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ASPECTS REGARDING THE TRANSMISSION OF THE REFERENCE SYSTEM FROM SURFACE TO THE UNDERGROUND ON A VERTICAL SHAFT

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Abstract

Reference system transmission from surface to underground consists in transmitting in the underground the coordinates of a point and a guideline from which lifting is done in the underground network. Depending on the access roads, the reference system transmission into the underground is realized by several methods including transmission on a vertical shaft, transmitting on two vertical shafts, transmitting on coastal galleries or inclined plane. In case of transmitting the reference system from surface to the underground through a vertical shaft there are also known several methods and in this paper it is studied the mechanical transmission. Mechanical transmission of the reference system from surface to the underground consists in designing the wires in underground and determining their position of equilibrium respectively connecting surface and underground measurements. This paper proposes an analysis of accuracy index analysis of the measurements connection on surface and underground depending on which connection method you choose.

Key words: *reference system, vertical shaft, underground, mechanical transmission*

INTRODUCTION

Measurements were made with Leica TCR 805 Reflectorless Total Station (Figure 1).

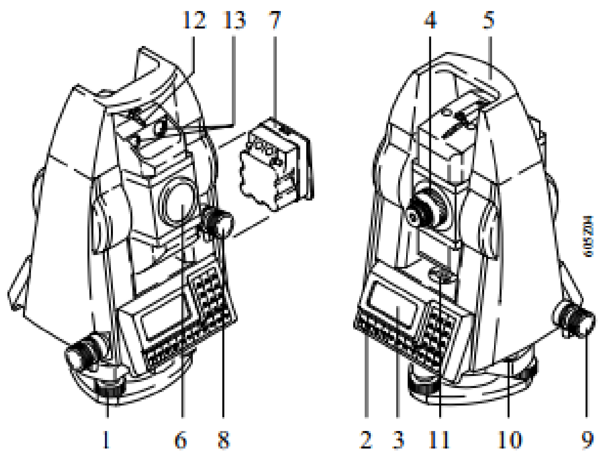
The TCR805 is particularly suitable for engineering, building and construction surveys with a focus on setting outs, volume determinations and tachometry surveys. Fast and easy coding facilities are provided. The accuracy of angle-measuring, and the range of its EDM module, are matched to one another. The measured data can be stored in the internal memory or can be output individually via serial interface to an external recorder.

Performing observations both Leica and Sokkia Reflective targets (Figure 2), and the light I could see that the smallest errors occur measurements made in prism. Thus we attach only those measurements.

The integrated programs enhance the functionality of the TC805 total station. Daily survey work is simplified by using internally stored coordinates. This largely eliminates the risk of entering wrong information in the field. Points with given coordinates or measured points can be used within the programs.

The following programs are installed in the instruments:

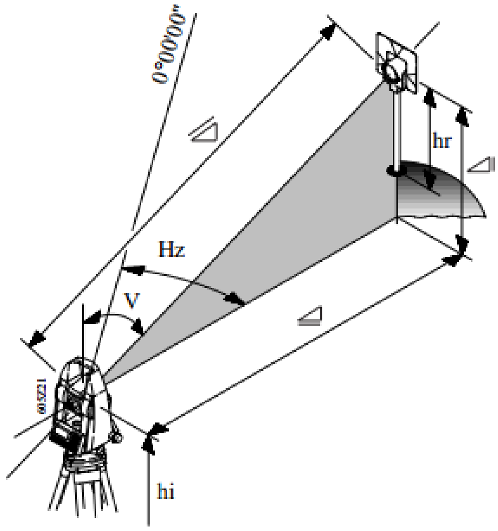
- Set Job and User (Set Job)
- Set Station and Orientation (Set Station)
- Free station (Free Station)
- Setting-out (Setout)
- Tie distance (Tie distance)
- Area computation (Calc Area)
- Rapid measurement and recording (Rapid Meas)
- Reference Line (Ref. Line)



1	Foot screw	8	Vertical drive
2	Keyboard	9	Horizontal drive
3	Display	10	Serial Interface RS-232
4	Focusing	11	Circular level
5	Carrying handle	12	Optical sight
6	EDM, Telescope	13	EGL1 (optional)
7	Battery		

