DEVELOPMENT OF GUIDELINES FOR SELECTION OF SUBSTRUCTURE FOR ABC PROJECTS

Quarterly Progress Report
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ACCELERATED BRIDGE CONSTRUCTION
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Submitted to:
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1. Background and Introduction

The concept of Accelerated Bridge Construction (ABC) using precast and prefabricated bridge elements is gaining popularity among transportation agencies primarily to minimize traffic delays and costs. Some other benefits associated with the ABC techniques are reduced on-site construction time, reduced impact on mobility, better work zone safety and improved quality. Previously, the focus of the ABC techniques was largely limited to specific prefabricated bridge elements such as bridge decks and pier caps. However, with the recent advancement in construction methods, many projects are using precast and prefabricated elements for other bridge elements such as substructures and foundations. In case of a new bridge construction, design of substructure by ABC technique will allow rapid construction to accommodate superstructure installation. For replacing an existing bridge, the substructure construction by an ABC technique will cause minimum interference with operation of the existing bridge. Currently, a number of potential ABC technologies are available to design and construct bridge substructures and foundations. A guideline for substructure and foundation, being developed in this project, will help the transportation agencies to select the suitable techniques for their specific needs.

2. Problem Statement

A number of previous studies have focused on the use of precast, prefabricated bridge superstructure elements. On the contrary, only few studies can be found in the literature focusing on the design and construction of substructure and foundation by the ABC method. Most of the time it is assumed that the substructure already exists and is ready to receive the superstructure. In reality, however, substructure construction can be the most time-consuming part of bridge construction. There is a need to have specific guidelines for design and construction of substructures and foundations for new bridges to obtain full benefits of the ABC method. Also, guidelines are needed for consideration of reusing, strengthening, and modifying substructure and foundations of an existing bridge. In addition, new, innovative and non-interruptive substructure and foundation design methods need to be explored and documented.

3. Research Approach and Methods

The overall approach of this project is to conduct a comprehensive literature search and document the ABC technologies available for design and construction of substructure and foundation. The current evaluation techniques of an existing substructure and foundation and problems associated with the evaluation techniques will also be investigated for replacing an existing bridge. Also, methods for strengthening or modifying an existing substructure will be discussed. The issues with the state-of-the art practices of ABC techniques for constructing a new bridge will be identified and potential solutions will be proposed based on the literature review. Attempts will be made to present few examples of new and innovative techniques of substructure and foundation construction. A survey will be conducted to find out the challenges faced by stakeholders during construction of bridge. The acceptability of new practices such as installation of prefabricated foundation elements and retrofitting will be investigated through this survey.

4. Description of Research Project Tasks

The following is a description of tasks carried out to date.

Task 1 – Develop Outline for the Guideline

Proposed task description:

An outline will be proposed as a first step of developing the guide for substructure and foundation by the ABC method. The outline will broadly encompass the topics related to substructure and foundation by the ABC method such as ABC definitions, design methodologies for new and existing bridges, materials for bridge construction by the ABC method, evaluation techniques of existing bridge elements and new methods of substructure and foundation construction. The outline will be updated periodically throughout the project to prepare a comprehensive guide.

Description of work performed up to this period:

An initial outline has been developed by the combined research team from FIU and OU. The outline will be updated periodically, as noted above.

Task 2 – Conduct Literature Search on Pertinent Topics

Proposed task description:

A comprehensive literature review will be conducted focusing on the design and construction of substructure and foundation by ABC techniques. Sources of literature include, but not limited to, TRB, FHWA, NCHRP, and DOTs. Other sources such as society journals will be consulted. Moreover, national and international conferences, symposia and workshops will be reviewed. The literature review will be continued throughout the duration of this project.

Description of work performed up to this period:

The following articles are examples of the reviewed papers during the reporting period.

i. Aktan and Attanayake (2015) evaluated the accelerated bridge construction techniques used by Michigan Department of Transportation (MDOT) and developed guidelines for foundation construction while an existing bridge is in service. A number of case studies related to foundation problem of bridges were presented. Based on these case studies, advantages and difficulties of using different foundation types under given constraints and impact of foundation installation on the stability of the existing foundations were presented in this report. A scoping flowchart was also developed and presented for foundation reuse, retrofit, or replacement decisions. In this report, conceptual examples of foundation reuse, retrofit, and replacement were included for future use.
ii. Hertlein and Walton (2000) discussed the use of several nondestructive test (NDT) methods available for assessment of deep foundations under buildings and bridges. Two NDT methods, namely impulse response test and the parallel seismic test were used for the evaluation of foundations. The working principles of the NDT methods were

discussed in this study. A number of case studies were presented where NDT methods were used to modify the original foundation design to include reuse of existing foundations. The cost savings associated with the projects involving rehabilitation or expansion of existing structures or reuse of existing foundations in new structures using NDT methods were also evaluated.

