TECHNICAL SOLUTIONS IN THE FIELD APPLICATION OF STRUCTURE PROJECTS

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Abstract
Topography is considered an indispensible part of the practical solving of structure projects. It has as a goal, besides the preparation of the topographic plan, the field application of some projects that have been made starting from topographic plan. The polar coordinates method represents the most practical method. It is also the most economical. This method is executed on an open field having the possibility to make surveys from the support points to the construction tracing points.
This method is easy to apply on the field and always, on any survey, we have the obligation to verify the newly traced point. The verification is done from another support point. After the unknown point tracing and the later verifications we have to determine de point position error. If the traced point error does not fall in the accepted tolerance limits a new tracing operation must be done.

1. INTRODUCTION

To solve the problem raised by the tracing of the structure projects topography brings many solutions. In the project field transposition the main problem is to ensure the required precision. By tracing we mean the operation set that has as goal the safe application of the project. The tracing operation entails office and field work. The office work consists of the preparation of the tracing plan with all the tracing elements: the tracing plan, the tracing scheme for every objective, the topographic tracing components and the used net points coordinate inventory. The main elements that are applied on the field are the angle and the distance.

2. TRACING METHODS PRESENTATION

2.1 The field tracing of directions and the tracing precision

In the angle field application we have three precision classes:

- angles traced with low precision

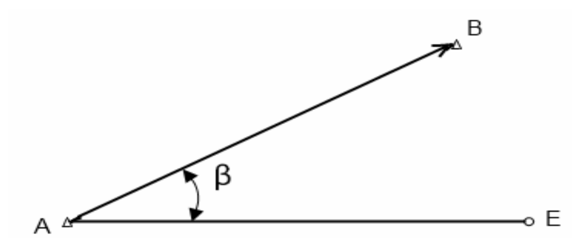

Figure 1

In this case the project angle is applied towards a reference direction with the theodolite's scope in one direction.

- angles traced with medium precision

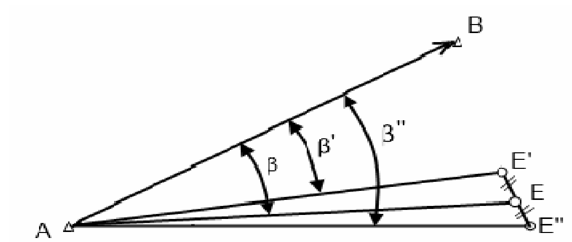

Figure 2

In this case the project angle is applied towards a reference direction with the theodolite's scope in two directions.

- angles traced with high precision

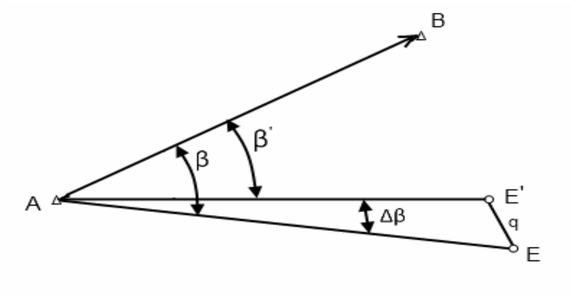

Figure 3

To plot an angle with high precision the angle will be traced in the first position of the scope. The temporary angle is measured using the repetition method thus obtaining a new value for the angle. Calculating the difference between the projected and measured angles we obtain the angle correction. Corresponding to this angular correction we will calculate the point's linear correction.
The tracing mean squared error of a direction on the field is given by the formula:

$$m_{dir} = \pm\sqrt{m_s^2 + m_r^2 + m_i^2 + m_m^2 + m_{ce}^2}$$

where:
m_s^2 – the error in the point station;
m_r^2 – the reduction error;
m_i^2 – the instrument error;
m_m^2 – the measuring error;
m_{ce}^2 – the exterior conditions error.

2.2 The filed tracing of project length and tracing precision

To field trace a project line length towards a fixed point of the line we transpose on the given direction the distance which size is reduced to the horizontal is equal to the project value.
The field tracing of project line lengths is done:

- by direct measurement with ribbons, measuring tapes or with invar strings;
- with precision optical tahimeters;
- by electronic device measurement;
- with electronic tahimeteres.

