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Strategic Initiative Materials in Flanders

Title of the project proposal:	Development of viable 3D printing methods for digital fabrication of geopolymer-based reinforced concrete.
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Start date – duration:	February 15, 2023 – 2.5 years.
Innovator zone(s):	Exploring the full potential of geopolymer-based concrete in structural application with 3D printing technique benefiting from the geometrical shape optimization of printed elements, as well as using the "green" geopolymer concrete in combination with conventional reinforcement on-site.

Content

Additive manufacturing of concrete using extrusion-based deposition methods has ground-breaking potential which fundamentally revolutionize the way we build concrete structures. Sustainable construction and efficient material use can be achieved by geometrical optimization of the printed elements, which in case of 3D concrete printing technique can be specifically adopted for an intended use. Together with the free-form buildings, a great example of such efficiency can be concrete columns and sewerage chambers with the manholes, 3D printed right on the construction site. The shape can be designed for an efficient load transfer within the element, thus, benefiting from the strictly required amount of materials and not requiring lost formwork anymore.

On the other hand, new environmentally friendly and cost-effective building materials such as geopolymer concrete have shown tremendous potential to replace traditional Portland cement concrete. Geopolymer binders can replace cement and fine aggregates in the mix up to 100% with no loss of strength, thus, reducing the embodied carbon by 80%.

In recent years, 3D-printing of *plain* (non-reinforced) *concrete* has advanced immensely and has allowed to reach levels of material exploitation never achieved before in history. However, plain concrete structures produced with today's 3D-concrete-printing methods are rarely suitable for use at the level of large-scale applications (buildings, bridges, etc.) because they show brittle fracture and have insufficient load-bearing capacities. For example, to ensure safety, a printed concrete wall without reinforcement should be produced having at least 3 layers, which leads to overdesign and inefficient material use. For the construction of robust and reliable structures that can ensure safety and durability within the intended service life and benefit from the incredible advantage of digital manufacturing (huge material efficiency), the integration of reinforcement into the 3D printing process is indispensable.

3D printing with geopolymer concrete reinforced with advanced types of reinforcement responds to the dual challenges of low carbon structures manufactured in ways leading to immense levels of material efficiency which will become the solution meeting the needs and requirements of sustainable and economic construction. In this project, a new long-term line on additive manufacturing (AM) of geopolymer RC structures will be developed and examined, expected to be one of the most revolutionary and game-changing technologies in the construction industry of the 21st century. The project will advance on the additive manufacturing methods frontline for RC structures, investigate the structural behaviour of geopolymer additively manufactured RC members immensely expanding the field of structural application of 3D printing technique. Based on lab experiments and numerical models, the developed methods will be optimized, and added reliability level validated for future real-world applications. The proposed research has out-standing novelty (AM of RC has so far not been achieved) and great potential for subsequent valorisation allowing material efficient, cost-effective and environmentally friendly construction.