Center for Transportation Infrastructure and Safety

Acquisition of Uniaxial Shaking Table for Dynamic Testing of Structural Elements

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A National University Transportation Center at Missouri University of Science and Technology

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16. Abstract
This project aims at acquisition of uniaxial shaking table for dynamic testing of structural elements. The new shaking table has a 5 x 5 platform, +/- 6 in stroke, and 10 ton payload. Several on-going projects will benefits from using the new shaking table. These projects were planned to be carried out using static cyclic testing. However, static cyclic testing does not necessary reflects the true behavior of a structural element under earthquake ground motion. Static cyclic testing has several limitations including determination of damping characteristics and strain rate effects. Both of them are essential characteristics to investigate the dynamic behavior of structural elements. The on-going projects that will benefit from the new shaking table focus on the development of several types of innovative and sustainable structural elements that can sustain damage due earthquake ground motions as well as accelerate bridge systems. Moreover, the tested elements will be monitored using innovative sensors.

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SUMMARY

This project aims at acquisition of uniaxial shaking table for dynamic testing of structural elements. The new shaking table has a 5 x 5 platform, +/- 6 in stroke, and 10 ton payload. Several on-going projects will benefits from using the new shaking table. These projects were planned to be carried out using static cyclic testing. However, static cyclic testing does not necessary reflects the true behavior of a structural element under earthquake ground motion. Static cyclic testing has several limitations including determination of damping characteristics and strain rate effects. Both of them are essential characteristics to investigate the dynamic behavior of structural elements. The on-going projects that will benefit from the new shaking table focus on the development of several types of innovative and sustainable structural elements that can sustain damage due earthquake ground motions as well as accelerate bridge systems. Moreover, the tested elements will be monitored using innovative sensors.

Earthquake simulator

The NUTC fund was used to acquisition of a new shaking table. The shaking table has 1.5 meter x 1.5 meter moving slip table guided by linear recirculating bearings. The table is designed for full biaxial upgrade. The table has a peak velocity of 1.4 m/sec unloaded and 1.2 m/sec with full payload. It has a payload of 10,000 kg and over turning moment of 15 metric ton-meters at full payload and full velocity operation with continuous operation possible. The table can run up to 2.4 g acceleration with full payload and frequency of 50 Hz. Fig. 1 shows the table

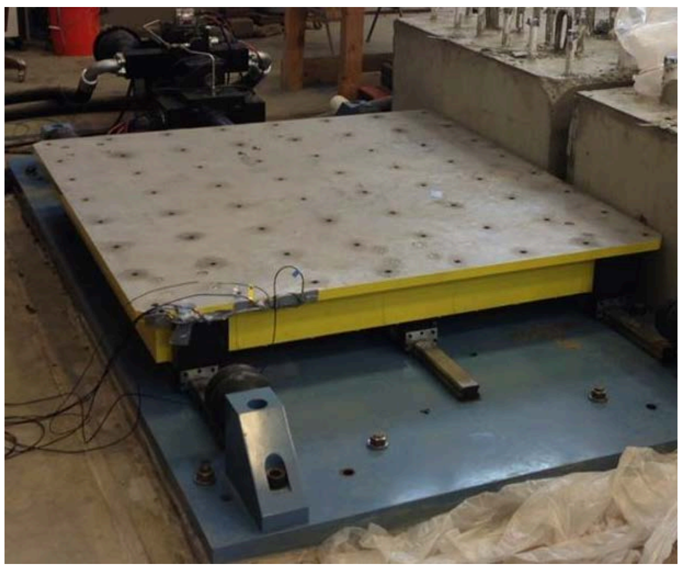

Fig. 1: The earthquake simulator installed in the High-bay lab at Missouri University of Science and Technology

The table is driven by a high performance fully fatigue rated with high strength heat treated alloy shaft linear hydraulic actuator. The actuator features 250 kN static force at 210 bar and +/- 200 mm dynamic stroke plus cushions. The actuator has a 3-stage servo valve 750 lpm with differential pressure sensor for stability.

The shaking table has a high performance servo valve, close-coupled accumulators and position transducer to allow displacement to be used as the inner feedback for loop closure, and inputs from accelerometers for outer loop closure. A 20/10 gal (Pressure/Return) performance accumulator package combined with close coupled accumulators is provided to augment the house HPS of 90 gpm at 3,000 psi.

The table is controlled using advanced seismic simulation software that uses non-linear multi-pass on-line iterative technology for the most accurate test result. The simulation package is able to produce the most accurate results in the least number of iterations and it works on real time prerecorded acceleration time histories, sine sweep and sine control. The control system is able to optimize the loop with delta P, linear displacement and accelerometer data to achieve a highly responsive digital control loop from 0-100 Hz. Fig. 2 shows the controller software and a sine wave output of the shaking table.

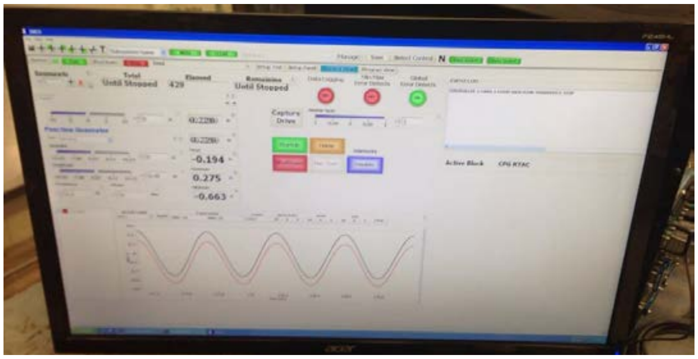

Fig. 2: Running the shaking table using a sine wave

Benefits of the earthquake simulator

This equipment purchase will enable the development and implementation of several types of innovative and sustainable structural elements for transportation infrastructure. For example, the development of durable accelerated bridge construction (ABC) that can sustain damage due to extreme events and seismic behavior of existing bridge columns are of prime interests. ABC reduces initial construction cost, construction time from months to days, and traffic disruption and lane closures. In addition, ABC improves work zone safety, constructability, and construction quality leading to long lasting bridges. ABC has a high level of sustainability and lower environmental impacts. It has lower life-cycle costs by using materials more efficiently and reducing construction waste. Finally, ABC reduces noise, leakage of wet concrete into waterways leading to harm to migrating fish, and fuel consumption due to congestion and rerouting. In particular the seismic behavior of innovative structural systems will be investigated. This includes hollow-core ultra-high performance segmental bridge columns, double-skin bridge columns, behavior of columns constructed out of self-consolidated concrete. Fig. 3 shows a reinforced concrete footing for testing self-centering bridge columns on the new shaking table.

Fig. 3: Reinforced concrete footing of a self-centering bridge column that will be tested on the new shaking table.