IHG: an Integrated Hydrological-Geotechnical model for large landslides' susceptibility assessments

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A large area (~ 5 km^2) in the north-east sector of the *Genoa-Province* (*Liguria* - Italy) is subjected to a diffused, continuous kinematic phenomenon. It is shaped into a top-valley gentle slope (circa 11°), which downgrades directly from the south-side faces of the *Northern Apennines* summits (1800 meters a.s.l.).

On this endangered site are situated a small town and six of its surrounding hamlets. In consequence of the widespread and differential movements at ground level, many buildings and structures are continuously damaged. Institutions, Land-Authorities, as well as the Citizens, are applying their economical efforts in the rehabilitations and the assessment/control of the active phenomena.

From the geological and morphological points of view, the topmost sediment is formed by a *pliocenic glacial till* and its body of widely assorted sediments had been reckoned as a large *relict landslide*. The loose-soils' thickness spans from few meters up to 90, before of reaching the local bedrock formations (*argillites*, *sandstones*, *mudstones*, *ophiolites* and *diabases in pillows*).

Former studies have underlined that the main trigger actions are represented by the seasonal rain/snow falls on the watershed and that the kinematic phenomenon is heavily influenced by the subsoil features.

The Authors have recently dealt with the characterization and study of this complex landslide [ref. @: the *International Association for Mathematical Geosciences (IAMG) Conference*, Salzburg (A), September 5-9, 2011 and the 2nd *World Landslide Forum*, Rome (I), October 3-9, 2011], giving particular attention to both the geotechnical and the hydrological aspects of the site.

Since the buried bedrock spatial morphology, depth and steepness have a key role, geophysical and seismic *array* techniques were used toinvestigate the micro-tremor characteristics and to correlate the emerging data to the geotechnical and geophysical properties of the shallowsediments. Noise measurements were made at more than 70 positions and, additionally, an array set-up of six seismic stations allowed the study of the *Rayleigh* and *Love* wave dispersion. Thus, by using the well known *Nakamura*'s technique, the overall spread of the bedrock depths was finally obtained.

Because of a rather large territorial dimension, the relevant issues were into finding the most proper techniques to assess an affordable but reliable site recognition over all its extension, as well as to spatially distribute both the loose-soils' depths information and the pertinent geotechnical/hydrological parameters, which are usually gathered at spot locations.

The entire sets of data were spatially distributed, by selecting the appropriate interpolators among those normally available within a Geographical Information System (*GIS*) platform.

GIS is a very useful and effective tool to integrate and analyze georeferenced information, thus allowing wide scale monitoring, management, planning, and supporting risk analyses. In particular, the overall model was developed using a free-open-source GIS environment (*GRASS*), which permit the direct implementation of additional features, which can then be re-used and updated by its worldwide *Users' Community*.

The whole watershed was tested, in order to better understand the zone from the hydrological point of view. The steady groundwater table was obtained by applying a suitable model to the extensive zone.

Within this Conference, the Authors shall present the details of the most recent research development which have been attained on this site's model. It consist into the on-GIS implementation of an ***Integrated Hydrological-Geotechnical*** method of analysis (***IHG***), which allows to obtain (1) the groundwater's level variations, due to selected rain histories, and (2) the spatially distributed susceptibility of the loose-soils' deposit to slide.

The IHG model's behavior shows a good conceptual fit with the ground level's movements, which were rendered

by a Permanent Scatterers' Interferometry analysis on SAR images (*PSInSAR*), yet carried out on this very site by Others.