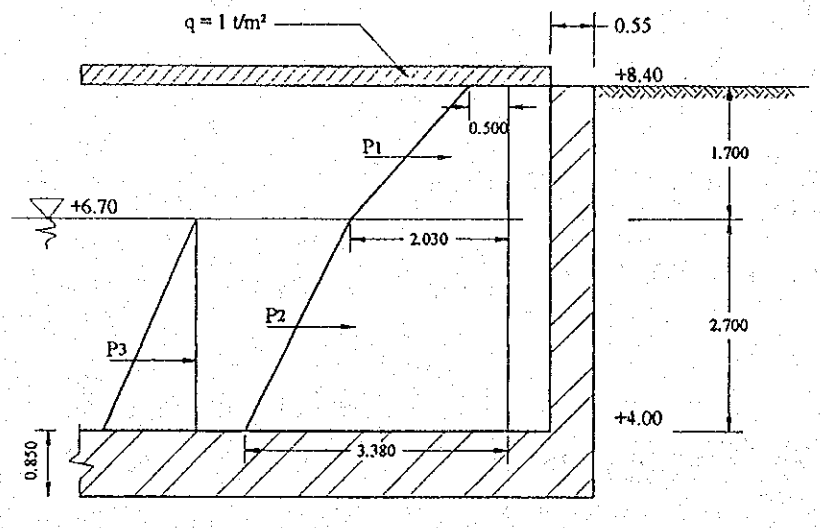
4.3.1.3 Retaining Wall Type 1 (Breast Wall at Irrigation Channel Side)



Wall

$- P_1 = \frac{0.5 + 2.03}{2} \times 1.70 = 2.151$ t.f

$Z_1 = 2.70 + \frac{2 \times 0.5 + 2.03}{3 \times (0.5 + 2.03)} \times 1.70 = 3.379$ m

$M_1 = 2.15 \times 3.379 = 7.265$ t.m

$- P_2 = \frac{2.03 + 3.38}{2} \times 2.70 = 7.304$ t.f

$Z_2 = \frac{2 \times 2.03 + 3.38}{3 \times (2.03 + 3.38)} \times 2.70 = 1.238$ m

$M_2 = 7.304 \times 1.238 = 9.042$ t.m

$- P_3 = ½ \times 2.70^2 = 3.645$ t

$Z_3 = \frac{2.70}{3} = 0.9$ m

$M_3 = 3.645 \times 0.90 = 3.281$ t.m

$- \Sigma p = 2.151 + 7.304 + 3.645 = 13.100$ t.f

$\tau = \frac{13200}{7/8 \times 100 \times 46} = 3.280$ kgf/cm² $< \tau = 6.5$ kgf/cm²

$- \Sigma_M = 7.268 + 9.042 + 3.281 = 19.591$ t.f m

$$Ca = \frac{46}{\sqrt{\frac{15\times 4591000}{100\times 1600}}} = 3.394$$

$Ca = 3.394$ } $\varnothing = 1.808$
$\delta = 0$ } $n\omega = 0.098$

$$A = \frac{0.098}{15}\times 100\times 46 = 30.053 \text{ cm}^2$$

Used D22 – 125 → A = 30.411 cm²

Slab

$$- P_1 = \frac{0.5+2.03}{2}\times 1.70 = 2.151 \text{ t.f}$$

$$Z_1 = \frac{0.85}{2} + 3.379 = 3.804 \text{ m}$$

$$M_1 = 3.804 \times 2.151 = 8.182 \text{ t.m}$$

$$- P_2 = \frac{2.03+3.38}{2}\times 2.70 = 7.304 \text{ t.f}$$

$$Z_2 = \frac{0.85}{2} + 1.238 = 1.663 \text{ m}$$

$$M_2 = 7.304\times 1.663 = 12.147 \text{ tf.m}$$

$$- P_3 = ½\times 2.70^2 = 3.645$$

$$Z_3 = \frac{0.85}{2} + 0.9 = 1.325 \text{ m}$$

$$M_3 = 1.325 \times 3.645 = 4.830 \text{ tf.m}$$

$$-- \Sigma_M = 8.182 + 12.147 + 4.830 = 25.159 \text{ t.f}$$

$$M = 25.156 \text{ tf.m}$$

$$N = -13.100 \text{ tf}$$

$$\ell = \frac{25.156}{-13.100} = -1.920 \text{ m}$$

$$\ell_a = -1.920 + \frac{0.85}{2} - 0.09 = -1.585 \text{ m}$$

$$N_{\ell a} = -1.585 \times -13.100 = 20.764 \text{ t.m}$$

$$Ca = \frac{76}{\sqrt{\frac{15\times 2076700}{100\times 1600}}} = 5.447$$

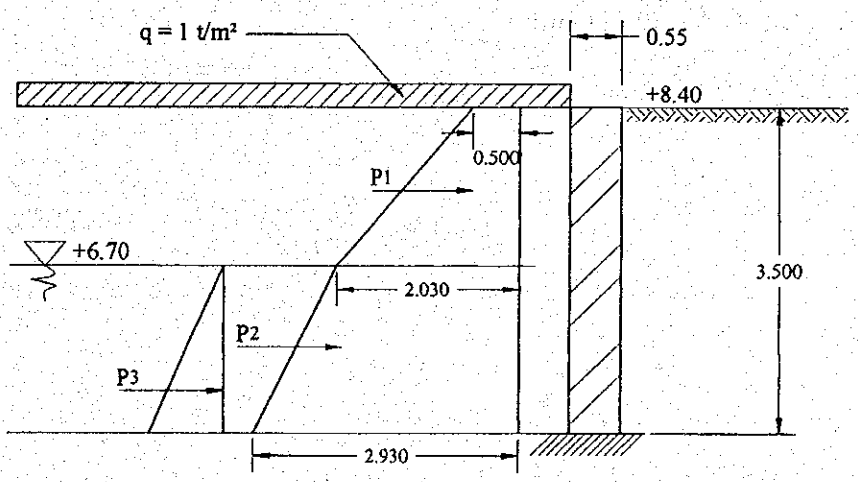
$Ca = 4.013$, $\delta = 0$ $\Rightarrow$ $\varnothing = 3.230$, $n\omega = 0.0366$, $\zeta = 0.921$

$$i = \frac{1}{1-0.921\times \frac{0.76}{-1.585}} = 0.694$$

$$IA = \frac{0.0366}{15}\times 100\times 76 = 18.544 \text{ cm}^2$$

$$A = \frac{18.544}{0.694} = 26.720 \text{ cm}^2$$

Used D22 – 125 → A = 30.411 cm²



$$- P_1 = \frac{0.5+2.03}{2}\times 1.70 = 2.151 \text{ t.f}$$

$$Z_1 = \frac{2\times 0.5+2.030}{3\times(0.5+2.030)}\times 1.70 + 1.80 = 2.479 \text{ m}$$

$$M_1 = 2.15 \times 2.479 = 5.330 \text{ tf}$$

$$- P_2 = \frac{2.03+2.93}{2}\times 1.80 = 4.464 \text{ t.f}$$

$$Z_2 = \frac{2\times 2.03+2.93}{3\times(2.03+2.93)}\times 1.80 = 0.846 \text{ m}$$

$M_2 = 0.846 \times 4.464 = 3.777$ tf

$- P_3 = \frac{1}{2} \times 1.80^2 = 1.620$ t

$Z_3 = \frac{1}{3} \times 1.8 = 0.6$ m

$M_3 = 1.62 \times 0.6 = 0.972$ tf.m

$- \Sigma_M = 5.331 + 3.777 + 0.972 = 10.080$ t.f

$$Ca = \frac{46}{\sqrt{\frac{15 \times 10080}{100 \times 1600}}} = 4.732$$

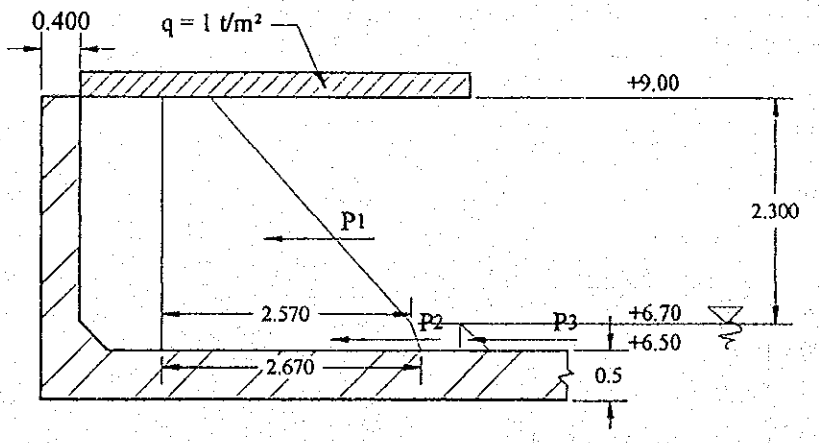
$Ca = 4.732$ } $\varnothing = 2.732$

$\delta = 0$ } $n\omega = 0.049$

$$A = \frac{0.049}{15} \times 100 \times 46 = 15.027 \text{ cm}^2$$

Used D22 – 250 → A = 30.411 cm²

4.3.1.4 Retaining Wall Type 2 (Earth Retaining Wall at Irrigation Channel)



Wall

$- P_1 = \frac{0.5 + 2.57}{2} \times 2.30 = 3.531$ t.f

$Z_1 = \frac{2 \times 0.5 + 2.57}{3 \times (0.5 + 2.57)} \times 2.30 + 0.20 = 1.092$ m

$M_1 = 3.531 \times 1.091 = 3.852$ tf.m

$- P_2 = \frac{2.57 + 2.67}{2} \times 0.20 = 0.524$ t.f

$Z_2 = \frac{2 \times 2.57 + 2.67}{3 \times (2.57 + 2.67)} \times 0.20 = 0.099$ m

$M_2 = 0.527 \times 0.099 = 0.052$ tf.m

$- P_3 = ½ \times 0.20^2 \times 1 = 0.020$ t.f

$Z_3 = \frac{1}{3} \times 0.20 = 0.067$ m

$M_3 = 0.02 \times 0.067 = 0.001$ tf.m

$- \Sigma p = 3.531 + 0.524 + 0.02 = 4.075$ t.f

$- \Sigma_M = 3.852 + 0.053 + 0.0013 = 3.906$ tf.m

Shear Stress

$$\tau = \frac{4075}{7/8 \times 100 \times 31} = 1.502 \text{ kgf/cm}^2 < \tau = 6.5 \text{ kgf/cm}^2$$

$$M = 3.906 \text{ tf.m}$$

$$h = 31 \text{ cm}^2$$

$$Ca = \frac{31}{\sqrt{\frac{15 \times 390600}{100 \times 1600}}} = 5.122$$

$$Ca = 5.122, \quad \delta = 0 \quad \Rightarrow \quad \varnothing = 3.0041, \quad n\omega = 0.0416$$

$$A = \frac{0.0416}{15} \times 100 \times 31 = 8.5973 \text{ cm}^2$$

Used D13 – 125 → A = 10.619 cm²

Slab

$$- P_1 = \frac{0.5 + 2.57}{2} \times 2.30 = 3.531 \text{ t.f}$$

$$Z_1 = \frac{2 \times 0.5 + 2.57}{3 \times (0.5 + 2.57)} \times 2.30 + 0.45 = 1.342 \text{ m}$$

$$M_1 = 3.531 + 1.341 = 4.872 \text{ tf.m}$$

$$- P_2 = \frac{2.57 + 2.67}{2} \times 0.20 = 0.524 \text{ t.f}$$

$$Z_2 = \frac{2 \times 2.57 + 2.67}{3 \times (2.57 + 2.67)} \times 0.20 + 0.25 = 0.349 \text{ m}$$

$$M_2 = 0.524 \times 0.349 = 0.1831 \text{ tf.m}$$

$$- P_3 = \tfrac{1}{2} \times 0.20^2 \times 1 = 0.020 \text{ tf}$$

$$Z_3 = \tfrac{1}{3} \times 0.20 + 0.25 = 0.317 \text{ m}$$

$$M_3 = 0.02 \times 0.316 = 0.006 \text{ tf.m}$$

$$- \Sigma p = 3.531 + 0.524 + 0.02 = 4.075 \text{ t.f}$$

$$- \Sigma_M = 4.872 + 0.1900 + 0.006 = 5.068 \text{ tf.m}$$

$M = 5.068$ t.m

$N = -4.095$ tf

$$\ell = \frac{5.068}{-4.095} = -1.238 \text{ m}$$

$$\ell_a = -1.237 + \frac{0.5}{2} - 0.09 = -1.077 \text{ m}$$

$$N_{\ell a} = -1.077 \times -4.095 = 4.410 \text{ tf.m}$$

$$Ca = \frac{41}{\sqrt{\frac{15 \times 441300}{100 \times 1600}}} = 6.588$$

$Ca = 6.588$, $\delta = 0$ $\Rightarrow$ $\varnothing = 4.029$, $n\omega = 0.0246$, $\zeta = 0.9337$

