Dynamic Analysis of Rotating Sliding Beam

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Abstract

A simple and effective consistent co-rotational total Lagrangian finite element formulation and a numerical procedure are proposed to investigate the geometric nonlinear dynamic response of the rotating sliding beam. To exactly predict the dynamic response of the rotating sliding beam, the total length of the rotating sliding beam is considered.

The motion of the beam element is not restrained when it is outside the prismatic joint. The lateral motion of the beam coincides with the rotation of the prismatic joint and is restrained relative to the prismatic joint when it is inside the prismatic joint. The ordinary beam element is used here when it is inside or outside the prismatic joint. A transition beam element is developed here when it is partially housed inside the prismatic joint. The kinematics, and deformations of the beam element are defined in terms of the element coordinate system constructed at the current configuration of the deformed beam element. The principle of virtual work, d'Alembert principle and the consistent second order linearization of the fully geometrically nonlinear beam theory are used to derive the deformation nodal force and inertia nodal force of the beam element. In element nodal forces, all coupling between bending and stretching deformations of the beam element is considered.

To conveniently describe the motion of the system, the equations of motion of the system are defined in terms of the prismatic joint coordinate system constructed at the current configuration of the prismatic joint.

An incremental-iterative method based on the Newmark direct integration method and the Newton-Raphson method is employed for the solution of nonlinear dynamic equilibrium equations. Numerical

examples are presented to demonstrate the accuracy and efficiency of the proposed method. From the results of the numerical examples, it seems that the lateral dynamic response of the rotating sliding beam with different initial conditions may be predicted or explained by an equivalent spring-mass system with single degree of freedom.