THE APLICATION OF A SPECIFIC METHOD FOR MINING TOPOGRAPHY IN THE CASE OF OBSERVATIONS FOR CROWDED AREAS

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Abstract. The paper presents the approach in carrying out topographical works for sites located in crowded areas, where few points are visible from the support network, and the choice of a less used method, which will provide however, the precision requirements imposed.

Keywords: connection, linking triangle, unsteady points, support networks

INTRODUCTION

The works in the field of terrestrial measurements are made in the specific projection system of our country. In order to connect to this system several methods can be used, depending on a number of factors such as: the area where the measurements are located, the existence of points belonging to the network of support, existing constructions and arrangements for their height. The choice of method should ensure the appropriate precision for the followed purpose.

This paper shows how a method specific for mining topography can be used in the case of surface measurements located in crowded areas, with the possibility of observing only a small number of points in the geodetic network, which are usually unsteady.

MATERIAL AND METHOD

The triangle connection method is used for the connection to the projection system in the mining domain. By using this method, the underground connection is transmitted as an orientation for a side made out of two unsteady points (represented by suspended wires) and their coordinates.

The use of the surface measurements method for heavily built areas, is only possible when the new point, which is next to be determined, has visibility to three known and unsteady points: two of which are relatively close to each other (for example: two towers of the same church and the spires of two nearby churches) and the new point, and also the third one at greater distance, although the observations are made from the new point .

The way to make observations is shown in Figure. 1. In this case , the known points TN, TS are two towers of the same church. and 47 is located at a distance of over 1.5 km. There is visibility between all three points.

The conditions necessary for applying the desired procedure are:

- the new B point has to be stationary;

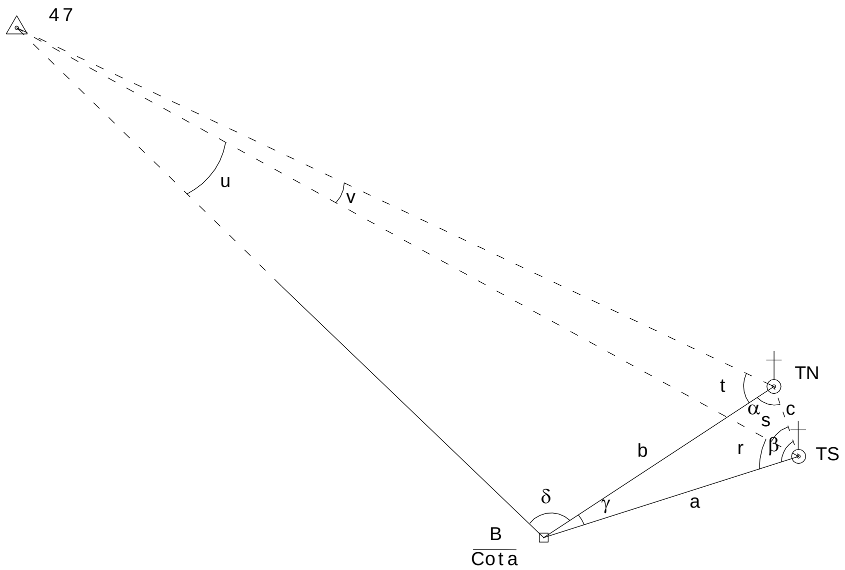


Fig. 1. The way to make observations

- there has to be visibility between the new B point and all three previously known points;
- the distances between the new point and the closest known points (points a,b) need to be measurable;
- the distance between the new point and the third known point has to be bigger than 1 km.

Therefore, the known points which are close to each other can be two unsteady points (for example the two towers of two close churches) between which there is no visibility, but the distance from the new point to each of these points has to be measurable.

The items determined throughout the observations are: the horizontal angles δ, γ and horizontal distances a, b.

Table 1

Point	Coordinates			Point
	X [m]	Y [m]	H [m]	
47	585465,406	388398,395	506,680	47
TN	585633,316	389985,965	398,180	TN
TS	585631,290	389985,280	398,100	TS

Table 1 contains the coordinates of the known points. and in Table 2 there are presented the values of the measured items, and also those calculated from the known points' coordinates (the c distance between TN and TS and the $\theta_{TN,TS}$ orientation).

