Proportioning of Oil Shale Ash for Sustainable 3D Printable Mortars

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A cement-based composite containing an alternative supplementary cementitious material, oil shale ash, is developed with strength comparable to concrete class C35/45 suitable for XF4 environments while reducing carbon emissions by 5%.

Fig.1. The developed concrete mixture is suitable for large-scale 3D printed objects, such as the one above.

Introduction

To achieve optimal strength and printability, **mortars** used in **3D printing** typically contain **high proportions of cement,** resulting in **high carbon footprint**.

The use of alternative **supplementary cementitious materials** such as **oil shale ash** (OSA) could **reduce the environmental impact** of mortars used in 3D printing.

It would also allow to **repurpose waste** from power plants in the Baltic states, where oil shale is intensively utilized.

Materials and Methods

The used mixtures contained varying amounts, ranging from **0% to 40%, of OSA** from power plants in Narva, Estonia, used as a **substitute for cement**.

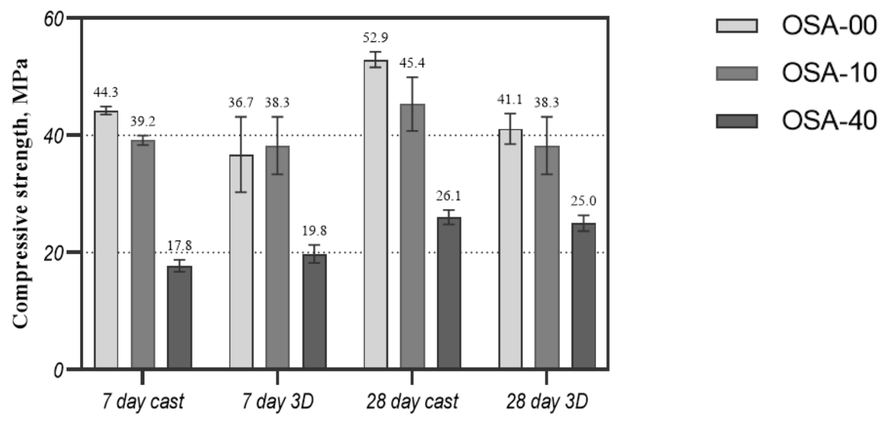
3D printing was carried out on a gantry type printer with batch type print-head. **Mechanical** and **durability** properties were measured for 3D printed and cast samples.

Fig.2. Small-scale print objects using mixture OSA-00, OSA-10, OSA-40

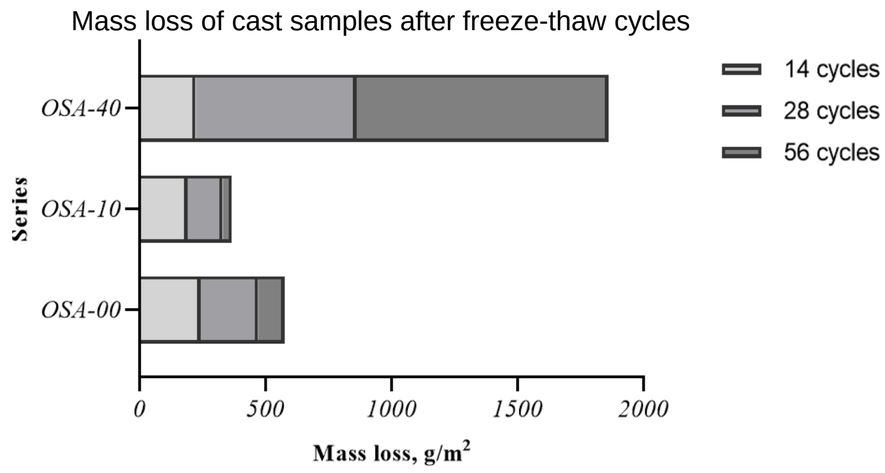
Life cycle assessment was performed to calculate carbon emissions from the developed composite.

Results and Conclusions

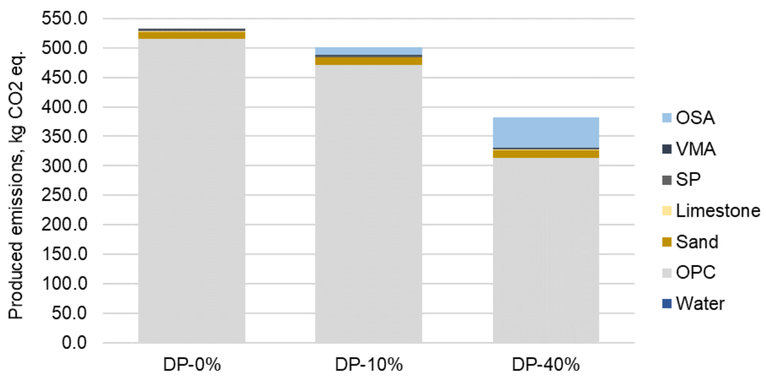
Replacement of **10%** of cement mass with OSA **does not** significantly **reduce** the **compressive strength** of concrete.



Replacing up to 10% of cement with **OSA can improve frost resistance** compared to concrete with no OSA, making it suitable for **XF4 environments**.



Mortars containing up to 10% **OSA** have a **reduced environmental impact**, emitting **5% less carbon emissions** compared to mortars without OSA.



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