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APLICATIONS OF GPS AND GNSS IN GEOLOGICAL MAPPING AND DEVELOPMENT OF ENGINEERING GEOLOGICAL MAPS AT EXAMPLE OF LANDSLIDE "JUNUZOVIĆI" SREBRENIK

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ABSTRACT

The use of modern global navigation system (GPS-GNSS) is massively being used in the modern research. Therefore, the use of these methods in science can do much to facilitate scientific research work. In this scientific work we analyzed the database obtained by the GPS device and field testing engineers, and the data is used to produce maps of the field, engineering geological map and we recorded elements of landslide that were used for mapping (cracks, landslide mass, water sources, forehead scar and glide plane). Based on the results obtained, we made morphology of landslide and landslide engineering geological map in scale 1:500.

Keywords: *engineering-geology mapping, global navigation satellite system, landslide*

INTRODUCTION

With field research, we defined engineering geological characteristics of landslide performing recording and tracing the landslide and its elements. In the absence of maps in cadastral of municipality Srebrenik, it was necessary to illustrate the terrain to a working map needed for the detail analysis of landslide. For this type of work one meter accuracy was sufficient, therefore "absolute positioning method" was used . All measurements were recorded and database was created using state coordinate system that could be used for GIS (Geographic Information Systems) analysis [1]. We recorded 22 characteristic points of landslide, and another 67 points of terrain. On the basis of these 89 points we have done an interpretation of the terrain of landslide and formed a 3D model of the landslide.

GEOGRAPHICAL ELEMENTS OF LANDSLIDE "JUNUZOVIĆI" SREBRENIK

Since in the municipality of Srebrenik there are no detailed (maps) of the area, nor any map of larger scale, creation of working maps with contour lines at equidistance of 1 meter was necessary. In order to better interpret landslide morphology 3D model of terrain was created. Since this work did not require significant precision absolute positioning method with a handheld GPS receiver (Magellan) was the equipment of choose. Used method gived the positioning coordinates in real time, and does not require post-processing of data. Positioning accuracy was several meters. In the area of approximately 3,600 square meters, recorded are 89 points (y, x, z). Based on those points

interpolation of contour lines of terrain were created with equidistance of 1 meter in the software package Surfer V.11 [2]. Points 22 of 87 have a more detailed description of elements of landslide, and their connection make contour of landslide. The table below shows the characteristic points recorded GPS GNSS system that are used to interpolate the parameters of landslide in table 1, [1].

Table 1 Characteristic points of landslide in state cordinate system

Tačka	y_ds	x_ds	z	Tačka	y_ds	x_ds	z
T0243	6542943	4950531	491	T0254	6542988	4950465	466
T0244	6542953	4950531	478	T0255	6542985	4950466	465
T0245	6542927	4950516	473	T0256	6542996	4950461	466
T0246	6542926	4950512	467	T0257	6543043	4950453	461
T0247	6542929	4950508	466	T0258	6543012	4950456	470
T0248	6542931	4950507	464	T0259	6543015	4950455	470
T0249	6542961	4950502	477	T0260	6543009	4950468	472
T0250	6542985	4950479	470	T0261	6543021	4950467	470
T0251	6542989	4950480	471	T0262	6543034	4950461	469
T0252	6542993	4950475	471	T0263	6543036	4950464	474
T0253	6542993	4950471	468	T0264	6543011	4950471	473

MORPHOMETRIC ELEMENTS OF LANDSLIDE

- Length of the landslide represents linear distance from the forehead of landslide and to the landslide toe.
- Coordinates of forehead landslide are recorded with GPS in points (T0243, T0244, T0264, T0263. Coordinates of landslide toe recorded with GPS in points (T0255, T0254, T0256, T0257)
- Slope Landslide was determined based on recordings for the whole landslide and it is approximately the same slope for whole sliding mass. Slope of landslide was determined based on recorded points. Slope of landslide is expressed in degrees. Intermediate slope of landslide is 5% calculated by the software "Autocad" [3].
- Width of the landslide represents distance from lateral edges of the landslide and it is measured perpendicular to the direction of movement of sliding mass, width of landslide in this case is 120 meters.
- Area of a landslide represents a total area of landslide edged from scar, lateral shear planes, and toe part. Area of landslide is 3601 square meters.
- The thickness of the landslide represents the vertical distance from the surface to the landslide slide surface. It is always initiated thickness of the sliding mass and is determined after a clearly defined sliding surface or sliding zone. The thickness of the landslide is 1,5 meters on average (assumed on the basis of field observations)
- The magnitude or volume of sliding mass is the mass of the entire landslide body. It is obtained by multiplying the average thickness and landslide area. ($3601m^2$ x 1,5 m = 5401,5 m^3)
- The direction of movement of the landslide represents a direction of movement of the sliding masses. It may be the general direction of the whole landslide or changeable. In this case landslide movement is determined as northeast-southwest.