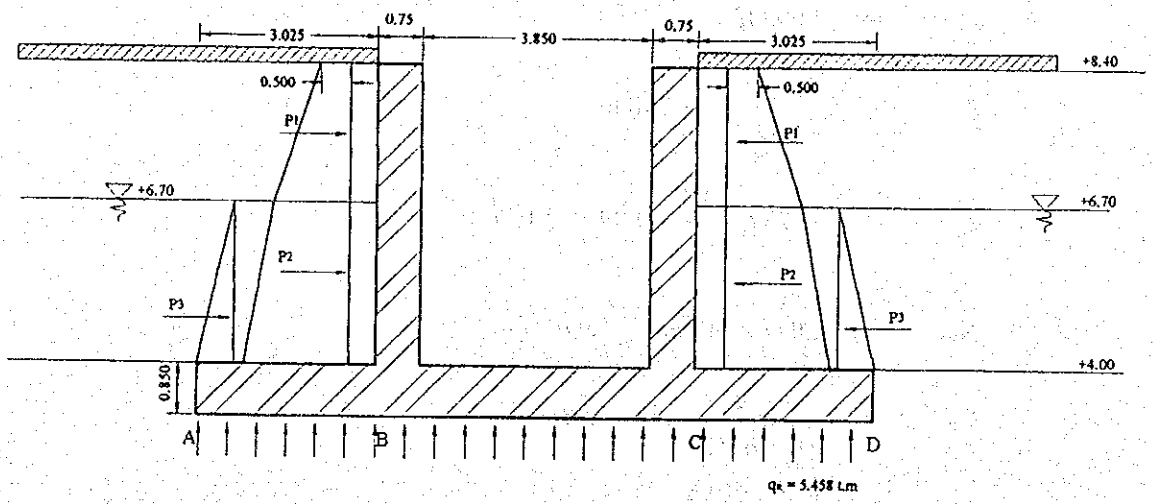
$$i = \frac{1}{1 - 0.934 \times {}^{0.41}/_{-1.0776}} = 0.738$$

$$iA = \frac{0.0246}{15} \times 100 \times 41 = 6.724 \text{ cm}^2$$

$$A = \frac{6.744}{0.738} = 9.138 \text{ cm}^2$$

Used D13 – 125 → A = 10.618 cm²

4.3.1.5 Retaining Wall Type 3 (Breast Wall at Irrigation Channel)



Wall

M = 19.591 t.m (see retaining wall type 1)

$$Ca = \frac{66}{\sqrt{\frac{15 \times 1959100}{100 \times 1600}}} = 4.870$$

Ca = 4.870, δ = 0 → ∅ = 2.898, nω = 0.0416

$$A = \frac{0.0416}{15} \times 100 \times 66 = 18.304 \text{ cm}^2$$

Used D19 – 125 → A = 22.682 cm²

Slab

–	Live load	= 1 × 3.025 × 2	=	6.050 tf
–	Weight of wall	= (4.4 × 0.75)× 2 × 2.5	=	16.500 tf
–	Weight of soil I	= (3.025 × 1.7)× 2 × 1.8	=	18.513 tf
–	Weight of soil II	= (3.025 × 2.7)× 2 × 2	=	32.670 tf
		Total	=	73.733 tf

$$q_R = \frac{73.733}{1 \times 12.40} = 5.914 \text{ t.f}$$

$q_t = 1.7 \times 1.8 + 2.7 \times 2 + 1 = 9.460$ t.f

$M_{CD-} = ½ \times (9.46 - 5.946) \times 3.4^2 = 20.311$ tf.m

M_{CB^-} = 25.156 – 20.311 = 4.845 tf.m

M_{Cd^+} = $\frac{1}{8} \times 5.946 \times 5.6^2 - 4.845$ = 18.463 tf.m

M_{CD^-} = 20.311 tf.m

Ca = $\frac{76}{\sqrt{\frac{15 \times 2031100}{100 \times 1600}}} = 5.508$

Ca = 5.508 } ∅ = 3.273

δ = 0 } nω = 0.0358

A = $\frac{0.0358}{15} \times 100 \times 76$ = 18.139 cm²

Used D19 – 125 → A = 18.158 cm²

M_{CB^-} = 4.845 tf.m

N = 13.10 tf

ℓ_o = $\frac{4.845}{13.10} = 0.370$ m

ℓ_{o1} = $\frac{1}{30} \cdot h_t = 0.028$ m

ℓ_o = 0.369+0.028 = 0.397 m

$\frac{\ell_o}{ht}$ = $\frac{0.398}{0.85}$ = 0.468 → C_1 = 1

C_2 = 6.89

ℓ_1 = $1 \times 6.89 \times \left(\frac{5.6}{100 \times 0.85}\right)^2 \times 0.85$ = 0.025 m

ℓ_2 = 0.15×0.85 = 0.128 m

ℓ = 0.398 + 0.025 + 0.128 = 0.551 m

ℓ_a = $0.551 + \frac{0.85}{2} - 0.165$ = 0.811 m

$N_{\ell a}$ = 0.811×13.10 = 10.624 tf.m

$$Ca = \frac{68.5}{\sqrt{\frac{15\times 1062500}{100\times 1600}}} = 6.863$$

$Ca = 6.863$, $\delta = 0$ $\Rightarrow$ $\varnothing = 4.222$, $n\omega = 0.0227$, $\zeta = 0.936$

$$i = \frac{1}{1-0.936\times 0.685/0.811} = 4.775$$

$$iA = \frac{0.0227}{15}\times 100\times 68.5 = 10.366 \text{ cm}^2$$

$$A = \frac{10.158}{4.775} = 2.127 \text{ cm}^2$$

Used D16 - 250 $\rightarrow$ A = 8.042 cm²

$M_{CB}+ = 18.446$ t.m

$N = 13.100$ tf

$$\ell_{o1} = \frac{18.446}{13.100} = 1.408 \text{ m}$$

$$\ell_{o2} = 1/30 \cdot 0.85 = 0.028 \text{ m}$$

$$\ell_o = 1.408 + 0.028 = 1.436 \text{ m}$$

$$\frac{\ell_o}{ht} = \frac{1.436}{0.85} = 1.689 \rightarrow C_1 = 1$$

$C_2 = 7$

$$\ell_1 = 1\times 7\times\left(\frac{5.6}{100\times 0.85}\right)^2\times 0.85 = 0.026 \text{ m}$$

$$\ell_2 = 0.15\times 0.85 = 0.128 \text{ m}$$

$$\ell = 1.436 + 0.025 + 0.128 = 1.589 \text{ m}$$

$$\ell_a = 1.589 + \frac{0.85}{2} - 0.09 = 1.924 \text{ m}$$

$N_{\ell a}$ = 1.925 × 13.10 = 25.218 t.m

$$Ca = \frac{76}{\sqrt{\frac{15 \times 254400}{100 \times 1600}}} = 4.943$$

Ca = 4.943
δ = 0

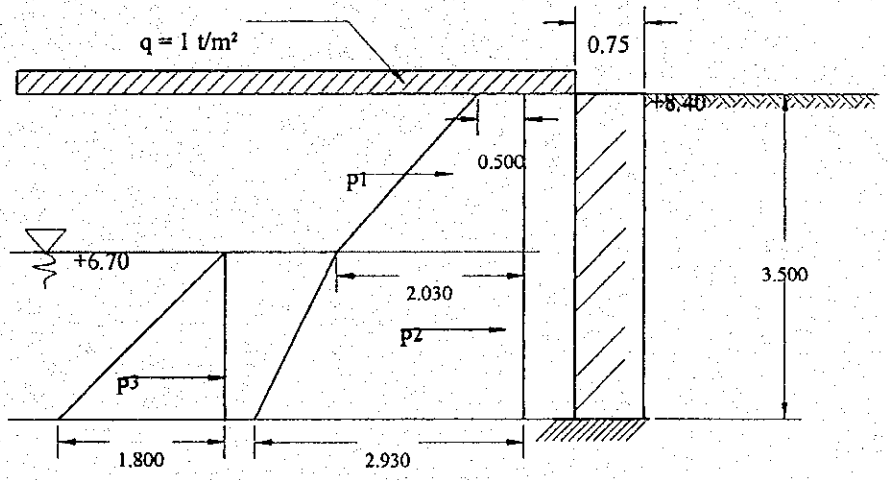
∅ = 2.879
nω = 0.045
ζ = 0.914

$$i = \frac{1}{1 - 0.914 \times \frac{0.76}{1.925}} = 1.565 \text{ cm}^2$$

$$iA = \frac{0.045}{15} \times 100 \times 76 = 22.800 \text{ cm}$$

A = 14.497 cm²

Used D19 – 125 → A = 22.682 cm²



$$-P_1 = \frac{0.5 + 2.03}{2} \times 1.70 = 2.151 \text{ t.f}$$

$$Z_1 = \frac{2 \times 0.5 + 2.03}{3 \times (0.5 + 2.03)} \times 1.70 + 1.80 = 2.479 \text{ m}$$

M_1 = 2.151 × 2.479 = 5.330 t.m

$$-P_2 = \frac{2.03 + 2.93}{2} \times 1.80 = 4.464 \text{ t.f}$$

$$Z_2 = \frac{2 \times 2.03 + 2.93}{3 \times (2.03 + 2.93)} \times 1.80 = 0.846 \text{ m}$$

$M_2 = 0.846 \times 4.464 = 3.777$ tf

$- P_3 = \frac{1}{2} \times 1.8^2 = 1.620$ tf

$Z_3 = \frac{1.80}{3} = 0.6$

$M_3 = 1.62 \times 0.60 = 0.972$ t.m

$- \Sigma_M = 5.331 + 3.776 + 0.971 = 10.078$ t.f

$$Ca = \frac{66}{\sqrt{\frac{15 \times 1007800}{100 \times 1600}}} = 6.790$$

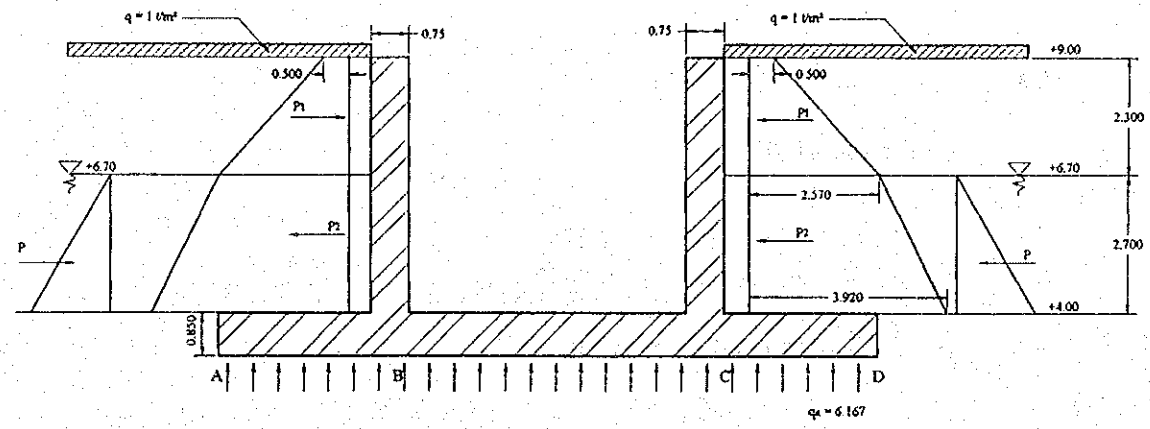
$Ca = 6.790$ } $\quad \varnothing = 4.170$

$\delta = 0$ } $\quad n\omega = 0.0232$

$$A = \frac{0.0232}{15} \times 100 \times 66 = 10.208 \text{ cm}^2$$

Used D19 – 250 → A = 10.208 cm²

4.3.1.6 Retaining Wall Type 4 (Breast Wall at Irrigation Channel)



$$- P_1 = \frac{0.5+2.57}{2} \times 2.30 = 3.531 \text{ t.f}$$

$$Z_1 = 2.70 + \frac{2\times 0.5 + 2.57}{3\times(0.5+2.57)} \times 2.30 = 3.592 \text{ m}$$

$$M_1 = 3.531 \times 3.592 = 12.683 \text{ tf.m}$$

$$- P_2 = \frac{2.57+3.92}{2} \times 2.70 = 8.762 \text{ t.f}$$

$$Z_2 = \frac{2\times 2.03 + 3.92}{3\times(2.57+3.92)} \times 2.70 = 1.256 \text{ m}$$

$$M_2 = 8.762 \times 1.256 = 11.005 \text{ tf.m}$$

$$- P_3 = \tfrac{1}{2} \times 2.70^2 = 3.645$$

$$Z_3 = \frac{2.70}{3} = 0.9 \text{ m}$$

$$M_3 = 3.645 \times 0.90 = 3.281 \text{ tf.m}$$

$$- \Sigma p = 3.531 + 8.762 + 3.645 = 15.938 \text{ t.f}$$

$$- \Sigma_M = 12.769 + 11.005 + 27.055 = 31.975 \text{ tf.m}$$

Shear Stress

$$\tau = \frac{15938}{\frac{7}{8} \times 100 \times 66} = 2.760 \text{ kgf/cm}^2 \quad < \tau = 6.5 \text{ kgf/cm}^2$$

M = 27.055 tf

h = 66 cm²

$$Ca = \frac{66}{\sqrt{\frac{15 \times 27.055}{100 \times 1600}}} = 4.144$$

Ca = 4.144, δ = 0 } ∅ = 2.324, nω = 0.0647

$$A = \frac{0.067}{15} \times 100 \times 66 = 29.48 \text{ cm}^2$$

Used D22 – 125 → A = 30.410 cm²

Slab

–	Live load (q)	= 2 × 3.025 × 1	=	6.050 tf
–	Weight of wall	= 5 × 0.75 × 2 × 2.5	=	18.750 tf
–	Weight of soil I	= (3.025 × 2.3)× 2 × 1.8	=	25.047 tf
–	Weight of soil II	= (3.025 × 2.7)× 2 × 2	=	32.670 tf
		Total	=	82.517 tf

$$q_R = \frac{82.517}{1 \times 12.40} = 6.655 \text{ tf.m}$$

q_l = 2.3 × 1.8 + 2.7 × 2 + 1 = 10.540 t.f

$$-P_1 = \frac{0.5 + 2.57}{2} \times 2.30 = 3.531 \text{ t.f}$$

Z_1 = 0.425 + 3.592 = 4.017 m

M_1 = 3.531 × 4.017 = 14.184 tf.m

$$-P_2 = \frac{2.57 + 3.92}{2} \times 2.70 = 8.762 \text{ tf.m}$$

Z_2 = 1.256 + 0.425 = 1.681 m

M_2 = 8.762 × 1.681 = 14.729 tf.m

$-P_3$ = ½ × 2.70² = 3.645 tf

Z_3 = 0.9 + 0.425 = 1.325 m

$M_3 = 3.645 \times 1.325 = 4.830$ tf.m

$-\Sigma_M = 14.729 + 14.729 + 4.830 = 34.288$ tf.m

$M_{CD^-} = \frac{1}{2} \times (10.540 - 6.655) \times 3.4^2 = 22.455$ tf.m

$M_{CB^-} = 34.288 - 22.455 = 11.833$ tf.m

$M_{CB^+} = \frac{1}{8} \times 6.655 \times 5.6^2 - 11.884 = 14.255$ tf.m

$M_{CD^-} = 22.455$ tf.m

$$Ca = \frac{76}{\sqrt{\frac{15 \times 2245500}{100 \times 1600}}} = 5.238$$

$Ca = 5.238$, $\delta = 0$ $\quad \varnothing = 3.085$, $n\omega = 0.0397$

$$A = \frac{0.0397}{15} \times 100 \times 76 = 20.115 \text{ cm}^2$$

Used D19 – 125 $\rightarrow$ A = 22.6828 cm²

$M_{CB^-} = 11.884$ tf.m

$N = 15.938$ tf

$$\ell_o = \frac{11.884}{15.938} = 0.746 \text{ m}$$

$$\ell_{o1} = \frac{1}{30} \cdot h_t = 0.028 \text{ m}$$

$\ell_o = 0.028 + 0.746 = 0.774$ m

$\frac{\ell_o}{ht} = \frac{0.774}{0.85} = 0.911 \rightarrow C_1 = 1$

$C_2 = 7$

$$\ell_1 = 1 \times 7 \times \left(\frac{5.6}{100 \times 0.85}\right)^2 \times 0.85 = 0.026 \text{ m}$$

