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The future of our cities: Engineers test resilient, intelligent infrastructure

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Researchers from the Cambridge Centre for Smart Infrastructure and Construction glue fiber-optic sensors to a test pipe in Cornell's Geotechnical Lifelines Large-Scale Testing Facility. Credit: Cornell University

Like many of today's household devices, modern infrastructure is gaining the ability to collect and exchange valuable data using wireless devices that monitor the health of buildings and bridges, for example, in real time. But wireless systems for underground infrastructure, such as utility pipelines, are much more difficult to test in the field, especially during rare and extreme events such as earthquakes.

Engineers at the Cornell Geotechnical Lifelines Large-Scale Testing Facility set out to change that by testing several advanced sensors developed by researchers at the University of California, Berkeley, and the University of Cambridge Centre for Smart Infrastructure and Construction. The sensors - which can collectively measure strain, temperature, movement and leakage - were installed along a 40-foot section of a hazard-resilient pipeline being tested for earthquake fault-rupture performance.

The pipeline itself is innovative, produced by the company IPEX using a molecularly-oriented polyvinylchloride material is engineered to stretch, bend and compress as it withstands extreme ground deformation similar to that occurring during earthquakes, floods and construction-related activity. Engineers from Oakland, California, and Vancouver, British Columbia, traveled to Ithaca to watch as the pipe experienced a simulated fault rupture while buried inside a hydraulically powered "split basin" filled with 80 tons of soil.

The test was the first use of the advanced sensors for the purpose of monitoring buried infrastructure, and gave an unprecedented look at the pipe's ability to elongate and bend while being subject to ground failure.

"It was a fantastic performance. It did really well," said Brad Wham, a geotechnical engineering postdoc at Cornell. "It was able to accommodate 50 percent more ground deformation than the last design based on modifications Cornell suggested from our testing four years ago."

The sensors drew interest from the attending municipal engineers, who need new ways to monitor the performance of underground infrastructure. And as cities begin to adopt the sensor technologies, more data will exist not just for infrastructure, but for the surrounding environment as well.

"You can learn something about sources of subsidence, corrosion that affect other structures, or something about the geographic distribution of earthquake or hurricane damage, which then allows you to make improved decisions about emergency response," said Tom O'Rourke, professor of civil and environmental engineering and principal investigator of the research project.

The test also proved that sensors provide valuable feedback to companies like IPEX that want to advance the engineering behind new products and improve systemwide performance.

"This is about having feedback and intelligence for underground lifeline systems, such as water supplies, electric power and telecommunications, which provide the services and resources that define a modern city," O'Rourke said. "It's pretty clear to me that within 20 years there will be intelligence integrated into every aspect of infrastructure."

"The vision we have is that our future infrastructure looks after itself by sensing and adapting to the changing environment," said Kenichi Soga, professor at Berkeley and principal investigator for the Berkeley and Cambridge teams. "Rapidly developing sensor technologies and data analytics give us the opportunity to make this happen."

The research team is excavating the pipeline and analyzing the massive amount of data collected by the sensors. "It's going to be game-changing," said Wham, who added that some of the devices are capable of recording up to a thousand measurements per second or more. "We have many, many gigs of data right now for measurements that were previously unattainable."

Provided by Cornell University