PERFORMANCE OF EXISTING ABC PROJECTS: INSPECTION CASE STUDIES
(ABC-UTC-2016-2-FIU02)

Quarterly Progress Report
For the period ending February 29, 2020

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ACCELERATED BRIDGE CONSTRUCTION
UNIVERSITY TRANSPORTATION CENTER

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1. Background and Introduction

Accelerated Bridge Construction (ABC) employs prefabricated bridge elements moved to the bridge location and installed in place. Accordingly, ABC reduces many uncertainties associated with construction processes and performance during service life. It also improves the life cycle cost by reducing construction time and traffic interruptions, better control over schedule, and normally by the higher quality of elements resulting in better life-cycle performance. Nevertheless, prefabricated elements need to be made continuous using cast-in-place joints. ABC “closure joints” connecting deck elements to each other and to the bridge girders have greater exposure to degrading environmental effects, and often there is more focus on their evaluation. These joints, expected to become serviceable quickly can therefore be viewed as critical elements of the ABC bridges. Instances of defective (leaky) joints have been reported, and concerns have been raised about the long-term durability of the joints. The long-term deflections and environmental loading can only exacerbate this situation. These may overshadow the many advantages of ABC specifically as life-cycle performance and costs are concerned. Hence, there have been questions on the long-term performance of ABC bridges. There have been limited investigations by some states to monitor the ABC bridges for determining their performance. ABC-UTC, through a collaborative effort by partner universities, is planning to embark on a coordinated and extensive inspection program to inspect several bridges in various states. The inspection protocol will be prepared by ISU, and all five partner universities will inspect a minimum of two bridges in their respective state. The results will be compiled and published on ABC-UTC website and will become available to outside users and researchers.

2. Problem Statement

Accelerated Bridge Construction (ABC) is a method in which bridge components are fabricated at a precast plant or near the construction site and then installed at the bridge site. Using prefabricated bridge elements in ABC methodology has many benefits over the conventional cast-in-place method, including among others, high-quality plant production under tight tolerances, low maintenance cost, reduced construction time at the site and reduced traffic interruption. In the meantime, the prefabricated elements need to be connected to each other using joints that are established at the site. Often, the ABC joints contain reinforcing bars and enclosures of various shapes that in some cases create congestion. This makes the ABC joints more vulnerable to defects and damages, and higher potential to perform poorly. Nevertheless, prefabricated elements themselves can also be prone to defects and performance flaws, let alone with lower potential. Literature with a focus on performance of ABC bridges are very limited. Perhaps the most detailed investigation on the evaluation of performance of ABC closure joints has been performed by Utah Department of Transportation [1]. Shrinkage cracks in blockouts has been reported after construction. The investigation also found that the major cause of the damages was the selection of an improper concrete mix. The report also mentioned bleeding of the excess water in concrete that contributed to increase in shrinkage (Figure 1). In another case, shrinkage crack in several blockouts were observed and selection of wrong construction materials was blamed as the major cause of the defect.
Other investigations have been conducted for evaluation of different types of cracks in closure joints. Reflective cracking is a type of crack that initiate from sharp corners and cold joints inside the deck, because of stress concentration and/or shrinkage, and finds its way to the surface through wearing surface or other upper layers. Longitudinal cracking along linear joints is

another type of damage which in turn causes leakage issues for closure joints. Leakage through joints and cracks itself become a cause for corrosion of reinforcement within the closure joints. One of the first sources pertinent to damages to closure joints in side-by-side box-beam bridge superstructure is a paper by Attanayake and Aktan [2]. They concluded that longitudinal reflective cracking is prevalent among all side-by-side box-beam bridges, regardless of the age of bridge constructions. For this type of bridges, cracks appear along the beam-shear key interface within two to three days after grouting the joints. These cracks were closed after post-tensioning but were still visible. Additionally, they noted that at about 15 days after deck placement, and often before the deck is subjected to live load, reflective cracks appeared in the deck. The cause of cracking was inferred to be environmental and intrinsic loading such as temperature variation and drying shrinkage. The cracking at joints resulted in leakage of water and corresponding damages shown in Figure 1. It is realized that ABC superstructures regardless of the type of closure joints are prone to surface discontinuities and corrosion of the embedded reinforcement.

