Earthquake Safety of Concrete Dams and Seismic Design Criteria for Major Dam Projects

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Hsinfengkiang buttress dam (1944 earthquake in China, 105 m high), Koyna gravity dam (1967 earthquake in India, 103 m high), Pacoima arch dam (1971 and 1994 earthquakes in California, 114 m high), Rapel arch dam (1980 earthquake in Chile, 110 m high) and Sefid Rud buttress dam (1990 earthquake in Iran, 145 m high) are the highest concrete dams, which have been exposed to very strong ground shaking and have suffered different degrees of damage but none of them has failed. Major repair and strengthening works were carried out for the Hsinfengkiang, Koyna and Sefid Rud dams and all dams are in operation. These dams, as most of the existing dams, were designed against earthquakes, using seismic design criteria and/or methods of seismic analysis, which are considered as obsolete or incorrect today. They have also experienced ground motions that were much more severe than those expected at the time of construction. In 1999, a secondary fault passing almost normal to the Shih-Kang concrete diversion dam experienced substantial vertical movements, destroying two spillway gates near the right abutment during the Chi-Chi earthquake in Taiwan. Water flowed through the damaged bays, but without catastrophic release of the reservoir. Unlike other actions from the natural and man-made environment, which dams have to resist, earthquakes pose probably the greatest challenge to dam engineers as earthquake ground shaking affects all structures (dam and appurtenant structures) and all components (hydromechanical, electromechanical etc.) at the same time. Thus all these elements have to be able to resist some degree of earthquake actions. The paper discusses the seismic design criteria for concrete dam projects, methods of dynamic analysis for strong ground shaking, and provides information on possible antiseismic design features for large arch dams.

Keywords: concrete gravity dams, arch dams, buttress dams, earthquake action, earthquake design criteria, nonlinear dynamic analysis models for dams, seismic design of concrete dams

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