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ASPECTS REGARDING THE PROJECTION OF TOPOGRAPHIC ELEMENTS FROM THE TOPOGRAPHIC SURFACE ON THE REFERENCE SURFACE

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Abstract:

Projection of topographic elements from the topographic surface on the reference surface is a very important operation necessary because the field observations are reported at the geoid vertical by the position of the plumb line, while the calculus are performed on ellipsoid after the instrumental observation were projected on the reference ellipsoid after the normal direction to the ellipsoid. For the correction calculus of reduction on ellipsoid of geodetic observation is necessary the preliminary determination of the „N" geoid undulation and the deviation components of vertical line. There are several methods in which we can bring geodetic points of the topographic surface to the reference surface. Some of the methods are: the design method, the development method, the Pizzetti method, the Bruns-Helmert method.

Key words: *azimuth, corrections, ellipsoidal surface, topographic surface.*

INTRODUCTION

Ellipsoidal geodesy is that part from geodesy which is dealing with the study of ellipsoid rotation surface, reference, physics surface of Earth, and also is dealing with rigorous determination of shapes and dimensions to mathematical curve surface of the Earth (Dima, 2005).

All the geodetic measurements which are performed on the physics topographic surface of the Earth (which is considered of being the contact surface between land and atmosphere or land and water) must be reduced to geoid surface (Ortelecan, 2006).

When geodetic current measurements (trilaterations, triangulations, polygonometry) ,the geoid can be approximated with an rotation ellipsoid, flattened at the poles, having the big semi-axis (equatorial) approximately 6380 km. Also, for geodetic works of small precision, the geoid surface will be approximated too with the surface of a medium radius sphere equal to 6370 km.

Through ellipsoidal geodesy methods is determined precisely the coordinates of a punctual network from the Earth surface, basic points of first order with the help of which we can determine then the points of second, third and forth order necessary for obtaining the graphic representations on large surfaces (Ghiţău, 1997).

MATERIALS AND METHODS

Before being used in calculus, the geodetic observations reduce on ellipsoidal reference surface. This operation is necessary because the field observations are reported to geoid vertical , given by the position of plumb line, while the calculus are performing on ellipsoid after the instrumental observations were projected on the reference ellipsoid by the normal direction to the ellipsoid.

For the reducing calculation of geodetic observations on ellipsoid is necessary the preliminary determination of the 'N' geoid undulations and of deviation vertical components ξ,η. Bringing the geodetic support network , existing on physics Earth surface, on the ellipsoidal reference surface can be achieved through many methods like : the design method and the development method (Postelnicu and Coatu, 1980).

In the development method the measured elements on physics surface of the Earth are reduced to the geoid surface (to the sea level), which will be subjected to a compensation depending on the geometry triangulation network. This method introduces systematic calculation errors, which get bigger as get further of the fundamental point and as outcome it can be used only for areas relatively small, for which it can be admitted that the reference ellipsoid folds perfectly over the geoid surface.

The designed method consists on bringing the measured elements (angles, directions, lengths) on the reference ellipsoid surface through the application of some corrections. In this method are known two versions : Pizzetti and Bruns-Helmert. The Pizzetti method has no applicability because of the fact that the vertical curvatures are unknown. The Bruns-Helmert consist of the projection of the "P" point from the physics surface of the Earth in P' point after the normal direction to the ellipsoid . The differences which are obtained through the use of both methods are insignificant (Manualul inginerului geodez vol.II, 1973).

Further, will be treated only the angular observations on which will be applied the following corrections: The correction for reducing to the geodetic line and the correction due to the height of the sighted point.

a) The correction for reducing to the geodetic line (figure 1) is applied to make the transition from the direct normal section, through which is represented the observation line on the ellipsoid surface, to the geodetic line. Considering the 'AB' observation line on the Earth surface is represented on ellipsoid through the 'AB' normal section, which has the 'Am' azimuth, obtained from measurements. The geodetic line being 'Ac' azimuth, it requires to correct the direct normal section azimuth with a 'C1' correction (named the correction for reducing to the geodetic line):

$$C_1 = Am - Ac \Rightarrow Ac = Am - C_1$$

The expression of the angular value of the 'C1' correction has the following formula:

$$C_1 = \frac{e^2 \cdot s^2}{12 \cdot R_m^2} \cdot \rho^{\parallel} \cdot \cos^2 \varphi_m \cdot \sin 2Am$$

