The path less traveled: Research is driving solutions to improve unpaved roads

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A Kansas State University graduate student sees the unpaved road ahead, and it's filled with biomaterial.

Wilson Smith, master's student in civil engineering, Independence, Mo., is working with lignin, a plant-based sustainable material that can be added to improve the quality of unpaved roads throughout Kansas.

More than 70 percent of the 98,000 miles of roads in Kansas are unpaved, Smith said.

"One of the problems with unpaved roads is that they are made from loose granular soils with particles that are not bound to each other on the road surface," Smith said. "This limits the speed of vehicles and often generates a lot of dust, denigrating the quality of the road."

But possible solutions could come from lignin, a biomass product that is present in all plants, including wheat straw, sugar cane and corn stover. Lignin is a waste product from other industries, including the production of biofuel and paper. These industries take plant mass and use the process of hydrolysis to separate useful materials, including cellulose and hemicellulose, from lignin.

"What we're trying to do is find new uses for this lignin co-product, which ties into sustainability," Smith said.

Several properties make lignin a valuable material. It is adhesive when it

becomes moist, making it good for binding soil particles together and providing cohesion. As a result, lignin works very well on unpaved roads by providing better support for vehicles and protecting the road from erosion.

Because Kansas is an agricultural state, lignin is an abundant resource and has the potential to improve unpaved roads, leading to less maintenance costs throughout the state, Smith said.

"Lignin can be extracted from many types of crop residue, and it can also be an extra source of income to farmers and the agricultural community if there is a demand for this crop residue," Smith said. "Lignin is a sustainable product. It's 100 percent nontoxic, unlike traditional soil stabilizers such as flash or cement, which do have some heavy materials in them that could contaminate soil."

Smith is working under the direction of Dunja Peric, associate professor of civil engineering.

"Kansas is strategically positioned for using lignin to stabilize unpaved roads," Peric said. "Kansas is located in the midst of the Great Plains, which is one of the largest wheat producing areas in the world. In addition, the construction of the nation's first commercial-scale cellulosic ethanol plant has recently begun in Hugoton."

For his research, Smith takes soil and mixes it with different amounts of water and lignin. He is testing five different lignin concentrations -- 2 percent, 4 percent, 6 percent, 9 percent and 14 percent -- to understand how different levels of lignin affect the soil cohesion and, consequently, road erosion.

Smith then lets the mixture dry in a controlled environment for different periods of time to understand how much it increases the strength of the

samples. Other members of Peric's research team have been testing the strength of lignin samples immediately after they are mixed rather than allowing them to dry.

Once the materials are dry, Smith uses a direct shear device to determine the strength of the different mixtures. The direct shear device simulates the stress that unpaved roads experience when cars and heavy machinery drive on them.

"When vehicles drive on unpaved roads, there is a lot of dust that is thrown into the air," Smith said. "In addition, travel is impaired because of raveling and washboarding, which are forms of soil collapse on the top surface of the road. These are all things that can be mitigated by lignin because it holds the soil particles together and in place."

Based on early results, the materials with lignin concentrations of 4 percent, 6 percent and 9 percent show the highest strength benefits. Smith will spend the spring semester further testing all of the different concentrations and how their strength develops with the amount of elapsed time.

"We want to get an exhaustive analysis of how the cohesion varies when you change the concentration of lignin, the water content and the compaction," Smith said. "That will determine in the field, what percentage of lignin is the best concentration to stabilize the soil."

Smith will give a research presentation titled "Feasibility of Using Lignin: Plant Derived Material for Stabilization of Unpaved Roads" at the Capitol Graduate Research Summit in Topeka in February.

Provided by Kansas State University