FAULT RUPTURE PROPAGATION THROUGH ZONED EMBANKMENT DAMS

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The seismic responses of structures due to near faults are the subject of researches in the recent years. Among the structures, the dynamic analysis of embankment dams and their safeties are of great importance. Analyses of dams without considering their surrounding active faults may result in catastrophic events. The destructive effect of fault activity in dam foundations can be evaluated in two ways; the time history analyses of embankment dams due to seismic loadings and the effect of permanent quasi-static offsets on the fault under the dam foundation.

Although, dam construction in the vicinity of an active fault should be avoided, however, in some cases, there is no better alternative. According to Sherard (1974), in highly active seismic regions, due to existence of many faults and the fact that river channels often follow the fault direction, dams are mostly built in locations where faults are recognized or suspected to exist. Furthermore, discovering the active faults in dam sites may not be possible unless a detailed geological survey is performed or the dam foundation is excavated; whereupon the extra costs will be imposed to the project (Bray, 1990). In addition, in some seismic regions such as the High Zagros region in Iran, almost all dam sites are in the vicinity of the faults that are likely to become active anytime (Wieland et al., 2008).

This research aims to develop deeper insight into the main mechanisms of dip-slip fault rupture propagation through an embankment dam. To have this accomplished, the numerical study is conducted for deformation of an embankment dam at the end of construction subjected to the reverse dislocation of the bedrock fault. The present study is mainly focused on the rupture patterns of the zoned embankment dam in which materials with different relative compactions are used. The effects of fault dip angle and the fault break position are also studied in sensitivity analyses.

The problem is schematically illustrated in Figure 1. A zoned dam with height of $H=28m$ composed of a central core, a transition zone on each side of the core and the outer shell is considered. At the base of the dam, a thrust fault with angle $\alpha=60^o$ makes upward vertical displacement of amplitude h. The fault displacement is imposed at the downstream base of the dam, while the upstream base is fixed in both directions. The location of the fault displacement is determined by D. A finite element base software (ABAQUS) is employed as a tool for the analyses assuming plane strain condition. Based upon the results of previous studies (Anastasopoulos *et al*., 2007), the elastoplastic Mohr-Coulomb constitutive model with isotropic strain softening is incorporated in this research to predict the soil behavior. The strain softening behavoir is modeled by reduction of both the mobilized friction angle φ_{mob} and the mobilized dilation angle ψ_{mob} with the increasing of the plastic shear strain.

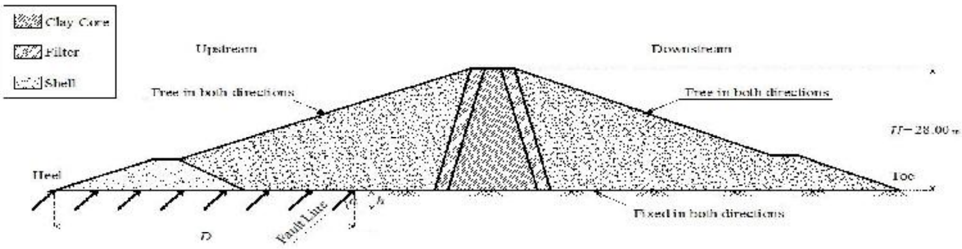

Figure 1. Schematic presentation of the 2D model used for the analyses and its boundary conditions

Two typical materials with different relative compactions are considered for shell and central core of the embankments which are representative of the dense and loos soils. Figure 2 compares the rupture path and the shear bound width for these two materials.

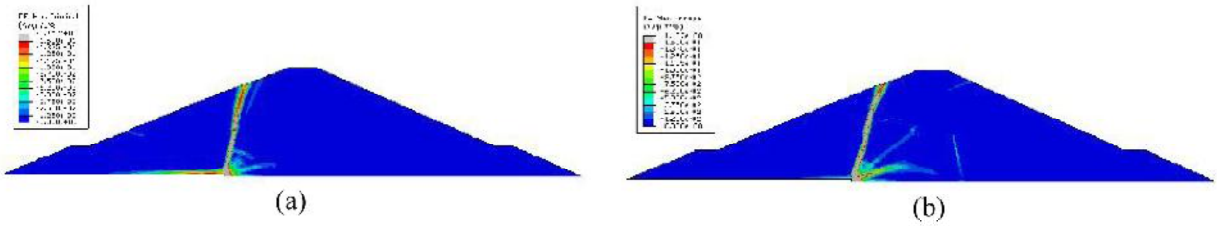

Figure 2. Contours of maximum strain for 45^{o} fault activated at D=60m in (a) Loose soil, (b) Dense soil

Results show that in the dense soils the orientation of the rupture tends to bend more compared to that in the loose materials. Furthermore, the maximum shear strains for the dense soils are concentrated in narrower parts rather than that of the loose soil. By the way, the fault scarp height can be assumed as one of the most important parameters which can affects the safety of the dam. Therefore, it is concluded that by increasing the relative compaction of the soils, the scarp height created by the emergence of the rupture on the surface are decreased.

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