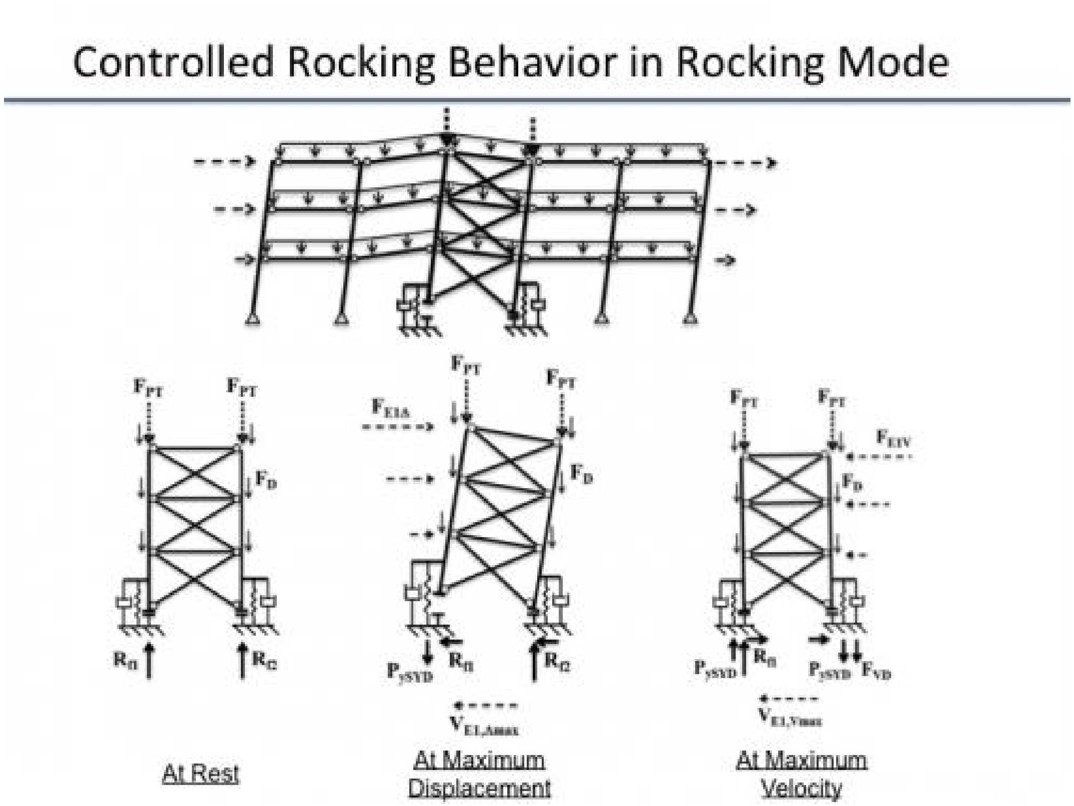
Buildings with 'rocking' technology would be more earthquake-resilient

February 11 2015



Computer modeling shows this alternative design for a three-story building frame suffers less damage than current designs used in earthquake-prone areas. Columns of the steel-braced frame are tethered to the foundation by viscous damping and steel-yielding devices that allow the building to rock during a quake. The devices stretch and compress, dissipating seismic energy. Credit: Michael Pollino

Buildings that rock during an earthquake and return to plumb would withstand seismic shaking better than structural designs commonly used in vulnerable zones of California and elsewhere, a Case Western Reserve University researcher has found.

Those buildings would also be more easily and cheaply repaired and put back into use more quickly, said Michael Pollino, an assistant civil engineering professor at Case School of Engineering.

Although Pollino didn't invent the technology, he developed a computer model that compares what are called "rocking steel-braced frames" to current earthquake standards used in low- to mid-rise buildings. His findings are featured in the journal *Engineering Structures*.

"Currently, engineers are designing low-rise structures for an earthquake that has a 10 percent chance of occurring in a 50-year-lifetime," he said. "We accept there will be damage, but no collapse or loss of life.

"But what about an event that has a 50 percent chance of occurring?" he continued. "You may still have to tear the building down afterward... I think this design should do more to make the building usable and repairable afterward."

Pollino is among a growing number of researchers who are finding advantages to the design, which has not yet made it into practice. There are still details to investigate. He and colleagues are discussing forming a technical committee of civil engineers that would advance the technology into practice.

Pollino's modeling suggests optimal sizes for two key components of rocking steel-based frames: viscous damping devices, which are akin to shock absorbers, and steel-yielding devices, which have been likened to electrical fuses because they limit the amount of force transferred to the rest of the structure.

But unlike fuses that break to prevent an electrical overload, the steel in steel-yielding devices stretches back and forth during a quake, dissipating seismic energy that would otherwise take its toll on the building structure and contents.

Buildings are typically constructed to resist the vertical loads of gravity and weight, but earthquakes create horizontal or lateral loads.

Current quake designs rely on building deformation and damage to absorb the loads and prevent collapse during quakes. The loads will stretch and deform or push and buckle traditional braces or the heavy joints where beams and columns meet.

The rocking frame would provide a better alternative, Pollino said.

To enable a three-story building to rock, the columns of the braced frame are not anchored to the building foundation, but tethered to the foundation by dampers and steel-yielding devices. When seismic shaking strikes, the building rocks as the frame lifts off the foundation and tilts. The devices stretch and compress, dissipating seismic energy.

A restoring force provided by the building's own self-weight and post-tensioning strands enables the building to return to plumb when the quake has subsided.

To understand what's happening inside the building, Pollino simulated and measured the motion passed from the ground to the floors of the building, including deformations and accelerations that tip bookshelves and damage air-conditioning and heating ducts, partition walls and plumbing.

That information was added to the requirements for protecting the building frame to calculate the optimal size of the dampers and yielding devices and locations of their connections to the foundation and frame.

"Others who have looked at rocking steel-braced frames have come to the same conclusion: there are small upfront costs but clear benefits," Pollino said.

Pollino is now applying for funding to begin physically testing designs in the university's structures laboratory. His goal is to help develop design standards for engineers building in earthquake zones.

Provided by Case Western Reserve University