Figure 1. Leica TCR 805 Total Station

Pointing and distance measurement



GPH1 prism holder with
GZT4 target plate

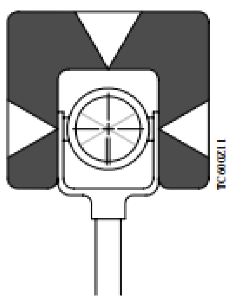


Figure 2. Pointing and distance measurements

MATERIALS AND METHODS

For transmitting the reference system through a vertical shaft are known following methods: mechanical, gyroscopic method, optical method and magnetic method.

Mechanical method is characterized in that the reference system in free space of the shaft is materialized with two lead wires launched in the shaft. Points defining the reference system, noted with F_1^S si F_2^S on surface and with F_{1S} si F_{2S} in the underground corresponding to the equilibrium positions of wires.

As you can see, the mechanical method of transmitting the reference system from surface to the underground require topographic operations regarding the total topographic elements on the surface, underground topographical elements and determining the equilibrium positions of lead wires (Dima et al., 1996).

To connect topographic measurements, on surface can use the following methods: bond triangle method, bond quadrilateral method, forced alignment method, radial method or intersections method.

Surface connection is to determine the coordinates of the two wires and the orientations between the two wires. Underground connection is to determine the coordinates of a point and an orientation.

Accuracy estimation of calculation of the coordinates and orientation between the two wires depends on the method chosen and in the case of triangle connection it depends on the shape of the bond triangle.

In surveying works and tracing underground lifting, distance is measured directly frequent, direct measurement of distances include: measures and precautions, proper measuring, calculating distance measured directly (Fodor, 1980).

Surface connection can be made through the bond triangle which can have different shapes, which implies, according to the study done by the theory of measurement error, the application of the most appropriate solution (Popia et al., 2008; Ortelecan et al., 1999).

Formulas for determining the angles in the bond triangle apply according to the shape of the bond triangle (Figure 3). We established three characteristic forms of the bond triangle:

- Elongated bond triangle;
- Elongated bond triangle which tends to isosceles;
- Bond triangle which tends to equilateral;

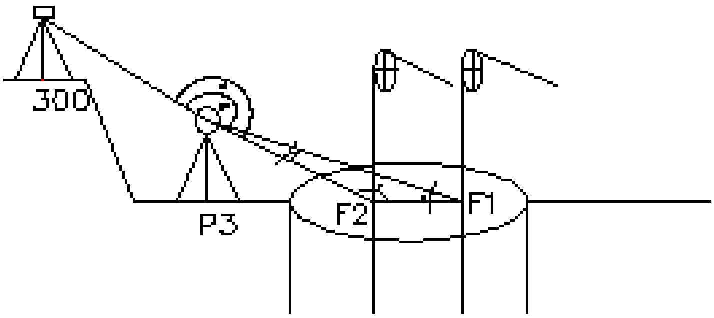


Figure 3. Bond triangle

Consists of two distinctive phases:

- initially designing two points in the underground and determine their position;
- in the second phase is connecting the measurements at surface and underground;

Are known: the x and y coordinates of the points P_3 and 300 and the orientation θ_{P3-300}.

Were measured: - angles γ_1 and γ_2;

- distances a, b and c.

We have to determine:

- x and y coordinates of points F_1, F_2 and 309;
- orientations θ_{P3-F1}, θ_{P3-F2}, θ_{F1-F2}, θ_{F1-309}, θ_{F2-309}

$$\theta_{P3-F1} = \theta_{P3-300} + \gamma_1$$
$$\theta_{P3-F2} = \theta_{P3-300} + \gamma_2$$
$$\theta_{F1-309} = \theta_{F1-F2} - \beta$$
$$\theta_{F2-309} = \theta_{F1-F2} - 200 + \alpha$$

In order to calculate the coordinates we will use the following formulas:

$$F1 \begin{cases} X_{F1} = X_{P3} + a*\cos\theta_{P3-F1} \\ Y_{F1} = Y_{P3} + a*\sin\theta_{P3-F1} \end{cases}$$

$$F2 \begin{cases} X_{F2} = X_{P3} + b*\cos\theta_{P3-F2} \\ Y_{F2} = Y_{P3} + b*\sin\theta_{P3-F2} \end{cases}$$

Orientation will be calculated as follows:

$\theta_{F1-F2} = \theta_{P3-F1} + 200 - \beta$

Angles α and β will be obtained by solving the bond triangle $P_3F_1F_2$.

