Buletinul Ştiinţific al Universităţii "POLITEHNICA" din Timişoara

Seria HIDROTEHNICA
TRANSACTIONS on HYDROTECHNICS

Tom 55(69), Fascicola 1, 2010

Considerations regarding operation of tracing the constructions objectives

* Doandeş Victor ** Popescu Daniela

Abstract – It presents the method of selection surveying equipment for tracing operation horizontally and vertically, depending on the desired accuracy

Keywords: surveying equipment, tracing, errors, angles, distances

1.INTRODUCTION

Transposition of a construction project in the field consists in determination, materialization and defining the location and tracking features of the building axes.

When tracing the designed buildings in the field, considering geometric elements of connection: distances, angles, rectangular coordinates, elevations, which are determined by the implemented construction project.

Connecting elements are established toward geodetic networks and topographic points of the area, points or alignments of neighboring buildings, details of enclosures with natural character, etc.

Drawing building objectives is made in stages:

-Projection plotting;
-network-plotting application in the field;
-Field-plotting of the objectives which have to be built;
-Reception of tracing works;

Operation implies plotting the horizontal plan, calling on proper equipment and vertical-plan plotting, also with proper equipment.

Most times, tracing operation depends on the provided equipment, which may be of class "classical" or class "modern."

Whatever the equipment is used an indispensable condition must be fulfilled: there should be accuracy in plotting within the admitted tolerance.

In general, items that need to be drawn are: angles, distances and elevations. By combining these elements, appropriate tracing methods in the field, have to be addressed.

2. MAIN SOURCES OF ERRORS IN TRACING OPERATION

2.1. Tracing the horizontal angles

2.1.1. With telescope in position I

The method applies when the precision required is small (1c ÷ 3c) and the theodolite was recently checked and corrected, in this case, instrumental errors can be known. Apply to temporary constructions.

The main sources of errors affecting the observation of one direction (AB) or (AN) are:

a). E_1 = centering error of the device at point A:

$$E_1 = (e_c \cdot \rho^{cc})/D \qquad (1)$$

where:

e_c = (5-10) mm → centering with plumb wire.
e_c = (3-5) mm→ centering with centering stick.
e_c = (1-3) mm→ optical centering device.
D = minimum value between D_{AB} and D_{AN}

b). E_2 = influence of eccentricity of signal from point B or the error of marking point N:

$$E_2 = (e_s \cdot \rho^{cc}) / D \text{ , where:} \qquad (2)$$

e_s = (10-15) mm → beacon signal
e_s = (1-5)mm → metal card signal.

c). E_3 = influence of targeting and reading error on the radius (calibrated dial):

$$E_3 = \sqrt{\left(\frac{200^{cc}}{M}\right)^2 + \left(\frac{p}{2}\right)^2} \qquad (3)$$

where: M = magnification of the telescope;
p = accuracy of the reading device.

For common instruments we have:

THEO – 080 (M = 16 , p = 1^c) ; THEO – 020 (M = 25 , p = 25^{cc}) ;
THEO – 010 (M = 30 , p = $0,5^{cc}$).

d). E_4 = influence of the instrumental errors:

*,**Faculty of Hydrotechnical Engineering Timisoara, CHIF Department, George Enescu Str. No. 1/A, 300022 Timisoara, E-mail: victordoandes@yahoo.com

$$E_4 = \sqrt{\varepsilon_G{}^2 + \varepsilon_c{}^2 + \varepsilon_v{}^2 + \varepsilon_y{}^2} \quad (4)$$

where: ε_G = error of calibrated dial and of the reading device, which can be considered $\varepsilon_G = \pm 10^{cc}$

ε_c = influence of the error of collimation k on one reading: $\varepsilon_c = k \cdot \sec\varphi$

$k = 0{,}5[(C_{II} - C_I - 200^g)]$; C_I , C_{II} represents readings on the horizontal circle with telescope about horizontal, with vertical circle to the left and right; φ = angle of inclination of telescope.