$\ell_2 = 0.15 \times 0.85 = 0.128$ m

$\ell = 0.774 + 0.026 + 0.128 = 0.928$ m

$$\ell_a = 0.927 + \frac{0.85}{2} - 0.09 = 1.262 \text{ m}$$

$N_{\ell a} = 1.262 \times 15.938 = 20.114$ t.m

$$Ca = \frac{68.5}{\sqrt{\frac{15 \times 2011800}{100 \times 1600}}} = 5.530 \text{ m}$$

Ca = 5.530, δ = 0 → Ø = 3.291, nω = 0.035, ζ = 0.923

$$i = \frac{1}{1 - 0.923 \times \frac{0.685}{1.262}} = 2.004$$

$$iA = \frac{0.035}{15} \times 100 \times 68.5 = 15.983 \text{ cm}^2$$

$$A = \frac{17.938}{3.244} = 5.530 \text{ cm}^2$$

Used Ø16 – 250 → A = 8.042 cm²

$M_{CB}+ = 14.206$ tf.m

N = 15.938 tf

$$\ell_{o1} = \frac{14.206}{15.938} = 0.891 \text{ m}$$

$$\ell_{o2} = \frac{1}{30} \times 0.85 = 0.028 \text{ m}$$

$\ell_o = 0.894 + 0.028 = 0.922$ m

$$\frac{\ell_o}{ht} = \frac{0.920}{0.85} = 1.082 \rightarrow C_1 = 1$$

$C_2 = 7$

$$\ell_1 = 1 \times 7 \times \left(\frac{5.6}{100 \times 0.85}\right)^2 \times 0.85 = 0.026 \text{ m}$$

$\ell_2 = 0.15 \times 0.85 = 0.128$ m

$\ell = 0.920 + 0.025 + 0.128 = 1.073$ m

$$\ell_a = 1.073 + \frac{0.85}{2} - 0.09 = 1.408 \text{ m}$$

$$N_{\ell a} = 1.407 \times 15.938 = 22.425 \text{ t.m}$$

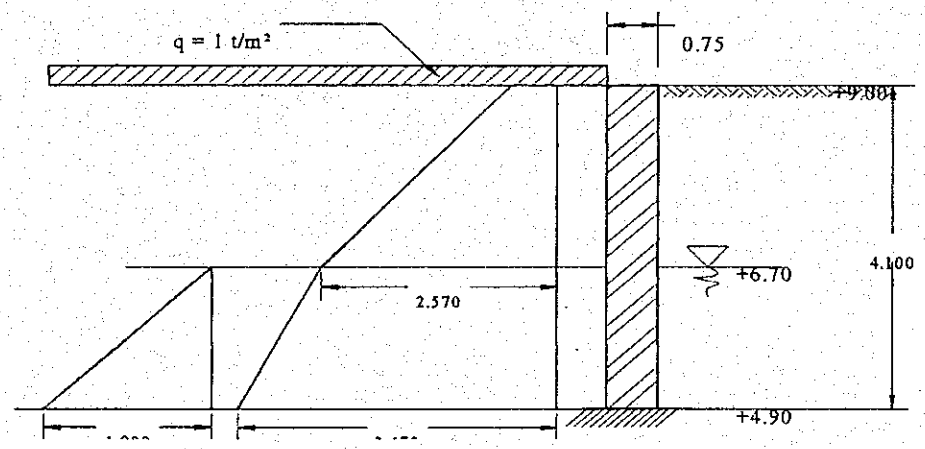
$$Ca = \frac{76}{\sqrt{\frac{15 \times 2244100}{100 \times 1600}}} = 5.240$$

$Ca = 5.240$, $\delta = 0$ $\Rightarrow$ $\varnothing = 3.685$, $n\omega = 0.0396$, $\zeta = 0.918$

$$i = \frac{1}{1 - 0.918 \times \frac{0.76}{1.407}} = 1.984 \text{ cm}^2$$

$$iA = \frac{0.0396}{15} \times 100 \times 76 = 20.064$$

$$A = \frac{20.093}{1.983} = 10.133 \text{ cm}^2$$



$$-P_1 = \frac{0.5 + 2.57}{2} \times 2.30 = 3.531 \text{ tf.m}$$

$$Z_1 = \frac{2 \times 0.5 + 2.57}{3 \times (0.5 + 2.57)} \times 2.30 + 1.80 = 2.692 \text{ m}$$

$$M_1 = 3.531 \times 2.692 = 9.505 \text{ tf.m}$$

$$-P_2 = \frac{2.57 + 2.47}{2} \times 1.80 = 5.436 \text{ t.f}$$

$$Z_2 = \frac{2 \times 2.03 + 2.93}{3 \times (2.03 + 3.38)} \times 1.80 = 0.855 \text{ m}$$

$M_2 = 0.855 \times 5.436 = 4.648$ tf.m

$- P_3 = \frac{1}{2} \times 1.8^2 = 1.620$ tf

$Z_3 = \frac{1.80}{3} = 0.6$ m

$M_3 = 1.62 \times 0.60 = 0.972$ tf.m

$- \Sigma_M = 6.813 + 4.678 + 0.971 = 12.462$ t.f

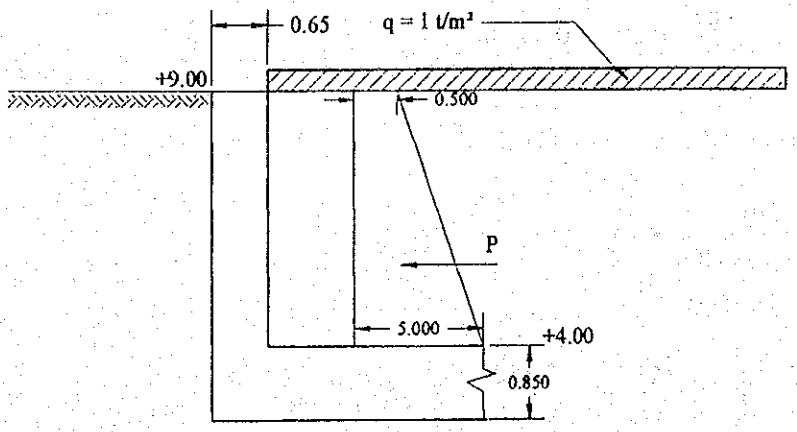
$$Ca = \frac{66}{\sqrt{\frac{15 \times 1246200}{100 \times 1600}}} = 6.106$$

$Ca = 6.106$, $\delta = 0$ $\Rightarrow$ $\varnothing = 3.691$, $n\omega = 0.0232$

$$A = \frac{0.0289}{15} \times 100 \times 66 = 12.716 \text{ cm}^2$$

Used D25 – 250 $\rightarrow$ A = 12.716 cm²

4.3.1.7 Retaining Wall Type 5 (Breast Wall at Floodway)



Normal Condition

$$P = \frac{0.5+5}{2} \times 5 = 13.750 \text{ t.f}$$

$$Z = \frac{2 \times 0.5 + 2.57}{3 \times (0.5+5)} \times 5 = 1.818 \text{ m}$$

$$M = 13.750 \times 1.818 = 12.683 \text{ tf.m}$$

$$Ca = \frac{56}{\sqrt{\frac{15 \times 2500000}{100 \times 1600}}} = 3.657$$

$$\left.\begin{array}{lll} Ca & = & 3.657 \\ \delta & = & 0 \end{array}\right\} \quad \begin{array}{lll} \varnothing & = & 1.988 \\ n\omega & = & 0.0841 \end{array}$$

$$A = \frac{0.0841}{15} \times 100 \times 56 = 31.397 \text{ cm}^2$$

Used D25 – 125 → A = 39.270 cm²

For Bottom Slab

$$P = \frac{0.5+5}{2} \times 5 = 13.750 \text{ t.f}$$

$$Z = \frac{0.85}{2} + 1.818 = 2.243 \text{ m}$$

$$M = 13.750 \times 2.243 - 9.375 = 21.466 \text{ tf.m}$$

$$N = -13.76 - 4.465 = -18.225 \text{ tf}$$

$$\ell = \frac{21.466}{-18.225} = -1.178 \text{ m}$$

$$\ell_a = -1.178 + \frac{0.85}{2} - 0.09 = -0.843 \text{ m}$$

$$N_{\ell a} = -0.843 \times -18.225 = 15.364 \text{ tf.m}$$

$$Ca = \frac{76}{\sqrt{\frac{15 \times 1536400}{100 \times 1600}}} = 6.333$$

Ca = 6.333
δ = 0

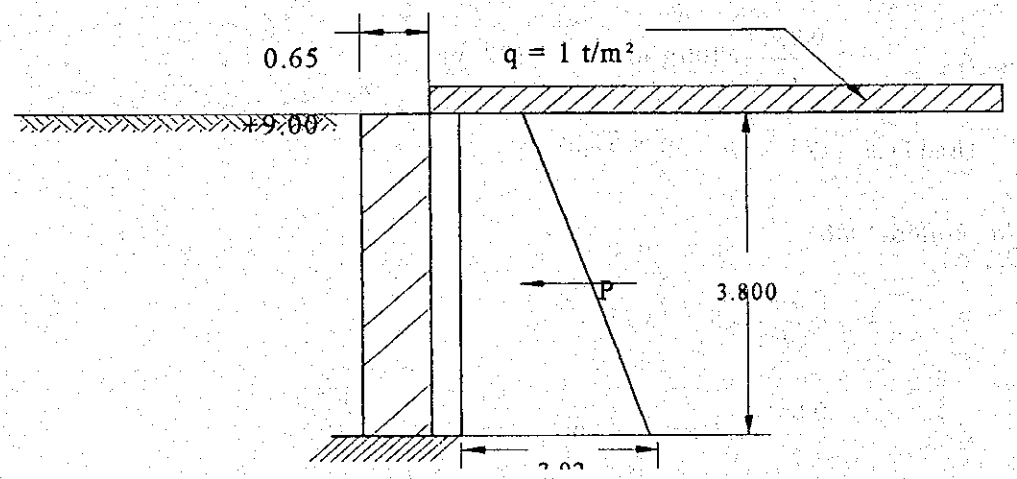
∅ = 3.850
nω = 0.0268
ζ = 0.931

$$i = \frac{1}{1 - 0.931 \times 0.76/-0.843} = 0.544 \text{ cm}^2$$

$$iA = \frac{0.0268}{15} \times 100 \times 76 = 13.579 \text{ cm}^2$$

$$A = \frac{13.567}{0.544} = 24.939 \text{ cm}^2$$

Used D22 – 125 → A = 30.411 cm²



$$P = \frac{0.5+3.92}{2}\times 3.8 = 8.398 \text{ t.f}$$

$$Z = \frac{2\times 0.50+3.92}{3\times(0.50+3.92)}\times 3.8 = 1.410 \text{ m}$$

$$M = 1.410 \times 8.398 = 11.841 \text{ tf.m}$$

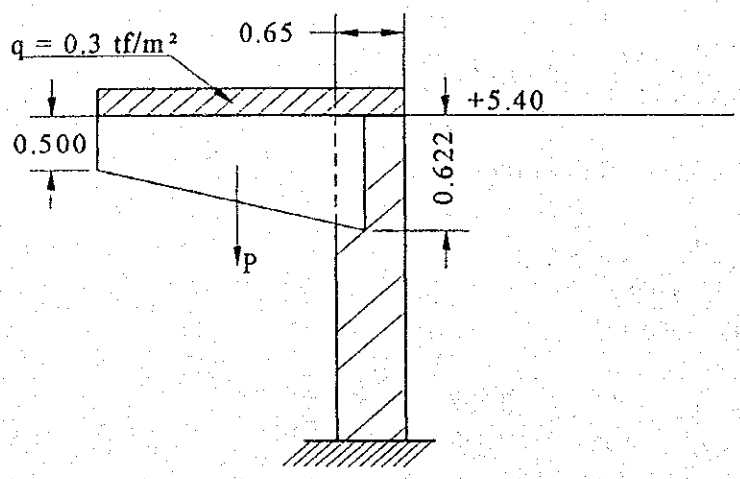
$$Ca = \frac{56}{\sqrt{\frac{15\times 1184100}{100\times 1600}}} = 5.315$$

$$\left.\begin{array}{l} Ca = 5.315 \\ \delta = 0 \end{array}\right\} \quad \begin{array}{l} \varnothing = 3.138 \\ n\omega = 0.038 \end{array}$$

$$A = \frac{0.038}{15}\times 100\times 56 = 14.187 \text{ cm}^2$$

Used Ø22 – 250 → A = 15.205 cm²

4.3.1.8 Control Tower



$- P_1 = \frac{0.5 + 0.622}{2} \times 1.075 \times 2.5 = 1.508$ t.f

$Z_1 = \frac{2 \times 0.50 + 0.622}{3 \times (0.50 + 0.622)} \times 1.075 = 0.518$ m

$M_1 = 1.508 \times 0.518 = 0.781$ tf.m

$- P_2 = 1.075 \times 0.3 = 0.323$ tf.m

$M_2 = ½ \times 0.3 \times 1.075^2 = 0.173$ t

$- \Sigma_P = 14.729 + 14.729 + 4.830 = 34.288$ t.f

$- \Sigma_M = 0.781 + 0.173 = 0.954$ tf.m

Shear Stress

$\tau = \frac{1831}{7/8 \times 100 \times 56} = 0.374$ kgf/cm² $< \tau = 6.5$ kgf/cm²