For this purpose may be used: Sine theorem; Cosine theorem; Half-angle tangent relationship.

RESULTS AND DISCUSSIONS

In case of sharp triangles (Figure 4), sinus theorem is recommended for use as it has the smallest error.

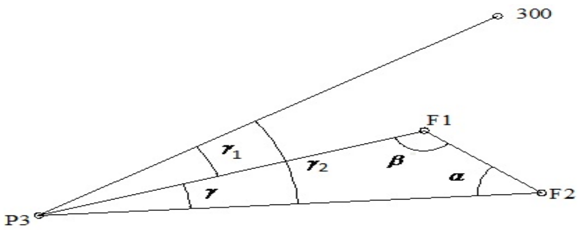


Figure 4. Surface connection through sharp triangle

$$\frac{a}{\sin\alpha} = \frac{b}{\sin\beta} = \frac{c}{\sin\gamma}$$

$$\sin\alpha = \frac{a}{c} \times \sin\gamma$$

$$\sin\beta = \frac{b}{c} \times \sin\gamma$$

Errors calculation of angles α and β:

To determine the mean squared error with which we obtain the angles α and β we proceed as follows (Table 1):

$$m_\alpha = tg\alpha\sqrt{\left(\frac{m_a}{a}\rho\right)^2 + \left(\frac{m_c}{c}\rho\right)^2 + \left(\frac{m_\gamma}{tg\gamma}\right)^2} = 185.5358^{cc}$$

$$m_\beta = tg\beta\sqrt{\left(\frac{m_b}{b}\rho\right)^2 + \left(\frac{m_c}{c}\rho\right)^2 + \left(\frac{m_\gamma}{tg\gamma}\right)^2} = -287.2622^{cc}$$

Table 1. Distance correction in the bond sharp triangle

	a			b			c		
Nr.crt	Oi	Vi	V V	Oi	Vi	V V	Oi	Vi	V V
1	11.571	-0.6667	0.4444	14.018	0.3333	0.1111	3.432	-1.4	1.96
2	11.571	-0.6667	0.4444	14.018	0.3333	0.1111	3.435	1.6	2.56
3	11.573	1.3333	1.7778	14.017	-0.6667	0.4444	3.433	-0.4	0.16
4							3.434	0.6	0.36
5							3.433	-0.4	0.16
[…]	34.72	0.00	2.67	42.05	0.00	0.67	17.17	0.00	5.20
	a	11.5717		b	14.0177		c	3.4334	
	m_0	1.1547		m_0	0.5774		m_0	1.1402	
	m	0.6667		m	0.3333		m	0.5099	

Errors calculation on orientations:

$$m_{\theta_{F1-F2}} = \sqrt{m_0^2 + m_{\gamma_1}^2 + m_{\beta_1}^2} = 289.3102^{cc}$$

$$m_{\theta_{F2-F1}} = \sqrt{m_0^2 + m_{\gamma_2}^2 + m_{\beta_2}^2} = 188.6912^{cc}$$

$$m_0 = \frac{e}{D} \cdot \rho = 16.7582$$

θ_{P3-300} = 103.7694

θ_{P3-F1} =164.5536

θ_{P3-F2} =178.3055

θ_{F1-F2} =231.0447

X_{F1}= 585585.145

Y_{F1}= 390937.124

X_{F2}= 585584.063

Y_{F2}= 390934.401

In case of sharp triangles (Figure 5), cosine theorem is recommended for use as it has the smallest error (Ionel, 2004; Bos et al., 2007).

