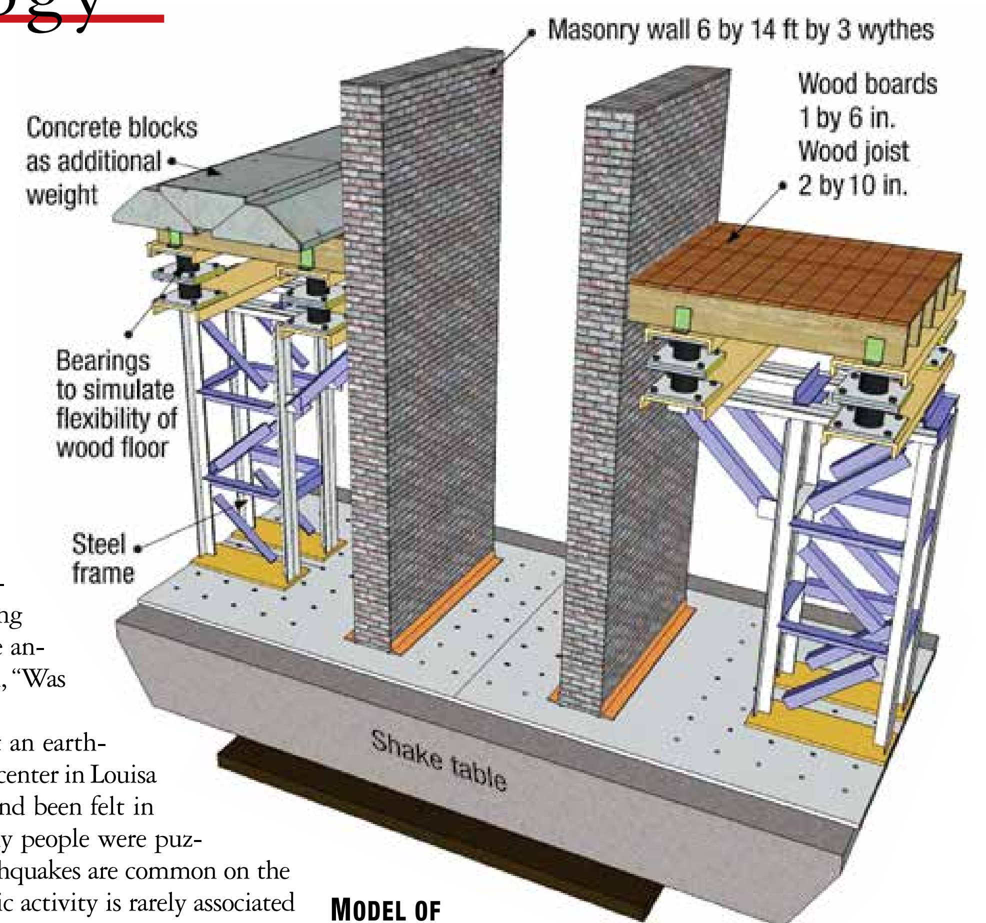
# Shake Test Gauges Seismic Vulnerability Of NYC's Row Houses




**Model of Experiment Test Setup**

ON THE afternoon of August 23, 2011, the ground in northern Virginia began to shake. As the shaking subsided, people looked at one another in bewilderment and asked, "Was that an earthquake?"

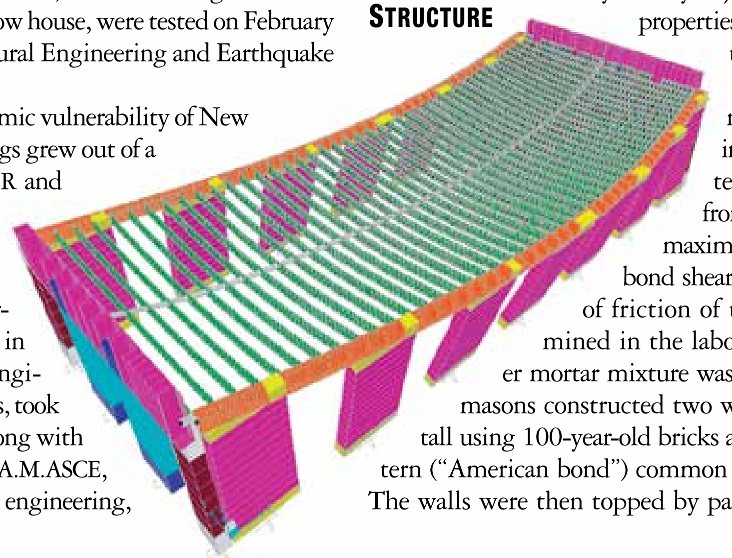
As news spread that in fact an earthquake of magnitude 5.8, its epicenter in Louisa County, Virginia, had struck and been felt in more than a dozen states, many people were puzzled. Everyone knows that earthquakes are common on the nation's West Coast, but seismic activity is rarely associated with the east. Reminding the region that it is not immune to moderate seismic events, the temblor prompted a recent study that examined what might happen if an earthquake of similar magnitude were to strike near the nation's most populated metropolis, New York City.

