Graduate Michael Montgomery and his supervisor Prof. Constantin Christopoulos have developed a new damping brace for buildings to improve their resiliency in the event of an earthquake.

Keith Beaty/Toronto Star

Back to Canadian engineering innovations 2012: Earthquake-proofing skyscrapers

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Stephen Leahy

Toronto’s tall buildings like to dance in the wind, potentially making penthouse owners sea sick as the tops of buildings sway as much as half a metre. To stop the swaying, structural engineers make taller buildings extra stiff and often plunk a concrete slab weighing 400 tonnes at the top. Now, two University of Toronto engineers aim to design buildings that can absorb the vibrational energy from the wind, and even powerful jolts from earthquakes, with minimal movement and no damage.

“We’ve developed viscoelastic-energy-dissipating dampers to replace many of the heavy concrete beams used in tall structures,” says Constantin Christopoulos, a professor of Civil Engineering and a seismic expert at the University of Toronto (U of T).

Known as the Wind-Earthquake Coupling Damper, this potentially game-changing device could first be installed in a new Toronto tower by the end of 2013.

“With the damper, buildings can offer more leasable space, be slimmer and taller, while also being safer,” said Christopoulos.

Cities are going vertical all around the world; some 2,500 buildings over 30 stories are being built or are in the planning stages, according to industry statistics.

Toronto leads the way with the most high-rise buildings under construction in North America.

Concrete, and lots of it, has been the traditional engineering approach to coping with the force winds can exert against tall buildings. That additional concrete adds to the cost and reduces the available occupancy space.

“Structural engineers have struggled with this problem for years,” said Christopoulos who studied earthquake engineering in California.

Ten years ago, Toronto high-rise building designers asked Christopoulos and other civil engineers at U of T to investigate. “We’re solving the vibration problem by damping, as opposed to stiffening, the building.”

The Wind-Earthquake Coupling Damper is a multiple-layer sandwich of steel plates and viscoelastic polymer or rubber, explains Michael Montgomery, a newly graduated PhD who worked under Christopoulos to test and perfect the device.

The damper is roughly two metres long, half a metre in depth and just over a half metre wide on average, and anchored firmly to the structural walls.

When a gust of wind starts to move a building the force or energy is absorbed by the rubber in the damper, Montgomery says. It is the combination of steel and rubber that enables the damper to soak up the vibration and yet retain its strength.

“We can add ‘structural fuses,’ so that the damper can handle the enormous energy from earthquakes,” said Montgomery.

Some of the steel plates can be engineered to fail when there’s a big spike in energy. These steel ‘fuses’ soak up the extra energy
rubber can’t absorb, protecting the gravity-bearing elements of the building.

“They’re designed to act like a fuse or breaker in an electrical circuit.”

After an extreme earthquake, the dampers can be inspected, and, if any structural fuses have been triggered, they can easily be repaired or replaced.

Well-built buildings in earthquake zones rarely collapse, but are often seriously damaged. Nearly all the buildings that survived the Magnitude 6.3 earthquake in downtown Christchurch, New Zealand cannot be re-occupied without major repairs, said Christopoulos.

Repairing fractured internal concrete beams is not always possible and most of these buildings in Christchurch will have to be pulled down.

The Toronto team’s damper successfully withstood large magnitude earthquakes and large hurricanes simulated in full-scale structural testing facilities at U of T and at the Ecole Polytech in Montreal.

The toughest phase of this 10-year project is to get builders and their engineers in what is a very conservative industry to use the dampers.

“Lots of them think its great, but hesitate to be first to use it. It’s not like trying out a new app. on your smart phone,” said Christopoulos.

However, one pioneering builder in downtown Toronto is ready to make a commitment.

“We’re hoping that, in the next 12 months, the first dampers will be installed.”