

ANALYSIS OF ORIENTATION ACCURACIES IN UNDERGROUND POLYGONAL ROUTES

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Abstract: Topography has an important role in the realization of underground mining works, hydro-technical constructions, roads, etc. Appropriate topographic measurements and processing are required to trace these objectives in the necessary safety and efficiency conditions. An appropriate topographic basis must first be established for which scientific analyzes focusing mainly on topographical guidance elements are required. It is considered an independent polygonal route, easy to achieve and with superior quality effects.

Keywords: topography, accuracy, underground routes, polygon

1. The importance and purpose of the paper

The topographical base of support has an important role for tracing underground works.

The topographic base may be dependent (linked to the surface geodetic network), but may be independent (free from orientation).

This eliminates errors in the transmission of surface orientation underground and increases the accuracy of underground directions.

Therefore, the propagation of orientation errors in a polygonal path (with two fixed points) is analyzed below.

2. The content of the paper

End points A, B (fig. 1) of the underground polygon are transmitted from the surface.

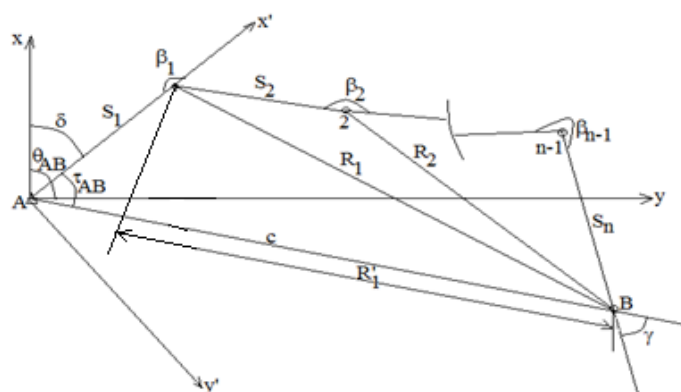


Fig. 1

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Without taking into account the design errors (they have a negligible influence on the orientation of the sides of the polygon), the analysis to be performed takes into account the influence of the measurement errors of the angles and sides of the polygon.

The quadratic error of the orientation of the sides in an underground polygonation as a function of the angle measurement errors is expressed by the relation [1], [2]:

$$m_{\theta_{\beta}}^2 = \sum_{i=1}^{n-1} \left(\frac{\partial \theta}{\partial \beta_i} \right) m_{\beta_i}^2 \quad (1)$$

but:

$$\theta = \theta_{AB} - \tau_{AB} + \tau \quad (2)$$

where:

θ_{AB} - orientation of the AB direction in the general reference system;

τ_{AB} - orientation of the direction AB in the particular reference system;

τ - side orientation in the particular system.

but how:

$$\frac{\partial \theta_{AB}}{\partial \beta} = 0$$

it results:

$$\frac{\partial \theta}{\partial \beta} = \frac{\partial \tau}{\partial \beta} - \frac{\partial \tau_{AB}}{\partial \beta} \quad (3)$$

on the other hand:

$$\operatorname{tg} \tau_{AB} = \frac{y'_B}{x'_B}$$

and:

$$\frac{d\tau_{AB}}{\cos^2 \tau_{AB}} = \frac{x'_B dy'_B - y'_B dx'_B}{x'^2_B}, \quad x'_B = c \cos \tau_{AB}$$

$$y'_B = c \sin \tau_{AB}$$

or:

$$\frac{d\tau_{AB}}{\cos^2 \tau_{AB}} = \frac{c \cos \tau_{AB} dy'_B - c \sin \tau_{AB} dx'_B}{c^2 \cos^2 \tau_{AB}}$$

where from:

$$c \tau_{AB} = \cos \tau_{AB} dy'_B - \sin \tau_{AB} dx'_B$$

or:

$$c \frac{\partial \tau_{AB}}{\partial \beta} = \frac{\partial y'_B}{\partial \beta} \cos \tau_{AB} - \frac{\partial x'_B}{\partial \beta} \sin \tau_{AB} \quad (4)$$

From the figure 1, it is observed that:

$$\frac{\partial x'_B}{\partial \beta} = -R \sin \gamma; \quad \frac{\partial y'_B}{\partial \beta} = R \cos \gamma \quad (5)$$

With these we can write:

$$\frac{c \partial \tau_{AB}}{\partial \beta} = R \cos(\tau_{AB} - \gamma) \quad (6)$$

$R \cos(\tau_{AB} - \gamma)$ is the projection of the radius R on the line AB and is denoted by R' [3].

