PROJECT TITLE: DEVELOPMENT OF GUIDELINES FOR SELECTION OF SUBSTRUCTURE FOR ABC PROJECTS

Quarterly Progress Report
For the period ending August 31, 2018

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ACCELERATED BRIDGE CONSTRUCTION
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Submitted to:
ABC-UTC
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1. Background and Introduction

The concept of Accelerated Bridge Construction (ABC) using precast and prefabricated bridge elements are 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 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, substructure design by ABC technique will allow rapid construction to accommodate superstructure installation. For replacing an existing bridge, the substructure construction by ABC technique will cause minimum interference with existing bridge operation. Currently, a number of potential ABC technologies are available to design and construct bridge substructures and foundations. A guideline will help the transportation agencies to select the suitable techniques for their specific need.

2. Problem Statement

A number of previous studies are available focusing on the use of precast, prefabricated bridge superstructure elements. On contrary, only few studies can be found focusing on the design and construction of substructure and foundation by ABC method as most of the time it is assumed that the substructure already exists and ready to receive the load from superstructure. However, substructure construction can be the most time-consuming work for a 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 ABC method. Also, guidelines are needed for consideration of reusing, strengthening, and modification of 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 an extensive 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 taken 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, retrofitting etc. 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 a guide for substructure and foundation by ABC method. The outline will broadly encompass the topics related to substructure and foundation by ABC method such as ABC definitions, design methodologies for new and existing bridges, materials for bridge construction by ABC method, evaluation techniques of existing bridge elements and new methods of substructure and foundation construction. The outline will be updated periodically to prepare a comprehensive guide.

Description of work performed up to this period:

An initial outline has been developed. The outline will be updated periodically, as needed.

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. AbdelSalam et al. (2010) conducted a nationwide survey of more than 30 DOTs on design and construction practices of deep foundations for bridges. It was found that about 52% of the DOTs had adopted the load and resistance factor design (LRFD) approach for the design of bridge deep foundations by June 2008, while 15% were still following the allowable (or working) stress design (ASD) approach. It was observed that the regionally calibrated LRFD resistance factors for sands and clays were either equal or greater than the AASHTO recommended values. For determining pile capacity, the α-method and the Nordlund method were found to be the most accurate method for cohesive and non-cohesive soils, respectively. From the survey, it was also observed that the DOTs' generally use dynamic analysis methods or dynamic formulas to verify the pile capacity estimated by a static analysis.
ii. Alizadeh et al. (2012) investigated the application of a controlled low-strength materials (CLSM) bridge abutment in a normal-span bridge through a full-scale laboratory test. For this purpose, a suitable CLSM mixture with optimum strength and flowability was designed. The CLSM bridge abutment was found to be capable of carrying bridge loads

with a reasonably large safety margin. With a proper design and construction, the CLSM abutments was found to withstand bridge loads with minimal deformations. Also, the CLSM abutments required a short construction time which was anticipated to save several weeks or even months compared to the conventional bridge abutments. Furthermore, the CLSM abutments were found to achieve stability without any embedment into the foundation soil.

iii. Hällmark et al. (2012) discussed different prefabricated bridge construction technologies commonly used in Europe and America. The paper presented the findings from the workshop on "Composite Bridges with Prefabricated Deck Elements" which was held in Stockholm, Sweden, in March 2009. It has been reported that prefabricating certain bridge elements would reduce the time spent at the construction site and also reduce the effects on the road users. Prefabrication of concrete decks was found to be a most common technology all over the world, however, prefabrication of piers, abutments, walls and combined steel girders and partial concrete decks could also be found in a limited scale. It was found that the composite action between the girders and prefabricated deck elements was desirable and could be achieved by casting concrete into preformed pockets attached to the girder flanges. Although not required, post-tensioning was found to be effective in achieving satisfactory performance. Authors also discussed the advantages of using dry joint to transfer lateral and vertical forces between bridge deck elements.

iv. Billington et al. (1999) presented a precast segmental substructure system which can support precast concrete girder superstructures in non-seismic regions. Authors proposed four different hollow column sizes with one basic cap shape to be used as single column, straddle and frame bents for varying heights and widths of standard bridges. A combination of pre-casting and the high-performance concrete was used to make the construction durable and attractive. Authors also explained the fabrication and erection sequences for this pre-cast system. Although the proposed substructure system was found to be expensive than the conventional system, high reuse of forms would lead to future savings and make this system economically compatible with cast-in-place system.

v. Hieber et al. (2005) discussed precast concrete systems for accelerated bridge construction and evaluated their suitability to be used within Western Washington. The connections of pre-cast system were found to be the most vulnerable element for strong earthquakes common in Western Washington. Four different types of precast concrete superstructure systems, such as full-depth precast concrete panels, partial-depth precast concrete panels, prestressed concrete multibeam superstructures, and preconstructed composite units were identified to exhibit acceptable seismic behavior. The design and construction of precast concrete pier systems, which was the combination of precast concrete columns and precast cap-beam components, were discussed in detail. Also, the connection between substructure components was reported to be critical for both constructability and seismic performance. Two general categories of connections, such as the match-cast pieces that met at epoxy-filled joints and were connected by posttensioning, and the grouted joints and spliced mild steel bars, were discussed in this report.

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 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, retrofitting etc. will be investigated through this survey. The questionnaire will be disseminated among DOTs and personals involve in research using ABC method. The FIU team is the lead of this survey.

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 guidelines will be based on the literature search and survey results. The guidelines will cover the topics mentioned in the 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. AbdelSalam, S. S., Sritharan, S., & Suleiman, M. T. (2010). Current design and construction practices of bridge pile foundations with emphasis on implementation of LRFD. Journal of Bridge Engineering, 15(6), 749-758.
ii. Alizadeh, V., Helwany, S., Ghorbanpoor, A., & Oliva, M. (2012). Rapid-construction technique for bridge abutments using controlled low-strength materials. Journal of Performance of Constructed Facilities, 28(1), 149-156.

iii. Hällmark, R., White, H., & Collin, P. (2012). Prefabricated bridge construction across Europe and America. Practice Periodical on Structural Design and Construction, 17(3), 82-92.
iv. Billington, S. L., Barnes, R. W., & Breen, J. E. (1999). A precast segmental substructure system for standard bridges. PCI journal, 44(4), 56-73.
v. Hieber, D. G., Wacker, J. M., Eberhard, M. O., & Stanton, J. F. (2005). State-of-the-art report on precast concrete systems for rapid construction of bridges (No. WA-RD 594.1). The Washington State Transportation Center, Seattle, Washington.