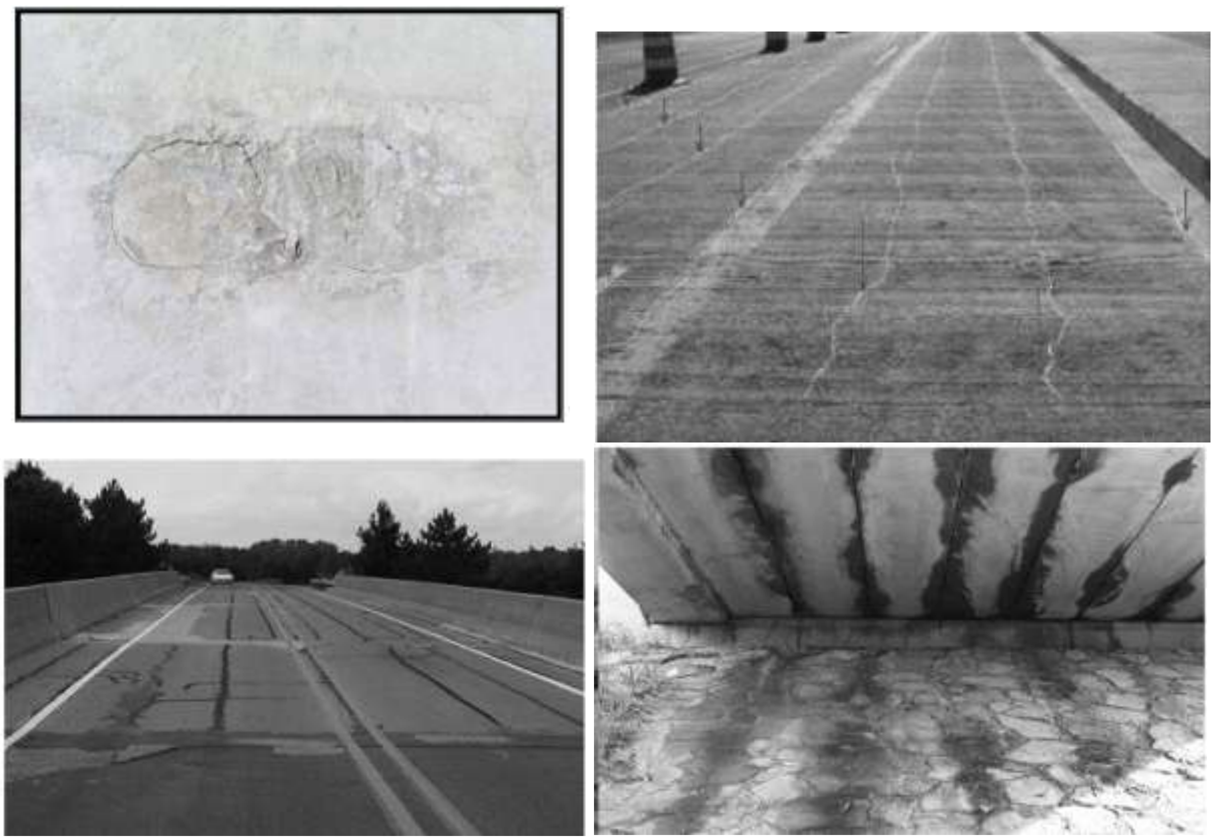


Figure 1: Examples of defects in ABC closure joints; shrinkage due to the excess water in concrete (left) [1], and longitudinal deck cracking of ABC closure joint (right) [2].

According to data collected by Accelerated Bridge Construction University Transportation Center (ABC-UTC) from the US State Departments of Transportation (Garber and Shahrokhi, 2018), the prevalent defects observed in bridge decks using ABC are cracks accompanied usually with efflorescence and leakage. Based on the reported survey, most of these problems were observed in the connections between deck panels and between deck panels and piers or abutments. Therefore, monitoring and performance evaluation of joints, particularly closure joints, should be emphasized.

