MICROGRAVITY INVESTIGATIGATION OF CEMENT SOLIDIFICATION

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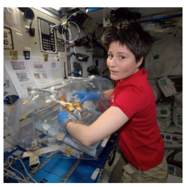
WHY DOES THIS RESEARCH MATTER ON EARTH TOO?

Concrete is the most widely used man-made material in the world, second only to water. The large –scale production of cements contributes to ~5% anthropogenic CO_2 emission.

Microgravity research can lead to more durable and hence more cost-effective material.

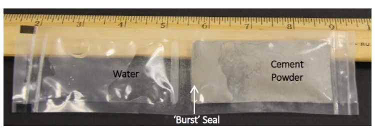
RESEARCH OBJECTIVES

The intent of this work is to utilize the microgravity environment aboard the International Space Station (ISS) to investigate the complex process of cement solidification.



Samples are going to be launched to ISS in 2018

Mixing and hardening takes place in 0*g*



BACKGROUND ON CEMENT HYDRATION

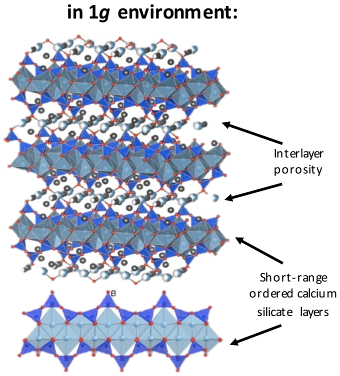
Microstructural development of hydrating cement results in elaborate combinations of amorphous and crystalline phases. The morphology, volume fraction, and distribution of these phases ultimately determine the hardened cement's material properties.

5 hours of hydration:

2 weeks of hydration:

Image credits: NIST

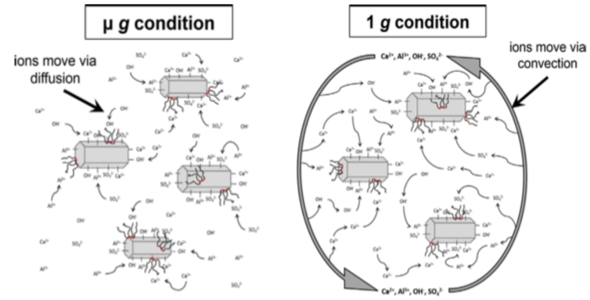
Microstructural development of cement in 1*g* environment:



Adapted from Richardson (2004)

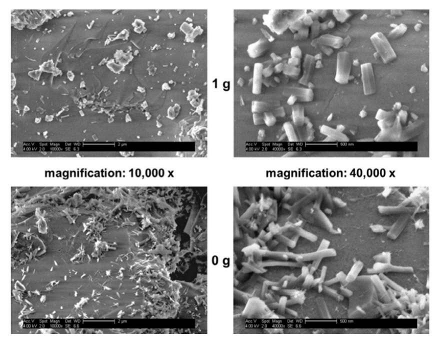
HYPOTHESIS

Minimizing gravity-driven phenomena, such as thermosolutal convective flow and sedimentation, will ensure crystal growth strictly by diffusion and a considerably different microstructure than that observed in typical laboratory conditions on Earth.



After Meyer and Plank, 2016.

The understanding of cement hydration in 0*g* is limited to 10 seconds in parabolic flight. Despite the short duration of the experiment, the amount of crystal, its size, and shape already present significant differences, as showing in the images below (Meyer and Plank, 2016).



RESEARCH DELIVERABLES:

- Determine the mechanical properties of hardened samples mixed in 0g;
- Petrographic and microstructural investigation
- Computer simulation of cement hydration, including the role of gravity.

Mindess, S.; Young J. F.; and Darwin D. (2003). Concrete – Second Edition. Pearson Education Inc. Chapter 4 – Hydration of Portland Cement, p. 57-91.

Richardson, I. (2004). Tobermorite/jennite-and tobermorite/calcium hydroxide-based models for the structure of CSH: applicability to hardened pastes of tricalcium silicate, β-dicalcium silicate, Portland cement, and blends of Portland cement with blast-furnace slag, metakaolin, or silica fume. Cement and Concrete Research, 34(9), 1733-77.

Meier, M. R.; and Plank, J. (2016). Crystal growth of $[Ca_3Al(OH)_6 . 12H_2O]_2 . (SO_4)_3 . 2H_2O$ (ettringite) under microgravity: On the impact of anionicity of polycarboxylate comb polymers. Journal of Crystal Growth, 446, 92-102.

Research Opportunities in Materials Science – Materials Lab Open Science Campaigns for Experiments on the International Space Station; Under Science and Technology and other Research and Development (ST)

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