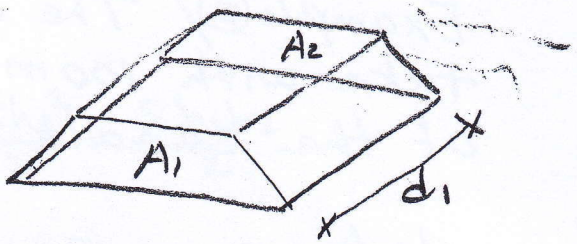
Volumes

1. Volumes from cross-sections.
2. Volumes from spot height or spot level.
3. Volumes from contour map.

1. Volumes from cross-sections.

(A) End-area (or trapezoidal) method

$$V = \frac{A_1 + A_2}{2} \cdot d_1$$



if N is the number of cross-sections

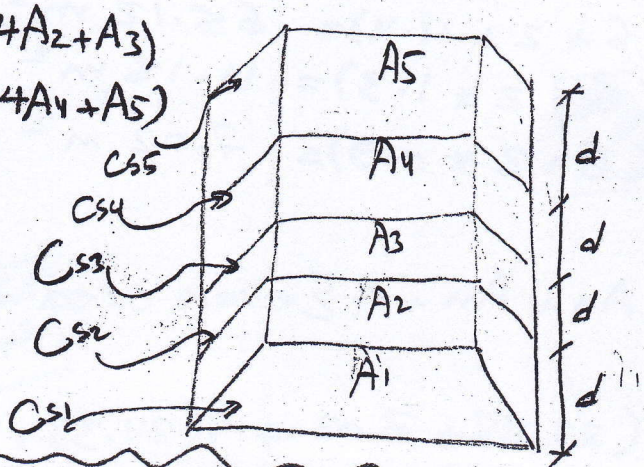
$$\therefore V_{total} = V_1 + V_2 + V_3 + \dots + V_n$$
$$= \frac{d_1}{2}(A_1 + A_2) + \frac{d_2}{2}(A_2 + A_3) + \frac{d_3}{2}(A_3 + A_4) + \dots \frac{d_{n-1}}{2}(A_{n-1} + A_n)$$

if $d_1 = d_2 = d_3 = d_{n-1}$

$$\therefore V_{total} = \frac{d}{2}(A_1 + A_n + 2(A_2 + A_3 + A_{n-1}))$$

(B) prismoidal method or Simpson's method

$$V_{1-3} = \frac{d}{3}(A_1 + 4A_2 + A_3)$$
$$V_{3-5} = \frac{d}{3}(A_3 + 4A_4 + A_5)$$



$$\therefore V_{total} = \frac{d}{3}(A_1 + A_n + 4\Sigma \text{even area} + 2\Sigma \text{odd area})$$

note: to apply the prismoidal method must be the number of cross-sections odd.

Example ① Calculate the volume of cut for the cross-section with length of cut 30 m, width of cut 8 m, the depth is 8 m and 5 m, and side slope 1:1. ②

Sol.

$$A = h(b + sh)$$

$$A_1 = 8(8 + 1*8) = 128\ m^2$$

$$A_2 = 5(8 + 1*5) = 65\ m^2$$

$$V = \frac{d}{2}(A_1 + A_2) = \frac{30}{2}(128 + 65) = 2895\ m^3$$

Example ②/ The elevation of the centre line of road take with 100 m change the depth elevation of the canale is

distance	0	100	200	300	400
Elevation(m)	2.2	2.3	4.4	1.3	0.9

Calculate the volume of cut while the width is 6 m and side slope of canale is 1:2

$$A = h(b + sh)$$

$$A_1 = 2.2(6 + 2*2.2) = 22.88\ m^2$$

$$A_2 = 2.3(6 + 2*2.3) = 24.38\ m^2$$

$$A_3 = 4.4(6 + 2*4.4) = 65.12\ m^2$$

$$A_4 = 1.3(6 + 2*1.3) = 11.18\ m^2$$

$$A_5 = 0.9(6 + 2*0.9) = 7.02\ m^2$$

$$V = \frac{d}{3}(A_1 + A_n + 4\Sigma \text{even area} + 2\Sigma \text{odd area})$$

$$= \frac{100}{3}(22.88 + 7.02 + 4(24.38 + 11.18) + 2(65.12))$$

$$= 10079.3\ m^3$$

Prismoidal correction (P.C)

for one-level section

$A_1 = h_1(b + sh_1)$

$A_2 = h_2(b + sh_2)$

$V_{\text{end area}} = \frac{d}{2}(A_1 + A_2) = \frac{d}{2}(h_1 b + sh_1^2 + h_2 b + sh_2^2)$

assuming $h_m = \frac{h_1 + h_2}{2}$, $A_m = \frac{A_1 + A_2}{2}$

$A_m = \frac{h_1 + h_2}{2}\left(b + s\frac{h_1 + h_2}{2}\right)$

$= \frac{h_1 b}{2} + \frac{h_2 b}{2} + \frac{sh_1^2}{4} + \frac{sh_2^2}{2} + \frac{sh_1 h_2}{2}$

$V_{\text{prismoidal}} = \frac{d}{3}(A_1 + 4A_m + A_2)$

$= \frac{d}{3}\left[(h_1 b + sh_1^2) + 4\left(\frac{h_1 b}{2} + \frac{h_2 b}{2} + \frac{sh_1^2}{4} + \frac{sh_2^2}{4} + \frac{sh_1 h_2}{2}\right.\right.$

$\left.\left. + h_2 b + sh_2^2\right)\right]$

$P.C = V_{\text{end area}} - V_{\text{prismoidal}}$

$= \frac{d}{6} \cdot s(h_1 - h_2)^2$

or Dam

Example/ Calculate the prismoidal correction (P.C) for the embankment while length 40m and width formation 6m and side slope 1:1, the height of the section is 6, 7.6, 9.2 m and the distance between the section is 20 m.

