GEODESIC NETWORKS FOR OBSERVING ROCK PIT DUMPS DYNAMICS

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During open mining pit dump works constitute the significant part of the whole complex. Pit dump life time ends with an open cast mine development completion; its project existing period is defined as 20-30 years.

In the process of exploitation of rock excavation dump of Sever-Kazgan mining where revealed rocks are transported by road, deformation of advance dump 1 soils of were observed and as a consequence – the dump itself. The length of work dump road dead end before deformation was 2 – 3 km, and in the process of deformation of the dump it reached 0,6 km whereas a rational length of a dump dead end for excavators with a dipper capacity is to be 1—2 km [5]; for defining sizes of active landslide zone and finding in the ongoing process it is required to obtain digital dimensional model of point displacement in time on the upper site of the dump edge and on pressed soils relatively to accepted static system of coordinates due to study of a new process of soils of advance dump, defining its main parameters there arises a necessity of performing detailed geodesic surveys of collapsing-displacing deformations of a landslide type at the dump comprised of alluvial and semi rocks, sandstones and siltstones. Height is about 30 m. Physical and mechanical properties are showed in the table.

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| --- | --- | --- | --- | --- | --- | --- |
| Soils | Thickness layer, m | Volume weight,  g/cm3 | Deformation modulus | Intrafriction angle, degree | Adhesion, kg/cm | Critical load, kg/cm 2 |
| Loams of quaternary age | 0,3-1,7 | — | — | — | — | — |
| Clay light grey with sand lenses | 0—6,4 | 2,04 | 90 | 25 | 0,12 | 2,4 |
| Clay many colored with gypsum nests | 0—10,2 | 2,02 | 100 | 12 | 0,60 | 4,23 |
| Clay blue grey | 4,4-35,2 | 2,01 | 60 | 14 | 0,62 | 3,97 |
| Clay black enriched with organic material | 4,4-35,3 | 1,73 | 74 | 14 | 0,45 | 2,88. |
| Clay green grey with interlayers of mudstone like clay | 19—92,6 | 1,97 | 180 | 19 | 0,34 | 4,30 |

The table data show no soils in the base of the dump that are able to prevent collapsing and displacing deformations of the dump, which causes a load on soils being 7 —7,5 kg/cm2. Engineering and geological information is given with the aim of demonstrating that is important to know in advance engineering and geological conditions of the works area. Such a condition as exceeding of load on base soils sooner or later will lead soil protrusion of the dump base.

This allows us to prepare the project for creating geodesic reference networks and dynamic networks in sufficient time taking into account expected deformations.

Observing (landslide) points were set at spacing up to 80m in deformation zones along the dump edge, at each soils protrusion bank of the advance dump and in the zone of non-deformable soils.

With the powerful dump forming machines available also the possibility of dumps deformations increases. In connection with that when locating reference points around the perimeter of the dump it is necessary to bear in mind such factors as time, rate of excavation as well as actual width of base soils protrusion deformation spread.

Soils deformation was registered at the distance of 180 m from the dump (by the change of leveling bench mark height of II class) whereas the instruction [2] allows a distance to the closest reference bench mark up to 100m. Taking into account this circumstance and planned duration of geodesic works execution, a distance from the dump footage to the points of horizontal and elevation reference geodesic network is proposed to be defined by the formula:



where Т — planned duration of geodesic works execution, years; Р — stacker capacity, m3/day, 5 — length of dump front, m; Н — dump height, m; D — distance from dump footage to non-deformable soils of advance dump, m.

With Т = 2 years, Р = 5000 m3/day, 5=1 km, # = 30 m and D = 180 m we have L = 302 m.

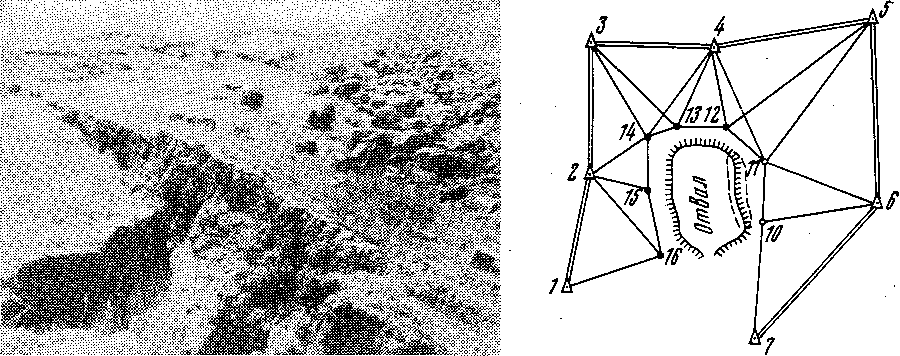


Fig. 1 Fig. 2

Starting from May 1972, during three years observation over change of contour parameters of the dump in the zone of deformation was done. It was found out that the dump edge due to excavation moves 116 m per a year which corresponds with the calculations well. Existing points of triangulation of 4th class were accepted as initial ones, distanced from the dump for 2- 5 km. Length of contouring line between seven triangulation points of 4th class was 19 km which does not allow the network deformation to grow towards the edges if there is a displacement shear of any initial point [6]. This was checked by calculation on computer EVM Minsk-22. Coordinates of initial point 6 were changed (Fig. 2) for 10 cm. After equation coordinates of only two closest to the site of deformation of defined points W and 11 underwent changing from 0,05 to 0,1 m. Hence this confirms feasibility of using a network with a contouring rigid line as initial one for surveying rock dumps deformations.

As there is no uniform norm method for grounding a necessity of precise measuring of displacement for landslides, we have a following question: what accuracy is required to measure landslide displacement for a dump deformation?

