Service

US Army Corps of Engineers®
Engineer Research and Development Center

Shock Testing of Structural Building Models

Description

Researchers at the ERDC Construction Engineering Research Laboratory (ERDC-CERL) test the ability of systems and facilities to survive under realistic conditions of weapons-induced shock and vibration, and earthquake ground motion using the Triaxial Earthquake and Shock Simulator (TESS), an experimental 3-dimensional "shake table." This can include a wide variety of tests, including testing shock survivability of computer equipment, computer floors, and shock isolation systems in military facilities. TESS's triaxial motion makes it ideal for studying the behavior of structural building models and components in seismic environments. Research in this area often focuses on ways to increase the seismic resistance of steel, reinforced concrete, and masonry structures (shown below), and results in the testing and implementation of innovative materials, design improvements, and building rehabilitation techniques.

Capabilities

In its biaxial mode, this unique dual-mode shock and vibration test facility simulates a wide range of transient shock vibrations typical of military applications requiring large accelerations over a wide frequency range with moderately heavy test specimens. In its triaxial mode, TESS can simulate a variety of vibration environments including earthquakes and random vibrations, as well as log-sweep and resonant searches. In this mode, it can test larger specimens over larger displacement ranges more typical of seismic vibrations. The shake table can also subject electronic systems to simulated transportation and seismic environments; and determine the effects of shipboard vibrations on naval systems. TESS is most frequently applied in four research areas:

1. *Facility Evaluation*. Scale models of susceptible structures are tested (sometimes to failure) to determine performance under severe, real-world conditions.

2. *Building Rehabilitation*. Materials and building techniques are tested for performance under shock-induced stress.

3. *New Facility Design and Construction*. These projects normally develop seismic design of new facilities.

4. *Equipment Qualification and Upgrade Development*. Critical equipment is subjected to seismic and shock loading to develop upgrade technology to protect the equipment.

Supporting Technology

The TESS combines a high payload capability with a broad frequency range, high acceleration performance, a wide displacement range, and simultaneous, independent control of up to three axes of vibration. Biaxial performance is rated with a 12,000 pound payload, and the triaxial performance with a 120,000 pound payload.

Larger payloads can be tested at lower acceleration levels, while smaller payloads can be tested at up to twice the rated accelerations. The size of the shake-table surface and its high payload capability allows testing of a wide range of test objects from equipment components to full-size electronic systems, from structural materials, to structural components and assemblies, structural scale models, to small building structures.

Benefits

Any government agency or university can benefit from the cooperative use of TESS, on a cost-reimbursable basis. Private companies may also gain access to the facility if their requirements are unique and cannot be performed by nongovernment facilities. TESS provides customers with a unique benefit—the capability to test equipment and structural models of various sizes under controlled, realistic shock, seismic, and vibration environments that cannot be economically produced in field tests. This provides a more realistic simulation of real-world vibration environments that can be applied in materials development and testing, structural design, and building rehabilitation.

Success Stories

One study that subjected two half-scale, low-rise reinforced masonry buildings with flexible roof diaphragms to carefully selected earthquake ground motion showed that low-rise masonry buildings with flexible roof diaphragms can be designed for seismic loads as single-degree-of-freedom systems. Another work modeled the Koyna dam—the only concrete dam to be significantly damaged due to ground shaking in 1967. A 1/20-scale model of the dam (the largest scale model of the dam ever to be so tested) was built and seismically tested to failure using TESS' sinusoidal motions to better predict the seismic response of concrete gravity dams.

Researchers used TESS to investigate the applicability of fiber-reinforced polymer (FRP) composite retrofit systems to strengthen unreinforced walls made of concrete masonry units or clay brick. Another study performed a detailed seismic evaluation of the Federal Aviation Administration (FAA) Airport Traffic Control Towers (ATCTs) located in Palo Alto, Salinas, San Carlos and San Luis Obispo, CA. The work evaluated the towers based on several directions of loading and developed retrofit schemes for the towers found to be vulnerable.

Another project used TESS to investigate cold-formed shear panel behavior under simulated seismic loading. A study done for the Dept. of Energy evaluated the ability of light wood construction to resist lateral loads resulting from earthquakes or strong winds. The project developed a procedure for establishing design capacities based on both test data and established baseline panel design capacity.

A recent study tested the vulnerability to seismic and shock loading of critical equipment components that were to be installed in racks that provide access for power, communications, and equipment cooling. Normally the equipment would be installed on raised computer floors, but study results showed that the best way to limit ground motion amplification was by supporting the equipment with rigid steel frames. The project developed upgrade technology to protect the equipment by ensuring that the final frame designs met design requirements.

ERDC POC

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