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LANDSLIDES' INFLUENCE ON THE ENVIRONMENT

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Abstract: In the area Bosnia, landslides on natural slopes are frequent occurrences that imperil some housing units, settlements, economic units and people's life or they imperil traffic safety on the roads, degrade agriculture and forest lands and they also lead to dislocation of surface and underground waters.
The main causes of landslides' activation are changes in level of underground waters, chopping down of forest, great rainfalls, snow melting, long drought periods, changes in slopes, changes in load of a slope, rock's wastage, uncontrolled diversion of surface waters, earthquakes etc. Researches on landslides are carried out in order to establish the cause of landslide's origin and to find out efficient overhaul measures. Landslide's overhaul success depends not only on established causes of landslide's origin, but also on use of technical measures for stopping that process. Overhaul measures' carrying out is important in protection of the environment.
This paper presents an analysis of co-action of natural factors and negative anthropogenic effect in a settled area, where landslides appear, by which studies and removing the causes are made conditions for the successful stabilization of landslides. The paper shows some characteristic landslides with defining of geomorphologic, geologic, engineer geologic, hydrogeologic and geotechnical characteristics of the terrain..

Key words: landslides, environment, influence on the environment, natural factors, anthropogenic effect

Introduction

Territory of Bosnia and Herzegovina is characterized by heterogeneous geological structure, the presence of igneous, sedimentary and metamorphic rocks of different ages from Paleozoic to Quaternary, which causes complex terrain stability in Bosnia and Herzegovina.

According to the data of entity Direction of Civilian Protection most landslides in the Federation was registered in Tuzla, Sarajevo and Zenica-Doboj Canton and in eastern parts of Republic of Srpska. In Canton Tuzla highest number of

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recorded landslides is in Tuzla about 350, Gradačac 210, Lukavac about 200, in Gračanica about 100 and in Kladanj about 90. During last ten years it have been analyzed 193 landslides that occurred in ten roads in Canton Tuzla. According to the Institute for Construction of Canton Sarajevo until 2009 in Canton Sarajevo was registered about 755 landslides and the highest number of recorded landslides are in Vogošća 189, New Town 172, Center 124 and Old Town 110.

Landslides may occur due human activities or natural factors. The main causes of landslides activation are changes of underground water level, changes in the volume of vegetation such as deforestation, high rainfall, long periods of drought, melting of snow, improperly made drainage system and uncontrolled drainaging of surface water, earthquakes, etc. Causes of landslides are located in the rocks itselfs, in the manner and conditions of their existence and even their elementary physical and mechanical properties that reflect the rock ability for faster or slower respond to endogenous and exogenous geological forces with the aim of decomposition and movement of rock masses from place of decomposition. Landslides can occur as a result of human activity in cases of performing construction, mining and other projects with the disturbance of natural relations on the slopes.

Influence of landslides on the environment is large due the destruction of vegetation, their leading to dislocation of groundwater and surface water and endangering wildlife. Also, the impact of the landslides on the air and soil pollution is common because landslides may threaten infrastructure, water, gas, oil and other installations. By defining properties of landslides and slopes where it was created, we can determine the causes of landslides and activities for their recovery.

Degree of terrain threat by landslides and dynamics of landslide development in some lithofacies areas

Studies of landslides are made with the aim of finding a cost-effective and rational technical solutions for the recovery and stabilization. Sliding can be catastrophic and can have serious consequences especially in populated areas.

Causes of landslides can basically be reduced to:

- Qualities due geological structure of the slope, which are basically consists of rocks affected by processes of decay and the formation of clay-sand-crush rock cover;
- Erosion-frost-dynamic processes;
- Smearing fecal and wastewater and their infiltration into the body of landslides;

- Uneven inflow and flow of groundwater within the surface cover;
- Poor geotechnical characteristics of cover;
- Unbalanced slope angle and sliding bodies;
- Uncontrolled and inappropriate construction of residential houses and
- Change the volume of vegetation (forest).

Figure 1 shows the zone of stable, unstable and conditionally stable terrain of the Federation of Bosnia and Herzegovina. That is defined as:

- Unstable terrain, high hazard and conditional probabilities of landslide formation > 10.67%
- Conditionally stable terrain, medium hazard and conditional probabilities of landslide formation 3.56 – 10.67%
- Stable terrain, low hazard, conditional probability of landslide formation < 3.56%.