ε_v = influence of the error of deviation from verticality of the axis of the reading the calibrated dial circle; $\varepsilon_v = \varepsilon_{VB} \cdot tg\,\varphi$; ε_{VB} = (0,1-0,2) of the sensitivity of the level on the alidad circle (when use old devices)

ε_y = influence of the error of inclination i of the axis (Y-Y); $\varepsilon_y = i\ tg\ \varphi$ of the axis of targeting with the vertical plan of the point target. If the distance between the two points is l, then $i^{cc} = (l.\ \rho^{cc})/2h$

e). E_5 = environmental influence by lateral refraction, uneven heating of the device, reduced visibility and influence of the wind. $E_5 \le 15^{cc}$ (device with protection against uneven heating and normal visibility conditions).

Assigning the five components an accidental nature, results the root mean square error of the observed direction:

$$E_{dir} = \sqrt{E_1^2 + E_2^2 + E_3^2 + E_4^2 + E_5^2} \quad (5)$$

and accepting the principle of equal influences:

$$E_{dir} = E_0\sqrt{5} \quad (6)$$

Mean square error of a plotted angle will be:

$$E_w = E_{dir}\sqrt{2} = E_0\sqrt{10} \quad (7)$$

Given the imposed accuracy of plotting: $E_w \le E_{lim}$, will result:

$$E_0 \le \frac{E_{\lim}}{\sqrt{10}} \quad (8)$$

relationship which may specify the technical conditions of plotting.

2.1.2. With both positions of the telescope (position I + position II)

By plotting with both positions of the telescope a part of the instrumental errors will be eliminated, so it is recommended when they cannot be assessed.

$$E_0 \le \frac{E_{\lim} - \varepsilon_G}{\sqrt{8}}$$

$$E_{dir} = E_0\sqrt{4} = \sqrt{E_1^2 + E_2^2 + E_3^2 + E_5^2} \quad (9)$$

2.2. Direct tracing of the distances

Use measuring tapes or ribbons placed directly on the ground. In this case, first will be calculated the inclined distance which mast be applied in the field (depending on slope angle "φ", the zenithal angle "Z" or the level difference "$\Delta H_{i,i+1}$").

$$D_i = \sqrt{d^2{}_0 + \Delta H^2{}_{i,i+1}} \quad ,or: D_i = \frac{d_0}{\cos\varphi} \quad ;D_i = \frac{d_0}{\sin Z} \quad , \quad (10)$$

where:

Di = the inclined distance that has to be plotted in the field [m];

d_0 = projected horizontal distance, [m];

$\Delta H_{i,i+1}$ = the difference of level between the ends of the distance [m];

φ = slope [grades]; Z = zenithal angle [grades]

The main sources of errors which affects the plotting of a distance with steel measuring tape, are:

a). influence of the error when determining the level difference ($e_{\Delta H}$):

$$E_{\Delta H} = (e_{\Delta H}{}^2 / 2\ .d_0) \quad (11)$$

b). influence of calibration error (e_e):

$$E_E = (d_0\ .\ e_e) / l_e \quad (12)$$

c). influence of temperature measurement error (e_t):

$$E_T = 0{,}0000125.d_0\ .\ e_t \quad (13)$$

d). influence of the error of deviation from the alignment (a):

$$Ea = \frac{a^2}{2l_e}\left(4\frac{d_0}{l_e} - 3\right) \quad (14)$$

e). influence of the error of sequence (e_i):

$$E_i = e_i\sqrt{\frac{d_0}{l_e}} \quad (15)$$

f). Influence of the actual tensile force (Fr) to the calibration tensile strength (Fe):

$$E_F = \frac{(Fr - Fe)l_e}{E.S}\sqrt{\frac{d_0}{l_e}} \quad (16)$$

where: E = 21000 Kgf/mm^2 and S = measuring tape cross section

g). Influence of the measuring tape up arrow (h) :

$$E_h \cong \frac{8h^2 d_0}{3l_e^2} \quad (17)$$

Given the systematic and accidental character of the component main errors, the total mean square error may be written under the following form:

$$E_D = E_E + E_a + E_h + \sqrt{E_{\Delta H}^2 + E_T^2 + E_i^2 + E_F^2} \quad (18)$$

or, the principle of equal influences is to be addmitted:

$$E_D = E_0(n_s + \sqrt{n_a}) = E_0(3 + \sqrt{4}) = 5.E_0\,. \quad (19)$$

Condition $E_D = E_{em}$ provides determining parameters of the tracing.

