysis function in Arc-GIS software will be used to develop possible detours when the bridge is shut down for construction or repair. The detour analysis results from GIS will be combined with traffic data obtained in Task 2 to generate the economic impact of road closure to the public.

Task 6: Cost-benefit evaluation
Develop a statistical model to combine the data obtained from Task 4 and Task 5. The cost-benefit ratio of the ABC option will be generated conditional on multiple factors including bridge type, traffic condition, site condition, existing and new bridge design, overall location of the bridge (GIS location), and the actual ABC techniques to be used. Currently available ABC techniques will be considered as options for this analysis. The model will provide the user with a consolidated indicator based on comparison of the additional benefit attained though ABC and the cost of implementing special construction. The final decision making can then be conducted through comparison between the indicator and a pre-defined threshold level (selected by the end user).

Task 7: Potential sites analysis for SD
The analysis procedure outlined in Task 6 will be applied to the potential sites identified in Task 2. The results from the analysis will be directly applicable to the replacement projects on these sites.

Task 8: Develop lecture materials on ABC for an undergraduate transportation class.
A guest lecture will be prepared on topic of ABC that summarizes the research work done in this study. The purpose of developing the lecture is to expose the undergraduate civil engineering students to the latest advancement in bridge construction techniques.

Task 9: Final report and technology transfer.
A comprehensive report will be prepared which summaries the literature review, research methodology, findings, conclusions and recommendations. The guideline will also be prepared. The project PI's will present the research procedures and findings to interested decision makers and engineers in South Dakota.

Project Cost and Duration:
Duration: 12 months
Total Project Costs: $55,000
MPC Funds Requested: $25,000
Matching Funds: $30,000 Source of Matching Funds: SDDOT

TRB Keywords:

Accelerated bridge construction, cost-benefit ratio, South Dakota, Bridge replacement

References:

[1] Ahmad A. Ardani, Rukhsana (Shana) Lindsey, and Jagannath Mallela (2010) "One-Weekend Job Rapid Removal and Replacement of 4500 South Bridge in Salt Lake City, Utah" Transportation Research Record: Journal of the Transportation Research Board, No. 2200, Transportation Research Board of the National Academies, Washington, D.C., pp. 12–16.

[2] Park, R. (2011). "ABC in Utah, Accelerated Bridge Construction: Research, Design, and Practice Workshop" Presented at the 90th Annual Meeting of the Transportation Research Board, Washington, DC.

[3] Bijan Khaleghi (2005) "Use of Precast Concrete Members for Accelerated Bridge Construction in Washington State" Transportation Research Record: Journal of the Transportation Research Board, CD 11-S, Transportation Research Board of the National Academies, Washington D.C., pp. 187–196.

[4] Bijan Khaleghi (2010) "Washington State Department of Transportation Plan for Accelerated Bridge Construction" Transportation Research Record: Journal of the Transportation Research Board, No. 2200, Transportation Research Board of the National Academies, Washington, D.C., pp. 3–11.

[5] M. Lee Marsh et al. (2011) "Application of Accelerated Bridge Construction Connections in Moderate-to-High Seismic Regions" transportation research board Washington, D.C.

[6] Khaleghi, B. (2005). "Use of Precast Concrete Members for Accelerated Bridge Construction in Washington State." Transportation Research Board—6th International Bridge Engineering Conference: Reliability, Security, and Sustainability in Bridge Engineering, Boston, MA, pp. 187–196.

[7] Chung, P., Wolfe, R., Ostrom, T., and Hida, S. (2008). "Accelerated Bridge Construction Applications in California—A Lessons Learned" Report. Caltrans. Sacramento, CA.

[8] Florida International University, Accelerated Bridge construction center, http://www.abc.fiu.edu/

[9] Culmo, M. (2009). "Connection Details for Prefabricated Bridge Elements and Systems." Report No. FHWA-IF-09-010. Federal Highway Administration, Office of Bridge Technology. Washington, DC.

[10] Michael P. Culmo (2011) “Accelerated Bridge Construction: Experience in design, fabrication, and erection of prefabricated bridge elements and systems” U.S. Department of Transportation, Federal Highway Administration, Washington, DC.

[11] PCI Northeast. (2006). “Guidelines for Accelerated Bridge Construction using Precast/Prestressed Concrete Components” Report No. PCINER-06-ABC. Precast/Prestressed Concrete Institute, Chicago, IL.

[12] Erik S. Rosvall, Marvin W. Halling, and Rukhsana Lindsey (2010) “Induced Stresses from Lifting and Moving Highway Bridges with Self-Propelled Modular Transporters” Transportation Research Record: Journal of the Transportation Research Board, No. 2200, Transportation Research Board of the National Academies, Washington, D.C., pp. 17–25.

[13] Zhu, P., and Ma, Z. J. (2010). “Selection of Durable Closure Pour Materials for Accelerated Bridge Construction” Journal of Bridge Engineering, 15(6), pp. 695–704.