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Accounting for the fibre orientation on the structural performance of flowable fibre reinforced concrete

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Synergies between fibre reinforcement and self-compacting concrete (SCC) have been demonstrated in terms of residual strength, see e.g. [1], and in terms of production aspects. Often large scatters are found in test results for fibre reinforced structural elements. A non-homogenous distribution of the fibres in the elements is probably the main explanation of the scatter.

This work focuses on a finite element based sensitivity analysis in order to explain the effect of non-homogenous and non-isotropic fibre distributions on the structural performance. The fibre structure can be characterised by a field of fibre orientation tensors and a maps of local fibre content. They can be assessed with Computed Tomography scanning or simulated with fluid dynamics modelling [2]. In the present study the fibre structure is considered as known.

Finite element modelling thus requires an accurate description of the fibres, especially where it comes to the non-uniform fibre dispersion. Moreover it requires an adequate constitutive model which takes into account the local fibre orientation and which describes the multi-axial behaviour and fracture of fibre reinforced concrete. Beghini et al [3], propose such a model based on a microplane formulation. In the present work a constitutive model is used based on an (local) orthogonal smeared crack formulation, assuming rotating crack orientations. Whereas the tensile strength is assumed to depend only marginally on the fibre orientation, the softening behaviour is defined based on the local fibre content, the local fibre orientation tensor and the principal stress direction.

As a case study, test series of beams are used. The beams were cut from a square fibre reinforced self-compacting concrete slab. The finite element modelling of the beams is validated and sensitivity studies with respect to the local fibre directions are performed. This work concludes with notes on the adequacy of the modelling in general and specifically discusses the modelling of strain hardening and softening of fibre reinforced concrete within standard smeared cracking models.

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