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Measurement Of Sediments Of Industrial And Civil Buildings And Structures By High-Precision And Accurate Levelling Of Short Rays

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ABSTRACT

To determine the height position of benchmarks and sedimentary marks, various geodetic methods are used: geometric levelling (classes I, II and III), hydrostatic levelling, stereophotogrammetric method, trigonometric levelling, etc. The article is devoted to the study of the problems of measuring the settlement of industrial and civil buildings and structures with high-precision and precise levelling of short rays.

KEYWORDS

Knowledge of the art of construction, soil mechanics, levelling marks with two horizons, assessing the levelling accuracy.

INTRODUCTION

Peculiarities of the sediment measurement technique. To determine the height position of benchmarks and sedimentary marks, various geodetic methods are used: geometric levelling, hydrostatic levelling, stereophotogrammetric method,

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trigonometric levelling, etc. time interval (1 - 3 months) to determine the rate of settlement of buildings in which cracks or other deformations have appeared. In the second case, the requirement for high accuracy is due to the need to establish the nature and magnitude of the precipitation during the operational period, when it is usually small (several millimetres per year). The accuracy of measuring the sediment and, consequently, the method of their measurement are prescribed by the terms of reference drawn up by the design and survey or scientific organization [1-4].

MATERIALS AND METHODS

One of the advantages of geometric levelling in comparison with other methods is that with one set of tools it is possible to intend the settlement of any number of points of the structure. In addition, levelling can be done at any time of the year without compromising measurement accuracy. From a surveyor who monitors deformations, not only knowledge and experience in organizing and conducting accurate levelling is required, but also good knowledge of the art of construction, since the volume, lines, accuracy and organization of observations are largely determined by the size, significance and design of the structure, and also the procedure for the production of construction work. Only knowledge of the construction business can help the surveyor expediently placemarks on the structure for measuring deformations and take measurements in a timely manner [2-5]. To correctly interpret the results of measurements of deformation of structures, the surveyor must be familiar with soil mechanics. As practice has shown, observations of the settlements of structures are more successful when all cycles of levelling marks are carried out by one observer. The degree of technical preparedness of the river operator has a serious impact on the accuracy and pace of observations. The observer should spare no time in instructing and training him. The conditions under which observations of deformations are performed differ significantly from the field conditions in the production of state levelling. Factors such as shaking from the work of machines, traffic, insufficient illumination of the interior, flows of unevenly heated air, damage or blockages of marks, significantly complicate the work and reduce the accuracy of its results. Even the conditions for carrying out measurements of the settlement of large hydraulic structures and the period of their operation cannot be compared with the observation conditions for accurate state levelling, since some levelling passes are laid along inclined construction adits, from the walls of which water drips, others pass along the crest of the dam, and others along the slopes of slopes, etc.

Significant interference during accurate levelling at thermal power plants is created by vibrations from operating turbines, the speed of the rotors of which reaches 2500 rpm. At the same time, the settlements of foundations caused by such vibration on sandy soils are especially significant; on the contrary, on clayey soils, they are small. The conditions described above do not always make it possible to accept the exact levelling method prescribed by the instruction [1-7] for the production of state levelling. In particular, it is usually impossible to maintain the length of the levelling arm of 50 m and transfer heights using two pairs of crutches and the conditions of the construction site.

The specificity of measuring the draft also lies in the fact that it is necessary to determine the vertical displacement of the points of the structure, which is located no further than 25 m from one another with an accuracy of tenths of a millimetre. That is why levelling with short shoulders is used to determine the size of the sediment. This circumstance, it would seem, should lead to an increase in the root mean square error and exceedances by 1 km of travel, but this does not happen, since when levelling with short beams, the influence of errors from external conditions (refraction, convection, etc.) is weakened.

Successful measurement of sediment levelling by short peeling depends on many conditions determined by the adopted organization and method of work. The most important of these conditions are set out below. The heights of the reference marks for measuring the draft with short beams should be practically unchanged during the entire observation period. For particularly accurate measurements, the altitude base should consist of at least three deep silt of fundamental benchmarks. State levelling signs are included in the local network only in those cases when their location relative to the object of observation turns out to be advantageous. In this case, one of these signs serves to transmit the height only in the first cycle of observations. In subsequent cycles, only deep or fundamental benchmarks installed in the construction area serve as reference signs. For carrying out mass measurements for industrial purposes, the vertical base can consist of ground benchmarks, laid before the start of excavation in groups, of three to four signs on both sides of the structure.

