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KEYNOTE

A Proposal of a Numerical Method to Compute Dynamic Responses for Complicated Systems Including Elastic/Viscoelastic Structures, Gas, Porous Medea, Nonlinear Restoring Force Element with Nonlinear Hysteresis and Living bodies with Reaction Using Fast FEM

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Abstract. A new numerical method was proposed to compute dynamic responses for complicated systems involving elastic/viscoelastic structures, gas, porous media and nonlinear restoring force with nonlinear hysteresis and living bodies with reaction using fast FEM.

In this method, there are three features mainly as follows.

(1) By applying asymptotic method to complex eigenvalue problem of the systems, explicit expressions of modal loss factor are derived. This method diminishes computational time for large-scale finite element models. By using this method, modal couplings of damping in the systems can be investigated and optimized. This numerical procedures were proposed by Yamaguchi and were named as Modal Strain and Kinetic Energy Method (MSKE method).

(2) MSKE method is extended for the systems having nonlinear restoring force with linear/nonlinear hysteresis. In this method, the restoring force has nonlinear function as power series of its elongation and nonlinear hysteresis damping using complex coefficients. The discredited equations in physical coordinate are transformed into the nonlinear ordinary coupled equations using normal coordinate corresponding to linear natural modes. This transformation yields computation efficiency. The proposed method is applied to simulation for impact responses of soft structures.

(3) The nonlinear restoring force element with nonlinear hysteresis is extended to apply impact responses of interaction systems between human bodies and machines (e. g. robots and vehicles). Dynamic responses can be computed for alive human bodies in consideration of difference between contraction and relaxing condition of muscle using complex coefficients for the nonlinear restoring force. Further, if negative values are given for the imaginary parts of the nonlinear restoring force element, influences of panic, precaution and foresight on the responses can be investigated.