Non-associative plasticity models for structural instability calculations in thick-walled metal shells

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ABSTRACT

Plastic buckling estimates using the J_2 flow theory are quite high with respect to experimental results, mainly due to the vertex (corner) developed on the yield surface at the loading point. On the other hand models accounting for yield surface corners (corner theories) produce estimates in closer agreement with experimental data [1,2]. However, corner theories are unsuitable for structural computations involving complex stress paths and loading/unloading conditions, since the evolution of all formed vertices would have to be monitored. A few alternative models have been proposed [3,4], which mimic the presence of a yield surface vertex, while retaining a smooth yield surface. These models employ non-associative flow rules, while their structure remains similar to the one of the associative model.

In the present study, the applicability of these models in shell structures is assessed, both for buckling calculations and for tracing the load-displacement equilibrium path. Material user subroutines, employing the models for shell elements, are developed and implemented in ABAQUS/Standard, to investigate buckling of thick-walled metal tubes under compressive loads. Nonlinear simulations show that employing such models can significantly impacts the response of the shell structure under compressive loading; and even for small departures from proportional loading, they lead to substantial variations from the behaviour of the associative model. These models are found capable of accounting for imperfection sensitivity, and of providing realistic buckling estimates, when compared against experimental results by [5].

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