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Information on the Video of the Two-Story House Shake-Table Testing at the University of California at San Diego

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Simulation of an Earthquake-Resistant House Subjected to an Earthquake Simulation

The video footage with multiple camera angles depicts a full-scale model of a modest-sized two-story house being tested by a simulated earthquake on a shake table at the University of California at San Diego on July 11, 2000. The test combined the simulation of very severe ground shaking with very strong construction. The goal was to verify that a new house that conforms to all building code regulations and in addition is specially engineered (though many houses do not receive the detailed design attention of a structural engineer) an escape with little damage from such an earthquake. As shown in the video, the performance of the house was excellent; only cracking of wall finish materials resulted.

CUREE-Caltech Woodframe Project

The testing was part of the CUREE-Caltech Woodframe Project funded by the Federal Emergency Management Agency through a grant administered by the California Governors Office of Emergency Services. The overall Project included other kinds of laboratory testing, statistical studies of the performance of wooden buildings in earthquakes, recommendations for building codes and standards, studies of economic aspects, and education and outreach activities.

Playback of Ground Motion Recording from the 1994 Northridge (Los Angeles) Earthquake

The earthquake shaking provided by the shake platform replayed the actual motion of the ground that occurred in an area where the shaking was intense in the January 17, 1994 Northridge (Los Angeles) Earthquake, except that this shake table moved back and forth in one direction whereas actual earthquake motions are a combination of horizontal motions in various directions, along with some vertical motions. The peak acceleration of that ground motion record was about 1 g, and thus this same severity of shaking is generated at the base of the house by the shake platform. The roof moved with an acceleration over two times greater (as is typical in structures—the motion of the base is amplified up the height by the response of the structure). The precise record of the jolts, or accelerations, of the shaking that was recorded at this Rinaldi utility station in the Northridge Earthquake was obtained by a strong motion seismograph, or accelerograph. This computerized record was then played back on the shake table at UC San Diego the way a sound recording, when played back on high-fidelity sound equipment, recreates very closely the original musical performance.

The Full-Scale Model Represents Above-average, Engineered Construction

The house was not designed to represent a typical building but rather an above-average, engineered case. Most houses are not designed with the benefit of a structural engineer's full set of calculations, nor is it common for an engineer to inspect an ordinary house during the construction phase, while both of these occurred in this test

case. Steel hardware concealed in the walls was designed for calculated design forces to tie the building together, and wood sheathing (oriented strand board panels) under the exterior stucco surface was attached to the 2x4 studs with a type and pattern of nails specified to resist the calculated forces. The small room size in the model structure also made it above-average in earthquake resistance.

Diagonal Lines on Exterior Are Merely Instrumentation, Not Bracing

The diagonal lines on the exterior of the house are part of the laboratory instrumentation to measure the amount the house leans over (amount of “deflection” from its at-rest geometry) during the tests. These diagonal lines are not structural braces; the house is laterally supported only by its solid walls, as is typical of residential construction.

Anchored and Unanchored Interior Furnishings and Contents Also Tested

The house was outfitted with pairs of anchored and unanchored nonstructural components. A living room TV cabinet was anchored to the wall and the television within it was also mounted so it could not fall out, while next to it was the same cabinet, unanchored, with a television that was not restrained. Similarly, anchored and unanchored pairs of water heaters, shelving, file cabinets, and other contents were installed and can be seen in various camera views. The contrast in performance between the anchored nonstructural components and their “evil twins” was dramatic. The items that were unrestrained tipped over, while those that were fastened to the wall remained in place and undamaged.

The Test Shown Was the Culmination of Several Months of similar Testing on the House

Researchers at the Department of Structural Engineering at UCSD began constructing and testing the house in phases more than six months prior to the July 11 test. At each phase of construction, the house was subjected to several earthquakes, and any damage was repaired before going on to the next phase. In this way, data was obtained on key variations in the construction, such as: comparing differences in the way the second floor plywood was attached to the joists, the effect of having or not having special steel hardware installed to tie down walls to keep them from rocking as the building moved sideways, the influence of the stucco applied to the outside and gypsum-board on the inside of walls as compared to the case where the bare wooden structure was shaken with the same simulated motions. Over 300 sensors in the building provided data on how each piece of the building moved or deformed in each test.

Researcher, Design Engineer, Builder

The director of the research on this house was Professor André Filiatrault. The full-scale model was installed on the uniaxial shake table inside one of UCSD’s Department of Structural Engineering Powell Research Laboratories. The structural engineer who designed the house was Kelly Cobeen, Cobeen & Associates, Lafayette, CA. A construction firm specializing in earthquake-resistant buildings, Valentine Construction, was the builder.

For Further Engineering Information

For further technical information about this testing, contact the lead researcher:

Professor André Filiatrault, Lead Researcher
Civil, Structural and Environmental Engineering
University at Buffalo-SUNY
Tel: 716-645-2114, ext: 2434
Email: af36@buffalo.edu