LECTURE NOTE

ON

LAND SURVEY-II **(TH.1)**

6TH SEMESTER IN CIVIL ENGG.

PREPARED BY

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-: TACHEOMETRY :-

→ It is a branch of surveying in which horizontal and vertical distances are determined by taking angular observation with an instrument known as tacheometer.

→ This surveying is adopted in rough and difficult terrain where direct levelling and chaining are either not possible or very tedious.

→ This surveying is very rapid and a reasonable contour map can be prepared for investigation works within a short time on the basis of such survey.

Objectives :- Tacheometry is the preparation of contour maps or plans requiring both the horizontal as well as vertical control. Also, on surveys of higher accuracy, it provides a check on distances measured with the tape.

Uses :

1. Preparation of topographic map where both horizontal and vertical distances are required to be measured.
2. Survey work in difficult terrain where direct methods of measurements are inconvenient;
3. Reconnaissance survey for highways and railways, etc.
4. Establishment of secondary control points.

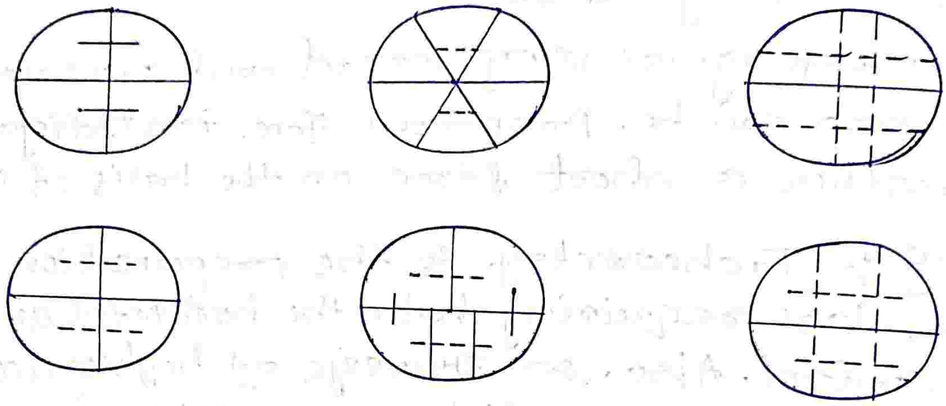
Tacheometric Surveying Instruments :-

Tacheometric surveying is done with the help of Tacheometer and Stadia Rod.

1. Tacheometer
2. Stadia Rod
3. Anallatic lens.

1. Tacheometer :- A transit theodolite fixed with special stadia diaphragm is known as tacheometer. It is the main instrument of tacheometric surveying. Its telescope contains two horizontal hairs called stadia hairs in addition to the regular crosshair.

The stadia hairs are equidistance from the central cross-hairs and they are specially termed as stadia lines or stadia webs. The common types of stadia diaphragms are shown below :



2. Stadia Rod :- For small distances (up to 100 meters) a level staff may be used for tacheometric surveying. But for greater distances stadia rod is needed. Stadia rod is of one piece having 3 to 5 meter length. The smallest subdivision is usually 5 mm.

3. Anallatic Lens :- It is an additional lens used in the instrument. It is a special lens which is placed between the object glass and the eyepiece of the telescope inorder to eliminate the additive constant. (f+d). This is done to make the expression for the distance between instrument station and staff position more simplified. The lens is only provided in an external focusing telescope but not in the internal focusing.

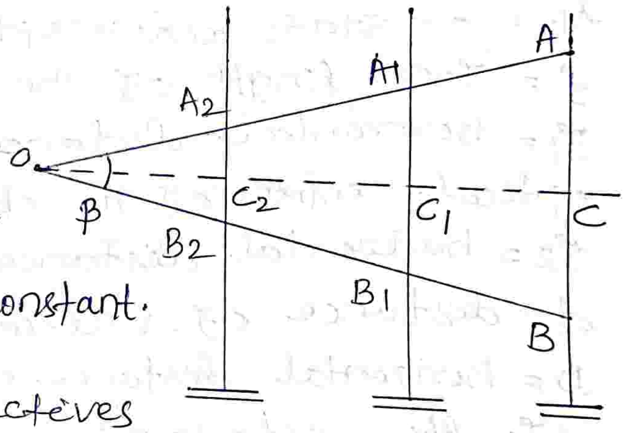
Features of Tacheometer :-

1. Multiplying constant value of 100 and additive constant zero.
2. Axial horizontal line should be exactly midway between the other two lines.
3. Telescope should be truly anallatic.
4. Telescope should be powerful, having a magnification of 20 to 30 diameters.

