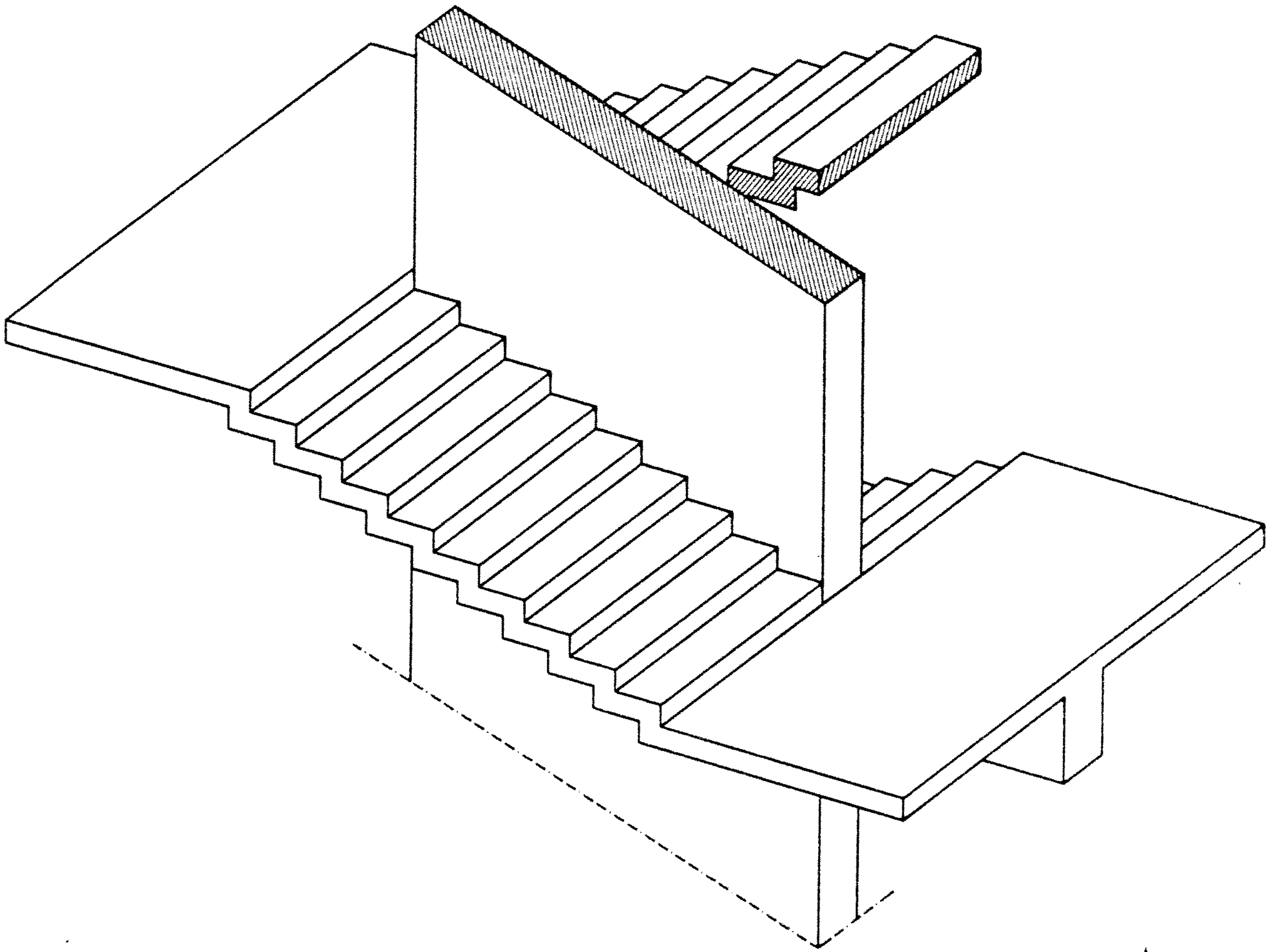
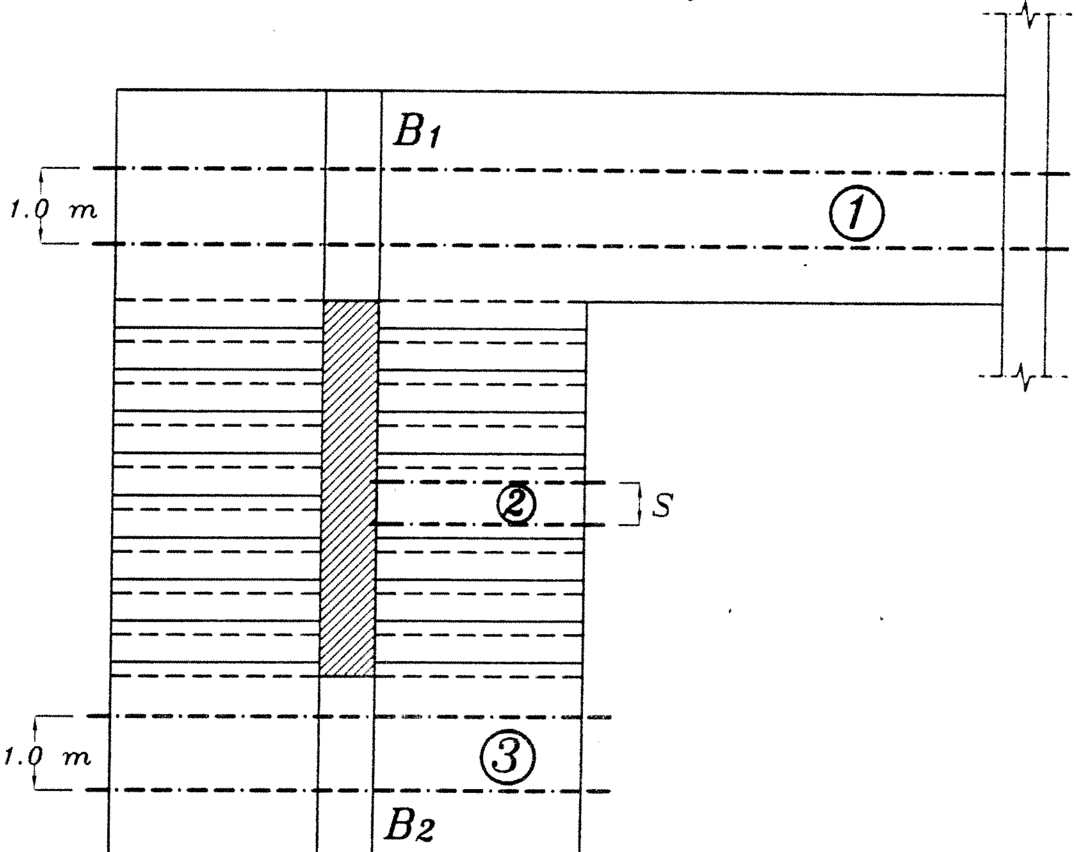
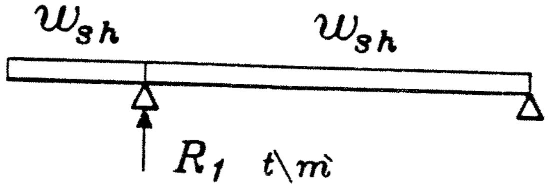
Example.



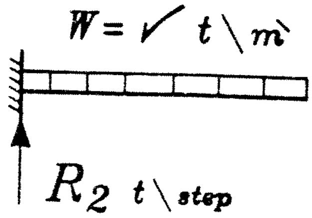


Slabs.

Strip ①

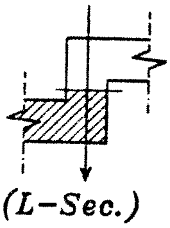


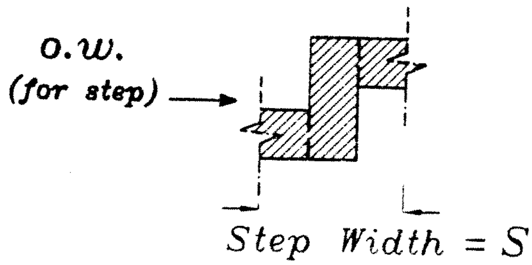
Strip ②



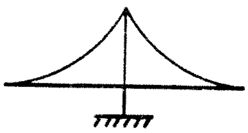
W = o.w. (For step) + (L.L.+ F.C.) (S) = ✓ t\step

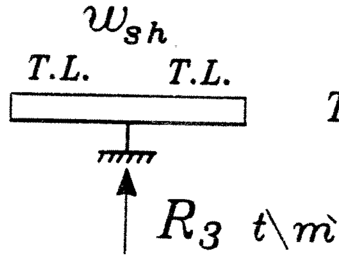
Design the strip as Beam (L–Sec.)





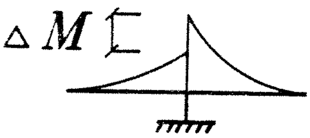
Strip ③

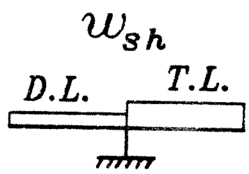




To design the slab

'orsion تعمل على B_1 → ΔM

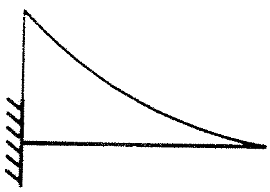


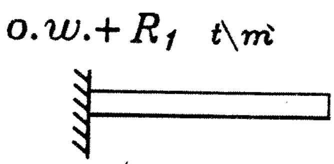


To get max. Torsion

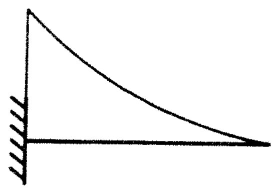
Beams.

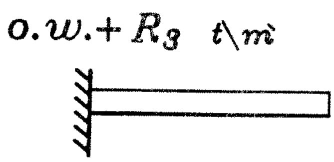
B_1



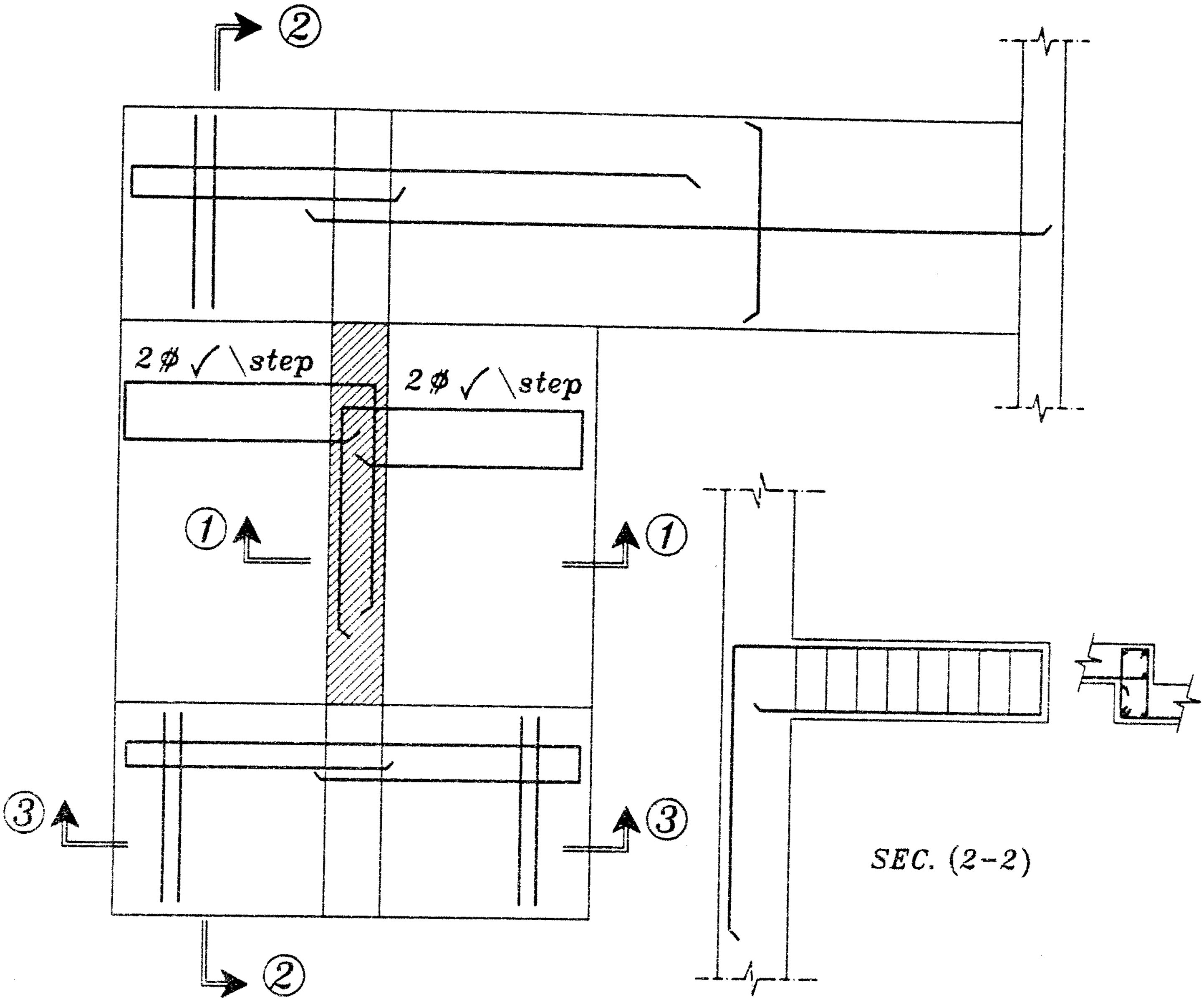


B_2

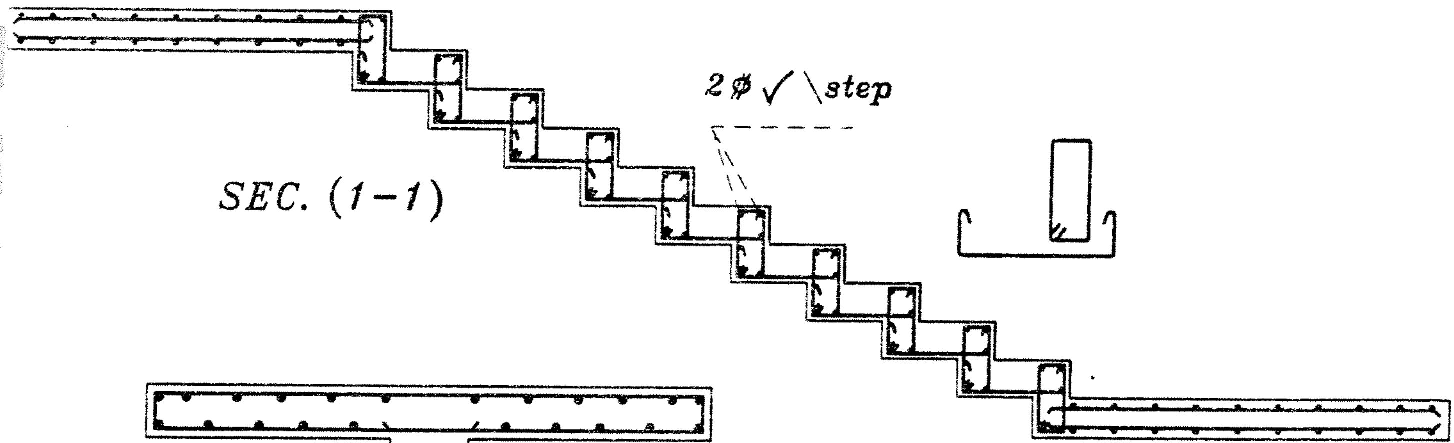




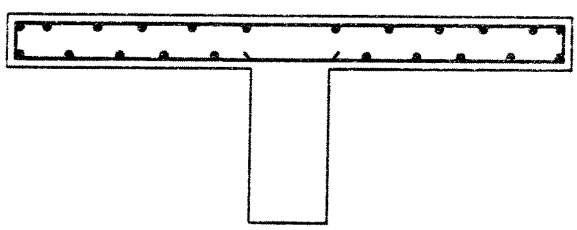
RFT. of the Slab.



SEC. (2-2)



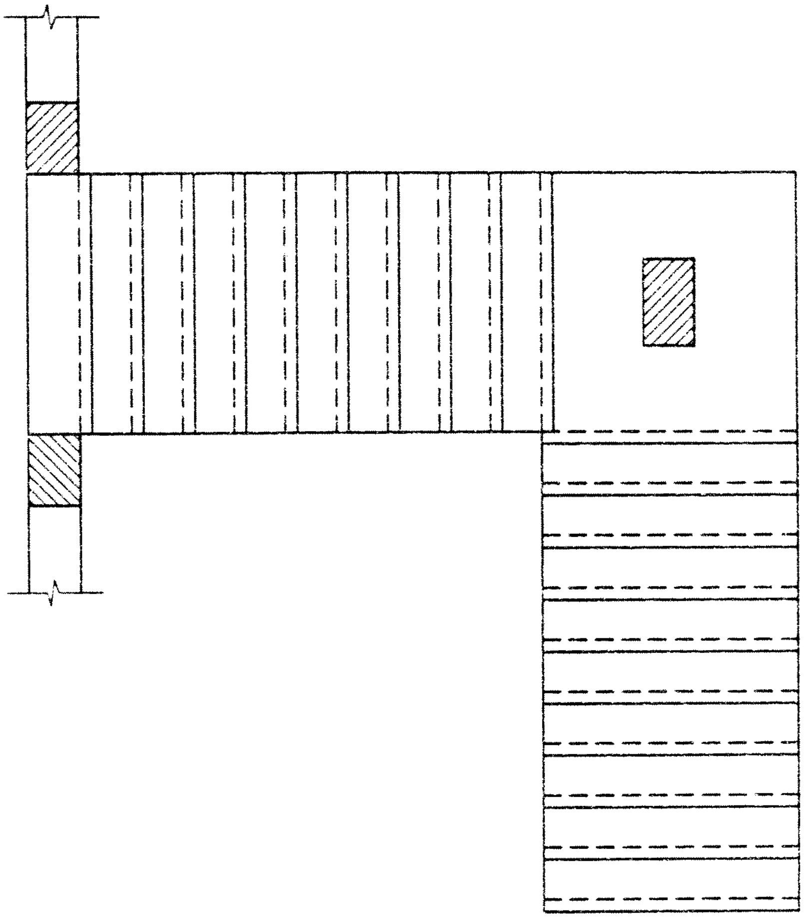
SEC. (1-1)



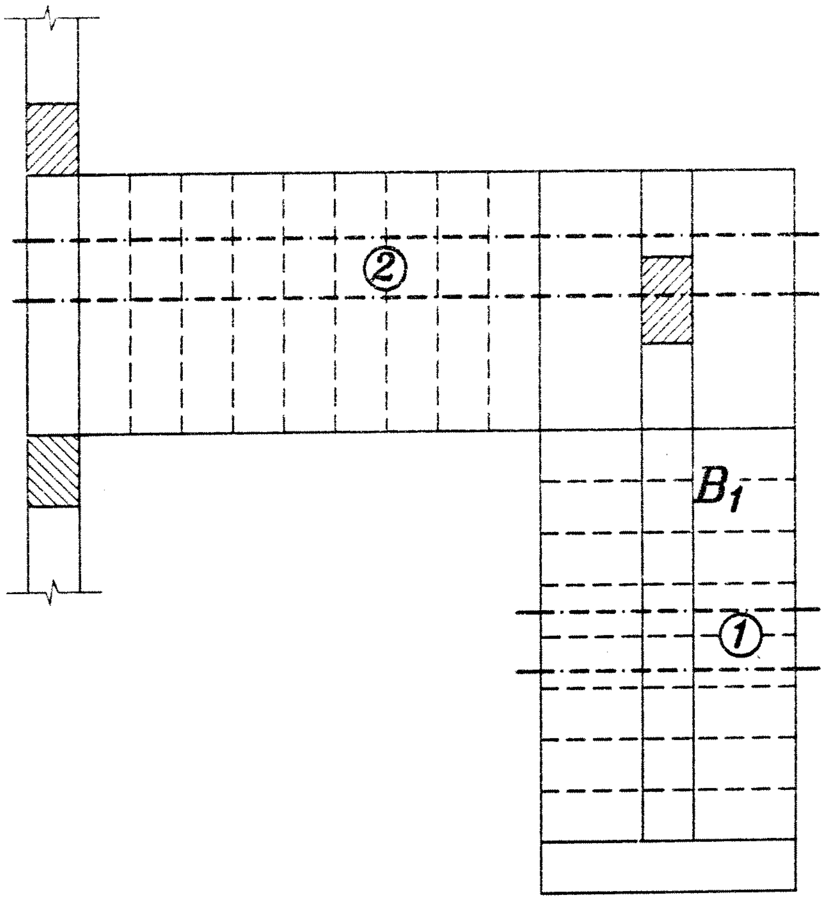
SEC. (2-2)

Example.

Arc. Plan

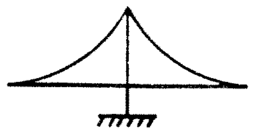


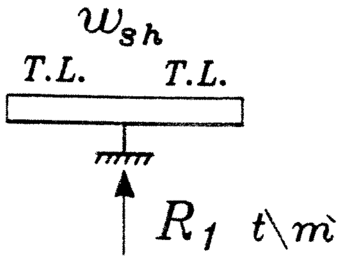
Struc. Plan



Slabs.

