DOTTORATO DI RICERCA IN INGEGNERIA CIVILE PER L'AMBIENTE ED IL TERRITORIO
XII Ciclo - Nuova Serie (2011-2013)
DIPARTIMENTO DI INGEGNERIA CIVILE, UNIVERSITÀ DEGLI STUDI DI SALERNO

ABSTRACT

QUANTIFYING THE RISK TO LIFE POSED BY HYPERCONCENTRATED FLOWS

(ANALISI QUANTITATIVA DEL RISCHIO PER LA VITA UMANA DA FLUSSI IPERCONCENTRATI)

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Finito di stampare il 31/01/2014

ABSTRACT

In recent years, the disasters caused by landslides tragically increased due to the demographic growth and the indiscriminate use of land. Among the different types of landslides, flow-like phenomena - often simultaneously affecting large areas - are associated with the most catastrophic consequences in terms of loss of human life and economic damage.

Understanding, forecasting and controlling the risk posed by flow-like phenomena are now recognised to be a priority for the safety of human life. As a result, a growing interest of both technical and scientific Communities, in performing risk analyses aimed at estimating the risk in a quantitative way has been recorded (Corominas et al., 2013).

This PhD Thesis focus on the use of the quantitative risk analysis (QRA) procedures, specifically aimed at estimating the risk to life posed by flow-like phenomena.

The use of QRA can allow the overcoming of some limits inherent to qualitative risk analyses in addressing practical problems (i.e. the prioritisation of management and mitigation actions as well as the allocation of associated resources). However, mainly theoretical contributions are provided on the topic at the international level. This can be due to the complexity of the procedures to be adopted for QRA purposes as well as to the significant amount of required input data (of both technical and socio-economic nature). The main goal of this research is to fill this gap by applying, improving and optimising the use of the QRA as a formal and structured tool for professionals involved in the management of the risk posed by flow-like phenomena.

In this regard, the research activities focus on the quantitative estimation of the risk for loss of life, at medium and site-specific scale, posed by the occurrence of hyperconcentrated flows.

The Thesis preliminarily provides a description of the main features of the flow-like phenomena, with an emphasis to those dealing with debris flows and hyperconcentrated flows. Then, the basic concepts and methodological approaches (with their limits and potentialities) of both qualitative and quantitative risk analysis and zoning are discussed. An overview of the current risk zoning in Italy, performed via qualitative risk analyses, is thus presented.

On the basis of the above premises, the relevant benefits that, at regional and at site-specific scales, can be achieved passing from a qualitative to a quantitative risk analysis are highlighted.

At medium scale, the analysis of historical records of landslide events in the Campania region (southern Italy) allows the identification and the characterisation of the different flow-like phenomena that may occur. In particular, these latter are individuated within a homogeneous geological context where carbonate slopes are covered by pyroclastic soils systematically affected by rainfall-induced slope instabilities later propagating as – often catastrophic in terms of life and properties losses – debris flows or hyperconcentrated flows.

The thorough studies and researches carried out as well as the original results achieved allow to make relevant considerations – from both technical and scientific points of view – concerning both their spatial and temporal distribution (in terms of frequency) and the initial and boundary conditions which influence their occurrence.

At detailed scale, the research activity focus on the quantitative estimate of the risk to life loss with reference to residents at the toe of Monte Albino (located in the Municipality of Nocera Inferiore (SA), Campania region), posed by the occurrence hyperconcentrated flows.

The novelty of the proposed procedure consists in conjugating the fundaments of the risk theory with the geotechnical approach, providing a deeper understanding of the mechanisms that leads to the different and complex stages of movement. To this aim, a thorough in-situ investigations (with the purpose of framing the geological and geomorphological characteristics and to identify the 'hillslope' proneness to different slope instabilities, to characterise the spatial distribution of soil pyroclastic covers and their litho-stratigraphic structure) and laboratory tests (in order to have a complete physical and mechanical characterisation of the involved soils) are carried out. This study represents the indispensable prerequisite for the correct engineering modelling of phenomena at detailed scale - from the triggering stage to

the propagation stage - obtaining in this way the definition of different hazard scenarios.
The obtained results are used to estimate the expected consequences in terms of loss of human life with reference both to the most exposed persons within each of the impacted houses (to which corresponds the highest temporal-spatial probability) and to the average exposed person in open space (representing the average behaviour of a group of people). Finally, the procedure of quantitative risk estimate has allow to rank the portions of the urbanised territory at risk and, consequently, to provide a prioritisation of the areas needing structural mitigation measures.