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MINE SURVEYING

TAPE CORRECTIONS

Following corrections are applied to the measured distances

Correction for Standardisation

The correction is required if the true length (actual length, on site length) of the tape is not equal to the nominal length (factory length, designated length).

Correction per tape length (C) = l' – l

where l is nominal(designated, factory length) length of the tape and l' is actual length(on site) of tape.

The correction is positive when the actual length (l') is greater than the nominal length (l) and vice versa.

Total correction in measured distance

$$C_a = \frac{(l' - l)}{l} \text{ x } L = \frac{C \text{ x } L}{l}$$

Correction for Slope

Correction $C_g = D - L = -L(1 - \cos\theta) = -2L \sin^2\theta/2$

where D = horizontal equivalent, L = slope distance and θ is angle of slope.

Alternatively $C_g = \sqrt{(L^2 - h^2)} - L$

where h is difference in elevation of the end points.

Correction for Pull

The correction for pull (C_p) is given by

$$C_p = \frac{(P - P_0)L}{AE}$$

where P is pull applied during measurement (N), P_0 is standard pull (N), L is measured length, A is cross sectional area of the tape and E is Young's modulus of elasticity (for steel E = 2 x 10^5 N/mm^2 or 2 x 10^5 MPa).

If the pull applied at the tape is greater than the standard pull, the actual length (on site) of the tape is greater than the nominal length (factory length), and a *positive* correction is required.

Correction for Temperature

The temperature correction is given by

$$C_t = \alpha(T - T_0)L$$

where α is coefficient of linear expansion, T is mean temperature of the tape (^{0}C) and T_0 is standard temperature (^{0}C). The sign of C_t is directly given by above equation.

For steel tapes, $\alpha = 1.15 \times 10^{-15}$.

Correction for Sag

Correction for sag is given by

$$C_s = -\frac{l_1(wl_1)^2}{24P^2}$$

where w is weight of tape per unit length (N/m), P is applied pull (N) and l_1 is length of the tape suspended between the supports (m).

The above equation can also be written as

$$C_s = \frac{l_1 W_1^2}{24P^2}$$

where W_1 = total weight of the tape between supports.

The sag correction is *always* negative.

If the tape is suspended between the supports is pulled by a large force, there is a decrease in the sag and an increase in the length of the tape because of tension applied. Normal tension (P_n) is the theoretical pull at which the pull correction is numerically equal to the sag correction.

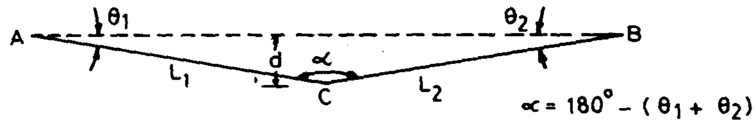
$$\frac{(P_n - P_0)l_1}{AE} = \frac{l_1 W_1^2}{24P_n^2}$$

or $$P_n = \frac{0.204 W_1\sqrt{AE}}{\sqrt{p_n - P_0}}$$

This equation can be solved by trial and error.

Correction for Misalignment

If the survey line is not accurately ranged out, the error due to misalignment occurs. The measured distance is always greater than the correct distance, and hence the error is positive and the *correction is negative*.



The correction due to misalignment is given by

$$C_m = (L_1 \cos\theta_1 + L_2 \cos\theta_2) - (L_1 - L_2)$$

or $$C_m = \sqrt{L_1^2 + L_2^2 - 2L_1L_2\cos\alpha} - (L_1 + L_2)$$

or $$C_m = \left[\sqrt{L_1^2 - d^2} + \sqrt{L_2^2 - d^2}\right] - (L_1 + L_2)$$

Correction for Local Scale Factor

A short traverse on a plane surface can be easily represented on a plan with grid lines without any apparent distortion, but in the case of larger areas the curvature of the spherical surface of earth greatly affect the actual shape of the map. Objects on the curved surface of earth can not be represented on a flat sheet of paper in the same relative positions which they occupied on the globe. A slight difference between the grid distances occurs because the meridians converge and the grid lines are drawn parallel to one central meridian. Therefore, in precise surveys of larger areas the distances computed from coordinate will require a correction by a factor known as "local scale factor". The value of the local scale factor will vary with geographical position and depending upon the departure east or west from the central meridian.

