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Nonlinear Dynamic Analysis of Base-Isolated Structures Using a Partitioned Solution Approach and an Exponential Model

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Abstract : The solution of the nonlinear dynamic equilibrium equations of base-isolated structures adopting a conventional monolithic solution approach, i.e. an implicit single-step time integration method employed with an iteration procedure, and the use of existing nonlinear analytical models, such as differential equation models, to simulate the dynamic behavior of seismic isolators can require a significant computational effort. In order to reduce numerical computations, a partitioned solution method and a one dimensional nonlinear analytical model are presented in this paper. A partitioned solution approach can be easily applied to base-isolated structures in which the base isolation system is much more flexible than the superstructure. Thus, in this work, the explicit conditionally stable central difference method is used to evaluate the base isolation system nonlinear response and the implicit unconditionally stable Newmark's constant average acceleration method is adopted to predict the superstructure linear response with the benefit in avoiding iterations in each time step of a nonlinear dynamic analysis. The proposed mathematical model is able to simulate the dynamic behavior of seismic isolators without requiring the solution of a nonlinear differential equation, as in the case of widely used differential equation model. The proposed mixed explicit-implicit time integration method and nonlinear exponential model are adopted to analyze a three dimensional seismically isolated structure with a lead rubber bearing system subjected to earthquake excitation. The numerical results show the good accuracy and the significant computational efficiency of the proposed solution approach and analytical model compared to the conventional solution method and mathematical model adopted in this work. Furthermore, the low stiffness value of the base isolation system with lead rubber bearings allows to have a critical time step considerably larger than the imposed ground acceleration time step, thus avoiding stability problems in the proposed mixed method.

Keywords : base-isolated structures, earthquake engineering, mixed time integration, nonlinear exponential model
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