Grant: AFC518-24

Title: A Hybrid Geopolymer-Biopolymer Cementitious Material for Pumpable Roof Support

Organization: University of Arizona

Principal Investigator: Lianyang Zhang

Topic: Ground Control Technologies

Concept Summary: This proof - of - concept research addresses the topic area "Ground Control Technologies" and will develop and demonstrate a novel hybrid geopolymer - biopolymer cementitious material with superior performance for effective pumpable roof support. Ground falls represent a significant hazard to underground mine workers. Although the mining industry has applied numerous technological and engineering advances, challenges still remain as evidenced by the persistent reoccurrence of fatalities and injuries due to ground falls. This is why roof support has continued to be one of the NIOSH Mining Program's research topics and is one of the research priorities in the Alpha Foundation 2017 Solicitation AFC518.

Effective roof support is critical to the prevention of ground falls and ground fall accidents. Over the years, pumpable roof supports have been increasingly used in mines to support the roof due to their advantages over other bulky standing roof support systems. An effective pumpable roof support should have high load stiffness, high peak strength and large yield strength. However, although considerable research has been conducted, the conventional cementitious materials currently used in practice, such as the calcium - sulfo - aluminate (CSA) cement and the Portland cement, still cannot achieve the normally conflicting responses such as high stiffness and large yield, as clearly stated in the Solicitation AFC518. To enhance the performance of pumpable roof supports so that ground falls and ground fall accidents are prevented, there is an urgent need to develop unconventional cementitious materials that possess the normally conflicting properties of high load stiffness, high peak strength and large yield strength.

Drawing upon the PI's unique expertise and experience on high performance cementitious materials, rock mechanics and ground control technologies and his direct working knowledge of mining, this research will develop and demonstrate a novel hybrid pumpable cementitious material through effective fusion of geopolymer and biopolymer. Geopolymer is a relatively new class of material produced by chemical dissolution and subsequent recondensation of aluminosilicates to form an amorphous three - dimensional framework structure. Geopolymer has many advantages compared to the conventional Portland cement, including rapid strength gain, high strength, low shrinkage, high thermal resistance, excellent acid resistance, and significantly reduced energy usage and greenhouse gas emissions. By incorporating biopolymer, a high molecular - weight organic material, in geopolymer, an interpenetrating cross - linked network will be formed and serve as a binding and toughening agent in the geopolymer matrix, further enhancing the performance of the composite cementitious material. This innovative approach mimics the unique bio - formation process of natural superior performance biological materials such as nacre of abalone shells.

At the end of the proof - of - concept phase, a new hybrid pumpable cementitious material possessing the normally conflicting properties of high load stiffness, high peak strength and large yield strength will be developed and demonstrated. Because the main source material for the geopolymer is fly ash, a waste from coal power plants, the new cementitious material will be more cost effective than the existing ones used in practice. Utilization of fly ash as the source material will also reduce the monetary and environmental costs related to disposal and management of fly ash. Moreover, geopolymer can be produced at ambient or slightly elevated temperatures and thus consumes much less energy and releases much less greenhouse gasses than the conventional Portland cement. The anticipated endpoint for development of a working prototype of the concept should additional funding be provided will be the hybrid pumpable cementitious material that can be easily tailored for effective field applications at different conditions.