5. Aperetutree of the objective should be 35 to 45mm in diameter to have a bright image.
6. For small distances (upto 100 meters), ordinary levelling staff may be used, for greater distances a stadia rod may be used.
7. A stadia rod is usually of one piece, having 3 to 5 meter length.
8. A stadia rod graduated in 5 mm (i.e, 0.005 m) for smaller distances and while for longer distances, the rod may be graduated in 1cm (i.e, 0.01m).

Principle of stadia method :-

The stadia method is based on the principle that the ratio of the perpendicular to the base is constant in similar isosceles triangles. Two rays OA and OB be equally inclined to central ray OC. Let A_2B_2, A_1B_1 and AB be staff intercepts.



From the figure we can write,

$$\frac{OC_2}{A_2B_2} = \frac{OC_1}{A_1B_1} = \frac{OC}{AB} = \frac{f}{i} = K$$

where $\frac{f}{i} = K$ is multiplying constant.

f = focal length of the objectives

i = interval between the stadia hairs (stadia interval)

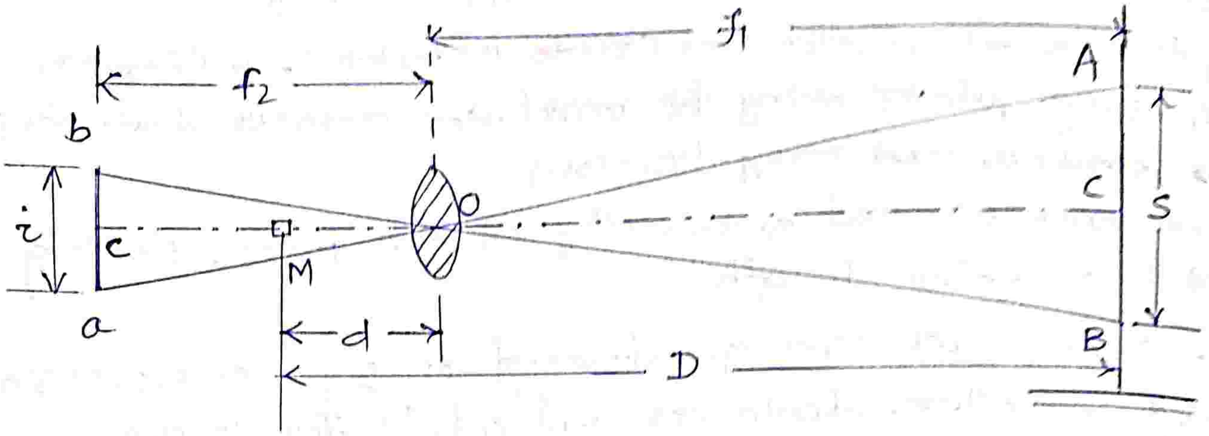
This constant K entirely depends upon the magnitude of the angle β.

→ In actual practice, observations may be made with either horizontal line of sight or with inclined line of sight.

→ In later case the staff may be kept either vertically or normal to the line of sight.

→ First the distance-elevation formula for the horizontal sights should be derived.

Horeizontal sights:



Considere the figuree, in which O is the optical centree of the objective of an exterenal focusing telescope.

Let A, C and B aree the points cut by the three lines of sight correesponding to three wirees. b, c and a aree the top, axial and bottom hairs of diaphragm.

ab = i = interval between the stadia hairs. (stadia intervals)

AB = s = staff intercept

f = focal length of the objective.

f_1 = horizontal distance of the staff from the optical centree of the objective

f_2 = horizontal distance of the creoss-wirees from O.

d = distance of vertical axis of instrument from O

D = horizontal distance of staff from vertical axis of the instruments.

M = Centree of the instrument, corresponding to the vertical axis.

Since the rays BOb and AOa pass through the optical centre, they aree straight so that AOB and aOb aree similare, Hence,

$$\frac{f_1}{f_2} = \frac{S}{i}$$

Again since, f_1 and f_2 aree conjugate focal distance we have from lens formula,

$$\frac{1}{f} = \frac{1}{f_2} + \frac{1}{f_1}$$

Multiplying throughout by ff_1, we get $f_1 = \frac{f_1}{f_2} f + f$
Substituting the values of $\frac{f_1}{f_2} = \frac{S}{i}$ the above equation we get, $f_1 = \frac{S}{i} f + f$
Horizontal distance between the axis and the staff is $D = f_1 + d$

$$D = \frac{f}{i} S + (f+d) = K \cdot S + C$$, this equation is known as the distance equation.

