DEVELOPMENT OF GUIDELINES TO ESTABLISH EFFECTIVE AND EFFICIENT TIMELINES AND INCENTIVES FOR ABC

Quarterly Progress Report
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ACCELERATED BRIDGE CONSTRUCTION
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Submitted to:
ABC-UTC
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D. PROPOSAL ABSTRACT:

Accelerated Bridge Construction (ABC) techniques have a great potential to minimize the traffic disruptions during the bridge repairs/replacements, promote traffic and worker safety, and improve the overall quality of the built bridges. Despite the major advances in design and construction of ABC techniques, transportation agencies are still hesitant about using ABC techniques largely due to perceived risks during construction and higher initial costs.

ABC techniques are perceived to add a cost premium to replacement of bridges. As such it's important to not only consider the initial costs (cost of material and labor required to design and construct the structure) but also the societal costs associated with the construction activities and attendant traffic disruptions. Many cases of implementation of the ABC techniques show that the time saved due to shorter construction duration in addition to the lower cost and higher quality of the standardized design approaches implemented in bundled designs would make up for the higher initial costs.

In order to find a balance between the additional initial costs and the decreased indirect costs in such a way that the total cost of ABC application is optimized for each specific project or for a bundle of projects, this proposal develops a decision-making framework that accounts for closure time classification (using the FHAW standard of mobility impact time to evaluate the closure time impact state), network reliability, traffic redistribution (re-assigning the daily traffic flow of the network and residual road capacity at retrofit links), direct and indirect cost calculation, and different incentivization mechanisms to balance between different ABC techniques and conventional construction .

E. DESCRIPTION OF RESEARCH PROJECT

E1 PROBLEM STATEMENT

Reduction of road closure times, traffic disruption and user costs, in addition to improvements in construction quality and utilizing prefabricated elements, are all attractive qualities of the implementation of ABC techniques that encourage the transportation agencies to use the technique for repair and replacement projects. ABC would help minimize onsite construction activities, result in decreasing the long-term presence of contractor related equipment, labor, and staging areas and consequently can decrease driver distractions and traffic disruptions that reduce the safety and mobility efficiencies of the transportation network.

The total cost of bridge replacement includes the direct costs which are commonly identified as the design, materials, and construction cost and indirect costs that are costs associated with the lower quality of network performance (due to traffic delays or longer reroutes) and opportunity losses that represent the socio-economic (and event environmental) losses due to the closure. The total cost of construction of the bridge is the addition of these two. One should note that some traffic safety issues also lead to inevitable costs, such as accidents occurring because of partial lane closures and drivers unfamiliar to the detour route.

This underlines the importance of implementing an effective strategy to repair/replace the bridges in the shortest possible time. Oftentimes long detours present opportunities where the use of ABC methods can provide more practical and economical solutions to those available with conventional construction methods.

Two time metrics are used when determining the amount of impact to the road user: i) Onsite construction time, which is the period of time when a contractor alters the project site location until all construction related activities are removed. This includes, but is not limited to, the removal of maintenance of traffic items, construction materials, equipment, and personnel. And ii) mobility impact time which is any period of time the traffic flow of the transportation network is reduced due to onsite construction activities (FHWA).

The mobility impact time is classified to five tiers: 1) traffic impacts within 1 to 24 hours, 2) traffic impacts within 3 days, 3) traffic impacts within 2 weeks, 4) traffic impacts within 3 months and 5) overall project schedule is significantly reduced by months to years. Each tier dictates the type of technology the owner will use. For example, a Tier 1 project would use a slide-in construction method, whereas a Tier 3 project would require on-site assembly of prefabricated bridge elements and systems

The main objective of the proposed project is two folds: 1) Provide guidelines to evaluate the direct and indirect costs (traffic delays and opportunity losses) under following conditions: conventional construction, only ABC techniques, only incentivizing strategies, and combination of ABC and incentivizing strategies. 2) Develop a decision-making framework to compare the total costs and durations of each of the candidate techniques to optimize for the lowest cost and construction duration techniques accordingly. Here, ABC techniques refer to foundation and wall elements, rapid embankment construction, prefabricated element and systems, self-propelled modular transporters (SPMTs), slide-in construction, longitudinal launching, horizontal sliding or skidding, and fast tracked contracting.

