Slope stability analysis based risk maps

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1. INTRODUCERE

Landslides risk natural map is the synthesis of data forecast steady state of the slopes, property damage and loss of human life that can be caused by landslides on a certain area and in a period of time. Elaborating the risk map of natural landslides is usually performed in an integrated information system, based on computerized databases and digital maps. Databank corresponding to natural hazard map of landslides is performed by collecting, storing and processing information and data required for:

-The basis of Surveying and Mapping (digitized maps, photograms, satellite images etc.);

-existing landslides and remedial work performed;

-characterization of the natural environment of geological, geomorphological, hydrological, hydrogeological, meteorological, pedological, vegetation point of view, etc.

-work on slopes that can change the natural balance of their (deforestation, earthworks, construction location on the slopes or on top of them, etc.);

-present and future use of the land (residential areas, industrial areas, agricultural

areas, forests, etc.);

-elements exposed to landslide hazard (buildings, land).

Map landslide hazard of the locality or of the district, has to be established in stages, starting with areas with a high density of elements exposed to landslide hazard and / or in areas that were identified occurrences of instability. Hazard map landslide shall be drawn up based on the plans and topographical maps, through documentation of studies and field research, taking into account data which include geological, geomorphological, hydrogeological, hydrological, meteorological, there landslides and remedial work of the slopes, data relating to interventions on the slopes of a nature to change the natural balance and others.

landslide hazard map is realized in two stages as follows:

- Phase I - at this stage is collecting all information about morphological, hydrological, climatic, geological, geotechnical and hydrogeological structure existing in documentation which was prepared earlier for various purposes, related to the area is surveyed and engineering geological mapping and hydrogeological very detailed; with collected data, in this phase draws to landslide risk map of the area researched, map which is considered satisfactory for the purpose of which was drawn up;
- -Phase II - to substantially increase the degree of accuracy of the landslide risk map to a zone will be executed of exploration (geophysics, mining, tests carried out in situ) and analysis geotechnical laboratory to determine the physical and mechanical characteristics rocks in the investigated area

For development of the landslide risk map of an area in second phase are necessary following useful maps:

- topographical map - based representation of risk maps to slip; These maps must exhibit a clear hydrographic, planimetric and especially leveling;
- geomorphological map - is modeled on surface mapping with data collected form topographic map materialize; geomorphological mapping work consist on identification and localization of erosion phenomena, landslides existing in various stages of development, presence coastal springs and other.; a particular attention should be paid to existing landslides because they are the most valuable sources of information on potential sliding slopes;
- structural lithological contact map bedrock formation coverings - this map is about identifying which is the foundation bedrock of the slope.

In this regard it is necessary to collect the following information on geological formations investigated:

- Age,
- Lithological composition,
- Current physical condition,
- Characteristic structural elements (cute, flexural, faults)

- The map distribution of the structural index of sliding on the contact form bedrock with diluvium - this map expressed by isolines likelihood of sliding of the slope, the areas of weakness located inside the bedrock and the contact surface of the deposits delluvial and bedrock

Map shall be drawn up to index sliding structurally defined as the ratio of apparent slip angle β 'and considered structural surface inclination angle α of the surface of the slope:

$$I_a = \frac{\beta'}{\alpha} \quad (1)$$

- In a certain point on the surface of a slope angle of inclination β apparently 'surface structural section oriented in the line of greatest slope of the surface of the slope is determined by the relationship:

$$tg\beta' = tg\beta \cdot \sin\omega \quad (2)$$

where β is the angle of inclination of the surface real structural and structural ω angle between the surface and the direction of geological section representation;
- Angle α is determined by the relationship:

$$\alpha = arctg \cdot \frac{\Delta h}{\Delta l} \quad (3)$$

Where Δh is the difference quota and Δl is the distance between contour lines between the falling points considered.
- If the positions of the slope surface and structural surface is expressed by azimuthally angles of inclination δv and δs areas considered, the angle ω is determined by the relationship

$$\omega = |\delta_v - \delta_s| + 90° \quad (4)$$

To draw up the distribution map of sliding index is needed to following next steps:

- the whole surface of the slope which is the subject of the drawing up the risk map is divided into a grid of square cells, cell size is determined by variations in the structural elements of rock investigated; will follow as within the square in the center of which the eye network node is taken into account both the structural and surface of the slope of rocks can be approximated as plane;
- for each network grid is calculated the structural index of slide;
- by interpolating values of the sliding structural index, marked in each network grid, is drawing curves of the equal value of this index.

- Izohipse map of contact with bedrock and deluvial sediments - this map is based on knowledge of absolute elevation of this area in an optimal number of points as evenly distributed on the surface studied; Absolute elevation value are obtained by surveying and documentation of existing materials: drilling, wells, excavations etc.;
- izopahite map of the delluvial deposits - is realized by overlaying topographic map and the map with izohips of contact surface between the

bedrock and delluvial sediments; this map is useful and necessary for evaluating potential fracture surfaces that might creep;

- hidroizohips and hydrogeological map with hidroizophreatic - state efforts within a massive earth is strongly influenced by the presence of water and its flow dynamics by side; Water can come both from deep aquifers and the surface storm water infiltration; in the work of drafting the maps this work is necessary to determine the absolute rates of hydrostatic levels measured in an optimal number of points in a short time interval corresponding to the same meteorological and hydrological conditions; map hidroizohips (lines of equal depth of surface or ground water under the ground surface) and map izofreats provides a distribution of groundwater in massive land and determination of parameters used in stability calculations such as gradients hydraulic forces filtration degrees moisture, submerged rock volume, the possibilities of producing hydrodynamic phenomena, etc.

