A GENERAL JOINT INTERFACE ELEMENT CONSIDERING IMPACT AND FRICTION DAMPING

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Mechanical joints often cause local stiffness change and become the primary source of energy dissipation in assembled structures. Micro-impact and stick-micro-macro-slip occurring along the joint interface are two mechanisms for these nonlinear dynamics of jointed structures. The development of low order dynamic joint models that are capable of accounting for complex joint interface mechanics and that can be readily incorporated into nonlinear finite element codes is crucial for accurate prediction of the dynamic response of large assembled structures. Finite element (FE) methods developed for general contact problems have been employed directly by researchers to simulate the dynamics of joints. In those analyses, node-to-node or node-to-segment contact models are employed, and the contact effects are accounted for at discrete nodes. To capture the mirco-stick-slip behavior, an extremely fine mesh must be used along the joint interfaces, which makes finite element joint models computationally intractable for dynamic analysis of jointed structures. Also, in conventional contact FE analysis, impact damping is generally neglected.

A general joint interface element, incorporating both dynamic impact and friction, has been developed by the authors. Here, segment-to-segment contact is considered, and contact effects are accounted for along continuous edges of the elements. Thus, stick-slip behavior at every point along the joint interfaces is considered even with a relative coarse mesh. In the segment-to-segment contact model, segment pairs are specified in advance as well as during the analysis, and contact is assumed to occur only between those segment pairs. This is generally true in dynamic analysis of jointed structures, since only small displacements and micro- and macro-slip occur in the joint interface.

The general joint interface element is composed of two parts: the joint impact element which accounts for impact effects (including impact damping) normal to the direction of the interface, and the joint friction element which considers the friction along the interface. A nonlinear friction law by Oden and Pires[1], which describes the microscopic relative motion due to the deformation of the asperities of two contacting bodies, is adopted in the joint friction element to account for the micro- and macro-slip phenomena along the interface. Numerical examples are given to illustrate the applications of the proposed general joint interface element.

References

[1] J. T. Oden, and E. B. Pires, “Nonlocal and Nonlinear Friction Laws and Variational Principles for Contact Problems in Elasticity”, ASME Journal of Applied Mechanics, v. 50, p. 67-76, 1983.

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