Discovering How to Monitor a Simulated Bridge Structure

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The U.S. Army Corps of Engineers (USACE) employs roughly 37,000 civilians and military personnel, who provide a wide range of engineering services in more than 130 countries. That makes it one of the world's largest public engineering, design, and construction management agencies. USACE's Engineer Research and Development Center (ERDC) provides science, technology, and expertise in engineering and environmental sciences, taking on a staggering array of problems in both civil and military engineering, geospatial sciences, water resources, and environmental sciences.

The Airfields and Pavements branch of the ERDC's Geotechnical and Structures Lab, one of four laboratories the ERDC operates in Vicksburg, Mississippi, is charged with R&D on new materials and designs. As electronics technicians, Tommy Carr and Tony Brogdon provide instrumentation support for any project for their branch that requires data acquisition or measurement systems, helping principal investigators (PIs) and engineers design and configure the instrumentation and sensor systems necessary to gather the data they need. Carr notes, "After we help design the instrumentation system for them, we either operate it or train somebody else to operate it to gather the data they need for their experiments."

Not surprisingly, Carr and Brogdon operate in a fairly fluid research environment, handling multiple projects simultaneously, each with its own set of data acquisition or measurement requirements and challenges. These research projects take anywhere from a few days to a year to complete. And, given that the projects they're assigned have finite equipment budgets, the data acquisition and control equipment they select must be highly flexible in terms of size, capabilities and compatible sensor types so it can be readily adapted to new research projects.

Projects in the Airfields and Pavements Branch often involve testing a variety of engineered products used in geotechnical applications, like roadways, airfields, railroads, etc. Beginning during the summer of 2016, a new phase of research began on a portable bridge designed for rapid deployment by military personnel. As Brogdon explained, "This was a multi-layered project and various other parts of the station were involved. Our particular part was to test the decking of the bridge using our Heavy Vehicle Simulator (Fig. 1). They build a test section and the HVS lets us simulate the effects of 20 years of traffic on the pavement and decking in a matter of six months."

Fig. 1. The Heavy Vehicle Simulator on the ERDC Vicksburg campus can simulate the wheel loads of vehicles ranging from heavy trucks to fully loaded cargo planes, and produce up to 500 passes/hour, around the clock. A combination of insulated removable panels and an air conditioning power plant allow heating the surface under test to up to 130°F or cooling it to 30°F.

Building the “bridge to nowhere”

The objective of the project was to gauge the durability of the proposed bridge deck design by stressing it to the failure point, then evaluating the structural changes that occurred in the bridge segment over time. By accelerating the testing process, the HVS allows PIs or engineers to experiment with different materials or engineered structures more quickly. In addition to the HVS, the project required test and measurement capabilities that the aging data acquisition hardware then in their equipment pool couldn’t handle. The need to begin testing to stay on schedule became an important factor in the choice of new equipment.

The bridge segment tested for the project was approximately 15 feet wide and 51 feet long, with a 40-foot long test area. Testing was performed in the ERDC Pavement Testing Facility (Fig. 2), a large, hangar-like structure that allows for construction of multiple full-depth pavement sections and comprehensive evaluation of pavement performance under real-world conditions.

Fig. 2. At 375 feet long and 145 feet wide, the ERDC Pavement Testing Facility is big enough to allow construction, traffic testing, and analysis of several test sections at once. It also includes offices for Carr and Brogdon, as well as storage space for construction materials, tools, equipment, and data acquisition instrumentation.

The system acquired 18 channels of sensor data from full-bridge strain gauges attached with glue or welded to the girders on the main supports and beneath the bridge decking to monitor and record stresses on the decking structure. Once the process of data reduction and analysis for the strain gauge data was completed, it was used in combination with results from later research projects to shape the next iteration of the bridge deck design.

Data acquisition system configuration

The strain gauges attached to the bridge were connected directly to the data acquisition system. A fiberglass housing located outside of the Pavement Testing Facility protected the data acquisition hardware from dust. Carr and Brogdon configured their system with two HBM QuantumX Model MX1615B 16-channel strain gauge bridge amplifier modules (Figure 3). Carr notes, “We had an older piece of legacy hardware that had been made by a company acquired by HBM, so when I started looking for support for it, I ended up working with Kevin Elliott, our local HBM sales engineer. That working relationship with Kevin helped steer us to the model we’re using now.” Carr and Brogdon chose the QuantumX system because of its durability, modular architecture, application flexibility, its ability to withstand high humidity, and compatibility with multiple sensor types.

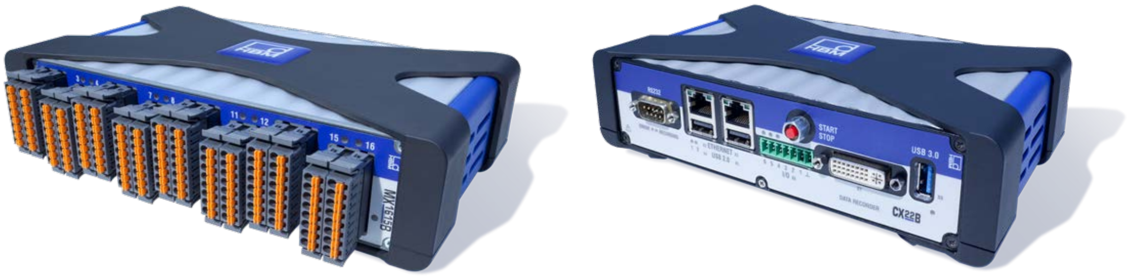

Fig. 3. A QuantumX Model MX1615B 16-channel strain gauge bridge amplifier module (left) and a QuantumX CX22B stand-alone data recorder (right).

Data was initially stored locally on the QuantumX data recorder running catman® AP data acquisition, visualization, storage, analysis, and reporting software. Purchasing a QuantumX CX22B stand-alone data recorder with catman AP gave Carr and Brogdon the flexibility to record locally on the data recorder or to stream it via Ethernet to a PC running catman AP. This remote PC was located in a control room in the Pavement Testing Facility, which allowed the research team to monitor data visually as it was acquired.

Carr and Brogdon chose catman AP software to interface with the QuantumX system because it required little programming knowledge to use effectively; catman automatically triggered the system to take data whenever the HVS was moving, then stop automatically when the vehicle stopped. Over the course of several months of acquiring data at a rate of 300 samples/second multiplied by 18 strain gauges, they have collected a massive amount of data that is still being analyzed.

Given the constant demand of new instrumentation development projects, the QuantumX hardware remains in regular use even though the data acquisition portion of the bridge project has been completed. Most recently, it was employed with a series of accelerometers to monitor the levels of vibration produced by concrete breaking equipment like jack hammers. In order to simplify equipment maintenance and increase flexibility over the long term, Carr and Brogdon are currently working on standardizing their data acquisition hardware solutions.