Example

What is normal pull ? Show that for a chain of 3 mm^2 area and 0.48 Kg weight ($E = 2x10^6$ Kg/cm^2) Standardised at 8 Kg tension, the normal pull is 12 Kg.

Solution

The pull which when applied to a tape supported in air over two ends equalizes the correction due to pull and the correction due to sag is known as normal pull.

The correction for pull = c_1 = $(P - P_0)/AE$ (+ ve)

The correction for sag $c_2 = LW^2/24P^2$ (-ve)

equating numerically the two equations , we get

$$(P-P_0)/AE = LW^2/24P^2$$

$$P = (0.204W\sqrt{AE} / \sqrt{(P-P_0)}$$

The value of normal pull `P' is determined by trial and error with the help of above equation.

Area $A = 3\ mm^2 = 0.03\ cm^2$

$E = 2 \times 10^6$ Kg/cm^2

W - 0.48 Kg,   P0 = 8 Kg

to prove P = 12 Kg

$P = 0.204 \times 0.48\sqrt{(0.03 \times 2 \times 10^6)} / \sqrt{(12 - 8)}$

$= 11.993 = 12$ Kg   Hence Proved.

Example

An mining land was measured with an incorrect 30 m chain and a plan was drawn. From these measurements the area on the plan was measured and calculated and was found to be 16.25 km^2. Find to correct area of the mining land, if the length of the chain was 30.06 m.

Solution

True area = $(L/30)^2 \times 16.25$ km^2 = $(30.06/30)^2 \times 16.25$ km^2 = 16.315 km^2

Example

A steel tape of nominal length 30 m was used to measure a line AB by suspending it between supports. If the measured length was 29.861 m when the slope angle was $3^0 45'$, and the mean temperature and tension applied were respectively 10^0C and 100 N, determine the corrected horizontal length.

The standard length of the tape was 30.004 m at 20^0C and 44.5 N tension. The tape weighted 0.16 N/m and had a cross-sectional area of 2 mm^2. $E = 2 \times 10^5$ N/mm^2. $\alpha = 1.12 \times 10^{-5}$ per ^{0}C.

Solution

Slope correction

$= -L(1 - \cos\theta)$

$= -29.861\,(1 - \cos 3^0 45')$

$= -0.064$ m

Standardisation correction

$$= Lx\left(\frac{l' - l}{l}\right)$$

$$= 29.861\left(\frac{30.004 - 30.000}{30.000}\right) = +0.004\,m$$

Temperature correction

$$= \alpha(T - T_0)L$$

$$= 1.12x10^{-5}(10 - 20)x29.861 = -0.003m$$

Pull correction

$$= \frac{(P - P_0)L}{AE}$$

$$= \frac{(100 - 44.5)x29.861}{2x2x10^5} = +0.004m$$

Sag correction

$$= \frac{w^2 l_1^3}{24P^2}\cos^2\theta$$

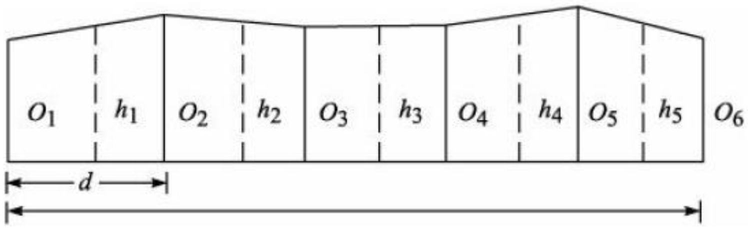
$$= \frac{-(0.16)^2 x(29.861)^3 x\cos^2 3^0 45'}{24x(100)^2} = -0.003m$$

