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Seismic response analysis of a tuff cliff by an effective stress non-linear 2D model approach: an example in Sorrento Peninsula, Italy

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We present a model to describe the behavior of a tuff cliff under the dynamic stress considering a law reference input motion. The studied area is located in the Sorrento Peninsula, a major Quaternary morpho-structural unit of the western flank of Southern Apennines. The peninsula forms a narrow and elevated mountain range (up to 1444 m) that separates two major embayments of the eastern Tyrrhenian margin and is characterized by a carbonate bedrock capped by pyroclastic deposits (i.e. "Campania Ignimbrite"), originated from the Campi Flegrei volcanic district.

The occurrence of steep slopes and the high relief energy of the area, along with the marine erosion at the base of the coastal cliff creates favorable conditions for the occurrence of a generalized instability of the slopes that is manifested by tuff rock falls as prevailing landslide phenomena.

These events are highly dangerous because of the sudden detachments of conspicuous volumes of rocks with high speed, especially when the rock fall initiates in the upper part of the slopes. Prediction of such landslides is difficult if not accompanied by accurate hydrogeologic and geotechnical monitoring and assessment.

The geometry of our model is represented by a tuff cliff of 48 m height, covered by a 8 m thick volcaniclastic layer. At the base of the tuff cliff marine sand deposits occur. The geotechnical parameters used for the analysis were selected from the literature.

We have used an effective stress non-linear 2D model to determine the dynamic stress field of our model. The effective stress non-linear algorithm uses the Direct Integration Method to compute the motion and excess pore-water pressures arising from inertial forces at user-defined time steps.

The seismic response analysis was performed using the field shear stress generated by synthetic 1-30 Hz band-limited accelerogram. The finite elements mesh considered for the test problem was established by 395 element and 401 nodal point.

Our results show a complex dynamic behavior of the analyzed 2D model. In fact, the materials (tuff, incoherent deposits and marine sand) respond in different ways with respect to dynamic load. There is a very clear occurrence of severe rupture and displacements within pyroclastic deposits located both in the upper part of the model section and within the sandy deposits located at the bottom of the section, while the displacements are of smaller entity within tuff rocks. The model also indicates that seismic amplification is maximum within pyroclastic deposits, towards the top of the modeled section, and displays a value of 2.1.