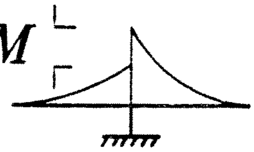
Strip ①

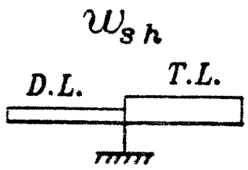




To design the slab

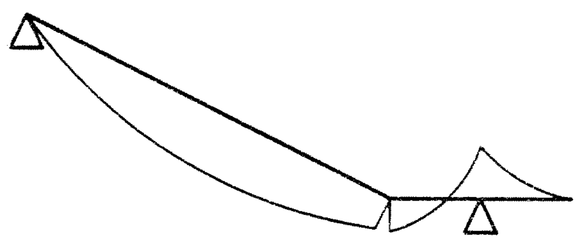
Torsion تعمل على B_1 → ΔM

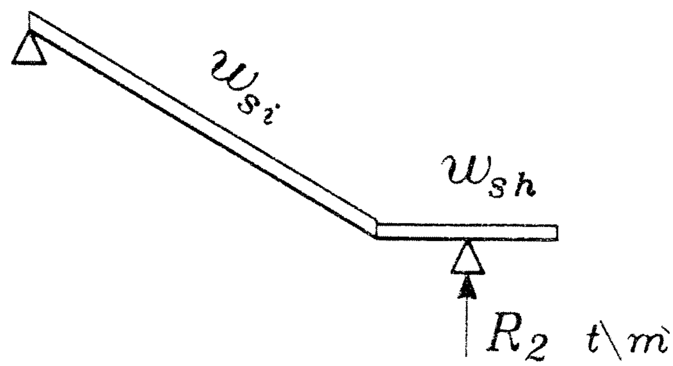




To get max. Torsion.

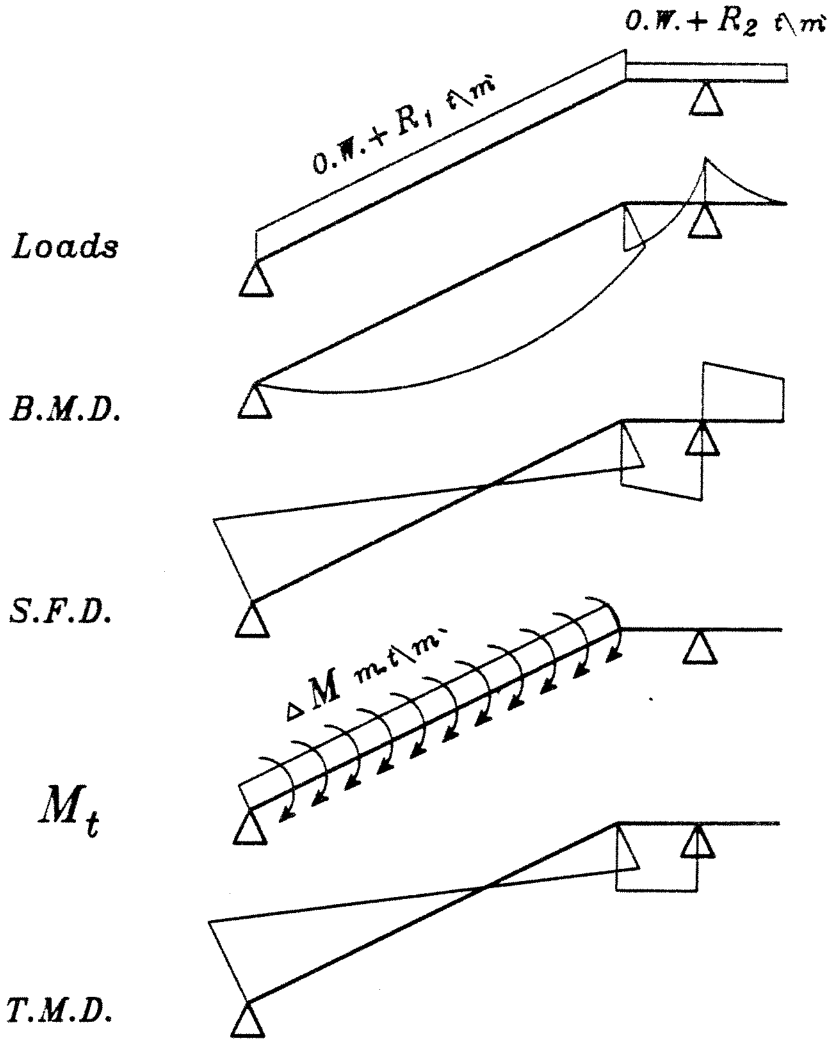
Strip ②



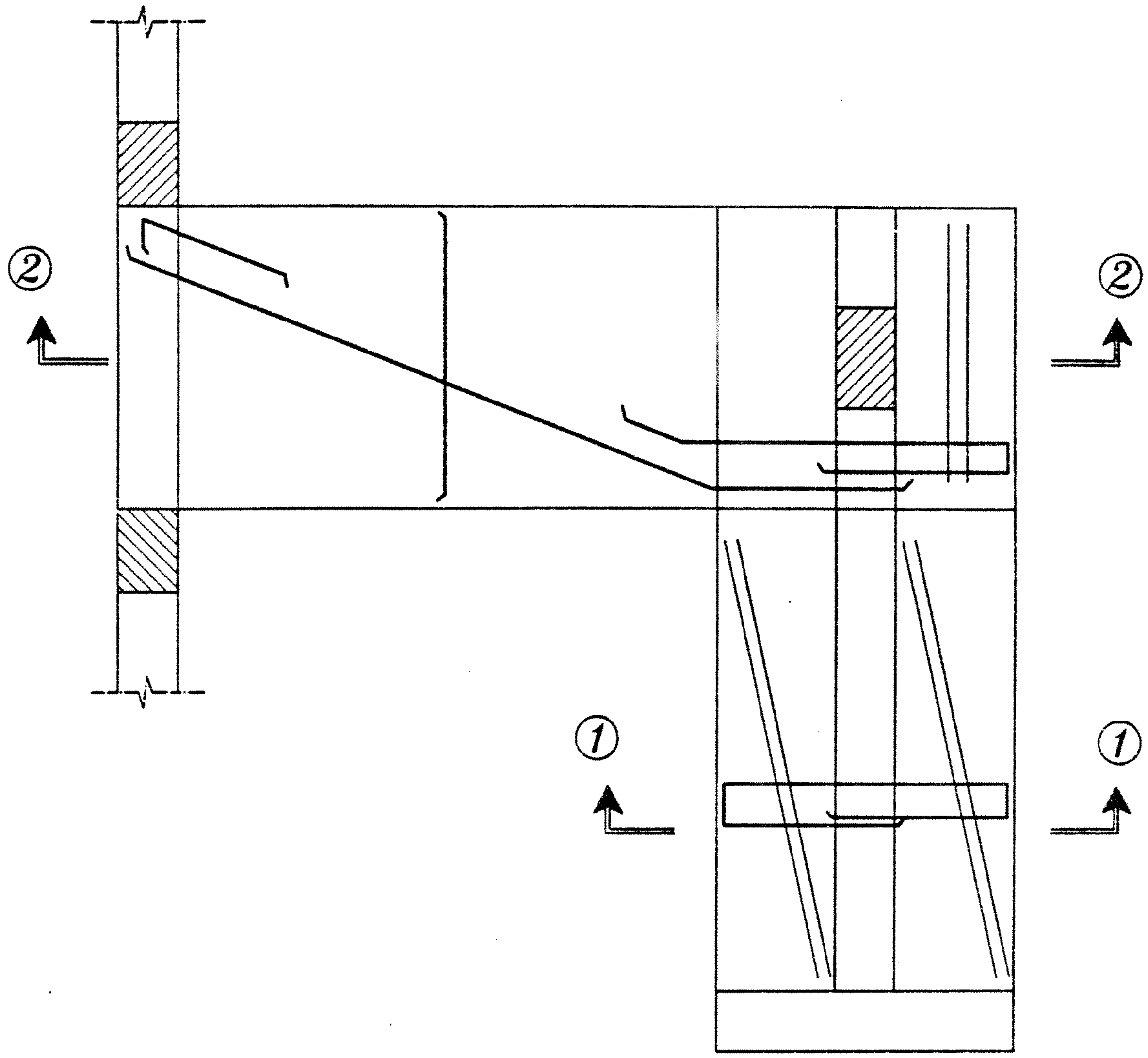


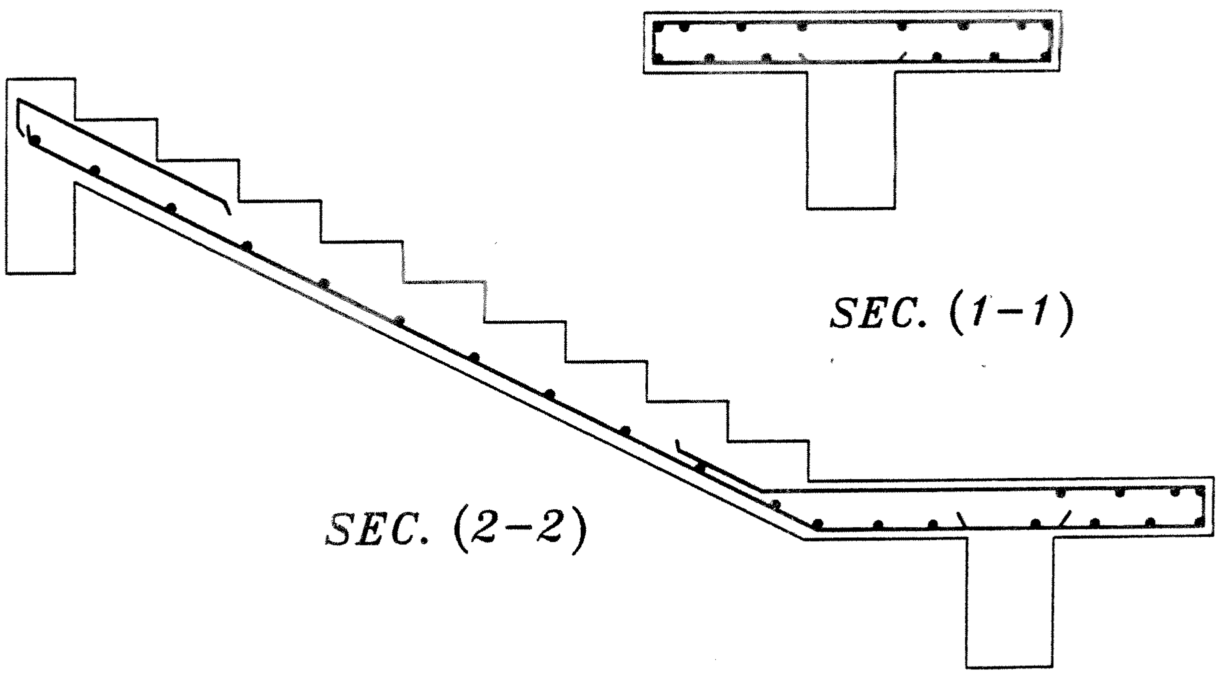
Beams.

B_1



RFT. of the Slab.



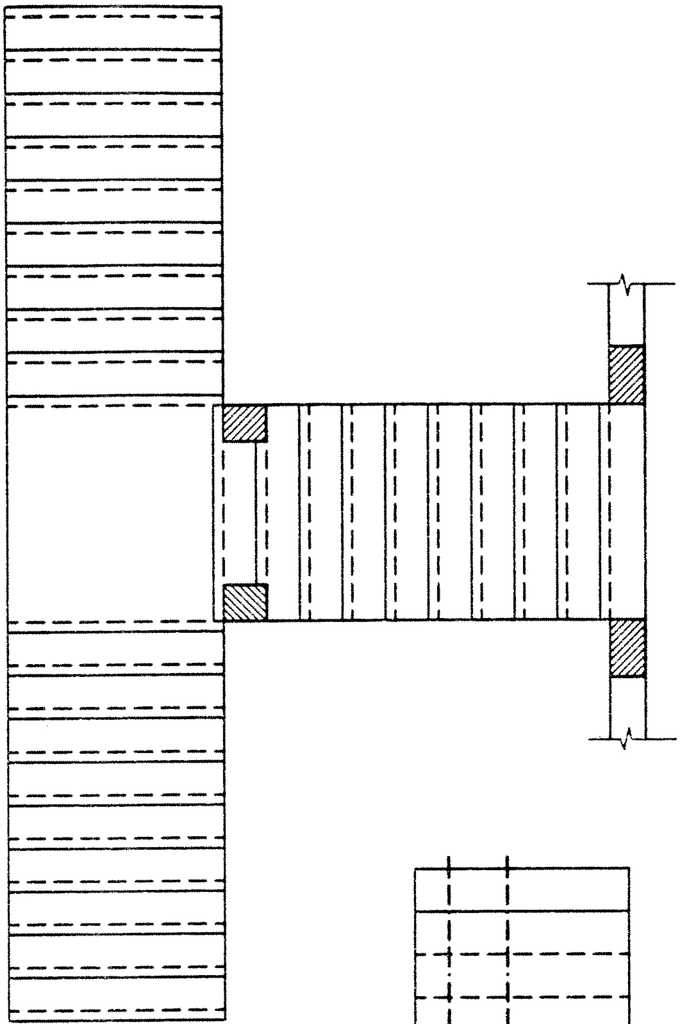


SEC. (1−1)

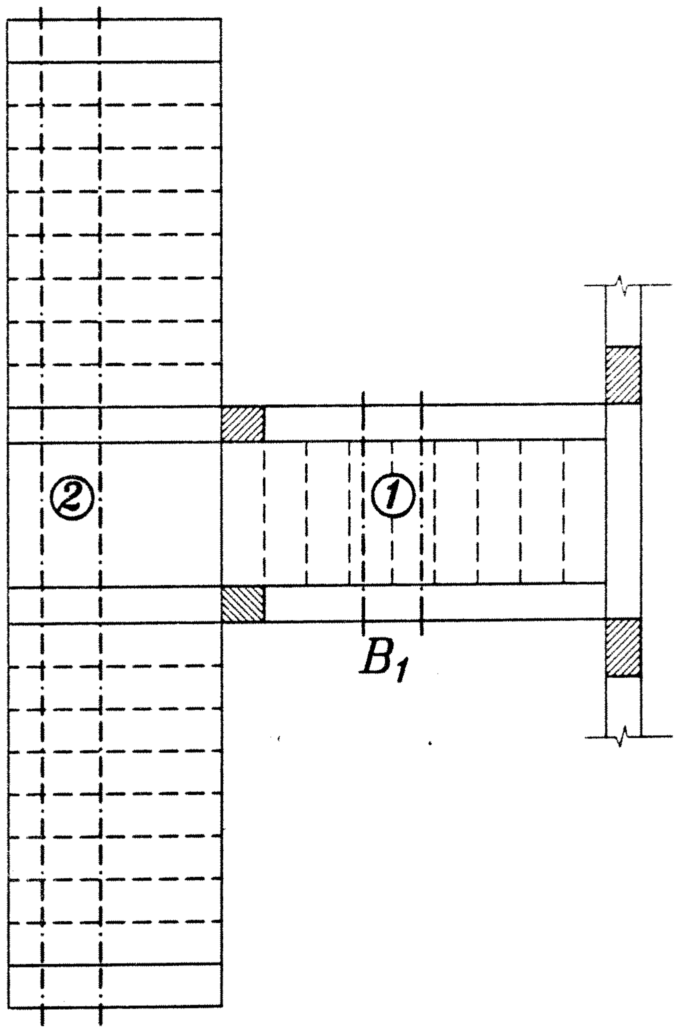
SEC. (2−2)

Example.

Arc. Plan

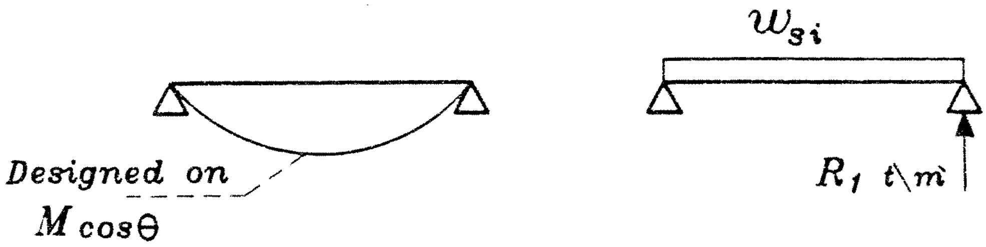


Struc. Plan

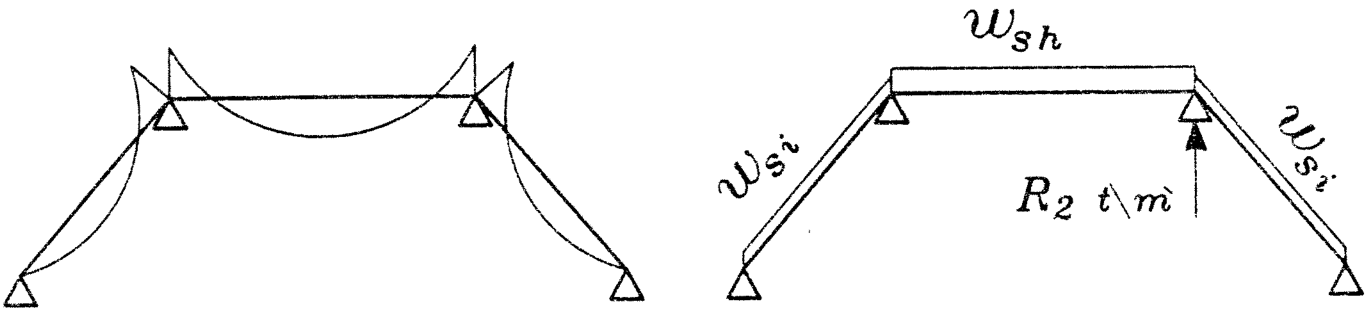


Slabs.

Strip ①

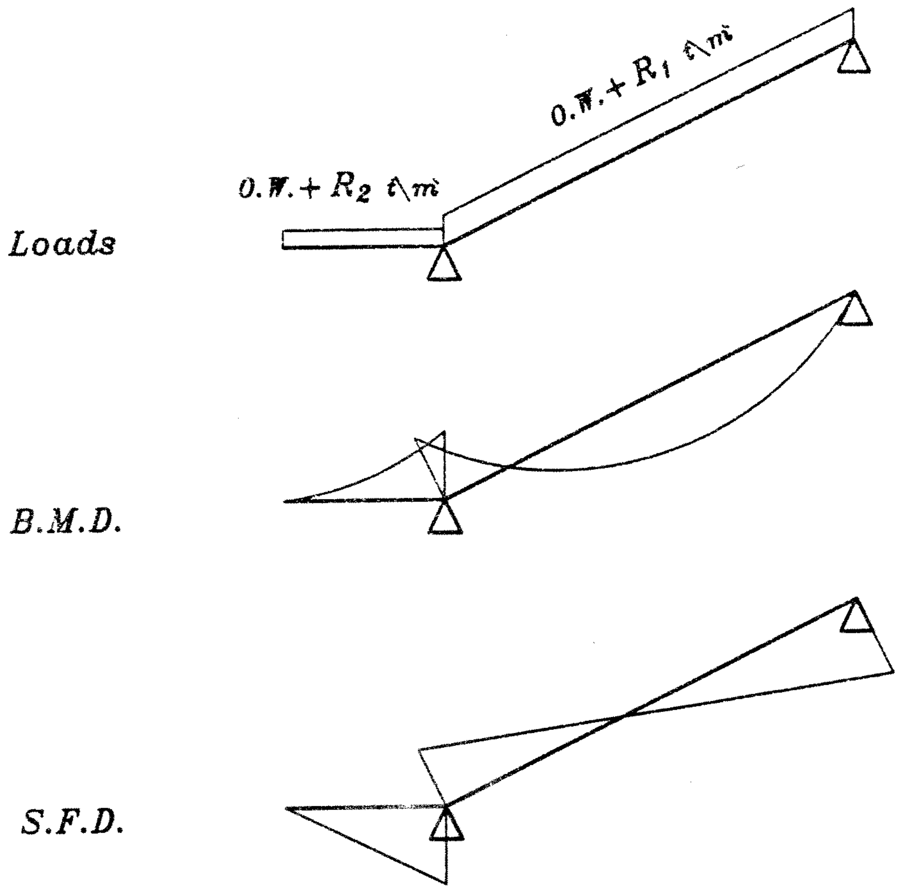


Strip ②

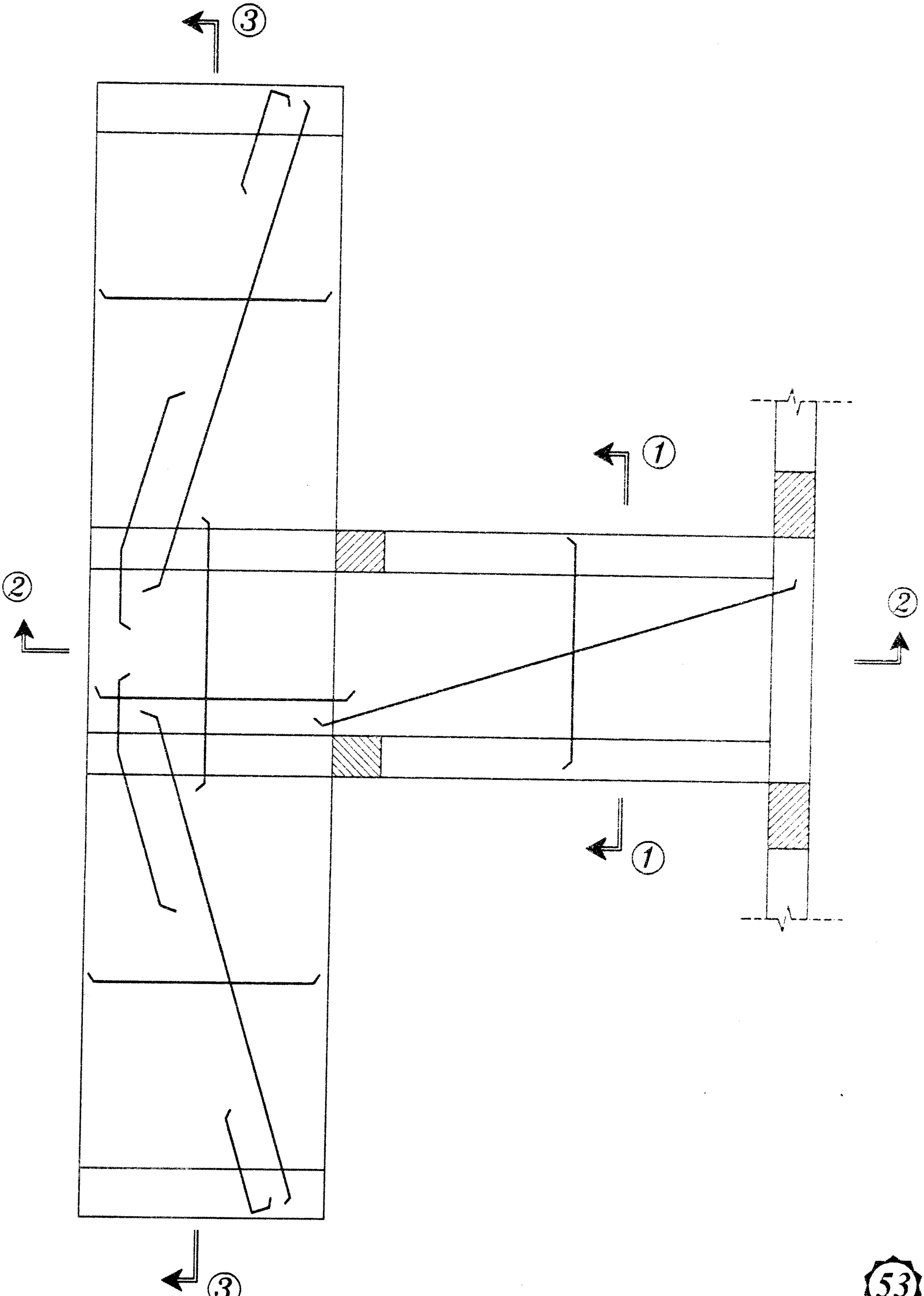


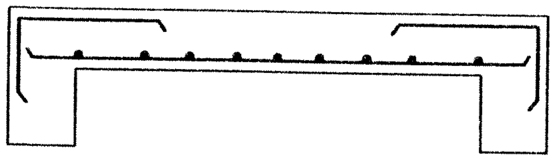
Beams.