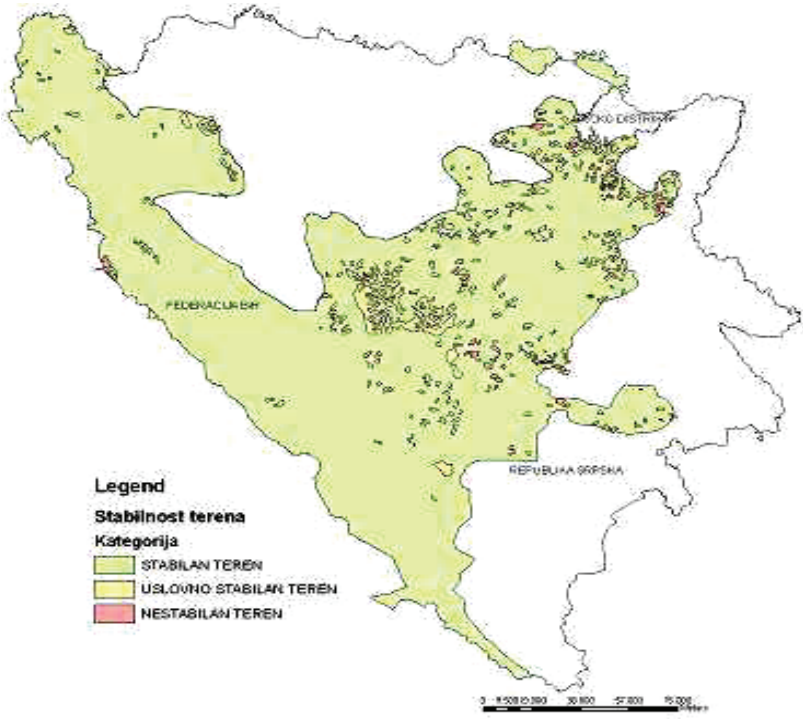

Figure 1 Ground stability in the Federation of Bosnia and Herzegovina (Hydro-Engineering Institute Sarajevo, 2009).

Neotectonic activity in the wider area of Sarajevo significantly influenced on changes of engineering-geological characteristics of the rock mass and

development of egzodynamic geological processes at slope areas. The wider urban area of Sarajevo, at slope areas has numerous landslides and rock fall, primarily due to geological and tectonic framework, highly heterogeneous composition of the individual lithofacies environment with variable physical and mechanical properties and genetically different types of Quaternary cover.

In morphological way terrain of the urban part of Novi Grad belongs to highland type of terrain with elevations from 520-530 m asl in the bottom of the valley of Buća Potok up to the 675 m asl. Denudation and fluvial erosion in combination with other causes has led to the development of gravitational processes, which resulted with creation of a large number of landslides. The terrain is built by sediments of Sarajevo-Zenica basin and Quaternary sediments. Polyfacies complex Upper Miocene "Koševo series" is built from clays, shale, marl, sand, gravel, sandstone and alevrolites. Beyond this complex lies quaternary eluviation-diluvial covers and anthropogenic dykes of material with dominant participation of clayey-silty-sandy material and subjected crush rock materials. Within eluviation-deluvial covers there are separated colluvial materials that represent materials for sliding body composed of topsoil, silty-sandy clay and fine-grained inwards. This cover in general represents a favorable environment for formation of landslides, and contact with the geological substrate represents critical discontinuity for generating of a sliding process. Beneath the surface covers lies geological substrate presented by marl clay, marl, and weathered sandstone "Koševo series".

Also in the area of landslides "settlement Ozimine" Municipality Trnovo, denudation and fluvial erosion in combination with other causes led to the development of gravitational processes and the development of numerous landslides in the region. Terrain of landslides is built from Jurassic-Cretaceous flysch represented by limestone, marl, claystone and sandstone that lie on the Middle and Upper Triassic dolomites and limestones (T2,3). Rock complex is covered by Quaternary eluviation-deluvial and colluvial cover, mainly clay-crush rock composition. Quaternary cover built most of the surface slope sections of the study area. These materials are formed by decomposition of geological substrate or anthropogenic activities due construction of roads and buildings. Beneath the surface cover there is a geological substrate made of crust of disintegrating and substrate. Crust of disintegrating is represented by decomposed limestone marl, shale and slate which due to effects of water and climate changes decompose in incoherent and meuble mass. Substrate is built by Jurassic-Cretaceous flysch sediments which are also susceptible to decomposition. Landslides are active with a tendency of spreading and are formed along contact line of cover- crust of disintegrating. In geological

structure of Tuzla Canton, participate rock masses of heterogeneous lithologic composition, with different origin and physico-mechanical properties. Therefore, the ground surface in different areas of Tuzla Canton, behave differently in terms of deformation, breakout, and movement of materials as well as reaction on action of surface water and groundwater. At urban part of Tuzla have been registered 538 landslides which occupy an area of 10290.010 m2 which presents 22.07% of the total area of the territory. Additionally on study area, have been registered 285 locations with labile parts of slopes, i.e. locations where currently there is no landslide but it represent potential environment for creating them. These sites cover 1086.096 m2 which makes 2.32% of labile terrain.

If we take into account the geological structure terrain and position of sliding planes in relation to structural material of the slope in the Tuzla area can be identified the following types of landslides:

Group of landslides, which derives from slow astounded rocks: marl, slate, sandstone, conglomerates and marly limestones

Group of landslides, which derives from the semi-cohesive rocks: overlying clay

Group of landslides, which derives from the unbound materials: dusty sands

Landslides of " crust of disintegrating"

Into first group are included landslides Žigići, Badre I, II and III, Katoličko groblje, Imamovo brdo, Medenice, Orašje, Šljivice and many other landslides. Landslides from the second group are: landslide in Zenica street and a group of landslides on Husino and landslides „Šikare“ in Ljepunicama, Smajići-D. Pasci. Landslides of the third group they appear and can occur in Moluhama, Drežniku, Paša Bunaru, Husinu, and Krojčici. Examples of landslides fourth group are those that commonly occur in the road or in cuts.

