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INCLUSION OF THE LOCAL GEODETIC NETWORK IN THE NATIONAL GEODETIC NETWORK

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Abstract: *The geodetic points that form the national geodetic network cover large areas, and the accuracy of their determination is a function of the distances between them. In mining areas, a local geodetic network superior in precision to the national geodetic network is required. However, it is necessary to include the geodetic points that form the local network in the national geodetic network. The present work represents the methodology for solving the mentioned purpose.*
Keywords: *geodesy, geodetic network, triangulation*

1. Introduction

In an area that represents a mining basin with underground or surface mining works, a local triangulation network is made in the form of a polygon with a central point (fig. 1) [1].

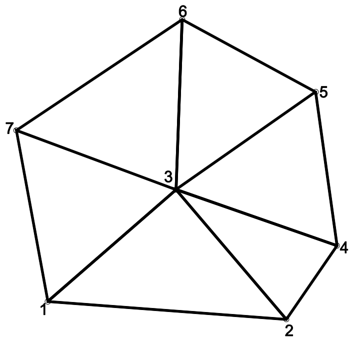

Figure 1. Local triangulation network

In the considered network, points 1 and 2 are part of the national triangulation network. The coordinates of points 3, 4, ..., 7 are determined in the local triangulation network (also called rigid) with superior precision compared to those in the national network. There will be differences that require compensation operations to introduce the local triangulation network into the network of national triangulation [2].

2. Content

Consider points 1, 2, 3 in figure 1 with invariable elements: the length and orientation of the side $\overline{12}$ (usually the longest).

Each point has three lines of coordinates [3]:
x', y' geodetic coordinates (fig. 2a)
x'', y'' local coordinates (fig. 2b)
x''', y''' integrated coordinates (fig. 2c)

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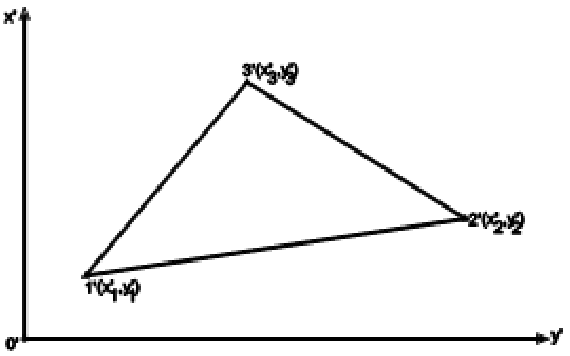
Figure 2a. Geodetic coordinates

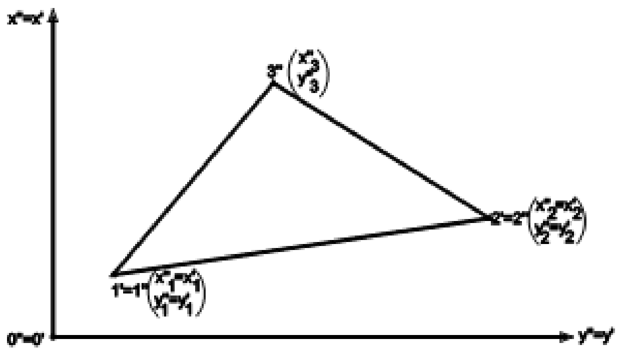
Figure 2b. Local coordinates

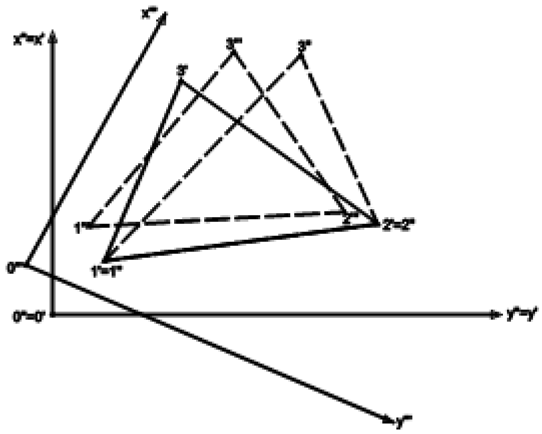
Figure 2c. Integrated coordinates

As a result, only the coordinates of point 3 undergo changes, points 1 and 2 remain unchanged, fig. 2b, so the reference systems $0', x', y'$ și $0'', x'', y''$ they do not differ from each other.

System $0''', x''', y'''$ differs from both systems in origin, orientation and unit of measurement of lengths, as a consequence of rigorous coordinate fitting (compensation)x'', y'' in the geodetic system $0', x', y'$ less rigorous. When fitting the coordinatesx'', y'' will receive the corrections:

$$\begin{aligned} \delta x_1 &= x_1''' - x_1'' = x_1''' - x_1' \\ \delta x_2 &= x_2''' - x_2'' = x_2''' - x_2' \\ \delta x_3 &= x_3''' - x_3''; \; x_3''' \neq x_3' \end{aligned} \tag{1}$$

and

$$\begin{aligned} \delta y_1 &= y_1''' - y_1'' = y_1''' - y_1' \\ \delta y_2 &= y_2''' - y_2'' = y_2''' - y_2' \\ \delta y_3 &= y_3''' - y_3''; \; y_3''' \neq y_3' \end{aligned} \tag{2}$$

According to the principle of least squares

$$\left[(\delta x_i^2 + \delta y_i^2)\right] = minimum \tag{3}$$

Corrections δx_2, δx_3, δy_2, δy_3 are calculated according to the translation$\delta x_1 \delta y_1$, rotation $\delta\theta$ and linear strain *(1+n)* between systems $0', x', y'$ și $0''', x''', y'''$ starting from the point 1.