B1

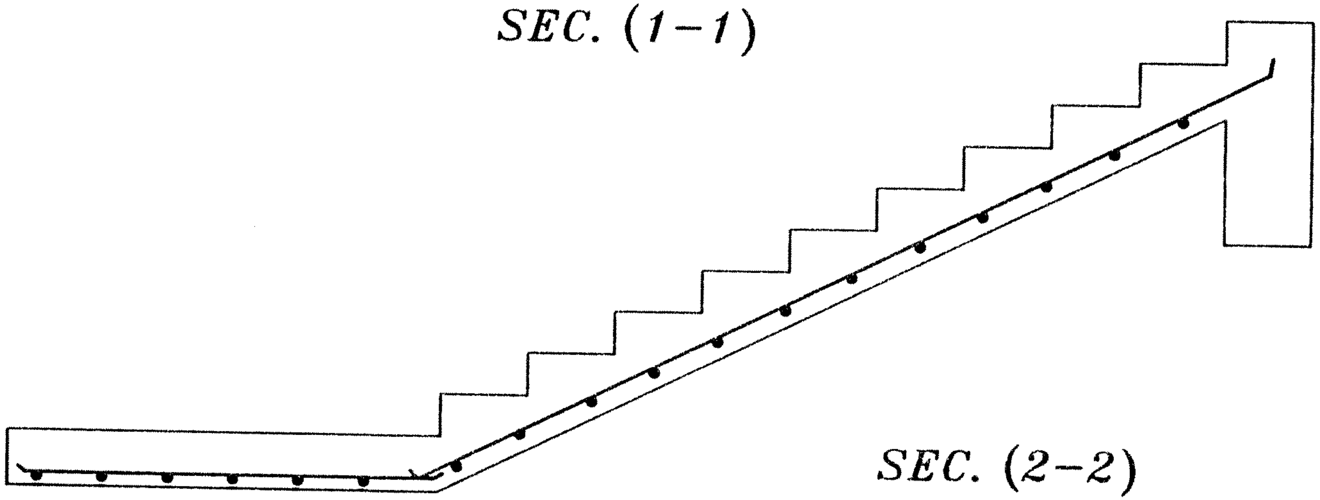


RFT. of the Slab.

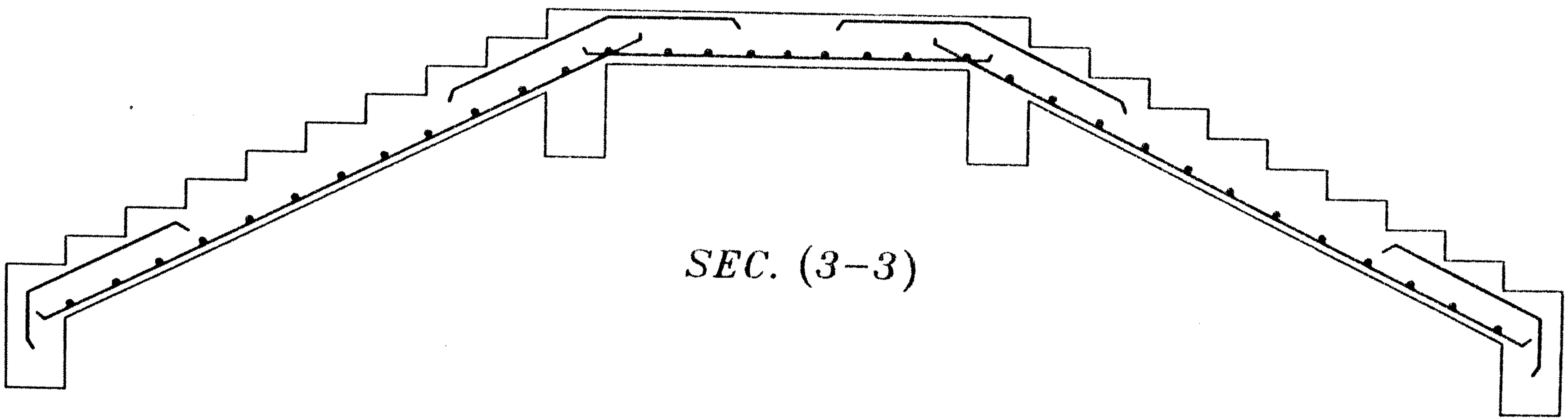




SEC. (1-1)



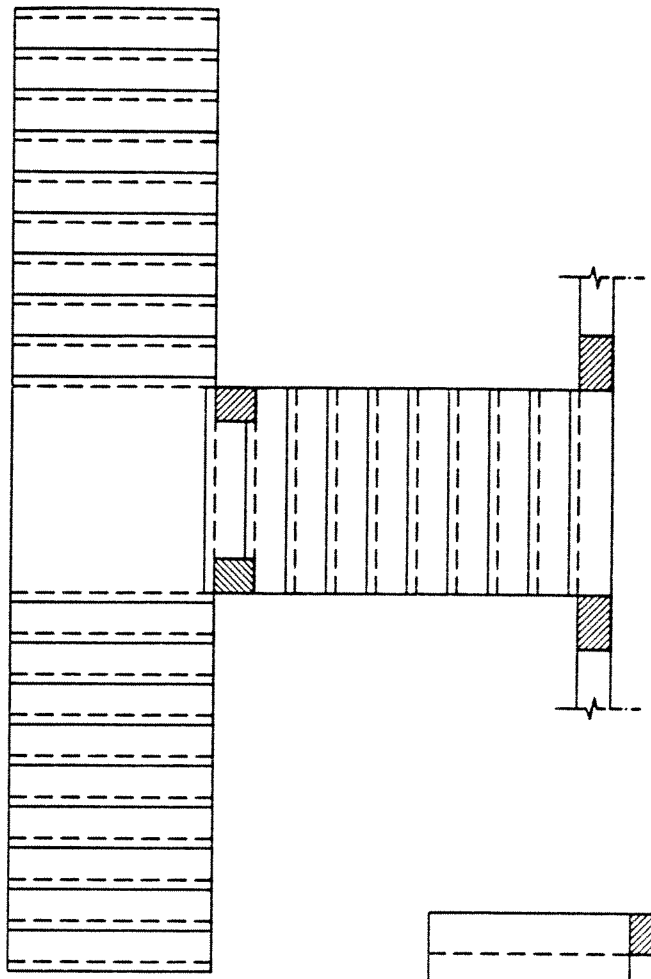
SEC. (2-2)



SEC. (3-3)

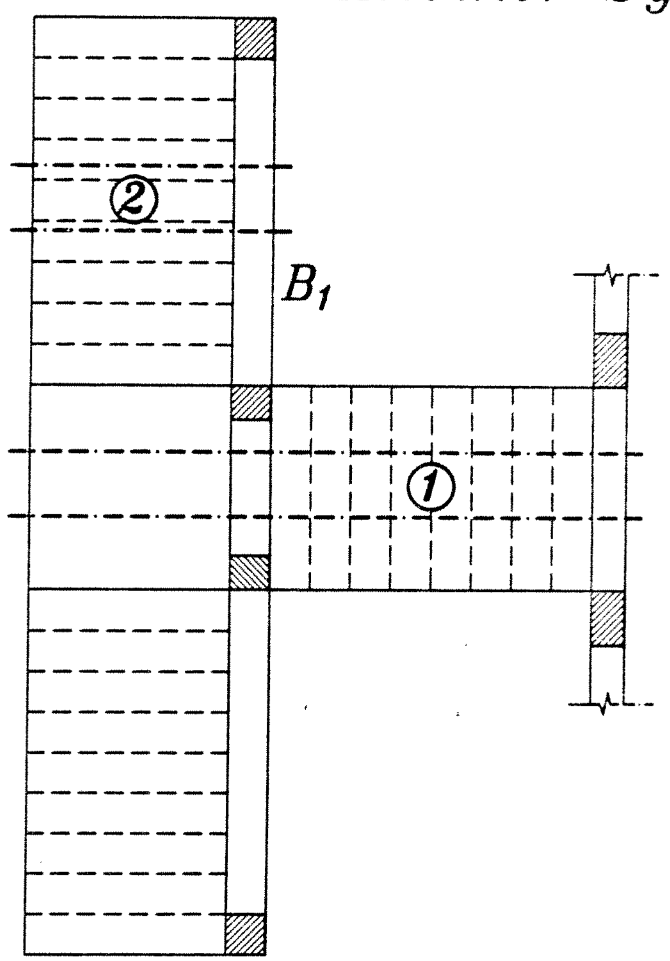
Example.

Arc. Plan



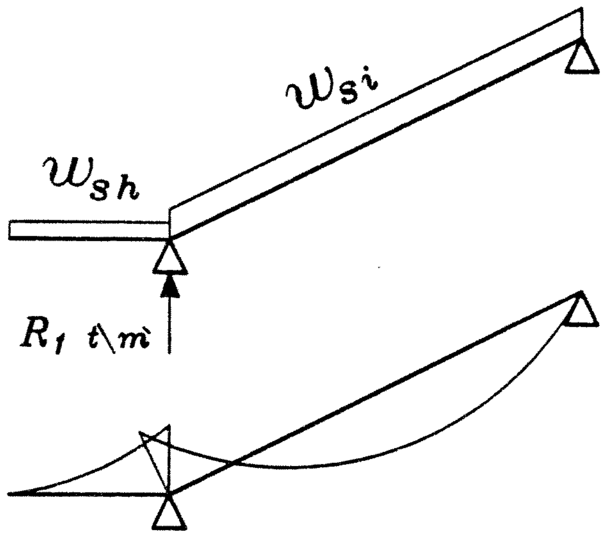
Another System

Struc. Plan

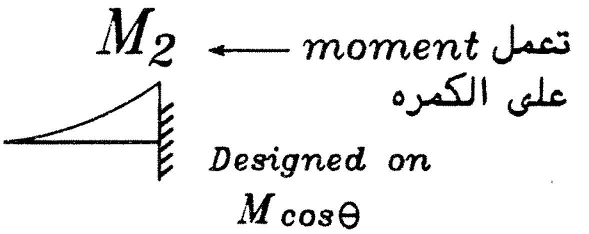


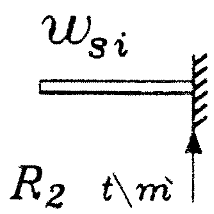
Slabs.

Strip ①



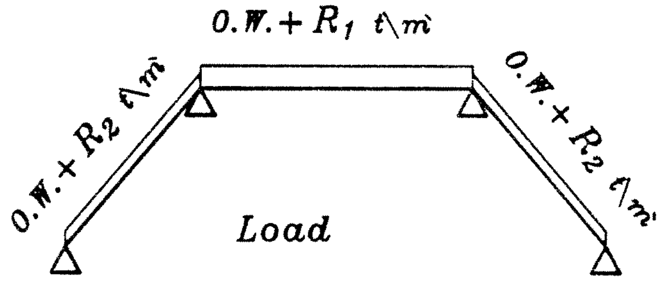
Strip ②

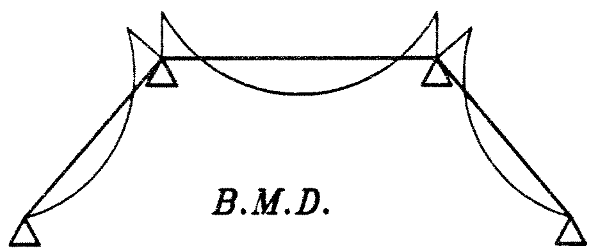


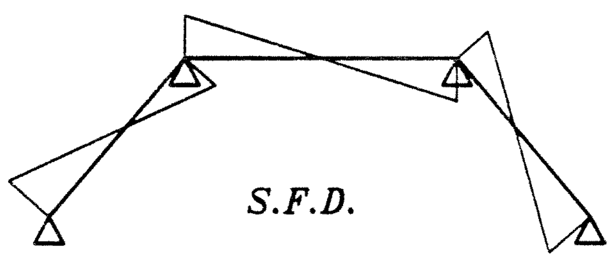


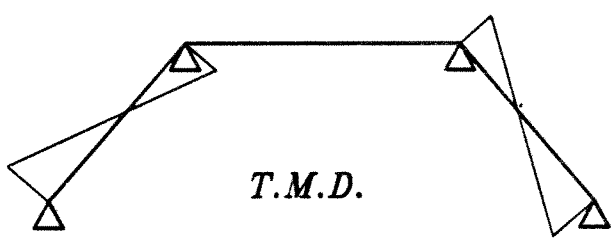
Beams.

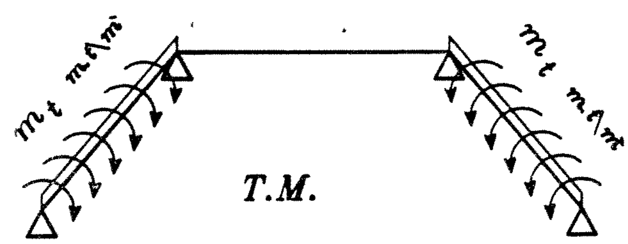
B1



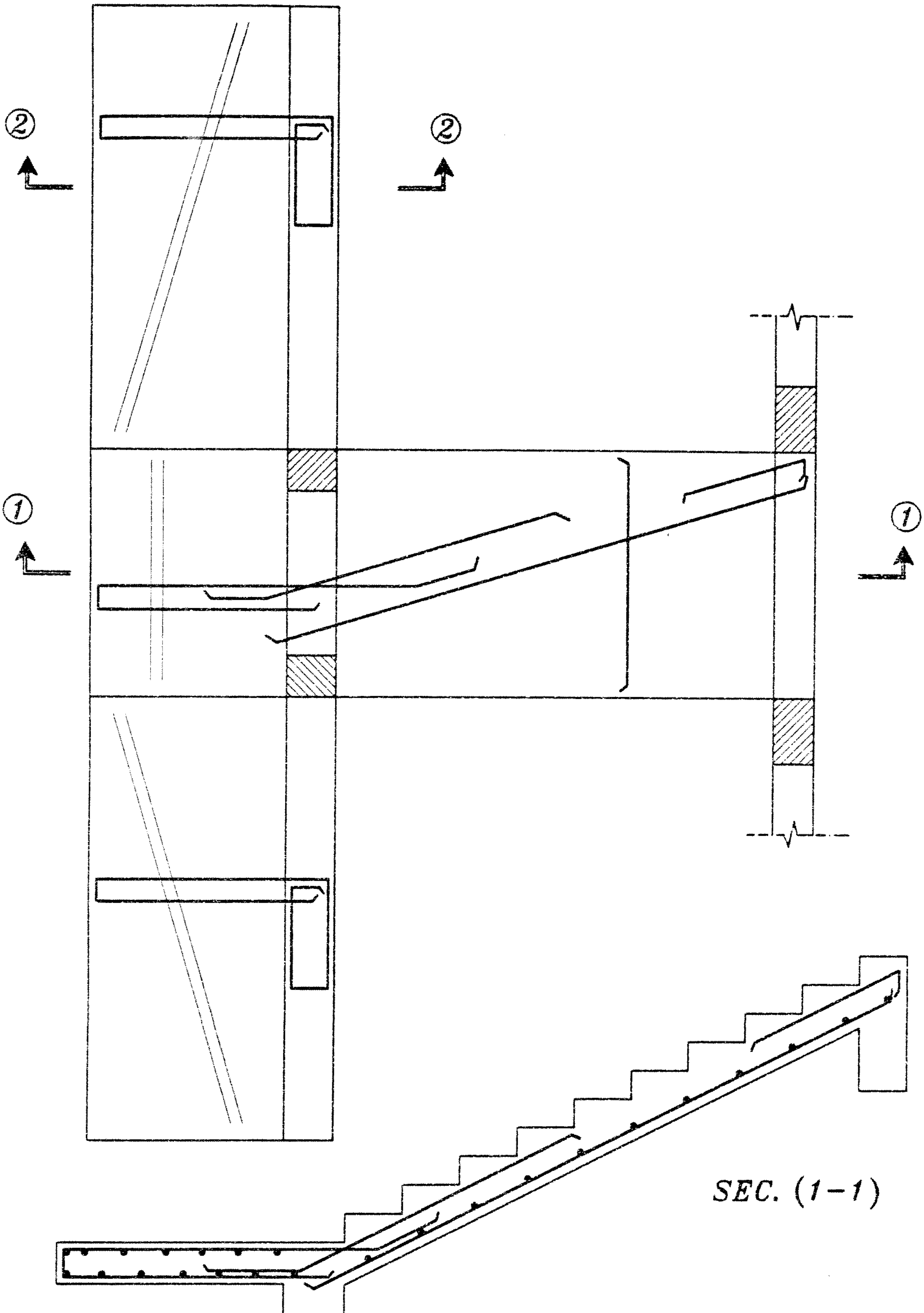




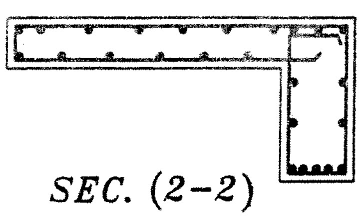




RFT. of the Slab.



