ENGINEERING SEISMO-GEOLOGICAL JUSTIFICATION OF THE BAYIL LANDSLIDE IN 2018

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Objective

Determining the contours of a probable landslide-prone territory based on the method of engineering seismic exploration and studying the deep structure of fractured environment.

Research method

The refracted microseismic method (Refraction Microtremor, Louie 2001) was used to study the fractured area observed on the Bayil slope in the area of the TV Tower using the seismic microtremor method. The method is a cost-effective seismic method for establishing a shear wave profile in a study area. This method provides useful seismic data directly in noisy urban areas. The refracted microseismic method (Refraction Microtremor, Louie 2001) uses the phase data of a given wave field.

Figure 1. General view of the landslide with observed main fractures in the area

Symbols:

\- cracks observed in the area, - the area of influence of the prognosed landslide, - Alley of Martyrs

To study fractured microseisms, an engineering seismic station GEODE-24 (made in the USA), 24 seismic receivers with a frequency of 4.5 Hz, a seismic streamer 115 m long, and an impact sledgehammer weighing 11 kg were used.

As seismic waves, seismic signals from environmental noise and from sledgehammer blows were received.

The Seismodule Controller software package was used to acquire records in the study area, and programs such as ReMiVspect4.0 and ReMiDisper4.0 were used to process the resulting records.

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Figure 2. View of houses in the affected area of the prognosed landslide (width 200 m, length 220 m).

Symbols:

- the direction of the prognosed landslide and the area of landslide affection

Figure 3. Scheme of seismic profiles in the study area (16 different profiles developed)

spr1 ÷16 - seismic profiles, - cracks observed in the area,

- observed groundwater places

16 seismic profiles were built and processed in the area. Profiles 1, 2, 4, 5, 6 and 15 were constructed by cutting through the fractured zone observed in the area. Profiles № 1÷12 have a length of 55 m, and profiles № 13÷16 - 115 m.

Before the start of the study, the site was visually inspected and a number of anthropogenic interventions affecting landslide activation were noted. These include the cutting of a slope in the form of a terrace for growing tree seedlings and for building houses, as well as the absence of a sewer line in these houses.

Figure 4. Visual observations at the site

Figure 5. Water leaks in sandstone layers in the northwestern flank of the landslide zone

Figure 6. Slope cut in front of the landslide zone and rock sampling from a shallow depth

Figure 7. Slope cut in front of the landslide zone

Figure 8. Placement of seismic receivers on the profiles of the study area and registration of seismic waves

Seismic line №1 is associated with an engineering exploration well drilled to a depth of 50 m. The relative height of the wellhead is 107 m. This well was drilled approximately 20 m south of the main fracture found in this area.

As can be seen from the geological section of the well, the upper lithological section of the study area is composed of a complex of rocks of the Quaternary (Q4) age (semi-hard clays, clastic limestones, fine-grained sands and sandy clays). Sandstone formations are often found among the engineering-geological elements mentioned. Groundwater was not observed during drilling (Fig. 9).

At the same time, 60-70 m to the north-west of the exploration well at a relative height of 95 m, groundwater leaks were found through sandstone layers, and when sampling soil from a depth of 2 m from the front of the fractured area, clay-loamy soils were found in the form of porridge (Fig. 5, 6).

One of the factors substantiating the reality of landslide risk is the deepening of sandstone layers, where water leaks were observed, under the predicted landslide massif (the area where cracks were observed) and the identification of clay-loamy soils in the form of a porridge on the front of the massif (based on sampling from 2 meter depth).

