Anisotropic tensile behaviour of UHPFRC: experiments, multi-scale modelling and non-destructive assessment

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The commonly designated Ultra-High Performance Fibre-Reinforced cementitious Composites (UHPFRC) belong to a family of materials constituted by an extremely compact cementitious matrix reinforced with short high-strength steel fibres. This combination provides distinctly high compressive and tensile strengths and excellent durability properties. The material finds application in the rehabilitation and strengthening of existing reinforced concrete structures or in innovative designs of slender structures that take advantage of its outstanding mechanical properties.

The tensile behaviour of UHPFRC is decisive in many applications and strongly depends on the fibre orientation, which may vary throughout the structure and differ from that of the laboratory specimens. The influence of the fibre orientation on the tensile behaviour of UHPFRC, particularly for a wide range of fibre orientation profiles, needs to be investigated and the resulting anisotropic behaviour characterized in order to enable the efficient design of structural UHPFRC elements.

In the first part of the presentation the experiments conducted at the University of Porto to disclose the dependency of the tensile response with respect to the amount and orientation of the fibres is described. A model based on a meso-level description of the involved mechanics is then presented which is capable of simulating the full tensile response of the material.

In the second part of the presentation a non-destructive test method currently under development based on the magnetic properties of the steel fibres is described. This method is shown to provide indicators of the fibre content and orientation which can be used as inputs of the mechanical model. It is demonstrated that the relative magnetic permeability of thin UHPFRC elements can be well approximated by a 2nd order tensor, providing the means to determine the relevant orientation parameters along any direction of interest based on a minimum number of measurements.

Finally, an outlook is given on how the meso-mechanical model and the NDT method can be combined to provide the necessary inputs for a macro-scale model of the material that is suitable for nonlinear analysis of real scale UHPFRC structures.