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Time-dependent modelling of quasi-brittle materials with a strong discontinuity approach

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The time-dependent behaviour of quasi-brittle materials can have a significant effect on serviceability and ultimate failure. E.g., in the case of concrete structures, the presence of cracking can evolve, propagate and gradually widen over time, therefore significantly changing the stress state and expected structural response. The development of models that can account for the discrete nature of cracking whilst predicting time-dependent behaviour can be of interest to many practical applications. The discrete strong discontinuity approach (DSDA) has been validated as a reliable formulation for simulating the cracking phenomenon by directly embedding the traction-separation constitutive relation within finite elements, therefore enabling (or enriching) standard finite element models with the ability to capture cracks, where material can separate without the need for remeshing. This work presents a generalisation of the DSDA to account for the long-term behaviour of cracked quasi-brittle materials, more specifically creep and shrinkage. To this end, a rate-type creep is first applied through a number of kelvin units; the interactive behaviour of the resulting response from the Kelvin chain system, shrinkage, and discrete cracking is developed to obtain a suitable constitutive model for the discrete crack simulations. Finally, the formulation is deployed on a finite element code where the performance of the proposed model is assessed through representative numerical examples.