МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ

НАЦІОНАЛЬНА АКАДЕМІЯ НАУК УКРАЇНИ

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COMPARISON OF DIFFERENT METHODS FOR DETERMINING THE RANDOM ERROR OF OBSERVATIONS AT A HIGH-PRECISION LEVELING STATION

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Introduction. Research purpose. At the geodynamic training ground (GTG) the methods of observing the dynamics of the land motions may differ from traditional ones. The accuracy of measured parameters is always no less important than their magnitude. The use of mathematical statistics methods to calculate the accuracy allows not only to establish the degree of reliability of the results, but also to obtain the probable values of the biased estimates of the measured distribution characteristics, the available systematic errors of measurements, and to establish the correspondence of empirical data to the normal distribution law. The purpose of the research is to choose the optimal method for determining the accuracy of re-leveling results on GTG.

Methods and results of research. At the GPG in Poltava [1] during 2001-2024, observations were made of two groups of benchmarks from one leveling station. Each of the elevations between the benchmarks of the first group was determined only once in each observation cycle. To obtain the root mean square error (RMSE) of one elevation we used a series of temporal relative changes in the elevations of the deepest benchmarks A1 and A4. The depth of these benchmarks is 6 m, so their seasonal vertical fluctuations are absent. Therefore, we a priori assumed that the temporal fluctuations of elevations between benchmarks A1 and A4 are random and are caused exclusively by measurement errors at the leveling station. In Figure 1 shows a histogram of the distribution of elevations A1 – A4 (series length 1086 values) after removing linear and polynomial trends and a normal distribution curve that corresponds to our experimental data.

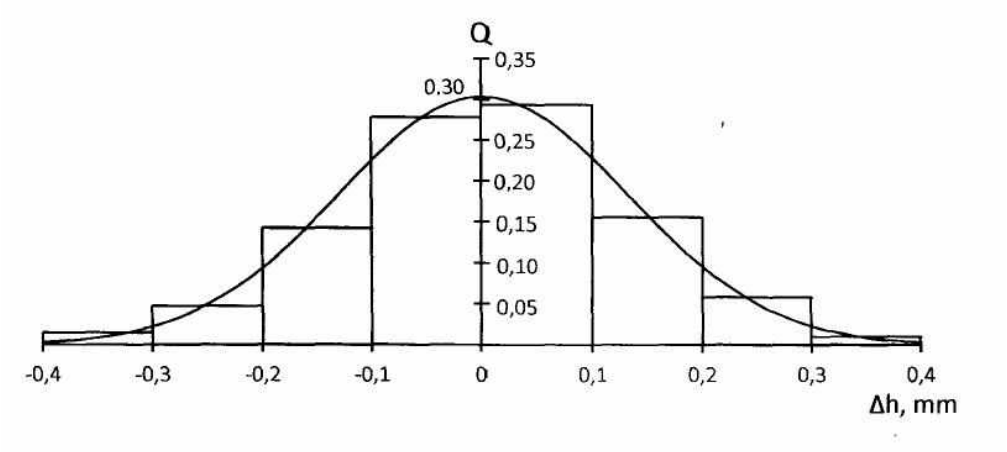

Fig. 1. Histogram of the distribution of elevations A1-A4 and the normal distribution curve

According to the Pearson's test (χ^2) [2] with the adopted significance level $q=0.05$ the empirical distribution corresponds to normal. This indicates a high quality of observations due to the predominant effect of random errors on the measurement results. The RMSE of one elevation was equal to 0.131 mm.

The methodology and conditions of observations of the second group of benchmarks were identical to the first. The only difference was that in each observation cycle the height position of the benchmarks relative to the original A1 was determined not once, but twice. This allowed us to calculate the accuracy of observations based on double measurements. Figure 2 shows a histogram of the distribution of elevation differences between the original and studied benchmarks and a normal distribution curve (the total number of values is 69).

According to the Pearson's test (χ^2) (significance level $q=0.05$) the empirical distribution corresponds to the normal one with very high reliability. The RMSE of one elevation is 0.069 mm, which is two times less than in the previous case. The systematic error at the leveling station is 0.014 mm, which is an insignificant value.

The theoretically calculated random error of one elevation, taking into account all sources of errors at the high-precision leveling station [3] and the features of our observation method is 0.061 mm. This value practically coincides with the RMSE obtained when using the differences in elevations of the second group of benchmarks.

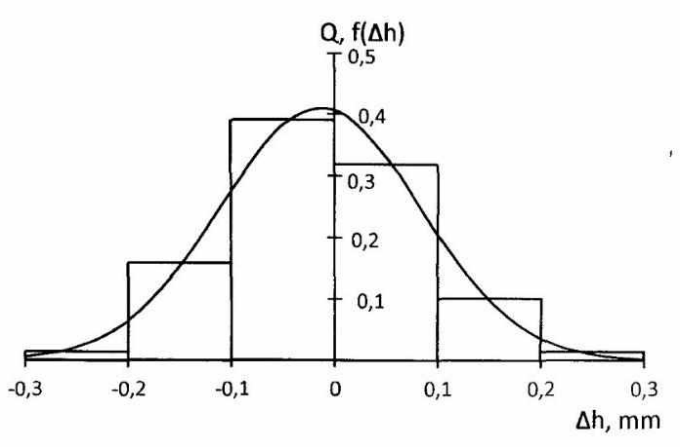

Fig. 2. Histogram of the distribution of the differences in elevations between the initial A1 and the studied benchmarks and the normal distribution curve

Conclusions. 1. The significant random error obtained from the observations of the elevations of benchmarks A1 – A4 indicates that even at a depth of 6 m from the surface unpredictable fluctuations of a random nature occur. This causes a significant underestimation of the RMSE at the leveling station.

2. Determining the error of one elevation based on the differences of double measurements is more objective. This method excludes possible vertical movements of benchmarks of any origin and its accuracy depends exclusively on the technical capabilities of the measuring instruments and the errors of the observer.

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