When calculating the required accuracy, acceptable value of a shift 7 cm on curve in conditions of current railway state [1]. Hence total value of measuring error 7 cm may be accepted; with that accuracy provision factor is taken as 2,2, as errors of initial data cause minimum distortion of measured elements in equated network with that factor [3].

According to the methods described by N. N. Lebedev [3] let us find the values of гп\ and т2 for 2 stages of setting up with the following formula



where / — number of development stage; M — total gross error of measuring; k — factor.

Inserting number values in the formula (2), we have т\ — = 2,9 сm, т2 —6,4 сm.

The first stage of reference plan network out of seven defined points (see Fig. 2), set along the perimeter of the dump with spacing being 0,3— 0,7 km, was created by the method of triangulation of 1 grade and served as an original for developing a short base polygonometry of 2 grade (second stage) for landslide points.

Predicted mean square error of mutual position of the projected network points came to be +0,023 m with given mean square error of measured angle 3", which satisfies т\. We see that for network equation obtained on the computer Minsk-22 we obtained mean square error of measured angle with triangle closure 3,1" (mean triangle closure is 4,3"), from the equation of 3" the highest correction in measured direction +3", mean square error of weight unit 2,1", mutual position of the points ±0,023 m. And at that average length of sides in the network was 2,2 km (from 0,6 to 3,9 km). Measuring angles at the points of the network was done by theodolite Т2 by circular method of 3 procedures defining corrections per reduction.

For a short base polygonometry of 2 grade with т2 = 6,4 сm and limit traverse length 2,5 km taking into account that the points in the middle of a traverse after equation are defined 2,5 times more precisely we obtain the required accuracy in a relative measure ^2:£limit=1: 15 600. Maximum acceptable relative error in a traverse is f2: £limit= 1 ; 8000.

Total length of traverses of the short base polygonometry developed on landslide points was 26 km with traverses length being 1,2—2,5km. The lines in the traverses were measured by segments of 40 m by parallax method applying two-meter invar bar, its length was defined with accuracy of 0,028 mm.

Parallactic angles were measured by the theodolite Т2 in five half-intakes. Traverse closure errors of the polygonometry were obtained 1:7600—1:11 000, mean square error of measured angles with closure errors in traverses is within 1,2—9", mean square errors of equated position of the defined points were 0,03—0,07 m.

Study of horizontal deformations of the working edge of the dump and the advance dump soils combined with the survey of vertical deformations. Measuring vertical displacement of observing points in the process of deformation was done by leveling of III class. When selecting the class of leveling we based on the fact that deviation in the level of track rail location from the norm on direct and curved areas of not chief put and dump railways is allowed not more than 7 mm.

Marks of initial bench marks were panned to be obtained from leveling of II class. With this aim two times in 1974 and in 1975 for the points of triangulation of I class leveling of II class was done; and engineering level НА! together with invar checked rod were used. The second cycle of leveling of II class in 1975 aimed at defining stability of bench marks. Traverse was developed taking into account possible deformation of land surface caused by pressure of the dump towards the base soils. Mean square random error of leveling of II grade was obtained being ±0,12 mm in 1974 and ±0,15 mm in 1975. Systematic error was not counted due to short length of the traverse (11 km).

On observing points of the profile lines (polygonometry of 2 grade) leveling of III class was done regularly. Regularity was caused by the following reasons: methods of observations should exclude distortion irregularity of obtained values of vertical displacement between difference cycles and also it is required to exclude excessive observations. Cycles’ frequency and their change shall be in conformance with fluctuation of soils vertical displacement rate [4] in the process of occurring deformation, either it is settlement or elevation of deforming surface point. The lower the vale of vertical displacement of observed point, the higher is ratio of observation error to the value of vertical displacement and hence observation cycles frequency should vary depending on the rate of deforming surface vertical displacement. The period between two consecutive cycles of observation was defined by the formula



where Ан — observation error, mm, at respective class of leveling; M — ratio of observation error to the value of vertical displacement, %, accepted depending on the required accuracy; v — rate of vertical displacement of deforming soils, mm/day.

Such method of counting time between two consecutive cycles of observation makes it possible to reduce unnecessary cycles and leads all observation results to a single degree of accuracy. As a result we can make a conclusion as follows.

Distance from the dump foot to the projected initial geodesic points taking into account the duration of geodesic works, intensity of dumps excavation and advance dump soils deformation are recommended to be defined by the formula (1).

For studying deformation of unstable soils of advance dump and the dumps themselves by means of repeated geodesic measurements it is recommended to use a network with a continuous contouring line (see Fig. 2).

When confirming the required accuracy of measuring land mass displacement at dump it is recommended to accept admissible shift on railway curve and deviation in rail trails level from the norm as a starting value.

LIST OF LITERATURE

1. Geodesy in railway. M., Gedesizdat, 1962. 343 p. Illustrated.   
   Author: A. F. Lutz, V. P. Sorokin, T. F. Finkovskaya and oth.
2. Instruction for observing deformations of edges, slopes, benches and dumps at pits and developing measures for providing their stability. L., issued by VNIMI, 1971. 188 p. Illustrated.
3. I. N. Lebedev. Course of engineering geodesy, M., Nedra, 1974. 358 p. Illustrated.
4. V. N. Popov. Experience of geodesic methods apply for studying swelling soils dynamics. Alma-Ata, issued by KasCNTIS, 1975. 14 p.
5. V. V. Rjevskii. Process of open mining works. M., Nedra, 1974. 520 p. Illustrated.
6. F. M. Urmantsev. About selecting initial points for studying horizontal movements of land surface. – “Geodesy and cartography”, 1975, No 2, p. 22 – 26. Illustrated.