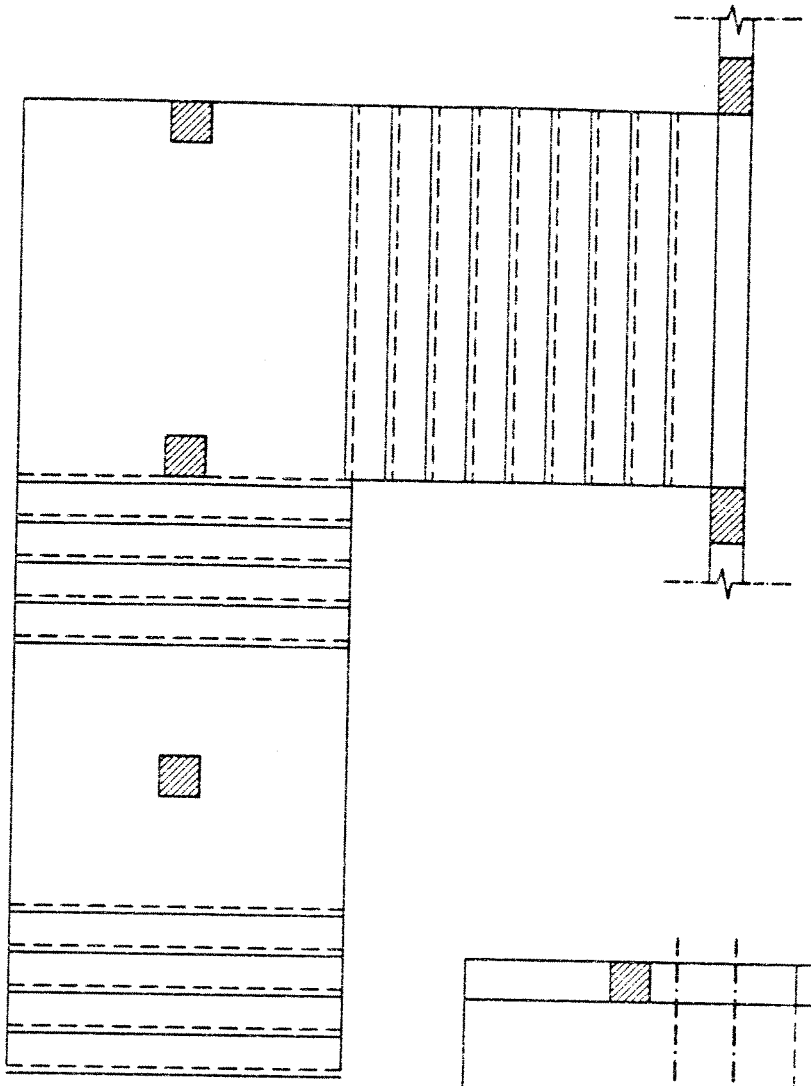
SEC. (1−1)



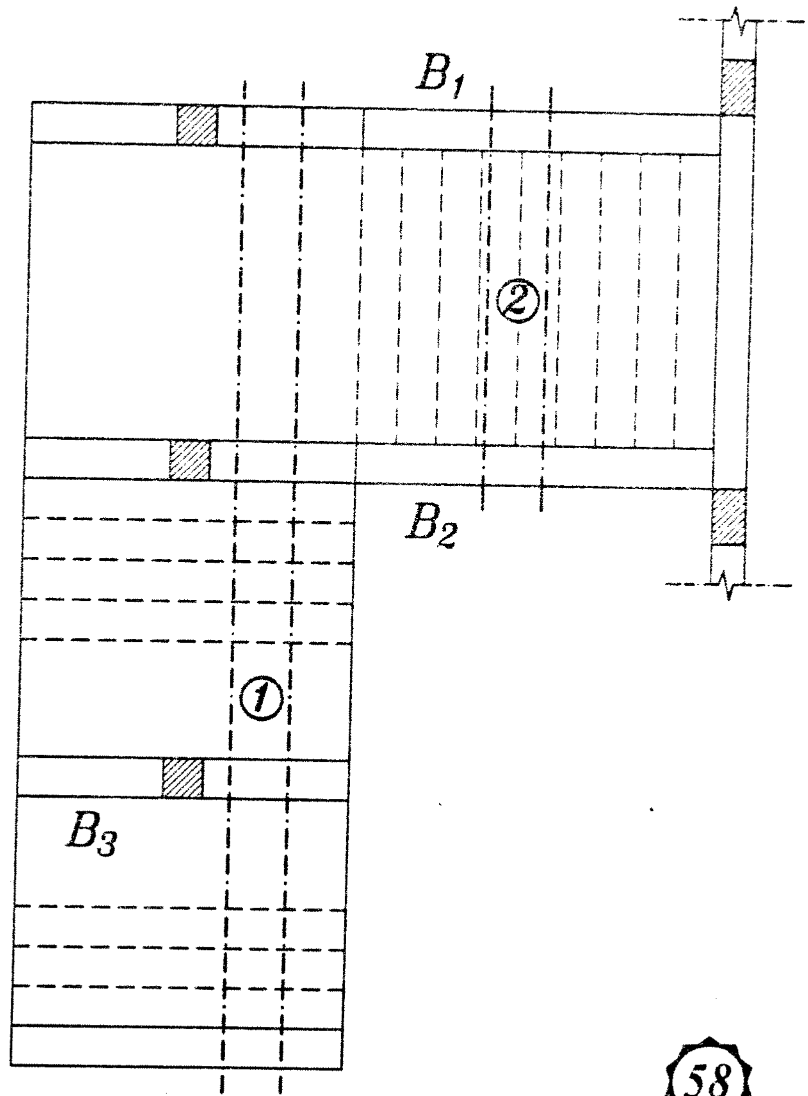
SEC. (2−2)

Example.

Arc.
Plan

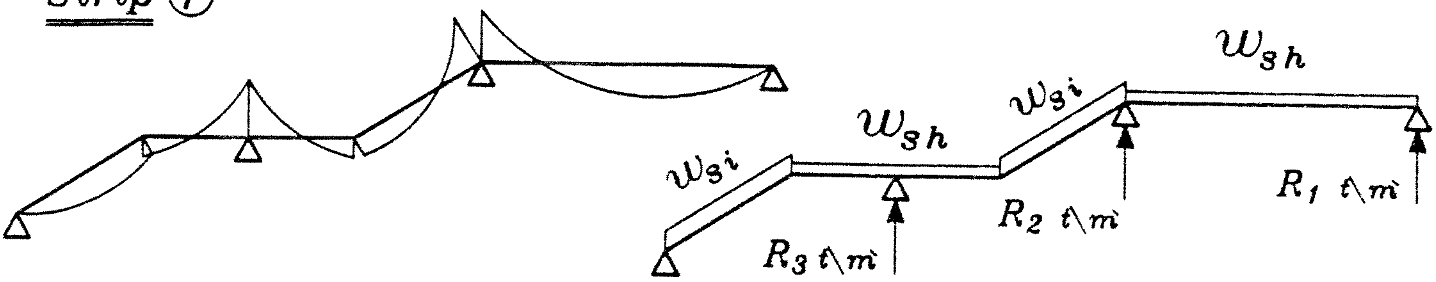


Struc.
Plan

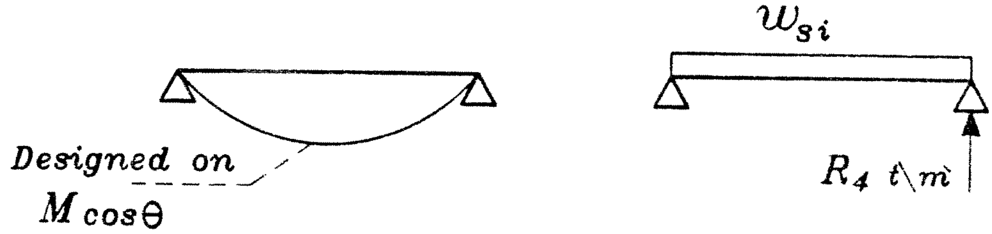


Slabs.

Strip ①

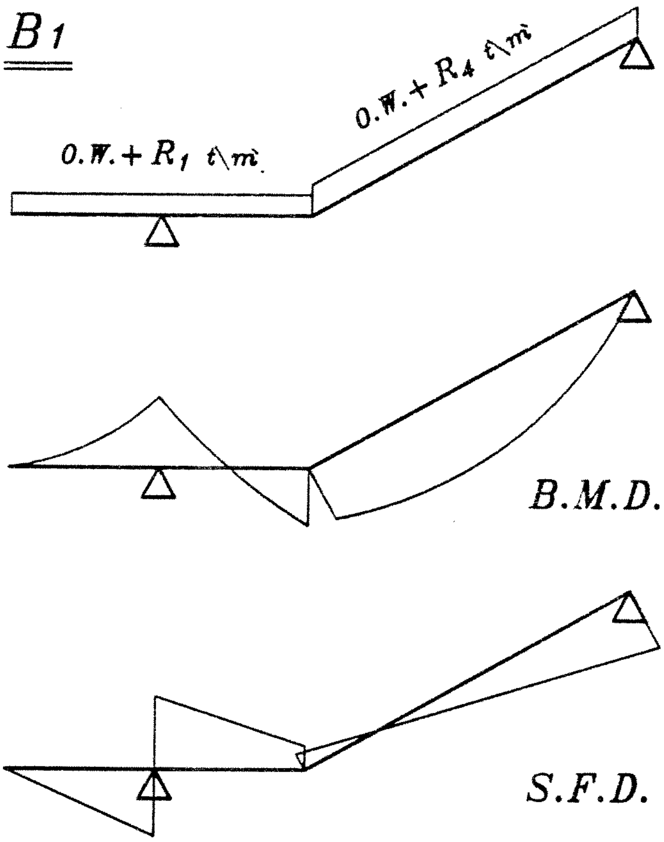


Strip ②

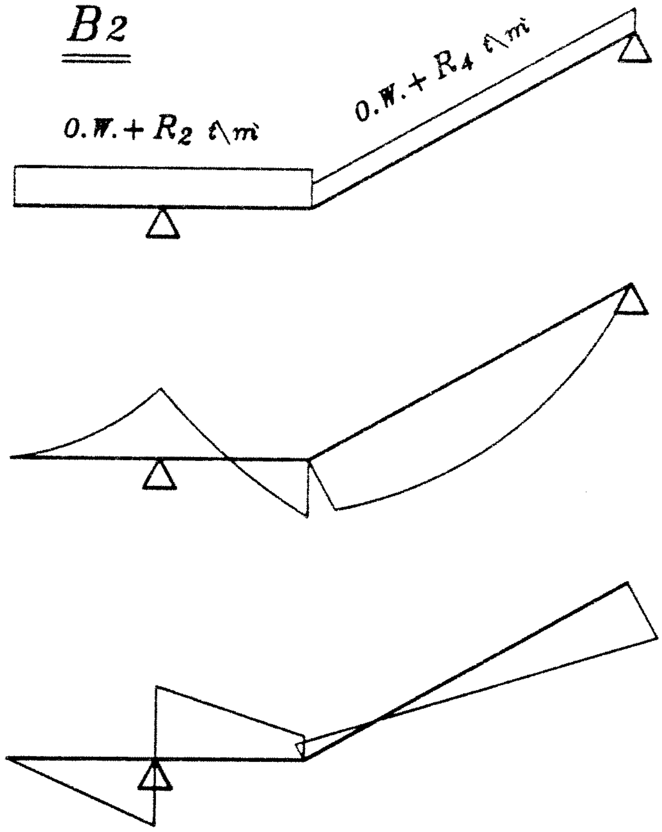


Beams.

B1

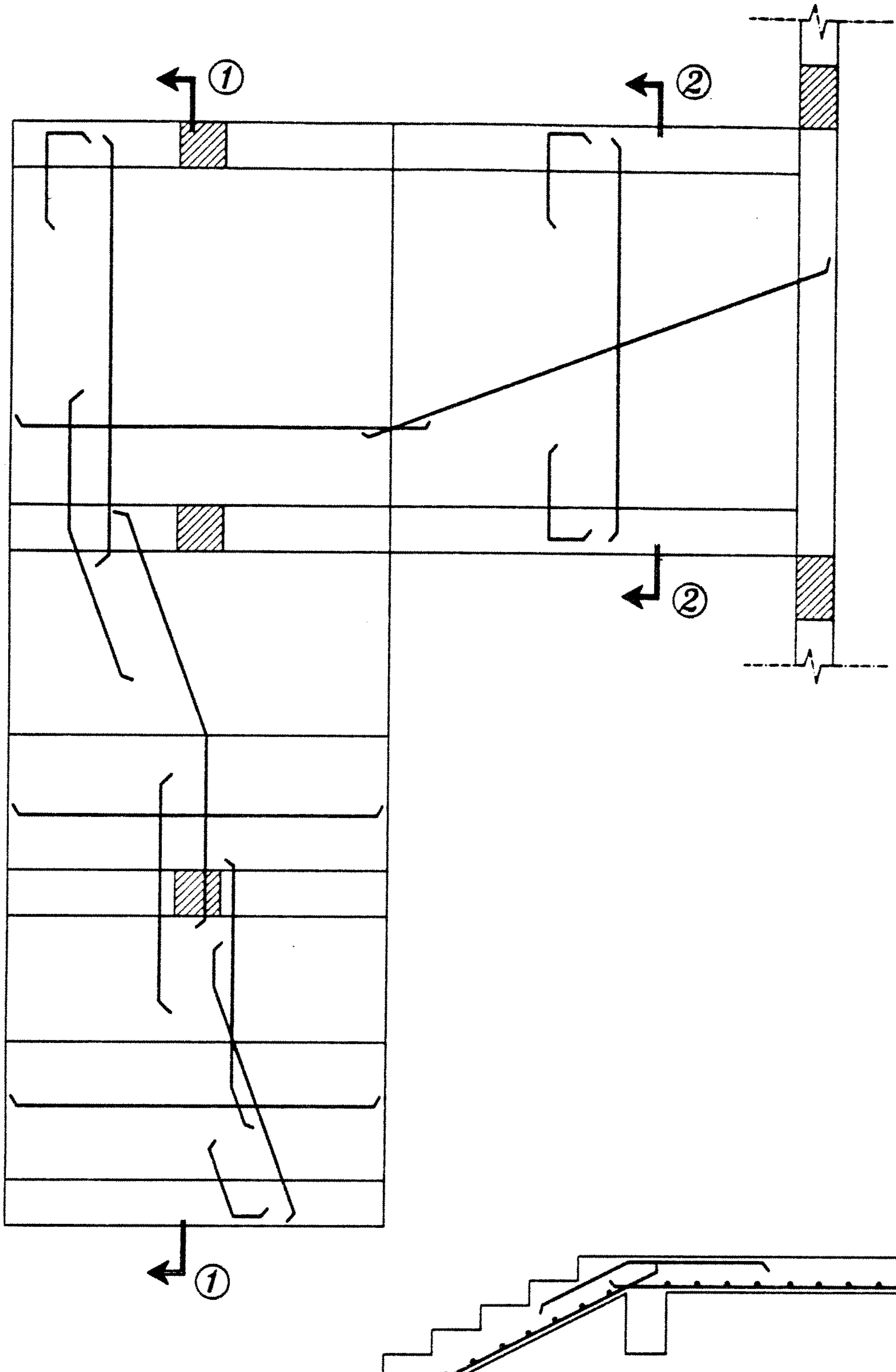


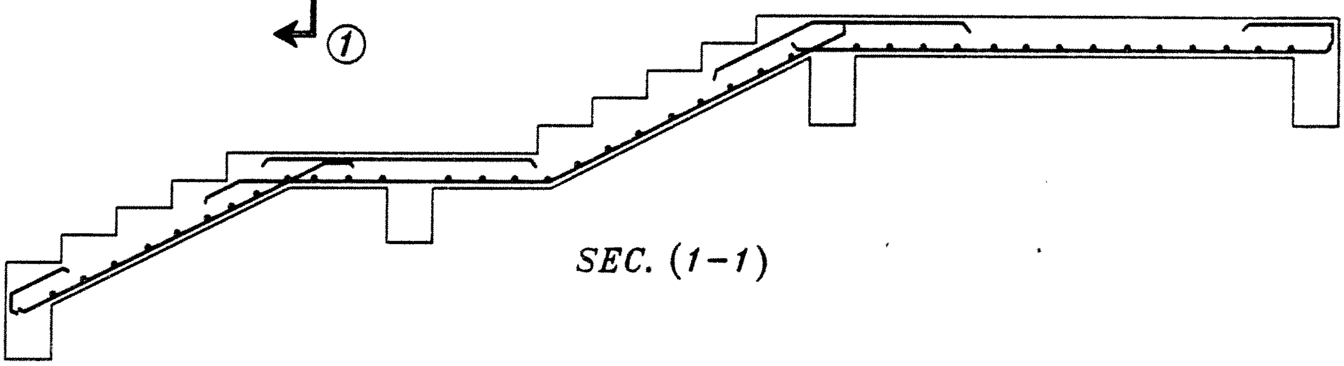
B2



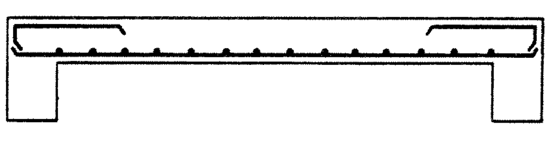
B3

RFT. of the Slab.





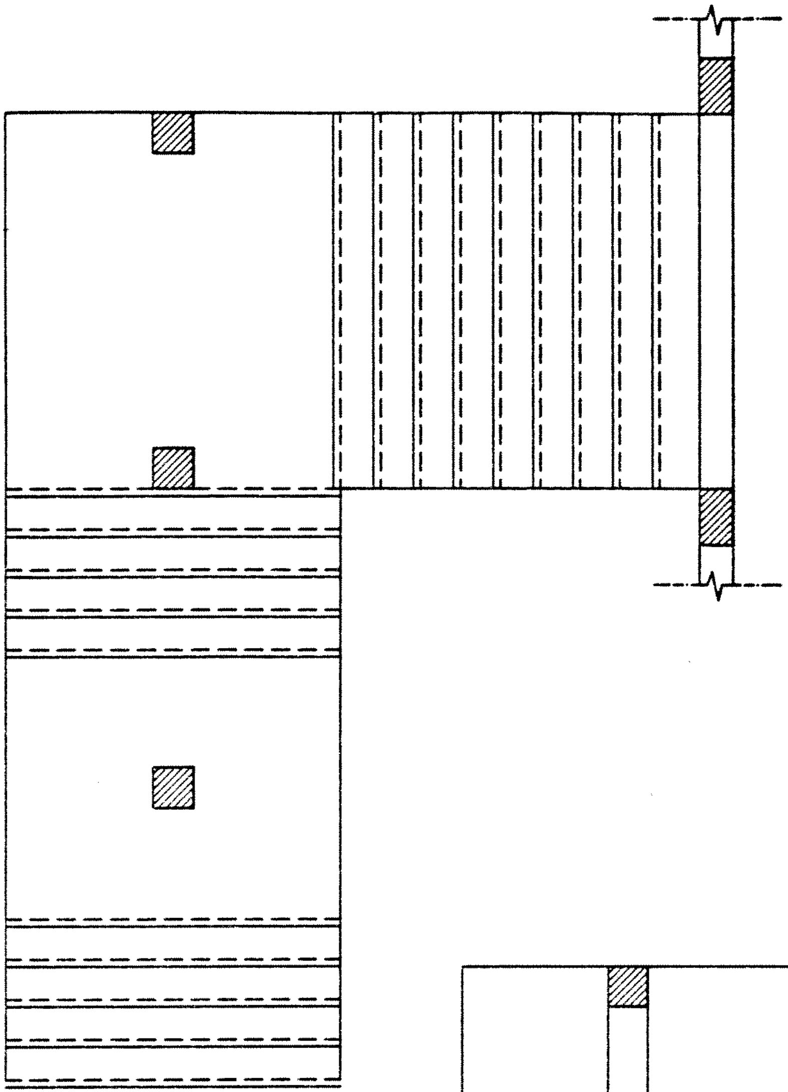
SEC. (1-1)



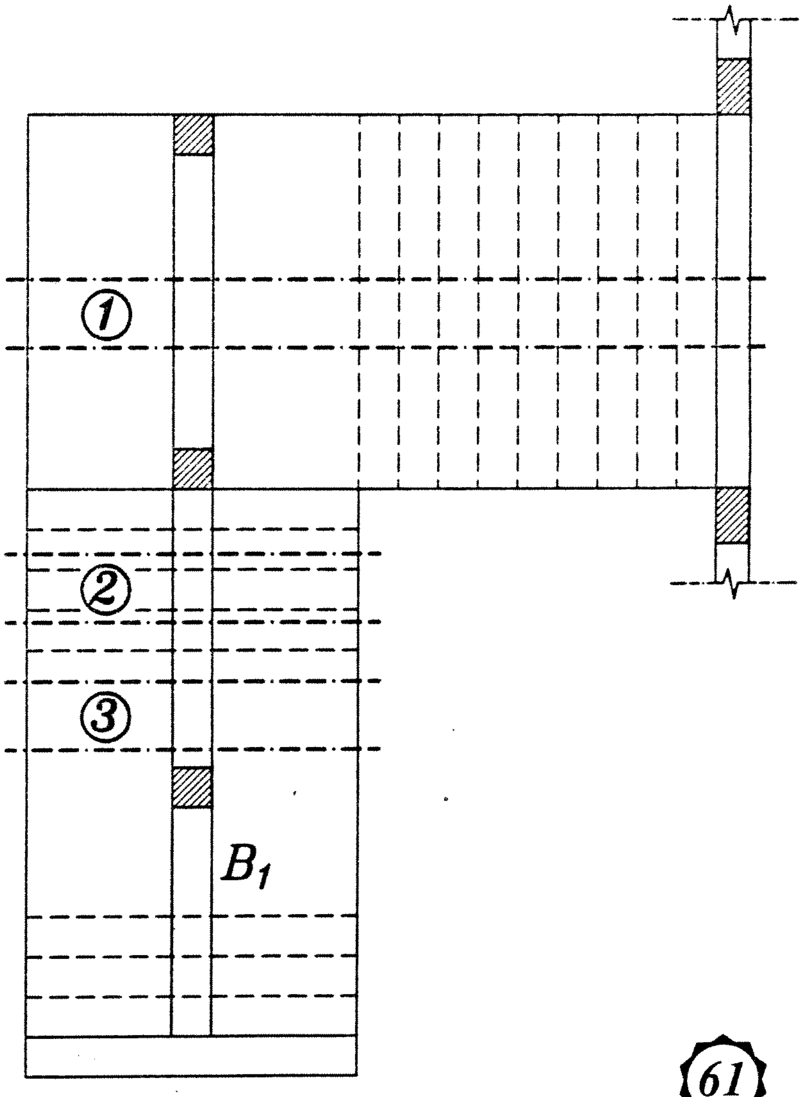
SEC. (2-2)

Example.

