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ON THE CHOICE OF THE NEW BASIS POINTS OF MONITORING STATIONS

V.A. Riabchii, V.V. Riabchii, M. Tregub, O. Yankin
State Higher Education Institution «National Mining University»

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State of the problem

The use of local geodetic networks to monitor landslides has some advantages over the use of public or state ones, especially in cases where precision of information is very important. Local geodetic network is usually created for observation of engineering structures or natural objects. Some of them were created at the time when the GNSS systems were not in use. The application of modern satellite systems is problematic in one local geodetic network and the most significant problem is the comparison of results measured during previous observations without satellite instruments.

With the destruction of the primary basis points is especially significant issue when you need to perform repeated geodetic measurements, but for various reasons, there is no mutual visibility between points of observation and most of measurements can only be performed using GNSS-receivers. Also, without taking into account the results of previous long-term observations there might be not appropriate and incomplete characteristics of the landslide.

Analysis of recent research and publications concerning the problem

Publication of Dyshlyk A. [1] devoted to the methods of geodynamic observations of soil mass of Sudak fortress. The authors have systematized the implementation of methods of geodynamic observations by the accuracy of their methods. There is an example of construction of geodynamic network for observations at the Sudak fortress.

Zuska A.V. [2] investigated landslide processes in Dnipropetrovsk, including in the area of «Sokol». According to a study conducted modeling soil mass changes over time, as of mid-1990.

Article of Tyschuk M. [3] indicates the importance of sharing disparate observations are five works.

The paper of Khoda O. [4] features monitoring by using GNSS equipment. The author researched the factors that significantly affect the accuracy of measurements, developed proposals for forecasting the relevant factors. Also proposed program campaigning GPS-observations on geodynamic polygons to study local deformation of the landslide.

According to research topic there are many other very important works of the following experts Voitenko S.P., Savchuk S., Trevoho I.S., Tretyak K.R., Chernyaha P.G. etc., but there was no research dedicated to the problem of new observations using GNSS methods when the basis points of local network are lost.

Aim of research

The aim of this study is to determine the methods of selection of new "temporary" starting points by comparing the lengths of lines between points of observation on the results of modern geodetic observations using GNSS equipment for the monitoring of natural landslides in Dnepropetrovsk. This task is dedicated to the problem when the primary basis points of observation stations are not protected.

The main material

Observation of landslides on natural landslide "Sokil" in Dnepropetrovsk were provided by the Department of Geodesy of the National Mining University during 1984 - 1993. The last series of observations conducted in autumn 1993. Fig. 1 shows the layout of observation points stations in this area.

To perform the research, the researchers designed the network of microtriangulation, polygonometry and height observation points by using geometric leveling of II class. Additionally, on the slopes of landslide set the sedimentary soil rapper, but as of autumn 1993 they were almost lost. The starting point of this network were 16 and 20. The observations were performed in cycles twice a year.

To suspend the landslide in the relevant territory was built a retaining wall and drainage systems. On this wall were also established observation points. The shift of the observation points allowed to talk about reducing the shear process in general.

