# A robust 3D constitutive law to describe the quasi-brittle materials behaviour under cyclic loading: application to the analysis of a 3D RC shearwall under cyclic loading

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## ABSTRACT

The formulation of robust constitutive law that can handle the complex behaviour of quasi-brittle materials such as concrete is still an open-question. Despite the fact that significant progresses have been noticed over the last decades, further efforts are still needed when dealing with the case of cyclic loadings [1,2]. This work aims at developing a new 3D constitutive law accounting for the major features characterizing the concrete behaviour. A specific attention has been paid to the strategy to describe the stiffness recovery when switching from tension to compression to preserve both the numerical robustness of the formulation and a strong physical meaning. Based on micromechanics consideration, smooth transitions including frictional sliding allows for a robust damage deactivation. The proposed constitutive law has been implemented in the finite element software Cast3M developed by the French Atomic Energy and Alternative Energies Commission (CEA). After exposing some local results at the Gauss' point level, a structure case study has been carried out. In order to qualify both the relevancy and the numerical robustness of the proposed constitutive law, a reinforced concrete (RC) shearwall tested within the framework of the French national project CEOS.fr has been considered. Representative post-test simulations based on a 3D finite element discretization have been carried out and the numerical results are compared with the experimental data considering not only the monotonic case but also the cyclic reverse case. Based on the numerical/experimental comparisons, the Authors are very confident in the formulation strategy they considered in this work. Dynamic simulations should be performed in a close future to qualify the relevancy of the proposed constitutive law.

## REFERENCES

[1] Richard, Benjamin, and Frederic Ragueneau. "Continuum damage mechanics based model for quasi brittle materials subjected to cyclic loadings: Formulation, numerical implementation and applications." Engineering Fracture Mechanics 98 (2013): 383-406.

[2] Richard, Benjamin, et al. "Isotropic continuum damage mechanics for concrete under cyclic loading: stiffness recovery, inelastic strains and frictional sliding." Engineering Fracture Mechanics 77.8 (2010): 1203-1223.