Total correction = - 0.064 + 0.004 - 0.003 + 0.004 - 0.003 = - 0.062

Correct horizontal distance = 29.861 – 0.062 = 29.799 m

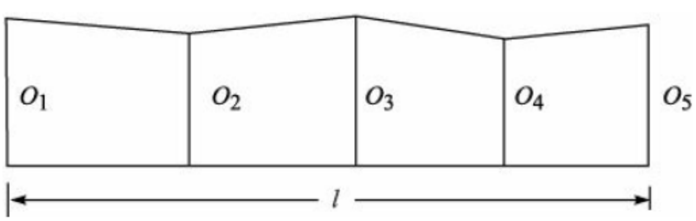
COMPUTATION OF AREA

Mid-ordinate Rule



Area = Common distance × sum of mid-ordinates

Average-ordinate Rule



Area = (sum of ordinates/no. of ordinates) x length of base line

Example

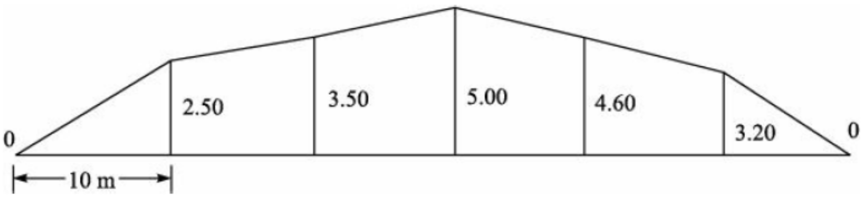
The following offsets were taken from a chain line to an irregular boundary line at an interval of 10 m:

0, 2.50, 3.50, 5.00, 4.60, 3.20, 0 m

compute the area between the chain line, the irregular boundary line and the end offsets by (i) the mid-ordinate rule (ii) average ordinate rule.

Solution

Figure



Mid ordinate rule

$h_1 = (0 + 2.50)/2 = 1.25$ m; $h_2 = (2.50 + 3.50)/2 = 3.00$ m;

$h_3 = (3.50 + 5.00)/2 = 4.25$ m; $h_4 = (5.00 + 4.60)/2 = 4.80$ m

$h_5 = (4.60 + 3.20)/2 = 3.90$ m; $h_6 = (3.20 + 0)/2 = 1.60$ m

Required area = 10(1.25 + 3.00 + 4.25 + 4.80 + 3.90 + 1.60) = 10 × 18.80 = 188 m^2

Average ordinate rule

Here, d = 10 m and n = 6 (no. of divisions)

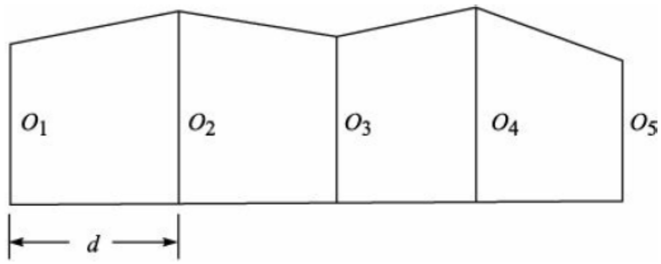
Base length = 10 × 6 = 60 m

Number of ordinates = 7

Required area = $60\,x\left(\frac{0+2.50+3.50+5.00+4.60+3.20+0}{7}\right)$ = 161.14 m^2

Trapezoidal Rule

While applying the trapezoidal rule, boundaries between the ends of ordinates are assumed to be straight. Thus the areas enclosed between the base line and the irregular boundary line are considered as trapezoids.



Total area = (d/2)(1st ordinate + last ordinate + 2 x sum of other ordinates)

Simpson's rule

Total area = (d/3)(1st ordinate + last ordinate + 4 x sum of even ordinates + 2 x sum of remaining odd ordinates)

Limitation This rule is applicable only when the number divisions is even, i.e. the number of ordinates is odd.

