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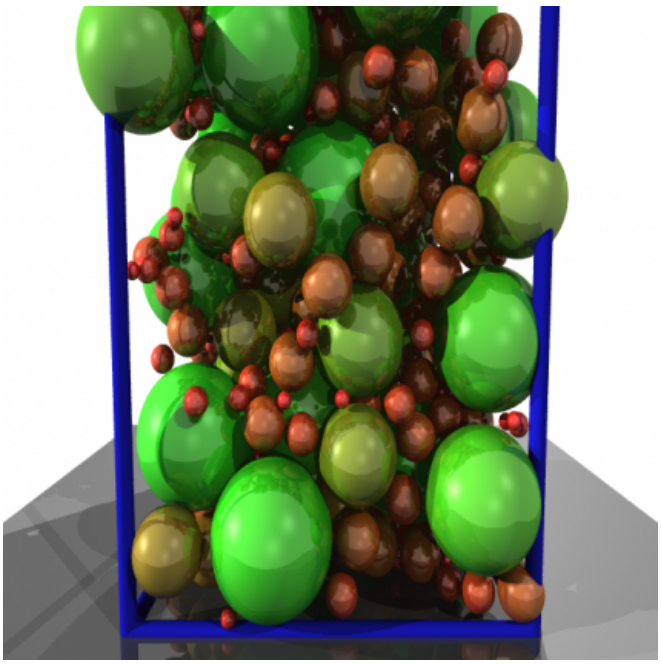

This figure illustrates how the size diversity of cement nanoparticles allows them to pack together tightly, increasing the strength of the cement.

Image: Enrico Masoero

Size diversity in cement nanoparticles optimizes packing density to give concrete its strength

Denise Brehm | Civil and Environmental Engineering
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Concrete may be one of the most familiar building materials on Earth, but its underlying structure remains a bit of a mystery. Materials scientists and concrete engineers still don't fully understand exactly how the cement paste that works as glue in concrete hardens during the first hours after water and cement powder are mixed.

New technologies are making it possible for researchers in MIT's Concrete Sustainability Hub to make steady progress toward solving this mystery. First they determined that cement paste is a granular material, where the particles or basic nanoscale units pack together most densely when arranged orderly. A few years later they discovered that the calcium-silicate-hydrate (C-S-H) molecules that make up the basic nanoscale unit of cement have a disorderly geometric arrangement, rather than the orderly crystalline structure scientists had long assumed.

In new work, researchers found that the size of C-S-H particles themselves is also somewhat disorderly: The particles form at random sizes, not in homogenous spheres, and this diversity in the size of the nanoscale units leads to a denser, disorderly packing of the particles, which corresponds to stronger cement paste.

The researchers hope this understanding will allow materials scientists and concrete engineers

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to alter the C-S-H particles at the molecular level to develop stronger, more durable concrete that will have a reduced environmental footprint. If concrete is stronger, less of it is needed. And if it's more durable, structures made from it will last longer.

Physical Review Letters recently published a paper about this work by Enrico Masoero, postdoctoral associate in the Department of Civil and Environmental Engineering (CEE); Professor Emanuela Del Gado of the Swiss Federal Institute of Technology; Roland J.-M. Pellenq, CEE senior research scientist; Franz-Josef Ulm, the George Macomber Professor in CEE; and Professor Emeritus Sidney Yip of the Department of Nuclear Science and Engineering and the Department of Materials Science and Engineering.

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