Building better bridges with geosynthetics

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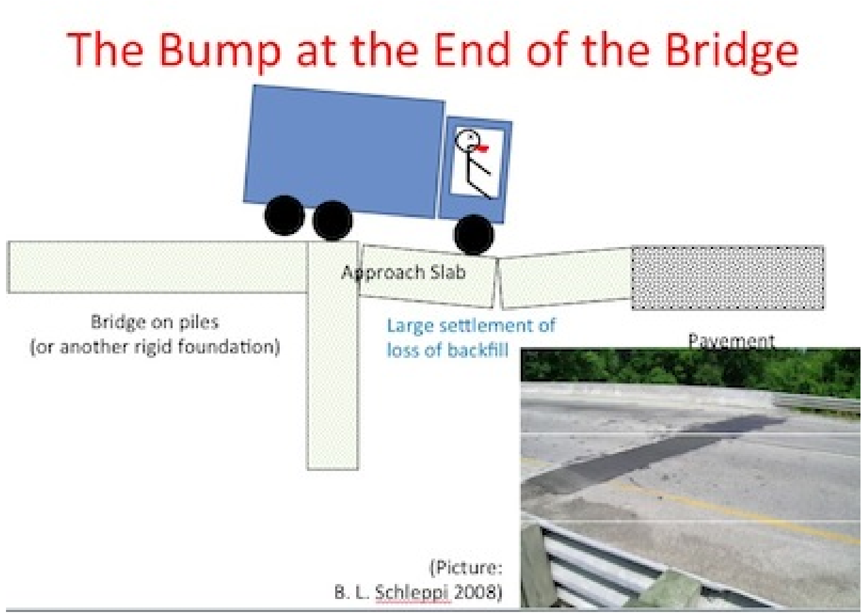

A diagram by Dante Fratta illustrates why "the bump at the end of the bridge" is a serious problem.

(Phys.org) —As the road leading up to a bridge presses down on the soil beneath its surface, the bridge tends to remain higher than the roadway, creating a problem that has menaced drivers and road engineers for years.

"It's called the bump at the end of the bridge," says Civil and Environmental Engineering Associate Professor Dante Fratta, who along with PhD student Maxmiliano Garnier-Villarreal and Professor Mike

Oliva is exploring how geosynthetic reinforced soil (GRS) can be used to keep bridges more even with the roads that lead onto them.

It might seem a rather pedestrian term for an engineer to use, but the bump at the end of the bridge is no mere annoyance. It damages vehicles and can cause drivers to lose control over steering. It exposes bridge decks to damage from snowplows. And, to lay asphalt between the bridge deck and the embankment, workers have to operate in potentially dangerous traffic conditions.

Fratta says the solution is to put the bridge and the embankment on the same support, instead of putting the embankment on compactable soil and the bridge on rigid piles. Using geosynthetic materials to support the soil, Fratta and his fellow civil engineers create a foundation that supports both the roadway embankment and bridge decks up to 120 feet long.

"Now, the pavement is still going to deform, but it's going to deform with the bridge," Fratta says. "Everything goes together."

The UW-Madison team, with funding from the Federal Highway Administration, is currently monitoring a small bridge that the Wisconsin Department of Transportation built using this approach in summer 2012. It spans a creek on a section of State Highway 40, south of Bloomer in Chippewa County.

Because of the frac sand mining boom in western Wisconsin, this bridge has been handling quite a lot of heavy truckloads, making it an ideal test subject.

"We hope that this technology becomes part of our standard toolbox for bridge construction," says Bill Oliva (no relation to Mike Oliva), chief of structures development for WisDOT's Bureau of Structures. He says that there are about 80 GRS bridges in the United States, including one currently being built along a stretch of Interstate 84 in Utah. The FHWA provides some guidelines for building such bridges, and WisDOT is working on adapting those guidelines to suit Wisconsin's weather conditions.

WisDOT wants to see not only how the bridge holds up under stress from heavy cargo trucks, but also how geosynthetic materials hold up against the environmental changes that occur on river and creek banks.

"Since GRS bridges don't have deep foundations, we need to consider the potential risk associated with erosion and scour," Bill Oliva says. "That might be one factor that prevents us from installation at some sites."

The team checks a set of survey points every month to track how the bridge and embankments rise or sink. The group also is monitoring a more conventionally built bridge on U.S. Highway 51 in Dane County, as a sort of control for the experiment.

One thing the researchers didn't anticipate at the Bloomer site was that water seeped into the soil and then froze over the winter, causing the embankments to rise above the bridge deck by three centimeters. However, as of April 2014, as winter recedes, the deck is 2 centimeters or less above the road level.

"Instead of the bridge being on top of the soil, the soil became higher, but the rest of the time the system behaved very well, " Fratta says. "So we might want to change the types of soils that we're using in the embankment. You see that swelling when you have fine particles, but if you use gravel, you won't have that problem."

Having tested the technology, WisDOT sees long-term benefits on several fronts. Because GRS bridge abutments can be installed rapidly and at relatively low cost, they're ideal for temporary applications—for instance, when crews are replacing an old bridge but need a stopgap to keep traffic moving while the new bridge is built. Because the abutments don't require specialized equipment like cranes and pile drivers, that opens up their construction to more contractors. (In fact, the abutment in Chippewa County was built by a Madison-based landscaping firm.) That could mean more competition and lower costs when WisDOT contracts out for bridge projects.

WisDOT already has incorporated some of the conclusions from the experiment into materials and manuals for internal designers and outside companies, which might encourage more people in the industry, and in local-level governments that maintain roads, to embrace the technology. "We worked hard to ensure that the lessons learned were institutionalized," Bill Oliva says. "We anticipate, as the industry becomes more comfortable with it, that it will become very economical."

Bill Oliva says WisDOT's goal is to build GRS bridges that can last as long as conventionally built ones—about 75 years.

So far, the solution works only for relatively small bridges. But, Fratta says, this could make it much easier to build and maintain bridges on state and county roads.

"You can build it pretty quickly and you don't have to wait for concrete to cure or anything like that," Fratta says. "And you avoid the bump at the end of the bridge."

Provided by University of Wisconsin-Madison