The measured items are processed in a first stage, using the methodology of connection for the linking triangle.

Table 2

Measured items		Calculated items	
Linear items		Linear items	
$D_{B,TN} = a$	$63{,}320m$	$D_{TN,TS} = c = \sqrt{\Delta x_{TN,TS}{}^{2} + \Delta y_{TN,TS}{}^{2}}$	$2{,}139m$
$D_{B,TS} = b$	$64{,}595m$		
Angular items		Angular items	
δ	$146^{g}80^{c}57^{cc}$	$\theta_{TN,TS} = arctg\,\dfrac{\Delta y_{tTN,TS}}{\Delta x_{TN,TS}}$	$220^{g}75^{c}63^{cc}$
γ	$1^{g}70^{c}92^{cc}$		

RESULTS AND DISCUSSION

Applying the appropriate relations to the shape of the formed triangle by the new point with the two known close points, the most likely values for the horizontal angles α, β, meaning (α), (β), are determined.

$$\cos\alpha = \frac{b^2 + c^2 - a^2}{2\cdot b\cdot c} = \frac{(64{,}595)^2 + (2{,}139)^2 - (63{,}320)^2}{2\cdot 64{,}595\cdot 2{,}139} \Rightarrow \alpha = 58^{g}49^{c}48^{cc} \qquad (1)$$

$$\cos\beta = \frac{a^2 + c^2 - b^2}{2\cdot a\cdot c} = \frac{(63{,}320)^2 + (2{,}139)^2 - (64{,}595)^2}{2\cdot 63{,}320\cdot 2{,}139} \Rightarrow \beta = 139^{g}79^{c}55^{cc} \qquad (2)$$

$$\alpha + \beta + \gamma = 199^{g}99^{c}95^{cc} \qquad (3)$$

$$\varepsilon = -5^{cc} \qquad (4)$$

$$c_T = -\varepsilon = 5^{cc} \qquad (5)$$

$$c_U = \frac{c_T}{2} = 2^{cc},5$$
(6)

$$(\alpha) = \alpha + c_U = 58^{g}49^{c}50^{cc},5 \qquad (7)$$

$$(\beta) = \beta + c_U = 139^{g}79^{c}57^{cc},5 \qquad (8)$$

The guidelines for the sides defined by the new point and the known close points are determined by the relations:

$$\theta_{TNB} = \theta_{TN,TS} + (\alpha) = 279^{g}25^{c}13^{cc},5 \qquad (9)$$

$$\theta_{TSB} = \theta_{TN,TS} + 200^{g} - (\beta) = 280^{g}96^{c}05^{cc},5 \qquad (10)$$

and the coordinates for the new point are calculated with the following expressions:

$$x_B = x_{TN} + D_{B,TN} \cdot \cos\theta_{TNB} = x_{TS} + D_{B,TS} \cdot \cos\theta_{TNB} = 585612{,}634m$$

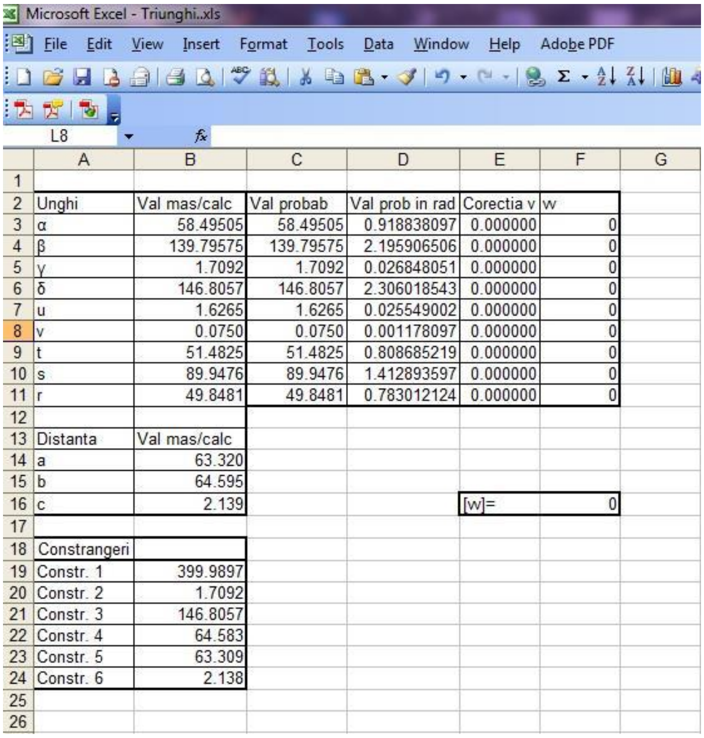
(11) $y_B = y_{TN} + D_{B,TN} \cdot \sin\theta_{TNB} = y_{TS} + D_{B,TS} \cdot \sin\theta_{TNB} = 389924{,}771m$

