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Grid-pattern optimization framework of novel hierarchical stiffened shells allowing for imperfection sensitivity

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Influenced by numerous local features, the post-buckling analysis and optimization for hierarchical stiffened shells suffer from heavy computational costs. By smearing the minor stiffeners based on a novel numerical implementation of asymptotic homogenization (NIAH) method, a novel hybrid model for hierarchical stiffened shells is presented. Then, the high prediction accuracy and efficiency of the hybrid model for post-buckling analysis and imperfection sensitivity analysis are validated. Furthermore, a grid-pattern optimization framework of novel hierarchical stiffened shells allowing for imperfection sensitivity is established. The illustrative examples indicate that, the hierarchical stiffened shell with candidate sub-structures is more competitive in load-carrying capacity than that with the fixed grid-pattern, and the presence of imperfections would greatly affect the results of grid-pattern optimizations.

Keywords: Hierarchical stiffened shell; Imperfection sensitivity; Asymptotic homogenization method; Buckling; Grid-pattern optimization.

1. Introduction

Stiffened shells are widely used in aerospace structures of launch vehicles and aircraft wings [1]. As a promising structure configuration, the hierarchical stiffened shell has shown higher load-carrying capacity than the traditional design [2]. To resist the skin local buckling between major stiffeners, Bushnell et al. [3] introduced sub-stiffening features between the major stiffeners. Watson et al. [4] captured the extra partial overall buckling mode from T-type hierarchical stiffened panels. Quinn et al. [5] discussed the high load-carrying capacity of hierarchical stiffened panels based on numerical and experimental methods. The low imperfection sensitivity characteristic was found by Wang et al. [2] and Hao et al. [6]. Additionally, the hierarchical concepts of bionics would be enlightening for the design of hierarchical stiffened shells. As an ultralight structure, the dragonfly wing can be divided into two hierarchies, including brawny major veins to bear axial load and close-knit minor veins to resist local deformation [7]. Through the natural selection,

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