Linda Engle Introduction: Sustainable Idaho is brought to you by the Portneuf Resource Council.

Madison Long: Welcome to Sustainable Idaho. I'm your host, Madison Long, and today I talked with Mustafa Mashal, a professor in civil engineering, special advisor to the vice president for research and economic development at Idaho State University, and lead inventor for Sweetcrete. In 2022, Mashal and a few colleagues developed the idea behind an innovative concrete blend that utilizes Idaho byproducts to reduce the burden on landfills and promote the idea for a circular economy where materials never become waste and nature is regenerated. What originally inspired your interest in creating an innovative concrete blend?

Mustafa Mashal: Concrete is the second most used material in the world after water. And the consumption of concrete is expected to go higher and higher everywhere around the world. The ingredients that make concrete are Portland cement, aggregates, and water. Cement acts as the binder, so it binds all those aggregates together. And once concrete is cured, then you end up with a strong rock type of material.

But producing cement is a complicated process, and it's also a very energy intensive process. We wanted to see if there are opportunities that we can reduce consumption of cement in concrete. If we could, that would be a saving not only cost, but also in terms of the resulting carbon footprint. And we have been doing this kind of research for several years now, looking into even replacing the aggregates with other alternatives, as well as reducing consumption by replacing a portion of cement with a product that can do the job.

ML: Between 2002 and 2021, the International Climate Research and the Global Carbon Project recorded concrete's global emissions to be around 2.9 billion tons, accounting for at least 8% of all carbon dioxide emissions.

Hoping to reduce emissions Sweetcrete replaces 30% of the cement ingredient with precipitated calcium carbonate, or PCC, which is a byproduct from sugar beets, as well as replacing 100% of the aggregate with upcycled crushed concrete pieces. Mashal mentioned that during research there might also be potential to replace the freshwater ingredient with treated wastewater. Most of the cost to mix the innovative concrete comes from transportation and construction materials. Ultimately, the current version of Sweetcrete has a cost saving of between 15 to 20% per cubic yard of concrete by utilizing materials that would otherwise end up in landfills.

Now, Sweetcrete is being taken to the next level by principal investigator Tadesse Wakjira, a researcher in the civil and environmental engineering department at ISU and the Center for Advanced Energy Studies.

MM: With the expanded research that we have currently as part of the Idaho Global Entrepreneurial Mission Higher Education Research Council project, we would like to raise the technology readiness level from a lower tier to a higher tier. So we would like to have a field application.

That's one reason we have been working with our industry partners throughout the state and region to see which projects are the most appropriate that we could utilize Sweecreate based on the amount of research we have available and the additional testing that we will be doing. We are also gathering feedback from engineers and industry on what thoughts or suggestions they have for this additional testing.

ML: What specific AI or machine learning tools were being used to optimize the mix design.

MM: Our colleague, Dr. Tadesse Wakjira, is the expert and he's driving that aspect for the project. And to my understanding, the plans are that we're going to be using several techniques, such as multi-objective optimization that simultaneously optimizes multiple variables in concrete. That's not only the ingredients, the portion, but it's actually taking into account all types of factors such as transportation costs, specific application and desired compressive strength, durability. Utilizing a very complex AI and machine learning model to guide us, to find the right recipe for Sweetcrete for each application, because Sweetcrete is not like a cookie cutter, where you could utilize one mix for all applications. We want to develop different mixes of Sweetcrete for each application. For example, maybe Sweetcrete for a sidewalk project will be different than a retaining wall or a sound wall. So that's where AI and machine learning will be used to help us come up with those mixes and solutions efficiently and quickly.

ML: Have field tests been run on Sweetcrete?

MM: So far we have not used Sweetcrete in an actual project, but we are working with our industry partners in the area to start with a project. And it doesn't have to be a very big or complex project, we can start with something that is a low hanging fruit. We're hoping to have that kind of application in the next 12 months. And obviously we want to make sure that people get to understand and learn about it and then be comfortable utilizing it. And most importantly, build confidence in the long term.

ML: As you're going into these field tests, what performance benchmarks will be used in real world testing?

MM: We want to make sure that the compressive strength for Sweetcrete is at least comparable to conventional concrete. That is about 4,000 PSI at 28 days once concrete is cured. We have set that in order to ensure that there's enough structural performance, because most properties of concrete are affected by its compressive strength.
We also would like to do testing on durability, including freeze on top. Because our area in Idaho, we get a lot of harsh winters, so we want to ensure that the type of concrete that we utilize can last those kinds of environment and conditions. And there are specific tests from American standards for testing and materials for concrete on those durability aspects. Once we have more data available from durability, then it will guide us to even further push for Sweetcrete applications where it could be a solution to conventional concrete where cost-saving can happen.

ML: American standards for concrete testing are governed by the American Concrete Institute. Concrete must have a high compressive strength, be able to withstand freezing and thawing, long-term exposure to water, resist erosion and abrasion, degradation due to industrial chemicals, reactions from aggregates, corrosion of steel, and resist expansion and cracking due to the sulfate in Portland cement.

Are there any performance differences that you observe compared to traditional concrete?

MM: Certainly, because you're utilizing byproducts and you're replacing a significant portion of cement, we noticed that if you go beyond 30% replacement of cement with PCC, the strength drops substantially. So that means that we cannot just go about and replace 50, 60% of it at this stage, unless we come up with better ways of mixing it and as well as proportioning it, and maybe even maybe some processing on PCC itself. For the first phase of the project that we did back in 2022, we used PCC as it was because you're utilizing a byproduct. You're trying to get rid of a burden. And the more process that you try to do on that ingredient, the more cost will be added to the project.

ML: Do you think that Sweetcrete, once it is field-tested and refined, could be used beyond Idaho and maybe internationally?

MM: Right now, the work we have done has been all at the laboratory. So taking it from laboratory to field application, it's just two different things. We don't want to go really complicated for the pilot project. Start small and then add complexity to it, learn from the deployment, try to come up with better ways to advance it for larger, more complicated projects.

We certainly think that our research goes beyond Idaho and could be utilized by other countries where we think that similar innovation can be taken advantage of to reduce the burden on landfill. It's always about ensuring that whatever we identify at the end of the day is something that will cost less, and have similar performance to conventional construction materials. We hope that whatever we are trying to achieve with this project is something of benefit to everyone who is involved, including students, researchers, faculty, and the industry, who are the end users of such technologies.

ML: Thank you to Mustafa Mashal for sharing the creative and ongoing research of Sweetcrete. If you want to stay in the loop about his research, follow Mustafa Mashal and Tadesse Wakjira on LinkedIn where they publish updates on their work. You can also follow the social media pages for the College of Science and Engineering who is helping to get the word out about this project.

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