UTSA® PROJECT SUMMARY

Texas Department of Transportation

0-6950: Evaluating Bridge Behavior Using Ultra-High Resolution Next-Generation Digital Image Correlation (DIC): Applications in Bridge Inspection and Damage Assessment

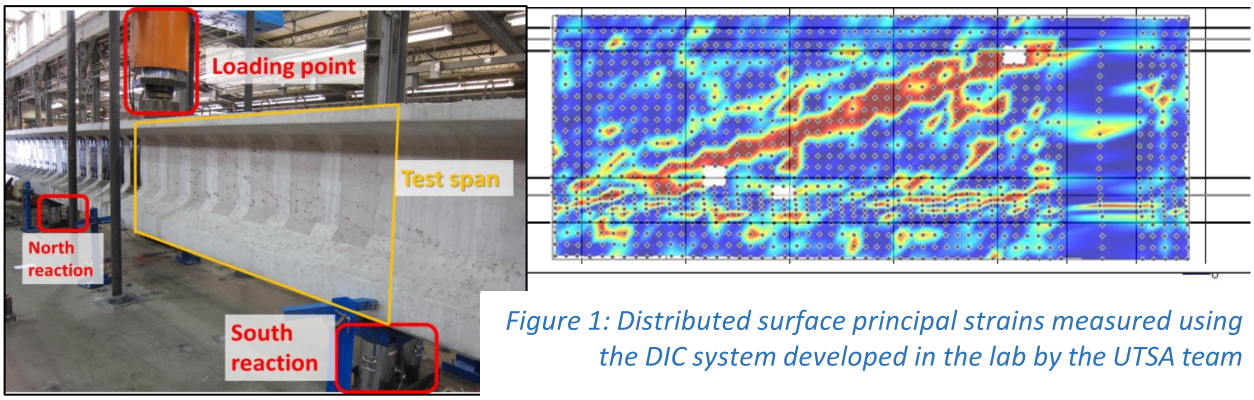

Figure 1: Distributed surface principal strains measured using the DIC system developed in the lab by the UTSA team

Background

Conservatism is deep-rooted in all structural engineering, and for good reason. Conservatism enhances structural safety, reduces working stresses, and extends the lifespan of structures. Additionally, when applied to the design of new structures, conservatism comes at a relatively low cost because it often translates into small adjustments in the amount of reinforcing steel or modest increases in section dimensions. However, when evaluating the capacity of an existing structure, applying the same level of conservatism as in new designs can have much greater cost repercussions. For example, if a bridge capacity is estimated below its demands, even if only by a fraction, costly retrofits, costlier replacement options, or restrictive load postings are triggered. Consequently, strengthening an existing bridge can be measurably more expensive than adding strength in new construction.

Due to heavy cost burdens, departments of transportation continuously seek technologies that can facilitate monitoring bridge portfolios and reduce the need for costly interventions. Deformation measurements, such as bridge deflections, material strains, and crack progression under load, are at the heart of damage and capacity evaluations for bridges. However, measuring the necessary structural deformations is time consuming, requires direct access to the structure when traditional contact instruments are used, and often suffers from user-bias.

Digital Image Correlation (DIC) is a non-contact technology that utilizes specialized digital cameras to deliver high-resolution deformation data between successive images and over large areas of a structure. This project's Research Supervisor has advanced DIC technology markedly over the last decade in laboratory settings, where it can deliver the necessary high-resolution deformation data that can greatly improve the accuracy and reduce the costly over-conservatism in structural evaluations (Fig. 1). But as the noise thresholds and light sensitivity of camera sensors improved, this technology has recently become ripe for high-resolution measurements in large-frame applications, such as monitoring the distributed surface deformations and strains of full-scale bridges in the field.

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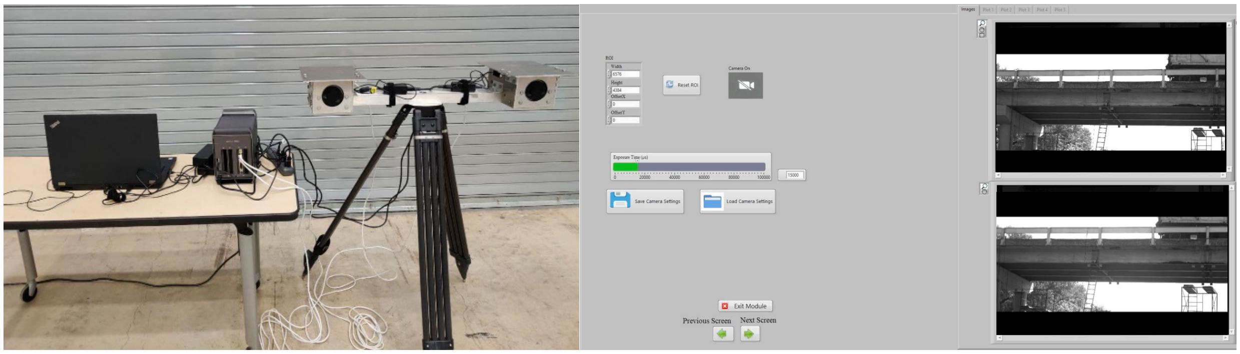

Figure 2: CIV system (left) and sample CIV software screen shot (right)

What the Researchers Did

Within this project, the research team at UTSA built upon the laboratory DIC software to arrive at a coupled software/hardware DIC system that can reliably monitor actual bridge deformations to an accuracy on the order of 1/100th of an inch. The system dubbed CIV (Civil Infrastructure Vision), can measure small deformations over a very large measurement volume that can encompass full bridge spans up to 110 feet away from the cameras.

Robust DIC algorithms were implemented in the CIV software to reduce the sensitivity of measurements to ambient light variations, which were a main obstacle to delivering high-accuracy field measurements. In addition, a user-friendly software interface was implemented to facilitate its use and minimize training needs for personnel using it (Fig. 2).

The CIV software/hardware system was delivered by UTSA to TxDOT at the end of the project. The research team also delivered training materials on how to use it, including two recorded workshops.

What This Means

TxDOT already has several projects where it expects to use this system. For instance, TxDOT will be using CIV during load testing of bridges classified as deficient by traditional conservative evaluation methods, despite them having no visible damage. For such bridges, it is believed that the deficiencies highlighted on paper are only a product of the methods used, and do not represent the true safe condition of the bridges. For this application, the CIV system will save TxDOT considerable cost in two ways: 1- by reducing the cost of bridge load testing significantly, and 2- by delivering the data necessary to reduce or even eliminate costly bridge interventions. The CIV system can be setup in as little as 2 hours without affecting traffic, making a bridge load-tests-feasible in less than half a day. This is in sharp contrast with how load tests are without the CIV system and using contact instruments. These tests typically take several days and incur traffic disruptions.

The unique high-accuracy of the CIV system developed by UTSA, coupled with its robustness with respect to light variations, and its simple user-friendly software place it at the forefront of bridge monitoring technologies. The CIV system is a versatile tool that TxDOT can leverage for enhancing the safety of transportation infrastructure and reducing costs for the state of Texas and its residents.

For More Information

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