Keeping Structures Sound

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The I-35 bridge collapse in Minneapolis, Minn. in 2007 killed 13 people and resulted in untold economic disruption for the Upper Midwest. It also brought to stark relief a problem with the nation's infrastructure: it is old and getting older every day.

Haim Waisman is developing computational techniques to help understand how and why things fall apart, and how this may be predicted and prevented. "Fractures govern our lives," he said. "Everything is connected by fractures."

Waisman is refining computational methods known as extended finite elements and multiscale modeling to design high-strength, nanocomposite materials that might one day shore up aging structures, such as pipes and bridges, in corrosive environments. He also has developed a non-invasive method of detecting fractures in things such as an airplane wing using measurements from only a few common stress sensors.

In particular, he has been using his methods to study how suspension bridge cables age. The main cables are made of thousands of wires clamped and wound together. When a wire breaks, the loads it carries are redistributed to neighboring wires. Understanding and predicting the fracture response of the entire cable considers as many as 50,000 wires wound into a tightly compressed bundle more than two miles long, and requires a supercomputer.

He has found that, when a wire breaks, friction between the remaining wires can effectively transfer the strain throughout the cable bundle without compromising the entire bridge. That's a relief for the millions of people who daily cross the graceful, but aging, bridges that lead into and out of Manhattan.

Fractures also play a role in nature and Waisman has recently turned his attention to a dramatic example—the collapse of ice shelves in Greenland and Antarctica. As the climate warms, water from melting ice seeps to the bottom of glaciers, allowing them to slide more easily over bedrock and forming networks of cracks in ice shelves.

In 2002, 1,250 square miles of the Larsen B ice shelf in West Antarctica shattered, sending icebergs into southern shipping lanes. Since then, several other shelves have collapsed, threatening sea-level rise around the world. Understanding how things like ice shelves and bridges break and fail is a necessary first step to understanding the inevitable changes going on all around us all the time.

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