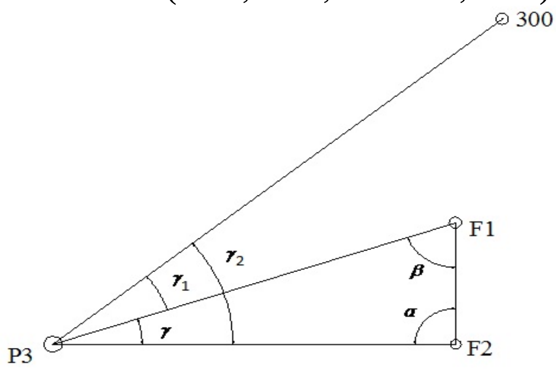


Figure 5. Surface connection through square triangle

Applying the cosine theorem in the bond triangle, we obtain:

$$a^2 = b^2 + c^2 - 2bc \times \cos\alpha$$

$$\cos\alpha = \frac{b^2 + c^2 - a^2}{2bc}$$

$$\alpha = ar\cos\frac{b^2 + c^2 - a}{2bc}$$

$$b^2 = a^2 + c^2 - 2ac \times \cos\beta$$

$$\cos\beta = \frac{a^2 + c^2 - b^2}{2ac}$$

$$\beta = \arccos\frac{a^2 + c^2 - b^2}{2ac}$$

Table 2. Distance correction in the bond square triangle

	a			b			c		
Nr.crt	Oi	Vi	V V	Oi	Vi	V V	Oi	Vi	V V
1	15.077	0.6667	0.4444	14.644	0.6667	0.4444	3.414	1	1
2	15.076	-0.3333	0.1111	14.643	-0.3333	0.1111	3.413	0	0
3	15.076	-0.3333	0.1111	14.643	-0.3333	0.1111	3.413	0	0
4							3.412	-1	1
5							3.413	0	0
[…]	45.229	0.00	0.67	43.93	0.00	0.67	17.07	0.00	2.00
	a		15.0763	b		14.6433	c		3.413
	m_0		0.5773	m_0		0.5773	m_0		0.7071
	m		0.3333	m		0.3333	m		0.3162

To determine the mean squared error with which we obtain the angles α and β we proceed as follows (Table 2):

$$m_\alpha = \frac{m_a}{a \cdot \sin\alpha}\rho^{cc}\sqrt{1 + \cos^2\alpha + \cos^2\gamma} = 19.652^{cc}$$

$$m_\beta = \frac{m_b}{b \cdot \sin\beta}\rho^{cc}\sqrt{1 + \cos^2\beta + \cos^2\gamma} = 21.132^{cc}$$

Errors calculation on orientations:

$$m_{\theta_{F1-F2}} = \sqrt{{m_0}^2 + {m_{\gamma_1}}^2 + {m_{\beta_1}}^2} = 40.3408^{cc}$$

$$m_{\theta_{F2-F1}} = \sqrt{{m_0}^2 + {m_{\gamma_2}}^2 + {m_{\beta_2}}^2} = 39.5858^{cc}$$

$$m_0 = \frac{e}{D} \cdot \rho = 16.7581$$

θ_{P3-300} = 103.7694

θ_{P3-F1} =164.5536

θ_{P3-F2} =282.0704

θ_{F1-F2} =382.8677

X_{F1}= 585587.613

Y_{F1}= 390916.556

X_{F2}= 585590.899

Y_{F2}= 390915.650

In case of isosceles triangles (Figure 6), Half-angle tangent relationship is recommended for use as it has the smallest error.

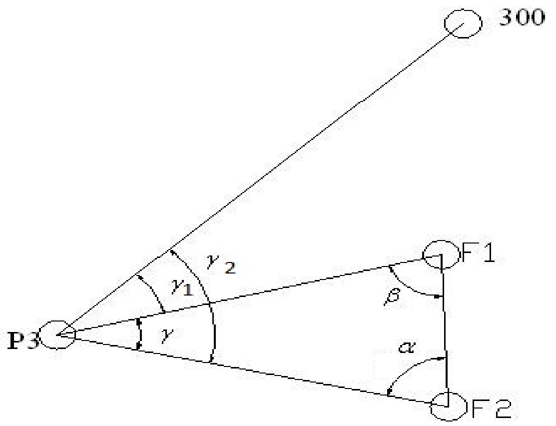


Figure 6. Surface connection through isosceles triangle

For determining the angles α and β we apply the following relations:

