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The influence of root system on slope stability in the view of numerical analysis

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The problem of slope stability is one of the most difficult issues, which constitutes the object of interest of engineering geology and geotechnics. The impact of vegetation, well developed bush root system in particular, on the improvement of slope and escarpment stability, is one of the often-omitted aspects in engineering practice. Vegetation may perform a double function within a geological medium:

- strengthening – by means of soil reinforcement and anchoring, binding of grains, which improves strength parameters, reduction of pore pressure and groundwater table by means of water interception;
- weakening – by means of the impact of specific gravity of vegetation on the subsoil, the impact of wind on a tree, which may lead to its inclination and creation of voids in the soil, moisture changes leading to shrinkage and loosening of the ground (Najder 2003, Greenwood et. al. 2004).

Plant roots demonstrate much tensile strength. They increase the ground's cohesion owing to their friction and adhesive properties. Changes of these parameters depend on the spatial reach and the type of root system. The following types may be distinguished: intensive (concentrated) and extensive (diffused) (Reubens et al. 2007). A given root type impact zone depends on the location of the potential slip surface and the kind of mass movement (Koda et al. 2010).

A landslide in Pietrzejowice, located on the Proszowice Plateau, at a distance of approximately 25 km from Cracow, is the object of the research (Kondracki 2010). Landslide movement was initiated on 14 May 2010. At night on 3–4 June further development of the landslide occurred, leading to the damage of two residential buildings. Surface deformations occurred in the area ofapproximately 3 ha. A geological medium was subdivided into five geotechnical layers: silty clay with different consistency and Miocene clay (Jaskólski et al. 2012).

Numerical analyses of the slope stability were carried out in the FLAC 7.0 programme, whose computational algorithm is based on the finite difference method. Two options of the root system development – concentrated and diffused – were adopted in the model.

Numerical simulations were carried out as per the scheme (Pilecki et al. 2014):

1) Static analysis of the data set for variable soil and water conditions with Duncan and Wright method (Kaczmarek & Popielski 2015).
2) Elaboration of the set of input data.
3) Elaboration of the physical model.
4) Elaboration of design model along with adopted initial and design conditions. The following options were considered:
   - variant I – natural slope condition,
   - variant II – condition after water accumulation,

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- variant III – development of concentrated root system,
- variant IV – development of diffused root system,
- variant V – water accumulation of option III,
- variant VI – water accumulation of option IV.

5) Calculation of the results and their verification.
6) Analysis of the probability of occurrence of mass movements for the adopted design options.

Statistical analysis of the set of input data and results of numerical simulations allowed determining the impact of the root system on changes of the safety factor with the soil variable and water conditions. The route of the slide surface and determination of the probability of the loss of stability, with local or global nature, are also important pieces of information. The results of numerical simulations indicate an increased value of safety factor for the slope with extensive root system. The results are of a reconnaissance nature and they describe the impact of the root system on stability in a general manner.

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