Bridge Construction Monitoring using LIDAR for Quantified, Objective Quality-Control Quality-Assurance (QOQCQA)

Quantifying the ability of LIDAR to inform Quality Control Quality Assurance during construction inspection

Transportation infrastructure construction quality control and quality assurance demand monitoring by field inspectors. Currently, inspectors monitor the infrastructure by measuring and photographing structures. Measurements allow them to assess any correction decision during construction and/or inform about the quality of the completed structure. This study aims to develop and implement an automation for inspections during construction to measure construction progress and compare it with the designed structure, quantifying the difference. This project includes an implementation for the development of DOT standards that could be added in future bridge construction documents. The New Mexico Department of Transportation (NMDOT) showed a strong interest in this topic. The experience of the PIs on bridge design and construction, inspection, and LIDAR technology was integrated in order to evaluate the results with impact both in research and in industry.

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Background

The New Mexico Department of Transportation (NMDOT) was interested in exploring new technology in the Quality-Control Quality-Assurance (QCQA) of bridge construction during concrete pour and concrete finishing phases. Currently, there are no 3D requirements in the form of LIDAR measurements satisfying QCQA standards for the constructed concrete structures (especially for bridge decks). If the entire volume/surface could be compared with the designed profile (in 3D), then the finished surface quality would be quantified and objective with more precision.

Based on preliminary research, the traditional inspection of rebar spacing in construction sites has some limitations. LIDAR technology can provide accurate 3D mapping of objects, which is useful for quality control related tasks.

Project Summary

The main objective of this study is to develop the use of new technologies (LIDAR) to solve the problem of the measurement of the quality of the bridge surface (especially bridge decks) during and after construction. Specific objectives are to: (i) develop research in assessing if LIDAR technology can quantify bridge construction quality (specifically, reinforced concrete). (ii) summarize the findings of LIDAR technology for the workforce and receive their feedback if this technology can be used in their day-to-day activities. (iii) compare the value of LIDAR with similar alternative technologies (lasers, sensors, cameras, etc.). (iv) develop a draft of new bridge specifications that use LIDAR technology to quantify bridge construction quality, using feedback from NMDOT. (v) promote outreach activities using technology and bridge engineering in open houses, STEM, and high school summer camps related to this project. (vi) promote workforce development by sharing new technologies that can be used as quality assurance during the construction of the bridge that otherwise would not be discussed.

Status Update

Researchers created 3D models for the bridge rebar cage with LIDAR scanned data for further analysis. LIDAR measurements of the rebar cage spacing in this study were compared using steel tape measurement (Figure1). It appeared that with a single 30 seconds scan of the rebar cage data collection, the developed algorithm was able to generate a comparable measurement of the rebar spacing with tape measurement. Both top and bottom rebar cages showed good accuracy in spacing comparison between LIDAR and tape measurer data.

Figure 1. Rebar data Collection. Left: Measurement using tape (conventional); Right: Measurement by LIDAR scanner (proposed automation).

With the developed slicing algorithm for the LIDAR data processing, the research team was able to generate and automatic 3D display of the rebar spacing errors for each bay of the rebar cage (Figure 2).

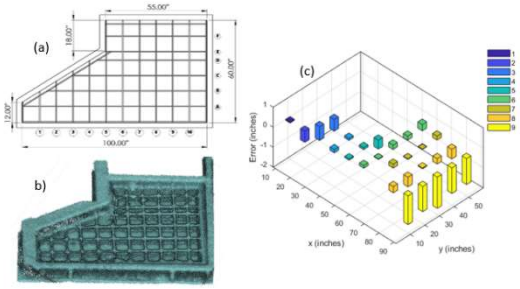

Figure 2. Rebar cage layout: (a) blueprint of rebar cage; (b) LIDAR point cloud model of rebar cage; (c) 3D plot of spacing error of each bay for the rebar cage.

Impacts

The main benefits of this study are the time saving during the inspection and the objective assessment of rebar spacing in the field, integrated to ease field operations and to increase objective assessment of structural concrete. This study enables the inspector to automatically obtain both top and bottom rebar meshes and propose a global rebar quality assessment score that is automatically computed for the entire structure.

The outcome of this study supported the development of STEM classes on LIDAR and technology to inform of reinforcement layout during construction. Students involved in this study also visited high schools and middle schools in New Mexico and introduced students to LIDAR application during construction. The methodology proposed herein transferred to assess the ability of new technologies that empowered inspectors of energy infrastructure systems (including water reservoirs, channels, and power plants). The successful outcome of this research provides evidence of the efficacy of the proposed partnership to further advance suggested technology for bridge construction inspections that are objective. Another ongoing component of this research is the scanning of a real bridge during construction. The research team visited a real deck rebar layout in one new bridge construction in Route 66 in coordination with NMDOT and the first scanning data is being currently processed and analyzed. Other future collaborations and implementation aspects of this research includes contacting construction associations in the SouthWest interested in this technology.

Tran-SET

Tran-SET is Region 6's University Transportation Center. It is a collaborative partnership between 11 institutions (see below) across 5 states (AR, LA, NM, OK, and TX). Tran-SET is led by Louisiana State University. It was established in late November 2016 "to address the accelerated deterioration of transportation infrastructure through the development, evaluation, and implementation of cutting-edge technologies, novel materials, and innovative construction management processes".

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