(12)

The resulting values (both the orientations of the sides and the coordinates of the new point) are affected by errors due to the fact that the orientation of the side formed by old points TN, TS (side which has the length in meters, no more than tens of meters) has been deducted from their coordinates, coordinates which were determined by the specific precision of the points category (for example, for the V category points the precision is of ± 15cm. Using the elements measured at the third known point, by using the module *Solver* which is attached to *Microsoft Excel*, probable corrections of guidelines and the possible values of the new point's coordinates are established. First, from the coordinates of the known points and the ones calculated for the new point, the sides orientations and the diagonals for the formed quadrilateral out of the four points are, and these are afterwards used for determining the values of the horizontal angles u, v, t, and r.

u $= 1^g62^c65^{cc}$ **v** $= 0^g07^c50^{cc}$ **t** $= 51^g48^c25^{cc}$ **s** $= 89^g94^c76^{cc}$ **r** $= 49^g84^c81^{cc}$ (13)

For processing with the help of *Solver* module, the input data specific for the set of points shown in Fig. 1 are represented by the horizontal angles δ, γ, α, β, **u, v, t, s, r** and the horizontal distances a, b, c. The worksheet is shown in Fig. 2.



	A	B	C	D	E	F	G
1							
2	Unghi	Val mas/calc	Val probab	Val prob in rad	Corectia v	w	
3	α	58.49505	58.49505	0.918838097	0.000000	0	
4	β	139.79575	139.79575	2.195906506	0.000000	0	
5	γ	1.7092	1.7092	0.026848051	0.000000	0	
6	δ	146.8057	146.8057	2.306018543	0.000000	0	
7	u	1.6265	1.6265	0.025549002	0.000000	0	
8	v	0.0750	0.0750	0.001178097	0.000000	0	
9	t	51.4825	51.4825	0.808685219	0.000000	0	
10	s	89.9476	89.9476	1.412893597	0.000000	0	
11	r	49.8481	49.8481	0.783012124	0.000000	0	
12							
13	Distanta	Val mas/calc					
14	a	63.320					
15	b	64.595					
16	c	2.139			[w]=	0	
17							
18	Constrangeri						
19	Constr. 1	399.9897					
20	Constr. 2	1.7092					
21	Constr. 3	146.8057					
22	Constr. 4	64.583					
23	Constr. 5	63.309					
24	Constr. 6	2.138					
25							
26							

Fig. 2. Working sheet containing input data

Column B contains the measured or calculated values of the angles or horizontal distances. In column C, the one which contains probable values, the measured / calculated values in column B will be copied, and column D the calculating relationship the probable values of the angles expressed in radians will be defined. The calculation expresión for the

v corrections (probable value minus the measured / calculated value) is defined in column E,and for vv, and $[vv]$ respectively, in column F. The restraints being applied to the set of points are found in rows 19-24 on the worksheet.The computing relationship for each restraint is specified below:

- restraint 1: $\alpha + s + r + \gamma + \delta + u + v = 400^{g}$ (14)

- restraint 2: probable value γ = measured value γ (15)

- restraint 3: probable value δ = measured value δ (16)

- restraint 4: $b = \dfrac{D_{47TN} \cdot \sin[(u)+(v)]}{\sin(\delta)}$ = measured value b (17)

