Bridge protection during catastrophic earthquakes

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Bridge damage hampers aid effort after earthquakes. Credit: Caleb Jones on unsplash

More than 1 million people have died in the 1800 magnitude 5+ earthquakes recorded worldwide since 2000.

Bridges are the most vulnerable part of transport infrastructure, obstructing emergency response, search and rescue missions and aid delivery, further increasing potential fatalities.

While engineers have designed structures to withstand destructive natural forces like extreme winds and tornadoes, catastrophic earthquakes such as the 2010 Haiti earthquake (over 310,000 fatalities) or the 2011 Tōhoku earthquake in Japan (over 20,000 fatalities) remain a challenge.

To mitigate the impacts of such major earthquakes, a team of researchers at University of Technology Sydney (UTS) have a developed an application for ground anchors as the main seismic resisting system for ultimate protection of bridges against catastrophic earthquakes.

Led by Associate Professor Behzad Fatahi and supported by Mootassem Hassoun (Ph.D. Candidate) at the School of Civil and Environmental Engineering this new application can protect bridges against earthquake levels well above code recommendation.

Despite the stringent design codes enforced globally, and technological advancement in seismic design and protection of structures, more effort is required to lower fatality rates and financial losses. This is particularly relevant as rapid urbanization creates higher population concentrations in seismically active zone such as Japan and Indonesia where 230,000 were recorded nationally following a single earthquake in 2004.

Associate Professor Fatahi and his team have developed an advanced three-dimensional computer model to simulate and evaluate the seismic capacity of anchored bridges subjected to some of the world's most catastrophic earthquakes.

Ground anchors are constructed from high tensile capacity steel cables commonly used to support deep excavations in city centers. The cables are light and flexible but can carry tremendous pulling capacity.

They are embedded into the ground behind the bridge, avoiding any effects on the bridge aesthetic looks, and grouted for a certain length in order to secure the anchors into the ground. The proposed ground anchors are passive and flexible, which allows the bridge to expand and shrink during its normal seasonal cycles without cracking.

The benefit of this technology is its low cost and high effectivity: it is cheap yet delivers incredible strength and energy dissipation into the ground—a material that is technically free.

"Our findings prove that bridges restrained with ground anchors have a superior seismic behavior compared to traditional or even modern bridges with modern seismic protection devices such as viscous dampers," said Associate Professor Fatahi.

This increases the feasibility of bridges with much lighter and economical foundations, and reduced size and cost of safe bridge construction while maintaining—or even increasing—the capacity of the bridge to sustain significant earthquake motions.

The team tested their solution for many high magnitude earthquakes, including the massive 1995 Kobe earthquake in Japan, which damaged nearly 400,000 structures. Their research shows that bridges equipped with the novel ground anchor technology could survive catastrophic earthquakes and remain nearly undamaged while bridges designed using conventional seismic mitigation techniques had collapsed.

Many nations could build or amend earthquake safe bridges at a low cost, as it can also be adopted to retrofit older bridges designed and constructed to previous codes and therefore under-designed against large earthquakes.

More information: Mootassem Hassoun et al. Novel integrated ground anchor technology for the seismic protection of isolated segmented cantilever bridges, *Soil Dynamics and Earthquake Engineering* (2019). DOI: 10.1016/j.soildyn.2019.105709

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