Landslides negatively influence on morphology of surface of area and it can be seen in examples of landslides in Suljaković near Maglaj and Bogatići at Trnovo. An example of the influence of landslides on vegetation is landslide Suljaković. According to the scale and catastrophic consequences, this landslide is one of the largest in BiH. During the construction of the M-17 there was already a landslide, which was then repaired. Landslide is certainly formed after recent rains. During the construction of houses, these were buried streams which are on the left and right sides of landslides. These streams were dragging surface water. Another cause is illegal construction. Cutting the slope at upper side of

facilities, including leveling and filling from lower side, resulting imbalance of mass, disturb is natural balance conditions and then worst happens (Figure 2).

Figure 2 Demolition of houses in Suljaković (Municipality Maglaj – Bosnia and Herzegovina) http://www.crometeo.net/phpbb/viewtopic.php?f=5&t=6614

One example of impact of landslides on forest vegetation is also landslide in Bogatići at Trnovo, which represents the largest and fastest landslide (Figure 3).

Figure 3 Lanslide in Bogatići (Municipality Trnovo – Bosnia and Herzegovina) http://www.tip.ba/2010/10/30

Some experts believe that based on the vegetation coverage and the environment can be reconstruct earlier development and engineering-geological processes that occurred in the past. Thus, Smith (1986) analyzes in detail the process of re-vegetation on landslides of destroyed forests in British Columbia, Canada, and came to some important theories related to the red alder. This region affected by sliding, is mainly inhabited by red alder tree. The author has determined percentage of prevalence of alder and time of ground moving.

According to, the Urban Plan (draft) of Zenica-Doboj Canton has been registered 179 landslides, or under landslide are 568.79 ha of land. The largest

number of registered landslides is located in Zenica 121, then in Kakanj where are registered 20 landslides.

In geological structure of area of Zenica participate rock of Paleozoic and Mesozoic era in the peripheral parts, while in the basin there are limnological - terrestrial sediments of the Central Coal Basin. The series consists of four complexes of polyfacies: Oligo-Miocene (tufa limestones), the older Miocene (upper, main and bottom coal zones), the younger Miocene (Orlac conglomerates, Koševo and Lašva series, and transition zone), and Pliocene (clay, sand, gravel, polyfacies complex).

Engineering-geological characteristics of the terrain can be considered in two directions according to the lithological composition and according to major physical-mechanical properties of layers such as surface covers and geological substrates. Geological substrate is characterized by a variable structure in terms of lithological composition which is subjected to processes of surface decomposition.

Studies of slopes stability, above the excavated coal seams done by underground mining are important in terms of potential urbanization. Slope stability is threatened by sinking over the excavated area and occurrences of landslides in the area of sinking of degraded areas. One of the areas affected by exploitation of underground coal work is the area pit Rača, Brown Coal Mine Zenica, which was investigated in detail in terms of slip hazard and it is a specific example of the different values of hazard. Area of closed coal mines Rača is characterized by complex geological and tectonic relationships. In area affected by underground mining of coal were registered a few minor faults. Beside the landslide surface of coal mines, to major landslides also belongs the landslide at open pit of iron ore Smreka in the municipality of Vareš.

Conclusion

Bosnia and Herzegovina is characterized by heterogeneous geological structure, and a high degree of tectonic and the seismic activity as well as various relief and the climatic characteristics and water flows of different gradients. All this reflected on engineering-geological characteristics of the terrain. Activation of landslides in Bosnia and Herzegovina commonly occurs due to increased amounts of groundwater and the unplanned construction of houses and other buildings, uncontrolled cutting of forest and mineral resources exploitation. The main reasons for increasing the number of landslides in urban municipalities of Bosnia and Herzegovina are the illegal construction on the slope areas. In addition to illegal construction, the most common cause of landslides is low

quality of precipitation drainage system and the sewage system. Before the construction it is necessary to conduct stability test of terrain and houses needs to be built denser, line up on small plots or in a series.

Influence of landslides on the environment is large because it leads to dislocation of groundwater and surface water, destroying agricultural estates, threatening infrastructure, flora and fauna. Implementation of rehabilitation measures is important for preservation of our environment. To rehabilitation of landslides should be given special attention because of the overall factors of landslides and their relationships are specific for each landslide. For largest number of landslides needs to be perform engineering-geological, hydrogeological and geomechanical studies and done project documentation with solution for rehabilitation of landslides. If rehabilitation of landslides is not well done, then it does not represent a safe area for people and objects.

Cadastre of landslides is needed for planning of treatment of the same and through them it is possible to follow the development of the existing as well as the occurrence of new landslides. By following earlier events in the sliding process and influence on environment it can be learn more, so that in the future negative effects of landslides on the environment can be reduced.

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