# ANALYSIS OF THE POSITIONING ERRORS IN TIME OF A POINT IN THE TRIANGULATION NETWORK OF THE MUNICIPALITY OF CLUJ-NAPOCA

**POP[1)*] Nicolae, Sergiu POP[2)]**

*[1)]University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Faculty of Horticulture, 3-5 Mănăștur st., Cluj, Romania*

*[2)]Tehnical University of Cluj Napoca, Faculty of Civil Engineering, C-tin Daicoviciu no. 15, Cluj, Romania*

*Corresponding author: popnocolae@gmail.com

**Abstract:** In this paper we wanted to carry out a study of the stability of the Triangulation point of the Turk Tutt, materialized by a ground pilast, due to the escavatiilir made at the base of the slope. The observed trangulation point is among the few points whose signaling pyramid has remained intact, being used in various topographical operations by authorized topographers. Thus, point stability is very important in the accuracy and accuracy of the topographical work that targets this point. In order to track the stability of the point, azimuth and zenithal observations were performed by the reiterated full reverberation method, targeting the triangulation points in the area. The planimetric stability was determined by comparing the known coordinates with the coordinates obtained by performing a multiple cross-junction and altimetric comparison of the resulting elevation by the trigonometric level with the known elevation of the target point. After comparing the coordinates, the values dx = -0,0834, dy = -0,0826, dz = 0,0624 were obtained. On the basis of the values obtained, it can be concluded that the triangulation point of the Turkish Cut is stable and can be used in subsequent topographical observations.

**Keywords**: Azimuth directions, zenith directions, multiple crossing, pilaster

## INTRODUCTION

The objective of this work aims to follow the stability of the triangulation point Turquoise Cut, due to the excavations made at the base of the slope (fig. 1), which leads to the weakening of the reactive momentum with respect to the active moment. Thus the safety coefficient that represents the ratio between the reactive moment and the active moment becomes subunit, which leads to the landslides and the instability of the point pursued.

**Fig. 1 Tilting the slopes on the slope**

## MATERIAL AND METHODS

Description of the instruments used: Leica TCR 805 total station

- is a total high precision station produced by one of the world leaders in the technology of topographic measurements.
- is part of the new generation of topographic instruments, having in principle the determination of distances based on measurements by electromagnetic waves.
- the advanced technology related to the total station allows the collection, storage and transfer in a PC of azimuthal, zenith and distance directions.

**Fig 2. Leica TCR 805 total station**

**Fig. 3. Pillar plate for spot centering**

Working method: In order to perform the multiple back-crossing necessary to evaluate the stability of the Turkish Cut point, the measurements consisted of performing three complete series, with zero reduction at the starting point Bis. St. Michael (46), the average of the reiterations are presented in table number 2.

**Table 1**

**The value of the directions reduced to zero**

| Punct | | CS | CD | Medie | Val. red. Zero |
|---|---|---|---|---|---|
| S | V | | | | |
| 212 | 46 | 0,0008 | 199,9971 | 399,999 | 0,00000 |
| | 833 | 38,6475 | 238,6504 | 38,64895 | 38,65000 |
| | 828 | 95,6467 | 295,6475 | 95,6471 | 95,64815 |
| | 836 | 245,9595 | 45,9621 | 245,9608 | 245,96185 |
| | 834 | 384,2224 | 184,2245 | 384,2235 | 384,22450 |
| | 46 | 399,9992 | 199,9992 | 399,9992 | 0,00025 |
| | | | | $W_d$ | -2,50000 |
| | | | | T | 13,41641 |

Since the value of the closing direction on the horizon is within the permissible tolerance, from the geodetic point of view the most probable values of the directions are the arithmetic means of the zero-repetitions on the visa direction.

In order to establish the most probable coordinates of the station point, in a first stage the provisional coordinates of the point are determined by the method of the barycentric coordinates.