In which:

e2= the first excentricity

s= the distance between A and B in kilometers

Rm= the medium radius for the medium latitude φ_m

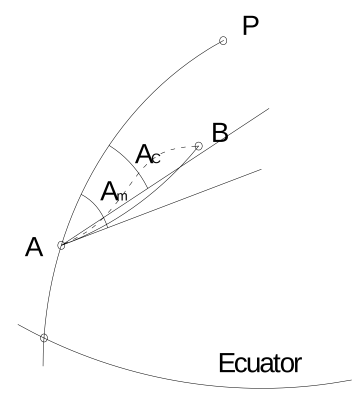

Figure 1- Reduction correction of the geodesic line

b) The correction due to the height of the sighted point (figure 2) is used because the points situated on the topographic surface have different heights, the observation lines are not included by the same level surface. Considering that 'A' is situated right on the ellipsoid surface (zero level surface) and 'B', the point to which the observation is made, will be on a certain level surface and it will have an 'H' height towards 'A'. The representation of ‘B’ on ellipsoid surface is made according to the normal direction to the ellipsoid which is passing through this point in ‘B1’.

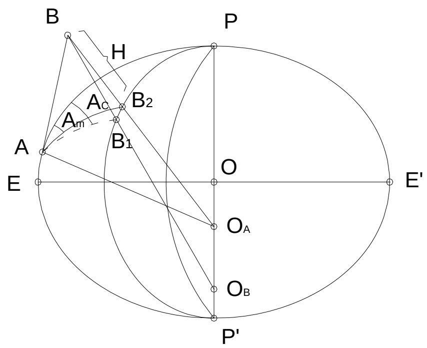

Figure 2 - The correction due to the height of the sighted point

Measuring the direction of the ’AB’ azimuth will be obtained the angle which is made by the normal direction section ’AB2’ with the meridian ’A’ point.

So having measured the ’Am’ angle must be dertminated ’Ac’ through the application of an ’C2’ correction named the correction due to the height of the sighted point.

$$Ac = Am + C_2$$

$$C_2 = \frac{e^2 \cdot H}{2M_2} \cdot \rho^2 \cos^2 \varphi_2 \cdot \sin 2Am$$

In which:

H- the height of the sighted point

M2- the small curvature radius in ’B’ with φ2 latitude

The correction due to the height of the sighted point is taken into consideration only if $H \geq 20m$.

c)The sides measured by electronic devices such as total stations (figure 3) are also processed preliminary through the application of physics corrections. The ’D’ distance resulting after this operation is situated to the level of the two points between the measurement was made. So, it is necessary the knowledge of ellipsoidal heights ’H1’ and ’H2’ and therefore the geoid undulations in these points (figure 4).

Figure 3. Total station

In the bellow figure is applied the generalized Pitagora ecuation resulting:

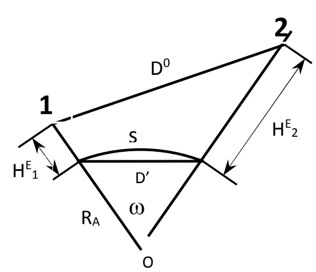

Figure 4. Reducing distances to reference surface

Developing the relation and introducing the notations:

$$(D^0)^2 = (R_A + H_1^E)^2 + (R_A + H_2^E)^2 - $$
$$- 2(R_A + H_1^E)(R_A + H_2^E)\cos\omega$$

$$\cos\omega = 1 - 2\sin^2\frac{\omega}{2};\quad D' = 2R_A\sin\frac{\omega}{2};\quad \Delta H_{12}^E = H_2^E - H_1^E$$