Arc. Plan

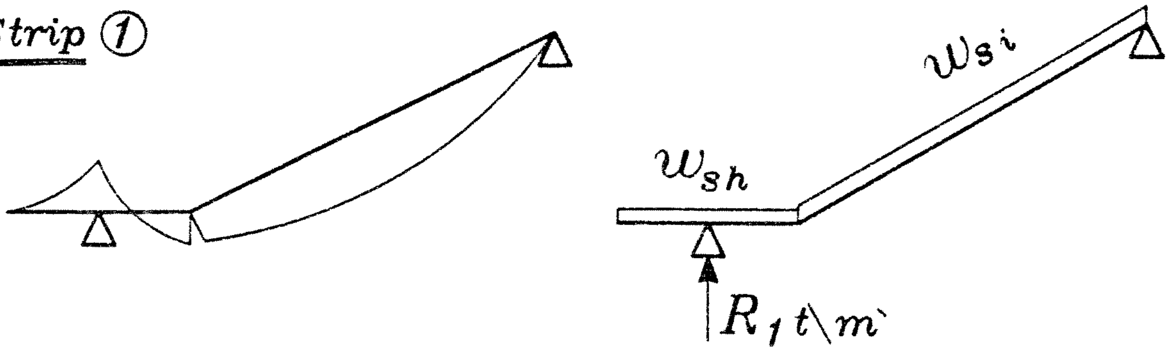


Struc. Plan

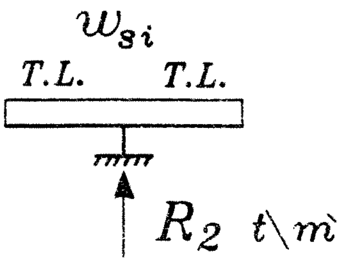


Slabs.

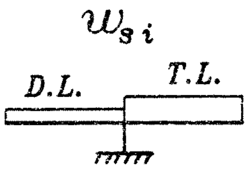
Strip ①



Strip ②

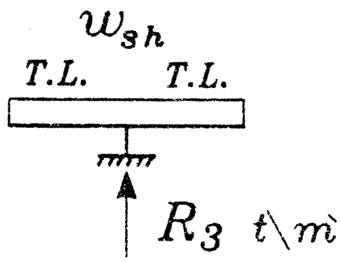


To design the slab

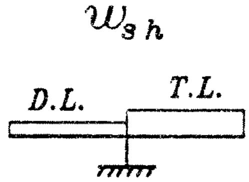


To get max. Torsion.

Strip ③



To design the slab



To get max. Torsion.

Beams.

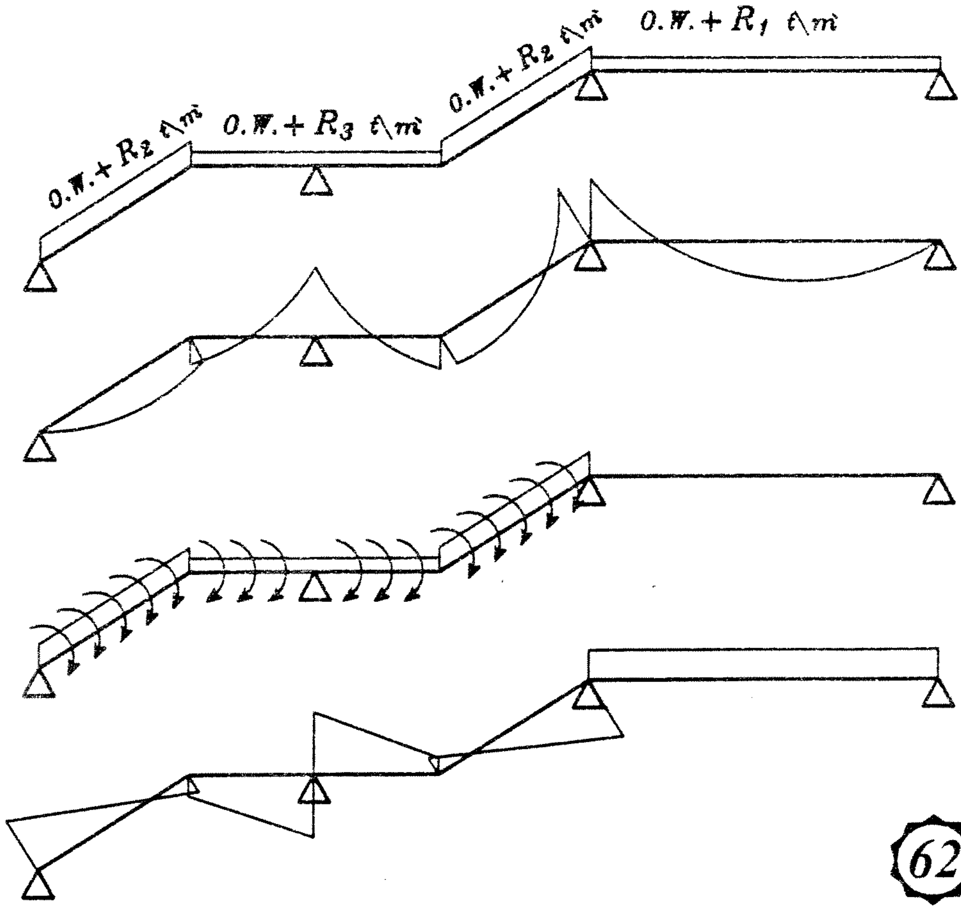
B_1

Load

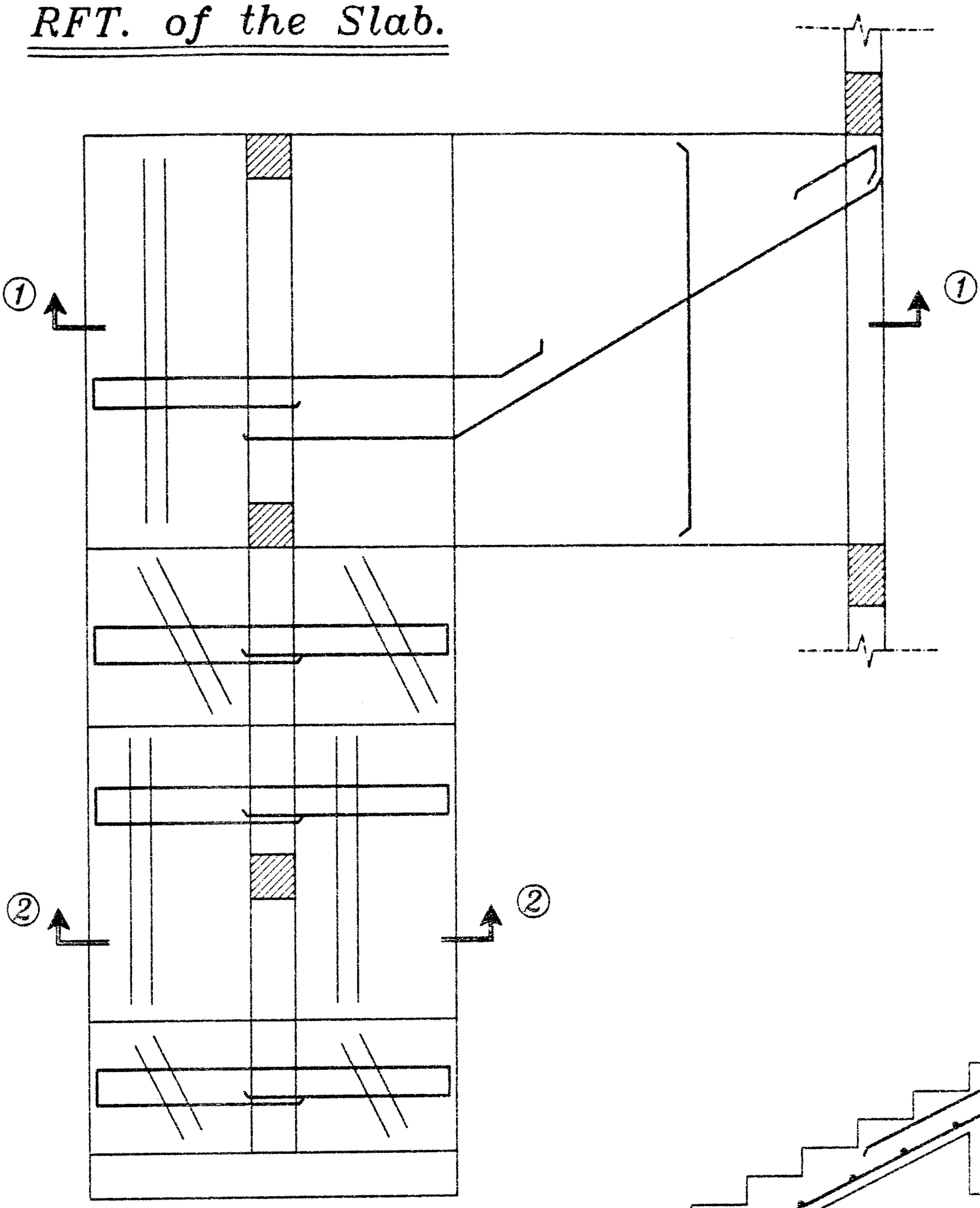
B.M.D.

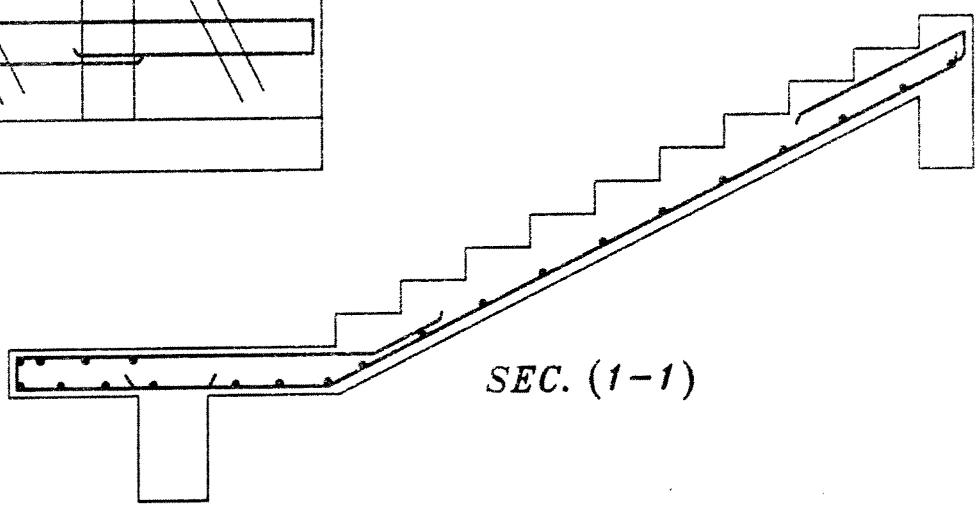
T.M.

T.M.D.

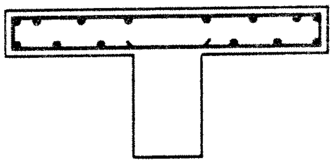


RFT. of the Slab.



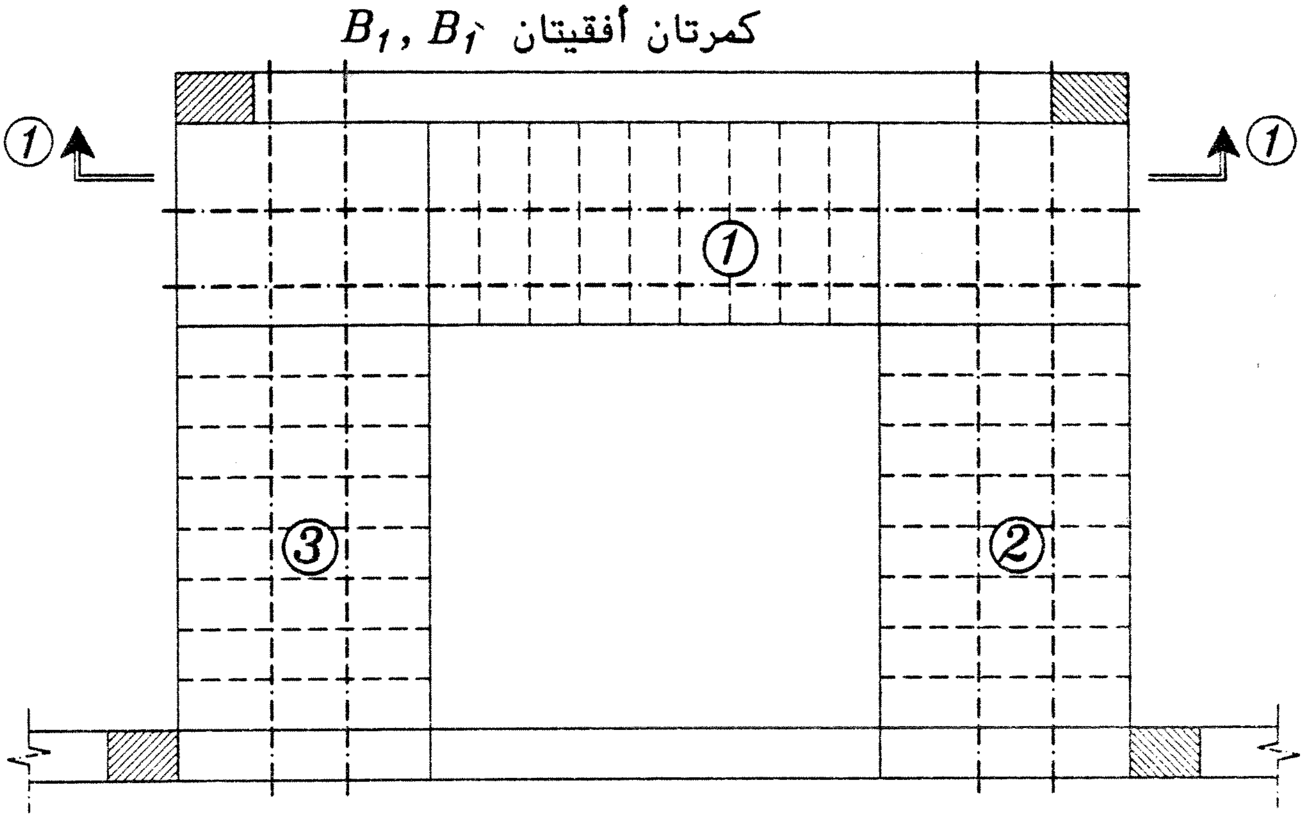


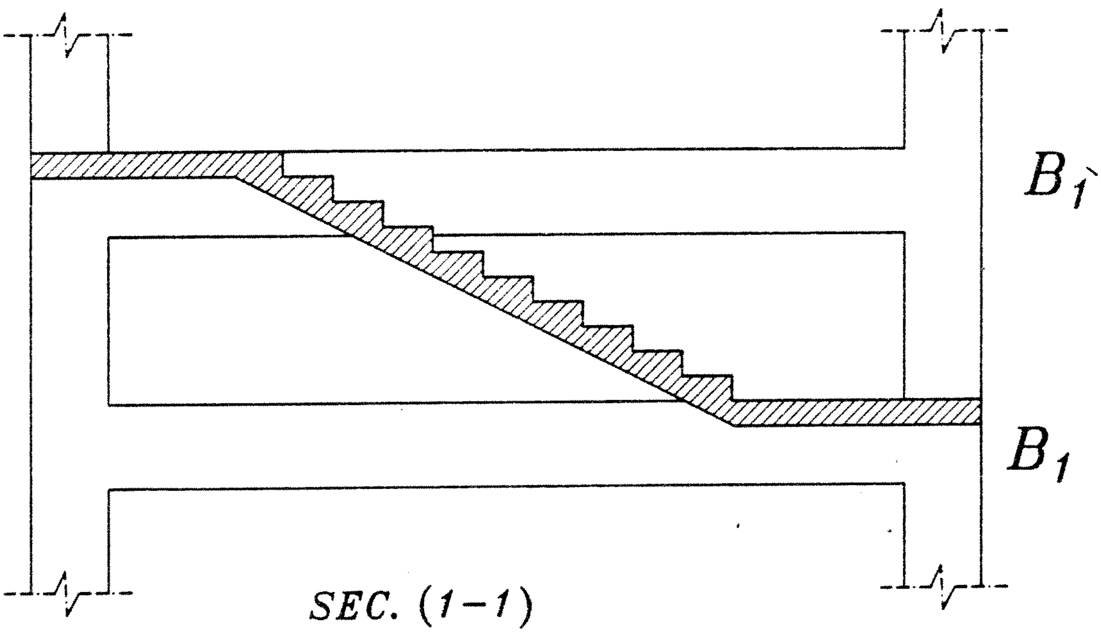
SEC. (1-1)



SEC. (2-2)

Example.

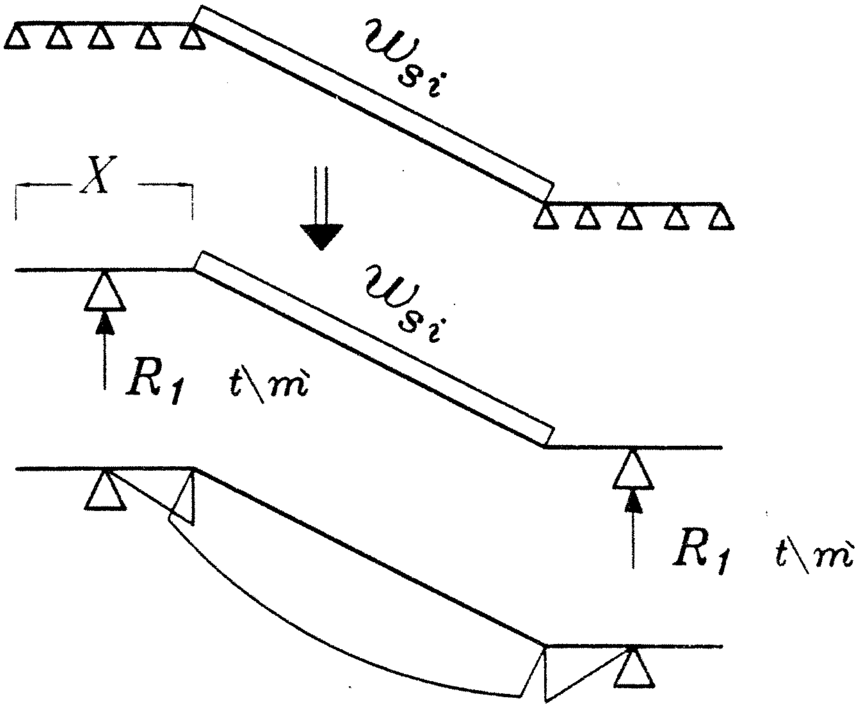




SEC. (1−1)

Slabs.

