The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

A multi-scale approach to localized damage indicators of a short-fibre reinforced high-performance concrete

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Keywords: *carbon short-fibre reinforced concrete, multi-scale modelling*

By using a novel short-fibre reinforced cement paste recipe in an additive manufacturing method, a highly anisotropic material with vastly improved flexural and tensile strength can be created. Extruding the paste through a small nozzle results in uniform fibre orientation. A fibre content of 3 vol.% results in static flexural strengths of above 100 MPa. High-strength fibre reinforced materials have great potential to be used as small, lightweight construction elements. In numerical simulations compared with experimental results, we investigate the mechanical behaviour and failure mechanisms of the material. Experiments with both miniature bending samples with cross-section of 3 mm $\times$ 3 mm as well as bone-shaped specimens with cross section areas of 4 mm $\times$ 5.97 mm and 50 mm $\times$ 50 mm provide information on damage indicators and local crack development. In the experiments, different standard methods, i.e. strain gauges, strain sensors and position sensors and further ex-situ micro-CT scans, optical microscopy, fibre-optic sensors, photogrammetry, acoustic emission analysis and ultrasonic based coda-wave interferometry are used. The numerical simulation of the mechanical behaviour of the material requires a multi-scale approach taking into account the scale of the carbon fibres besides the specimen scale. We use an approach in the sense of computational homogenisation [1], which requires the determination of a (local) material law in each macroscopic material point by solving cell problems in representative volume elements (RVE). An essential criterion for the developed methods is the simplicity and efficiency of the numerical models with sufficiently accurate representation of the relevant mechanisms.

The methods and current results will be presented at the conference.

REFERENCES

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