Decking out infrastructure with wires and sensors is the goal of many future-leaning urban planners and architects who are working to realize the dream of a true smart city. Now, the interconnected hyper-reality of interactive skins on buildings and bridges that signal when they need fixing is moving one step closer to fruition.

Several research groups have developed and patented unique formulas for electrically conductive concrete, which could deice roadways, sense when infrastructure needs repairs or even create cyber-secure buildings.

Concrete typically has three main ingredients: cement, water and an aggregate, which is usually stone. But start playing around with that recipe, and the final product will have interesting properties. Add in a conductive aggregate - like materials science wunderkind graphene - and you've got electrically conductive concrete. The formula can be tweaked depending on the material's intended use.

Here are a few applications for conductive concrete that researchers are investigating:

One Canadian research group envisions the new concrete being employed in roads, sidewalks and bridges to melt dangerous ice, and to heat the floors of homes.

The invention is being developed around the world - and has been for several years. But it's been the subject of intensive investigation at the Building Envelope and Structure research group at the National Research Council of Canada (NRC), a country with particularly harsh winters. The NRC has already patented and proven the technology in small-scale applications.

According to NRC's Rick Zaporzan, their material's applications go beyond deicing and heating. "With a few tweaks, it can be used for developing a crack-detection system if it's hooked up to proper sensors that can monitor and interpret that data," he says.

That's a useful application, considering that in the United States alone, one in nine bridges is

structurally deficient, according to Transportation for America.

Electrified concrete can block electromagnetic signals, which means that if it is used to insulate a building, no information could get in or out.

But what about catching an Internet signal? “A building could be electronically secured and still have Wi-Fi,” says Zaporzan. “This is already done in, for example, military shelters. But the concrete is quicker, more effective and less costly than other ways of shielding a building.”

Blocking unwanted electromagnetic signals is useful beyond creating cyber-secure buildings, explains Zaporzan. It can also shield individual objects within buildings. “The concrete can also be used to protect extremely sensitive medical equipment, and that’s a huge application,” he says.

How long until electric concrete is available on the market? “It could be commercialized within one to two years, but we need industry partners,” Zaporzan says. “These partners could be anybody who wants to take their product further, from building or bridge owners, medical equipment manufacturers, or architects and urban designers.”

There are a few limitations to the technology, such as its power source. Hardwiring the concrete to the power grid is, to date, the best option. That means that heating up an entire highway isn’t practical, but heating up particularly vulnerable stretches or parts of a bridge is.

But as Zaporzan says, “Anything is possible if you can create enough power. There are so many energy options available, from wind power to hydrogen fuel cells, solar and regenerative power. Down the road, heating up an entire highway is in the realm of the possible.”

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