Our new anti-earthquake technology could protect cities from destruction

July 2 2015, by Pierfrancesco Cacciola

Protecting cities from earthquakes is still a grand challenge that needs addressing, as recent disasters in Nepal, Japan, Haiti, and Chile confirm. Although significant progress has been made in understanding seismic activity and developing building technology, we still don't have a satisfactory way of protecting buildings on a large scale.

For new buildings, anti-seismic technology is today considered quite advanced and it is possible to build individual structures that can withstand the vast majority of recorded earthquakes. Devices such as isolation systems and dampers, which are designed to reduce the vibrations (and as a consequence the damage) of structures induced by earthquakes, are successfully employed in the design of new buildings.

But large numbers of buildings exist in earthquake zones that don't have built-in protection, particularly in developing countries where replacing them or introducing stricter – and more expensive – building codes aren't seen as an option. More than 130,000 houses were destroyed by the earthquake in Nepal in April 2015.

What's more, these technologies are rarely used for protecting existing buildings, as they generally require substantial alteration of the original structure. In the case of heritage buildings, critical facilities or urban housing especially in developing countries, traditional localised solutions might be impractical.

This means there is a need for alternative solutions that protect multiple existing buildings without altering them using a single device. At the University of Brighton, we have designed a novel vibrating barrier (ViBa) to reduce the vibrations of nearby structures caused by an earthquake's ground waves. The device would be buried in the soil and detached from surrounding buildings, and should be able to absorb a significant portion of the dynamic energy arising from the ground motion with a consequent reduction of seismic response (between 40-80%).

The idea behind this is to look at buildings as an integral part of a city model, which also includes the soil underneath and the interaction between each element, rather than as independent structures. Each ViBa can be designed to protect one or more buildings from an earthquake but also it forms part of a network of devices placed at strategic locations in order to protect entire cities.

The ViBa itself is essentially a box containing a solid central mass held in place by springs. These allow the mass to move back and forth and absorb the vibrations created by seismic waves. The entire structure is connected to the foundations of buildings through the soil to absorb vibrations from them. The box's position underground would depend on how deep the surrounding foundations went and could even be placed on the surface.

As the ViBa is designed to reduce all vibrations in the soil, it could also be used to insulate buildings against ground waves from human activities such as road traffic, high-speed trains, large machinery, rock drilling and blasting. In this way, the technology would be able to absorb a larger quantity of energy than traditional measures used to insulate railways such as trenches or buried sheet-pile walls.

Starting construction

The problem with the ViBa is its size – it would need to be at least 50% of the mass of the average building it was protecting – and how much money it would cost to build and install as a result. So compared to current technologies to protect single buildings it would likely come with a much higher price tag. But as the ViBa can be designed to reduce the vibrations of more than one building or for buildings of historical importance for which current technologies are impractical, it can still be considered as a viable solution.

So far we have only modelled how the ViBa would work, using computers and prototypes in the lab. To be deployed in the real world we would need to do a lot more experimenting to understand exactly how it would work and to make sure it didn't produce any damaging side-effects on the surrounding buildings. We would also need to work with industry to work out how to build and install it in the most cost-effective way.

But our latest research suggests the ViBa is a viable alternative strategy for protecting buildings from earthquakes. In the long term, it could lead to safer cities that are better equipped to deal with disasters and ultimately save lives.

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