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Evaluation of the Accuracy of Measurements of Lines and Angles in Construction of Planning Networks

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Annotation: This article describes the construction of a planning network, the accuracy of geodetic measurements during design, planning and installation work, the calculation of the accuracy of geodetic measurements performed at the facility or during construction, the sources, magnitudes and characteristics of errors that may occur in linear and angular measurements.

Keywords: Measurement errors, Meter tilt error, RMS line length error.

Main part

The construction of the planning network serves as the starting point for the regulations for the installation of prefabricated structures in determining the accuracy of geodetic measurements when performing design-planning and installation axes, installation work. The accuracy of geodetic measurements performed on site or during construction should be taken into account in advance. Therefore, it is important to know the sources, magnitudes and properties of errors that can occur when measuring lines and angles in structures.

Measurement errors or laying lines on the ground. It shows the effect of various errors on distance measurement accuracy, one of which is random and the other systematic

When measuring the distance S with a length meter l, if you put it on the ground n times, then random errors will accumulate in proportion to $\sqrt{n}$.

In accordance with the theory of measurement errors, the root-mean-square errors of the measurement results, random root-mean-square ($m_{сул}$) and systematic (mc) errors are determined by the following formulas

$$m_s^2 = m_{сул}^2 n + m_c^2 n^2 \qquad (1)$$

or

$$m_{тас} = \mu\sqrt{l}, \quad m_c = \lambda l \quad \text{and} \quad n = \frac{s}{l}, \qquad (2)$$

Given that this

$$m_s^2 = \mu^2 S + \lambda^2 S^2,$$

Where μ is the coefficient of random influence, determined experimentally depending on the type of this measuring instrument; λ is the systematic impact factor.

At the construction site, lines of different lengths are measured: the results obtained are checked by placing the measuring device on the ground several times, often once, in this case between predetermined (given) points on the ground or by re-measuring according to a modified program.

If a line is repeatedly measured several times with the same accuracy, the result is taken as the arithmetic mean of the obtained results as the final result.

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The root mean square error of the sum of rows measured by n lines is as follows

$m_{\Sigma} = m_{S'}\sqrt{n},$ (3)

$m_{s'} = \frac{m_{\Sigma}}{\sqrt{n}}$ ($m_{s'}$ − standard error of one measurement).

In turn, the root-mean-square error of the arithmetic mean in the measurement results is determined by the following formula

$M = \frac{m_{s'}}{\sqrt{n}} = \frac{m_{\Sigma}}{n}.$

$M^2 = \frac{m^2_{\text{Гас}}}{n} + m_c^2.$ (4)

It follows from this formula that with an increase in the number of transverse measurements, the rms error decreases by a factor of $\sqrt{n}$, while the systematic rms error of a given series of equally accurate measurements remains constant.

Consider the errors that significantly affect the measurement.

Compression error of the measuring device. If we take the calculation by adjusting the bar with a magnifying glass, assuming a standard error of 0.05 mm, and compare it twice with a measuring device with a Geneva ruler, the standard error of the seal will be as follows.

$m_1 = 0{,}05\sqrt{l}$ мм, (5)

where *l* is the length of the measuring device, m.

When compressing a 20-meter steel tape measure m_1 = ± 0.25mm.

The error of deviation of the measuring device from the axis of the measured line. The deviation of the ends of the meter, if it is greater than the specified e, causes the following line length error

$m_2 \approx \frac{2\varepsilon^2}{l}.$ (6)

At *l* = 20 m and ε = 30 mm, m2 is equal to 0.09 mm.

Error due to the tilt of the switchgear. Given the error in determining the relative height of the ends of the measuring device, the error in measuring the length of the line in the field can be determined by the following formula

$m_3 = \frac{h}{l} m_h.$ (7)

where mh – *l* is the average quadratic error of determining the last part of the relative height h of the cutting ends of length *l*. At h≤0.03*l* and mh=±5 mm, m3=±0.15 mm.

