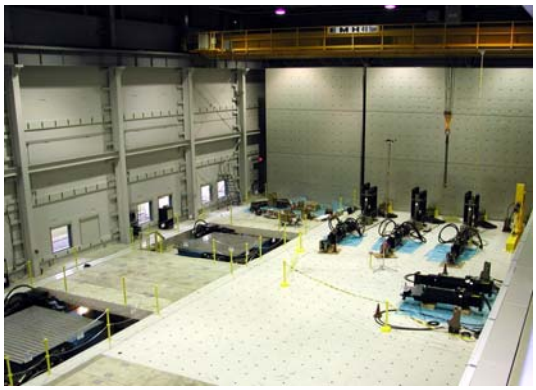
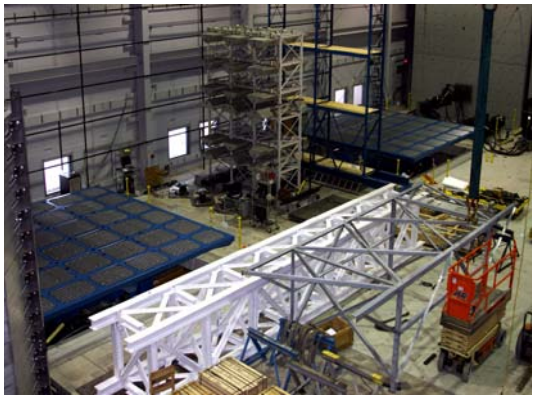
SEESL Simulation Systems and Test Protocols

The Structural Engineering and Earthquake Simulation Laboratory (SEESL), at the University at Buffalo within the Department of Civil, Structural, and Environmental Engineering (CSEE), is part of the Network for Earthquake Engineering Simulation (NEES) and is one of the laboratories affiliated with MCEER. The SEESL/UB-NEES laboratory is housed in a 13,000 square foot building. The laboratory is capable of conducting testing of full or large-scale structures using dynamic or static loading. This is enabled by the availability of two shake (earthquake simulation) tables that can be relocated in a 125 foot long trench; large-scale dynamic and static servo-controlled actuators that have a cumulative capacity to apply forces of up to 7800 tons; a 3,400 square foot strong floor; and a 30x60 foot reaction wall; and a 40-ton capacity crane. To achieve the high loading rates, required for seismic simulation, the test equipment is supported by a high-capacity, high-performance hydraulic supply and distribution system (capable of supplying up to 6000 lpm), operated by numerous high-performance digital control systems.

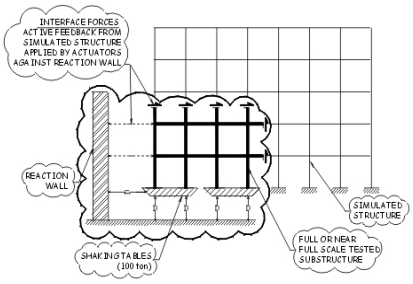
The six degree-of-freedom twin shake tables can be rapidly (within 2 days) repositioned, within the trench, from locations directly adjacent to one another, or in various positions at 3.05 m c/c, up to 30.5 meters apart (center-to-center of the platforms). The nominal payload for each of the table is 20 metric-tons, but specimens up to 50 metric-tons, per table, albeit at reduced levels of shaking (maximum overturning moment capacity is 46 ton-meter). Together, the tables can support specimens of up to 100 metric-tons and as long as 36 meters. Table excitations (motions) can be fully in-phase or totally uncorrelated dynamic excitations.