M = 0.954 tf.m

h = 56 cm²

$Ca = \frac{56}{\sqrt{\frac{15 \times 954000}{100 \times 1600}}} = 18.728$

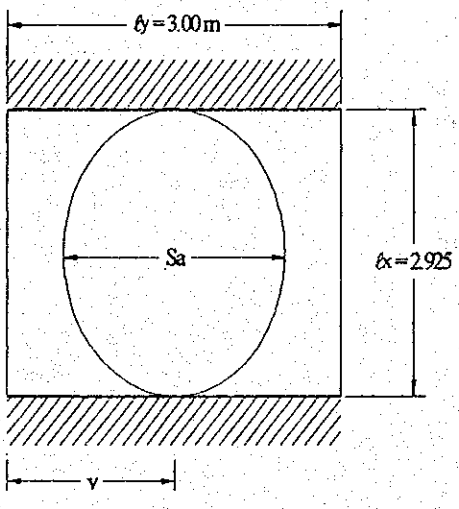
Ca = 18.728 ; Ø = 12.586
δ = 0 ; nω = 0.0029
ζ = 0.975

$$A = \frac{0.0029}{15} \times 100 \times 56 = 1.0827 \text{ cm}^2$$

Used D13 – 250 → A = 1.0287 cm²

Bending moment caused by weight of gate

Weight of gate = 2.5 tf



ly = 3.00 m

lx = 2.925 m

R lx = 1 × 2.925 = 1.295

ly > lx

Sa = **¾a + ¼R lx + v** ;v = 0.8 cm
;a = 0

Sa = ¾ × 0 + ¼ × 2.295 + 0.8 = 1.531 tf.m

$M_o = \frac{1}{8} \times 2.5 \times 2.925^2 = 2.674$ tf.m

$M_1 = \frac{2.674}{1.5314} = 1.746$ tf.m/m

Moment caused by weight of concrete and live load

–	Live load (q)		=	0.3 tf/m²
–	Weight of concrete = 0.65 × 2.5		=	1.625 tf
		Total	=	1.925 tf/m²

$M_2 = \frac{1}{8} \times 1.925 \times 2.925^2 = 2.059$ tf.m

Total Moment = 1.746 + 2.058 = 3.804 tf.m

assumed $h_t = 0.60$ m

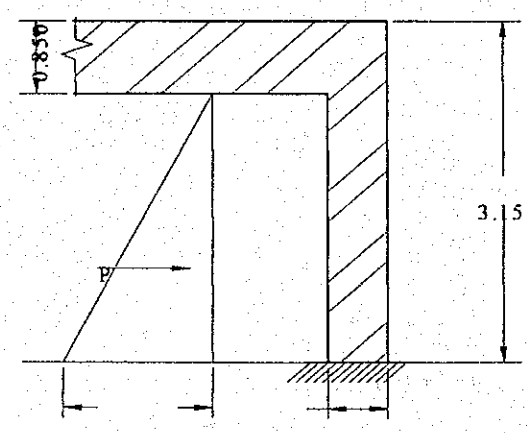
$$Ca = \frac{0.51}{\sqrt{\frac{15 \times 380400}{100 \times 1600}}} = 8.540$$

Ca = 8.540, δ = 0 → Ø = 5.40017, nω = 0.0144

$$A = \frac{0.0144}{15} \times 100 \times 51 = 4.896 \text{ cm}^2$$

Used Ø13 – 125 → A = 10.618 cm²

4.1.3.9 Cut-off wall at Floodway



P = 0.5 × 2.835 × 3.15 = 4.465 t.f

$Z = \frac{2}{3} \times 3.15 = 2.100$ m

M = 2.10 × 4.465 = 9.375 tf.m

$$Ca = \frac{51}{\sqrt{\frac{15 \times 937600}{100 \times 1600}}} = 5.440$$

$Ca = 5.440$, $\delta = 0$ $\Rightarrow$ $\varnothing = 3.225$, $n\omega = 0.0366$

$$A = \frac{0.0366}{15} \times 100 \times 51 = 12.444 \text{ cm}^2$$

Used D25 – 250 $\rightarrow$ A = 19.635 cm²

Slab

$$P = 0.5 \times 2.835 \times 3.15 = 4.465 \text{ t.f}$$

$$Z = 2.10 + \frac{0.85}{2} = 2.525 \text{ m}$$

$$M = 4.465 \times 2.525 = 11.274 \text{ tf.m}$$

$$N = 4.465 \text{ t}$$

$$\ell = \frac{11.274}{4.465} = -2.525 \text{ m}$$

$$\ell_a = -2.525 + \frac{0.85}{2} - 0.165 = -2.265 \text{ m}$$

$$N_\ell = -4.465 \times -2.265 = 10.113 \text{ t.m}$$

$$Ca = \frac{68.5}{\sqrt{\frac{15 \times 2011300}{100 \times 1600}}} = 7.035$$

$Ca = 7.035$, $\delta = 0$ $\Rightarrow$ $\varnothing = 4.343$, $n\omega = 0.0216$, $\zeta = 0.897$

$$i = \frac{1}{1 - 0.897 \times 0.685/-2.265} = 0.787$$

$$iA = \frac{0.0216}{15} \times 100 \times 68.5 = 9.864 \text{ cm}^2$$

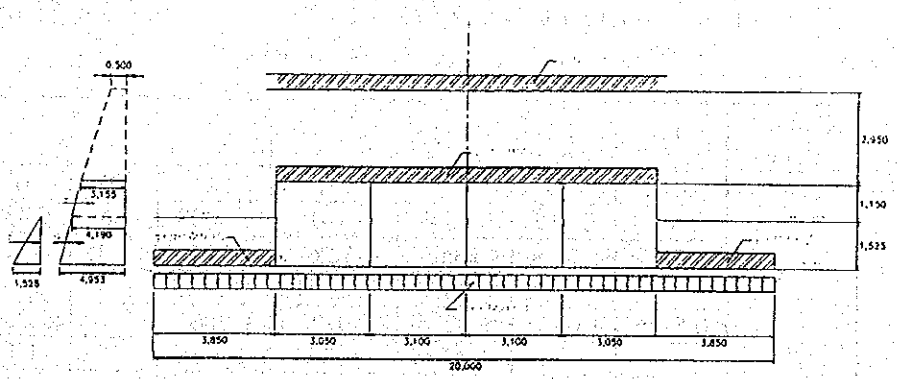
$$A = \frac{9.841}{0.779} = 12.633 \text{ cm}^2$$

Used Ø16 – 12.50 → A = 16.085 cm²

4.3.2 Right Bank Intake Structure

4.3.2.1 Standard Box Culvert

Normal Case



- Live load	= 20 x 1	=	20	tf/m
- Weight of soil I	= 20 x 2.7 x 1.8	=	97.2	tf/m
- Weight of soil II	= (20 – 13.050) x 1.40 x 1.80	=	17.514	tf/m
- Weight of soil III	= (20 – 13.050) x 1.10 x 2.00	=	15.290	tf/m
- Weight of top slab	= 13.05 x 0.5 x 2.5	=	16.313	tf/m
- Weight of side wall	= 2 x 2 x 0.75 x 2.5	=	7.5	tf/m
- Weight of middle wall	= 3 x 2 x 0.85 x 2.5	=	12.75	tf/m
- Weight of other concrete	= $\frac{0.2 \times 0.2}{2}$ x 1.8 x 2.5	=	0.90	tf/m
		=	187.467	tf/m

$$q_R = \frac{187.467}{20} = 9.373 \text{ tf/m}$$

q_1 = 1 + 2.7 x 1.8 + 0.5 x 2.5 = 7.11 tf/m

q_2 = 1 + (4.1 x 1.8) + (1.1 x 2) = 10.58 tf/m

M_{BA} = ½ x (10.58 – 9.373) x 3.850^2 = 8.945 tf/m

$M_{IH} = M_{HI}$ = 1/12 x 7.11 x 3.05^2 = 5.512 tf/m

$M_{JI} = -M_{IJ}$ = 1/12 x 7.11 x 3.10^2 = 5.694 tf/m

$M_{BC} = -M_{CB}$ = 1/12 x 9.373 x 3.05^2 = 7.260 tf/m

$M_{CD} = -M_{CD}$ = 1/12 x 9.373 x 3.10^2 = 7.500 tf/m

$$x\,[1/2 \times 2.675^2 \times (1.525^2 - 0^2) - 2/3 \times 2.675$$
$$x\,(1.525^3 - 0^3) + \tfrac{1}{4} \times (1.525^4 - 0) = -3.1625 \text{ tm}$$

$$M_{HB} = 2.675^2 \text{ X } (2 \times 3.155 + 3 \times 5.5625)/60 - 0.918/2.675^2$$
$$x\,(1/2 \times 2.675^2 \times (2.675^2 - 1.15^2) - 2/3 \times 2.675$$
$$x\,(2.675^3 - 1.15^3) + \tfrac{1}{4} \times (2.675^4 - 1.15^4) = 2.6735 \text{ tfm}$$

Contact Point	D	C			B		
Member	DC	CD	CI	CB	BC	BA	BH
	none	0.315	0.3649	0.3201	0.5608	none	0.4392
	-7.5	7.5	none	-7.26	7.26	8.945	-3.1625
			0.0672	-3.6571	-7.3142		-5.7283
	0.5276	1.0522	1.2224	1.0723	0.3562		2.2577
			-0.4425	-0.7329	-1.4659		-1.148
	0.1851	0.3703	0.4289	0.3762	0.1881		0.2591
			-0.1041	-0.1254	-0.2508		-0.1964
	0.0361	0.0723	0.0837	0.0735	0.0367		0.0463
			-0.0199	-0.0233	-0.0465		-0.0365
	0.0068	0.0136	0.0158	0.0138	0.0069		0.0086
			-0.0037	-0.0043	-0.0087		-0.0068
	0.0013	0.0025	0.0029	0.0026	0.0013 -0.0016		0.0016 -0.0013
Bending Moment (tf m)	-9.7431	9.0139	1.2507	-10.2646	-1.2385	8.945	-7.7065

Contact Point	H		I			J
Member	HB	HI	IH	IC	IJ	JI
	0.7935	0.2065	0.132	0.7383	0.1297	none
	2.6735	-5.512	5.512	none	-5.694	5.694
	-2.8641	0.012	0.024	0.1344	0.0236	0.0118
	4.5155	1.1751	0.5876	0.6112	none	none
	-0.574	-0.0791	-0.1582	-0.8851	-0.1555	-0.0777
	0.5182	0.1349	0.0674	0.2145	none	none
	-0.0982	-0.0186	-0.0372	-0.2081	-0.0366	-0.0183
	0.0927	0.0241	0.0121	0.0419	none	none
	-0.0182	-0.0036	-0.0071	-0.0399	-0.007	-0.0035
	0.0173	0.0045	0.0023	0.0078	none	none
	-0.0034	-0.0007	-0.0013	-0.0075	-0.0013	-0.0007
	0.0033	0.0008	0.0004	0.0015	none	none
	none	none	-0.0003	-0.0014	-0.0005	
Bending Moment (tf m)	4.2626	-4.2626	6.0017	-0.1307	-5.8713	5.806

Slab AB

$S_{AB} = 3.85 \times (10.58 - 9.373) = 4.647$ tf

Slab BC

$$S_{BC} = \tfrac{1}{2} \times 3.05 \times 9.373 - \frac{10.2646 + 1.2383}{3.05} = 10.522 \text{ tf}$$

$$S_{CB} = \tfrac{1}{2} \times 3.05 \times 9.373 - \frac{1.2383 - 10.2646}{3.05} = 18.065 \text{ tf}$$

$S = 0 \rightarrow 10.522 - 9.373\,x = 0 \rightarrow x = 1.149$ m

$M_{max} = 10.522 \times 1.149 - \tfrac{1}{2} \times 9.375 \times 1.149^2 + 1.2383$

$= 7.140$ tf

Slab CD

$$S_{CD} = \tfrac{1}{2} \times 3.10 \times 9.375 - \frac{6.7431 + 9.0139}{3.10} = 15.264 \text{ tf}$$

$$S_{DC} = \tfrac{1}{2} \times 3.10 \times 9.375 - \frac{9.0139 - 6.7431}{3.10} = 13.799 \text{ tf}$$

$S = 0 \rightarrow 15.264 - 9.375\,x = 0 \rightarrow x = 1.628$ m

$M_{max} = 15.264 \times 1.628 - \tfrac{1}{2} \times 9.375 \times 1.628^2 - 9.0139$

$= 3.412$ tf

Slab HI

$$S_{HI} = \tfrac{1}{2} \times 7.11 \times 3.05 - \frac{6.0017 - 6.2626}{3.05} = 10.273 \text{ tf}$$

$$S_{IH} = \tfrac{1}{2} \times 7.11 \times 3.05 - \frac{4.2626 - 6.0017}{3.05} = 11.413 \text{ tf}$$

$S = 0 \rightarrow 10.273 - 7.11\,x = 0 \rightarrow x = 1.445$ m

$M_{max} = 10.273 \times 1.445 - \tfrac{1}{2} \times 7.11 \times 1.445^2 - 4.1626$

$= 3.158 \quad \text{tf m}$

Slab IJ

$$S_{IJ} = \tfrac{1}{2} \times 7.11 \times 3.10 - \frac{5.806 - 5.8713}{3.10} = 11.042 \quad \text{tf}$$

$$S_{JI} = \tfrac{1}{2} \times 7.11 \times 3.10 - \frac{5.8713 - 5.806}{3.10} = 10.999 \quad \text{tf}$$

$$S = 0 \rightarrow 11.071 - 7.11\,x = 0 \rightarrow x = 1.553 \quad \text{m}$$

$$M_{max} = 11.042 \times 1.553 - \tfrac{1}{2} \times 7.11 \times 1.553^2 - 5.8713$$
$$= 2.703 \quad \text{tf m}$$

