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The George E Brown, Jr. Network for Earthquake Engineering Simulation

ADVANCING EARTHQUAKE ENGINEERING WITH FAST (REAL TIME) HYBRID TESTING

By

MTS

Center for Fast Hybrid Testing
Department of Civil Environmental and Architectural Engineering
University of Colorado
UCB 428
Boulder, Colorado 80309-0428

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Advancing earthquake engineering with fast (real-time) hybrid testing

Thomas Bowen, site operations manager at the George E. Brown, Jr., Network for Earthquake Engineering Simulation (NEES) at the University of Colorado (CU) at Boulder, talks about the Fast Hybrid Test (FHT) system, developed using MTS hardware, software and support.

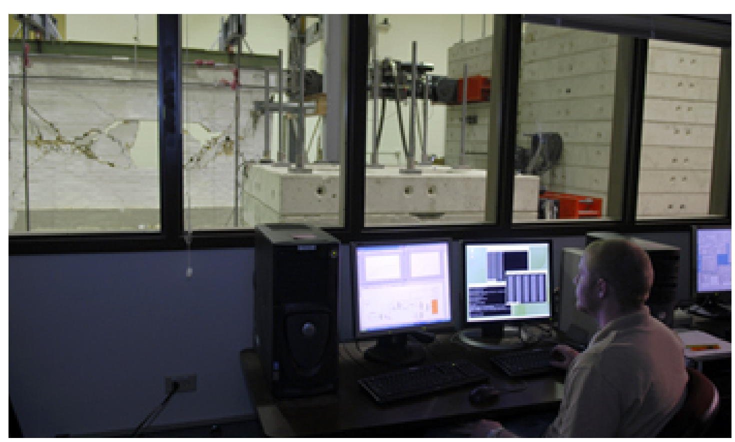
The Customer
The George E. Brown, Jr., Network for Earthquake Engineering Simulation (NEES) is a national, networked seismic simulation resource that serves a geographically distributed network of experimental research sites, including the University of Colorado (CU) at Boulder. NEES strives to accelerate the science of seismic engineering, with the ultimate goal of optimizing the performance of civil and mechanical infrastructure systems.

The Challenge
Historically, earthquake engineers have been forced to choose one of two directions for evaluating the performance of a structural system under earthquake loads: pseudodynamic testing, which uses multiple actuators to apply force and motion to specific portions of a structure ; or employing a large seismic simulator, or shake table, to physically shake the entire structure . Each testing method has strengths and limitations.

Pseudodynamic testing costs less and is capable of testing much larger structures than a seismic simulator, but it applies forces and motions at a slower rate than would be experienced in an actual earthquake event. In fact, the rate of loading is often 100 times slower than the actual real-time response rate of a structure to an earthquake. As a result, while pseudodynamic testing is a good tool for measuring structural strength and stiffness, it cannot sufficiently evaluate dynamic properties, which are essential to assessing a structure's seismic performance. To date, most hybrid simulation systems have been based on the pseudodynamic test method.

The second test method, using a seismic simulator, does provide a realistic response rate for evaluating vibration dynamics. However, many test labs consider mounting a full structure on a shake table cost-prohibitive, due to the significant time and expense required for setup. In addition, structures that can be tested are limited by the size and payload capacities of the test equipment itself.

The Solution
To best serve its member labs, NEES pursued real-time hybrid simulation technology, which combines the strengths of virtual and physical testing to yield unprecedented speed, accuracy and cost-efficiency.

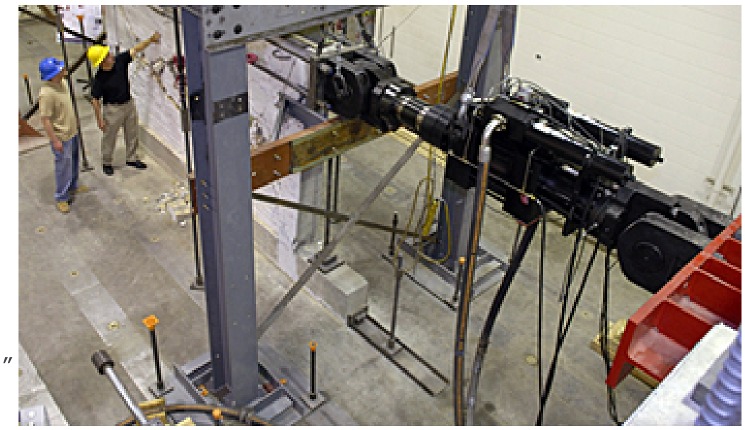


NEES at CU-Boulder collaborated closely with MTS to develop a state-of-the-art Fast Hybrid Testing (FHT) system, designed to physically test a substructure, while computer models digitally simulate the physical influence of the structure surrounding the substructure.

Both simulations are tightly coupled and operate at 1024 Hz, which enables the accurate evaluation of vibration dynamics in addition to strength and stiffness testing. Common FHT applications include shear wall tests, bridge column tests, and testing base-isolation systems and other passive and active response-mitigation devices.

"Real-time, or fast hybrid simulation is made possible by today's fast computer processing capabilities, which can apply the advanced algorithms necessary to reconcile physical testing and virtual modeling data into a single simulation," said NEES site manager Tom Bowen. "But most significant, this testing occurs at a rate approaching the real-time response of a structure under actual earthquake loads. That means you get the cost-efficiency of pseudodynamic testing, along with a highly realistic response rate that could formerly only be achieved using a shake table."

According to Bowen, NEES chose to use MTS hardware, software and consultative support for the project, due to MTS' excellent standing in the field and its reputation for providing unmatched after-sale support.



"We asked ourselves what would be required in equipment and expertise to create a real-time hybrid system, and MTS repeatedly rose to the top," Bowen said. "The MTS proposal came in a bit higher than others, but we chose to work with MTS anyway because we saw the value. This is excellent testimony coming from a state university that is primarily driven by budget."

Composed entirely of MTS hardware and software, The FHT system consists of three high-speed, high-capacity actuators controlled by MTS 493 control systems, which are linked via a high-speed interface into a real-time computer simulation application. The system features online access to an array of data management and sharing tools, enabling seismic engi¬neers at CU-Boulder to collaborate with peer researchers at remote NEES locations.

MTS also helped NEES develop the necessary algorithms to support real-time hybrid simulation. "The actuators can't achieve this rapid response rate by themselves," Bowen said. "Rather, they have to be told what to do, and MTS was instrumental in developing the necessary computational capabilities to drive such speed."

The FHT facility is available to 15 seismic research facilities located across the country. Tests can be run either onsite in Boulder, or distributed remotely via the Internet.

The Results

The FHT system significantly enhances seismic testing, by making the high loads and real-time response rates of an actual earthquake event available to test labs across the country. The system is technologically superior to traditional pseudodynamic testing and a cost-effective alternative to a shake table, and it allows for the improved understanding of complex coupled systems.

Virtual models created with the FHT system can be easily shared

with other test labs, saving engineers at these locations valuable time when conducting their own tests on substructures and components.

"In addition to providing more robust test data, the FHT system allows seismic engineers to spend more time researching and less time worrying about how to support their testing initiatives," Bowen said. "It permits the open exchange of information across the entire community. We're all drawing from a collective level of expertise that is not available at any one test lab, and the entire industry is benefiting from it."

Bowen says that a key ingredient to the FHT system's success was who NEES originally selected to work with on the program. "I know this term gets overused, but MTS was a partner to us in the truest sense," he said. "There have been no limits to the expertise and support MTS has provided."

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