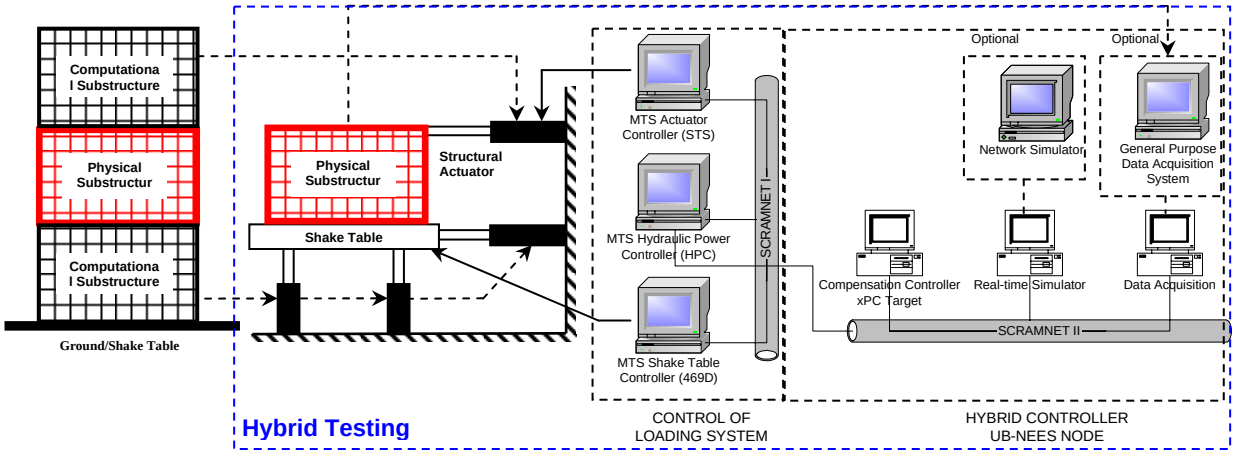


The parent platform of each shake table is 3.6 meters x 3.6 meters. The maximum horizontal (2-axis) and vertical displacements are ±150 mm, ±150 mm, and ± 75 mm respectively, maximum velocities are 1250 mm/sec, 1250 mm/sec and 500 mm/sec, respectively, and maximum accelerations are ±1.15 g, ±1.15 g and ±1.15 g , respectively, for a 20-ton specimen. The maximum frequency of operation is 50 hertz at the nominal payload, and 100 hertz maximum. The deployable surface of the shake tables has been increased to 7 meters x 7 meters with the installation of platform extensions (see photo right) allowing for the testing of larger test specimens with no appreciable change in performance. These extensions can be removed to access the original platforms if required.

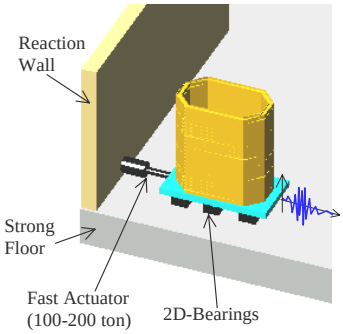


The use of modern testing techniques, such as Pseudo-Dynamic and Real-Time Dynamic Hybrid Testing are possible, along with conventional Dynamic, Quasi-static, and Static Force techniques. *Real-Time Dynamic Hybrid Testing* is a new form of testing being developed at UB in which shake table and/or dynamic 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 structures, including buildings and bridges, without the need to physically test the entire structure.

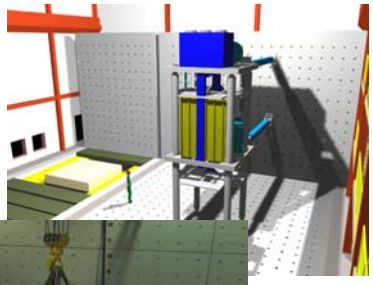


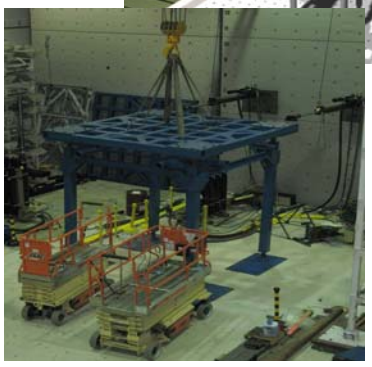


A major component of the SEESL/UB-NEES facility is a modular 2-D geotechnical laminar box for 1-g soil and soil-structure interaction testing. In its largest configuration, the box measures 2.75x5.0x6.2 meters and is constructed of 24 laminates, separated by ball-bearings facilitating 2-D motions. It has the ability to simulate sloping ground subjected to large deformations. The laminar box can simulate boundary stresses closely to that of free ground and can be reconfigured into smaller modules. The modular design of the laminar box enables full scale tests to be performed on the strong floor as illustrated (left) or it may be divided into two modules, each deployed on the twin shake tables.