Wall BH

$$S_{BH} = \frac{2 \times 5.5625 + 3.155}{6} \times 2.675 - \frac{4.2626 + 7.7065}{2.675}$$
$$+ (1.526 \times 0.61) \times \frac{1.913}{6} = 8.310 \text{ tf}$$

$$S_{HB} = \frac{2 \times 3.155 + 5.5625}{6} \times 2.675 - \frac{7.7065 + 4.2626}{2.675}$$
$$+ (1.526 \times 0.61) \times \frac{0.763}{2.675} = 4.271 \text{ tf}$$

$$S = 0 \rightarrow 4.271 - 3.133\,x - \frac{5.5625 - 3.155}{2 \times 2.675} x^2 = 0$$

$$4.271 - 3.133\,x + 0.45\,x^2 = 0$$

$$x^2 - 6.962\,x + 9.491 = 0$$

$$x = \frac{-6.961 + \sqrt{6.962^2 - 4 \times 9.491}}{2} = 1.168 \text{ m}$$

$$M_{max} = 4.271 \times 1.168 - \frac{3.155}{2} \times 1.168^2 - \frac{5.5625 - 3.155}{6 \cdot 2.675} \cdot 1.168^3 - 4.2626$$

$$= -1.665 \quad \text{tf m}$$

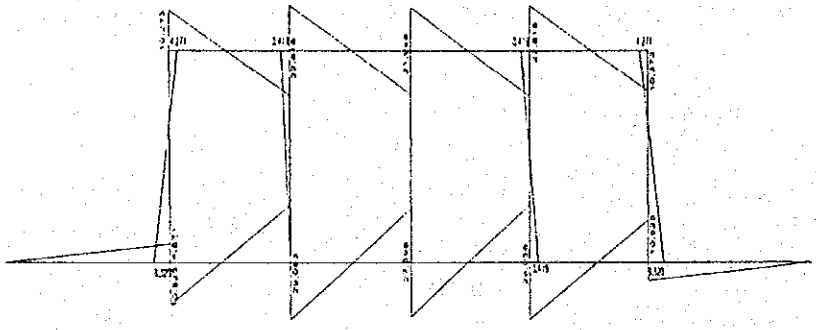
Wall CI

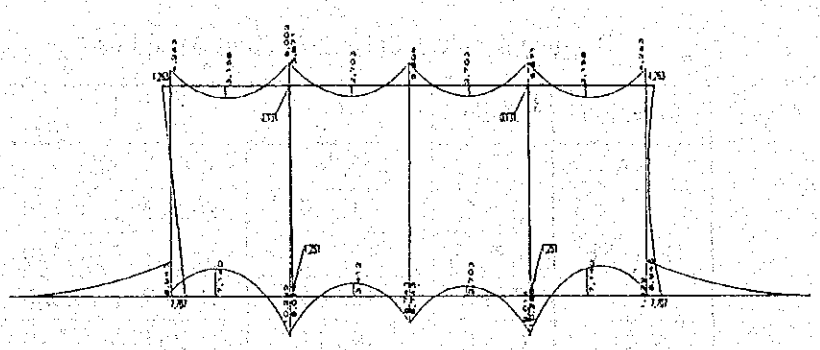
$$S_{CI} = \frac{1.2507 - 0.1307}{2.675} = 0.4187$$

$$S_{IC} = \frac{0.1307 - 1.2507}{2.675} = 0.4187$$

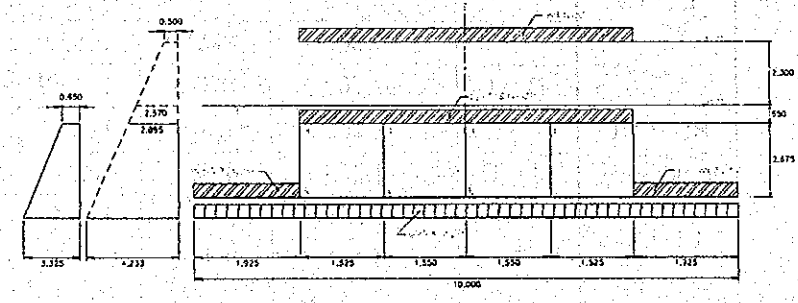
Bending Moment, Shear Force and Axial Load

Location	Point	M (tf · m')	S (tf)	N (tf)
BA		-8.945	4.647	-
BC = FE	B = C	+1.239	10.522	8.320
		+7.140	-	8.320
	C = E	-10.2646	18.065	8.320
CD = ED	C = E	-9.014	15.264	8.739
		+3.412	-	8.739
	D	-6.743	13.799	8.739
HI = LK	H = L	-4.263	10.273	4.271
		+3.158	-	4.271
	I = K	-6.002	11.413	4.271
IJ = KJ	I = K	-5.871	11.042	3.852
		+2.703	-	3.852
	J	-5.806	10.999	3.852
BH = HL	B = I	-7.707	8.320	15.169
		-1.665	-	12.721
	H = L	-4.263	4.271	10.273
CI = IK	C = K	-1.251	0.419	22.455
	I	-0.131	0.419	22.455
DJ	-	-		
	-	-		





Flooding Case



Reaction Sub grade q_R =

- live load = 20 x 1		=	20	tf/m
- weight of Soil I	= 20 x 2.3 x 1.80	=	82.8	tf/m
- weight of Soil II	= 20 x 0.4 x 2.00	=	16.00	tf/m
- weight of Soil III	= (20 – 13.050) x 2.90 x 2	=	40.31	tf/m

- weight of top Slab = 13.05 x 0.5 x 2.5 = 16.313 tf/m
- weight of side wall = 2 x 2 x 0.75 x 2.5 = 7.50 tf/m
- weight of middle wall = 3 x 2 x 0.85 x 2.5 = 12.75 tf/m
- weight of others concrete = 0.2 x 0.2 x 18 x 2.5 = 0.90 tf/m

= 196.573 tf/m

$$Q_R = \frac{196.573}{20} = 9.8287 \text{ tf/m}^2$$

q_1 = 1 + (2.3 x 1.80) + (0.4 x 2) + (0.5 x 2.5) = 7.19 tf/m^2

q_2 = 1 + (2.3 x 1.80) + (2.9 x 2) = 10.94 tf/m'tf/m^2

M_{BA} = ½ x (10.94 – 9.8287) x 3.850^2 = 8.2361 tf.m

M_{IH} = – M_{HI} = 1/12 x 7.19 x 3.05^2 = 5.574 tf.m

M_{JI} = – M_{IJ} = 1/12 x 7.19 x 3.10^2 = 5.758 tf.m

M_{BC} = – M_{CB} = 1/12 x 9.8287 x 3.05^2 = 7.619 tf.m

M_{CD} = – M_{CD} = 1/12 x 9.8287 x 3.10^2 = 7.8711 tf.m

M_{BH} = – 2.675^2 x (2 x 3.545 + 3 x 7.559)/60 = 3.550 tf.m

M_{HB} = 2.675^2 x (2 x 7.559 + 3 x 3.545)/60 = 3.0713 tf.m

Contact Point	D	C			B		
Member	DC	CD	CI	CB	BC	BA	BH
	-	0.3150	0.3649	0.3201	0.5608	-	0.4392
	-7.8711	7.8711	-	-9.6190	7.6190	8.2361	-3.5500
	-0.0397	-0.0794	-0.0920	-0.0807	-0.0403		0.9929
			-0.0105	-3.7175	-7.4349		-5.8228
	0.5872	1.1743	1.3603	1.1933	0.5967		1.1559
			-0.3621	-0.4914	-0.9829		-0.7697
	0.1344	0.2688	0.3114	0.2732	0.1366		0.1784
			-0.0746	-0.0883	-0.1767		-0.1383
	0.0257	0.0513	0.0594	0.0521	0.0261		0.0327
			-0.0141	-0.0165	-0.0330		-0.0258
	0.0048	0.0196	0.0112	0.0098	0.0049		0.0061
			-0.0027	-0.0031	-0.0062		-0.0048
	0.0009	0.0018	0.0021	0.0018	0.0009		0.0012
			-0.0005	-0.0006	-0.0012		-0.0009
		0.0004	0.0004	0.0003			
Bending Moment (tf m)	-7.1578	9.2979	1.1883	-10.4862	-0.2910	8.2361	-7.9451

Contact Point	H		I			J
Member	HB	HI	IH	IC	IJ	JI
	0.7935	0.2065	0.1320	0.7383	0.1297	-
	3.0713	-5.5740	5.5740	-	-5.7580	5.7580
	1.9859	0.5168	0.2584	-0.0460		
	-2.9114	-0.0019	-0.0637	-0.0210	-0.0037	-0.0018
	2.3117	0.6016	0.3008	0.6802		
	-0.3849	-0.0647	-0.1295	-0.7242	-0.1272	-0.0636
	0.3568	0.0928	0.0464	0.1557		
	-0.0692	-0.0133	-0.0267	-0.1492	-0.0262	-0.0134
	0.0655	0.0170	0.0085	0.0297		
	-0.0129	-0.0625	-0.0050	-0.0282	-0.0049	-0.0024
	0.0122	0.0032	0.0016	0.0056		
	-0.0024	-0.0005	-0.0009	-0.0053	-0.0009	-0.0004
	0.0023	0.0005	0.0003	0.0011		
	-0.0005	-0.0001	-0.0002	-0.0010	-0.0002	-0.0001
	0.0005	0.0001				
Bending Moment (tf m)	4.4249	-4.4250	6.0240	-0.1026	-5.9211	5.6766

Slab AB

$S_{AB} = 3.85 \times (10.94 - 9.8287) = 4.279$ tf

Slab BC

$$S_{BC} = \tfrac{1}{2} \times 9.8287 \times 3.05 - \frac{10.4862 + 0.2910}{3.05} = 11.455 \text{ tf}$$

$$S_{CB} = \tfrac{1}{2} \times 9.8287 \times 3.05 - \frac{-0.2910 - 10.4862}{3.05} = 18.522 \text{ tf}$$

$S = 0 \rightarrow 11.455 - 9.8287x = 0 \rightarrow x = 1.1655$ m

$M_{max} = 11.455 \times 1.1655 - \tfrac{1}{2} \times 9.8287 \times 1.1655^2 + 0.2910E$

$= 6.966$ tf

Slab CD

$$S_{CD} = \tfrac{1}{2} \times 9.8287 \times 3.10 - \frac{7.1578 + 9.2979}{3.10} = 15.925 \text{ tf}$$

$$S_{DC} = \tfrac{1}{2} \times 9.8287 \times 3.10 - \frac{9.2979 - 7.1578}{3.10} = 14.544 \text{ tf}$$

$$S = 0 \rightarrow 15.925 - 9.8287x = 0 \rightarrow x = 1.620 \text{ m}$$

$$M_{max} = 15.925 \times 1.620 - \tfrac{1}{2} \times 9.8287 \times 1.620^2 - 9.2979E$$
$$= 3.603 \text{ tf}$$

Slab HI

$$S_{HI} = \tfrac{1}{2} \times 7.19 \times 3.05 - \frac{6.0240 - 4.4250}{3.05} = 10.440 \text{ tf}$$

$$S_{IH} = \tfrac{1}{2} \times 7.19 \times 3.05 - \frac{4.4250 - 6.0240}{3.05} = 11.489 \text{ tf}$$

$$S = 0 \rightarrow 10.440 - 7.19x = 0 \rightarrow x = 1.452 \text{ m}$$

$$M_{max} = 10.440 \times 1.452 - \tfrac{1}{2} \times 7.19 \times 1.452^2 - 4.4250$$
$$= 3.155 \text{ tf m}$$

Slab IJ

$$S_{IJ} = \tfrac{1}{2} \times 7.19 \times 3.10 - \frac{5.6766 - 5.9211}{3.10} = 11.223 \text{ tf}$$

$$S_{JI} = \tfrac{1}{2} \times 7.19 \times 3.10 - \frac{5.9211 - 5.6766}{3.10} = 11.065 \text{ tf}$$

$$S = 0 \rightarrow 11.223 - 7.19x = 0 \rightarrow x = 1.561 \text{ m}$$

$$M_{max} = 11.223 \times 1.561 - \tfrac{1}{2} \times 7.19 \times 1.561^2 - 5.9211E$$
$$= 2.837 \text{ tf m}$$

Wall BH

$$S_{BH} = \frac{2 \times 7.559 + 3.545}{6} \times 2.675 - \frac{4.4249 + 7.9451}{2.675} = 9.636$$

$$S_{HB} = \frac{2 \times 3.545 + 7.559}{6} \times 2.675 - \frac{7.9451 + 4.4249}{2.675} = 5.215$$

$$S = 0 \rightarrow 9.363 - 7.559x - \frac{3.545 - 7.559}{2 \times 2.675}x^2 = 0$$

$$9.636 - 7.559\,x + 0.750\,x = 0$$
$$x^2 - 10.075x + 12.843 = 0$$
$$x = \frac{10.075 \pm \sqrt{10.075^2 - 4 \times 12.843}}{2} = 1.497 \text{ m}$$

$$M_{max} = 9.636 \times 1.497 - \frac{7.559}{2} \times 1.497^2 - \frac{3.545 - 7.559}{6 \cdot 2.675} \cdot 1.497^3 - 7.9451$$

$$= -1.1509 \text{ tf m}$$

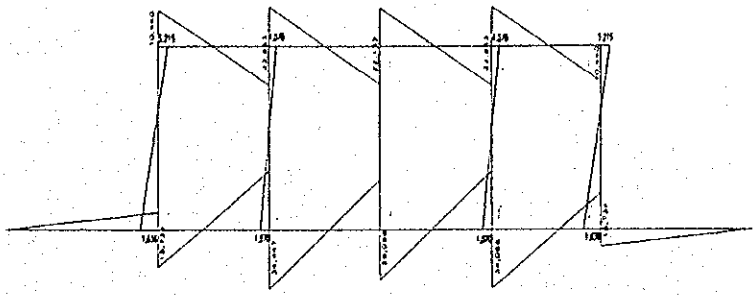
Wall CI

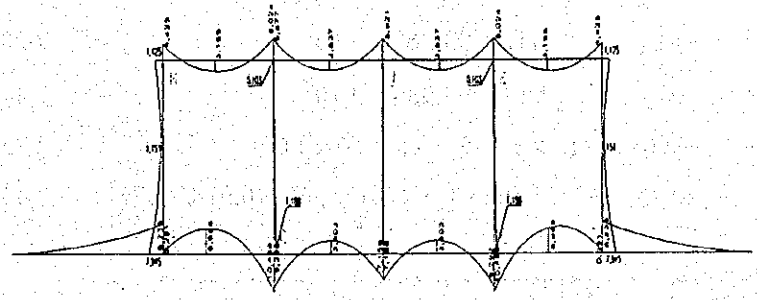
$$S_{CI} = \frac{1.883 - 0.1026}{2.675} = 0.407$$

$$S_{IC} = \frac{0.1026 + 1.1883}{2.675} = 0.407$$

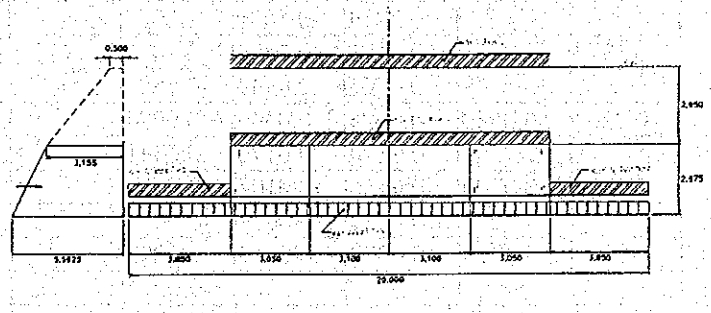
Bending Moment, Shear Force and Axial Load