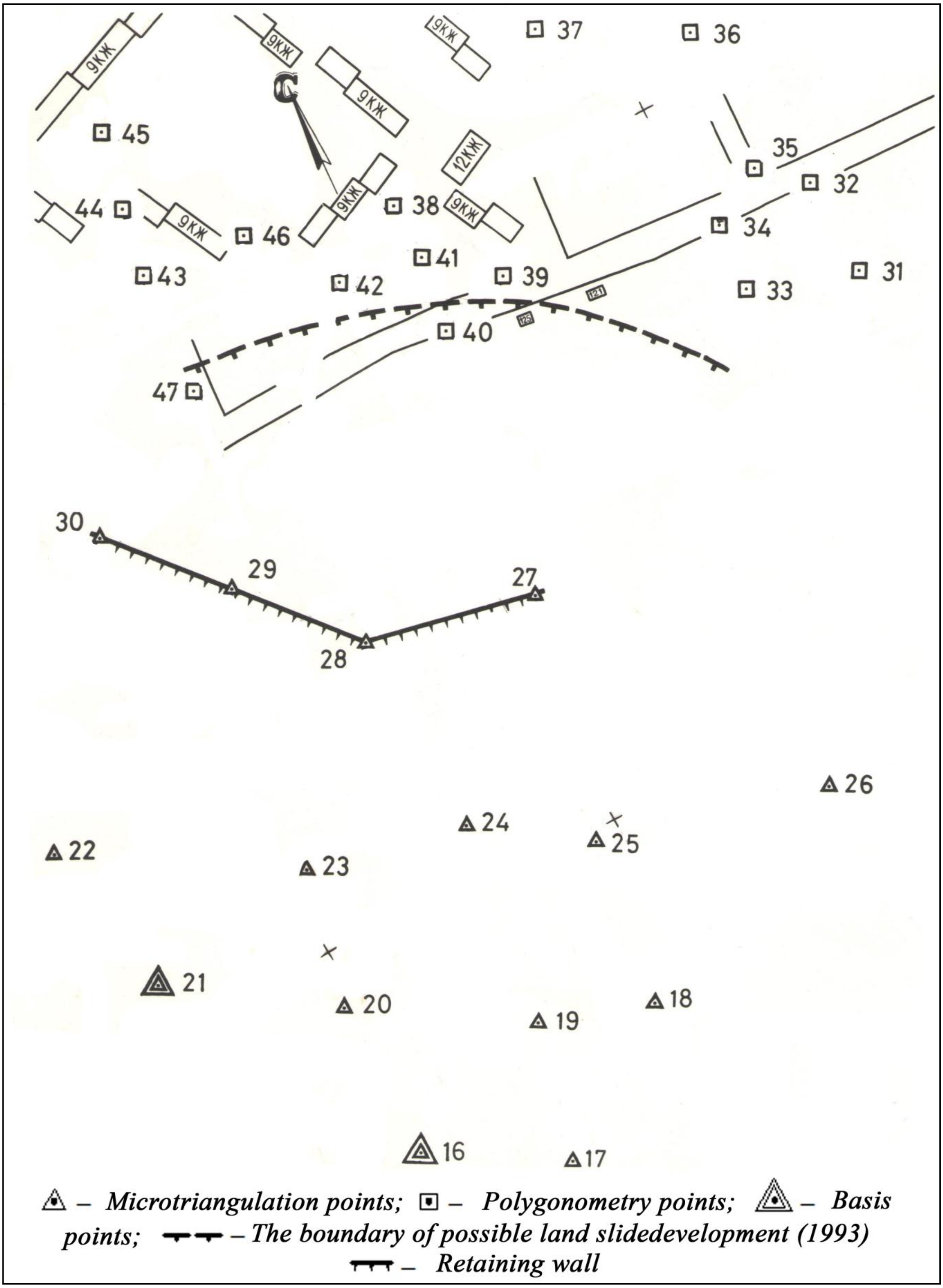

Fig. 1. Scheme of points tracking station on the section " Sokol " (Autumn 1993)

For personal initiative of teachers of the Department of Geodesy in April 2015 was made the survey at the following areas. According to the results of the survey established that only at tracking station shown in Fig. 2

the points are preserved, and some of them, including the basis points , were destroyed.

Fig. 2. Scheme of points available on the section of observation station "Sokol" (Spring 2015)

Station 28 on the retaining wall is not completely preserved, only its base remains. Stations 22, 23 and 24 are lost as a result of the widening of the ravine. Stations 16, 17, 20 and 21 are destroyed as a result of human activity.

Also, the results of survey at this area shown that carrying out new observations using only electronic total stations practically impossible, because there is no mutual visibility between points of observation stations. It was therefore decided to carry out work using geodetic GNSS-receivers TrimbleR3.

To receive the results that can be compared with previous cycles of observations the most important was to recalculate the current observations to the local coordinate system. The ideal solution of the problem could be using the basis points of previous network 21 - 16, but they were destroyed. Were analyzed every possible combination of basis points from those remaining and the most stable items are selected according to the results of existing geodetic observations from 1984 to 1993. The new basis points are 18, 19 and 41.

