Nonlinear reduced order model for aeroelastic static deformations of cantilevered rectangular high aspect ratio wing model

ABSTRACT

The paper is motivated by the increasing interest in the use of high aspect ratio (HAR) wings to utilize its aerodynamic properties to gain better endurance. Nevertheless, the drawback of the issue is that with increment in the aspect ratio of the wing, the geometric nonlinearity gains more significance hence the linear solution is no longer acceptable. Even though, a number of nonlinear solution package are available in the market, but the solution is a very time consuming process. Hence, to help reduce the complexity of the nonlinear aeroelastic analysis, a Combined Model/Finite Element (CMFE) technique is employed to develop a Nonlinear Reduced Order Model (NROM) which describe the nonlinearity of the HAR wing from a solution of nonlinear static analysis for a range of prescribed loading cases. Three loading types were considered for the production of the NROM of which the force subjected to the wing model was normalized to follow the normal mode of the wing model. The three loading types are of the first bending mode, the first torsional mode and a combination of the first bending and torsional modes. The NROM equations are then developed utilizing the backward regression method. In order to verify the NROM equation accuracy with respect to the results obtained from the finite element analysis (FEA) software, the comparisons are made in terms of mean error and standard deviation of the error. The results indicate the NROM developed using a combination of the first bending mode and first torsional mode of the wing model has better accuracy than the NROM developed with the modes individually. The NROM also portrays greater accuracy when developed using the data due to the load from the first bending and the first torsional mode.

Keyword: Combined Model/Finite Element (CMFE); High aspect ratio wing; Nonlinear