All helpful maps must be drawn to the same scale synthesis map, which is full of risk to slip. Risk map slip of the stage II builds on diagrams of variation of thrust forces corresponding to each section of calculation, their coherence within the perimeter analyzed, yielding finally a map of isolines of equal force thrust, while having the stability and factors that calculation sections considered.

According methodologies into force for drawing the map landslide hazard is required the following steps:

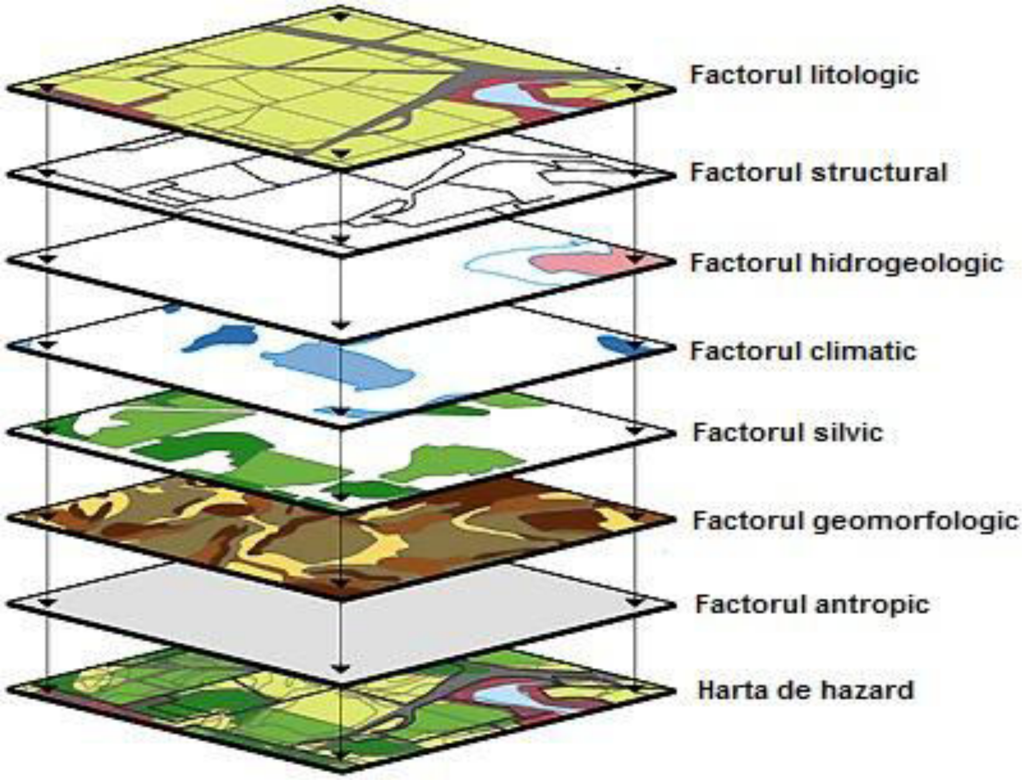

Figure 1: Factors taken into account

- The estimated amount and geographical distribution of risk coefficients $K_{a \div h}$ based on the criteria set out in the norms in the field of variation specific lithology (K_a), geomorphological (K_b), structural (K_c), hydrological and climatic (K_d) hydrogeological (K_e), seismic (K_F), forestry (K_g), anthropogenic (K_h) (Figure 1);
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- Establishing degrees of potential (low, medium, high) associated with a certain probability of occurrence of landslides (practically zero, low, medium, medium-high, high and very high);
- Dividing the area that is desired drawing hazard map landslides in polygonal surfaces bounded to represent deposits as homogeneous lithologic and structural;
- Assessment for each polygonal surface, the risk coefficients $K_{a \div h}$;
- The average coefficient calculation of hazard K_m corresponding to each polygonal surfaces analyzed the relationship:

$$K_m = \sqrt{\frac{K_a \cdot K_b}{6} \cdot (K_c + K_d + K_e + K_f + K_g + K_h)}$$

(5)

- Drawing the map of the geographic distribution of environmental hazard coefficient $K_{m.}$

Map of landslide risk includes mainly the following areas delimitation:

- areas declared under the law risk areas to landslides;
- construction areas exposed to erosion and to establish measures to mitigate and / or eliminate effects of landslides;
- areas where high frequency and magnitude of landslides do not allow the execution of remedial works and establishment of the ban imposed definitive building placement.

Interpretation of the risk map natural landslides categories allow adoption of measures for preventing landslides and mitigation, consisting mainly of:

- changes in land use; restriction and, where appropriate, banning of buildings and / or land use, depending on the category of use and limitations induced landslide risk;
- land destination change and adopting more constructive measures, where is necessary;
- developing programs of insurance of persons and for cases of landslides;
- monitoring landslides in the establishment of forecasting and warning systems;
- judicious allocation of funds for the implementation of measures aimed at mitigating the risk of landslides;
- making intervention plans in case of disaster.

CONCLUSIONS:

If properly prepared, risk maps allow effective action to prevent potential disasters due to landslide occurrence and making rational decisions concerning the location and execution of construction excavations without being jeopardized stability of the ground.

In a first phase slip hazard maps should become mandatory documents for all construction areas and potential Building, following the action of drawing them to be extended gradually to cover the entire territory of the country.

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