

Fiber Reinforced Cement-free Concrete

A demonstration of the applicability of cement-free (geopolymer) concrete in tunnel lining segments

With concrete being the most used construction material in the world, the current trends towards a green transition in the construction industry often point attention towards the CO₂ emissions related to the use of traditional concrete. A complete replacement with alternative materials is not a viable solution, however, with the cement production alone accounting for the majority of the total emissions for the concrete material, a new generation of production ready concrete materials completely free of conventional Portland Cement becomes an attractive alternative

Geopolymer Concrete

In brief, geopolymer concrete is a material similar to traditional concrete, consisting of comparable constituents such as water, aggregates, and a binder material. In geopolymer concrete, the traditional Portland cement binder is replaced by calcium aluminosilicate-rich materials (slag and clay) activated by an alkaline solution. When mixed in optimal proportions, geopolymers can achieve comparable or even superior performance characteristics compared to Portland cement-based binders. As slag is a byproduct of the metallurgy industry, the potential for reductions in CO₂ emissions is as high as 80 %, when the content of slag is reduced by local precursor materials, e.g. calcined clay produced in Denmark.

Potential and Challenges

With the highly reduced environmental impact of geopolymer concrete compared to conventional concrete, the potential as a new widely used construction material is great. However, experimental studies show concerning trends regarding long-term properties as well as a time dependent or environmental dependent decrease in mechanical properties.

Research Approach

This research project aims to demonstrate the applicability of cement-free geopolymer concrete in tunnel lining segments, where characteristics of creep and shrinkage are of little concern. The project will focus on the influence of the environmental conditions on the long-term properties of fiber reinforced geopolymer concrete, tested on material level as well as on structural scale up to the size of actual tunnel lining segments. The fundamental idea is to document the influence of varying environmental conditions on a longer time range on the performance of the material and study the observations from a material point of view to understand the driving mechanisms of the time dependent behavior. Focus will be given to the typical conditions inside and outside of a bored tunnel.

Project Organization

The project will take place at the DTU Department of Civil and Mechanical Engineering (DTU Construct) while researchers from Construct's sections of Structures & Safety and Digital Building Technologies, will be engaged utilizing the experimental facilities in DTU Structural Lab. Spanning two years, this project engages leading specialists from both DTU and COWI.

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