Sol. $A = h(b + Sh)$

$A_1 = 6(6 + 1 * 6) = 72\ m^2$

$A_2 = 7.6(6 + 1 * 7.6) = 103.36\ m^2$

$A_3 = 9.2(6 + 1 * 9.2) = 139.84\ m^2$

$V_1 = \frac{d}{2}(A_1 + A_2)$

between A_1 & A_2

$= \frac{20}{2}(72 + 103.36) = 1753.6\ m^3$

$\hookrightarrow P.C_1 = \frac{d}{6} S(h_1 - h_2)^2 = \frac{20}{6} * 1(6 - 7.6)^2 = 8.53\ m^3$

$V_2 = \frac{d}{2}(A_2 + A_3)$

$= \frac{20}{2}(103.36 + 139.84) = 2432\ m^3$

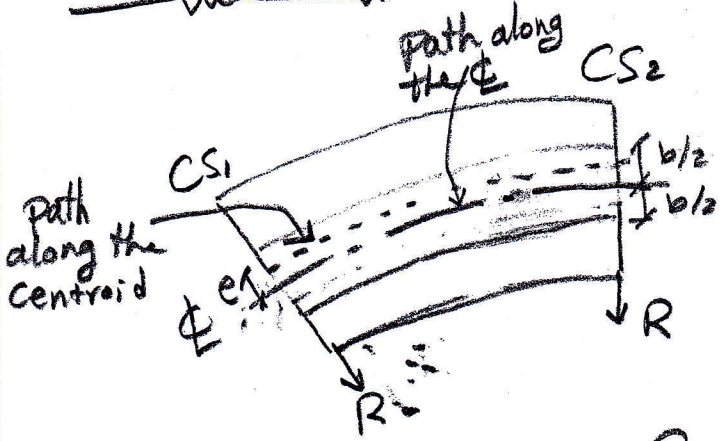
between A_2 & A_3

$P.C_2 = \frac{d}{6} S(h_1 - h_2)^2 = \frac{20}{6} * 1(7.6 - 9.2)^2 = 8.53\ m^3$

$V_{total} = 4168.54^3$

$\hookrightarrow (V_1 - P.C_1) + (V_2 - P.C_2)$

Effect of curvature

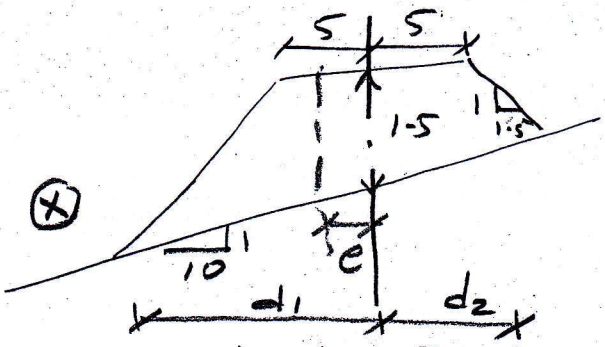


$V_{corrected} = V_{incorrected} \pm C.C$

$$C.C = \frac{1}{6}(d_1^2 - d_2^2)\left(\frac{b}{2S} + h\right) * \frac{D}{R}$$

Example/ The embankment with width 10 m and height 1.5m on centre line, side slope 1:1.5 with earth slope 1:10. Calculate the corrected curvature when the embankment is construction on the circle curve with R = 1000 m and 100 m long where the natural ground slope to the center of curve

Sol.



$$d_1 = \left(\frac{b}{2} + Sh\right)\left(\frac{n}{n-S}\right)$$

$$= \left(\frac{10}{2} + 1.5 * 1.5\right)\left(\frac{10}{10-1.5}\right)$$

$$= 8.53\ m$$

$$d_2 = \left(\frac{b}{2} + Sh\right)\left(\frac{n}{n+S}\right)$$

$$= \left(\frac{10}{2} + 1.5 * 1.5\right)\left(\frac{10}{10+1.5}\right)$$

$$= 6.30\ m$$

$$A = \frac{1}{2}\left[\frac{b}{2S} + C\right](d_1 + d_2) - \frac{b^2}{4S}$$

$$= \frac{1}{2}\left[\frac{10}{2*1.5} + 1.5\right](8.53 + 6.3) - \frac{1^2}{4(1.5)}$$

$$= 19.17\ m^2$$

$$C.C = \frac{1}{6}(d_1^2 - d_2^2)\left(\frac{b}{2S} + h\right) * \frac{D}{R}$$

$$= \frac{1}{6}(8.53^2 - 6.3^2)\left(\frac{10}{2*1.5} + 1.5\right) * \frac{100}{1000}$$

$$= 2.66\ m$$

$V_{incorr.} = A * L$
$= 19.17 * 100$
$= 1917\ m^3$

$V_{corrected} = V_{incorrected} - C.C = 1917 - 2.67$
$= 1914.34\ m^3$