Controlling Microcracking in Low Embodied Energy Concrete

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Abstract: The US cement industry requires a significant amount of energy for the production of ordinary Portland cement clinker (550 × 1012 British thermal units in 2000), and with the industry accounting for at least 5-8% of anthropogenic CO_2 emissions there is mounting pressure from government and society to rapidly implement sustainable cement alternatives. Geopolymer cement is fast emerging as a viable low embodied energy alternative to traditional ordinary Portland cement (OPC). However, several fundamental hurdles must be overcome prior to widespread implementation of geopolymer concrete in the built environment. A primary fundamental hurdle is microcrack formation in the cement and therefore decreased durability. This proposal seeks to develop a new class of low embodied energy geopolymer cement by tailoring gel chemistry and additives for optimal binding properties that limit microcrack formation and propagation, with the geopolymer concrete company Zeobond acting in an advisory role to ensure industrial relevance. A unique combination of X-ray scattering and electron imaging studies across length-scales (atoms to microns) will elucidate the causes of microcracking and accelerate the design of additives (polymers and/or seeding nanoparticles) to mitigate this problem. The results of this research along with the connections that will be forged between the Andlinger Center and Zeobond will open pathways for North America's $10 billion cement industry to significantly reduce the impact cement production has on the environment.