The marks are set at the same level as possible so that the readings on the staff are close to each other, which reduce the influence of errors in the divisions of the staff [8-12]. The lengths of the short sighting beams should be in the range from 3 to 25 m with an average length of 10 to 15 m. Levelling is carried out by the method of aligning the bisector of the grid of threads with the image of the nearest bar of the staff scale. For this, well-adjusted blind levels with a plane-parallel plate and dashed invar comparative bars are used. The basic condition of the level and the circular level at the racks are checked daily. The results of the verification are recorded in the field journals. Levelling is done strictly from the middle. Compliance with this condition causes an increase in the number of stations in the passages, which in turn reduces the accuracy in the transmission of heights. Therefore, to reduce the number of stations in the moves, it is allowed to level individual intermediate marks by the one-sided sighting.

In fig. 1 shows an approximate scheme for levelling marks, the first scheme (Fig. 1, a) has the advantage that all 10 sedimentary marks are included in a closed passage with 10 stations. Thanks to this, the calculations of the heights of all marks are controlled. However, the expected discrepancy of the traverse can be several times greater than for the traverse (Fig. 1, b) shown in the second diagram (five stations in a closed course and five separate stations). Levelling marks is performed with closed or double strokes with two tool horizons. During subsequent levelling, the tool is, if possible, positioned in the same places as during the previous levelling. At the same time, they try to keep the same directions of the passages and the number of stations in them. Levelling, as a rule, is carried out with only one staff. In the case of using two rails (with an even number of stations in moves), to eliminate errors for the difference of zeros at the second horizon, the racks are rearranged.

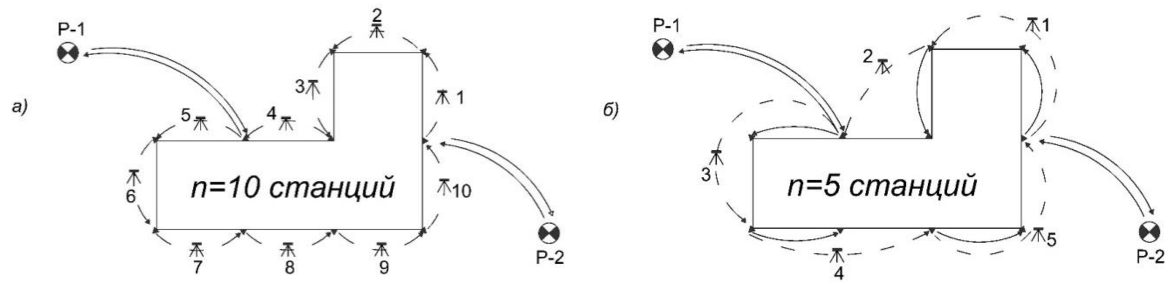

Fig. 1. Approximate scheme for levelling sedimentary marks

Under unfavourable environmental conditions (poor base under the tripod legs, one-sided heating of the instrument, etc.) during levelling, it is necessary to shorten the observation period as much as possible. In long hanging moves (from three or more stations), levelling is performed in forwarding and backward directions with two tool horizons. In this case, the limiting difference between the excess obtained from the forward and reverse moves should not exceed, where n is the number of stations in the course. The settlements of structures are measured periodically, in cycles. The frequency of measurements depends on the intensity of the pressure increase on the base and the rate of sediment development and should be such that the measured values correctly reflect the course of this process [9-11]. The main observation cycles are timed to coincide with a certain time of the year, for example, in autumn, due to which similarity is achieved in the external conditions of observations.

Simultaneously with conducting separate measurement cycles, information about the growth of the actual pressure on the foundation soils is measured. All sedimentary marks, as well as the original elevation marks, must be kept in full working order and in cases of destruction or building up, immediately restored. The newly established mark is assigned a tuning number with the addition of the letter "H" (new). The new grade is considered to have the same draft as the old one, with the addition of the amount of draft increment that occurred between the last change cycle and the date the new grade was installed. The estimated increment in the draft can be obtained by approximate calculation based on the increment in the draft of any nearest (recovered) grade or by extrapolation based on the rate of draft of the old grade in the period preceding its destruction. After each levelling of all marks, the foundations and walls of the building are examined to identify cracks. An entry with a sketch is made in the

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journal about the detected cracks. The balancing of the levelling moves is carried out in any strict way after each measurement cycle. If the levelling network consists of two or three small polygons (8-10 stations in each) and the resulting residuals do not go beyond 1 mm, then the balancing is performed by comparing the residuals. When assessing the levelling accuracy, the mean square error of the most distant mark is calculated. It is assumed that the stability of the vertical base is not in doubt and is reliably controlled by the constancy of the excess between them in each separate measurement cycle. If the stability of the high-rise base cannot be verified during fieldwork, then after any subsequent measurement, it is possible to jointly balance the levelling results of each repeated and initial observation cycle. Measurement of vertical displacements on special soils (subsidence and swelling). In this case, systematic observations of the foundations of structures are aimed at:

a) Determination of the actual amount of settlement and its increase over time, both during the construction and operational periods;

b) Timely identification of the moment of occurrence of subsidence of loess, bulk and permafrost soils, as well as elevations of foundations on swelling clays;

c) Establishment of the centre for the development of soil subsidence in the absence of external load, i.e., in a stressed state from the own weight of the soil in the zone of probable sources of soaking;

d) Determination of the absolute value of deformations and their development over time in the bearing structures of buildings (cracks, rolls, deflections, etc.).