Accordingly:

$$\frac{\partial \tau_{AB}}{\partial \beta} = \frac{R'}{c} \quad (7)$$

And relation (3) is:

$$\frac{\partial \theta}{\partial \beta} = \frac{\partial \tau}{\partial \beta} - \frac{R'}{c} \quad (8)$$

Using the equality (8) the errors of the orientation of the sides can be established in this way [4]:

First side orientation error

In this case

$$\tau_1 = 0;$$

and as a consequence:

$$\frac{\partial \tau_1}{\partial \beta_i} = 0; \quad i = 1, 2, \dots, n-1$$

It results from (8):

$$\frac{\partial \theta_1}{\partial \beta_i} = -\frac{R_i}{c} \quad (9)$$

With the sizes in (9), the equality (1) becomes:

$$m_{\theta_1 \beta}^2 = k \sum R_i^2 \quad (10)$$

It was noted:

$$k = \left(\frac{m_\beta}{c} \right)^2$$

Second side orientation error

In this case [5]:

$$\tau_2 = \tau_1 + \beta_1 \pm 200^g$$

and as a consequence:

$$\frac{\partial \tau_2}{\partial \beta_1} = 1; \quad \frac{\partial \tau_2}{\partial \beta_i} = 0; \quad i = 2, 3, \dots, n-1$$

It results:

$$\frac{\partial \theta_2}{\partial \beta_1} = 1 - \frac{R'_1}{c}$$

$$\frac{\partial \theta_2}{\partial \beta_i} = -\frac{R'_i}{c}; \quad i = 2, \dots, n-1$$

With these we can write:

$$m_{\theta_2 \beta}^2 = k \sum_{i=1}^{n-1} R_i + kc(c - 2R'_i)$$

or:

$$m_{2\beta}^2 = m_{1\beta}^2 + kc(c - 2R'_i) \quad (11)$$

On long polygonal routes

$$c - 2R'_i < 0$$

and as a consequence:

$$m_{\theta_{2\beta}} < m_{\theta_{1\beta}}$$

Side orientation error i

By generalization one can write:

$$m_{\theta_{i\beta}}^2 = m_{\theta_{1\beta}}^2 + kc \sum_{j=1}^{i-1} (c - 2R'_j) \quad (12)$$

or:

$$m_{\theta_{i\beta}}^2 = m_{\theta_{1\beta}}^2 + kc \left[(i-1)c - 2 \sum_{j=1}^{i-1} R_j \right]$$

The influence of side measurement errors on their orientations shall be determined taking into account the equality of:

$$\theta = \theta_{AB} - \tau_{AB} + \beta$$

and

$$\frac{\partial \theta}{\partial s} = \frac{\partial \tau_{AB}}{\partial s}; \quad \frac{\partial \theta_{AB}}{\partial s} = 0; \quad \frac{\partial \beta}{\partial s} = 0$$

With these we can write:

$$m_{\theta_s}^2 = \sum_{i=1}^n \left(\frac{\partial \theta}{\partial s_i} \right)^2 m_{s_i}^2$$

but:

$$\frac{\partial \theta}{\partial s_i} = - \frac{\sin \varepsilon_i}{c}$$

Accordingly:

$$m_{\theta_s}^2 = \sum_{i=1}^n \left(\frac{\sin \varepsilon_i}{c} \right)^2 m_{s_i}^2 \quad (13)$$

Influence of errors in measuring angles and distances in the calculation of guidelines results from cumulative relationships (12) and (13). You get:

$$m_{\theta_i} = \pm \sqrt{m_{1\beta}^2 + k[(i-1)c - 2 \sum_{j=1}^{i-1} R'_j] + \sum_{i=1}^n \left(\frac{\sin \varepsilon_i}{c} \right)^2 m_{s_1}^2} \quad (14)$$

3. Conclusions

The analysis performed were completed through relationships that were easy to apply in practice. The sizes used can be obtained by geometrically representing the polygonal path.

The orientation of underground works in the process of their technical execution is controllable, precise and safe.

The topographic elements of interest are located in the development points of the topographic base.

References

- [1] **Dima N., Pădure I.**, 1997
Mine surveying (in Romanian), Corvin Publishing, Deva
- [2] **Dima N., e.a.**, 1999
Error theory and least squares method (in Romanian), Universitas Publishing, Petroșani
- [3] **Cucăilă M., Cucăilă S.**, 2021
Evaluation of topographic works necessary for underground mining activities (in Romanian), Universitas Publishing, Petroșani
- [4] **Filip L., Dima N.**, 2014
Special mining surveying (in Romanian), Universitas Publishing, Petroșani
- [5] **Vereș I.**, 2006
Automation of topo-geodetic works (in Romanian), Universitas Publishing, Petroșani



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