Foamed Geopolymer Made by Additive Manufacturing for the Construction Technology Applications (3D-FOAM) M-ERA.NET Call 2021, M-ERA.NET3/2021/115/3D-FOAM/2022

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Abstract: Additive manufacturing (AM) is a rapidly evolving industrial sector and a potentially disruptive technology. It offers new possibilities for the construction industry, particularly in terms of geometrical flexibility, reduction of labor costs, improved efficiency and safety, suitability for harsh environments, and sustainability. This project addresses emerging challenges in AM, such as resource efficiency, energy savings, and sustainability, which are critical compared to conventional construction methods. Despite the successful implementation of 3D printing in industries such as aerospace and automotive, its application in concrete construction remains in its early stages. The full exploitation of 3D AM processes is currently limited by the performance of available material sets, both during processing and in-service conditions. To meet market and societal demands, particularly in the context of circular economy principles, this research focuses on developing zero-waste 3D printing technology by utilizing waste materials such as crushed clay bricks, aerated concrete, and disintegrated cement as raw materials. The primary objective was to engineer foamed ceramic materials tailored for additive manufacturing, specifically geopolymer composites (GP) and hybrid geopolymer composites (HGP) with optimized properties for construction applications. The research involved: Preliminary assessment of the physicomechanical properties of raw materials; development of long-term performance characteristics of printed structures; evaluation of durability, fire resistance, and thermal properties; optimization of processing techniques to enhance sustainability. The developed materials exhibit: controlled porous structure; low density; high thermal resistance and low thermal conductivity; satisfactory mechanical properties; excellent fire and heat resistance; eco-friendliness and cost-effectiveness. This novel class of materials is designed for use as thermal insulators while maintaining non-flammable properties, making them particularly attractive for the construction sector. Lightweight materials with superior thermal performance have the potential to revolutionize sustainable building technologies.

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