The error of weighing (tension) of the measuring device. If the line is drawn with a length meter *l* with a force F (kg), we take into account the standard error mF, then the error of the line length will be as follows: if the meter is suspended,

$m_4 = \left(\frac{\mathrm{p}^2}{12F^2} + \frac{1}{\omega E}\right) l m_F,$ (8)

If the measurement is carried out in a plane,

$m_4' = \frac{l}{\omega E} m_F,$ (9)

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Where p is the mass of the measuring instrument (kg), ω is the cross-sectional area of the measuring instrument, mm^2 E is the modulus of elasticity, 2 x 10^4 for steel and 1.6 x 10^4 for invar wire.

With a cross-sectional area of 10x0.15 mm (ω-1.5 mm^2) p =0.23 kg, the average quadratic error of gravity with a 20-meter steel tape measure

m_F = 0,5 кг, then (3.2.7) and (3.2.7') determined by the formulas m_4 = 0,52 мм and m_4 = 0,33 мм, if m_F = 3 кг, m_4 = 2,2 мм and m_4 = 2,0 мм accordingly.

A dynamometer will be required to provide tension with an accuracy of 0.5 kg.

Wind influence error when measuring the line with a tape measure in the open position. The impact of the wind plane ϑ (m/sec) a hanging tape measure with a length of l (m) and a width of a (mm) causes overload and increases the thrust of the boom from constant voltage.

If, when measuring with a roulette wheel, an oscillation of the arrow f is detected between the marked points, then the following formula determines the correction to the number obtained on the roulette wheel

$$m_5 = \frac{8}{3} \cdot \frac{f^2}{l}. \qquad (3.2.8)$$

The tax arrow between the roulette wheel is determined by the following formula

$$f = \frac{ql^2}{8H}, \qquad (3.2.9)$$

Where the value of q is determined by the formula $(3')$

Replace the value of f in formula (3.2.8) by formula (3.2.9) and get the following

$$m_5 = 0{,}65 \cdot 10^{-3}\, H^{-2}\delta^2 l^3 v^4 мм$$

Or (3.2.10)

$$m_5 = 0{,}65 \cdot H^{-2}\delta^2 l^3 v^4 мм$$

If $v = 3{,}5$ м/h, $l = 20$м, $\delta = a = 6$мм, $H = 10$ кг

$$m_5 = 0{,}65 \cdot 10^{-2}\,(6 \cdot 10^{-3})^2\,(2 \cdot 10)^3\,(3{,}5)^4 = 0{,}28 мм.$$

The measuring device will affect the measurement error of the temperature difference. The root - mean - square error of the string length is determined by the following formula

$$m_6 = \alpha l m_t\ , \qquad (3.2.11)$$

where α is the coefficient of linear expansion of steel, equal to 12 · 10^{-6} 6); l is the length of the measuring device in meters; mt is the average quadratic error of the measuring instrument taking into account temperature, if l = *20 м,*, $m_t = \pm 1^0$ $m_6 = \pm 0{,}24$ мм.

The resulting error under the influence of errors in fixing and counting the ends (ends) of the measuring instrument is calculated using the following formula.

$$m_7 = \sqrt{m_{окр}^2 + m_{ф}^2}, \qquad (3.2.12)$$

Where $m_{окр} = \frac{\alpha}{\sqrt{3}}$ is the standard error of rounding when counting or measuring, mf is the standard error of fixing the measured end of the section.

If you accept $\alpha = \pm 0{,}2$мм, $m_ф = \pm 0{,}3$мм, $m_7 = \pm 0{,}32$ from the considered The errors m1, m2, m5 are systematic, and m3, m4, m6, m7 are errors with random effects.

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Depending on the solution of the problem, differentiated requirements may be imposed on the accuracy of calculating the causes of the error. By increasing the requirement to determine one of the measurement errors, it is possible to reduce the requirements for others, or the influence of errors in general can be reduced to imperceptible measurements.

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