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The Use of the TRIGRS Model and Geophysics Methodologies to Identify Landslides Susceptible Areas: Case Study of Campos do Jordao-SP, Brazil

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Abstract : Gravitational mass movements are recurrent events in Brazil, usually triggered by intense rainfall. When these events occur in urban areas, they end up becoming disasters due to the economic damage, social impact, and loss of human life. To identify the landslide-susceptible areas, it is important to know the geotechnical parameters of the soil, such as cohesion, internal friction angle, unit weight, hydraulic conductivity, and hydraulic diffusivity. The measurement of these parameters is made by collecting soil samples to analyze in the laboratory and by using geophysical methodologies, such as Vertical Electrical Survey (VES). The geophysical surveys analyze the soil properties with minimal impact in its initial structure. Statistical analysis and mathematical models of physical basis are used to model and calculate the Factor of Safety for steep slope areas. In general, such mathematical models work from the combination of slope stability models and hydrological models. One example is the mathematical model TRIGRS (Transient Rainfall Infiltration and Grid-based Regional Slope- Stability Model) which calculates the variation of the Factor of Safety of a determined study area. The model relies on changes in pore-pressure and soil moisture during a rainfall event. TRIGRS was written in the Fortran programming language and associates the hydrological model, which is based on the Richards Equation, with the stability model based on the principle of equilibrium limit. Therefore, the aims of this work are modeling the slope stability of Campos do Jordão with TRIGRS, using geotechnical and geophysical methodologies to acquire the soil properties. The study area is located at southern-east of Sao Paulo State in the Mantiqueira Mountains and has a historic landslide register. During the fieldwork, soil samples were collected, and the VES method applied. These procedures provide the soil properties, which were used as input data in the TRIGRS model. The hydrological data (infiltration rate and initial water table height) and rainfall duration and intensity, were acquired from the eight rain gauges installed by Cemaden in the study area. A very high spatial resolution digital terrain model was used to identify the slopes declivity. The analyzed period is from March 6th to March 8th of 2017. As results, the TRIGRS model calculates the variation of the Factor of Safety within a 72-hour period in which two heavy rainfall events stroke the area and six landslides were registered. After each rainfall, the Factor of Safety declined, as expected. The landslides happened in areas identified by the model with low values of Factor of Safety, proving its efficiency on the identification of landslides susceptible areas. This study presents a critical threshold for landslides, in which an accumulated rainfall higher than 80mm/m² in 72 hours might trigger landslides in urban and natural slopes. The geotechnical and geophysics methods are shown to be very useful to identify the soil properties and provide the geological characteristics of the area. Therefore, the combine geotechnical and geophysical methods for soil characterization and the modeling of landslides susceptible areas with TRIGRS are useful for urban planning. Furthermore, early warning systems can be developed by combining the TRIGRS model and weather forecast, to prevent disasters in urban slopes.

Keywords : landslides, susceptibility, TRIGRS, vertical electrical survey
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