3. Objectives and Research Approach

The primary objective of this project is to collect much needed information on performance of in-service ABC bridges. This will help the designers and owners to avoid problematic details or seek means to improve the performance. The inspection protocol will be developed by ISU to facilitate for a consistent data collection among all partner universities. However, it is envisioned that inspection will include routine visual inspection, special inspection of certain details, and application off NDT methods wherever needed. The results will be compiled in a format for effective recording and will be reported accordingly.

It will be attempted to recognize and document differences in design, construction and detailing for the ABC bridges subject to this inspection program in comparison with non-ABC, conventional bridges with similar geometric and design features. The research team will also try to collect as much as possible prior inspection results as well as construction records for verifying any construction-phase and later issues with the specific ABC system used in these bridges.

Non-destructive testing (NDT) methods have been commonly used for inspection of bridges in general. Some of these methods are used for localized detection of damages in bridge elements, and some can be used further to determine global damage in the bridge structure [3]. A review concentrating on NDT techniques applicable to ABC closure joint found the top five NDT techniques most applicable to closure joints to be Impact Echo, Ground Penetrating Radar, Ultrasonic, Infrared Thermal Imaging, and Impulse Response methods. All but one of these methods are available to the research team and will be used for inspection if needed.

4. Description of Research Project Tasks

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

Task 1 – Communicate with other Universities for establishment of test protocol

The research team will communicate and exchange information for development of an effective inspection protocol by the lead university. This task should also generate the inspection forms to be used during site inspection activity.

ISU generated a series of test protocols for the inspection program and communicated with the other universities. The protocols were adopted directly from FHWA LTBP program and amended for application to ABC bridges.

Task 2 – Identify candidate bridges to be inspected

Through communication and coordination with the State DOT officials, two ABC bridges will be selected that are more representative of typical state ABC bridges in regards with age, type, geometry, and traffic and environmental factors. Any information available on prior inspections and construction records will also be sought to be reviewed in conjunction with the planned inspection results.

Database of ABC bridges in the state of Florida was reviewed at ABC-UTC Database to identify bridges for inspection. Five bridges were identified in the first stage;

1- 2007 - I-10 Bridge over Escambia Bay (Replacement Spans)
2- 2006 - Graves Avenue over I-4
3- I-10 Bridge over Escambia Bay (original emergency repair)
4- 1990- Edison Bridge, Constructed 1990 (D1 and D7)
5- St. George Island Bridge (Bryant Patton Bridge) completed in 2004. (D3)

The following criteria was communicated for appropriateness of the bridges for inspection;

- ABC superstructure, substructure or combination
- Aged for some years. I realize that ABC bridges may be mostly newer, but older the better
- Easily accessible for inspection (from top and bottom)- we have limited budget and cannot afford special access equipment and crew, unless Districts would lend us that assistance.
- Easier MOT requirements- I realize that unless FDOT or Districts are interested in a specific case, busy roads would not be good candidates. We will also need assistance from districts for MOT.
- Closer distance to FIU (if possible)
- Bridges for which some issues have been reported previously could be good candidates

Although these bridges represent good candidates for inspection, the accessibility and the interstate traffic crossing the bridges will pose difficulty in the inspection process. These bridges are also in relatively far distance from the university posing logistical difficulties. More options were investigated in the last two periods in coordination with the FDOT and its Districts.

The following four bridges were identified by reviewing FIU prior work, communication with FDTO District 6, and the University of Miami.