☞ Sometimes one, or both, of the end ordinates may be zero. However, they must be taken into account while applying these rules.

Example

The following offsets were taken at 15 m intervals from a survey line to an irregular boundary line:

3.50, 4.30, 6.75, 5.25, 7.50, 8.80, 7.90, 6.40, 4.40, 3.25 m

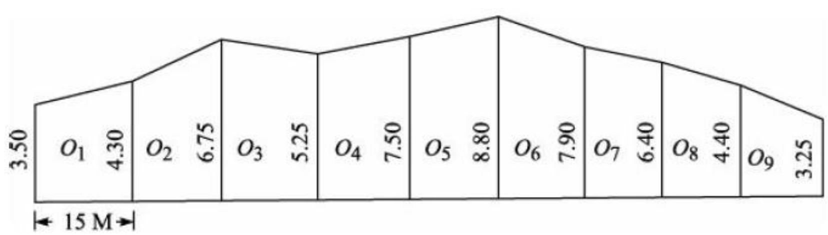
Calculate the area enclosed between the survey line, the irregular boundary line, and the first and last offsets, by

(a) The trapezoidal rule

(b) Simpson's rule

Solution

Figure



Trapezoidal Rule

Required area

$=(15/2)\{3.50 + 3.25 + 2(4.30 + 6.75 + 5.25 + 7.50$
$+ 8.80 + 7.90 + 6.40 + 4.40)\} = (15/2)\{6.75 + 102.60\} = 820.125\ m^2$

Simpson's Rule

If this rule is to be applied, the number of ordinates must be odd. But here the number of ordinate is even (ten).

So, Simpson's rule is applied from O_1 to O_9 and the area between O_9 and O_{10} is found out by the trapezoidal rule.

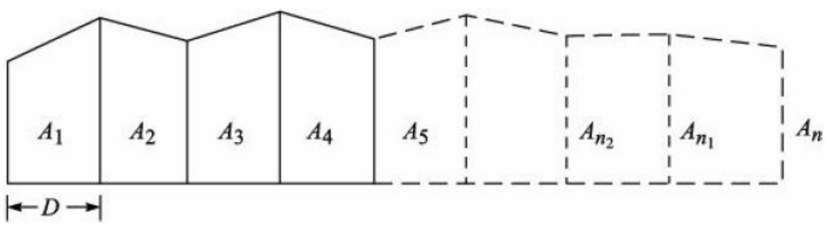
$A_1 = (15/3)\{3.50 + 4.40 + 4(4.30 + 5.25 + 8.80 + 6.40) + 2(6.75 + 7.50 + 7.90)\}$
$= (15/3)\{7.90 + 99.00 + 44.30\} = 756.00\ m^2$

$A_2 = (15/2)\{4.40 + 3.25\} = 57.38\ m^2$

Total area $= A_1 + A_2 = 756.00 + 57.38 = 813.38\ m^2$

COMPUTATION OF VOLUME

Calculation of Volume by trapezoidal rule



Volume = (Common distance/2) x {area of first section + area of last section
+ 2 (sum of area of other sections)}

Calculation of Volume by Prismoidal rule

V = (common distance/2) {area of first section + area of last section + 4(sum of areas of even sections) + 2 (sum of areas of odd sections)}

☞ *The prismoidal formula is applicable when there are an odd number of sections. If the number of sections is even, the end strip is treated separately and the area is calculated according to the trapezoidal rule. The volume of the remaining strips is calculated in the usual manner by the prismoidal formula. Then both the results are added to obtain the total volume.*

Example

The areas enclosed by the contours in a lake are as follows:

Contour (m)	*270*	*275*	*280*	*285*	*290*
Area (m^2)	*2,050*	*8,400*	*16,300*	*24,600*	*31,500*

Calculate the volume of water between the contours 270 m and 290 m by (a) the trapezoidal formula, and (b) the prismoidal formula.

