Indonesia earthquake—how scrap tyres could stop buildings collapsing

August 15 2018, by Juan Bernal-Sanchez

Credit: AI-generated image (disclaimer)

At the time of writing, 436 people have died following an earthquake in the Indonesian island of Lombok. A further 2,500 people have been hospitalised with serious injuries and over 270,000 people have been displaced.

Earthquakes are one of the deadliest natural disasters, accounting for just 7.5% of such events between 1994 and 2013 but causing 37% of deaths. And, as with all natural disasters, it isn't the countries that suffer the most earthquakes that see the biggest losses. Instead, the number of people who die in an earthquake is related to how developed the country is.

In Lombok, as in Nepal in 2015, many deaths were caused by the widespread collapse of local rickety houses incapable of withstanding the numerous aftershocks. More generally, low quality buildings and inadequate town planning are the two main reasons why seismic events are more destructive in developing countries.

In response to this issue, my colleagues and I are working on a way to create cheap building foundations that are better at absorbing seismic energy and so can prevent structures from collapsing during an earthquake. And the key ingredient of these foundations is rubber from scrap tyres, which are otherwise very difficult to safely dispose of and are largely sent to landfill or burnt, releasing large amounts of carbon dioxide and toxic gases containing heavy metals.

Many homes in Lombok have been destroyed. Credit: EPA/Adi Weda

Rubber-soil mixture

Previous attempts to protect buildings from earthquakes by altering their foundations have shown promising results. For example, a recently developed underground vibrating barrier can reduce between 40% and 80% of surface ground motion. But the vast majority of these sophisticated isolation methods are expensive and very hard to install under existing buildings.

Our alternative is to create foundations made from local soil mixed with some of the 15m tonnes of scrap tyre produced annually. This rubber-soil mixture can reduce the effect of seismic vibrations on the buildings on top of them. It could be easily retrofitted to existing buildings at low cost, making it particularly suitable for developing countries.

Several investigations have shown that introducing rubber particles into the soil can increase the amount of energy it dissipates. The earthquake causes the rubber to deform, absorbing the energy of the vibrations in a similar way to how the outside of a car crumples in a crash to protect the people inside it. The stiffness of the sand particles in the soil and the friction between them helps maintain the consistency of the mixture.

My colleagues and I have shown that introducing rubber-soil mixture can also change the natural frequency of the soil foundation and how it interacts with the structure above it. This could help avoid a well-known resonance phenomenon that occurs when the seismic force has a similar frequency to that of the natural vibration of the building. If the vibrations match they will accentuate each other, dramatically amplifying the shake of the earthquake and causing the structure to collapse, as happened in the famous case of the Tacoma Narrows bridge in 1940. Introducing a rubber-soil mixture can offset the vibrations so this doesn't happen.

A promising future

The key to making this technology work is finding the optimum percentage of rubber to use. Our preliminary calculations echo other investigations, indicating that a layer of rubber-soil mixture between one and five metres thick beneath a building would reduce the maximum horizontal acceleration force of an earthquake by between 50% and 70%. This is the most destructive element of an earthquake for residential buildings.

We are now studying how different shaped rubber-soil mixture foundations could make the system more efficient, and how it is affected by different types of earthquake. Part of the challenge with this research is testing the system. We build small-scale table models to try to understand how the system works and assess the accuracy of computer simulations. But testing it in the real world requires an actual earthquake, and it's almost impossible to know exactly when and where one will strike.

There are ways of testing it through large scale experiments, which involve creating full-size model buildings and shaking them to simulate the force from recorded real earthquakes. But this needs funding from big institutions or companies. Then it is just a question of trying the solution on a real building by convincing the property owners that it's worthwhile.

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