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Nonlinear Seismic Analysis of Nuclear Containment with Soil-structure Interaction: Study on Stresses and Damage Criteria

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Abstract

One of the most popular sources of clean energy, nuclear power plants are very critical structures as any failure in them is associated with huge ecological and economic losses, hence this necessitates investigating the response when subjected to dynamic loading. In this study, a nuclear containment structure is modelled and analyzed under unidirectional equivalent sine-sweep earthquake data considering soil-structure interaction using five different types of underlying media. Tension and compression damage is evaluated in the structure by considering non-linear material properties of concrete. The maximum stress in the vertical direction is achieved in the critical elements at the junction of the cylindrical wall of the containment and the raft foundation, normal to the application of earthquake excitation, for fixed base and also over rock media. Significant tensile damage is also observed in the critical elements in the aforementioned cases. When stratified soil is used with rock at the top and stiff soil at the bottom, the acceleration response of the structure is lower than that of homogeneous stiff soil underneath. Whereas, when stratified soil with stiff soil at the top and rock at the bottom is used, the acceleration response is much more than that of homogeneous stiff soil but less than that of homogeneous rock. The above observation is in line with the response of a composite spring in series subjected to lateral excitation. The stress response of the critical elements of the structure also follows a similar pattern.

Keywords: Nuclear containment, Nonlinear analysis, Soil-structure interaction, Stratified soil, Damaged plasticity model