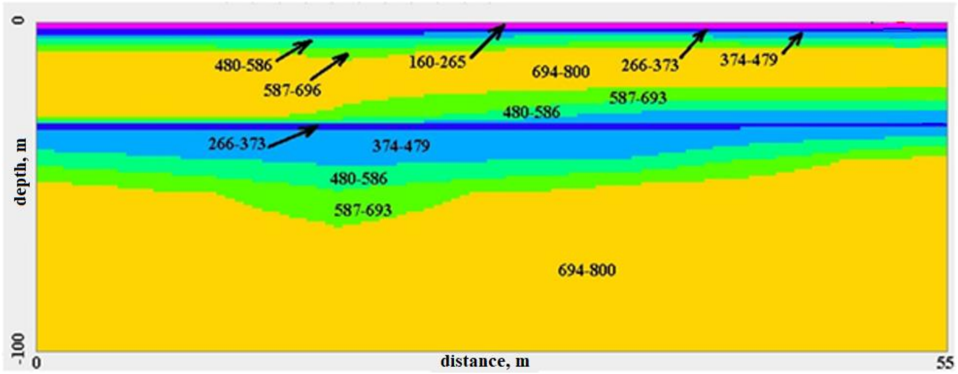

Figure 9. 2D shear wave velocity section on seismic profile №.1

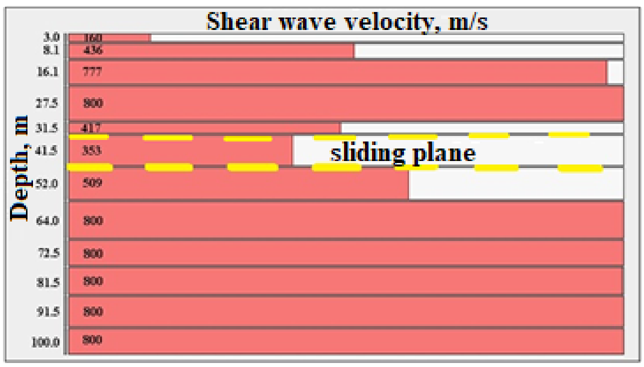

Figure 10. 1D shear wave velocity section on seismic profile № 1

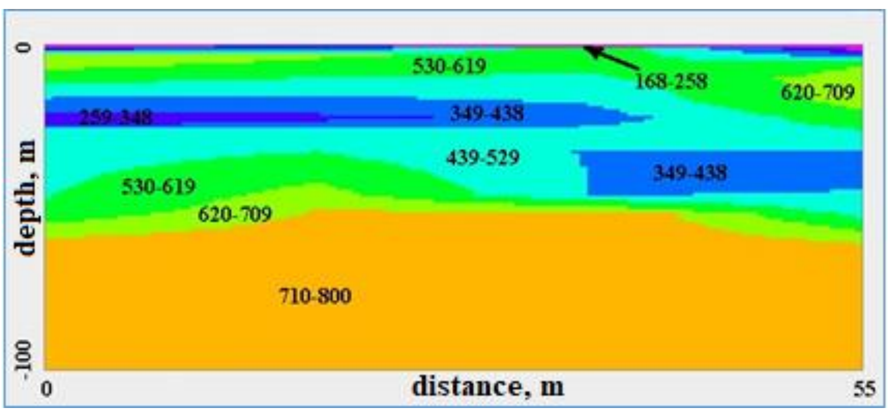

Figure 11. 2D shear wave velocity section on seismic profile № 3

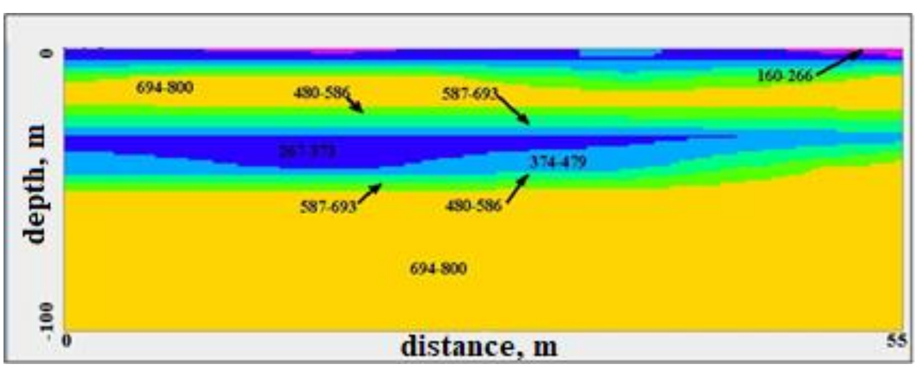

Figure 12. 2D shear wave velocity section on seismic profile № 5

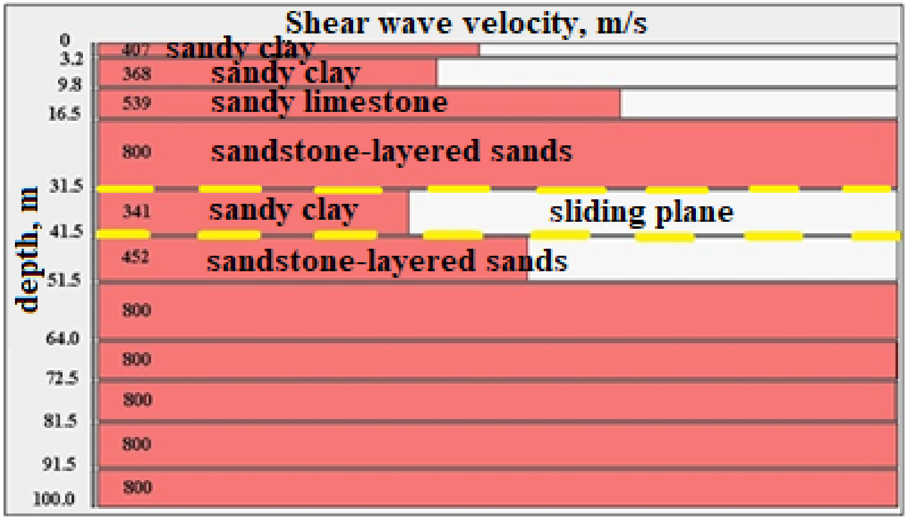

Figure 13. 1D shear wave velocity section on the seismic profile № 5 and seismic georeferencing

According to seismogeological data on seismic profiles № 1, 5 and 6, sandy-argillaceous rock layers were revealed at a depth of 31.5-41.5 m, with a thickness of 10 m and a low wave speed of 350 m/s (on profile 1), 340 m/s (on profile 5), 360 m/s (on profile 6) and at a depth of 28-44 m, with a thickness of 16 m (on profile 7) with a wave velocity of 360 m/s.

On February 10, 2018, a landslide occurred in the study area, four houses, fences and outbuildings were destroyed, cracks formed in the remaining houses and a very dangerous situation arose (Figure 15-18).

Thanks to the timely notification of the landslide to the relevant government agencies and the accuracy of the research work, the residents were evacuated from the risk zone even before the incident and it was possible to avoid human casualties.

Figure 14. Landslide on February 10, 2018

Symbols:

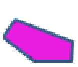 -the area of the real landslide,  - the area of the prognosed landslide

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Figure 15. Terrain change observed at a depth of about 10 m at a distance of 19 m at the top of the landslide

Figure 16. Relocation of a stone fence

Figure 17. Destruction, observed cracks and uplifts on the surface at a distance of 130 m from the edge of the landslide

Conclusion

- it was found that the slip plane is located in the form of a thin lens on the roof of the layers of sandy-argillaceous (loam) rocks at a depth of 31.5-41.5 m (the shear wave speed in the layer is 350 m/s), at the border with a layer of fine-grained sands containing interlayers of sandstone;
- it was established that the landslide occurred as a result of water flowing out of the upper part of the slope and moistening of the Quaternary (Q4) clay-sand layers with sewage water, as well as a cut in many places of the slope;

- the total area of the landslide territory was determined as 11430 m^2, the volume of the observed landslide mass was 360000 m^3.

References:

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