A constitutive model for concrete subjected to hard impact

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Keywords: Constitutive modelling, Damage, Strain-rate effect

Protective structures have become a fundamental concept for the engineering society in the framework of disaster preparedness. This type of structure is commonly made of concrete and serves as a defence mechanism for infrastructure areas. The shielding system of a critical unit is designed to resist intense loadings such as missile impact.

Hard missile impact induces complex failure modes of a concrete target as described by Kennedy [1]. Typical failure modes of the struck concrete structure consist of spalling on the front face, penetration with tunnelling in the centre and scabbing on the rear face. Extensive damage may result in full perforation of the concrete target. The failure mechanisms behind a hard impact are devoted to unconfined compression, shear under high triaxial pressures, and tensile behaviour.

Finite element (FE) approaches are extensively used for the design of protective structures, and advanced concrete models may be able to predict the ballistic response of concrete slabs. However, such models are based on sophisticated constitutive expressions and often require numerous modelling parameters, which can be challenging to quantify. This study presents a rather simple concrete constitutive model capable of thoroughly predicting ballistic impact in concrete targets. The proposed model is an extension of the modified version of the Holmquist, Johnson and Cook (MHJC) model [2]. The extension of the MHJC model includes (1) tensile damage and (2) segregation of the strain rate enhancement between tension and compression.

The constitutive parameters of the extended MHJC model are identified using material experiments (cylinder compression and tensile splitting, in addition to triaxial compression). The accuracy of the proposed concrete model is validated with the simulations of series of ballistic experiments conducted at SIMLab on concrete slabs [3].

References

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