The offset coordinates will be [4, 5]:

$$\begin{aligned} x_1''' &= x_1'' + \delta x_1 = x_1' + \delta x_1 \\ x_2''' &= x_2'' + \delta x_2 = x_2' + \delta x_2 \\ x_3''' &= x_3'' + \delta x_3 = x_3' + (x_3'' - x_3') + \delta x_3 \end{aligned} \tag{4}$$

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$$
\begin{gathered}
y_1''' = y_1'' + \delta y_1 = y_1' + \delta y_1 \\
y_2''' = y_2'' + \delta y_2 = y_2' + \delta y_2 \\
y_3''' = y_3'' + \delta y_3 = y_3' + (y_3'' - y_3') + \delta y_3
\end{gathered} \tag{5}
$$

On the other hand it can be written:

$$
\begin{gathered}
x_2''' = x_1''' + (1+\mu)\overline{12}\cos(\theta_{12} + \delta\theta) = x_1''' + (1+\mu)\overline{12}\,(\cos\theta_{12} cos\delta\theta - sin\theta_{12}\delta\theta) = \\
= x_1''' + (1+\mu)\overline{(12}\cos\theta_{12} - sin\theta_{12}\delta\theta)
\end{gathered}
$$

or:

$$x_2''' = x_1''' + \overline{12}\cos\theta_{12} + \mu\overline{12}cos\theta_{12} - \overline{12}sin\theta_{12}\delta\theta$$

$\mu sin\theta_{12}\delta\theta \approx 0$ (is neglected)

and:

$$x_2''' = x_1''' + (1+\mu)\Delta x_{12} - \Delta y_{12}\delta\theta \tag{6}$$

or:

$$x_2''' = x_1' + \delta x_1 + \Delta x_{12} f - \Delta y_{12}\,\delta\theta; \quad f = 1 + \mu \tag{7}$$

and:

$$
\begin{gathered}
x_2''' = x_2' + \delta x_1 + \Delta x_{12} f - \Delta y_{12}\,\delta\theta \\
x_3''' = x_3' + \delta x_1 + \Delta x_{12} f - \Delta y_{12}\,\delta\theta + (x_3'' - x_3')
\end{gathered} \tag{8}
$$

Analogous:

$$
\begin{gathered}
y_2''' = y_1' + \delta y_1 + \Delta y_{12} f + \Delta x_{12}\,\delta\theta \\
y_2''' = y_2' + \delta y_1 + \Delta y_{12} f + \Delta x_{12}\,\delta\theta \\
y_3''' = y_3' + \delta y_1 + \Delta y_{12} f + \Delta x_{12}\,\delta\theta + (y_3'' - y_3')
\end{gathered} \tag{9}
$$

The obtained system of error equations (7)+(8)+(9) corresponds to the conditional measurements.
To solve it, we proceed by reduction to indirect measurements and the system results:

$$
\begin{gathered}
\delta x_1 = \delta x_1 \\
\delta x_2 = \delta x_1 - \Delta y_{12}\,\delta\theta + \Delta x_{12} f \\
\delta x_3 = \delta x_1 - \Delta y_{13}\,\delta\theta + \Delta x_{13} f + (x_3'' - x_3') \\
\delta y_1 = \delta y_1 \\
\delta y_2 = \delta y_1 + \Delta x_{12}\,\delta\theta + \Delta y_{12} f \\
\delta y_3 = \delta y_1 + \Delta x_{13}\,\delta\theta + \Delta y_{13} f + (y_3'' - y_3')
\end{gathered} \tag{10}
$$

Denote by a, b, c, d, l, the coefficients of the corrections and the free terms.
The general form of system (10) is:

$$
\begin{gathered}
a_i\delta x_1 + b_i\delta y_1 + c_i\delta\theta + d_i f + l = v_i \\
i=1, 2, \ldots, 6
\end{gathered} \tag{11}
$$

It is observed that the free terms only have the corrections δx_3 *and* δy_3
The unknowns $\delta x_1, \delta y_1, \delta\theta, f$, are obtained from the following system of normal equations:

$$
\begin{aligned}
[aa]\delta x_1 + [ab]\delta y_1 + [ac]\delta\theta + [ad]f + [al] &= 0 \\
[bb]\delta y_1 + [bc]\delta\theta + [bd]f + [bl] &= 0 \\
[cc]\delta\theta + [cd]f + [cl] &= 0 \\
[dd]f + [dl] &= 0
\end{aligned}
$$

With the values $\delta x_1, \delta y_1, \delta\theta, f$, obtained from system (12) the corrections are obtained $\delta x_2, \delta y_2$ and $\delta x_3, \delta y_3$, using the relations (10).
The offset coordinates are obtained with relations (4) and (5).

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3. Conclusions

The precision of the framed grid is inferior to the local (rigid) grid but superior to the geodesic grid. After framing the compensated mesh whose coordinates are x''', y''' it cannot differ from the geodetic grid, except within the limit 1:100.000.

Otherwise, the observations are redone and the calculation of the geodetic grid is checked.

It should be emphasized that through the presented method a portion of the geodetic network with improved local precision is obtained, increasing the number of usable points for filling, in order to ensure a homogeneous and rigorous reference system imposed on the activity of underground mining topography.

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