1. SR 714 (Martin Downs Blvd.) over Danforth Creek (D4)
    - Bridge deck consists of Sonovoid panels
    - Cracks had developed at the longitudinal joints between deck panels
    - 2014 inspection detected the cracks and leakage through the cracks
    - A repair project was initiated by FDOT D2 and all but one longitudinal joint was repaired using UHPC details
    - Asphalt overlay exist on the panel and joints
    - Approximate address: Palm City, Florida 34990, 27.172193, -80.270734, (2-hour drive)
    - https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/structures/innovation/fastfacts/fastfacts_430617-1.pdf?sfvrsn=ffd65707_2

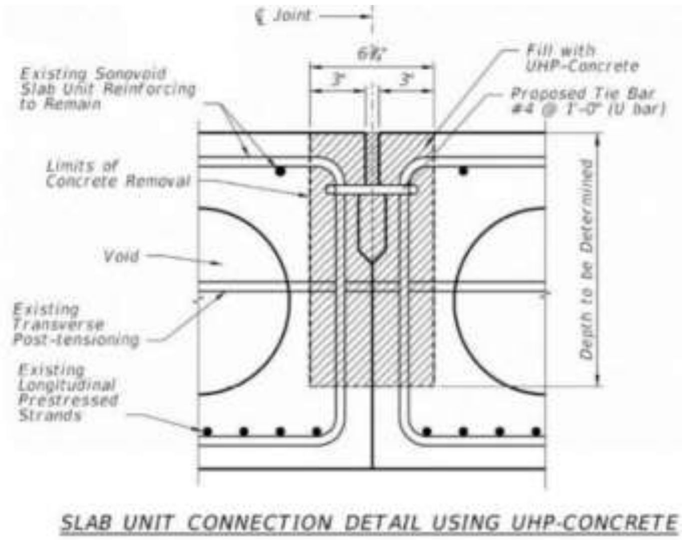


Figure 2: Repair implemented for SR 714 Bridge

This bridge is an ideal case for inspection for several reasons;

2. Jacksonville (30.41747222, -81.53111111)
   This likely also uses Sonovoid panels and reflective cracks can be seen along longitudinal closure joints.

Figure 3: Jacksonville Bridge identified via google map

FDOT structures research office was also contacted to receive their input for bridges that could be subject to inspection,

In further communication with districts near FIU campus, another bridge was identified with ABC component. This bridge is:

3. SR 90/TAMIAMI TRAIL BRIDGE FROM Mile Post 14.038 TO Mile Post 17.230. (D6)

The bridge is a mile long structure consisting of driven precast-prestressed concrete piles, precast pile cap, precast-prestressed concrete girders, and cast-in place deck with stay-in-place form. This is a very new bridge recently opened to traffic. The piles and precast pile caps are considered ABC components, and can be subject to inspection under this project. The bridge is over the water and the inspection will require the use of boat. District 6 of FDOT has been contacted and their maintenance team has graciously agreed to provide logistic help. The bridge has many piers, but the inspection will limit itself to one east-end abutment and up to 3 piers next to that abutment.

Figure 4: Tamiami Trail Bridge

Furthermore, communicating with our contacts in the University of Miami (UM), another bridge was identified that offers a great opportunity for inspection.

4- University of Miami (UM) Campus Bridge, College Drive Bridge at 1231 Dickenson Drive, Coral Gables, FL

This bridge is a simple span structure with the 55-ft span and 32'8" total width consisting of 20'8" roadway, 1.5' raised walkway on one side and 11'5" raised walkway on the other side. The deck consists of 8 Sonovoid Precast-Prestressed concrete panels, each 48" wide and 21" deep. An asphalt wearing surface of about 3" thick covers the deck. Reflective cracking over the panel joints and elsewhere is visible all over the deck. The bridge is over a creek in the UM Campus and has a very low traffic volume. Architectural panels are bolted on both sides of the bridge that serve also as guard railing. There is no drawing or design calculation available for this bridge. Because of an upcoming construction near the bridge, the University Facilities is concerned with the load carrying capacity of the bridge that would experience heavy construction traffic. The Civil Engineering Department of the University of Miami is charged with proof load testing and load rating of the bridge. The UM has welcomed cooperation with FIU in investigation on the bridge. The bridge is easily accessible, and the inspection will not interrupt the traffic significantly. Hence, this bridge is a great candidate for inspection. Additionally, the collaboration with UM, will generate a large volume of information from load testing in addition to the inspection results that can be used for future projects.

