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GEOPOLYMER CONCRETE FOR CONSTRUCTION 3D PRINTING

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3D printing offers revolutionary prospects of "smart" technologies for the construction industry due to the following rationale. 3D printing, along with advances in Industry 4.0, has a high potential to lead to more efficient and sustainable construction because of the considerable advantages over conventional construction methods. Such advantages include formwork and mould-free manufacturing, increased geometrical freedom, improved safety in construction, reduction in construction waste, time, labour, and lower cost [1].

However, the introduction of 3DCP as a novel construction technology poses several challenges regarding material properties. Firstly, the printable material should be flowable enough to be pumped through the transporting system to the printing nozzle [2, 3]. Secondly, the printable material should secure quick structural build-up to retain the designed shape and to withstand its own weight as well as deposited layers on the top right after the extrusion [2-4]. Ordinary Portland cement (OPC) concrete to be printable requires a great number of additives, plasticizers, and stabilizing agents which increase its initial cost. Moreover, the production of OPC triggers stronger CO_2 emissions (8% of global CO_2 emissions) [5]. The global standards of the modern construction industry imply the commitments to abate greenhouse gas emissions and to decrease the energy-consuming process produced by OPC [5]. Therefore, current 3DCP technology needs to identify high-performing printable cementitious materials considering the need for controlled rheology, rapid hardening properties, and sustainable solutions.

Geopolymers have been introduced as a promising alternative to OPC with a staggering 90% lower CO_2 footprint. The distinctive advantage of a geopolymer over an OPC is that geopolymer cement can be synthesized at room temperature while OPC cement requires a four times higher amount of embodied energy for production [6]. Geopolymers are innovative solutions for industrial waste disposal of Russia and Kazakhstan's massive mining and metallurgical industries. The growing building industry in aforementioned countries has contributed to a rise in the production of construction materials by more than three times [7]. However, the implementation of industrial waste for the production of construction material remains negligibly low.

Several types of geopolymer concrete based on industrial by-products in Kazakhstan are already developed from fly ash, GGBS and kaolin clay. The compressive strength for the developed Fly-ash/slag and kaolin-based geopolymers is between 40-60 MPa (Fig. 1), flexural strength between 8-10 MPa, freeze-thaw resistance 400-500 cycles, water-resistance, W12-16, and higher depending on the mix.

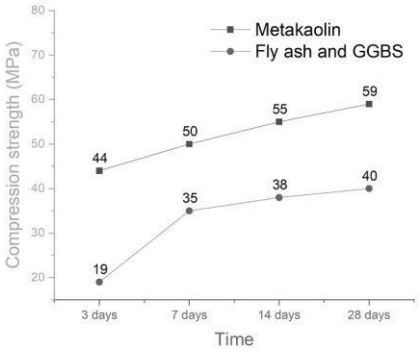

Fig.1. Compression strength of Fly-ash/GGBS geopolymer concrete and Kaolin based geopolymer concrete

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