Location	Point	M (tf · m)	S (tf)	N (tf)
BA		8.2361	4.279	-
BC = FE	B = F	+0.2910	11.455	9.636
		+6.966		9.636
	C = E	-10.486	18.522	9.636
CD = ED	C = E	-9.298	15.925	9.229
		+3.603		9.229
	D	-7.158	14.544	9.229
HI = LK	H = L	-4.425	10.440	5.215
		+3.155		5.215
	I = K	-6.024	11.440	5.215
IJ = KJ	I = K	-5.677	11.223	5.622
		+2.837		5.622
	J	-5.921	11.066	5.622
BH = HL	B = I	-7.945	9.636	15.754
		-1.151	-	13.689
	H = L	-4.425	5.215	10.440
CI = IK	C = K	-1.188	0.407	34.447
	I	-0.103	0.407	22.663
DJ		-		22.132
		-		22.132





Construction Case



- Live load = 20 x 1 = 20 tf/m
- Weight of soil I = 20 x 2.7 x 1.80 = 97.2 tf/m
- Weight of soil II = (20 – 13.050) x 1.80 x 2.5 = 31.275 tf/m
- Weight of top slab = 13.05 x 0.5 x 2.5 = 16.313 tf/m
- Weight of side wall = 2 x 2 x 0.75 x 2.5 = 7.5 tf/m
- Weight of middle wall = 3 x 2 x 0.85 x 2.5 = 12.75 tf/m

- Weight of other concrete $= \frac{0.2 \times 0.2}{2} \times 1.8 \times 2.5 = 0.90$ tf/m

$= 185.938$ tf/m

$q_R = \frac{185.938}{20} = 9.2969$ tf/m

$q_1 = 1 + 2.7 \times 1.8 + 0.5 \times 2.5 = 7.11$ tf/m

$q_2 = 1 + 5.2 \times 1.8 = 10.36$ tf/m

$M_{BA} = ½ \times (10.36 - 9.2969) \times 3.850^2 = 7.879$ tf/m

$M_{IH} = -M_{HI} = 1/12 \times 7.11 \times 3.05^2 = 5.512$ tf/m

$M_{JI} = -M_{IJ} = 1/12 \times 7.11 \times 3.10^2 = 5.694$ tf/m

$M_{BC} = -M_{CB} = 1/12 \times 9.8969 \times 3.05^2 = 7.207$ tf/m

$M_{CD} = -M_{CD} = 1/12 \times 9.2989 \times 3.10^2 = 7.445$ tf/m

$M_{BH} = -2.675^2 \times (2 \times 3.155 + 3 \times 5.5625)/60 = 2.733$ tm

$M_{HB} = 2.675^2 \times (2 \times 5.5625 + 3 \times 3.155)/60 - 0.918/2.675^2 = 2.4413$

Contact Point	D	C			B		
Member	DC	CD	CI	CB	BC	BA	BH
	-	0.3150	0.3649	0.3201	0.5608	-	0.4392
	-7.4450	7.4450	-	-7.2070	7.2070	7.8790	-2.7330
	-0.0375	-0.0750	-0.0868	-0.0762	-0.0381		12.1840
			-0.0339	-3.7947	-7.5895		-5.9438
	0.6030	1.2060	1.3971	1.2255	0.6128		1.1815
			-0.3714	-0.5031	-1.0062		-0.7881
	0.1377	0.2755	0.3191	0.2799	0.1400		0.1827
			-0.0765	-0.0949	-0.1809		-0.1417
	0.0207	0.0540	0.0625	0.0549	0.0274		0.0334
			-0.0148	-0.0170	-0.0341		-0.0267
	0.0050	0.0100	0.0116	0.0102	0.0051		0.0063
			-0.0027	-0.0032	-0.0064		-0.0050
	0.0009	0.0019	0.0022	0.0019	0.0009		0.0012
					-0.0012		-0.0009
Bending Moment (tf m)	-6.7089	8.9174	1.2064	-10.1237	-0.8632	7.8790	-7.0157

Contact Point	H		I			J
Member	HB	HI	IH	IC	IJ	JI
	0.7935	0.2065	0.1320	0.7383	0.1297	-
	2.4410	-5.5120	5.5120	-	-5.6940	5.6940
	2.4388	0.6342	0.3172	-0.0434		
	-2.9719	-0.0060	-0.0121	-0.0678	-0.0119	-0.0060
	2.3630	0.6149	0.3075	0.6985		
	-0.3940	-0.0664	-0.1328	-0.7427	-0.1305	-0.0652
	0.3653	0.0951	0.0475	0.1596		
	-0.0709	-0.0134	-0.0273	-0.1529	-0.0269	-0.0134
	0.0669	0.0174	0.0087	0.0313		
	-0.0133	-0.0026	-0.0053	-0.0295	-0.0052	-0.0026
	0.0126	0.0034	0.0016	0.0058		
	-0.0025	-0.0005	-0.0010	-0.0055	-0.0010	-0.0005
	0.0023	0.0006	0.0003	0.0012		
		-	-0.0002	-0.0011	-0.0002	-
Bending Moment (tf m)	4.2353	-4.2353	6.0161	-0.1465	-5.8697	5.6063

Slab AB

$S_{AB} = 3.850 \times (10.36 - 9.2969) = 4.093$ tf

Slab BC

$$S_{BC} = \tfrac{1}{2} \times 3.05 \times 9.2969 - \frac{10.1237 + 0.8632}{3.05} = 10.5755 \text{ tf}$$

$$S_{CB} = \tfrac{1}{2} \times 3.05 \times 9.1969 - \frac{0.8632 - 10.1237}{3.05} = 17.7810 \text{ tf}$$

$S = 0 \rightarrow 10.5755 - 9.2969\,x = 0 \rightarrow x = 1.1375$ m

$M_{max} = 10.5755 \times 1.1375 - \tfrac{1}{2} \times 9.2969 \times 1.1375^2 + 0.8632$

$= 6.8782$ tf

Slab CD

$$S_{CD} = \tfrac{1}{2} \times 3.10 \times 9.2969 - \frac{6.7089 + 8.9174}{3.10} = 15.1226 \text{ tf}$$

$$S_{DC} = \tfrac{1}{2} \times 3.10 \times 9.2969 - \frac{8.9174 - 6.7089}{3.10} = 13.6977 \text{ tf}$$

$S = 0 \rightarrow 15.1226 - 9.2969\,x = 0 \rightarrow x = 1.6266$ m

$M_{max} = 15.1226 \times 1.6266 - \frac{1}{2} \times 9.2969 \times 1.6266^2 - 8.9174$

$= 3.3820$ tf

Slab HI

$$S_{HI} = \frac{1}{2} \times 3.05 \times 7.11 - \frac{6.0161 - 4.2353}{3.05} = 10.259 \text{ tf}$$

$$S_{IH} = \frac{1}{2} \times 3.05 \times 7.11 - \frac{4.2353 - 6.0161}{3.05} = 11.426 \text{ tf}$$

$S = 0 \rightarrow 10.259 - 7.11\,x = 0 \rightarrow x = 1.443$ m

$M_{max} = 10.259 \times 1.443 - \frac{1}{2} \times 7.11 \times 1.443^2 - 4.2353$

$= 3.166$ tf m

Slab IJ

$$S_{IJ} = \frac{1}{2} \times 3.10 \times 7.11 - \frac{5.6063 - 5.8697}{3.10} = 11.105 \text{ tf}$$

$$S_{JI} = \frac{1}{2} \times 3.10 \times 7.11 - \frac{5.8697 - 5.6063}{3.10} = 10.936 \text{ tf}$$

$S = 0 \rightarrow 11.105 - 7.11\,x = 0 \rightarrow x = 1.562$ m

$M_{max} = 11.105 \times 1.562 - \frac{1}{2} \times 7.11 \times 1.562^2 - 5.8697$

$= 2.803$ tf m

Wall BH

$$S_{BH} = \frac{2 \times 5.5625 + 3.155}{6} \times 2.675 - \frac{4.2353 - 7.0157}{2.675}$$

$= 7.406$

$$S_{HB} = \frac{2 \times 3.155 + 5.5605}{6} \times 2.675 - \frac{7.0157 + 4.2353}{2.675}$$

$= 4.253$

$$S = 0 \rightarrow 7.406 - 5.5625\,x - \frac{5.5625 - 3.155}{2.2675}\,x^2 = 0$$

$$7.6106 - 5.5625\,x + 0.45\,x^2 = 0$$

$$x^2 - 12.361\,x + 16.457 = 0$$

$$x = \frac{+12.361 \pm \sqrt{12.361^2 - 4 \times 16.457}}{2} = 1.518\ \text{m}$$

$$M_{max} = 7.406 \times 1.518 - \frac{5.5625}{2} \times 1.518^2 - \frac{3.155 - 5.5625}{6 \cdot 2.675} \cdot 1.518^3 - 7.0157$$

$$= -1.658 \quad \text{tf m}$$

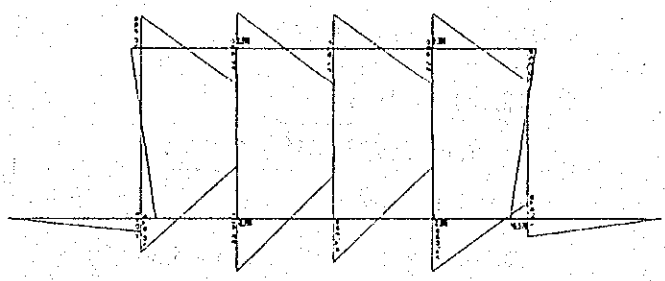
Wall CI

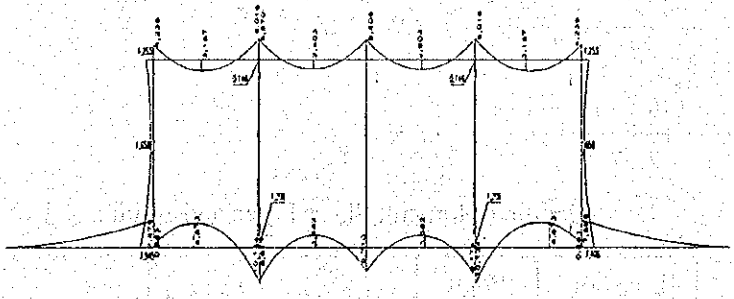
$$S_{CI} = \frac{1.2064 - 0.1465}{2.675} = 0.3.96 \quad \text{tf}$$

$$S_{IC} = \frac{0.1465 - 1.2064}{2.675} = 0.396 \quad \text{tf}$$

Bending Moment, Shear Force and Axial Load

Location	Point	M (tf · m')	S (tf)	N (tf)
BA		-7.879	4.043	-
BC = FE	B = C	+0.863	10.576	7.406
		+6.878	-	7.406
	C = E	-10.124	17.780	7.406
CD = ED	C = E	-8.917	15.123	7.802
		+3.382	-	7.802
	D	-6.710	13.698	7.802
HI = LK	H = L	-4.235	10.259	4.231
		+3.167	-	4.231
	I = K	-6.016	11.426	4.231
IJ = KJ	I = K	-5.870	11.105	3.835
		+2.803	-	3.835
	J	-5.606	10.936	3.835
BH = HL	B = I	-7.016	7.406	14.619
		-1.658	-	12.619
	H = L	-4.235	4.253	10.619
CI = IK	C = K	-1.206	0.396	22.531
	I	-0.147	0.396	32.903
DJ	-	-	-	-
	-	-	-	-





Description	Unit	Normal Condition	Flood Condition	During Construction
I. Slab BA				
Joint A				
s	kgf	4647	4279	4043
h	cm	76	76	76
$\tau = \frac{s}{7/8 \times 100 \times h}$	kgf/cm^2	0.698	0.643	0.608
II. Slab BC				
a Joint B				
s	kgf	10522	11455	10576
h	cm	68.5	68.5	68.5
$\tau = \frac{s}{7/8 \times 100 \times h}$	kgf/cm^2	1.755	1.911	1.765
b Joint C				
s	kgf	18065	18522	17780
h	cm	68.5	68.5	68.5
$\tau = \frac{s}{7/8 \times 100 \times h}$	kgf/cm^2	3.014	3.090	2.966
III. Slab CD				
a Joint C				
s	kgf	15264	15925	15123
h	cm	68.5	68.5	68.5
$\tau = \frac{s}{7/8 \times 100 \times h}$	kgf/cm^2	2.547	2.657	2.523
b Joint D				
s	kgf	13799	14544	13698
h	cm	68.5	68.5	68.5
$\tau = \frac{s}{7/8 \times 100 \times h}$	kgf/cm^2	2.302	2.426	2.285
IV. Slab HI				
a Joint H				
s	kgf	10273	10440	10259
h	cm	41	41	41
$\tau = \frac{s}{7/8 \times 100 \times h}$	kgf/cm^2	2.864	2.91	2.860
b Joint I				
s	kgf	11413	11440	11426
h	cm	41	41	41
$\tau = \frac{s}{7/8 \times 100 \times h}$	kgf/cm^2	3.181	3.189	3.185
V. Slab IY				
a Joint I				
s	kgf	11052	11223	11105
h	cm	41	41	41
$\tau = \frac{s}{7/8 \times 100 \times h}$	kgf/cm^2	3.078	3.128	3.095