Strip ①

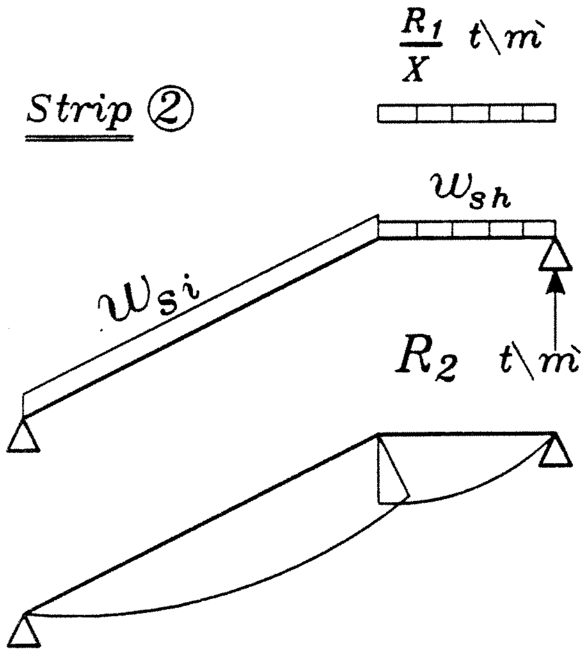


ملحوظة

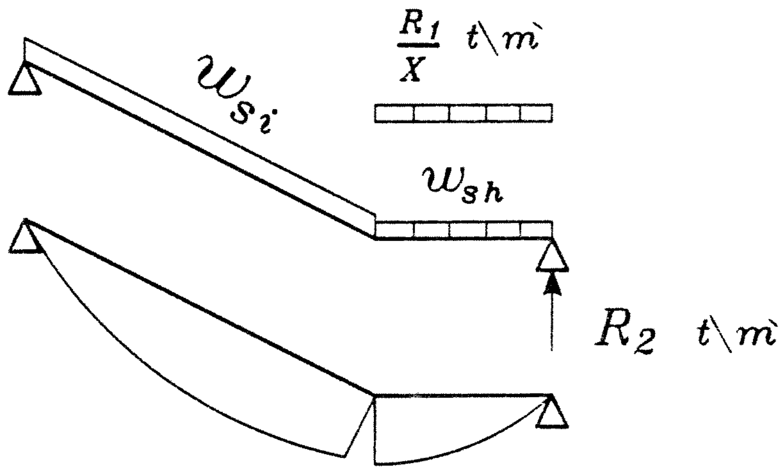
Strip ① محمولة على

البلاطة لـ Strip ②

Strip ②

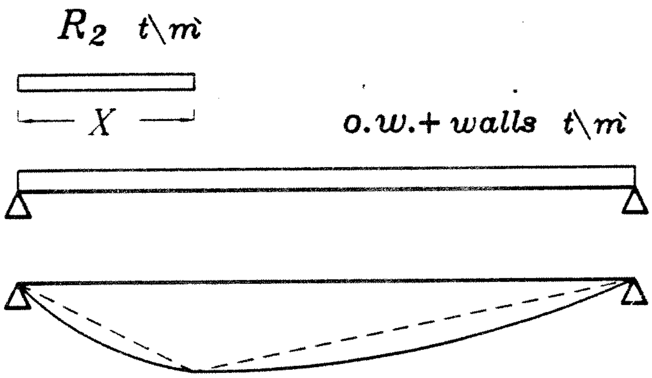


Strip ③

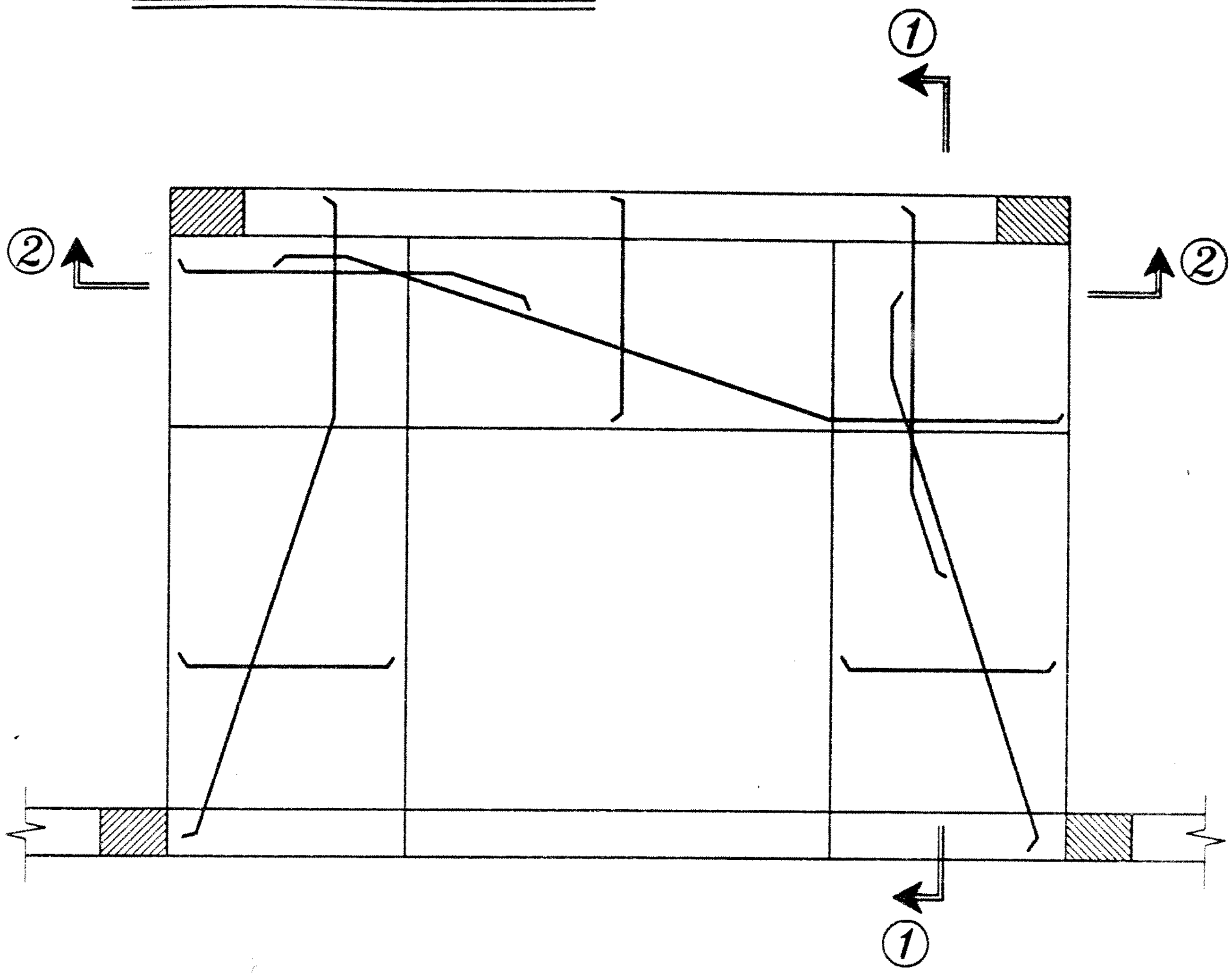


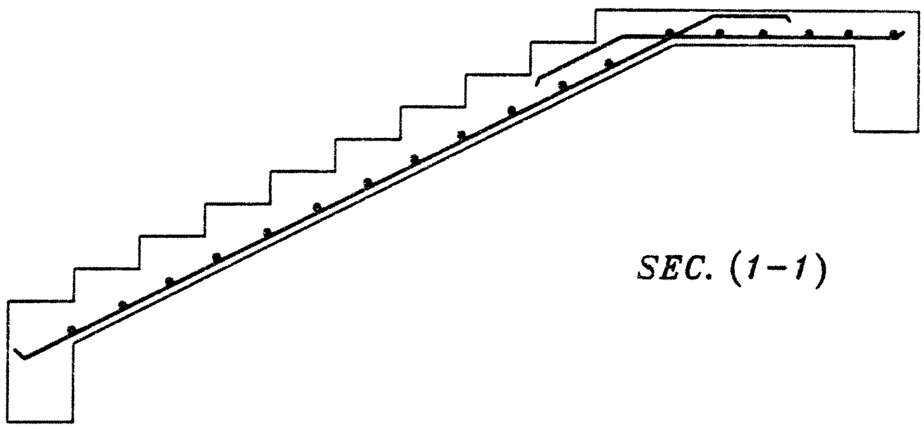
Beams.

B1, B1`

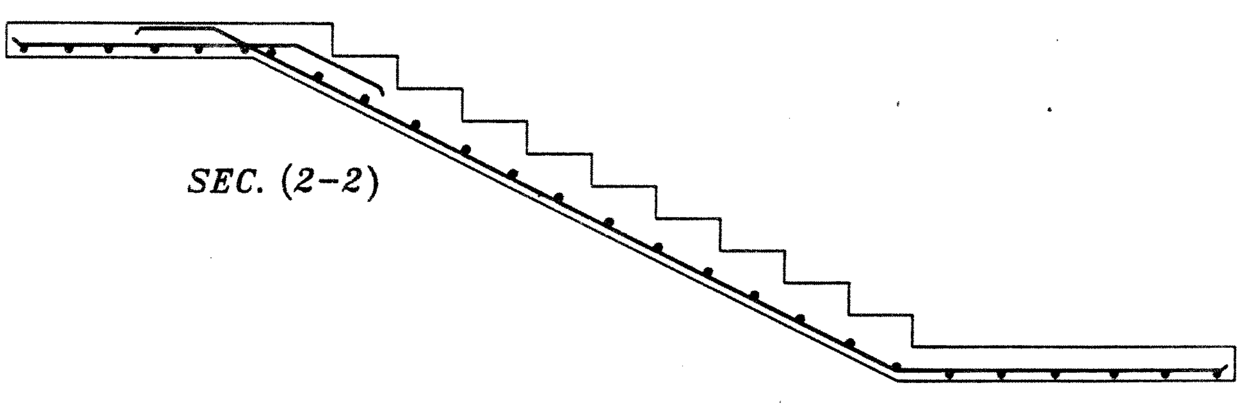


RFT. of the Slab.





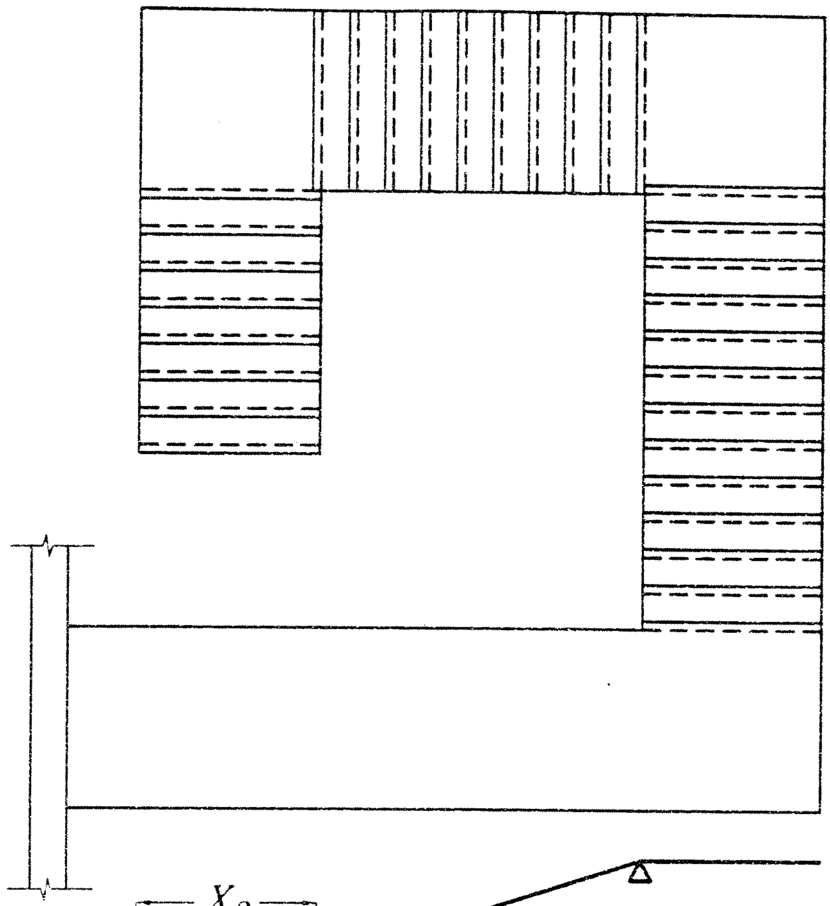
SEC. (1-1)



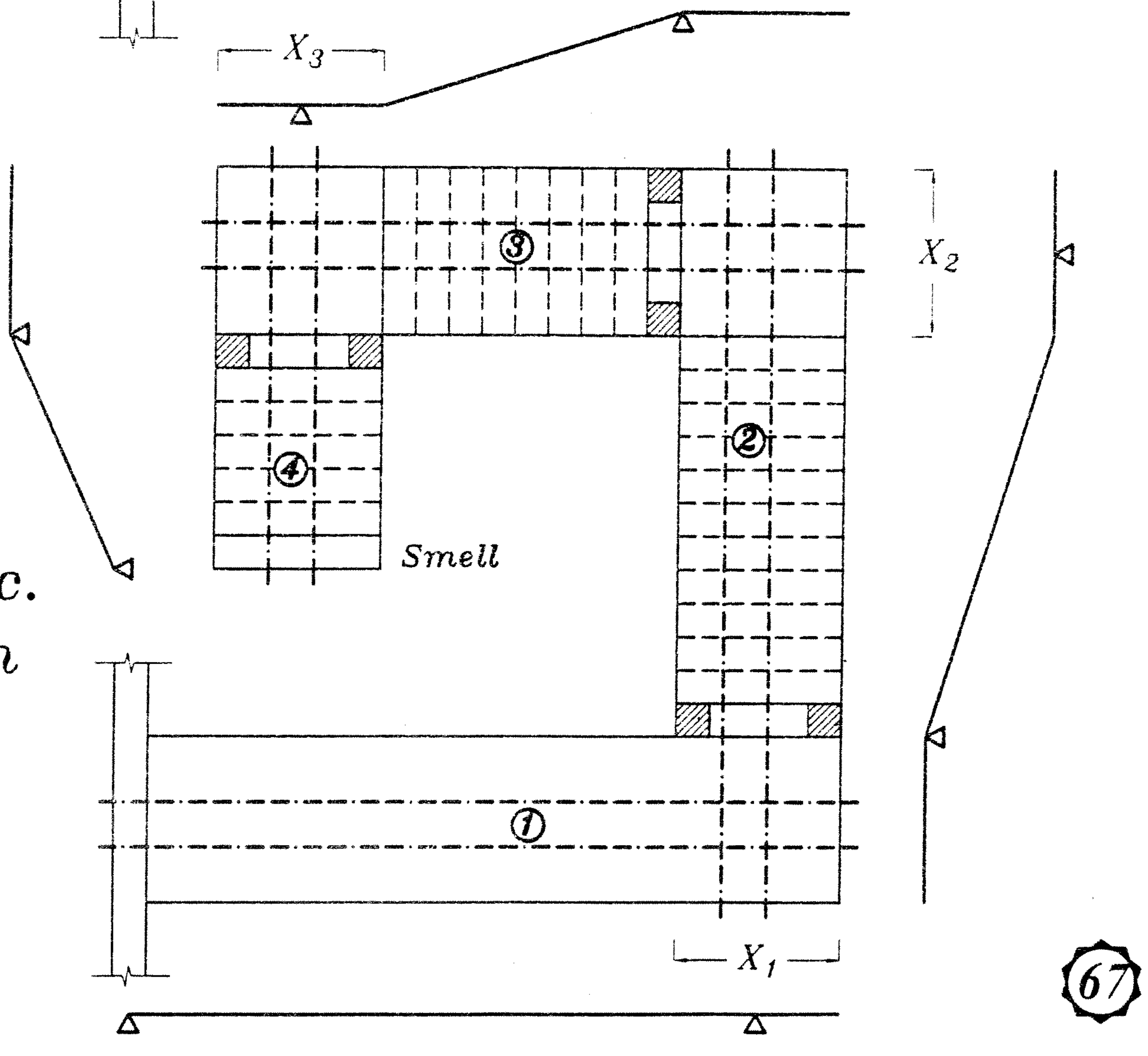
SEC. (2-2)

Example.

Arc. Plan

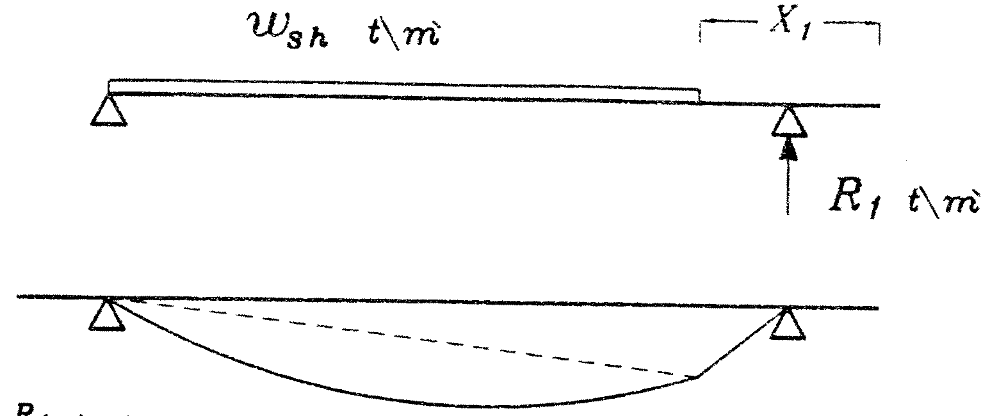


Struc. Plan

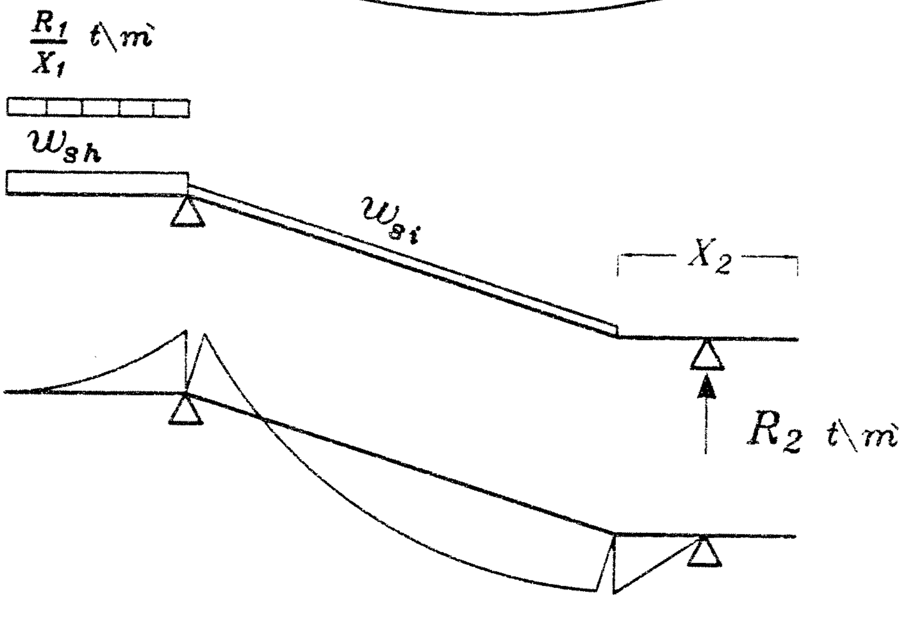


Slabs.

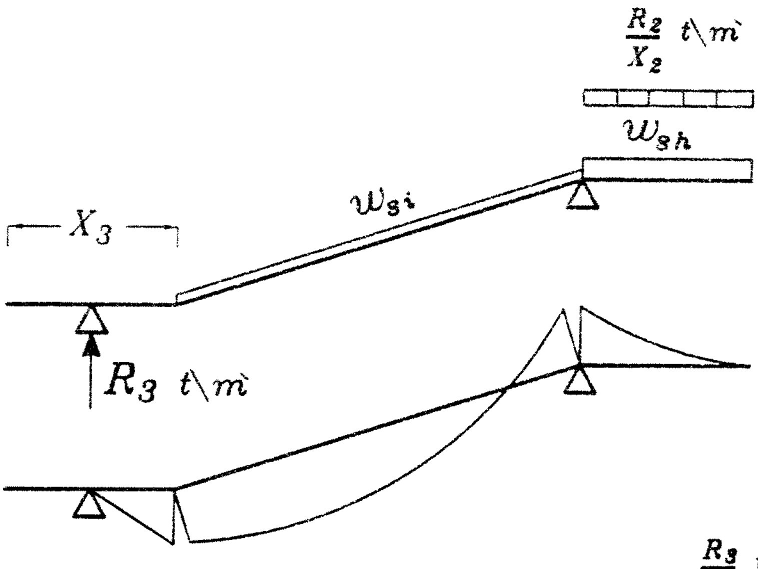
Strip ①



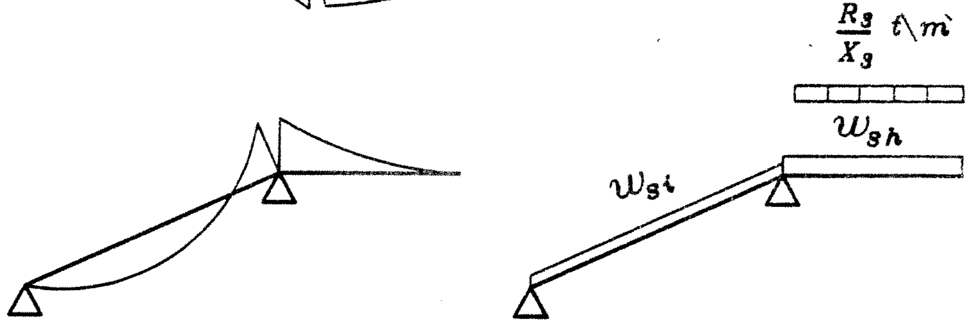
Strip ②



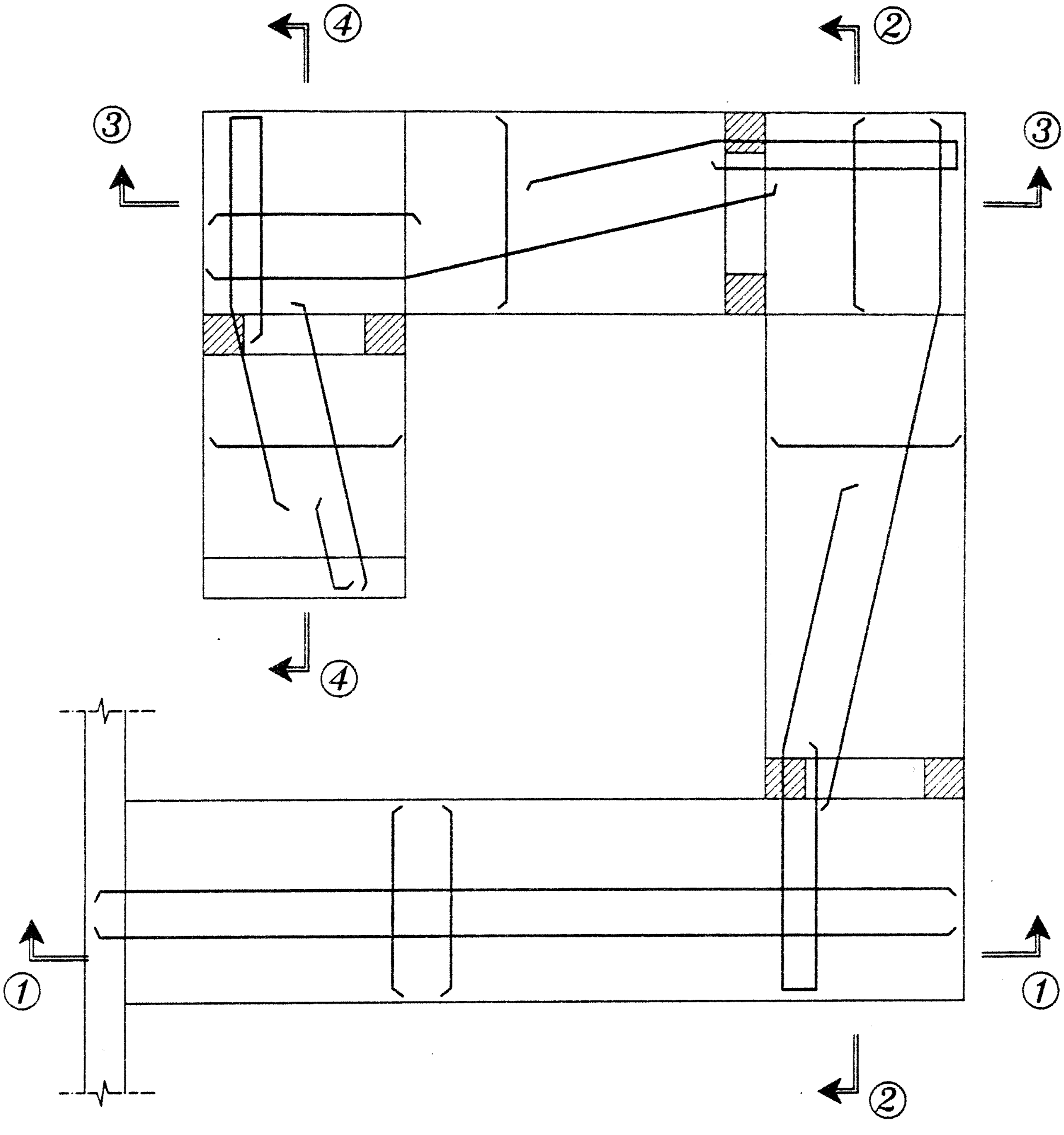
Strip ③

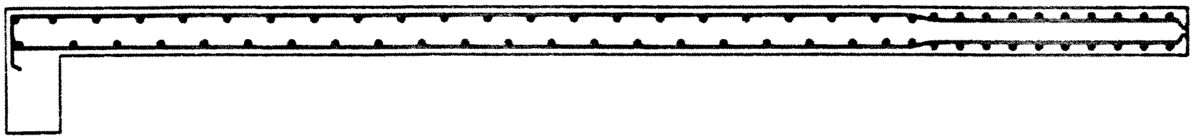


Strip ③

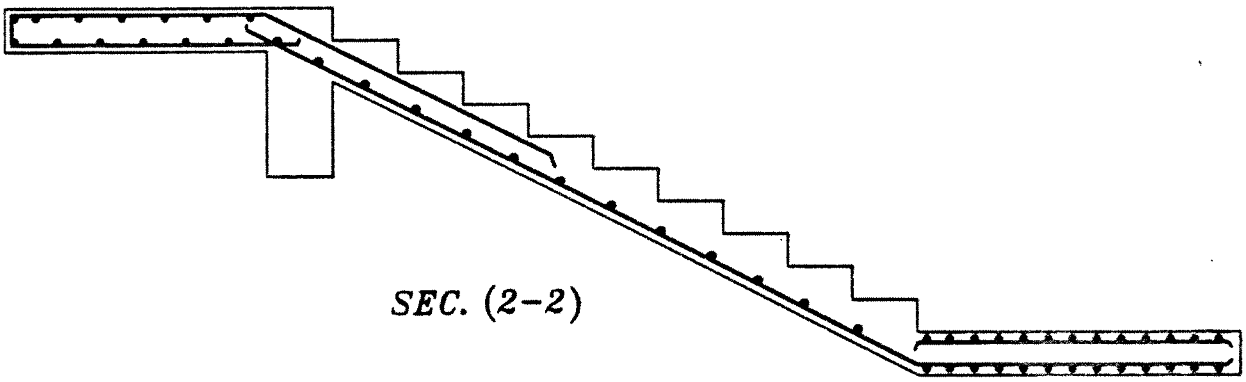


RFT. of the Slab.