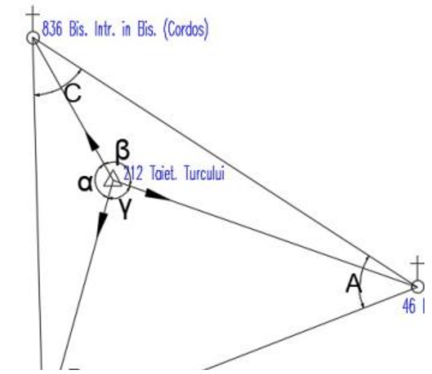


**Fig. 4. Provisional classification of the point**

**Table 2**

**Provisional classification of the point**

| | | | |
|---|---|---|---|
| A | θ46-828 | 276,3662 | 60,2426 |
| | θ46-836 | 336,6087 | |
| B | θ828–46 | 76,3662 | 78,0192 |
| | θ46–836 | 398,3469 | |
| C | θ836–828 | 198,3469 | 61,7382 |
| | θ836–46 | 136,6087 | |
| α | θ212–836 | 245,9605 | 150,3137 |
| | θ212–828 | 95,6468 | |
| β | θ212–46 | -0,0014 | 154,0382 |
| | θ212–836 | 245,9605 | |
| γ | θ212–828 | 95,6468 | 95,6482 |
| | θ212–46 | -0,0014 | |
| P1 | | | 0,5778 |
| P2 | | | 0,6687 |
| P3 | | | 1,6203 |

**Table 3**

**Provisional coordinates**

| | |
|---|---|
| x’212= | 587271,0947 |
| y’212= | 390437,4623 |

Determination of corrections and accuracy indices: In the second stage, the corrections of the provisional coordinates and their precision indices are determined. In this respect, the system of correction equations will be written according to figure 5.

Ecuaţii de erori pentru direcţiile măsurate:

$$-dZ_{812} - a_1 dX_{812} - b_1 dY_{812} + l_1 = v_1$$
$$-dZ_{812} - a_2 dX_{812} - b_2 dY_{812} + l_2 = v_2$$
$$-dZ_{812} - a_3 dX_{812} - b_3 dY_{812} + l_3 = v_3$$
$$-dZ_{812} - a_4 dX_{812} - b_4 dY_{812} + l_4 = v_4$$
$$-dZ_{812} - a_5 dX_{812} - b_5 dY_{812} + l_5 = v_5$$

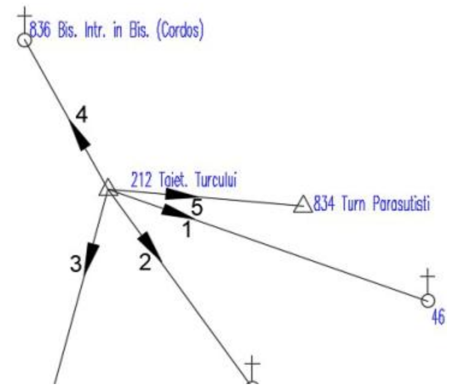


**Fig. 5. Target points in the geodetic network**

Applying Schreiber's equivalence rules 1 and 3, the system becomes (Dima N. 2005; Ghițău D. 1985; Ortelecan M. 2006):

$$
\begin{aligned}
&-a_1 dx_{812} - b_1 dy_{812} + l_1 = v'_1 && p = 1\\
&-a_2 dx_{812} - b_2 dy_{812} + l_2 = v'_2 && p = 1\\
&-a_3 dx_{812} - b_3 dy_{812} + l_3 = v'_3 && p = 1\\
&-a_4 dx_{812} - b_4 dy_{812} + l_4 = v'_4 && p = 1\\
&-a_5 dx_{812} - b_5 dy_{812} + l_5 = v'_5 && p = 1\\
&\frac{-[a]}{\sqrt{5}} dx_{812} - \frac{[b]}{\sqrt{5}} dy_{812} = v' && p = -1
\end{aligned}
$$

