A multiaxial constitutive model for concrete in the fire situation including transient creep and cooling down phases

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The present thesis aims to develop an efficient and reliable multiaxial concrete model for implementation in finite element software dedicated to the analysis of structures in fire. The need for proper concrete model remains a challenging task in structural (fire) engineering because of the complexity in characterising the concrete mechanical behaviour and the severe requirements for the material models raised by the development of performance-based design.

The combination of elastoplasticity theory and damage theory allows for the development of a phenomenological model suitable for concrete behaviour modelling within the pragmatic and robust theoretical framework of continuum constitutive models based on the smeared crack approach. The state of damage in concrete, assumed isotropic, is modelled by means of a fourth order damage tensor to capture the unilateral effect. When complex performance-based situations are considered, the effect of transient creep strain at high temperatures must be taken into account by an explicit term in the strain decomposition. A generic transient creep model is therefore developed based on experimental data and the model is calibrated to yield the same results as the Eurocode implicit model in simple prescriptive situations. The concrete model comprises a limited number of parameters that can be identified by three simple tests. Furthermore, a standard set of values to be used in predictive calculations is clearly defined for these parameters. Numerical simulations can deal with all stress states as the model is developed as fully three-dimensional. A large number of examples highlight the capabilities of the model that range from the modelling of sample tests to the modelling of large scale composite structures developing membrane action.

The proposed concrete model can be used in advanced structural fire engineering calculations. Design by advanced methods may lead to significant reduction in the building costs and to improved robustness of the structures.