Elasto-plastic-damage model for concrete subjected to high strain rates

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Concrete structures subjected to extreme dynamic events, such as impact and explosion, exhibit failure processes in the form of crushing and spalling which differ significantly from those obtained from statically loaded structures [1]. Numerical modelling of these processes requires constitutive models which can describe the increase in tensile and compressive strength with increasing strain rate. In addition, the models should be robust and be based on as few as possible input parameters, which can be determined easily from experiments.

In the present work, a strain rate dependent damage-plasticity model is proposed for modelling both cracking and crushing, and also the strain rate dependence of these processes. The model is based on the previously developed rate-independent version of CDPM2 [2]. The plasticity model is extended by introducing the plastic strain rate in the yield surface while satisfying the consistency conditions as it was proposed in Drysdale and Zak [3]. The damage part is formulated so that a mesh-independent crack opening response is obtained. The constitutive model is implemented in the finite element software OOFEM [4]. The model of concrete is compared to experimental results for a spalling test reported in Schuler et al. [5] and a splitting test reported in Grote et al. [6]. The model is also compared to an earlier version of an extension of CDPM2 in which the damage part was made dependent on the elastic strain rate [7]. Future work will focus on applying the model to reinforced concrete structures for further validation.

References

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