$a_i$, $b_i$ is calculated in table number 4 according to the provisional coordinates of point 812

**Table 4**

**Calculation of steering coefficients**

| Punct | x | Y | Nr. Viză | tg | sin | D | a | control |
|---|---|---|---|---|---|---|---|---|
| | | | | ctg | cos | D | b | a/b=-tg |
| | | | | θ | | D | | b/a=-ctg |
| 212 | 587271,095 | 390437,462 | 1 | -2,8506 | 0,9436 | 2093,3768 | -2,8697 | 2,8506 |
| 46 | 586578,130 | 392412,817 | | -0,3508 | -0,3310 | 2093,3768 | -1,0067 | 0,3508 |
| Δ | -692,965 | 1975,355 | | 121,4790 | | 2093,3768 | | |
| 212 | 587271,0664 | 390437,4655 | 2 | -0,7233 | 0,5861 | 1522,1954 | -2,4511 | 0,7233 |
| 833 | 586037,700 | 391329,590 | | -1,3825 | -0,8103 | 1522,1954 | -3,3887 | 1,3825 |
| Δ | -1233,366 | 892,125 | | 160,1343 | | 1522,1954 | | |
| 212 | 587271,095 | 390437,462 | 3 | 0,2757 | -0,2658 | 1698,8450 | 0,9960 | -0,2757 |
| 828 | 585633,360 | 389985,910 | | 3,6269 | -0,9640 | 1698,8450 | -3,6126 | -3,6269 |
| Δ | -1637,735 | -451,552 | | 217,1272 | | 1698,8450 | | |
| 212 | 587271,095 | 390437,462 | 4 | -0,5612 | -0,4894 | 1058,4988 | 2,9436 | 0,5612 |
| 836 | 588194,150 | 389919,400 | | -1,7817 | 0,8720 | 1058,4988 | 5,2448 | 1,7817 |
| Δ | 923,055 | -518,062 | | 367,4409 | | 1058,4988 | | |
| 212 | 587271,095 | 390437,462 | 5 | -11,1096 | 0,9960 | 1208,4236 | -5,2470 | 11,1096 |
| 834 | 587162,760 | 391641,020 | | -0,0900 | -0,0896 | 1208,4236 | -0,4723 | 0,0900 |
| Δ | -108,335 | 1203,558 | | 105,7149 | | 1208,4236 | | |

The free terms are calculated in table number 5:

**Table 5**

**Calculation of free terms**

| Punct S | Punct V | Nr. Viza | □ c | ri | zi=□i-ri | zm | □m | li=(□c-□m)*10000 |
|---|---|---|---|---|---|---|---|---|
| 212 | 46 | 1 | 121,4790 | 0,0000 | 121,4790 | | 121,4835 | -44,4891 |
| | 833 | 2 | 160,1343 | 38,6486 | 121,4857 | | 160,1321 | 21,9215 |
| | 828 | 4 | 217,1272 | 95,6468 | 121,4804 | 121,4835 | 217,1302 | -30,4891 |
| | 836 | 5 | 367,4409 | 245,9605 | 121,4804 | | 367,4439 | -30,4891 |
| | 834 | 7 | 105,7149 | 384,2231 | 121,4918 | | 105,7066 | 83,5458 |
| [ ] | | | | | 607,4174 | | | 0,0000 |

The solution of the system of corrections was solved by the method of successive reductions (Gauss-Doolittle algorithms) in table number 6.