E.2. CONTRIBUTION TO EXPANDING USE OF ABC IN OPEARTIONAL PRACTICE

ABC provides an opportunity to use innovative planning, design, material and construction techniques in a safe-cost effective manner to reduce the onsite construction time. It results in improved constructability, project delivery time, construction quality, and work zone safety. It is perceived that the ABC technique results in higher construction costs but because of the reduction on traffic reroutes, on site construction time, and environmental impacts it helps with the total project cost (which includes the indirect costs). Depednign on the construction technique adopted under the umbrella of ABC, the duration of the project could vary. There has been numerous efforts that address the prioritization and selection of candidate bridges for ABC application. However, no studies have looked into the effect of the selected ABC technique on duration and total cost of construction. This research aims to address the current gap in selection of a suitable ABC technique depending on the specific characteristics of each site. This project will provide a pathway to analyze the total cost of construction via different strategies and propose a decision making framework to optimize the cost and duration of ABC projects in each site.

E.3. RESEARCH APPROACH AND METHODS

To achieve the goals of the project, three major steps will be taken: i) A decision-making framework and system will be developed and used to estimate the cost and time difference among various construction strategies. ii) the decision-making system will be implemented for the state of Iowa bridges as a test-bed and its effectiveness in operational conditions will be evaluated, and iii) the framework and analysis system can be extended when other innovation construction methods are imported into projects. After this project, the whole analysis processes can be improved as a direction tool for the operational construction.

E.4. DESCRIPTION OF TASKS TO BE COMPLETED IN RESEARCH PROJECT

The proposed research will develop a holistic decision making framework to optimize the project duration and total costs. The following tasks will be executed to achieve the project goals:

Task 1- Literature review:

The project will start with a thorough literature review on: i) Available ABC techniques and FHWA ABC requirements (2011) [1,2]; ii) the cost and duration of the ABC projects through the FHWA Accelerated Bridge Construction Project Exchange (a database of 100 ABC projects throughout the US), iii) data and experiences from Design-Build (DBE) projects from Missouri "Safe and Sound" and public-private partnership (P3) projects from Pennsylvania [4], and iv) the best practices for indirect costs analysis [5,6].

<u>Progress in this cycle:</u> The literature review is undergoing. Engineers and contractors involved in the Missouri "Safe and Sound" and public-private partnership (P3) projects from Pennsylvania have been identified for the surveys. The team has scoured through the data from more than 100 existing ABC projects and collected data for construction techniques, time, and cost (50%).

Task 2: Identify different construction techniques and contracting mechanisms

The common approach in ABC is to use various combinations of prefabrication and effective contracting strategies to achieve the accelerated onsite construction timeline and minimize costs. In order to reduce and control the closure time, different bidding strategies and incentive/disincentive strategies such as "A" + "B" (bid items + Critical Duration) and "A"+"B"+"C" (bid items + bridge closures + single lane closures) are utilized.

In this project the cost and closure time of each construction technique will be evaluated. Furthermore, useful mechanisms to establish incentives/disincentives will be provided.

Task 3: Investigate the bridge closure status to estimate the indirect costs

Direct cost is recognized as the sum of construction cost and costs resulted from ABC technique application (mentioned at Task 2). The indirect cost -unit of hours or days- includes the cost caused by traffic delay and changes in travel demand before and after retrofit in addition to the opportunity losses, socio-economic and environmental impacts of the closure. The direct costs are normally straightforward to estimate and are considered as a one-time value. The indirect costs on the other hand are accrued during the full/partial closure of the bridge. The current practice is to only consider the traffic impacted by diversion as the indirect cost, in which case would result in a linearly increasing function overtime. Considering other factors such as the socio-economic impacts of the closure or environmental effects, would result in a nonlinear increase in indirect cost. This project will examine the possibility of using more holistic metrics such as social return on investment (SROI) to estimate the indirect costs.

Progress in this cycle: A data mining technique is being developed to extract the closure times for different projects. (20%)

Task 4: Optimize the total cost and select the best ABC technique

The cost effective scheduling is one of the most important aspects of the construction project management. The selection of any mode of execution for each project leads to a distinct time and cost for that project. The combination of various possible execution modes produces several project plans where each project plan has a unique duration and cost (Schematic figure below). To find the most optimized approach a linear mathematical optimization model will be developed, which minimizes project total cost and takes into account the project duration. The model guarantees the optimal solution, in which precise discrete activity time-cost function is used. Details of model formulation will be illustrated on an example project.

