Finite volume analysis of reinforced concrete structure cracking using a thermoplastic-damage model

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ABSTRACT

This paper proposes modifications to the phenomenological model formulation called CDPM2 developed by Grassl et al. (2013). The proposed modifications are designed to enhance model performance with coupling to temperature effects. A very strong coupling between nonlinear elasticity, plasticity, nonlocal damage evolution and temperature gradient is used to simulate arbitrary crack propagation. The use of FVM to model solid damage is a numerical challenge. This approach presents some advantages such as: ensuring that discretization is conservative even when the geometry is changing; providing a simple formulation that can be obtained directly from a difference method; and employing unstructured meshes. Most authors have neglected the nonlinearity of concrete in the elastic domain from the start of loading to the plastic domain. In this paper we confirm that concrete rheology is not linear even under low loading. Also, since the so-called fracture energy is a key parameter needed to determine crack size and how they propagate in space, we consider that the fracture energy is both material and geometrical parameter dependent. For this reason, we developed a new approach which includes adaptive mesh, nonlinear rheology and thermal effects to re-calculate fracture energy at each time step. Many authors use a constant value obtained from experiments to calculate fracture energy, others use a numerical correlation. In this study, the fracture energy parameter is not constant and can vary with temperature or/and with a change in geometry due to concrete failure. As is well known, mesh quality of complex geometries is very important for determining accurate predictions. A new meshing tool was developed using the C++ programming language. This tool is faster, more accurate and produces a high quality structured mesh. The predictions obtained were compared to a wide variety of experimental data and showed good agreement.

Key words: Crack, damage, OpenFOAM, fvm, plasticity, elasticity, concrete, armature, rheology, temperature

REFERENCES