**Table 6**

**Solving the normal system of equations by the Gauss-Doolittle scheme**

| | a] | b] | l] | s] | comtrol | Qxx | Qyy |
|---|---|---|---|---|---|---|---|
| | 42,6444 | 21,2244 | 484,5429 | 548,4117 | | -1,0000 | 0,0000 |
| | -1,0000 | -0,4977 | -11,3624 | -12,8601 | -12,8601 | 0,0234 | 0,0000 |
| dx | -12,8626 | 51,1844 | 118,7208 | 191,1297 | | 0,0000 | -1,0000 |
| | | 40,6209 | -122,4395 | -81,8186 | 0,0000 | 0,4977 | -1,0000 |
| | | -1,0000 | 3,0142 | 2,0142 | 2,0142 | -0,0123 | 0,0246 |
| | dy | 3,0142 | 11298,8959 | 11902,1596 | Qxx, Qyy | 0,0295 | 0,0246 |
| | | | -5874,6340 | -6477,8977 | | | |
| | | [v v]= | 5424,2619 | 5424,2619 | | | |

## RESULTS AND DISCUSSION

The most probable values of the Turkish Cut point coordinates are obtained with the relations: $(X_{812}) = X_{812} + dX_{812}$ ; $(Y_{812}) = Y_{812} + dY_{812}$

**Table 7**

**Corrections dx and dy**

| | | Δ/10000 |
|---|---|---|
| dx | -12,863 | -0,001286 |
| dy | 3,014 | 0,000301 |

The precision indices are calculated below:

**Table 8**

**Calculation of precision indices**

| | |
|---|---|
| mo= | 24,5499 cm |
| mx= | 4,2200 cm |
| my= | 3,8519 cm |

The displacement of the Turkish Cut point is obtained as a difference between the most probable calculated values and the values known initially. This results:

**Table 9.**

**Calculation of coordinate differences**

| Punct | Valorile cele mai probabile | | Coordonate rect. absolute | | Diferente | |
|---|---|---|---|---|---|---|
| | x | y | x | y | x | y |
| 212 | 587271,093 | 390437,463 | 587271,010 | 390437,380 | -0,0834 | -0,0826 |

Din punct de vedere altimetric cota punctului Tăietura Turcului (212) s-a calculat prin nivelment trigonometric prin aplicarea corecției de sfericitate și refracție.

**Table 10**

**Calculation of the most probable value of the quota**

| Punct stație | punct vizat | p | p*Hc′ | Cota calcualtă | Cota absolută | Diferențe |
|---|---|---|---|---|---|---|
| 812 | 46 | 0,228194517 | 96,27282575 | 422,5024041 | 422,44 | 0,0624041 |
| | 833 | 0,431577889 | 182,1615185 | | | |
| | 828 | 0,346491426 | 146,9102541 | | | |
| | 834 | 0,684796634 | 289,1325139 | | | |
| | ∑ | 1,691060466 | 714,4771122 | | | |

## CONCLUSIONS

Based on the azimuthal and zenith observations made at the triangulation point Tăietura Turcului (212), respectively based on their processing by the method of indirect measurements, it is found that the difference between the coordinates obtained and those initially known fall within the permissible tolerances. As such, it is considered that the point taken in the study is stable and can be used in subsequent topographic observations.

Although the excavations were executed at the base of the slope, the Turkish Cut point did not enter a sliding process on the slope, as the resulting slope of the layers is discordant with the slope of the terrain, which made the reactive moment greater than the moment active, and the safety coefficient is superunitarian**.**

## REFERENCES

1. DIMA N., ș.a., 1999, Teoria erorilor și metoda celor mai mici pătrate, Ed., Univ., Petroșani.

2. NAȘ SANDA, MIRELA VĂCARU, 2010, Topografie noțiuni de teorie și aplicații, Ed., Argonit, Cluj-Napoca.

3. Ortelecan M. Pop N., 2005, Metode topografice de urmarire a comportarii constructiilor si terenurilor înconjuratoare, Ed., Academic Press.

4. Ghitau D., 1983, Geodezie si grvimetrie geodezică, Ed. Did. și Ped. București.

5. Dima N., 2005, Geodezie, Ed., Universitarias, Petroșani.

6.Ortelecan M., 2006, Geodezie, Ed. Academic Press.

7. Botez M. 1961, Teoria erorilor si metoda celor mai mici pătrate, Ed., Did. și Ped., București.