$$tg\frac{\alpha}{2} = \sqrt{\frac{(p-b)(p-c)}{p(p-a)}}$$

$$p = \frac{a+b+c}{2}$$

$$tg\frac{\beta}{2} = \sqrt{\frac{(p-a)(p-c)}{p(p-b)}}$$

Table 3. Distance correction in the bond isosceles triangle

	a			b			c		
Nr.crt	Oi	Vi	V V	Oi	Vi	V V	Oi	Vi	V V
1	14.203	0	3.1554E-24	14.282	-1	1	3.313	-0.4	0.16
2	14.204	1	1	14.283	0	0	3.315	1.6	2.56
3	14.202	-1	1	14.284	1	1	3.312	-1.4	1.96
4							3.313	-0.4	0.16
5							3.314	0.6	0.36
[…]	42.61	0.00	2.00	42.85	0.00	2.00	16.57	0.00	5.20
	a	14.203		b	14.283		c	3.3134	
	m0	1		m0	1		m0	1.1402	
	m	0.5774		m	0.5774		m	0.5099	

To determine the mean squared error with which we obtain the angles α and β we proceed as follows (Table 3):

$$m_\alpha = \frac{m_a}{a \cdot \sin\alpha}\rho^{cc}\sqrt{1+\cos^2\alpha+\cos^2\gamma} = 36.6335^{cc}$$

$$m_\beta = \frac{m_b}{b \cdot \sin\beta}\rho^{cc}\sqrt{1+\cos^2\beta+\cos^2\gamma} = 36.1220^{cc}$$

Errors calculation on orientations:

$$m_{\theta_{F1-F2}} = \sqrt{{m_0}^2 + {m_{\gamma_1}}^2 + {m_{\beta_1}}^2} = 49.85618$$

$$m_{\theta_{F2-F1}} = \sqrt{{m_0}^2 + {m_{\gamma_2}}^2 + {m_{\beta_2}}^2} = 50.22799$$

$$m_0 = \frac{e}{D}\cdot\rho = 16.7582$$

θ_{P3-300} = 103.7694
θ_{P3-F1} =170.5062
θ_{P3-F2} =185.5801
θ_{F1-F2} =276.3990

X_{F1}= 585582.263
Y_{F1}= 390936.099
X_{F2}= 585581.129
Y_{F2}= 390932.924

Data processing of the measurements made in the underground is done using the same formulas as for surface processing (Table 4, 5, 6).

For determining the coordinates of point 309 we will use the following relations:

$$X_{309} = X_{F1} + a \cdot \cos\theta_{F1-309}$$

$$Y_{309} = Y_{F1} + a \cdot \sin\theta_{F1-309}$$

where:

$$\theta_{F1-309} = \theta_{F1-F2} - \beta$$

Also, the coordinates of point 309 can be determined according to the calculated point F2.

For the sharp triangle (Figure 7):

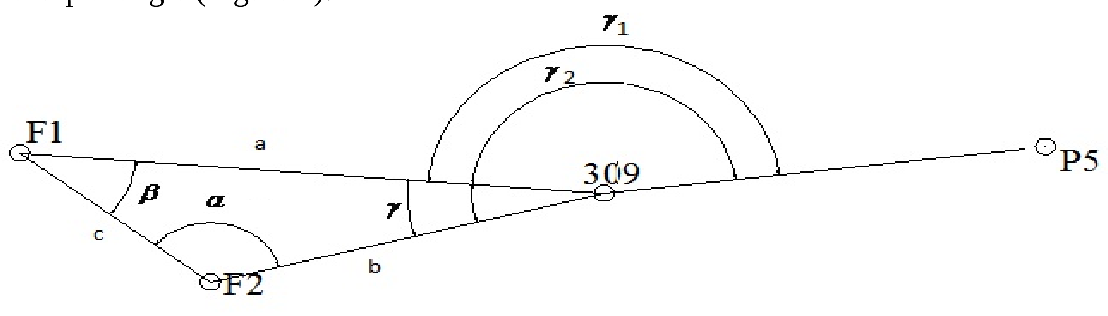


Figure 7. Underground connection through sharp triangle

$$m_\alpha = tg\alpha\sqrt{\left(\frac{m_a}{a}\rho\right)^2 + \left(\frac{m_c}{c}\rho\right)^2 + \left(\frac{m_\gamma}{tg\gamma}\right)^2} = -200.1734^{cc}$$

