The geotechnical model of landslides in the weathered Neogene marls with reference to Belgrade area, Serbia

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Extended abstract

The nature of instability processes in Serbia depends on hypsometric, geological and morphological characteristics, runoff and infiltration of surface waters, engineering geological composition and mechanical properties of rock masses, man-made influences and other factors. In fact, the territory of the Republic of Serbia has complex geological history, which certainly has an influence on the vulnerability of some regions to various types of slope instabilities (Abolmasov, 2010).

The analysis of the distribution of engineering geological complexes and the distribution of the landslides within them shows that around 18% of the territory is formed of Neogene sediment and complexes (clays, marls, sands, gravels), and that 25% of that territory is affected by landslide processes. The largest number of landslides in Serbia is found on the outskirts of the Pannonian Plain on the right banks of Sava and Danube, as well as in the central parts of Serbia in the isolated Neogene basins. Within landslides which appear in the Neogene basins two main types are rekognised: landslides of the right banks of Sava and Danube rivers (wider Belgrade area) and landslides in Neogene basins of the foothills of Central Serbia (Šumadija). They have in common the fact that they all originated in the complexes of Neogene sediments made of different lithological elements and most often clays, sands and marls with pronounced zone of weathering up to approx. 10-25 meters deep. Landslides of the right banks of Sava and Danube are of deep landslide surfaces (over 20 m), formed on the contact of the weathered zone and fresh clay or clay-marl sediments. The basic trigger of the processes, apart from precipitation, is prolonged erosion of the right banks of Sava and Danube rivers. Most landslides are active or temporarily dormant, with the periods between reactivation phases from some years to several decades. Typical landslides are Umka, Duboko, Vinča, Ritopek, Grocka, Karaburma, etc. Based on the landslide database for the inner part of the Belgrade City area(Lokin et al. 2010), out of the total number of mapped

landslides (868) on the 437 km^2 area, 30% are active landslides, 23% are suspended landslides and 19% are dormant landslides. Only 3% of the total numbers of landslides are stabilized. Landslides in Neogene basins of the inland Serbia are directly triggered by the precipitation regime, appearing in the periods of intense precipitation and sudden snowmelt. They are also most often temporarily dormant or dormant landslides with reactivation period of 5 to 10 years, depending on the precipitation regime. Typical landslides are landslides in the vicinity of Valjevo, Kragujevac, Kraljevo, Niš and in Leskovac area (Mihalić et al, 2012).

The good example of the first type of landslides is Umka landslide near Belgrade. The large active and slow moving landslide in the depth of 10-26 m, created in marly clays, takes up the area of 1.8 sq.km.This landslide is fan-shaped, with the length along the slope of 900 m, toe width of 1450 m, area of 100 hectares and average depth of 14 m, volume 14.000.000 m^3 and average gradient of 9°. Upstream landslide part is surroundedby the steep frontal scar with the height from 5 to 25 m, whereas downstream landslide part doesn't have a pronounced leap (Fig 1).

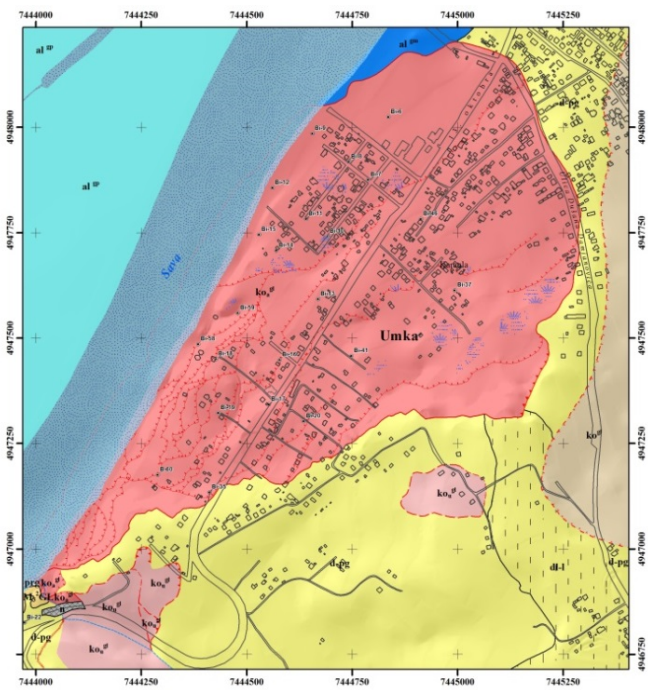

Figure 1 Engineering geological map of Umka landslide

Neogene - Miocene sediments i.e. silty - clayey massive soft rocks have the dominant role in geologic composition of terrain, and these are: grey marls (M_3^2L), more than 200 m thick and upper weathered part - marly clays (M_3^2GL), 10-25 m thick. Stable landslide underlying stratum is made of grey marls. Under the triaxial test conditions, the shearing strength parameters within the natural moisture amount to φ = 18 - 28° and c = 30 - 200 kPa. Colluvial deposits (ko) emerged from the gravitational motion of rock masses down the slopes. Material set in motion in the course of time changed its primary structure, water content and physical-mechanical properties. As a rule, colluvium thickness is predisposed by border between more plastic weathered marly clays and hard marls (Fig 2).

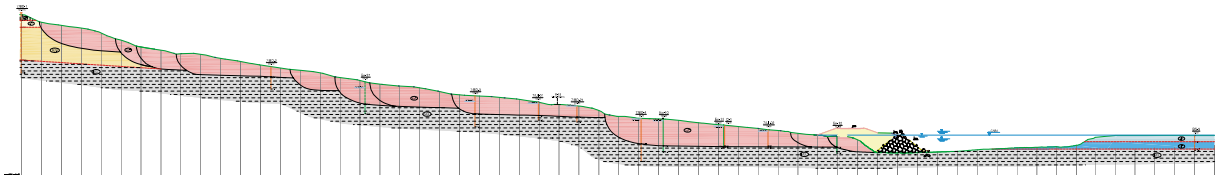

Figure 2. Engineering geological cross section of Umka landslide

Physical - mechanical properties of the colluvium vary in a wide range due to the complexity of its composition and susceptibility to external impacts. Shearing strength parameters along active sliding surfaces are φ_r= 7-13°. Genesis of the landslide is, apart from geological predisposition caused by contact between weathered clay marls and fresh marls, closely connected with erosion of the right bank and evolution of the meanders of the Sava river (Jelisavac et al 2006, Abolmasov et al 2012).

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