Fixed point Algorithm resolution and model reduction for jointed structures dynamic simulation.

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Abstract

The bolted joints have a strong impact on the damping and the stiffness of the structures. This impact remains difficult to predict because of the difference between the length scale of the real contact area and the wavelength of the vibration modes, and the uncertainties on the real geometry of the contact area. The method proposed in this paper is to divide the jointed structure into two parts: the linear part (L) and the non-linear one (NL) located around the joint. First, a linear analysis is performed on the global structure, neglecting dissipation inside the joint, to determine the normal modes of the structure. The normal modes subspace is normalized to the stiffness matrix to associate to each eigenvectors the same strain energy. In the neighborhood of the bolted joint, eigenmodes are not orthogonal one to each other's. Thus, it is possible to reduce the size of the subspace spanned by the local eigenmodes. Moreover, most of them do not dissipate energy. Thus, it is possible to select the most dominant ones, i.e those that induce non-linear behavior in the joint. We introduce the Principal Joint Strain Basis (PJSB) which is the optimal Ritz basis deduced from the structure eigenmodes, and simplified thanks to the analysis of the dissipation potential of each eigenmode. The dissipation potential is estimated by the energy coupling in the joint computed from the sensitivity of the eigenfrequency to the tightening configuration, i.e. when the surfaces of the interface are tied or when the tightening is very low. Then, we assume that a meta-model is able to represent the behavior of the joints. In order to build it, we apply the PJSB as a loading on a finite element model of the joint and we post-process the results in order to use them in a reduce order model. Different strategies of resolution are proposed, depending on the number of modes selected.

In order to guarantee the numerical stability of the proposed scheme, it is then essential to set up a relaxation (or damping) method by modifying the formulation at each iteration (Gauss-Seidel form). This consists in introducing a parameter which makes it possible to determine the new state by weighting the value of the predicted state and the one of the old state. This relaxation method will also be coupled with an Aitken type acceleration method. The theoretical frame proposed in this paper allows to simulate at a lower cost the dynamic behavior of the assembled structures. The metamodel method presented is very efficient, in particular, when several modes load the connection in the same way or several connections are loaded in the same way.

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