$$m_\beta = tg\beta\sqrt{\left(\frac{m_b}{b}\rho\right)^2 + \left(\frac{m_c}{c}\rho\right)^2 + \left(\frac{m_\gamma}{tg\gamma}\right)^2} = 142.0953^{cc}$$

θ_{F1-309} = 191.4255
θ_{F2-309} = 180.3711
X_{309} = 585570.9298
Y_{309} = 390939.0501

Table 4. Distance correction in the bond sharp triangle

	a			b			c		
Nr.crt	Oi	Vi	V V	Oi	Vi	V V	Oi	Vi	V V
1	14.346	0.667	0.444	11.414	0.00	0	3.432	-1.4	1.96
2	14.345	-0.333	0.111	11.415	1.00	1	3.435	1.6	2.56
3	14.345	-0.333	0.111	11.413	-1.00	1	3.433	-0.4	0.16
4							3.434	0.6	0.36
5							3.433	-0.4	0.16
[…]	43.04	0.00	0.67	34.24	0.00	2.00	17.17	0.00	5.20
	a	14.345		b	11.414		c	3.433	
	m_0	0.577		m_0	1		m_0	1.14	
	m	0.333		m	0.577		m	0.51	

For the square triangle (Figure 8):

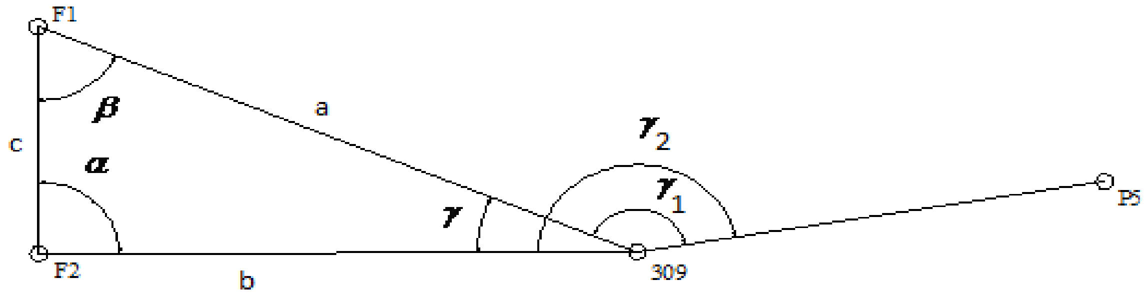


Figure 8. Underground connection through square triangle

Table 5. Distance correction in the bond square triangle

	a			b			c		
Nr.crt	Oi	Vi	V V	Oi	Vi	V V	Oi	Vi	V V
1	11.274	-1.6666	2.7777	10.793	0.3333	0.1111	3.414	1.00	1
2	11.277	1.3333	1.7777	10.792	-0.6666	0.4444	3.413	0.00	0.00
3	11.276	0.3333	0.1111	10.793	0.3333	0.1111	3.413	0.00	0.00
4							3.412	-1.00	1.00
5							3.413	0.00	0.00
[…]	33.83	0.00	4.67	32.38	0.00	0.67	17.07	0.00	2.00
	a	11.2756		b	10.7926		c	3.413	
	m_0	1.5275		m_0	0.5773		m_0	0.7071	
	m	0.8819		m	0.3333		m	0.3162	

$$m_\alpha = \frac{m_a}{a \cdot \sin\alpha}\rho^{cc}\sqrt{1+\cos^2\alpha+\cos^2\gamma} = 68.80312^{cc}$$

$$m_\beta = \frac{m_b}{b \cdot \sin\beta}\rho^{cc}\sqrt{1+\cos^2\beta+\cos^2\gamma} = 29.00129^{cc}$$

