Dynamic simulation of masonry materials at different loading velocities using an updated damage delay algorithm of regularization: theory and practical applications – CFRAC 2019

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ABSTRACT

Buildings and structures in many cities have recently been exposed to an increased number of highly dynamic hazards. These include not only floods and earthquakes but also man made threats such as ballistic impacts and blasts. Thus, the assessment of the dynamic performance of structures made of quasi-brittle materials must account also for high strain rate loadings. In engineering software, numerical simulations of dynamic failure processes are often carried out in a framework of damage mechanics, in which failure is interpreted as a degradation of the elastic material capacity. However, for many damage models, the link between the implemented numerical functions representing the corresponding physical mechanisms aimed is still a controversial issue. This is also the case because damage models suffer from a numerical pathology which prevents the objective evaluation of failure for different spatial discretization. To solve this issue, non local regularization algorithms are often used to solve mesh dependence, often at the expenses of complex identification procedures and non-trivial code implementation. Instead, a locally regularized rate dependent model has been developed by the authors for the static assessment of unbaked masonry materials made of clay sand and silt [1]. It adapts damage delay functions originally proposed in [2] in a local damage model developed for cementitious materials [3] based on the decomposition of the Dirichlet boundary conditions solved with an implicit solver. The regularization properties of the model were shown in [1] in statics. The regularization properties of the algorithm are analysed in this contribution for the dynamic problem of a bar uniaxially compressed at high velocity deformation rates. Furthermore, the physical background of the delay formulation is interpreted in light of the main failure processes commonly depicted for quasi-brittle materials in dynamic tests. In particular, the material parameters of the delay function in [1] are linked in this study to the bridging processes of micro-cracks starting from initial flaws inside the material and the resulting macro-crack development up to failure. Considering the physics shown in literature for quasi-brittle materials under multi-strain rate tests, the constant parameters in [1] are made functions of internal and environmental factors, namely material mineralogical properties and applied loading rates in this study. The resulting delay formulation produces an improvement in the capability of the model both to address the complete stress-strain curve of the response of traditional masonry materials subjected to a dynamic load and the rate of enhancement of the main mechanical parameters typical for these rate sensitive materials when subjected to multi-strain rates tests. This is shown in this paper by means of theoretical tests and practical applications with regards to the results of an experimental campaign performed by the authors on adobe specimens subjected to dynamic tests at three different strain rates, ranging from statics to Split Hopkinson bar tests.

REFERENCES

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