The UB-NEES Versatile High Performance Testing Facility

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ABSTRACT

The intent of the NEES Equipment Site at UB (SUNY) is to develop the most versatile earthquake engineering research facility possible, designed to provide testing capabilities that can revolutionize the understanding of how very large structures react to a wide range of seismic activity, even when tested to complete failure. Under NEES, the existing Structural Engineering and Earthquake Simulation Laboratory (SEESL) facility* received $21.2 million grants ($11.0M form NSF, $9.0M from SUNY, $1.2M form Department and Industries) for expansion that includes the addition of dual, movable, six-degrees-of-freedom shake tables, a large reaction wall, a significantly expanded strong floor area, high-performance dynamic and static actuators, and associated hydraulic and control systems, and networked equipment with capabilities of teleoperation and teleobservation. The facility is now capable of testing full or large-scale structures using static or dynamic loading. The use of modern techniques such as *Fast Hybrid Pseudo-Dynamic, Effective Force*, and *Real-Time Dynamic Hybrid* testing are possible, along with conventional S*tatic, Quasi-static,* and *Dynamic Force* techniques. The *Real-Time Dynamic Hybrid Testing (RTDHT)* is a new form of testing being explored at UB in which shake table and/or dynamic force experiments on substructures are combined in real-time with computer simulations of the remainder of the structure. This provides a more complete picture of how earthquakes would affect large systems, including buildings and bridges, without the need to physically test the entire structures.

EXPANSION OF EXISTING LAB (SEESL)

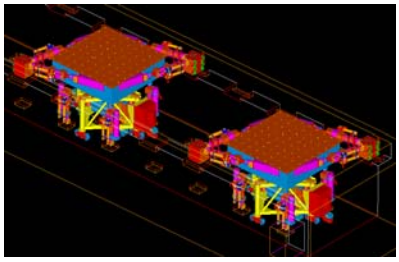
•13,000 sq.ft expansion of lab area to 27,000 sq.ft.
•3,400 sq. ft. additional strong floor to 6400 sq.ft.
•1,800 sq. ft. reaction wall (60 ft long 30 ft high)
•120 ft. long shake table trench
•40-ton overhead crane
•1600 gpm Hydraulic Power Supply

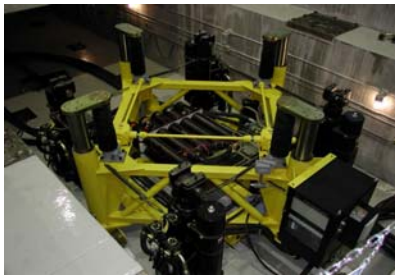
DUAL SIX DEGREES OF FREEDOM RELOCATABLE SHAKE TABLES

A set of two movable, high-performance, 6 degrees-of-freedom 50 tons capacity shake tables. It will be possible to easily and quickly reposition the shake tables in order to accommodate models of various lengths. Together, the tables can host specimens weighing up to 100 metric tons and measuring up to 125 feet, and subject them to fully in-phase or totally uncorrelated dynamic excitations.

Table size:3. 6 meter x 3.6 meter
Maximum specimen mass: 50 ton maximum / 20 ton nominal
Maximum Overturning Moment:46 ton meter
Maximum Off Center Loading moment:15 ton meter
Frequency of operation: .1~50 hertz nominal/100 hertz maximum
Nominal Performance: X axis Y axis Z axis:
- ***•Stroke:±.150 m ±.150 m ±.075 m***
- ***•Velocity: 1250 mm/sec 1250 mm/sec 500 mm/sec***
- ***•Acceleration:±1.15 g ±1.15 g ±1.15 g (w/20ton specimen)***

Controllers : MTS469 with Adaptive Controls
Control Interface: MTS STEX 2004





**** The NEES laboratory at the University at Buffalo is a part of the Structural Engineering and Earthquake Simulation Laboratory (SEESL) of the Department of Civil, Structural, and Environmental Engineering and which is also one of the laboratories affiliated with the Multidisciplinary Center for Earthquake Engineering Research (MCEER).***

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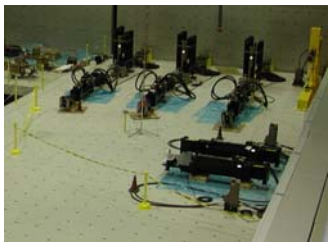
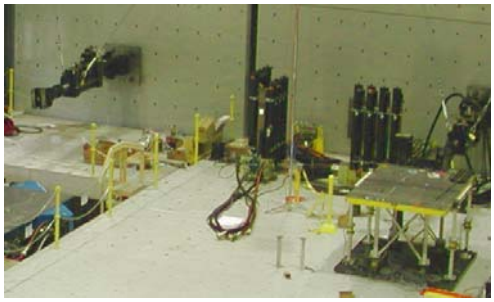
LARGE SCALE SERVOHYDRAULIC ACTUATORS

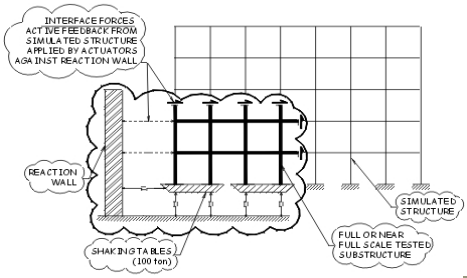
Another key element of the SEESL upgrade is the integration of three high-performance dynamic actuators (having ±1000 kN capacity, ±500mm stroke, 1.0 m/s max. velocity, and 800gpm servovalves), and two static ±2000 kN ±500mm stroke actuators. A flexible controller system is included with software to conduct in addition to quasi-static step-by-step testing also pseudo-dynamic testing. Source code is included such that more complex structural configurations, higher levels of sub-structuring, and other more advanced formulations of pseudo-dynamic testing can be developed and implemented. A digital control system also provide the fully flexible platform needed to develop new approaches in structural testing using real-time control, such as the RTDHT system or the effective force control technique (EFCT).

