GRAVITATIONAL SLOPE DEFORMATIONS IN GEOLOGICAL UNITS OF SLOVAKIA

MALGOT JOZEF and BALIAK FRANTIŠEK

Department of Geotechnics Slovak University of Technology, Radlinského 11, 813 68 Bratislava

Abstract: The occurrence of gravitational slope deformations in the territory of Slovakia is distributed quite unevenly. In the areas of the Carpathian flysch they cover about 20% of the slopes. In intramontane basins, for example in Liptov basin, 30% of slopes. Many deformations, mainly landslides, occur in the Neovolcanic mountains. Paper deals with the conditions and causes of landslide origin, with environmental and economic impact of landslides.

Key words: Slovakia, gravitational deformation of slopes, landslides, causes of origin, environmental and economic impact.

Gravitational slope deformations belong among the most dangerous geodynamic phenomenon in Slovakia. Frequent occurrence of these deformations (failures) is conditioned by young geological development of the Slovak Carpathians, by the occurrence of rock with the bad physic-mechanical properties and by the relatively humid Centraleuropean climate.

A systematic regional research of slope deformations began in 1962-1963 (Matula and Nemčok, 1966). The results of this registration were followed by the investigation of the principles of the formations and the development of slope deformations in Slovakia by scientific workers of Slovakia Unviersity of Technology (Nemčok, 1982; Mahr and Baliak, 1973; Malgot, 1977; Malgot and Baliak, 2000), Comenius University, State Dionýz Štúr Institute of Geology (Kováčik and Suchánková, 1993). The systematic research of slope deformation is now organised by Ministry of Environment. The overview of up to the present works on landslides is given in the paper Wagner et al (2000). The works will finish in 2004-2005 by the compilation of the Atlas of maps of slope stability of Slovakia in scale 1:50.000.

Actual regional investigation carried out in the territory of Slovakia more than 16.000 gravitation deformations, which cover the area about 1700-2000 km^2, representing around 3,3-4% of the whole area of Slovakia.

Slope deformation types

According to classification of slope gravitational movements (Nemčok, Pašek, Rybář, 1974) we divide them into 4 essential group – creep, sliding, flowing, falling. Each type of movement results in certain group of slope gravitational deformations – failures.

Creep is a long-continued downslope movement of the rock material due to gravitational forces and represents the initial phase of all other types of slope movements. The movement occurs in relatively thick shear zones. The result of this type of movement is loosening and disruption of mountainous massifs and gravitational folding on slopes composed of rigid or relatively plastic rocks. The deformations of block type represent an important group which develop on slopes of rigid rocks (limestones, sandstones, volcanics) lying on relatively plastic, softer bedrock (clay, shales, tuffs).

Sliding is a relatively rapid, short-lasting gliding movement of the rock mass along one or several shear planes. According to the shape of the shear plane we distinguish rotational, planar and combined landslides.

Flowing represents a short-lasting movement of debris mass in the viscid phase. During the movement the influence of water present in soil reaching up to 50% of the total mass volume plays a prominent role. According to the granular distribution of soils we can distinguish the earth flows and debris flows (mures).

Falling represents a sudden short-term movement of rock mass down steep slopes, whereby the rock is at least partially displaced by the fall. Resultant forms of this movement are rock topples or planar rock falls.

According to the degree of activity we distinguish stabilized slope failures, which may be triggered only by anthropogeneous impact, calm - potential slope failures which may be activated by the influence of the natural factors. Indisputably active failures display present movements as a single sliding body or at least in some parts of a landslide mass.

Principles of the regional extent of slope deformations

In the Slovak Carpathians the slope failures are concentrated mainly in the regions of High Mountains. Flysch Belt, Neovolcanics of the Middle and East Slovakia and Intramontane basins.

1.Mountainous and high mountain areas of core mountains

In the region of core mountains slope failures are mainly found in areas of the highest altitudes of the West Carpathians Mts.. and are composed Variscian granitoids and metamorphites of Paleozoic age, or consolidated sedimentary rocks (limestones, dolomites, marly shales) of Mesozoic age (Nemčok,1972; Mahr and Baliak,1973).

In the high mountains (Tatry, Malá Fatra, Nízke Tatry) creep deformations reaching up to 250-300 m depth are prevalent.

2.Carpathian Flysch region

The area composing Carpathian Flysch is characterised by extraordinarily frequent occurrence of slope failure with a total area of ca. 900 km^2.

Block displacements and block fields develop in places where in the upper parts of slopes, heavy-bedded sandstones prevail.

The most numerous and most extensive landslides originate in area consisting of fine-rhythmical flysch sediments or of prevailingly claystone flysch rocks. The principles of the landslide development in the flysch region where described in minute detail by Nemčok (1982).

3.Neogene volcanics

Most of Middle and East Slovakia is formed by neovolcanic rocks (andesites, basalts, rhyolites and tuff), which originated during the Miocene volcanic activity. In many places the slopes of volcanic mountains are characterised by a geological structure of hard volcanic rocks resting upon substratum, either of plastic tuff and tuffits or older claystone sedimentary series of marine origin of Neogene or Paleogene age. Such structures are very liable to generate slope movement.

The most extensive slope failures in a neovolcanic region were studied in Middle Slovakia around Handlová and westwards from B. Bystrica near Malachov and Kordíky, in East Slovakia, on the edge of the Slánske vrchy Mts. (Malgot, 1977).

Various types of slope failures are found in disrupted areas. They are formed by coarse blocks of volcanic rocks (50-300 m), which have sunk into the bedrock and displaced downslope.