To reduce the amount of the present publication we show the changes of coordinates of only three points 18, 19 and 41 not all that were analyzed. Summary results determined coordinates and elevations of points on the first and the last five cycles with their differences are shown in the table 1. The results of geodetic observations last (seventeenth) cycle in 1993 compared with previous established that these points almost did not change their position.

Table 1

Results of planned and altitudinal displacement of points 18, 19, 41

№ point / cycle	Coordinates of points, m			The deviation from previous, mm			The planned shift, mm	The spatial shift, mm
	X	Y	H	X	Y	H		
18/1	83.642	375.013	134.045					
18/13	83.711	375.050	134.040				-	-
18/14	83.722	375.061	134.040	11	11	0	15.6	15.6
18/15	83.731	375.059	134.040	9	-2	0	9.2	9.2
18/16	-	-	134.044	-	-	4	-	-
18/17	-	-	134.045	-	-	1	-	-
19/1	103.024	301.505	136.652					
19/13	103.027	301.506	135.650				-	-
19/14	103.030	301.512	135.649	3	6	-1	6.7	6.8
19/15	103.038	301.509	135.651	8	-3	2	8.5	8.8
19/16	-	-	135.649	-	-	-2	-	-
19/17	103.032	301.506	135.654	-6	-3	5	6.7	8.4
41/1	574.703	432.351	129.944					
41/13	574.691	432.373	129.942				-	-
41/14	574.703	432.362	129.945	12	-11	3	16.3	16.6
41/15	574.701	432.365	129.943	-2	3	-2	3.6	4.1
41/16	-	-	129.945	-	-	2	-	-
41/17	574.738	432.366	129.946	37	1	1	37.0	37.0

In May 2015 the teachers of Department of Geodesy have performed observations on saved points of the station "Sokol". The base receiver was installed at point 41, where it worked for the cycle at all observation points. Observations on other points performed by rapid static mode. Time of observations on points ranged from 25 to 35 minutes depending on the geometry of the constellation satellites.

In software Topcontools were transformed the coordinates of all observation points from WGS 84 to the local coordinate system, which conducted geodetic monitoring of landslides in the past.

The choice of new basis points performed in that order. First, the results of GNSS observations in spring 2015, were calculated lengths of lines between all points of observation. Then there were calculated the same length of lines on the results of the last cycle of observations fall of 1993 after the comparing of the lengths of all lines was done. The results of this comparison are presented in Table. 2 and Fig. 3.

Table 2

Compare distances

between points of observation stations

№ distance	Distance from the results of GNSS observations, m	Distance based on observations last cycle in 1993, m	The difference between the distances, m
18 – 19	76.025	76.043	-0.018
18 – 26	174.262	174.883	-0.621
18 – 27	269.190	269.830	-0.640
18 – 30	460.741	460.938	-0.197
19 – 26	236.679	237.425	-0.746
19 – 27	270.647	271.096	-0.449
19 – 30	415.245	415.481	-0.236
27 – 30	279.698	278.852	0.846
41 – 18	494.322	494.340	-0.018
41 – 19	489.482	489.521	-0.039
41 – 26	424.258	424.652	-0.394
41 – 27	225.232	224.585	0.647
41 – 30	269.867	269.664	0.203

As can be seen from Table. 1 and Fig. 3 of all possible lengths of lines between points of observation have changed the least distance between points 41, 18 and 19.

As point 41 and points 18 and 19 located on different sides of the ravine, with a significant likelihood that it can be concluded about the stability of these points and they are outside of the landslide. But, as seen on differences in lengths between other points, landslides still continue.