The calculation of the necessary precision for the projection at length measurement starts with the admitted tolerance of the project distance tracing.

The mean squared error in length case will be composed by systematic errors and random errors:

$$M = \pm\sqrt{m_s^2 + m_{in}^2}$$

where:

m_s^2 – systematic error;
m_s^2 – random error.

2.3 The field tracing of the project levels and tracing precision

The field tracing of the project levels – red levels – is realized by geometric or trigonometric surveying starting with the known surveying level. The middle geometric surveying is the most practical in the project levels' application by the targeting plan levels' calculation towards we trace the rest of the project levels. The middle surveying level is applied to surfaces with a low level of height variation.
To field trace the project levels using trigonometric surveying we calculate the scope's tilt angle towards the horizontal, corresponding to the level difference. The trigonometric surveying is applied to surfaces with a high level of height variation.
The geometric surveying precision is given by the following formula:

$$T = e\sqrt{L}(km)$$

In the case of the geometric surveying we have the following errors:

- $m_{Z_{RN}}$ – initial data error;
- $m_{C_{RN}}$ – instrument read error;
- m_C – instrument's placement error;
- m_f – project point fixation error.

The mean squared error formula for the geometric surveying is:

$$m_Z^2 = m_{Z_{RN}}^2 + m_{C_{RN}}^2 + m_C^2 + m_f^2$$

The mean squared error formula for the trigonometric surveying is:

$$m_{Z_X} = \pm\sqrt{m_{Z_{RN}}^2 + m_{\Delta Z_{RN-X}}^2}$$

where:
$m_{Z_{RN}}$ – the level calculation mean error;
$m_{\Delta Z_{RN-X}}$ – the level difference transmitting mean error.

3. PLAN CONSTRUCTION POINTS TRACING METHODS

The plan construction points tracing methods are:

- the polar coordinates method;
  It is used on the field at the project points tracing when the tracing base is a construction topographic network.
- the rectangular coordinates method;
  This method is practical when on the field we have traced a network of squares or rectangles named topographic construction network and the project points have rectangular coordinates in the traced network.
- the forward intersection method;
  It is used when tracing large constructions on narrow areas. The method is used where the distance measurement form the support point to the traced point is difficult to determine or impossible.
- the triangle method;
  This method is used to raise the points tracing precision by using the previous method (the forward intersection method).
- the backward intersection method;
- the linear intersection method
  This method consists in the field tracing of the characteristic points by intersecting the distances.
- the sighted intersection method

This method is used to trace the construction details during the projection realization.

3.1 The polar coordinates method

It is considered to be the most economically and technically convenient method in the field project point tracing.

The A point from the construction is traced on the field with the help of the theodolite from the station point S1 based on the projected angle β towards the reference direction S1-S2 and the distance b from S1 to A taken from the project.

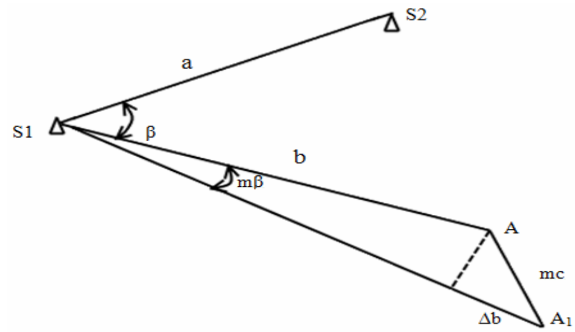

Figure 4

The distance b and angle β are determined during the topographic preparation using the following formulas:

$$\tan\theta_{S_1S_2} = \frac{y_{S_2} - y_{S_1}}{x_{S_2} - x_{S_1}}$$

$$\theta_{S_1S_2} = \operatorname{atan}\left(\frac{y_{S_2} - y_{S_1}}{x_{S_2} - x_{S_1}}\right)$$

$$\tan\theta_{S_1A} = \frac{y_A - y_{S_1}}{x_A - x_{S_1}}$$

$$\theta_{S_1A} = \operatorname{atan}\left(\frac{y_A - y_{S_1}}{x_A - x_{S_1}}\right)$$

$$b = \sqrt{\Delta x_{S_1A}^2 + \Delta y_{S_1A}^2}$$

$$\beta = \theta_{S_1A} - \theta_{S_1S_2}$$

The control of the A traced point is realized either by tracing the point A from another support point using the same method or by tracing the point A using a different method.

