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Fibre reinforced concrete in dapped-end beams

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ABSTRACT

Dapped beam ends represent a case where the combination of stresses concentrated around a small area and geometry changes cause the need to provide a complex and congested reinforcement solution to ensure the transfer of shear in these critical regions. The application of fibre reinforced concrete (FRC) in these regions is studied due to the great potential to simplify the reinforcement layout.

The experimental test series of full scale dapped end beams has shown that elements cast with 1% steel fibres can perform the same shear capacity as traditionally reinforced elements with ordinary concrete, by reducing the total ordinary reinforcement around the dapped-end by 35% (Backe-Hansen and Hamstad 2011).

Finite element analyses of the dapped end beams with fibre reinforcement contribute to a better understanding of the structural behaviour of these discontinuity regions (termed D-regions) and, especially, to characterization of the fibre effect. The evaluation of the capacity for different fibre types and contents, the analysis of the optimized reinforcement solution and the study of different geometries are some examples which can be further investigated by the FE-method.

In addition, the industrial application of FRC in these elements requires further development of the design methods. In that respect, the interest lies in adapting the strut-and-tie models used for the traditional design (Elliott 2002; Standardization 2004; Alexander, Brekke et al. 2006) to include the fibre contribution for D-regions in general. The fibre effect is considered by fictitious ties with an effective cross-section area (Kanstad, Juvik et al. 2011). However, the choice of the tensile strength and geometry of these ties remains uncertain and needs further investigation. In this regard, finite element analyses are presented as a validity support for the design method development.

The model approach consists of a nonlinear analysis using two dimensional plane stress elements. The smeared crack model with rotating cracks has been used for the nonlinear FRC modelling. In a primary stage, the tensile properties of concrete have been determined according to the stress-strain design method proposed by RILEM (Vandewalle, Nemegeer et al. 2003). Results show a good agreement with regard to the load-deflection behaviour up to the maximum load. However, the model underestimates the capacity for larger deflections. Further work includes the evaluation of other approaches for characterizing the tensile behaviour of FRC.

Finally, the significant effect of the non-homogenous fibre orientation on the mechanical behaviour of this material highlights the need to consider this effect on the structural performance. Therefore, a model that accounts for the fibre non-homogeneities represents a relevant future development of the present work.

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