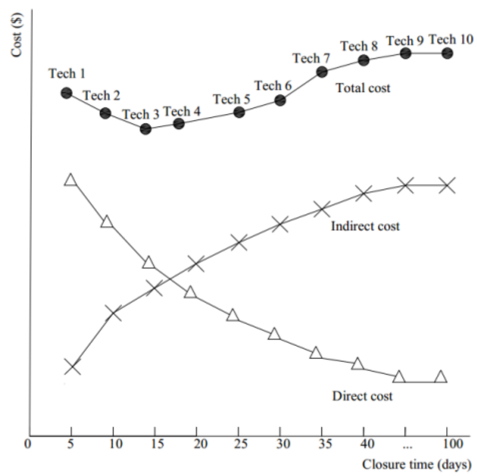

Figure: Project Time-Cost Curve

Task 5 – Final report and an executable guideline for state DOTs

A final report will be developed that documents the entire project with the accompanying guidelines for the construction technique selection.

E.5. EXPECTED RESULTS AND SPECIFIC DELIVERABLES

The primary deliverable will be a set of guidelines and best practices to select the most optimized construction technique.

E.6. TIMELINE (GANTT CHART)

	Year 1												Year 2											
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Task 1	■	■	■	■																				
Task 2				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
Task 3				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
Task 4													■	■	■	■	■	■	■	■	■	■	■	■
Task 5																							■	■

F. DISCUSSION OF PERTINENT COMPLETED AND IN PROGRESS RESEARCH.

FOR PROJECTS CO-FUNDED BY OTHER SOURCES, COPY OF THE COFUNDED PROPOSAL SHOULD BE ATTACHED AS AN APPENDIX.

404-17-35: An Integrated Project- to Enterprise-Level Decision Making Framework for Prioritization of Accelerated Bridge Construction

A metric used by the World Bank to prioritize funding for aid in developing countries: social return on investment (SROI) is implemented to estimate the value of investment in ABC techniques to reduce social, economic, and environmental impacts to the road network users. The Missouri Department of Transportation (MoDOT) completed the replacement of more than 500 bridges as part of the “safe and sound” project using the ABC techniques. Five counties mostly in the agricultural part of Missouri were used as the case study and estimated the benefits/costs of the utilization of ABC. The results showed that using holistic metrics such as SROI that consider a socioeconomic perspective of project impact can be effectively used as a prioritization tool for future projects.

G. DESCRIBE THE PLAN FOR COOPERATING WITH OTHER ABC-UTC CONSOURTIUM UNIVERSITY MEMBERS

As part of this work, the research team will form a Technical Advisory Committee (TAC) to oversee and guide the work. Each of the other ABC-UTC consortium members will be asked to nominate a member to serve on the TAC. The TAC for this project shall meet at least once per quarter (to be scheduled in advance) such that the research team can provide regular and timely updates on project status, problems, and results. The team at ISU has also identified colleagues in Construction Engineering and Transportation

Engineering that would be able to collaborate with on different aspects of this project. o ensure a streamlined collaboration, monthly web meetings will be scheduled where the two-teams will share their progress and findings.

H. KEY WORDS

Bridge closure, ABC, Decision making, Incentive/disincentive, Traffic delay, Direct and indirect costs

I. LITERATURES CITIED

1. Accelerated Bridge Construction, Federal Highway Administration Official Website of U.S. Department of Transportation.

2. Accelerated Bridge Construction: Experience in Design, Fabrication, and Erection of Prefabricated Bridge Elements and Systems, FHWA, Pub. No. HIF-12-013, November 11, 2011.

3. PBES Cost Study: Accelerated Bridge Construction Success Stories, FHWA, 2006

4. P. Barutha, N. Zhang, A. Alipour, C. Miller, and D. Gransberg, Social Return on Investment as A Metric to Prioritize Use of Accelerated Bridge Construction in Rural Region, Transportation Research Board, Washington DC, January 11, 2017.

5. Furtado, M.N., and A.A. Alipour. Cost Assessment of Highway Bridge Network Subjected to Extreme Seismic Events. In Transportation Research Record: Journal of the Transportation Research Board, No. 2459, Transportation Research Board of the National Academies, Washington, D.C., 2014, pp. 29–36.

6. Shinozuka, M., Y. Zhou, S. Kim, Y. Murachi, S. Banerjee, and S. Cho. Socio-economic Effect of Seismic Retroft Implemented on Bridges in the Los Angeles Highway Network. Division of Research and Innovation, California Department of Transportation, Sacramento, 2008.

J. STAFFING PLAN (Should correspond with budget)

This work will be conducted by Dr. Alice Alipour and Dr. Jennifer Shane.