The Multidisciplinary Center for Earthquake Engineering Research (MCEER) at the State University of New York at Buffalo sponsored a shake table test to analyze the effects that an earthquake similar to the one in Virginia might have on the unreinforced masonry buildings in New York City known as row houses, which make up an estimated 80 percent of the housing there. Two masonry walls, each simulating an exterior wall in the upper story of a row house, were tested on February 19 at the university's Structural Engineering and Earthquake Simulation Laboratory.

The idea to assess the seismic vulnerability of New York City's masonry buildings grew out of a relationship between MCEER and the Structural Engineers Association of New York. Juan Aleman, a doctoral candidate in civil engineering and a Fulbright scholar in the university's School of Engineering and Applied Sciences, took on the research challenge, along with Gilberto Mosqueda, Ph.D., A.M.ASCE, an associate professor of civil engineering, Amjad Aref, Ph.D., M.ASCE, a professor of civil engineering, and Andrew Whittaker, Ph.D., S.E., M.ASCE, the director of MCEER and the chairman of the civil engineering department.

The team worked with the International Masonry Institute to create two masonry walls that would accurately represent the exterior walls of the city's row houses. They began by collecting and studying samples of demolished masonry buildings from New York City. "A key objective was to compare the properties of different mortar mixtures in the laboratory to mortar in existing…[unreinforced masonry] buildings," Aleman said in written responses to questions from *Civil Engineering.* "The maximum compressive strength, bond shear strength, and coefficient of friction of the samples were determined in the laboratory." Once the proper mortar mixture was established, professional masons constructed two walls 1 ft thick and 14 ft tall using 100-year-old bricks arranged in the brick pattern ("American bond") common in the city's row houses. The walls were then topped by parapets and given timber floors supported by elastomeric seismic isolation bearings to simulate the flexibility of a diaphragm.

**Deformed Shape of One-Story Unreinforced Masonry Structure**

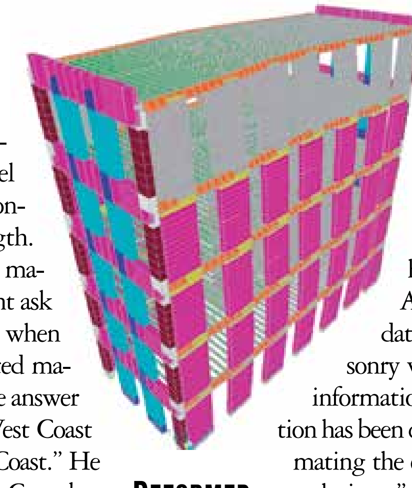


MCEER/STATE UNIVERSITY OF NEW YORK AT BUFFALO/JUAN ALEMAN. *ALL*

While construction of one of the walls ended there, the other wall was reinforced with steel braces and anchors at the floor and parapet connections, giving those joints additional strength. Such retrofits have been used to help stabilize masonry buildings on the West Coast. "You might ask the question, why did we run a series of tests when there have been tests performed on unreinforced masonry walls [in the west]?" Whittaker says. The answer is "in part because the construction on the West Coast is different from the construction on the East Coast." He adds that previous studies focused on the West Coast because "that's where the perceived earthquake problem was many years ago."

The walls were positioned side by side on a shake table, and both were subjected to earthquake conditions similar to those experienced in Virginia in 2011 and in Christchurch, New Zealand, that same year. "A goal of the experiment is to validate numerical models, so it's beneficial to impose different types of ground motions to ensure that our numerical models are robust," Whittaker explains. "We don't seek to calibrate these models; we want a physics-based understanding of how these walls behave, so subjecting the walls to multiple ground motions is instructive."

The tests had both expected and unexpected results. As anticipated, the parapet of the unreinforced wall toppled under the earthquake shaking. What was not expected was the sliding failure that occurred at the connection of the floor diaphragm on the reinforced wall. While some of the results were surprising, the data will help improve existing computer models, Aleman said. "We now have experimental data on out-of-plane seismic behavior of masonry walls with parapets," he said. "Also, new information about the wall-to-diaphragm connection has been collected and will certainly be used in estimating the effectiveness of this particular retrofitting technique."



**Deformed Shape of Archetype Building**

The experiment has already resulted in numerical modeling tools, but the team hopes to continue working with the Structural Engineers Association of New York to develop reliable computer models for masonry buildings in New York City and throughout the eastern part of the United States and Canada. "A long-term goal would be to understand the seismic risk or potential losses to unreinforced masonry construction in New York City and beyond, and that's a much, much larger undertaking," Whittaker says. "But we've taken some important first steps." —JENNY JONES

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