ABSTRACT

The prediction of performance of concrete gravity dams during earthquakes is a challenging problem in structural dynamics. This is due to the complicated shapes of the dam and its adjacent reservoir and foundation rock. Moreover, the determination of dynamic response of concrete dam is a complex problem because of coupled dam-reservoir-foundation interaction effects. Therefore, the dynamic interaction between an inelastic dam structure, compressible water and foundation rock below the dam has been the subject of intensive research in recent years. Furthermore, the subject received much attention from researchers during the past two decades because of concern for dam safety during earthquakes. A large number of literature are available for numerical analysis of concrete gravity dams. The review indicates that the nonlinear seismic analysis of concrete gravity dam is necessary for predicting its accurate response.

A methodology has been developed for the finite element analysis of aged concrete gravity dam-reservoir-foundation coupled system subjected to earthquake forces. Acoustic element is used to model the reservoir water. An infinite acoustic element is adopted at the truncated boundary to include the infinite reservoir effects. A suitable boundary condition has been adopted to truncate the unbounded soil domain for finite element analysis. The degraded material properties of the concrete with age, subjected to the environmental factors and mechanical loadings, are determined introducing an isotropic degradation index. The concrete damage plasticity model is used to evaluate the nonlinear seismic response of the aged concrete dam. From the linear and nonlinear response results, it is observed that there is a plastic deformation in the material after the occurrence of damages in the dam structure. It is interesting to note that there is a huge difference in response if nonlinear behavior of the dam material is taken into consideration.

A shaking table experimental setup has been developed indigenously as a part of this study to conduct the dynamic tests on model dam and dam-foundation coupled system. A new bentonite mix concrete is designed to construct the small-scale models for experimental investigation of Koyna dam. Dynamic tests on model dam and dam-foundation are conducted on a shake table for data calibration. Sinusoidal motion has been applied to the shake table to investigate the time history responses such as crest displacement, stress and propagation of damage in both dam and dam-foundation models. It is clearly observed that numerical analysis provides satisfactory results with experimental data.

KEYWORDS: Concrete gravity *dam, concrete degradation, damage plasticity model, earthquake excitation, finite element method, nonlinear analysis, similitude requirement, dam-reservoir-foundation coupled system, shake table test*