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Analysis of a highway embankment failure associated with the 1999 Düzce, Turkey earthquake

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Abstract

An embankment slope on a major highway totally collapsed during 12 November 1999 Düzce earthquake (M_w=7.1) due to the intense near field ground motion. The slope had performed satisfactorily, without even minor deformations or cracks, during the İzmit earthquake (M_w=7.4), another major event that occurred 3 months before and was far field. Predominantly coarse-grained fill of the embankment exhibited typical non-brittle behavior during laboratory tests, implying that the prefailure shear strength would remain relatively unchanged. Stability and failure mechanism of the embankment slope were investigated through a series of static, pseudostatic and fully coupled non-linear dynamic analyses. While respective performances were correctly predicted by the pseudostatic method on a failure—no failure basis during the two earthquakes, the computed failure surface geometry did not conform to that observed. Fully coupled dynamic response analysis, on the other hand, predicted the failure mechanism and failure surface configuration in conformance with the post-failure observations. Computed displacements were generally less than those observed and critically dependent on the potential uncertainties.

Keywords: Back analysis; Non-linear analysis; Seismic slope stability