Is obtained:

$$(D^0)^2 = R_A^2 + 2R_A H_1^E + (H_1^E)^2 + R_A^2 + 2R_A H_2^E + (H_2^E)^2 -$$
$$-2(R_A + H_1^E)(R_A + H_2^E) + 4R_A^2(1 + \frac{H_1^E}{R_A})(R_A + \frac{H_2^E}{R_A})\sin^2\frac{\omega}{2} =$$
$$= (H_1^E)^2 - 2H_1^E H_2^E + (H_2^E)^2 + (1 + \frac{H_1^E}{R_A})(R_A + \frac{H_2^E}{R_A})(D')^2 =$$
$$= (\Delta H_{12}^E)^2 + (1 + \frac{H_1^E}{R_A})(R_A + \frac{H_2^E}{R_A})(D')^2$$

$$D' = \sqrt{\frac{(D_0)^2 - (\Delta H_{12}^E)^2}{\left(1 + \frac{H_1^E}{R_A}\right)\left(1 + \frac{H_2^E}{R_A}\right)}}$$

The lenght of the 's' arc which represents the lenght of the measured side reduced on the ellipsoidal surface is obtained with the following formula:

$$s = R_A\omega = 2R_A\frac{\omega}{2} = 2R_A arc\sin\frac{D'}{2R_A}$$

RESULTS AND DISCUSSIONS

We picked three points from the triangulation network from our city to exemplify the calculus of the correction for reducing to the geodetic line, the correction due to the height of the sighted point and the reducing of the measured sides by the electronic devices.

We know:

Point	x	y	z
Dl.Borzas	586099.15	399284.5	464.51
DL. Melic	586811.57	400084.26	401.14
DL. Criseni	585419.13	400957.18	478.19

The calculus steps are:

1. The transformation of degrees, minutes and seconds in radians
2. The calculus of the ellipsoidal reference parameters
3. The calculus of the distance

D1=10.7105477 km

D2=16.4343496 km

D3=18.0562609 km

4. The calculus of azimuth

A= θ+γ => A1=0.79734878694

A2=2.36543219489

A3= 5.15365918203

5. The calculus of medium radius:

Rm= $\sqrt{M * N}$ => Rm1=6333538.65

Rm2= 6237026.775

Rm3=6206286.737

M= $\frac{a(1-e^2)}{W^3}$

N= $\frac{a}{W}$

W= $\sqrt{1 - e^2 * \sin^2 B}$

6. The calculus of the radius after an azimuth:

Ra= $\frac{M*N}{N*\cos^2 A + M*\sin^2 A}$ =>

Ra1= 6335345.289

Ra2= 6229984.436

Ra3= 6343470.093

7. The calculus of corrections:

$$C_1 = \frac{e^2 \cdot s^2}{12 \cdot R_m^2} \cdot \rho^{\parallel} \cdot \cos^2\varphi_m \cdot \sin 2Am$$

C11=0.000000407

C1=-0.000001303

C31= -0.01323112

C12= 32.58069

C22= -45.934

C32= -26.0681

8. The calculus of the length of the chord

$$D' = \sqrt{\frac{(D_0)^2 - (\Delta H_{12}^E)^2}{\left(1 + \frac{H_1^E}{R_A}\right)\left(1 + \frac{H_2^E}{R_A}\right)}}$$

D1'= 1069.105

D2'= 1641.513

D3'= 1805.44

9.The calculus of the measured length side, reduced on the ellipsoidal surface

s= 2*Ra*arcsin$\frac{Di}{2*Ra}$ =>

s1= 1069.105

s2= 1641.513

s3= 1805.44

CONCLUSIONS

Analyzing the calculus performed above we came to the following conclusions: due to the fact that the distances among the three points (Dealul Borzaș, Dealul Melic și Dealul Crișeni) which are included between ten and eighteen kilometers, the correction for reducing to the geodetic line may not be taken into consideration because the corrections resulted after the application of calculus do not fit into the given criteria, since these are too small.

Also, because of the fact that the altitude of the three points are bigger than 20 meters we applied the correction due to the height of the sighted point. It can be observed significant differences among the corrections, so we can say that the observation lines are included by the different level surfaces.

Furthermore, through the reducing of the measured sides performed with electronic devices we can notice that it is not necessary the knowledge of the vertical deviations among the points because the obtained results for the chord length (D') and also for the arc length (s) are equal.

In conclusion, the projection of topographic elements from the topographic surface on the reference surface require a laborious calculation, therefore the final results are more accurate, so closer to the reality.

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