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Monitoring and modelling of landslide and debris flow impact on transport and building infrasructure in the Carpathians

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Mechanisms and factors of formation of landslide and debris flow processes are examined in terms of model objects in the Carpathians. The study area is within Eastern Carpathians and Transcarpathian depression (Tisa river basin). There were investigated more than 220 stabilized and active landslides. The analysis of water-gravitational processes in this region with complex heterogeneous geological structure confirmed the priority nature of occurrence of structural landslides in rheologically different geological environments, and made it possible to create a new classification of structural landslides and conditions of their formation with the decisive influence of destructive zones. This classification is the basis for constructing geological, physical and mathematical models of landslide slopes, and subsequent modeling of the landslide hazard based on the determination of the stress-strain state of slopes. Under the proposed mathematical model, the examined phenomenon is described as thermoelastic-plastic equilibrium of the isotropic matrix under effect of applied mass (gravitational field of the Earth) and surface efforts, inhomogeneous stationary temperature field. In addition, it is assumed that the Young modulus at each point of the matrix depends on the water saturation.

Debris and mudflows in the Carpathians have a stage character, non-stationary and avalanche movements.

The territory is prone to be affected by debris and mudflows, due to the geological, geomorphological and climatic conditions. Therefore the main conditions of the mudflow formation are as follows:

- the presence of the rock destruction products which could be a solid phase of debris mudflow;
- presence of the enough quantity of the rainfall runoff for the unconsolidated material removal;
- ruggedness of relief that provides simultaneous movement of the big values of the water-soil mass with the big velocities.

The algorithm calculating the mudflow impact on infrastructure objects in Carpathians has been developed. It based on the empiric data and fundamental hydrodynamic lows, on formula Bernoulli in particular. Using this formula we obtain the expression for the impingement hydrodynamic pressure:

$$P_{\ total} = 0,1\,\gamma_c\left(5H_0 + v_c^2\right) \quad ,$$

where $P_{\ total}$ $[T/m^2]$ – total pressure; γ_c $\left[T/m^3\right]$ – mudflow density; H_0 $[m]$ – mudflow depth;

$v_c[m/\text{sec}]$ – mudflow velocity.

The selection of the velocity calculating technique is of fundamental importance. We propose to define the velocity by Shezi formula with Manning coefficient:

$$V = k_1 Q^{\frac{1}{4}} I^{\frac{3}{8}}, \quad k_1 = 0,075(\frac{1}{n})^{\frac{3}{4}} k^{\frac{1}{2}},$$

where– average channel slope, ; $\frac{1}{n}$ – surface irregularity coefficient; $k = \frac{R}{\sqrt{\omega}}$ – coefficient of the channel cross section; R – hydraulic radius, m; ω– section square, m^2.

These formulas are used in calculating-analytical module for the testing comparison of calculating results obtained by other express methods. These methods are based upon mostly empiric generalized data.

We propose the channel division on three groups according to the channel length:
1) $L_1 < 1$ km; 2) $1 \leq L_2 < 5$ km; 3) $L_3 \geq$5 km. For each group empirical functional dependences have been assumed. The consideration is given to variable shower intensity and critical velocities: $v_1 = 5\sqrt{T}$; $v_2 = 3\sqrt[4]{T}$; $v_3 = 2\sqrt[6]{T}$.

Taking into account the mudflow parameters and geological features they are the instrument of the mudflow risk assessment and aim towards the identification of potential mudflow impact.