Description	Unit	Normal Condition	Flood Condition	During Construction
b Joint J				
s		10999	11066	10936
h	kgf cm	41	41	41
$\tau = \frac{s}{\frac{7}{8} \times 100 \times h}$	kgf/cm^2	3.066	3.085	3.048
VI. Wall BH				
a Joint B				
s	kgf	8320	9636	7406
h	cm	66	66	66
$\tau = \frac{s}{\frac{7}{8} \times 100 \times h}$	kgf/cm^2	1.441	1.669	1.282
b Joint H				
s	kgf	4.271	5215	4.253
h	cm	66	66	66
$\tau = \frac{s}{\frac{7}{8} \times 100 \times h}$	kgf/cm^2	0.740	0.903	0.736
VII. Wall CI				
a joint C				
s	kgf	419	407	396
h	cm	76	76	76
$\tau = \frac{s}{\frac{7}{8} \times 100 \times h}$	kgf/cm^2	0.063	0.061	0.060
b Joint I				
s	kgf	419	407	396
h	cm	76	76	76
$\tau = \frac{s}{\frac{7}{8} \times 100 \times h}$	kgf/cm^2	0.063	76	0.060

All of shear stress $\tau \leq$ allowable shear stress $\bar{\tau} = 6.5$ kgf/cm^2

Slab BC (Joint B)

Description	Unit	Normal Condition	Flood Condition	During Construction
M	tfm	1.239	0.291	0.863
N	tf	8.320	9.636	7.406
ht	m	0.85	0.85	0.85
h	m	0.76	0.76	0.76
$eo_1 = M/N$	m	0.149	0.030	0.117
$eo_2 = 1/30\ ht$	m	0.028	0.028	0.028
$eo = eo_1 + eo_2$	m	0.177	0.059	0.145
eo/ht	-	0.208	0.069	0.170
C_1	-	1	1	1
C_2	-	6.66	5.86	6.54
$e_1 = C_1 \times C_2 \left(\frac{lk}{100\,ht}\right)^2 \times ht$	m	0.007	0.006	0.007
$e_2 = 0.15\ ht$	m	0.128	0.128	0.128
$e = eo + e_1 + e_2$	m	0.312	0.192	0.280
$ea = e + \frac{1}{2}\ ht - d$	m	0.647	0.527	0.615
$N \cdot ea$	tfm	5.383	5.082	4.551
$Ca = \frac{h}{\sqrt{\frac{n \cdot N \cdot ea}{b \cdot \sigma a}}}$	-	10.698	11.009	11.635
δ	-	0	0	0
ϕ	-	6.920	7.140	7.581
nw	-	0.009	0.009	0.008
ζ	-	0.958	0.959	0.961
$i = \frac{1}{1 - \zeta h / ea}$	-	-7.990	-2.618	-5.299
$iA = \frac{nw}{n} b \cdot h$	cm^2	4.621	4.358	3.894
$A = \frac{iA}{i}$	cm^2	-0.578	-1.664	-0.735

Used D19 a 250 → A = 11.341 cm^2

Slab BC (Joint C)

Description	Unit	Normal Condition	Flood Condition	During Construction
M	tfm	10.265	10.486	10.124
N	tf	8.320	9.636	7.406
ht	m	0.85	0.85	0.85
h	m	0.685	0.685	0.685
$eo_1 = M/N$	m	1.234	1.088	1.367
$eo_2 = 1/30\ ht$	m	0.028	0.0028	0.028
$eo = eo_1 + eo_2$	m	1.262	1.116	1.395
eo/ht	-	1.485	1.314	1.642
C_1	-	1	1	1
C_2	-	7	7	7
$e_1 = C_1 \times C_2 \left(\frac{lk}{100\,ht}\right)^2 \times ht$	m	0.008	0.008	0.008
$e_2 = 0.15\ ht$	m	0.128	0.128	0.128
$e = eo + e_1 + e_2$	m	1.397	1.252	1.530
$ea = e + \frac{1}{2}\,ht - d$	m	1.657	1.512	1.790
$N \cdot ea$	tfm	13.788	14.566	13.260
$Ca = \frac{h}{\sqrt{\frac{n \cdot N \cdot ea}{b \cdot \sigma a}}}$	-	6.025	5.862	6.143
δ	-	0	0	0
ϕ	-	3.634	3.520	3.718
nw	-	0.0297	0.0314	0.0285
ζ	-	0.928	0.926	0.929
$i = \frac{1}{1 - \zeta h / ea}$	-	1.622	1.7233	1.552
$iA = \frac{nw}{n} b \cdot h$	cm^2	13.556	14.350	13.019
$A = \frac{iA}{i}$	cm^2	8.356	8.327	8.391

Used D19 a 250 → A = 11.341 cm^2

Slab BC (positive moment)

Description	Unit	Normal Condition	Flood Condition	During Construction
M	tfm	7.140	6.966	6.878
N	tf	8.320	9.636	7.406
ht	m	0.85	0.85	0.85
h	m	0.76	0.76	0.76
$eo_1 = M/N$	m	0.858	0.723	0.929
$eo_2 = 1/30$ ht and ≥ 0.02 m	m	0.028	0.028	0.028
$eo = eo_1 + eo_2$	m	0.887	0.751	0.957
eo/ht	-	1.043	0.884	1.126
C_1	-	1	1	1
C_2	-	7	6.98	7
$e_1 = C_1 \times C_2 \left(\frac{lk}{100\,ht}\right)^2 \times ht$	m	0.008	0.008	0.008
$e_2 = 0.15$ ht	m	0.128	0.128	0.128
$e = eo + e_1 + e_2$	m	1.022	0.886	1.092
$ea = e + \frac{1}{2}$ ht $- d$	m	1.357	1.221	1.427
$N \cdot ea$	tfm	11.287	11.769	10.570
$Ca = \frac{h}{\sqrt{\frac{n \cdot N \cdot ea}{b \cdot \sigma a}}}$	-	7.388	7.235	7.635
δ	-	0	0	0
ϕ	-	4.590	4.483	4.764
nw	-	0.0195	0.020	0.018
ζ	-	0.940	0.939	0.942
$i = \frac{1}{1 - \zeta h / ea}$	-	2.113	2.406	2.007
$iA = \frac{nw}{n} b \cdot h$	cm^2	9.871	10.306	9.226
$A = \frac{iA}{i}$	cm^2	4.671	4.283	4.597

Used D19 a 250 → A = 11.341 cm^2

Slab CD (Joint C)

Description	Unit	Normal Condition	Flood Condition	During Construction
M	tfm	9.014	9.298	8.917
N	tf	8.739	9.229	7.802
ht	m	0.85	0.85	0.85
h	m	0.685	0.685	0.685
$eo_1 = M/N$	m	1.031	1.007	1.150
$eo_2 = 1/30\ ht$	m	0.028	0.028	0.028
$eo = eo_1 + eo_2$	m	1.060	1.036	1.178
eo/ht	-	1.247	1.209	1.386
C_1	-	1	1	1
C_2	-	7	7	7
$e_1 = C_1 \times C_2 \left(\frac{lk}{100\ ht}\right)^2 \times ht$	m	0.008	0.008	0.008
$e_2 = 0.15\ ht$	m	0.128	0.128	0.128
$e = eo + e_1 + e_2$	m	1.195	1.171	1.314
$ea = e + \frac{1}{2} ht - d$	m	1.455	1.431	1.574
$N \cdot ea$	tfm	12.717	13.209	12.227
$Ca = \frac{h}{\sqrt{\frac{n \cdot N \cdot ea}{b \cdot \sigma a}}}$	-	6.273	6.155	6.385
δ	-	0	0	0
ϕ	-	3.809	3.726	3.887
nw	-	0.027	0.028	0.026
ζ	-	0.931	0.929	0.932
$i = \frac{1}{1 - \zeta h / ea}$	-	1.780	1.801	1.682
$iA = \frac{nw}{n} b \cdot h$	cm^2	12.468	12.967	12.022
$A = \frac{iA}{i}$	cm^2	7.006	7.199	7.146

Used D19 a 125 $\rightarrow$ A = 11.341 cm^2

Slab CD (Joint D)

Description	Unit	Normal Condition	Flood Condition	During Construction
M	tfm	6.743	7.158	6.710
N	tf	8.739	9.229	7.802
ht	m	0.85	0.85	0.85
h	m	0.685	0.685	0.685
$eo_1 = M/N$	m	0.772	0.776	0.860
$eo_2 = 1/30\ ht$	m	0.028	0.028	0.028
$eo = eo_1 + eo_2$	m	0.800	0.804	0.888
eo/ht	-	0.941	0.946	1.045
C_1	-	1	1	1
C_2	-	6.99	6.99	7
$e_1 = C_1 \times C_2 \left(\frac{lk}{100\,ht}\right)^2 \times ht$	m	0.008	0.008	0.008
$e_2 = 0.15\ ht$	m	0.128	0.128	0.128
$e = eo + e_1 + e_2$	m	0.935	0.939	1.024
$ea = e + \frac{1}{2}\,ht - d$	m	1.195	1.199	1.284
$N \cdot ea$	tfm	10.446	11.069	10.016
$Ca = \frac{h}{\sqrt{\frac{n \cdot N \cdot ea}{b \cdot \sigma a}}}$	-	6.922	6.724	7.069
δ	-	0	0	0
ϕ	-	4.263	4.125	4.366
nw	-	0.022	0.024	0.021
ζ	-	0.937	0.935	0.938
$i = \frac{1}{1 - \zeta h / ea}$	-	2.159	2.146	2.002
$iA = \frac{nw}{n} b \cdot h$	cm^2	10.176	10.802	9.744
$A = \frac{iA}{i}$	cm^2	4.714	5.034	4.868

Used D19 a 250 $\rightarrow$ A = 11.341 cm^2

Slab CD (positive moment)

Description	Unit	Normal Condition	Flood Condition	During Construction
M	tfm	3.412	3.603	3.382
N	tf	8.739	9.229	7.802
ht	m	0.85	0.85	0.85
h	m	0.76	0.76	0.76
$eo_1 = M/N$	m	0.360	0.390	0.433
$eo_2 = 1/30\ ht$	m	0.028	0.028	0.028
$eo = eo_1 + eo_2$	m	0.388	0.419	0.462
eo/ht	-	0.456	0.493	0.543
C_1	-	1	1	1
C_2	-	6.89	6.89	6.92
$e_1 = C_1 \times C_2 \left(\frac{lk}{100\,ht}\right)^2 \times ht$	m	0.008	0.008	0.008
$e_2 = 0.15\ ht$	m	0.128	0.128	0.128
$e = eo + e_1 + e_2$	m	0.523	0.554	0.597
$ea = e + \frac{1}{2}\ ht - d$	m	0.858	0.889	0.932
$N \cdot ea$	tfm	7.499	8.205	7.273
$Ca = \frac{h}{\sqrt{\frac{n \cdot N \cdot ea}{b \cdot \sigma a}}}$	-	9.064	8.665	9.204
δ	-	0	0	0
ϕ	-	5.769	5.489	5.868
nw	-	0.0128	0.014	0.0124
ζ	-	0.951	0.949	0.951
$i = \frac{1}{1 - \zeta h / ea}$	-	6.329	5.290	4.460
$iA = \frac{nw}{n} b \cdot h$	cm^2	6.487	7.113	6.286
$A = \frac{iA}{i}$	cm^2	1.025	1.345	1.410

Used D19 a 125 $\rightarrow$ A = 11.341 cm^2

Slab HI (Joint H)

Description	Unit	Normal Condition	Flood Condition	During Construction
M	tfm	4.263	4.425	4.235
N	tf	4.271	5.215	4.231
ht	m	0.50	0.50	0.50
h	m	0.41	0.41	0.41
$eo_1 = M/N$	m	0.998	0.849	1.001
$eo_2 = 1/30\ ht$	m	0.02	0.02	0.02
$eo = eo_1 + eo_2$	m	1.018	0.869	1.021
eo/ht	-	2.036	1.737	2.042
C_1	-	1	1	1
C_2	-	7	7	7
$e_1 = C_1 \times C_2 \left(\frac{lk}{100\,ht}\right)^2 \times ht$	m	0.013	0.013	0.013
$e_2 = 0.15\ ht$	m	0.075	0.075	0.075
$e = eo + e_1 + e_2$	m	1.106	0.957	1.109
$ea = e + \frac{1}{2}\ ht - d$	m	1.266	1.117	1.269
$N \cdot ea$	tfm	5.408	5.823	5.369
$Ca = \frac{h}{\sqrt{\frac{n \cdot N \cdot ea}{b \cdot \sigma a}}}$	-	5.758	5.549	8.779
δ	-	0	0	0
ϕ	-	3.448	3.302	3.462
nw	-	0.0326	0.0352	0.0324
ζ	-	0.925	0.922	0.925
$i = \frac{1}{1 - \zeta h / ea}$	-	1.428	1.512	1.426
$iA = \frac{nw}{n} b \cdot h$	cm^2	8.912	9.622	8.846
$A = \frac{iA}{i}$	cm^2	6.242	6.363	6.201

Used D13 a 125 → A = 10.618 cm^2

Slab HI (Joint I)

Description	Unit	Normal Condition	Flood Condition	During Construction
M	tfm	6.002	6.024	6.016
N	tf	4.271	5.215	4.231
ht	m	0.50	0.50	0.50
h	m	0.41	0.41	0.41
$eo_1 = M/N$	m	1.405	1.155	1.422
$eo_2 = 1/30\ ht$	m	0.02	0.02	0.02
$eo = eo_1 + eo_2$	m	1.425	1.175	1.442
eo/ht	-	2.851	2.350	2.884
C_1	-	1	1	1
C_2	-	7	7	7
$e_1 = C_1 \times C_2 \left(\frac{lk}{100\,ht}\right)^2 \times ht$	m	0.013	0.013	0.013
$e_2 = 0.15\ ht$	m	0.075	0.075	0.075
$e = eo + e_1 + e_2$	m	1.513	1.263	1.530
$ea = e + \frac{1}{2}\ ht - d$	m	1.673	1.423	1.690
$N \cdot ea$	tfm	7.147	7.422	7.150
$Ca = \frac{h}{\sqrt{\frac{n \cdot N \cdot ea}{b \cdot \sigma a}}}$	-	5.009	4.915	5.008
δ	-	0	0	0
ϕ	-	2.925	2.859	2.924
nw	-	0.044	0.045	0.044
ζ	-	0.915	0.914	0.915
$i = \frac{1}{1 - \zeta h / ea}$	-	1.289	1.357	1.285
$iA = \frac{nw}{n} b \cdot h$	cm^2	11.906	12.384	11.912
$A = \frac{iA}{i}$	cm^2	9.237	9.124	9.267