Figure 5: College Drive Bridge, University of Miami

Bridges Selected for Inspection

Based on the information gathered and analyzed on candidate bridges, the inspection for this project is planned to be performed on two bridges below:

1. University of Miami (UM) Campus Bridge, College Drive Bridge at 1231 Dickenson Drive, Coral Gables, FL.
2. SR 90/TAMIAMI TRAIL BRIDGE. (D6)

Task 3 – Perform inspection
The research team will travel to bridge location to perform the inspection.

The following inspections were completed in this period;

1- Inspection of College Drive Bridge in the University of Miami Campus

Inspection of this bridge was performed on Tuesday February 25, 2020. The inspection results are currently being compiled and will be included in the progress report for the next period.

2- Inspection of SR 90/Tamiami Trail Bridge

Inspection of this bridge was performed on Thursday March 5, 2020. The inspection results are currently being compiled and will be included in the progress report for the next period.

Task 4 – Compilation of results and reporting

The results and findings of the inspection will be reported in a manner consistent with testing protocol agreed with other partner universities.

No work performed for this task in this period.

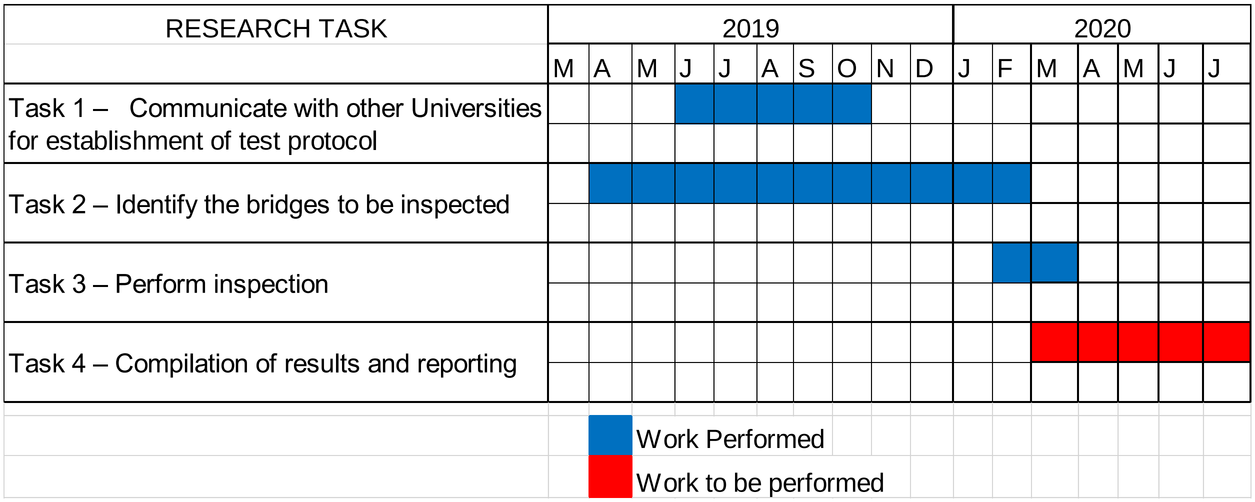
5. Expected Results and Specific Deliverables

The main deliverable for this project is an inspection report for two bridges inspected.

6. Schedule

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

Item	% Completed
Percentage of Completion of this project to Date	60



7. References

1. Utah Department of Transportation (UDOT) Research Division, "Lessons Learned After Construction: Bridge County Road Over I-80," Project No. IBHF-80-4(90)160, 2014.
2. Attanayake. U., and Aktan, H., 2015, 'First-generation ABC system, evolving design, and half a century of performance: Michigan side-by-side box-beam bridges,' J. Perform. Constr. Facil., vol. 29, no. 3, pp. 1–14.
3. S. Farhangdoust, A.B. Mehrabi, S.F. Almosawi, "NDT Methods Applicable to Health Monitoring of ABC Closure Joints," 27th Research Symposium - The American Society for Non-destructive Testing (ASNT), Orlando, Fl, 26-29 March, 2018.