ELEMENTS OF LANDSLIDE

- Geology of terrain consists of the surface layer represented by Neogene sediments, which lies over Jurassic limestone that represents parts of ofiolite central zone of Bosnia and Herzegovina. The thickness of upper layer is up to 2 meters with Jurassic limestone remains with diameters up to 2,0 meters.
- Through entire length of landslides there are indications of groundwater, (willow and marsh grass), including small stream which is located on the lower part of landslide [4].
- Climate of area is moderate continental climate. General characteristics of the climate are existence of four seasons, relative humidity and cloudiness, the maximum rainfall during the warmer months, and the minimum at the end of winter.
- Morphological elements on slope are determined based on general morphological characteristics of the terrain, slope and relief forms. Morphological elements are shown on figure 1.
- Anthropogenic elements represent all the anthropogenic interventions on the ground regardless of the purpose, from cutting of the forest, road construction, the seismic effect of artificial earthquakes induced by mining and surface deformations caused by underground mining and settlement [5]. At the upper and lower part of the landslide residential buildings are present, and the road passes around the whole landslide. Contours of landslide are determined through the recorded traces (Trag0001) given in Table 2.

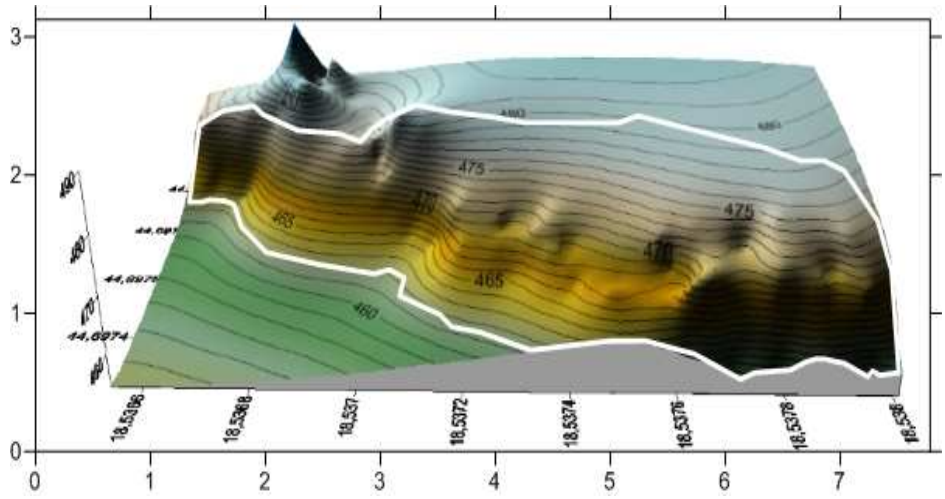

Figure 1. 3D Model, interpolation of contour line of landslide, (GPS) software Surfer.

Table 2 Recorded traces

Trag0001	44.69799	18.53688	480	Trag0001	44.69783	18.53654	467
	44.69797	18.53685	485		44.69779	18.53658	466
	44.69801	18.53673	479		44.69776	18.53668	464
	44.69798	18.53669	478		44.69774	18.53675	470
	44.69787	18.53676	483		44.69772	18.53683	472
	44.69783	18.53681	484		44.69772	18.53692	475
	44.69783	18.53674	476		44.69772	18.53703	482
	44.69785	18.53667	476		44.6977	18.53709	480
	44.69786	18.53657	475		44.6977	18.53703	477

GENESIS OF LANDSLIDE

Elements of the development of landslide are in relation to the timeline of the landslide, its development, movement and natural stabilization. [6]

- Inception zone of landslide is related to the occurrence of the first tension cracks as the first direct indicator of the beginning of the development of landslide. This zone is important since it becomes zone where rainwater percolates into cracks created by tension and watering the slide surface. This zone may exist and it be identified before the start of landslide and before the first tension cracks. Inception zone of landslide is shown on Picture 3 (Profile 2-2')
- Zone of transport includes total mass sliding along the entire length of landslides. In this zone masses are sliding from one position to another. Zone of transport is shown in Picture 3 (Profile 3-3').
- Zone of accumulation is located at the toe of landslide where sliding masses are accumulated. Landslide in its course may have more zones of accumulation. This zone is shown in Picture 3 (Profile 1-1').

Elements of the development of landslide are shown in the figure below, with two longitudinal and one cross section.