A continuous circle of landslides with total thickness up to 40 m originates on the margin of the block fields. Planar landslides dominate, less frequent are the stream – like and the frontal types. According to their activity stabilized, potential and active landslides occur. The average angle of slopes recorded in more then 100 landslides range form 60^0 to 80^0. Earth flows are an inherent part of landslides areas. They most frequently develop in depressions on slopes in the places with concentrated runoff of ground and surface waters. They may be over 1000 m in length, 100-200 m in width. On predisposed rock walls rockfalls of toppling type are the most frequent.

4.Basins and lowlands of Slovakia

In Slovakia there are numerous tectonic intramontane basins. They are filled, either with flyschoid sediments of Paleogene age, or with sands and clays of Neogene age. The topography of basins is hilly and is dissected by river activity, which has created a system of river terraces.

The most common type of slope failures in the region of intramontane basins and lowlands of Slovakia are landslides. They develop mainly as a result of rainfall anomalies in the depressions and shallow valleys on slopes. Most are formed on slopes with geological structure favourable to their development, and consist of beds of terrace gravels resting upon Tertiary flyschoid rocks or Neogene sand-clay substratum.

The causes of the landslide activation

Potential landslides are activated usually by natural factors weathering of rocks, erosion, extreme precipitation's and uplift of the ground water table.

Stabilized landslides are activated rarely by natural influences. The most frequent causes are loading of slopes (buildings, embankments), undercutting of slopes (cuttings, excavations for roads, plants) and artificial vibrations. Particularly dangerous are the artificial interventions, which induce the groundwater regime changes.

Economic aspects of the landslides

Slope sliding causes substantial reduction in the utility value of the affected area. Landslides cause different types of direct or indirect damage. They represent a potential hazard not only to the existing structures, but also to further constructions

in the affected area. They have a negative influence on further development of the area and on the environment in general (Malgot and Baliak, 1993).

Sliding causes total devastation of the slopes surface. A slide area is excluded for decades from the possibility of agricultural use.

Of particular significance are landslides on forested by forests. Together with the negative effects of industrial pollution, landslides play a considerable part in the deterioration of forest growth.

Slope movements are an important factor affecting urban planning. In Slovakia are 548 villages and towns, built either entirely or partly on the bodies of old landslides, are under threat. Damages to houses in threatened villages occur frequently due to activation of part of landslide area.

Large geotechnic problems arise in building communication structures (road, expressways, highways) and pipe lines in hilly parts of Slovakia. Their construction often necessitates undercutting or loading the landslides. According to the investigation carried out to date the landslides threat the communication on more than 1.600 sectors. Their real number is much higher.

The problems with the slope stability occurred in building of almost all the water plants and dams in Slovakia. Mainly along banks of reservoires built in flysch areas landslides are activated in a great number, which endanger or directly damage numerous technical objects.

Conclusion

Slope movements are the most widely distributed geodynamic process in hilly part of Slovakia. Previously dormant or stabilized landslides reactivated by unwise human activity are particularly harmful. The landslides damage the forests, the arable soils, meadows and pastures. They endanger and failure the railways and roads. They limit extension of towns and villages in to unstable surroundings. The slope stability is a limiting factor in an optimum landscape use. The systematic investigation of unstable slopes is very important for further development of the country. The regional engineering geological research detect in the studied areas the distribution and the degree of activity old gravitational deformations, which represent a potential (hidden) threat to existing and planned structures. Taking account of such deformations in planning and preventive stabilization substantially reduces the consequential damages. The cost of prevention works are five times lower than those

required for correction measures without damages caused by reactivated landslides, of coarse.

References

Baliak, F., Mahr, T., 1979: Slope deformation in the high mountains in Slovakia, SAV, Bratislava, 143-145.

Kováčik, M., Suchánková, Z., 1993: Systematic inventory of slope deformations in the Slovak Republic, its use and possibilities. In: Proc. of the 7th inter. conf. on landslides. Balkema, Rotterdam, 43-50

Mahr, T., Baliak, F., 1973: Regional Investigation of Slope Deformations in the High Mountain Areas of the West Carpathians. Proc. 10th Congr. of the CBGA, Sec. 5, Bratislava, 169-178.

Malgot, J., 1977: Deep - seated Slope Deformations in Neovolcanics Ranges of Slovakia. Bull. of. I.A.E.G., Krefeld, 16, 106-109.

Malgot, J., Baliak, F., 2000: Landslides in Slovakia, their effects on the environment and on important engineering structure. Mineralia Slovaca, 32, Bratislava, 341–350.

Matula, M., Nemčok, A.: 1966: Prehľad zosuvných procesov na Slovensku. Inžinierske stavby 1, Bratislava, 29-30.

Nemčok, A., 1972: Gravitational Slope Deformations in the High mountains in Slovakia. Sbor. geol. věd, HIG, Praha, 10, 7-38.

Nemčok, A., 1982: Landslides in Slovak Carpathians (in Slovak). Veda. Bratislava.

Nečok, A., Baliak, F., 1977: Gravitational deformations in Mesozoic rocks of the Carpathian mountain ranges. Bull. of I.A.E.G., 16, Krefeld, 109-111.

Nemčok, A., Pašek, J., Rybář, J., 1974: Klasification of Slope Movements. In: Zbor. Geol. věd, HIG (Praha), 77-79.

Wagner, P., Malgot, J., Modlitba, I., Andor, L., 2000: History and perspectives of landslide studies in Slovakia. Mineralia Slovaca,32,Bratislava, 335-339.