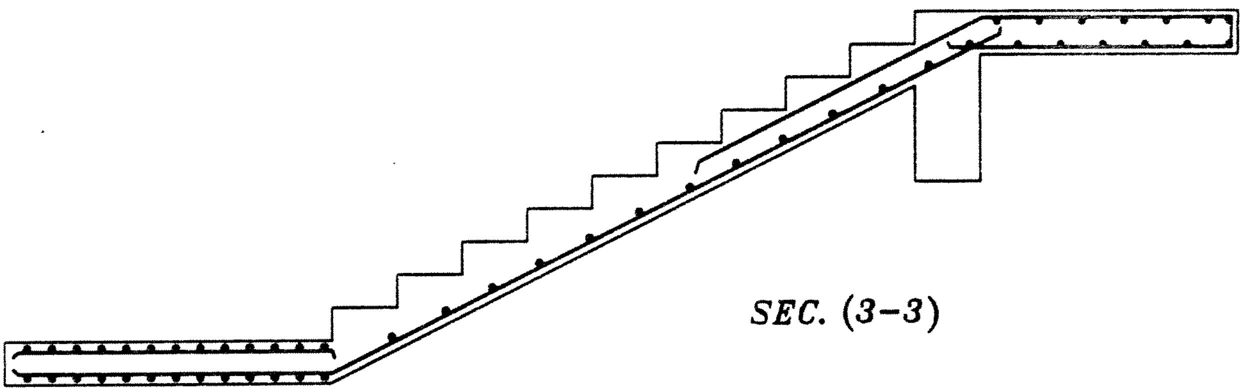




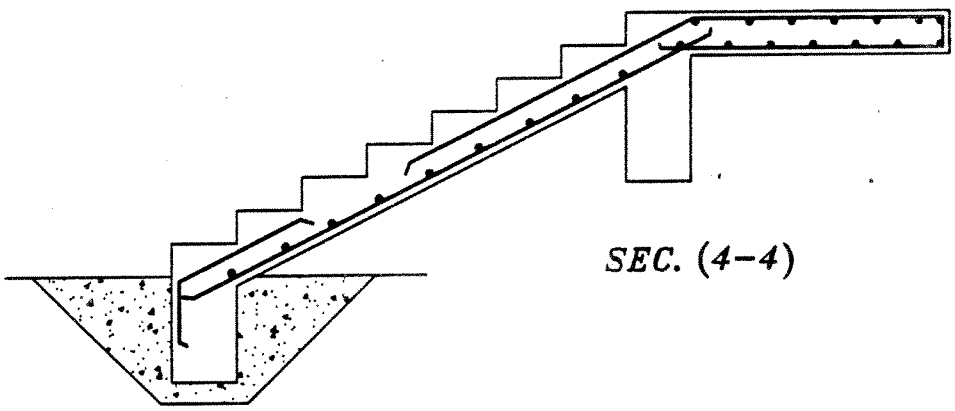
SEC. (1-1)



SEC. (2-2)

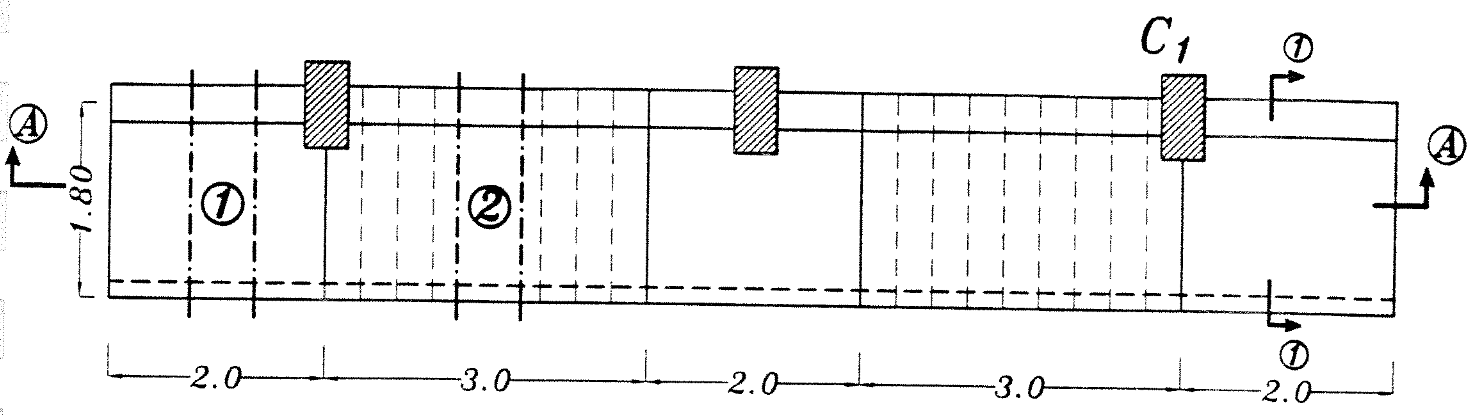


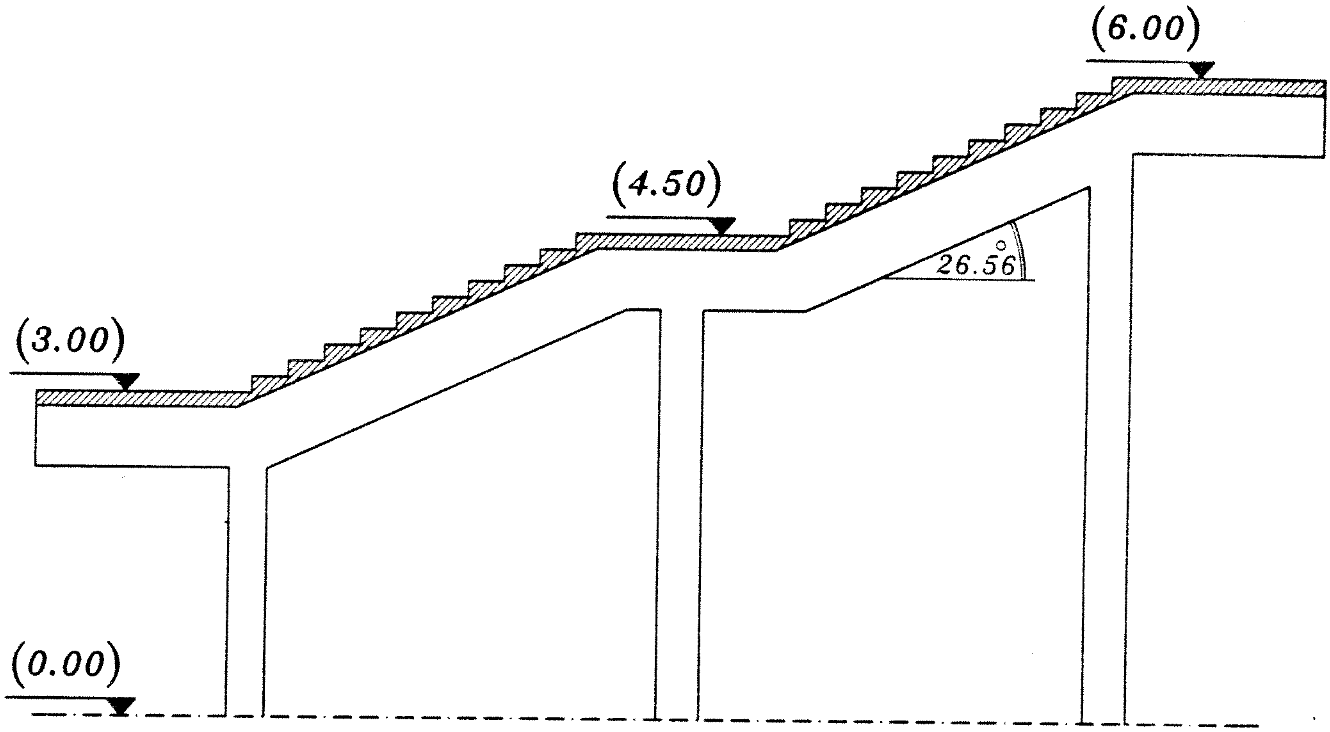
SEC. (3-3)



SEC. (4-4)

Example.



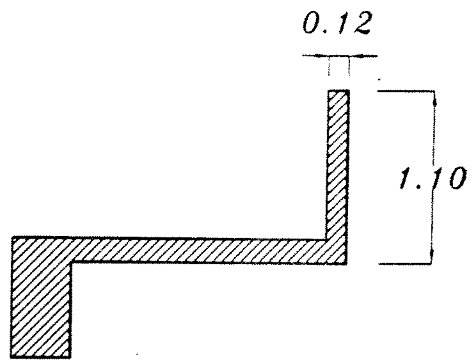


Sec. (A−A)

Data.

$F_{cu} = 250\ kg\backslash cm^2$ $\quad F_y = 3600\ kg\backslash cm^2$

$L.L. = 400\ kg\backslash m^2$ $\quad F.C. = 200\ kg\backslash m^2$



Sec. (1−1)

Req.

1− Design the slab as solid slab and Draw details of RFT. in Plan.

2− Design the Beam and Draw details of RFT. in ELEV.

3− Design the Column C_1.

Design The slab.

$t_s = \frac{180}{15} + 2 = 14.0\ cm.$ $\boxed{t_s = 14.0\ cm.}$

$t_{av.} = t_s + 7.0\,cm = 21.0\ cm.$

$(w_{sh}) = 1.4\,(t_s\,\gamma_c + F.C.) + 1.6\,(L.L.)$

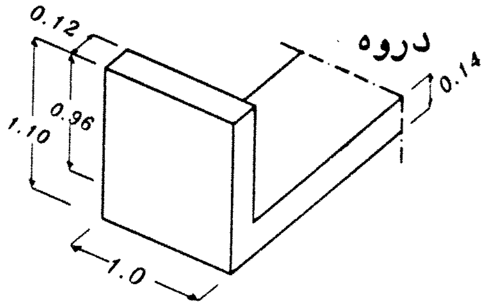
$(w_{sh}) = 1.4\,(0.14 * 2.5 + 0.15) + 1.6\,(0.4) = 1.34\ t\backslash m^2$

$(w_{si}) = 1.4\,(t_{av.}\,\gamma_c + F.C.) + 1.6\,(L.L.)\ Cos\,\theta$

$(w_{si}) = 1.4\,(0.21 * 2.5 + 0.15) + 1.6\,(0.4)\ Cos\ 26.565^\circ = 1.517\ t\backslash m^2$

Weight of the Fence

$= 1.4\,(0.12 * 0.96 * 1.0)\,(2.5) = 0.40\ t\backslash m$



Strip ①

Sec. ①

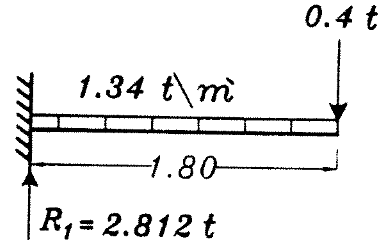
$M_{U.L.} = 2.89\ mt\backslash m$

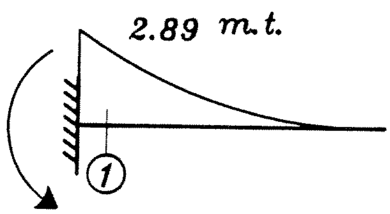
$t_s = 14\ cm.\ ,\ d = 14 - 1.5 = 12.5\ cm.$

$12.5 = C_1\sqrt{\frac{2.890 * 10^5}{250 * 100}} \longrightarrow C_1 = 3.67 \longrightarrow J = 0.79$

$A_S = \frac{2.890 * 10^5}{0.790 * 3600 * 12.5} = 8.13\ cm^2/m$

(7 ϕ 13 \ m)





Strip ②

شريحة أفقية فى بلاطة مائلة

Sec. ①

$M_{U.L.} = 3.177\ mt\backslash m$

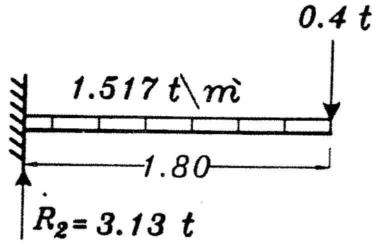
$M_{des.} = 3.177 * Cos\ 26.565^\circ = 2.840\ mt\backslash m$

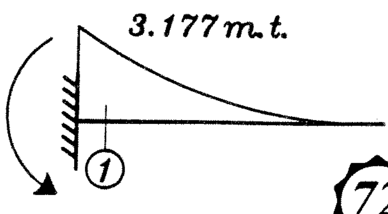
$t_s = 14\ cm.\ ,\ d = 14 - 1.5 = 12.5\ cm.$

$12.5 = C_1\sqrt{\frac{2.840 * 10^5}{250 * 100}} \longrightarrow C_1 = 3.708 \longrightarrow J = 0.795$

$A_S = \frac{2.840 * 10^5}{0.795 * 3600 * 12.5} = 7.93\ cm^2/m$

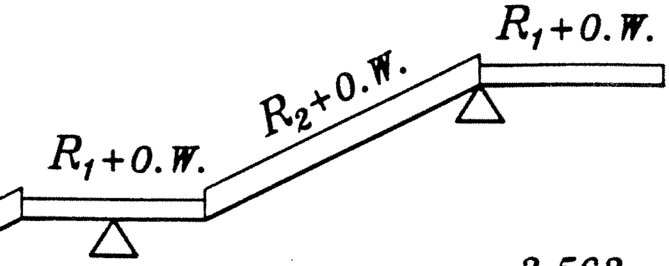
(6 ϕ 13 \ m)

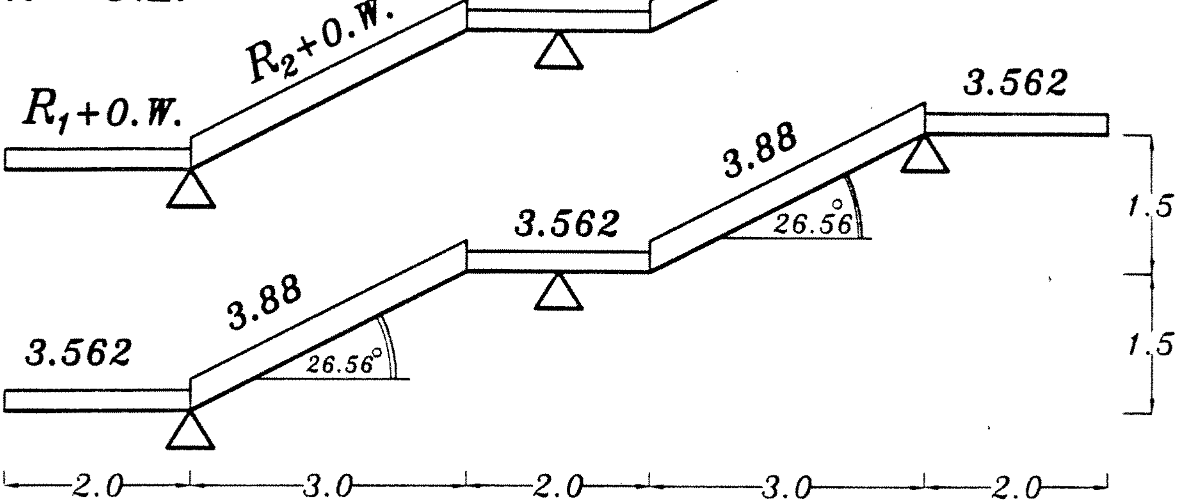


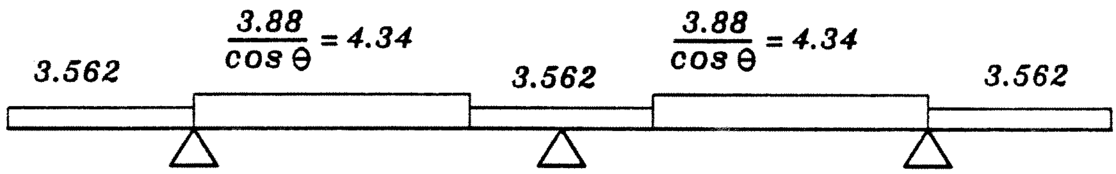


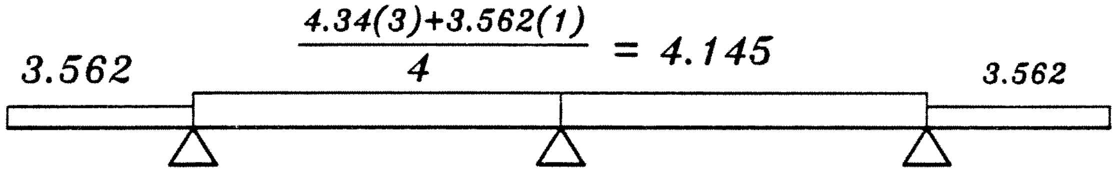
Design The Beam.

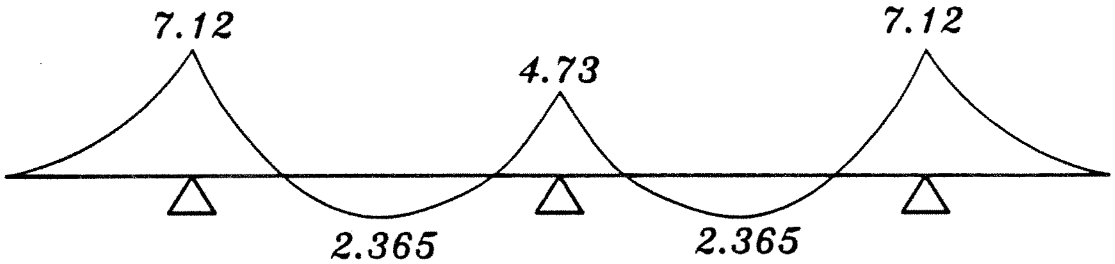
Take o.w. of beam
= 0.5 t\m` working
= 0.75 t\m` U.L.