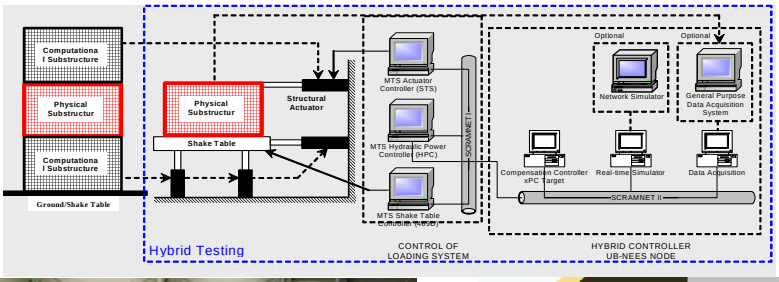




REAL TIME DYNAMIC HYBRID TESTING SYSTEM

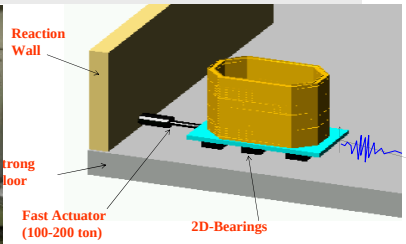
The new UB-NEES expansion facilitates use of modern testing techniques, such as **Real-Time Dynamic Hybrid Testing** and **Fast Pseudo-Dynamic Hybrid Testing**, along with conventional Static, Quasi-static, and Dynamic Force techniques. The new form of dynamic substructure testing, **Real-Time Dynamic Hybrid Testing** developed at UB with the new equipment, combines *shake table and/or dynamic force experiments* of **substructures** with *real-time computer simulations* of the **remainder of the structure**. This provides a more complete picture of how earthquakes would affect large systems, including buildings and bridges, without the need to physically test the entire structures. The system at UB uses an in-house developed parallel computing approach with a SCRAMNET link providing shared memory and asynchronous operations. The systems operates in FORCE CONTROL and is capable to implement EFFECTIVE FORCE Technique, FAST PSEUDO-DYNAMIC HYBRID Technique as well as REAL TIME DYNAMI HYBRID technique





LAMINAR GEOTECHNICAL BOX

5.0x2.75x6.2m (85 cubic meter maximum capacity)
Modular Multilayer-Laminate-Bearing Design;
Simulate 2-D Ground Response for
Soil-Foundation-Structure Interaction Studies
At/or Near Full Scale
1-g Geotechnical Studies on Shake Table
1-g Geotechnical Studies on Strong Floor



NETWORK FOR SIMULATION, TELEOPERATION AND TELEPARTICIPATION

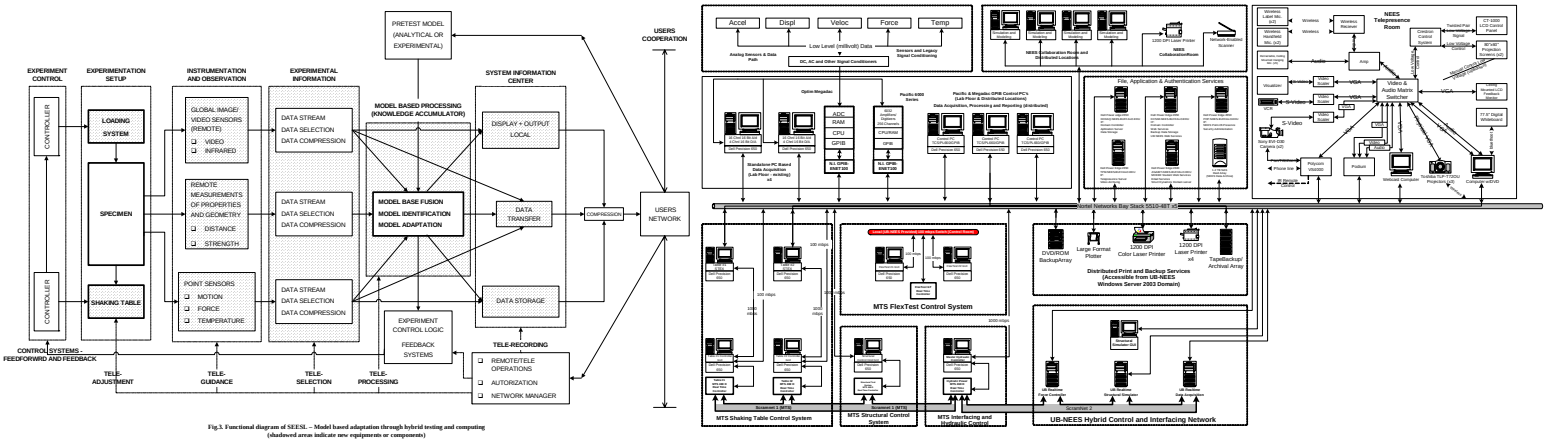


Fig.3 Functional diagram of SEESL – Model based adaptation through hybrid testing and computing (shadowed areas indicate new equipments or components)