The constant $K = \frac{f}{i}$ is known as the multiplying constant or stadia interval factor and the constant $(f+d) = C$ is known as the additive constant of the instrument.

Determination of constant K and C :

1st Method :- This is the laboratory method. In this method, the additive constant $C = (f+d)$ is measured from the instrument while the multiplying constant K is computed from field observation.

1. Focus the instrument to a distant object and measure along the telescope the distance between the objective and cross-hairs.

$$\frac{1}{f} = \frac{1}{f_1} = \frac{1}{f_2}$$

2. The distance d between the instrument axis and the objective is variable in the case of external focusing telescope, being greater for short sights and smaller for long sights. It should, therefore be measured for average sight. Thus the additive constant $(f+d)$ is known.
3. To calculate the multiplying constant K, measure a known distance D_1 and take the intercept S_1 on the staff kept at that point, the line of sight being horizontal. Using the equation,

$$D_1 = KS_1 + C \quad \text{or} \quad K = \frac{D_1 - C}{S}$$

For average value, staff intercepts, S_2, S_3, etc can be measured corresponding to distance D_2, D_3, etc can mean value can be calculated.

2nd Method :- In this method, both the constants are determined by field observations as under:-

1. Measure a line about 200m long, on fairly leveled ground and drive pegs at some interval, say 50 meters.
2. Keep the staff on the pegs and observe the corresponding staff intercepts with horizontal sight.
3. Knowing the values of D and s for different points, a number of simultaneous equation can be substituting the values of D and s in equation $D = ks + c$. The simultaneous solution of successive pairs will give the values of k and c, and the average of these can be found.

For example, if S_1 is the staff intercept corresponding to distance D_1 and S_2 corresponding to D_2 we have,

$$D_1 = kS_1 + C \quad \text{—— (I)} \quad \text{and} \quad D_2 = kS_2 + C \quad \text{—— (II)}$$

Subtracting (I) from (II) we get,

$$k = \frac{D_2 - D_1}{S_2 - S_1} \quad \text{—— (1)}$$

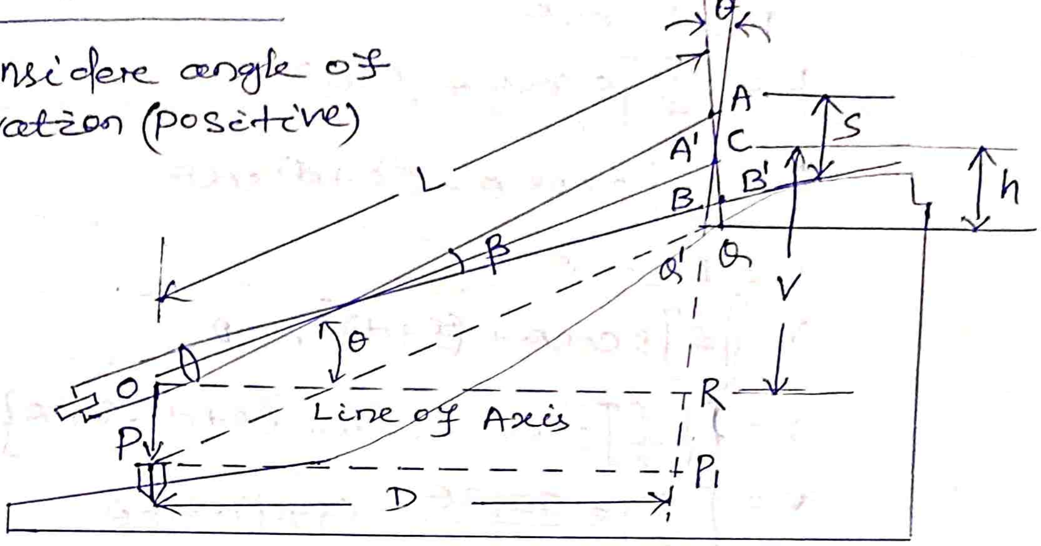
Substituting the value of k in (I), we get,

$$C = D_1 - \frac{D_2 - D_1}{S_2 - S_1} S_1 = \frac{D_1 S_2 - D_2 S_1}{S_2 - S_1} \quad \text{—— (2)}$$

Thus equation (1) and (2) give the values of k and C.

