Nonlinear reduced order model of rectangular high aspect ratio wing with and without follower force effects

ABSTRACT

This paper describes a technique proposed to characterized the nonlinear properties of the High Aspect Ratio (HAR) wing model by developing a Nonlinear Reduced Order Model (NROM) via Combined Modal/Finite Element (CMFE) approach. In this study, nonlinear static analysis of HAR wing model under non-follower and follower forces was performed through the Finite Element Method (FEM) using MSC NASTRAN software. Three types of loading (uniform loading, twist loading and leading edge loading) are considered in order to demonstrate the bending and twisting deformations including a combination of bending-twisting deformation for both non-follower and follower force effects. For verification, the accuracy of the developed NROM is presented in the form of mean error and its corresponding standard deviation against the conventional FEM of nonlinear static analysis. It was found that the developed NROM via CMFE approach had shown a good accuracy compared to FEM analysis with a significant saving in computational time. Another finding shows that the NROM by combining uniform and twist loading cases can sufficiently predict the leading edge case; hence provide a possibility to predict the nonlinear aerostatic behaviour. Besides that, comparison for the load case under non-follower and follower force effects are also demonstrated. The results show that the inclusion of the follower force effect indicates a greater deflection than the system of non-follower force for all the considered load cases.

Keyword: Follower forces; High aspect ratio wing; Nonlinear; Reduced order model