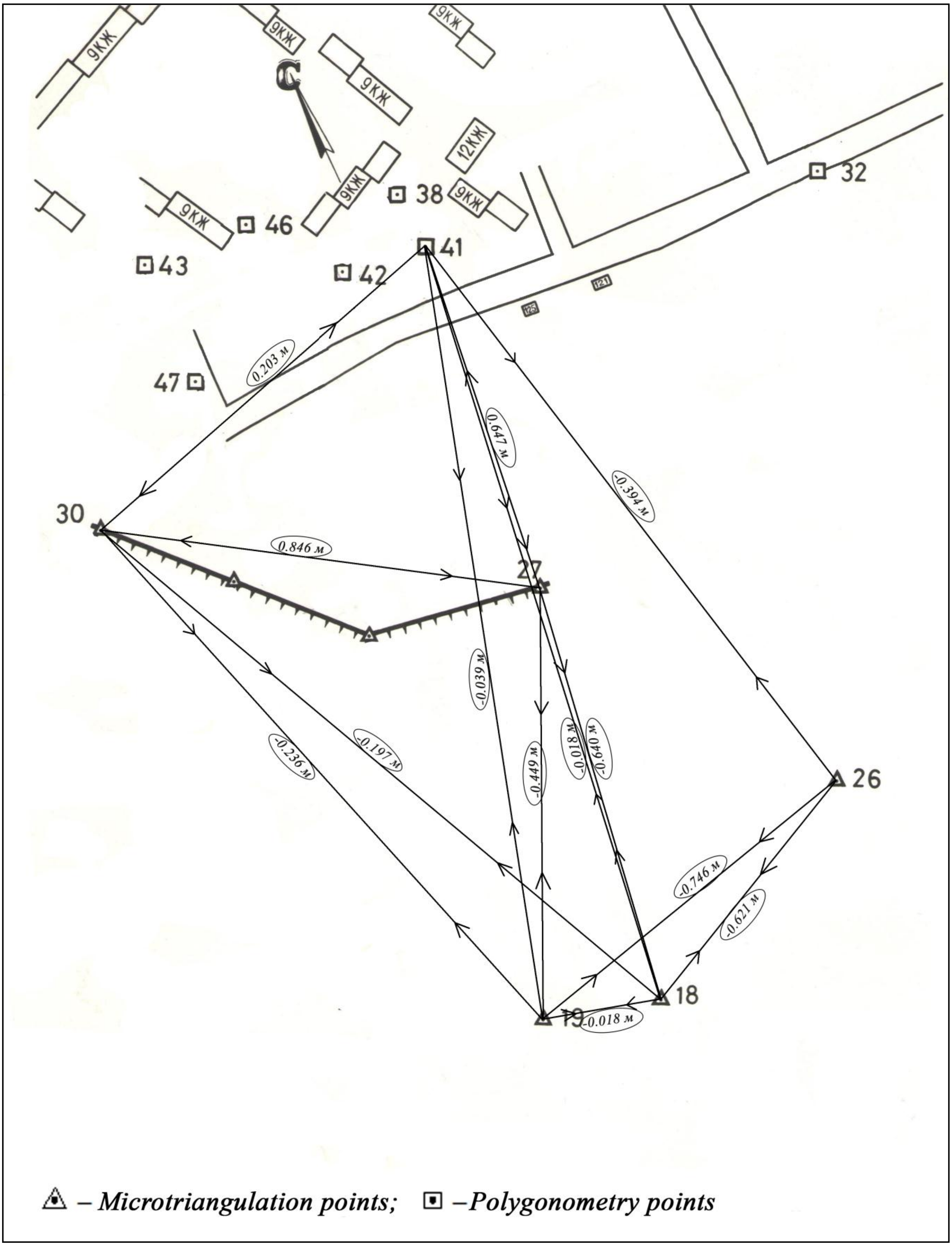

Fig. 3. Directions and distances between the change in the network on the section " Sokol " (Spring 2015)

Conclusions and recommendations

Summarizing the information above, the following conclusions can be reached.

1. If you lose the starting points of local geodetic network observations, to select new starting points it is proposed to apply the method of lengths comparison of lines between all points of observation.

2. Application of this technique allows to further use the observations of previous years.

Prospects for further research is to create a base outside the ravine, which will be set in the state geodetic network USC 2000 and local coordinate system of Dnipropetrovsk city. Also repeated observations are advisable to carry out using multifrequency and multisystem GNSS-receivers.

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On the choice of the new basis points of monitoring stations

V.A. Riabchii, V.V. Riabchii, M. Tregub, O. Yankin

The results of mathematical processing of modern geodetic observations of landslide processes in Dnepropetrovsk on points of monitoring stations at lost basis points are presented. A new method of determining the "temporary" basis points by comparing the lengths of lines between points of observation is offered.