Solution

Volume according to trapezoidal formula

$$V = (5/2) \times \{2{,}050 + 31{,}500 + 2(8{,}400 + 16{,}300 + 24{,}600)\} = 330{,}375 \text{ m}^3$$

Volume by prismoidal formula

$$V = \{2{,}050 + 31{,}500 + 4(8{,}400 + 24{,}600) + 2(16{,}300)\} = 330{,}250 \text{ m}^3$$

Example

An embankment of 10 m width and side slopes 1½ : 1 is required to be made on a ground which is level in a direction transverse to the centre line. The central heights at 40 m intervals are as follows:

0.90, 1.25, 2.15, 2.50, 1.85, 1.35, and 0.85

Calculate the volume of earth work according to the trapezoidal formula.

Solution

Area, $\Delta = (b + sh) \times h$

$$\Delta_1 = (10 + 1.5 \times 0.90) \times 0.90 = 10.22 \text{ m}^2$$

$$\Delta_2 = (10 + 1.5 \times 1.25) \times 1.25 = 14.84 \text{ m}^2$$

$$\Delta_3 = (10 + 1.5 \times 2.15) \times 2.15 = 28.43 \text{ m}^2$$

$$\Delta_4 = (10 + 1.5 \times 2.50) \times 2.50 = 34.38 \text{ m}^2$$

$$\Delta_5 = (10 + 1.5 \times 1.85) \times 1.85 = 23.63 \text{ m}^2$$

$$\Delta_6 = (10 + 1.5 \times 1.35) \times 1.35 = 16.23 \text{ m}^2$$

$$\Delta_7 = (10 + 1.5 \times 0.85) \times 0.85 = 9.58 \text{ m}^2$$

Volume according to trapezoidal formula:

$$V = (40/2) \times \{10.22 + 9.58 + 2(14.84 + 28.43 + 34.38 + 23.63 + 16.23)\}$$

$$= 20\{19.80 + 235.02\} = 5{,}096.4 \text{ m}^3$$

DISTORTED OR SHRUNK SCALES

Due to change in climatic conditions, the plans and maps generally get distorted. If no graphical scale is drawn on the plan, correct scale of the distorted plan (or map), may be calculated by the following method:

Step 1

Measure a distance between any two well defined points on the plan and calculate its corresponding ground distance from the scale i.e.,

1 cm = x metres. Let it be l metres.

Step 2

Measure the horizontal distance between the same points on the ground by chaining. Calculate the distance on plan with the scale. Let it be y cm.

Step 3

Calculate the shrinkage ratio or shrinkage factor which is equal to shrunk length / the actual length.

Step 4

Shrunk scale of plan = Shrinkage factor × Original scale.

Example

The area of a plot on a map is found, by planimeter, to be 10.22 cm^2. The scale of the map was 1:25000, but at present it is shrunk such that a line originally 5 cm on the map is now 4.8 cm. What is the correct field area in hectares ?

Solution

The area of the plot measured by the planimeter on the shrunk map = 10.22 cm^2 (Given)

The ratio of shrinkage = 4.8/5.0 = 0.96

The ratio of shrinkage of the area = $(0.96)^2 = 0.9216$

The area of the plot on unshrunk map on 1:25,000 scale = 10.22/0.9216 = 11.08941 cm^2

Area of 1 cm^2 on scale 1:25000 = 250 × 250 = 62500 m^2

$\therefore$ Area of 11.08941 cm on scale 1 : 25000 = 62500 × 11.08941

= 693088.12 m^2

= 69.3088 hectares.

Example

An old map was plotted to a scale of 40 m to 1 cm. Over the years, this map has been shrinking, and a line originally 20 cm long is only 19.5 cm long at present. Again, the 20 m chain was 5 cm too long. If the present area of the map measured by a planimeter is 125.50 cm^2, find the true area of the land surveyed.

Solution

According to the given conditions,