The features of systematic instrumental measurements of vertical displacements on subsiding soils include the consistent use of two classes of levelling. Levelling of the II class is used to determine the absolute value of the settlement or rise of the foundation (until they are completely stabilized within 1-2 mm / year) and to establish the beginning of the settlement; levelling of the III class is used to determine the full value of the subsidence and to establish the nature of its development in time until the onset of conditional stabilization (<5 mm/month). In construction areas, where subsiding loess soils occur, it is necessary to avoid laying the initial benchmarks at a shallow depth. In such cases, the lower support part of the benchmark is laid in the top of the underlying loess layer to a depth of 1 m in sandy-pebble deposits and 2 m in dense clays. With a significant thickness of the layer of subsiding soils, it is allowed to lay the lower end of the benchmark to a depth of 3-5 m. At the same time, the benchmark should be located at a distance greater than double the thickness of the subsiding soil layer from the routes of the water supply, sewage or other structures carrying water. In areas of permafrost soils, benchmarks are installed near the structure, 1-2 m below the design depth of the bottom of the thawing bowl and at least threefold thickness of the seasonal thawing layer if the benchmarks are installed away from the structures. In areas with swelling soils, benchmarks should cut through their entire thickness and be laid in the underlying layer. With a significant thickness of the swelling layer, the depth of the benchmark should be related to the mark where the

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natural pressure of the soil exceeds the pressure from swelling (practically about 3 kg/cm2). When installing protective wells at benchmarks, the sinuses of the pits are covered with local soil with dense layer-by-layer compaction. To avoid stagnation of water near the covers of the benchmarks, the upper part of the wells is raised 0.5 m above the planning mark, and circular blind areas with a slope of 1: 5 made of asphalt, concrete, brick or compacted soil sown with grass are arranged around. The invariability of the altitude position of the newly installed benchmarks in each measurement cycle is checked by mutual excesses between them or by excesses from city benchmarks. The criterion for immobility K is the limiting value expressed by the formula:

$$K \leq \pm 2 m_{cm} \sqrt{2n} \quad mm,$$

Where $m_{ст}$ – mean square error of elevation at one station (where class I ± 0.13 mm, for class II ± 0.43 mm); n is the number of levelling stations in the course linking the compared benchmarks.

The root-mean-square error of the excess at one station for levelling class I was obtained based on direct determination by TsNIIGAiK [11], and for class II it was obtained by the author by calculation based on the maximum permissible levelling error per 1 km of travel. According to the limiting error of 1 km of travel for class II is equal to Δkm = ± 6 mm. Then the mean square error of the excess at 1 station will be determined by the formula

$$m_{прев} = \pm \frac{\Delta_{км}}{\sqrt{n} \cdot \sqrt{2} \cdot 2} \approx \pm \frac{6}{\sqrt{25} \cdot \sqrt{2} \cdot 2} \approx \pm 0{,}43 \quad мм$$

where n is the average number of stations per 1 km of travel ≈25;

$\sqrt{2}$ – coefficient taking into account the determination of the excess at two horizons;

2 - coefficient of transition from the limiting to the root mean square error. Due to the significant unevenness of subsidence, sedimentary marks on the foundations or plinths of buildings are placed on supporting structures at least 5-6 m later. To establish the centre of development of soil subsidence from its weight in the zone of probable sources of soaking, temporary surface marks are installed. These grades are pieces of reinforcement with a diameter of 15 - 20 mm, a length of 50 - 70 cm, driven into pits 5 - 10 cm below the ground surface and protected from damage by wooden boxes with hinged lids. Surface marks are placed every 3 - 5 m along the diameters, divided perpendicular to the facades of the building and spaced from each other at a distance of 5 - 10 m. The height position of the marks is determined by levelling the III class. After processing the numerical results of levelling, lines of equal subsidence are applied to the plan with stamps, after 5-10 cm in height. Such a plan gives a visual representation of the location of the centre of subsidence, the size and depth of the subsidence funnel.

CONCLUSION

Simultaneously with the measurement of the settlement and subsidence of buildings, the dates of the appearance of cracks in the soil are recorded, the distances between them are measured, and the values of the differences in their edges in height are determined on the characteristic cracks. Along with this, they also observe the rolls, cracks and deflections of buildings. The frequency of observations (in emergency cases) is prescribed, taking into account the rate of subsidence, from twice a day to once every 10 days. With a decrease in the subsidence rate to 0.5 mm/day, the measurement periods are lengthened to 15 - 30 days.

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