Engineers develop fast, automated, affordable test for cement durability

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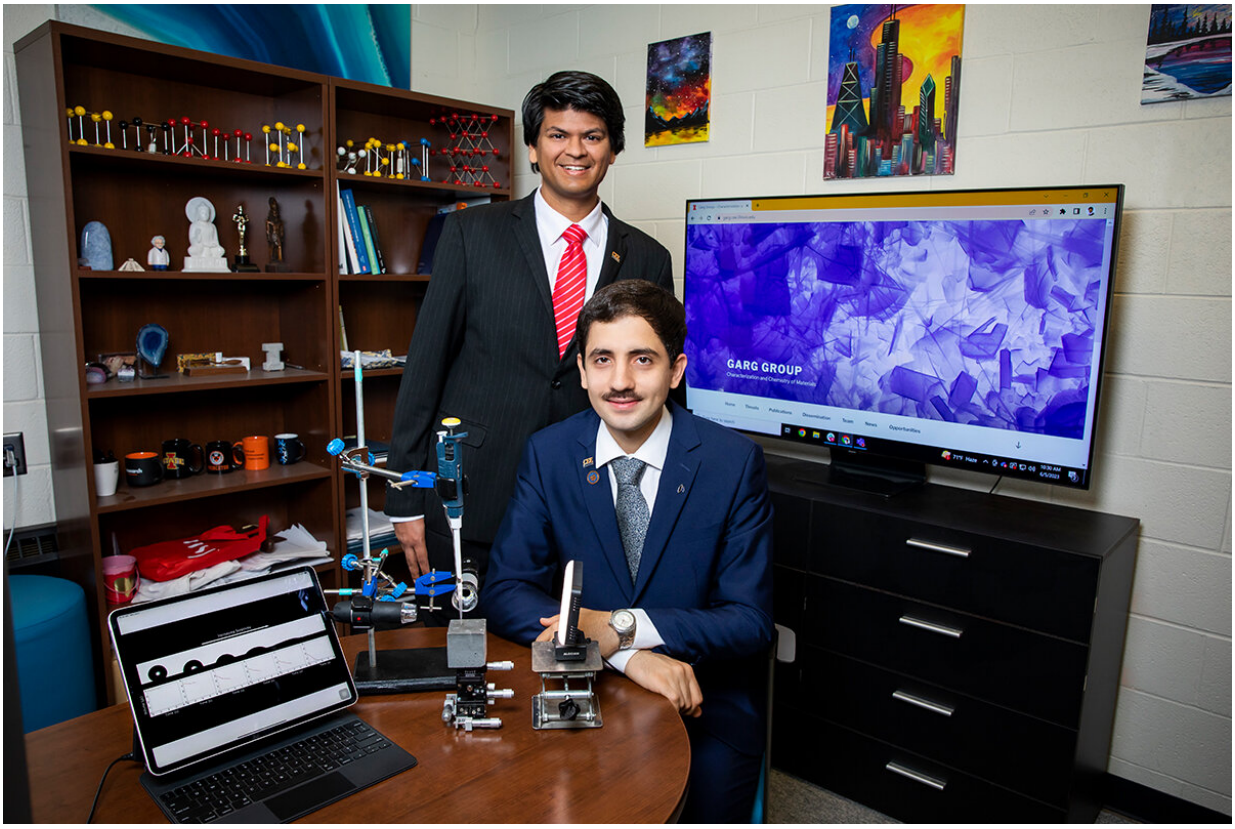

Professor Nishant Garg, standing, and graduate student Hossein Kabir used computer vision to develop a fast and convenient method for testing cement durability that can be used in the field or laboratory. Credit: Michelle Hassel

Engineers at the University of Illinois Urbana-Champaign have

developed a new test that can predict the durability of cement in seconds to minutes—rather than the hours it takes using current methods. The test measures the behavior of water droplets on cement surfaces using computer vision on a device that costs less than $200. The researchers said the new study could help the cement industry move toward rapid and automated quality control of their materials.

The results of the study, led by Illinois civil and environmental engineering professor Nishant Garg, are reported in the journal *npj Materials Degradation*. The paper is titled "Rapid prediction of cementitious initial sorptivity via surface wettability."

"Concrete is one of the most consumed materials on our planet, second only to water," Garg said. "Over time, the concrete used to build our infrastructure degrades over time via exposure to deicing salts; freeze and thaw cycles; and ingress of water—all of which can lead to corrosion of the rebar that is used to strengthen the structures. Ultimately, this leads to failure, sometimes catastrophically, as seen in the 2021 condominium collapse in Surfside, Florida, where 98 lives were lost."

One of the key tests used to predict the durability of cementitious systems is based on the ability of cement paste—a mixture of cement-based binder and water—to absorb water, Garg said. Water absorption is linked to cement's durability; the more porous the cement paste is, the more water it will absorb, ultimately leading to corrosion of the embedded rebar in reinforced concrete.

A standard test, known as ASTM C1585, is performed in a lab by exposing a concrete sample that contains cement paste to water while a technician continuously measures the "sorptivity"—or how much water the sample absorbs and transmits—by observing its weight change for several hours, if not days.

In the study, the new device predicts initial sorptivity using computer vision to see how quickly a single water droplet is absorbed into the surface within the first few seconds or minutes. Garg said the test is far less tedious than the current ASTM method and can be performed on the fly in the field or in the lab.

"We performed the new test on more than 60 unique samples, and there's a fairly good correlation between our results and the results from the conventional ASTM test method," Garg said. "So we are now proposing our new testing method as an alternative to test the durability of cementitious systems in a few seconds."

In addition to the importance of droplet absorption, the research team also learned that the initial angle at which water droplets come into contact with the cement surface matters, too.

"The dynamics of absorption change quickly while the water droplets change shape on the surface," Garg said. "Intricacies like these are all factored into our new test."

The team is currently working on ways to scale up the test for mortars and more varieties of concrete, which are texturally and chemically more complex.

"The key takeaway from the study is that testing the durability of building materials is very slow, tedious and labor-intensive," Garg said. "With the availability of technologies like computer vision and analysis, we can develop tests that are faster, automated and convenient."

More information: Rapid prediction of cementitious initial sorptivity via surface wettability, *npj Materials Degradation* (2023). DOI: 10.1038/s41529-023-00371-4