Researchers building stronger, greener concrete with biofuel byproducts

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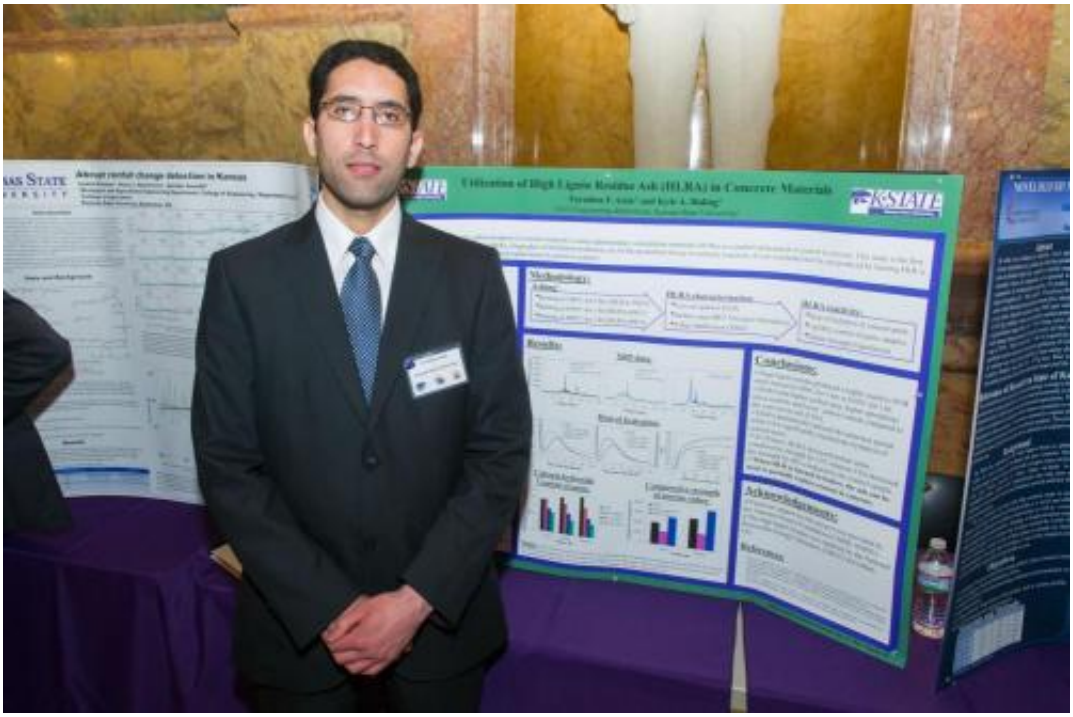

Feraidon Ataie, doctoral student in civil engineering, is building better concrete by adding biofuel byproducts. He presented his research at last month's Capitol Graduate Research Summit in Topeka.

Kansas State University civil engineers are developing the right mix to reduce concrete's carbon footprint and make it stronger. Their innovative ingredient: biofuel byproducts.

"The idea is to use bioethanol production byproducts to produce a

material to use in concrete as a partial replacement of cement," said Feraidon Ataie, doctoral student in civil engineering, Kabul, Afghanistan. "By using these materials we can reduce the carbon footprint of concrete materials."

Concrete is made from three major components: portland cement, water and aggregate. The world uses nearly 7 billion cubic meters of concrete a year, making concrete the most-used industrial material after water, said Kyle Riding, assistant professor of civil engineering and Ataie's faculty mentor.

"Even though making concrete is less energy intensive than making steel or other building materials, we use so much of it that concrete production accounts for between 3 to 8 percent of global carbon dioxide emissions," Riding said.

To reduce carbon dioxide emissions from concrete production, the researchers are studying environmentally friendly materials that can replace part of the portland cement used in concrete. They are finding success using the byproducts of biofuels made from corn stover, wheat straw and rice straw.

"It is predicted that bioethanol production will increase in the future because of sustainability," Ataie said. "As bioethanol production increases, the amount of the byproduct produced also increases. This byproduct can be used in concrete."

The researchers are specifically looking at byproducts from production of cellulosic ethanol, which is biofuel produced from inedible material such as wood chips, wheat straw or other agricultural residue. Cellulosic ethanol is different from traditional bioethanol, which uses corn and grain to make biofuel. Corn ethanol's byproduct—called distiller's dried grains—can be used as cattle feed, but cellulosic ethanol's

byproduct—called high-lignin residue—is often perceived as less valuable.

"With the cellulosic ethanol process, you have leftover material that has lignin and some cellulose in it, but it's not really a feed material anymore," Riding said. "Your choices of how to use it are a lot lower. The most common choices would be to either burn it for electricity or dispose of the ash."

When the researchers added the high-lignin ash byproduct to cement, the ash reacted chemically with the cement to make it stronger. The researchers tested the finished concrete material and found that replacing 20 percent of the cement with cellulosic material after burning increased the strength of the concrete by 32 percent.

"We have been working on applying viable biofuel pretreatments to materials to see if we can improve the behavior and use of ash and concrete," Riding said. "This has the potential to make biofuel manufacture more cost effective by better using all of the resources that are being wasted and getting value from otherwise wasteful material and leftover materials. It has the potential to improve the strength and durability of concrete. It benefits both industries."

The research could greatly affect Kansas and other agricultural states that produce crops such as wheat and corn. After harvesting these crops, the leftover wheat straw and corn stover can be used for making cellulosic ethanol. Cellulosic ethanol byproducts then can be added to cement to strengthen concrete.

"The utilization of this byproduct is important in both concrete materials and biofuel production," Ataie said. "If you use this in concrete to increase strength and quality, then you add value to this byproduct rather than just landfilling it. If you add value to this byproduct, then it is a

positive factor for the industry. It can help to reduce the cost of bioethanol production."

The researchers have published some of their work in the American Society of Civil Engineer's *Journal of Materials in Civil Engineering* and are preparing several other publications. Ataie also was one of two Kansas State University graduate students named a winner at the 2013 Capitol Graduate Research Summit in Topeka. His poster was titled "Utilization of high lignin residue ash (HLRA) in concrete materials."

Provided by Kansas State University