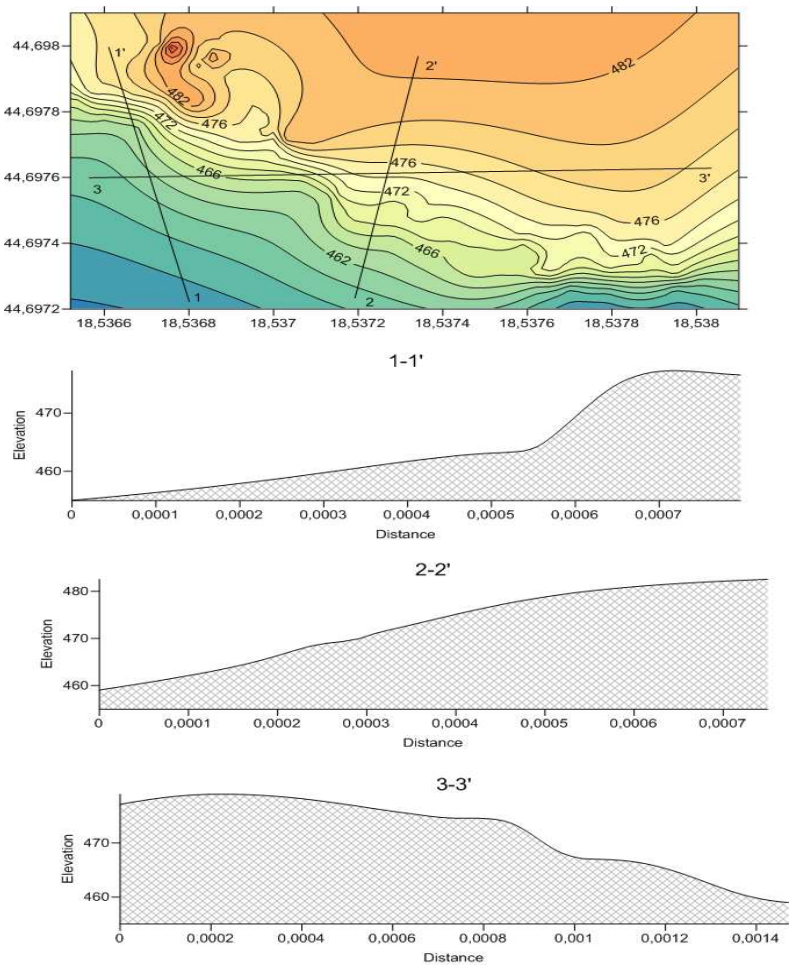

Figure 3 Elements of landslide obtained by interpolation after shooting a GPS in the software (Surfer) and profiles of landslide.

GENESIS ELEMENTS OF LANDSLIDE "JUNUZOVIĆI"

Main scarp of landslide is at the upper side of landslide. At our case main scarp is 2 m height, which in the northern part extends to 3m. Shape of scarp represents extending arc from top to bottom, with successive slide. Foot of landslide represents hypsometrically lowest point of the landslide and in this area sliding masses are stopped and accumulated. At the lower right side of the landslide exists the spring. At this area marsh vegetation is developed indicating high level of underground water. In the picture 4, specific terrain undulation can be seen, accumulation of mass that makes foot (toe) of landslide.

Picture 4 Landslide „foot“ (accumulated mass of landslide)

Radial cracks are visible through the entire length of the foot area.

Surface of rupture separates the main body of landslide and underground. In this case, assuming upon field observations, rupture surface consist of mixed clay layers.

In our case, the rupture surface is "hidden".

Flanks of landslide represent lateral plane of shear landslide that clearly separates sliding masses and original ground surface. Landslide flanks of are divided to left and right, looking from the direction of sliding.

Main body and foot of landslide represent material that is depleted from the head of landslide.
Landslide main body is filled with parallel transverse cracks and radial cracks.

The picture 5, shows the landslide body with zone of accumulation and influence of the mass movement on the trees located at the landslide.

Height (thickness) of the foot goes up 4 to 5 meters, and the height (thickness) of the main body varies.

Cracks in a landslide in this case can be divided into:

- Transverse cracks
- Radial cracks

And in our case presented were olso:

- Drying cracks.

Picture 5 Landslide accumulation zone

CLASSIFICATION OF LANDSLIDE

Classification elements of the landslide "Junizovići" by a sliding surface [7,8]:

- circular cylindrical – rotationally

Elements of kinematics slip:

- translation

Type of movement of materials:

- slide

Current stage slip into:

- calming stage

Development of landslide in relation to the slope:

- progressively sliding mass of progress in upper landslide zone

CONCLUSION

Use of GPS-GNSS systems and devices greatly assist the work on the field for field engineers. The data can be easily stored and found in the database in case of need in the future, through GIS systems. As we have seen in the paper, almost all element of landslide are derived from the database formed through detailed survey and field mapping, including map interpolation, and creation of engineering-geological map. In this paper defined are the most important parameters and information of landslide recorded for the cadastre of landslides. GPS-GNSS systems could be largely used for engineering needs becoming a necessity in today's modern filed work of the geological engineer. The purpose of this paper is to demonstrate the possibility of application of GPS-GNSS systems at field to future engineers, which greatly ease the tasks of gathering of information, mostly in cases when there are no detailed geodetic surveys of area. Recommendation is that training of use GPS-GNSS in the state coordinate system becomes integral part of courses at faculty.

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