Depending on the precision required and of the tracing conditions will choose the device and method may lead to expected result.

2.3. Tracing on vertical plane

The main sources of errors when tracing on vertical plane are:

a). reading error on the levelling rod:

$$E_C = \frac{D_p.10^{-4}}{0,25.M} \quad (20)$$

where: D_p = size of lengts in meters, M = magnification of telescope;

b). Error of horizontal deviation of the sighting line (guide line):

$$E_N = \frac{D_p.S^{cc}}{10.\rho^{cc}} \quad (21)$$

where: S = sensitivity of the levelling staff, ρ = 636620;

c). Reading error on staff due to thickness of the spider lines:

$$E_F = 5.10^{-6} . D_p \quad (22)$$

d). Rounding errror of the scale marks of the staff:

$$E_R \approx \pm 0,5 \text{ mm} \quad (23)$$

e). Tracing error of the scale marks of the staff:

$$E_D = 0,25 \text{ mm} \quad (24)$$

f). Error due to spherical shape of the Earth: E_S =

$$\frac{\Delta D_p^2}{2.R} \quad (25)$$

where: ΔD_p = difference between the two lenghts, R = 6400 km;

g). Error due to parallel missalignment between the sighting line and the axis of the levelling staff

$$E_i = \frac{\varepsilon^{cc}.\Delta D_p}{\rho^{cc}} \quad (26)$$

where :

$$\varepsilon = \frac{\Delta H_m - \Delta H_c}{D}.\rho^{cc} \quad (27)$$

h). The plotting error for point E_m depends on the tracing method and can have values between 0,5 to 1 mm.

Taking account of the nature of the component errors, the total error shown when tracing a level difference is:

$$E_{\Delta H} = E_S + E_i + \sqrt{2(E_C^2 + E_N^2 + E_F^2 + E_R^2 + E_D^2 + E_m^2)} \quad . \quad (28)$$

$$E_{\Delta H} = 2.E_0 + E\sqrt{12} \quad (29)$$

For an imposed value $E_{\Delta H}$ resulting E_0 through which tracing parameters (device and method) can be determined.

3. CONCLUSION ON TRACING OPERATION

- All devices (equipment) have to be checked and corrected;
- Ribbons and tapes must have length stated on them, not to be torn, not to be riveted and must be checked;
- Leveling rods used for tracing must be checked from the point of view of scale marks and be endowed with spirit levels for the vertical set up.
- Prior to tracing operation it will check the planimetric and elevation position of the points in the support network towards the tracing is performed.
- When tracing angles use devices with $p_s \geq 1^C$ and pay particular attention when centering in the standing point (optical centering) and also, centering the signal from the other point of the tracing network (when high precision is required it is recommended to use sighting targets).
- Marking of points to be made with greater precision: steel pickets, nails, surveying rods with nails, pencil marking, etc. Avoid long distance tracing. In order to plot levels it is recommended geometrical leveling from the middle with less than 50 meters lengths.
- Any tracing should be accompanied by verification operation immediately after the marking points are marked.
- When using electronic equipment, to draw distances will verify the measuring accuracy to comply with standards in force, in order to comply within the tolerances allowed for tracing.

4. REFERENCES :

[1].V.Doandeş, Topografie, Ed.Politehnica, 2008

[2].V.Doandeş, Topografie Specială, Ed.Politehnica, 2002

[3].Îndrumătorul privind executarea trasării de detaliu în construcții,indicativ C.83-75