A novel equipment component of the SEESL/UB-NEES facility is the Nonstructural Component Simulator (NCS). The NCS is a modular and versatile two-level platform for experimental performance evaluation of nonstructural components and equipment under realistic full scale floor motions as shown. The NCS can provide the dynamic stroke necessary to replicate full-scale displacements, velocities and accelerations at the upper levels of multi-story buildings during earthquake shaking. Both displacement sensitive and acceleration sensitive nonstructural components and equipment can be experimentally evaluated under full-scale floor motions to understand, quantify and control their seismic response. The NCS testing frame is composed of two square platforms having an inter-story height of 14 ft. The platforms are activated using two identical high performance dynamic actuators, supplied by MTS Corporation. The NCS is capable of subjecting nonstructural components and equipment up to 3g horizontal accelerations. Uni-axial and bi-axial testing configurations are possible. Vertical accelerations can also be included in an experiment by mounting the testing frame on one of the existing shake tables at the SEESL UB-NEES facility.





Networked tele-experimentation capabilities using modular and expandable tele-observation and tele-operation equipment, tied to the testing systems using discrete and global sensors, including high-resolution digital video and imaging capabilities, making it possible for remote collaborators and observers to access the SEESL/UB NEES facility. A NEES collaboration room located adjacent to the laboratory is equipped with NEES-Grid enabled equipment to supports the NEES collaborative activities.

These state of the art equipment components, hardware and facility infrastructure collectively enable the assemblage of variety of **Simulation Systems** as detailed in the attached table. These **Simulation Systems** are capable of reproducing (simulating) prior recorded seismic events or test protocols such as those defined in ASTM or a multitude of other industry or government standards. The expert faculty and staff also provide consulting services, to researchers and commercial clients, based on their vast and state of the art knowledge to enhance or substitute test protocols and procedures where standards are not applicable to achieve the test objectives.

Major Simulation Systems at SEESL/UB-NEES

Testing Systems / Equipment/ Resources	(A) Shake Table #1 Simulator	(B) Shake Table #2 Simulator	(C) Coupled Shake Tables #1 & #2 Simulator	(D) Large Scale Quasi Static System	(E) Pseudo-Dynamic and Dynamic System	(F) Real Time Dynamic Hybrid Testing System	(G) Geotechnical Laminar Box Testing System	(H) Nonstructural Components Simulator	(I) Shake Table #0 Simulator
Check System									
6DOF Shake Table #1 (NEES)	X		X			X	X		
6DOF Shake Table #2 (NEES)		X	X			X	X		
Dynamic Actuators (NEES)					X	X	X	X*	
Static Actuators (NEES)				X					
Reaction Wall (RxnW) (Non-NEES)						X	X	X	
Strong Floor (S.F.) (Non-NEES)				X	X	X	X	X	
Flex Test Controller (NEES)				X	X			X	
Hybrid Controller (NEES)					X	X			
Data Acquisition (NEES & Non-NEES)	X	X	X	X	X	X	X	X	X
Instrumentation (NEES & Non-NEES)	X	X	X	X	X	X	X	X	X
3D Optical Coordinate Tracking System (NEES)	X	X	X	X	X	X	X	X	X
Video/Digital Cameras (NEES)	X	X	X	X	X	X	X	X	X
Geotechnical Laminar Box (NEES)							X		
5DOF Shake Table #0 (Non-NEES)									X

* **Special long stroke dynamic actuators**

X: **Equipment/Resources Required in Testing**

X: **Optional and Alternative Equipment/Resources Used in Testing**

Add additional equipment or special needs below: