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Stability assessment of underground cavities and forecast of sinkhole dimensions by limit analysis and numerical modelling

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The forecast of safety threshold of underground cavity roof and of correspondent sinkhole area at ground surface level is a problem presenting complicated solution and toward which many researcher's efforts have been devoted[1,2,3]. Main difficulty consists of proper definition of mechanical properties of the system mass involved in the collapse and of the kinematical assumption on the collapse mechanism. To investigate cavity stability, limit analysis is considered by several authors assuming both Greemberg and Radenkovic formulations for standard, i.e. presenting associated flow rule, or non standard materials respectively [4,5]. Present study is aimed to compare theory based forecast and to analyse some cavities present in the Neapolitan area.

Neapolitan underground is characterised by several cavities having different origin. A record of the known cavities in Naples area can be found in [6] where almost 900 cavity are recorded where it is quoted that many other cavity remain unknown yet. In many cases the cavity was built as ancient water reservoir or crypt and changed its destination trough stone mine to waste disposal. The soil where the cavity is formed is generally constituted by some layers of pyroclastic soil over at first Neapolitan tuff hard soil and finally Neapolitan tuff bedrock. The cavity is excavated into the tuff bedrock and one or more chimneys lead to the ground surface across the rock and soil layers. Global stability of the cavity system concerns the stability of the chimneys and the stability of the rock roof . Many sinking occurred where chimneys have been involved, sometimes the cavity roof has collapsed producing superficial sinkhole.

In present paper different material models and cavity geometrical description have been used in order to keep into account effective aspect, namely different constitutive laws, i.e. Hoek-Brown, Mhor-Coulomb and Page Domains considering the influence of soil moisture, moreover the influence of flow rule, namely the post critical behaviour of the rocks, have been accounted for.

It is in present authors opinion that the influence of the constitutive law, i.e. strength parameters and inelastic strain rate definition, plays a minor role with respect to the actual definition of the effective kinematics of the collapse that keeps into account both plastic and slip, say frictional, energy dissipation. Starting on this stand point, numerical simulation have been carried on to verify the accuracy of the proposed hypotheses with respect to the case of study and experimental evidences.

Kinematics of collapsing rock gives more qualitative information about safety assessment rather than constitutive laws accurate knowledge because of the qualitative aspects that results into more accurate estimation of the safety factor that can be over estimated when wrong mechanism assumption is done.

Finally, the comparison with experimental evidence allows choosing the correct modelling option and the accurate forecast of the sinkhole dimension. In order to evaluate the influence of sinking on the existing settlement on the ground surface, complete information are furnished on the displacement by means of inelastic numerical calculation, moreover comparison of numerical simulation and actual damages on existing buildings are presented.

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