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Seismic initiation mechanisms of fast granular flows

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ABSTRACT

Fast granular flows can be initiated through different mechanisms. Soil liquefaction triggered by seismic loading is one of them. Soil liquefaction is a process by which a fluid saturated soil (typically with water) loses strength and behaves as a viscous liquid rather than as a solid. This condition is reached after a series of actions the first of which is the soil skeleton being subjected to volumetric plastic strains due to seismic loading. If the soil is in undrained condition volumetric plastic strains cause pore pressure build up. Finally, if the pore pressure reaches a value similar to total stress the effective stress is practically reduced to zero and the soil behaves as a viscous fluid.

If the soil is partially saturated, its behavior depends on the coupling between the solid skeleton and the pore air and water. In the limit case of a dry soil, the air has to flow out from the pores for the material to consolidate, but typical air consolidation times are much smaller than those of the water. Therefore, in practical cases, the role of air pressures is neglected, as the characteristic time of loading is much larger than consolidation time. However, it is possible to imagine situations with much smaller loading times, where coupling between pore air and soil skeleton plays a paramount role. This is the case of fluidized granular beds, just to mention a particular example of industrial interest. It would also be the case of a low density dry soil (air saturated) subjected to seismic action or other types of fast boundary condition change.

Bishop [1] describes the case of Jupille flowslide [2], which happened in Belgium in February 1961. A tip of uncompacted fly ash located in the upper part of a narrow valley collapsed suddenly, and the subsequent flow slide travelled for about 600 m at very high speeds (130 km/h) until it stopped. Triggering mechanism was suggested to be "collapse due to undermining of a steep, partly saturated and slightly cohesive face". Dry liquefaction can be exhibited also by soils such of volcanic origin. Some of the catastrophic landslides caused in El Salvador by the 13th of January 2001 earthquake can be explained by this mechanism, the collapse of the material under the dynamic loading could make the pore air pressure increase. This is the case of the

landslide in dry volcanic soil of Las Colinas, in San Salvador [4].

In order to obtain a numerical model of dry liquefaction a dynamic coupled formulation is necessary. This type of formulation includes a displacement field to model the solid skeleton, a pore pressure field to account for the interstitial air, and all the relevant forces including those due to inertial effects. [8],[9],[11]

In order to model the constitutive behavior of the volcanic soil in Las Colinas a Generalized Plasticity framework has been chosen. The soil is known to be initially cohesive. However the landslide eventually produced a fluidized material. In the present work it has been assumed that seismic action produces loss of cohesion or bond breakage, so that the soil is transformed into a material with a similar constitutive behavior to a loose sand. The constitutive model used in the present work [3].is an enhancement of the Pastor-Zienkiewicz model for sands [6] to account for the initially bonded condition of the material. An implicit algorithm [7] was used to integrate the constitutive equations.

Results with a simplified geometry (an air saturated soil stratum) were obtained in a previous work [5]. In the present work a more accurate representation of the geometry and boundary conditions is used.

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