$\theta_{F1\text{-}309} = 301.5874$
$\theta_{F2\text{-}309} = 282.0125$
$X_{309} = 585587.89$
$Y_{309} = 390905.28$

For the isosceles triangle (Figure 9):

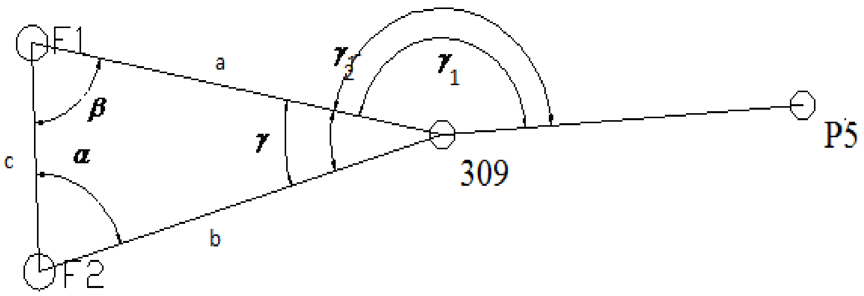


Figure 9. Underground connection through isosceles triangle

Table 6. Distance correction in the bond isosceles triangle

	a			b			c		
Nr.crt	Oi	Vi	V V	Oi	Vi	V V	Oi	Vi	V V
1	11.469	-1.3333	1.7777	11.363	-0.3333	0.1111	3.313	-0.4	0.16
2	11.47	-0.3333	0.1111	11.363	-0.3333	0.1111	3.315	1.6	2.56
3	11.472	1.6666	2.7777	11.364	0.6666	0.4444	3.312	-1.4	1.96
4							3.313	-0.4	0.16
5							3.314	0.6	0.36
[…]	34.41	0.00	4.67	34.09	0.00	0.67	16.57	0.00	5.20

a	11.470	b	11.363	c	3.313
m_0	1.528	m_0	0.577	m_0	1.140
m	0.882	m	0.333	m	0.510

CONCLUSIONS

In the study undertaken showed that precision indices and accuracy values obtained from transmission of the reference system from surface to the underground is conditioned by the shape of the bond triangle and by the calculus relations used for angles.

Based on the simulation about the triangle shape results that the best values for the coordinates transmitted to the underground are obtained for the bond triangle with a sharp shape.

After checking the un-closures on the bond triangles taken into study it is found that the lowest values were obtained for square triangle.

Also, calculation precisions of angles a and b obtained from observations resulted to apply formulas:

$$m_\alpha = tg\alpha\sqrt{\left(\frac{m_a}{a}\rho\right)^2 + \left(\frac{m_c}{c}\rho\right)^2 + \left(\frac{m_\gamma}{tg\gamma}\right)^2}$$

$$m_\beta = tg\beta\sqrt{\left(\frac{m_b}{b}\rho\right)^2 + \left(\frac{m_c}{c}\rho\right)^2 + \left(\frac{m_\gamma}{tg\gamma}\right)^2}$$

$$m_\alpha = \frac{m_a}{a\cdot\sin\alpha}\rho^{cc}\sqrt{1+\cos^2\alpha+\cos^2\gamma}$$

$$m_\beta = \frac{m_b}{b\cdot\sin\beta}\rho^{cc}\sqrt{1+\cos^2\beta+\cos^2\gamma}$$

Checking the calculation accuracy of the orientation of the two wires underground transmitted by orientation calculation according to the angles measured and calculated, from the orientation calculated from coordinates of the wires is found that the best accuracy is obtained for the first case.

REFERENCES

Dima Nicolae, Padure I., Herbei O. Topografie miniera, Editura Corvin, 1996

Fodor D.,Exploatari miniere la zi, Editura Didactica si Pedagogica, 1980

Rodica Popia, Adrian Popia, Masuratori subterane. Îndrumator pentru lucrari de laborator, editura Tehnopress, 2008

Mircea Ortelecan, Palamariu Maricel, Jurca Traian, Trasarea lucrarilor miniere, Editura Infomin, 1999

AutoCAD 2004, Simion Ionel, Editura Polirom,2004

Bos, N., Iacobescu, O., 2007, Topografie moderna, Editura C. H. Beck, Brasov