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Model Order Reduction of Complex Airframes Using Component Mode Synthesis for Dynamic Aeroelasticity Load Analysis

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Abstract : Airframe structural optimization at different design stages results in new mass and stiffness distributions which modify the critical design loads envelop. Determination of aircraft critical loads is an extensive analysis procedure which involves simulating the aircraft at thousands of load cases as defined in the certification requirements. It is computationally prohibitive to use a Global Finite Element Model (GFEM) for the load analysis, hence reduced order structural models are required which closely represent the dynamic characteristics of the GFEM. This paper presents the implementation of Component Mode Synthesis (CMS) method for the generation of high fidelity Reduced Order Model (ROM) of complex airframes. Here, sub-structuring technique is used to divide the complex higher order airframe dynamical system into a set of subsystems. Each subsystem is reduced to fewer degrees of freedom using matrix projection onto a carefully chosen reduced order basis subspace. The reduced structural matrices are assembled for all the subsystems through interface coupling and the dynamic response of the total system is solved. The CMS method is employed to develop the ROM of a Bombardier Aerospace business jet which is coupled with an aerodynamic model for dynamic aeroelasticity loads analysis under gust turbulence. Another set of dynamic aeroelastic loads is also generated employing a stick model of the same aircraft. Stick model is the reduced order modelling methodology commonly used in the aerospace industry based on stiffness generation by unitary loading application. The extracted aeroelastic loads from both models are compared against those generated employing the GFEM. Critical loads Modal participation factors and modal characteristics of the different ROMs are investigated and compared against those of the GFEM. Results obtained show that the ROM generated using Craig Bampton CMS reduction process has a superior dynamic characteristics compared to the stick model.

Keywords : component mode synthesis, craig bampton reduction method, dynamic aeroelasticity analysis, model order reduction
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