ACCELERATED BRIDGE CONSTRUCTION
UNIVERSITY TRANSPORTATION CENTER

ABC-UTC GUIDE FOR:

INSPECTION AND QA/QC FOR ABC PROJECTS

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ABSTRACT

This report summarizes the work activities undertaken in the study and presents the results of those activities toward development of this ABC-UTC Guide for the inspection and QA/QC of ABC projects. The information will be of interest to highway officials, bridge construction, safety, design, and research engineers, as well as others concerned with the inspection and quality assurance of infrastructure with an emphasis on those constructed using ABC practices.

ACKNOWLEDGMENTS

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1. INTRODUCTION

Recent advances in materials and construction methods have caused increased adoption of accelerated bridge construction (ABC) techniques. While ABC leads to notable benefits such as lower costs and shorter closure times, the construction team must ensure that prefabricated elements, cast-in-place elements, and field-constructed joints and connections will perform as designed in order to guarantee structural integrity. A solution is to perform nondestructive evaluation (NDE) for inspection and quality assurance/quality control (QA/QC) purposes.

Currently, there is a lack of QA/QC incorporated into ABC projects with respect to joints and other cast-in-place components. While great research and expertise has gone into the design of ABC projects to ensure needed safety and capacity requirements, the bond strength and quality of the materials used in the field are not currently assessed after final placement.

The objective of this project was to present a thorough literature review of NDE techniques and their associated capabilities, and subsequently gauge the technology's ability to specifically perform QA/QC for ABC structures. This guide summarizes the key points found during this effort.

2. OVERVIEW OF NON-DESTRUCTIVE METHODS

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2.1. AUDIO-VISUAL METHODS

Audio-visual methods are techniques that heavily rely on an inspector's experience and judgement. Audio-visual methods that were explored include:

- Visual inspection
- Hammer sounding/chain dragging

2.2. ACOUSTIC-SEISMIC METHODS

Acoustic-seismic methods involve the traveling of wave forms through a medium, and for the purposes of this research that is limited to concrete. These parameters are sensitive to changes in physical properties of concrete, which includes changes in microstructure and composition.

Acoustic-seismic methods that were explored include:

- Acoustic emission
- Impact echo
- Ultrasonic methods

2.3. ELECTRO-MAGNETIC METHODS

Electro-magnetic methods were limited to ground penetrating radar (GPR) for this work based upon capabilities.

2.4. THERMAL METHODS

Thermal methods include the measurement or mapping of surface temperatures as heat is transferred. Infrared Thermography was the method that was of greatest capability for this group.

2.5. RADIOGRAPHIC METHODS

Radiography can be used to detect porosity, voids, and structural features via differences in thickness or density. X-ray and Gamma-ray technology were identified.

3. SUMMARY OF APPLICATIONS

Based upon the information collected, the following table summarizes key findings regarding applicability of the methods identified. This table can serve as a starting point for agencies that are interested in implementing nondestructive QA/QC elements to ABC projects.

NDE Method	Cost	Delaminations	Expertise Level	General Applicability
Visual Inspection	Low	F	Low	Rapid detection of flaws and anomalies on the surface, and inspection of leaks and alignment of connections
Hammer-Sounding and Chain Drag	Low	F	Low	Detect the area of delaminations and spalls in concrete
Impact Echo (IE)	Low	G	Medium	Detection of delamination, surface opening cracks, ducts, voids, and overlay bonding, and evaluation of the modulus of elasticity, compressive strength, and grouting characteristics
Ultrasonic Testing (UT)	Medium	G	Medium	Inspection of the internal structure of concrete, such as quality and uniformity of concrete, location of reinforcement, as well as defect and anomaly detection. Capabilities depend upon the quantity and type of transducer employed by the device

Ground Penetrating Radar	Medium	G	Medium	Location of reinforcement, prestressing strands, cables, voids, cracks, and delaminations in concrete, and estimation of concrete cover depth, density, and moisture content variations
Infrared (IR) Thermography	Medium	G	Medium	Rapidly inspect large surfaces to detect delamination, internal voids, and cracks over bridge decks

The following categories are expressed:

• Cost: Low, Medium, and High cost

• Delaminations: Good, Fair, and Poor capability

• Expertise Level: Low, Medium, and High

The listed NDE methods are being extensively researched, and some of their proposed variations in literature can yield good performance at detecting non-listed anomalies. It is also important to note that one may combine various NDE techniques to empower the inspection process and capitalize upon multiple individual technology strengths to achieve greater detection capabilities. Based on the results from this study, it is recommended that GPR, ultrasound, and thermographic methods be further explored via laboratory or field studies to allow for broader implementation in future projects. These methods show the greatest promise when considering efficiency, cost, and overall detection capabilities. With respect to GPR, both traditional and airborne methods may prove beneficial for QA/QC of ABC projects. It is anticipated that a combination of methods would provide the most powerful assessment due to each one's unique capabilities.

