Research may curb economic losses to power plants after earthquakes

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Sitting atop power transformers are wavy shaped bushing systems that play a critical role in supplying communities with electricity. However, these objects are also susceptible to breaking during earthquakes. Once damaged, bushings can cause widespread outages and burden the state with expensive repairs.

In a recent study, Texas A&M University researchers have shown that during high seismic activity, the structural integrity of bushing systems can be better maintained by reinforcing their bases with steel stiffeners. Also, by using probability-based loss assessment studies, they found that the economic burden due to damage to bushing systems from earthquakes is up to 10 times lower for steel-reinforced transformer bushing systems compared to other bushing configurations.

"Transformer bushing systems are vital to electrical substation networks, and these components are especially vulnerable in high-seismic regions, like in California or parts of the northeast," said Dr. Maria Koliou, assistant professor in the Zachry Department of Civil and Environmental Engineering. "We have conducted a full risk and loss assessment of the impact of damaged bushings in terms of cost and time to recovery for electrical power networks."

The details of the study are provided in the July issue of the journal *Structure and Infrastructure Engineering.*

An electrical bushing is a sleeve-like covering that surrounds a conductor carrying a high voltage electrical current. Generally found at close proximity to transformers or circuit breakers, these systems ensure that electric currents do not leak out of metal wires. Thus, bushings are made of insulators, porcelain in particular, and are filled with mineral oil.

Despite their ability to withstand strong electric fields, bushings are brittle and can crack easily in the event of high seismic activity. Consequently, any damage to them is an electrical hazard. More extensive structural injuries to the bushing system can cause widespread power outages and high replacement costs.

One possible way to mitigate damage and thereby repair is by strengthening the bushing with steel plates. Just like a strong foundation can improve a building's stability, steel flexural stiffeners as close as possible to the bushing base has been shown to improve bushing stability during earthquakes. However, Koliou said a more comprehensive analysis of the impact of seismic vulnerability on bushing systems in terms of recovery costs has been lacking.

To address this gap, Koliou and her graduate student, Andrew Brennan, conducted a probabilistic analysis to compare the economic losses incurred from the damage of bushings for different intensities of ground motions. They investigated bushings of different geometries representative of medium- and high-voltage scenarios. More importantly, some bushings had steel plate stiffeners and others did not in their original designs.

Koliou and Brennan found that the economic losses for the earthquake intensities considered in the study were 33-55% lesser when the bushings' bases are reinforced with steel plates. In fact, the expected annual losses for bushings without the steel stiffeners were at least 2.5-10 times larger when subjected to different ground motions.

"Our results show that steel stiffeners are effective at preventing bushings from damage, but what 'effective' means for a structural engineer can have little meaning for someone who is not. We wanted to generalize our findings in more practical terms for stakeholders other than engineers," said Koliou. "And so, we quantified the benefit of using steel stiffeners in terms of a dollar value and the time it would take to recover for a variety of earthquake scenarios, which is more easily interpretable."

More information: Andrew L. Brennan et al, Probabilistic loss assessment of a seismic retrofit technique for medium- and high-voltage

transformer bushing systems in high seismicity regions, *Structure and Infrastructure Engineering* (2020). DOI: 10.1080/15732479.2020.1785513

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