iii. Kase and Ross (2003) evaluated the integrity of foundation structures of transportation facilities and infrastructures by using a non-destructive test, called cross-hole sonic logging (CSL). It was found that three-dimensional representation by CSL provided greater detail of the interior structure making defects easier to classify. Two case studies for deep foundation integrity assessment using CSL were presented in this study. It was concluded that the use of CSL would help design engineers to better understand the complex geologic environment of the site.

iv. Culmo (2011) prepared a manual on the state of the art practices of accelerated bridge construction methods. A number of foundation construction methods such as continuous flight auger piles, geosynthetic reinforced soil integrated bridge system (GRS/IBS) and prefabricated pier cofferdams were explained. Also, different types of foundation elements commonly used on ABC projects were discussed. In case of re-using foundations for superstructure replacement projects, it was suggested to investigate the foundation capacities before use. Furthermore, a brief discussion on the challenges during construction of foundation for bridges was presented in this manual.

v. Khaleghi (2010) explained the use of precast concrete bridge systems as an effective and economical design solutions for new and existing bridge construction by accelerated bridge construction method. The seismic response of the bridges with precast components was also discussed. The use of precast bent caps was found to be cost-effective and safe. Due to the lack of monolithic action between the superstructure and the bent cap in precast, prestressed concrete beam systems, the foundations were required to carry substantially increased load. It was observed that a moment connection between the superstructure and substructure may resulted in less expensive foundations. Also, the Washington DOT strategic plan and decision-making criteria for accelerated bridge construction project were discussed in this paper.

Task 3- Identify Stakeholders and Conduct Survey.

Proposed task description:

A survey will be conducted to find out the state of the art practices of foundation design and construction methods by the ABC method. Also, the challenges faced by engineers during construction of foundation will be investigated. The acceptability of new practices such as installation of prefabricated foundation elements and retrofitting will be investigated through this survey. The questionnaire will be disseminated among DOTs and personnel involved in research using the ABC method.

Description of work performed up to this period:

A survey questionnaire form is being prepared. The questionnaire will be disseminated as soon as the questionnaire form is ready, and the stakeholders are identified.

Task 4- Analyze Literature Search and Survey Results

Proposed task description:

The literature reviewed for this project will be summarized and analyzed in order to prepare the guidelines for this project. A report will be prepared on the survey feedback and will be included in the final guideline.

Description of work performed up to this period:

Not pursued during this reporting period.

Task 5- Identify Issues and Potential Solutions

Proposed task description:

Based on the literature review and survey results, issues with the state-of-the art practices of ABC techniques for constructing bridge foundation and substructure will be identified and potential solutions will be proposed.

Description of work performed up to this period:

Not pursued during this reporting period.

Task 6- Develop Draft Guideline

Proposed task description:

One of the deliverables from this project will be a draft guideline on design and construction of bridge foundation and substructure by ABC techniques. The guideline will be based on the literature search and survey results and will cover the topics mentioned in Task 1.

Description of work performed up to this period:

Not pursued during this reporting period.

Task 7- Prepare Final Report

Proposed task description:

A final report will be prepared based on the outcome of the project. the final report and the draft guideline will be submitted to the ABC-UTC and other professionals for further review.

Description of work performed up to this period:

Not pursued during this reporting period.

5. Expected Results and Specific Deliverables

At the end of the project a user-friendly guideline on design and construction of bridge foundation and substructure by ABC techniques will be available for transportation authorities, engineers and other stakeholders. The specific deliverables from this project will be:

i. Progress reports at the end of every quarter
ii. A draft guideline on design and construction of bridge foundation and substructure by ABC techniques
iii. A final report

6. Schedule

Progress of tasks in this project is shown in the table below.

Research Task	2018												2019					
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
Task 1 – Develop Outline for the Guideline																		
Task 2 – Conduct Literature Search on Pertinent Topics																		
Task 3- Identify Stakeholders and Conduct Survey																		
Task 4- Analyze Literature Search and Survey Results																		
Task 5- Identify Issues and Potential Solutions																		
Task 6- Develop Draft Guideline																		
Task 7- Prepare Final Report																		
	Work Performed								Work to be Performed									

7. References

i. Aktan, H., & Attanayake, U. (2015). Research on evaluation and standardization of accelerated bridge construction techniques (No. RC-1618A).
ii. Hertlein, B., & Walton, W. (2000). Assessment and reuse of old foundations. Transportation Research Record: Journal of the Transportation Research Board, (1736), 48-52.
iii. Kase, E. J., & Ross, T. A. (2003, December). Quality assurance of deep foundation elements. In 3rd International Conference on Applied Geophysics, Hotel Royal Plaza, Orlando, Fla.
iv. Culmo, M. P. (2011). Accelerated bridge construction-experience in design, fabrication and erection of prefabricated bridge elements and systems (No. FHWA-HIF-12-013).
v. Khaleghi, B. (2010). Washington State Department of Transportation Plan for Accelerated Bridge Construction. Transportation Research Record: Journal of the Transportation Research Board, (2200), 3-11.