Expression of Horizontal distance and vertical Elevation, if line of sight is inclined and staff is held vertical :-

Case-(i) Consider angle of elevation (positive)



(Line of sight is inclined and staff held vertical)

Let P = Instrument station; Q = Staff station

M = Position of instruments axis;

O = optical centre of the three hairs.

S = AB = Staff intercept ; i = stadia interval

θ = Inclination of line of sight from the horizontal

L = Length OC measured along the line of sight.

D = OR = Horizontal distance between the instrument and staff.

V = Vertical intercept at Q between the line of sight and the horizontal line.

h = height of the instrument;

r = central hair reading

β = Angle between two extreme rays corresponding to stadia hairs.

Draw a line A'CB' normal to line of sight OC. Angle AA'C = $90^\circ + \beta/2$, being the exterior angle of the Δ COA'

Similarly, from Δ COB', angle OB'C = angle BB'C = $90^\circ - \beta/2$

Since $\beta/2$ is very small (its value = 17'11" for k = 100)

$\angle AA'C$ and $\angle BB'C = 90^\circ$

from Δ ACA', $A'C = AC\cos\theta$ or $A'B' = AB\cos\theta = S\cos\theta$

Since line A'B' is perpendicular to line of sight OC, equation $D = ks + c$ is directly applicable.

We have, $S' = AC\cos\theta + BC\cos\theta$

$S' = (AC + BC)\cos\theta$

$S' = S\cos\theta$

$D = L\cos\theta$

$L = \left[\frac{f}{i}\right] s\cos\theta + (f+d)$

$D = \left[\frac{f}{i}\right] s\cos^2\theta + (f+d)\cos\theta$

$V = L\sin\theta$

$V = \left\{\left[\frac{f}{i}\right] s\cos\theta + (f+d)\right\}\sin\theta$

$V = \left\{\left[\frac{f}{i}\right] s\cos\theta\cdot\sin\theta + (f+d)\cdot\sin\theta\right\}$

$V = \left[\frac{f}{i}\right] s\,\frac{\sin 2\theta}{2} + (f+d)\cdot\sin\theta$

* If line of sight is inclined upwards = H.I. of instrument axis + V − h
* If line of sight is inclined downwards = H.I. of instrument axis − V − h.

Case-(ii) Consider angle of depression (negative).

$L = \left(\frac{f}{i}\right) s\cos\theta + (f+d)$

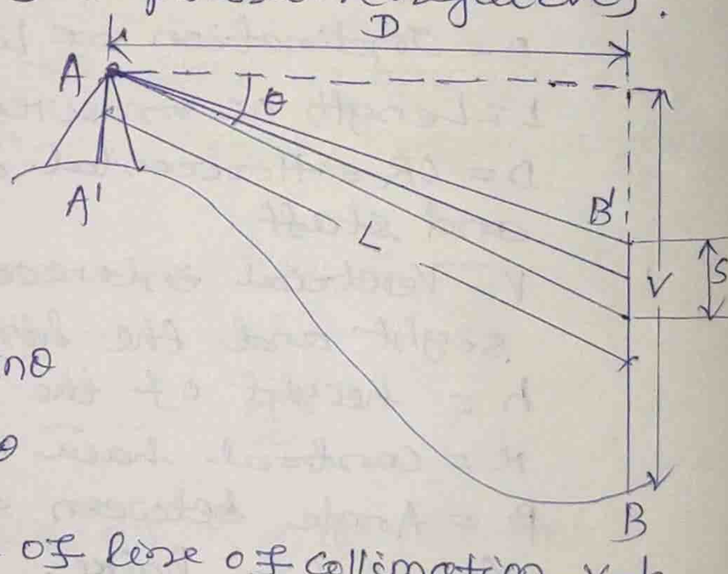
$D = L\cos\theta$

$D = \frac{f}{i} s\cos^2\theta + (f+d)\cos\theta$

$V = L\sin\theta$

$V = \left(\frac{f}{i}\right) s\cos\theta\cdot\sin\theta + (f+d)\sin\theta$

$V = \left(\frac{f}{i}\right) s\,\frac{\sin 2\theta}{2} + (f+d)\sin\theta$



R.L of staff station = RL of line of collimation − V − h