- restraint 5: $a = \dfrac{D_{47TS} \cdot \sin(u)}{\sin[(\delta)+(\gamma)]}$ = measured value a (18)

- restraint 6: $c = \dfrac{D_{47TN} \cdot \sin(v)}{\sin(s)}$ = measured value c (19)

The *Solver Parameters* window (Figure 3.) is activated from the *Tools* menu, by the *Solver* command. In that window, in the *Set Target Cell* box, the cell containing the size needing improvement will be registered, $[vv]$,and also the value sought for this size – *Min* in the *Equal to* box. The cell block which demand modifications (the horizontal probable angles) falls into the *By Changing Cells* box, and in the *Subject to the Constraints* box, register the cells that contain conditioning terms.

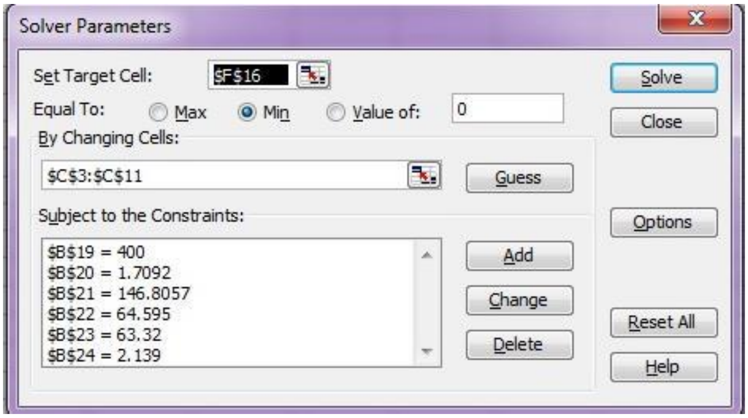


Fig. 3. Solver Parameters window

By using the *Solve* command, in the worksheet will appear the values for $[vv]$, v corrections and the probable values of the angles (Fig. 4); using the help of latter ones the final values for the sides orientation is determined.

J24

	A	B	C	D	E	F
1						
2	Unghi	Val mas/calc	Val probab	Val prob in rad	Corectia v	w
3	α	58.49505	58.522669	0.919271935	0.027619	0.000763
4	β	139.79575	139.79575	2.195906506	0.000000	0
5	γ	1.7092	1.7092	0.026848051	0.000000	0
6	δ	146.8057	146.8057	2.306018543	0.000000	0
7	u	1.6265	1.62679188	0.025553587	0.000292	8.52E-08
8	v	0.0750	0.0750	0.001178301	0.000013	1.68E-10
9	t	51.4825	51.510119	0.809119058	0.027619	0.000763
10	s	89.9476	89.8747881	1.41174987	-0.072812	0.005302
11	r	49.8481	49.875719	0.783445962	0.027619	0.000763
12						
13	Distanta	Val mas/calc				
14	a	63.320				
15	b	64.595				
16	c	2.139			[w]=	0.00759
17						
18	Constrangeri					
19	Constr. 1	400.0000				
20	Constr. 2	1.7092				
21	Constr. 3	146.8057				
22	Constr. 4	64.595				
23	Constr. 5	63.320				
24	Constr. 6	2.139				
25						
26						

Fig. 4. Working sheet after doing the calculations

The final coordinates of the new point are calculated with the expressions:

$$x_B = \frac{y_{47} - y_{TN} + x_{TN} \cdot tg\,\theta_{TNB} - x_{47} tg \cdot \theta_{47B}}{tg\,\theta_{TNB} - tg\,\theta_{47B}} = 585612{,}612m \tag{20}$$

$$y_B = y_{TN} + (x_B - x_{TN}) \cdot tg\,\theta_{TNB} = y_{47} + (x_B - x_{47}) \cdot tg\,\theta_{47B} = 389924{,}793m \tag{21}$$

CONCLUSIONS

The method presented in this paper offers the possibility of solving some issues at the geodetic network connection, in unfavourable situations, when the visibility of the working area and the possibility of using GNSS type technology are affected by the existing buildings or other disruptive factors, ensuring the adequate precision for small-scale works.

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