The method's precision.

When we trace a point using the polar coordinates method the following errors intervene:

- projection angle tracing error;
- centering and reduction error;
- field length application error;
- traced point field placement error;
- support point field placement error.

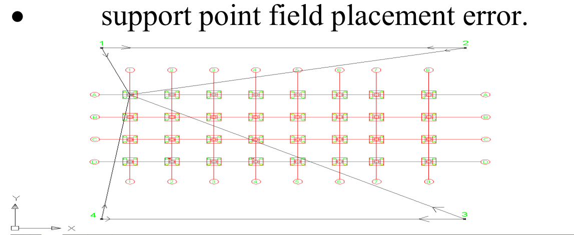

Figure 5

The Figure 2 presents the polar coordinates tracing method. We have 4 support points named compensation points. We will precede at the project point's tracing starting from two points belonging to the support network, position that will be verified using two other support points calculating the errors that appear in the tracing process of the project point. We will pay attention that the traced point error does not exceed the accepted values. If the error exceeds the tolerance value the point will be retraced.

3.2 The tracing precision when tracing a point using the polar coordinates method

The tracing error when using the polar coordinates tracing method the factors that influence the mβ angle error are:

- the measuring error;
- the exterior conditions error
- the instrument error.

$$m_{\beta(mm)} = \frac{m_{\beta}^{cc} . b_{(mm)}}{\rho^{cc}}$$

Other errors that appear when using this method are the **centering and reduction errors**. These two errors cause a shift of the newly traced point but they don't directly influence the applied angle precision. The linear deviation is caused by the fact that the device placement on the support point is incorrect therefore the point that is about to be traced will be moved with the same erroneous value corresponding with the erroneous orientation value. The centering error has a random character.

The mean squared value of this error will be:

$$m_{e}^{2} = \frac{e^{2}}{2\pi}\int_{0}^{2\pi}\left[1+\left(\frac{h}{a}\right)^{2} sin^{2}\alpha + 2\frac{h}{a}\sin(\beta-\theta)\, sin\alpha\right] d\alpha$$

Solving this integral we finally obtain:

$$m_{e}^{2} = e^{2}\left[1+\frac{1}{2}\left(\frac{b}{a}\right) - \frac{b}{a}cos\beta\right]$$

The above relation shows us that the centering error influence on the newly traced point dependents on the tracing angle size.

Another error that appears when using this method is the **reduction error**. In this case also the traced point will be moved because of the support point's incorrect observation.

Following the same reasoning as with the centering error we have:

$$m_{r}^{2} = \frac{(e')^{2}}{2\pi}\int_{0}^{2\pi}\left[\left(\frac{b}{a}\right)^{2} sin^{2}\alpha'\right] d\alpha'$$

After the integration we have:

$$m_{r} = \frac{e^{2}}{\sqrt{2}}\cdot\frac{b}{a}$$

When using the polar coordinates method an error that appears is the **distance field tracing error**:

$$m_{b} = \frac{b}{T_{med}}$$

The **field trace point tag error** depends on the observation projection process.

The main error that has an influence on traced point precision is the geodesic points placement error.

3.3 Conclusions and proposals

The polar coordinates method represents the most practical method. It is also the most economical. This method is executed on an open field having the possibility to make surveys from the support points to the construction tracing points.

This method is easy to apply on the field and always, on any survey, we have the obligation to verify the newly traced point. The verification is done from another support point. After the unknown point tracing and the later verifications we have to determine de point position error. If the traced point error does not fall in the accepted tolerance limits a new tracing operation must be done.

4. REFERENCES

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