Cementing our place in space

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As your dog drags you around the block for his morning walk, you're probably not thinking about the wonders of the neighborhood sidewalk. But that concrete is pretty great. Next to water, it's the most widely used material on Earth. In the future, concrete may be equally useful off the planet—when humans construct a permanent base on the moon. They'll need sturdy stuff that can weather bombardments from solar radiation and meteorites. No one wants a crack in their moon base!

The key to making 'out-of-this-world' concrete may be to study it … out of this world. Two experiments have taken place aboard the International Space Station (ISS) to do just that. The Microgravity Investigation of Cement Solidification (MICS) and Multi-use Variable-g Processing Facility (MVP Cell-05). Researchers from Pennsylvania State University and NASA's Marshall Space Flight Center are analyzing the studies' results.

Concrete is a mixture of sand, gravel, and rocks 'glued' together by cement paste made of water and cement powder. And it's not as mundane as it looks. Under the surface, it's quite complex. What goes on there is key to its strength and durability. Yet scientists still don't understand all the details of concrete's chemistry and microscopic structure. Processing methods aren't 'cast in stone'; there's plenty of room for improvement.

Aleksandra Radlinska, Principal Investigator for both experiments, says, "Our experiments are focused on the cement paste that holds the concrete mixture together. We want to know what grows inside cement-

based concrete when there is no gravity driven phenomenon, such as sedimentation."

It all begins when water is added to the cement. To put it very simply, the cement's molecular structure changes when the cement grains dissolve.

Radlinska explains, "As the 'old' molecules dissolve, calcium silicate hydrate and calcium hydroxide start to crystalize."

Myriads of these tiny crystals form all through the mixture, interlocking with one another and with the other concrete ingredients, such as gravel. The ISS experiments are researching how this all plays out in space.

Radlinska says, "It could change the distribution of the crystalline microstructure, and ultimately the material properties."

The ratio of the water/cement powder is critical to making the concrete components combine effectively and determining the strength and durability of the final concrete. Will this ratio need to be different on the moon, where gravity is about 1/6th of Earth's? That's the kind of question the experiments will shed light on.

For the MICS experiment, astronauts added water to a series of packets containing dry cement powder, then added alcohol to some of the packets to stop the hydration process at specified times. For MVP Cell-05, astronauts also hydrated dry cement, but for this experiment they used a centrifuge on-board the ISS to simulate gravity at a number of strengths, including lunar gravity and Martian gravity. For both experiments, the samples were returned to Earth for analysis.

"We're already seeing and documenting unexpected results," says Marshall's Richard Grugel, co-Principal Investigator for MVP Cell-05.

Radlinska adds, "What we find could lead to improvements in concrete both in space and on Earth. Since cement is used extensively around the world, even a small improvement could have a tremendous impact."

We might even end up with better sidewalks for walking our dogs.

More information: For more from the International Space Station, go to www.nasa.gov/iss-science

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