# Unilateral damage model based on subloading surface model

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## ABSTRACT

The elastoplastic-damage constitutive equation is formulated by incorporating the subloading surface model [1][2] which is capable of describing the monotonic, the cyclic and the non-proportional loading behaviors of elastoplastic materials rigorously. When the material undergoes the damage, the microdefects may close during compression in the most materials. This is more often the case for very brittle materials. The partial closure of microcracks revives the effective area which can carry the load in compression and the stiffness may then be partially or fully recovered. It is called the *unilateral microdefect closure effect* by Ladeveze and Lemaitre [3]. Here, the influence of the damage in the negative (compressive) principal stress plane is smaller than that in the positive (tension) principal stress plane in general. However, note that the damage effect changes discontinuously in the transitional state from the positive to the negative principal stress or vice versa in all the past formulations of the unilateral damage phenomenon (Lemaitre, and Desmoral [6], Voyiadjis et al. [8] after Ladeveze and Lemaitre [3]. In addition, various transformation tensor of the actual damaged stress to the virtual undamaged stress is defined in them, while they are quite complicated formulations.
The subloading surface model is extended to describe the damage phenomenon in this article. Further, it is extended to describe the unilateral damage phenomenon by formulating the actual Young's modulus tensor as the function of the signs of the principal actual damaged stresses and the damage variable. Here, the ordinary deformation analysis can be performed simply in the virtual undamaged state.

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