Coupling of non-matching interfaces in a component mode synthesis method for 3D finite element method

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Abstract

The component mode synthesis (CMS) method are often be utilized on modal analysis to understand the vibration characteristics of the complex structure which is commonly divided into several substructures. However, the finite element models of different components are often designed by different groups and their respective finite element models usually require different mesh resolutions. In such cases, the finite element substructure models are typically non-conforming on their interfaces. Besides, gaps are easily produced along the curved interfaces with different sizes of mesh and these problems is getting worse when the analysis of substructures with geometric uncertainty. To overcome the problem, a gap element method is employed into a free-interface CMS method, where both displacements and forces of the nodes on the incompatible interfaces are introduced by two independent Lagrange multipliers to enforce the compatibility conditions. When the method applied to the dynamic analysis of the complex structure, the reduced order models (ROMs) of each components are generalized by a free-interface CMS method, in which the degrees of freedom of the nodes located on the interface are all reserved as master degrees. Then, between two components, a discrete interface is created by these nodes. Gap elements, similar as common tetrahedron element, are produced on the both sides of the interface which fill the void area and carry no energy. Finally, the synthesis of components is accomplished by these gap elements and the ROMs of the whole structure is obtained. By compared with the result of total finite element model, the accuracy of the ROM produced by new method is proved that it can be used on the dynamic analysis of the 3D finite elements models with non-matching blade-disk interfaces and the proposed gap elements continue to be applicable when the interface gaps disappear.

Keywords: Non-matching interfaces; Localized Lagrange multipliers; Structural dynamic analysis; Component mode synthesis;