Used D13 a 125 → A = 10.618 cm^2

Slab HI (positive moment)

Description	Unit	Normal Condition	Flood Condition	During Construction
M	tfm	3.158	3.155	3.167
N	tf	4.271	5.215	4.231
ht	m	0.50	0.50	0.50
h	m	0.41	0.41	0.41
$eo_1 = M/N$	m	0.739	0.605	0.749
$eo_2 = 1/30\ ht$	m	0.02	0.02	0.02
$eo = eo_1 + eo_2$	m	0.759	0.625	0.769
eo/ht	-	1.519	1.250	1.537
C_1	-	1	1	1
C_2	-	7	7	7
$e_1 = C_1 \times C_2 \left(\frac{lk}{100\,ht}\right)^2 \times ht$	m	0.013	0.013	0.013
$e_2 = 0.15\ ht$ and ≥ 0.02 m	m	0.075	0.075	0.075
$e = eo + e_1 + e_2$	m	0.847	0.713	0.857
$ea = e + \frac{1}{2} ht - d$	m	1.007	0.873	1.017
$N \cdot ea$	tfm	4.308	4.553	4.301
$Ca = \frac{h}{\sqrt{\frac{n \cdot N \cdot ea}{b \cdot \sigma a}}}$	-	6.455	6.276	6.457
δ	-	0	0	0
ϕ	-	3.936	3.810	3.937
nw	-	0.026	0.027	0.26
ζ	-	0.932	0.931	0.932
$i = \frac{1}{1 - \zeta h / ea}$	-	1.612	1.776	1.603
$iA = \frac{nw}{n} b \cdot h$	cm^2	7.034	7.457	7.032
$A = \frac{iA}{i}$	cm^2	4.365	4.198	4.387

Used D13 a 125 → A = 10.618 cm^2

Slab IY (Joint I)

Description	Unit	Normal Condition	Flood Condition	During Construction
M	tfm	5.871	5.677	5.870
N	tf	3.852	5.622	3.835
ht	m	0.50	0.50	0.50
h	m	0.41	0.41	0.41
$eo_1 = M/N$	m	0.524	1.010	1.531
$eo_2 = 1/30\ ht$	m	0.02	0.02	0.02
$eo = eo_1 + eo_2$	m	1.544	1.030	1.551
eo/ht	-	3.088	2.060	3.101
C_1	-	1	1	1
C_2	-	7	7	7
$e_1 = C_1 \times C_2 \left(\frac{lk}{100\,ht}\right)^2 \times ht$	m	0.13	0.013	0.013
$e_2 = 0.15\,ht$	m	0.075	0.075	0.075
$e = eo + e_1 + e_2$	m	1.633	1.118	1.639
$ea = e + \frac{1}{2}\,ht - d$	m	1.793	1.278	1.799
$N \cdot ea$	tfm	6.905	7.186	6.899
$Ca = \frac{h}{\sqrt{\frac{n \cdot N \cdot ea}{b \cdot \sigma a}}}$	-	5.096	4.995	5.098
δ	-	0	0	0
ϕ	-	2.985	2.915	2.987
nw	-	0.042	0.044	0.0410
ζ	-	0.916	0.915	0.916
$i = \frac{1}{1-\zeta h/ea}$	-	1.265	1.415	1.264
$iA = \frac{nw}{n} b \cdot h$	cm^2	11.487	11.975	11.478
$A = \frac{iA}{i}$	cm^2	9.080	8.461	9.081

Used D13 a 125 → A = 10.618 cm^2

Slab IY (Joint Y)

Description	Unit	Normal Condition	Flood Condition	During Construction
M	tfm	5.806	5.971	5.606
N	tf	3.852	5.622	3.835
ht	m	0.50	0.50	0.50
h	m	0.41	0.41	0.41
$eo_1 = M/N$	m	1.507	1.062	1.462
$eo_2 = 1/30$ ht	m	0.02	0.02	0.02
$eo = eo_1 + eo_2$	m	1.527	1.082	1.482
eo/ht	-	3.055	2.164	2.964
C_1	-	1	1	1
C_2	-	7	7	7
$e_1 = C_1 \times C_2 \left(\frac{lk}{100\,ht}\right)^2 \times ht$	m	0.013	0.013	0.013
$e_2 = 0.15$ ht	m	0.075	0.075	0.075
$e = eo + e_1 + e_2$	m	1.616	1.171	1.570
$ea = e + \frac{1}{2}$ ht $- d$	m	1.776	1.331	1.730
$N \cdot ea$	tfm	6.840	7.480	6.636
$Ca = \frac{h}{\sqrt{\frac{n \cdot N \cdot ea}{b \cdot \sigma a}}}$	-	5.120	4.896	5.198
δ	-	0	0	0
ϕ	-	3.002	2.846	3.057
nw	-	0.042	0.046	0.040
ζ	-	0.917	0.913	0.918
$i = \frac{1}{1 - \zeta h / ea}$	-	1.268	1.392	1.278
$iA = \frac{nw}{n} b \cdot h$	cm^2	11.375	12.485	11.021
$A = \frac{iA}{i}$	cm^2	8.967	8.971	8.624

Used D13 a 125 → A = 10.618 cm^2

Slab IY (positive moment)

Description	Unit	Normal Condition	Flood Condition	During Construction
M	tfm	2.703	2.837	2.803
N	tf	3.852	5.622	3.835
ht	m	0.50	0.50	0.50
h	m	0.41	0.41	0.41
$eo_1 = M/N$	m	0.702	0.505	0.731
$eo_2 = 1/30\ ht$	m	0.02	0.02	0.02
$eo = eo_1 + eo_2$	m	0.722	0.525	0.751
eo/ht	-	1.443	1.049	1.502
C_1	-	1	1	1
C_2	-	7	7	7
$e_1 = C_1 \times C_2 \left(\frac{lk}{100\,ht}\right)^2 \times ht$	m	0.013	0.013	0.013
$e_2 = 0.15\ ht$	m	0.075	0.075	0.075
$e = eo + e_1 + e_2$	m	0.810	0.613	0.839
$ea = e + \frac{1}{2}\,ht - d$	m	0.970	0.773	0.99
$N \cdot ea$	tfm	3.737	4.346	3.832
$Ca = \frac{h}{\sqrt{\frac{n \cdot N \cdot ea}{b \cdot \sigma a}}}$	-	6.927	6.424	6.840
δ	-	0	0	0
ϕ	-	4.267	3.913	4.206
nw	-	0.022	0.0260	0.023
ζ	-	0.937	0.932	0.936
$i = \frac{1}{1 - \zeta h / ea}$	-	1.655	1.977	1.623
$iA = \frac{nw}{n} b \cdot h$	cm^2	6.082	7.108	6.242
$A = \frac{iA}{i}$	cm^2	3.674	3.594	3.845

Used D13 – 125 → A = 10.618 cm^2

Wall BH (Joint B)

Description	Unit	Normal Condition	Flood Condition	During Construction
M	tfm	7.707	7.945	7.016
N	tf	15.169	15.734	14.619
ht	m	0.75	0.75	0.75
h	m	0.66	0.66	0.66
$eo_1 = M/N$	m	0.508	0.505	0.480
$eo_2 = 1/30\ ht$	m	0.025	0.025	0.025
$eo = eo_1 + eo_2$	m	0.533	0.530	0.505
eo/ht	-	0.711	0.707	0.673
C_1	-	1	1	1
C_2	-	6.96	6.96	6.94
$e_1 = C_1 \times C_2 \left(\frac{lk}{100\,ht}\right)^2 \times ht$	m	0.007	0.007	0.007
$e_2 = 0.15\ ht$	m	0.113	0.113	0.113
$e = eo + e_1 + e_2$	m	0.652	0.649	0.624
$ea = e + \frac{1}{2}\,ht - d$	m	0.937	0.934	0.909
$N \cdot ea$	tfm	14.217	14.697	13.289
$Ca = \frac{h}{\sqrt{\frac{n \cdot N \cdot ea}{b \cdot \sigma a}}}$	-	5.717	5.623	5.913
δ	-	0	0	0
ϕ	-	3.419	3.353	3.556
nw	-	0.033	0.034	0.031
ζ	-	0.925	0.924	0.927
$i = \frac{1}{1 - \zeta h / ea}$	-	2.866	2.877	3.057
$iA = \frac{nw}{n} b \cdot h$	cm^2	14.563	15.073	13.579
$A = \frac{iA}{i}$	cm^2	5.081	5.238	4.441

Used D13 – 125 → A = 10.618 cm^2

Wall BH (Joint H)

Description	Unit	Normal Condition	Flood Condition	During Construction
M	tfm	4.263	4.425	4.235
N	tf	10.273	10.440	10.619
ht	m	0.75	0.75	0.75
h	m	0.66	0.66	0.66
$eo_1 = M/N$	m	0.415	0.424	0.399
$eo_2 = 1/30\ ht$	m	0.025	0.025	0.025
$eo = eo_1 + eo_2$	m	0.440	0.449	0.424
eo/ht	-	0.587	0.598	0.565
C_1	-	1	1	1
C_2	-	6.92	6.92	6.92
$e_1 = C_1 \times C_2 \left(\frac{lk}{100\,ht}\right)^2 \times ht$	m	0.007	0.007	0.007
$e_2 = 0.15\ ht$	m	0.113	0.113	0.113
$e = eo + e_1 + e_2$	m	0.559	0.568	0.543
$ea = e + \frac{1}{2} ht - d$	m	0.844	0.853	0.828
$N \cdot ea$	tfm	8.671	8.905	7.270
$Ca = \frac{h}{\sqrt{\frac{n \cdot N \cdot ea}{b \cdot \sigma a}}}$	-	7.320	7.223	7.270
δ	-	0	0	0
ϕ	-	4.543	4.475	4.507
nw	-	0.0199	0.0204	0.020
ζ	-	0.940	0.939	0.939
$i = \frac{1}{1 - \zeta h / ea}$	-	3.772	3.659	3.983
$iA = \frac{nw}{n} b \cdot h$	cm^2	8.737	8.980	8.862
$A = \frac{iA}{i}$	cm^2	2.316	2.454	2.225

Used D13 – 125 → A = 10.618 cm^2

Wall CI Joint C

Description	Unit	Normal Condition	Flood Condition	During Construction
M	tfm	1.251	1.188	1.206
N	tf	22.455	34.447	22.531
ht	m	0.85	0.85	0.85
h	m	0.76	0.76	0.76
$eo_1 = M/N$	m	0.056	0.034	0.054
$eo_2 = 1/30\ ht$	m	0.028	0.028	0.028
$eo = eo_1 + eo_2$	m	0.084	0.063	0.082
eo/ht	-	0.100	0.074	0.096
C_1	-	1	1	1
C_2	-	5.86	5.86	5.86
$e_1 = C_1 \times C_2 \left(\frac{lk}{100\,ht}\right)^2 \times ht$	m	0.005	0.005	0.005
$e_2 = 0.15\ ht$	m	0.128	0.128	0.128
$e = eo + e_1 + e_2$	m	0.216	0.195	0.214
$ea = e + \frac{1}{2} ht - d$	m	0.551	0.530	0.549
$N \cdot ea$	tfm	12.383	18.266	12.376
$Ca = \frac{h}{\sqrt{\frac{n \cdot N \cdot ea}{b \cdot \sigma a}}}$	-	7.053	5.808	7.055
δ	-	0	0	0
ϕ	-	4.356	3.482	4.357
nw	-	0.0214	0.032	0.021
ζ	-	0.938	0.925	0.938
$i = \frac{1}{1 - \zeta h / ea}$	-	-3.421	-3.061	-3.361
$iA = \frac{nw}{n} b \cdot h$	cm^2	10.860	16.228	10.854
$A = \frac{iA}{i}$	cm^2	-3.175	-5.304	-3.229

Used D19 – 250 → A = 11.341 cm^2

Wall CI (Joint I)

Description	Unit	Normal Condition	Flood Condition	During Construction
M	tfm	0.151	0.103	0.147
N	tf	22.455	22.663	32.903
ht	m	0.85	0.85	0.85
h	m	0.76	0.76	0.76
$eo_1 = M/N$	m	0.006	0.005	0.004
$eo_2 = 1/30\ ht$	m	0.028	0.028	0.028
$eo = eo_1 + eo_2$	m	0.034	0.033	0.033
eo/ht	-	0.040	0.039	0.039
C_1	-	1	1	1
C_2	-	4	4	4
$e_1 = C_1 \times C_2 \left(\frac{lk}{100\,ht}\right)^2 \times ht$	m	0.003	0.003	0.003
$e_2 = 0.15\ ht$	m	0.128	0.128	0.128
$e = eo + e_1 + e_2$	m	0.165	0.164	0.164
$ea = e + \frac{1}{2}\,ht - d$	m	0.500	0.500	0.500
$N \cdot ea$	tfm	11.228	11.303	16.128
$Ca = \frac{h}{\sqrt{\frac{n \cdot N \cdot ea}{b \cdot \sigma a}}}$	-	7.407	7.383	6.128
δ	-	0	0	0
ϕ	-	4.604	4.587	3.706
nw	-	0.0194	0.0195	0.039
ζ	-	0.940	0.940	0.923
$i = \frac{1}{1 - \zeta h / ea}$	-	-2.328	-2.310	-2.403
$iA = \frac{nw}{n} b \cdot h$	cm^2	9.818	9.886	14.523
$A = \frac{iA}{i}$	cm^2	-4.216	-4.270	-6.043

Used D19 – 250 → A = 11.341 cm^2