4. FEASABILITY STUDY – AIRBORNE GPR

As identified in the above table, ground penetrating radar was identified as a nondestructive evaluation method that showed promise for evaluating ABC projects. This was based on its ability to detect delaminations and subsurface characteristics, as well as the medium cost and expertise level required. A recent advancement to this technology by means of coupling GPR technology with drones presented a unique opportunity to be considered from a feasibility study perspective. As part of this research, a field feasibility study was performed by ADOJAM, LLC using airborne GPR. Although other nondestructive testing methods previously detailed were not studied in the field, airborne GPR, called ADOJAM Difficult Access Advanced Ground Penetrating Radar (DAA GPR), was presented and explored on an ABC bridge in Iowa to determine direct applicability on ABC structures. DAA GPR is an airborne-capable small unmanned aircraft system (sUAS) platform with unique, integrated sensing and measurement capabilities and the potential to provide actionable civil infrastructure asset information. DAA GPR sensing and measurement capabilities include spatially synchronized surface LIDAR data together with subsurface GPR data. Concrete infrastructure deterioration and QC/QA features, such as surface cracking, are readily detectable with LIDAR, while subsurface voids, moisture, and larger cracks are often detectable with radar. In addition, QC/QA features can be measured and evaluated via DAA GPR prior to ABC fit up, reducing costs. This approach may permit accelerated bridge construction to proceed uninterrupted and on schedule while QC/QA benefits of DAA GPR can be rapidly obtained when bridge components are delivered to the construction site (as they are most readily accessible for DAA GPR measurements). Outputs produced by DAA GPR technologies include DAA GPR data fusion results comprised of fully integrated GPR and LIDAR output (Figures 1). Integrated data fusion outputs offer significant advantages for analysis, as surface and subsurface data can be viewed from any angle and can be geometrically partitioned/sliced to view or analyze any captured internal or external bridge deck detail of interest.

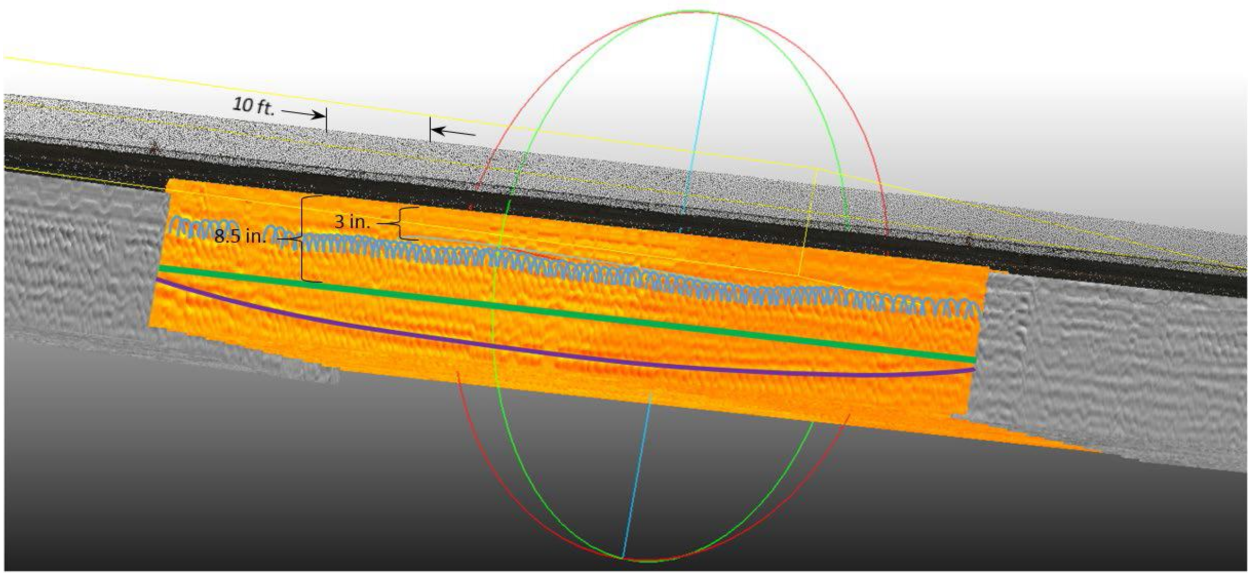
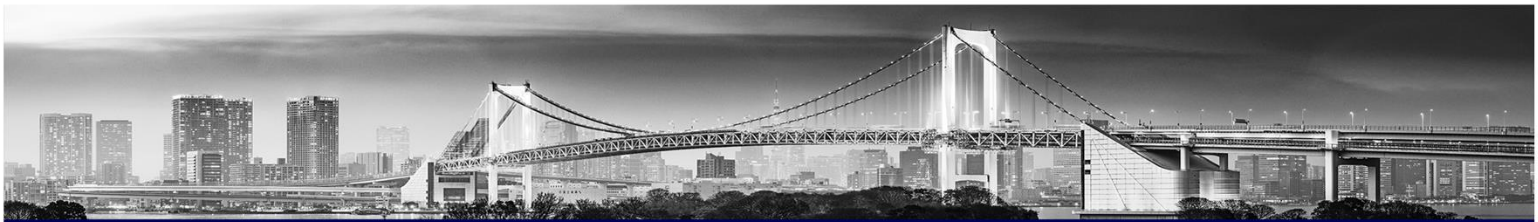


Figure 1. Keg Creek Bridge results showing fused GPR and LIDAR results in a zoom view of span 2 plus reinforcing steel (light blue hyperbolas), concrete deck bottom surface reflection (green), and steel beam (purple) responses

Airborne GPR shows promise for bridge QA/QC applications, as made evident by this sample output from the field study. However, it is important to note that Airborne GPR has the same limitations as those of traditional GPR, with the added limitation of wind sensitivity and the added requirement of a skilled pilot for the drone maneuvering. These are important limitations to keep in mind before engaging in deployment of the technology.

This field feasibility study provides an example of the future work that is needed on the other highlighted technologies in order to determine actual feasibility for ABC inspections.



ABC UTC

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