Numerical modeling of low velocity impact of thin metallic structures using shell finite element enriched by interpolation covers

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ABSTRACT

In modern societies, environmental policies impose more and more strict reductions of carbon dioxide emissions and material recyclability which are becoming critical issues for most of industrial sectors such as automotive, aeronautics, civil engineering, etc. As a consequence, the deployment of thin-shell structures in various engineering areas, especially in the transportation sector, is becoming increasingly important because it represents one of the solutions to satisfy sustainability requirements. Despite their lightness, thin-shell structures remain vulnerable to impact accidents, which can result in serious damages [1], such as local buckling accompanied with permanent deformations or even rupture caused by transverse impacts. Therefore, there is a strong need to predict accurately their dynamic response to transient dynamic loading [1].

This investigation is devoted for the numerical modeling of the low velocity impact of thin metallic structures using an enriched shell finite element model. Indeed, recently a new enriched Finite Element (FE) method for low-order elements based on the use of Interpolation Cover Functions (ICF), has been proposed by Kim and Bathe [2].

The main idea of the ICF method, resides in the use of the standard FE shape functions enriched with new set of interpolation cover functions developed over patches of elements to increase the convergence of the FE scheme. It has been shown been shown, through the analysis of linear elastic problems of structures, that the ICF method is able to capture higher gradients of a field variable and also smooth out inter-element stress jumps [3].

In the present work, the ICF method has been extended to the solution of impact problems involving large elastoplastic strains and strain rate effects while exhibiting large displacements and rotations. Present solutions for several impact benchmarks [4], [5] are compared with Experimental and Finite Element (FE) solutions available in the literature. The predictive capability of the ICF method is demonstrated by comparison of the results with experimental data for the impact response of thin metallic structures.

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