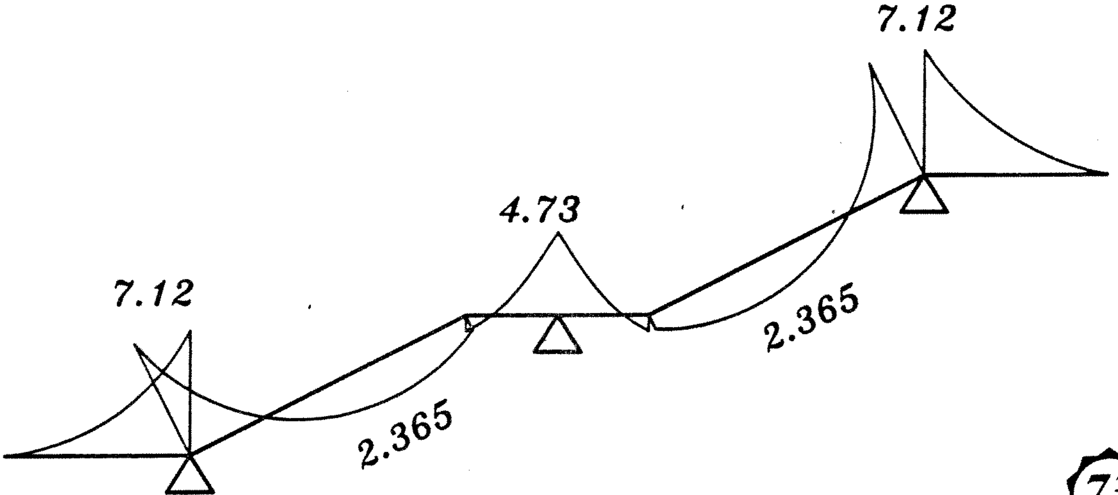




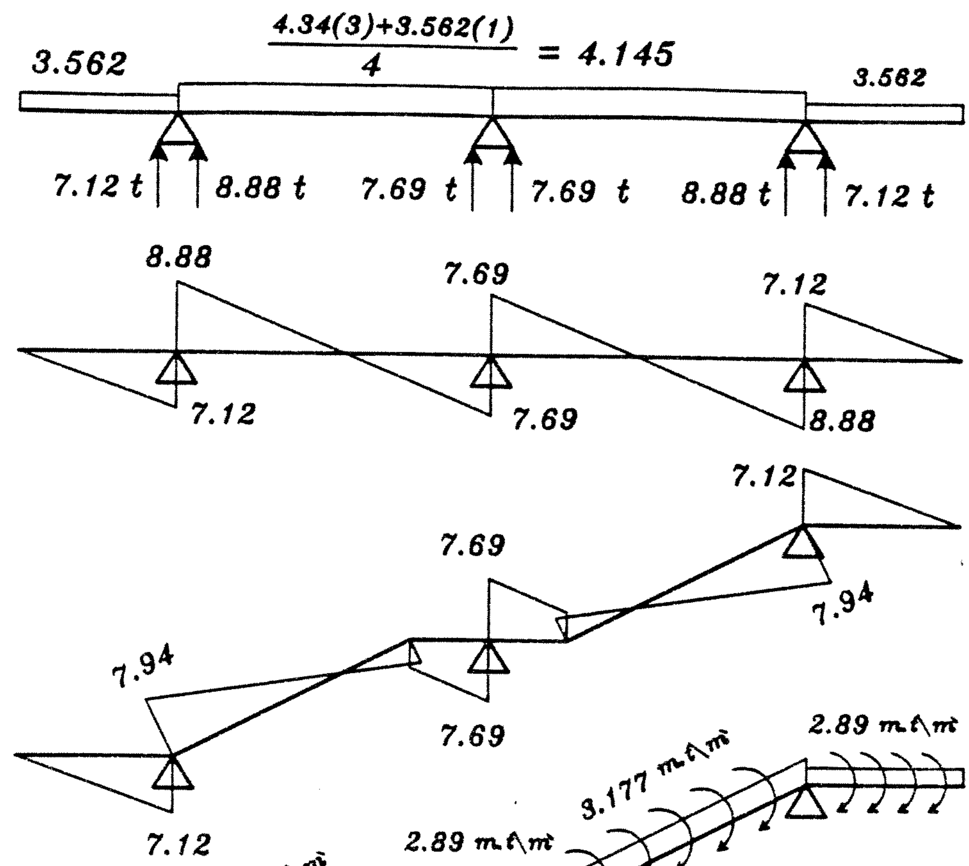






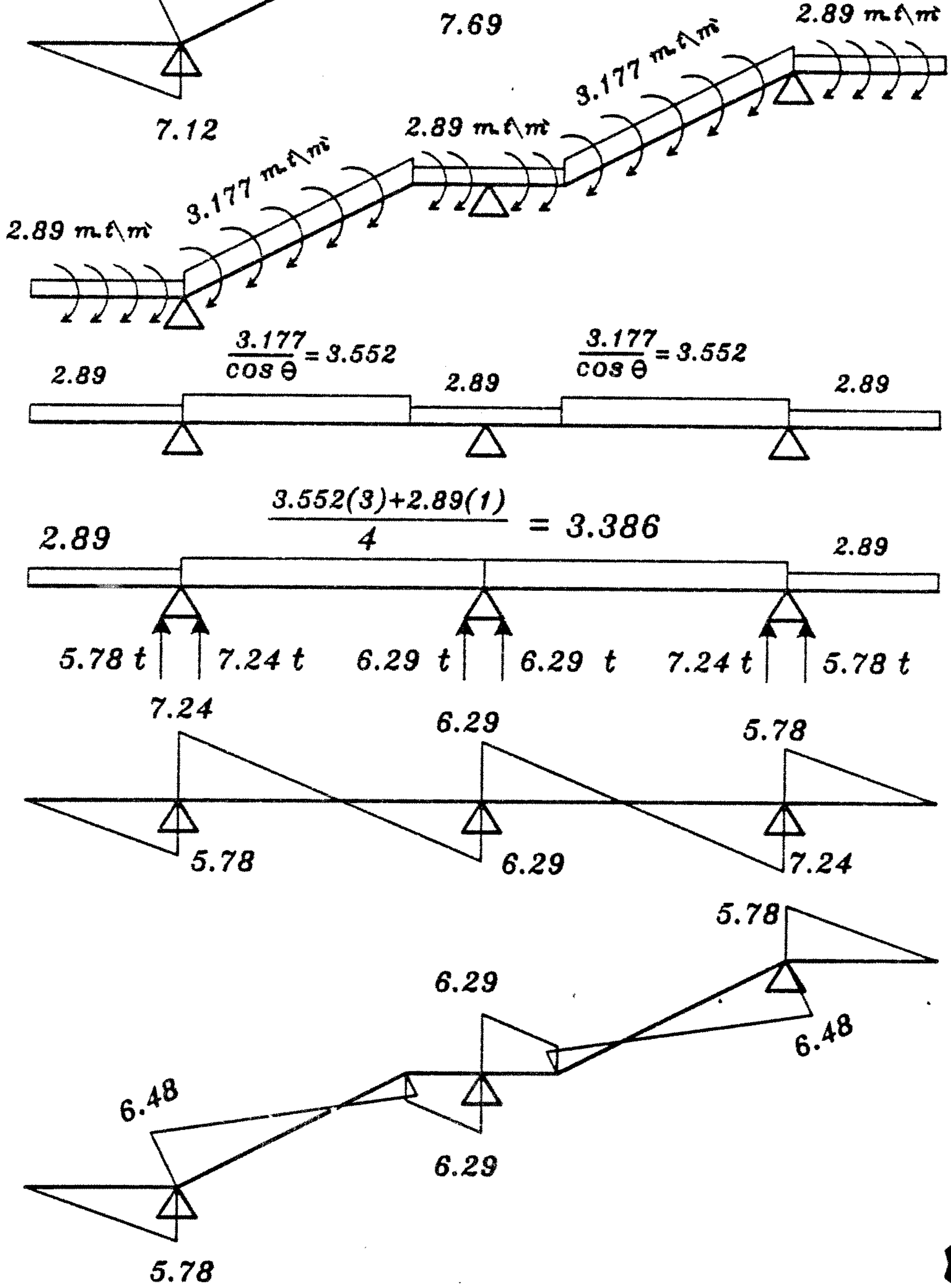


B.M.D.



4.34(3)+3.562(1) / 4 = 4.145
3.562
3.562
7.12 t
8.88 t
7.69 t
7.69 t
8.88 t
7.12 t
8.88
7.69
7.12
7.12
7.69
8.88
7.12
7.69
7.94
7.94
7.69
7.12

S.F.D.



2.89 m.t\m
3.177 m.t\m
2.89 m.t\m
3.177 m.t\m
2.89 m.t\m
2.89
3.177/cos θ = 3.552
2.89
3.177/cos θ = 3.552
2.89
3.552(3)+2.89(1) / 4 = 3.386
2.89
2.89
5.78 t
7.24 t
6.29 t
6.29 t
7.24 t
5.78 t
7.24
6.29
5.78
5.78
6.29
7.24
5.78
6.29
6.48
6.48
6.29
5.78

T.M.D.

Dimensions of the Beam.

Take $b = 35$ cm.

$Q = 7.94$ t $\quad M_t = 6.48$ m.t. $\quad M = 7.12$ m.t.

$$* \; t_{ben.} = 3.50 \sqrt{\frac{M}{F_{cu}\, b}} = 3.50 \sqrt{\frac{7.12 * 10^5}{250 * 35}} = 31.57 \text{ cm.}$$

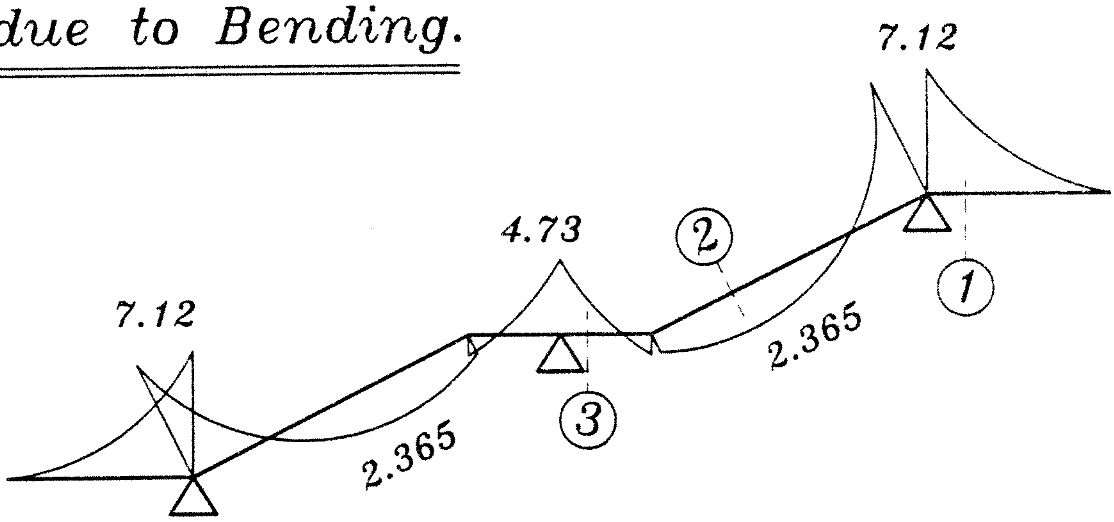
$$* \; t_{tor.} \simeq \frac{3 M_t}{b^2 \, (15 \rightarrow 17)} = \frac{3 * 6.48 * 10^5}{35^2 * 16} = 99.18 \text{ cm.}$$

$t = 100$ cm.

Take the Beam $(35 * 100)$

Design due to Bending.

B.M.D.



Sec. ① $M_{U.L.} = 7.12$ m.t. $\qquad$ R-Sec.

, $t = 100$ cm. , $d = 100 - 5.0 = 95.0$ cm.

$$95 = C_1 \sqrt{\frac{7.12 * 10^5}{250 * 35}} \longrightarrow C_1 = 10.53 \longrightarrow J = 0.826$$

$$A_S = \frac{7.12 * 10^5}{0.826 * 3600 * 95} = 2.52 \text{ cm}^2$$

$$A_{S\,min} = \frac{11}{3600}(35)(95) = 10.16$$
$$= 1.3\,(2.52) = 3.276$$
$\}$ 4.784

$$\frac{0.15}{100}(35)(95) = 4.98$$

$\}$ $= 4.98$ cm^2

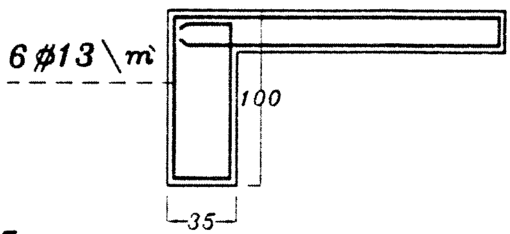
Take Sec. ②, Sec. ③ the same as Sec. ①

Design due to Shear + Torsion.

Shear	Torsion
$q_s = \frac{Q}{b\,d} = \frac{7.94 * 10^3}{35 * 95} = 2.38 \ kg\backslash cm^2$	$q_t = \frac{3 M_t}{b^2\,t} = \frac{3 * 6.48 * 10^5}{35^2 * 100} = 15.86 \ kg\backslash cm^2$
$\delta_{si} = \frac{1}{\sqrt{1+\left(\frac{15.86}{2.38}\right)^2}} = 0.148$	$\delta_{ti} = \frac{1}{\sqrt{1+\left(\frac{2.38}{15.86}\right)^2}} = 0.989$
$q_{scu} = (0.148)\,(0.75)\sqrt{\frac{250}{1.5}} = 1.433$	$q_{tcu} = (0.989)\,(0.75)\sqrt{\frac{250}{1.5}} = 9.575$
$q_{su_{max}} = (0.148)\,(2.20)\sqrt{\frac{250}{1.5}} = 4.20$	$q_{tu_{max}} = (0.989)\,(2.20)\sqrt{\frac{250}{1.5}} = 28.09$

$\because \quad q_{s_{cu}} < q_s < q_{su_{max}} \quad , \quad q_{t_{cu}} < q_t < q_{tu_{max}}$

$\therefore$ Use RFT. for Shear+Torsion



* Stirrups.

ⓐ Torsion.

$X_1 = 30 \ cm \ , \ y_1 = 95 \ cm \ , \ \alpha_t = \frac{2}{3} + \frac{1}{3}\left(\frac{95}{30}\right) = 1.722 > 1.50$

$$A_{str} = \frac{\left(q_t - \frac{q_{tcu}}{2}\right) S_t \, b^2 \, t}{3 \, \alpha_t \, X_1 \, y_1 \left(\frac{F_y}{\delta_s}\right)} \qquad \therefore 1.33 = \frac{\left(15.86 - \frac{9.575}{2}\right) \ S_t \ (35)^2 \ (100)}{3 \ (1.50)\,(30)\,(95)\,(3600/1.15)}$$

$\therefore \boxed{S_t = 39.367 \ cm.}$

ⓑ Shear.

$$q_s - \frac{q_{scu}}{2} = \frac{n \, A_s (F_y \backslash \delta_s)}{b \ S_s} \qquad \therefore 2.38 - \frac{1.433}{2} = \frac{2\,(1.33)\,(3600/1.15)}{(35)\ S_s}$$

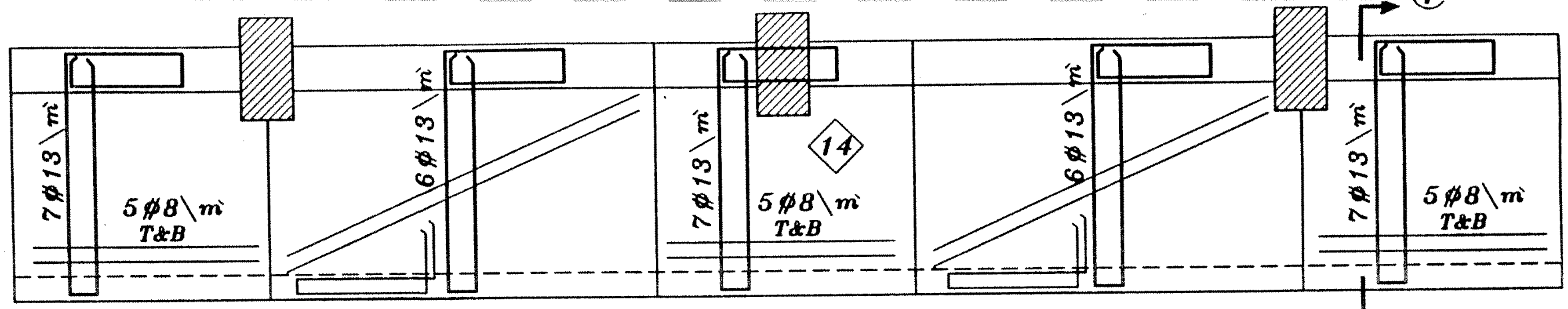
$\therefore \boxed{S_s = 143.02 \ cm.}$

No of stirrups (required) \m $= \frac{100}{S_s} + \frac{100}{S_t} = \frac{100}{143.02} + \frac{100}{39.367} = 3.24 < 6.0$ o.k.

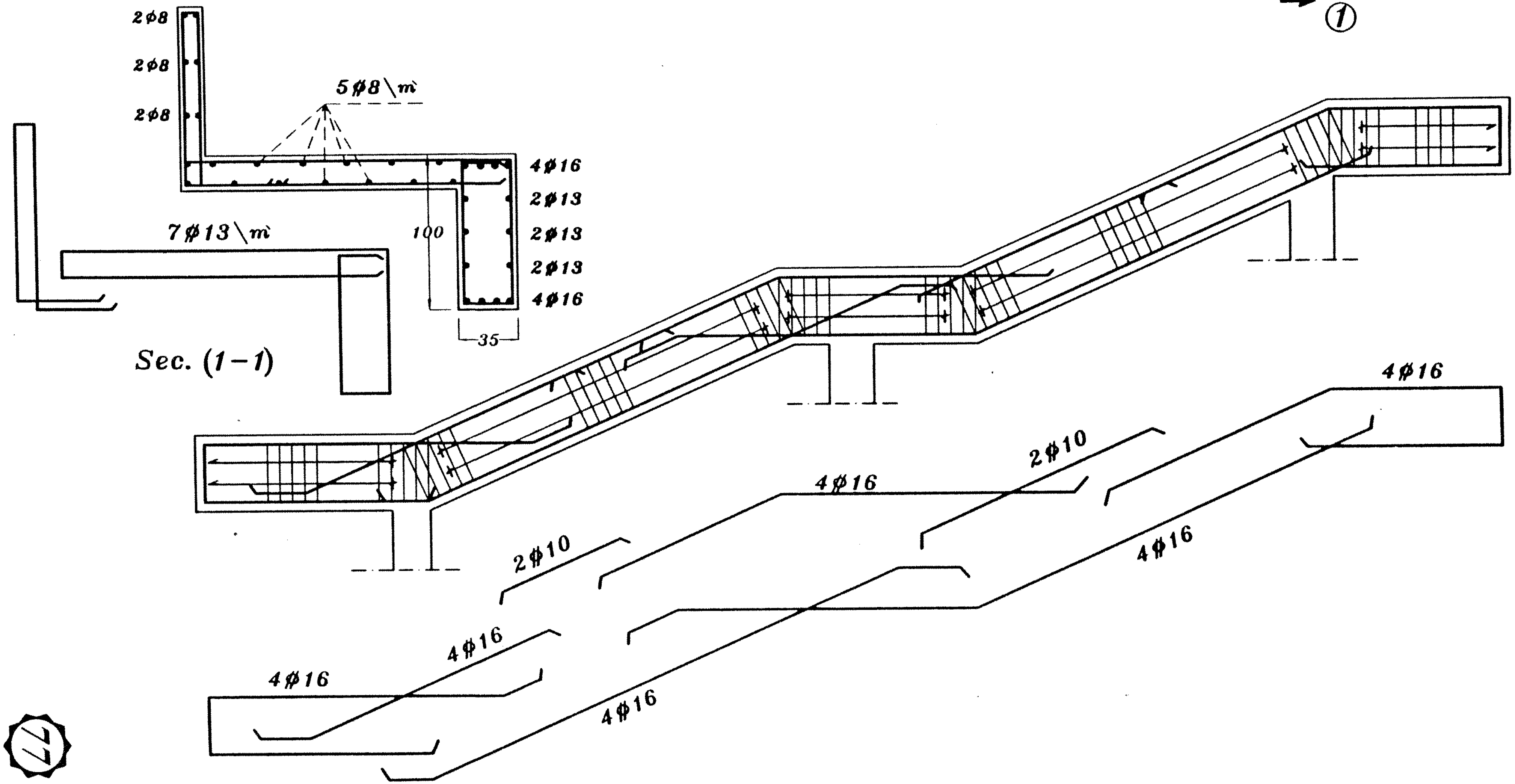
* Longitudinal Bars.

$$A_{sl} = 2 \ (1.33) \ \frac{(30+95)}{39.367}\left(\frac{3600}{3600}\right) = 8.446 \ cm^2 \qquad \therefore \frac{A_{sl}}{4} = 2.11 \ cm^2$$

$A_s = 4.98 + 2.11 = 7.09 \ cm^2$ $\boxed{4 \phi 16}$

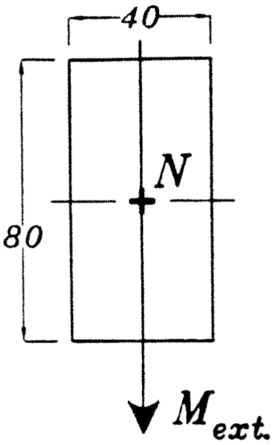


7Ø13\m`
5Ø8\m`
T&B
6Ø13\m`
7Ø13\m`
14
5Ø8\m`
T&B
6Ø13\m`
7Ø13\m`
5Ø8\m`
T&B
1
1



2Ø8
2Ø8
2Ø8
5Ø8\m`
4Ø16
2Ø13
2Ø13
2Ø13
4Ø16
100
35
7Ø13\m`
Sec. (1-1)
4Ø16
2Ø10
4Ø16
2Ø10
4Ø16
4Ø16
4Ø16
4Ø16

Deesign of Column C_1



Take the column. (40 * 80)

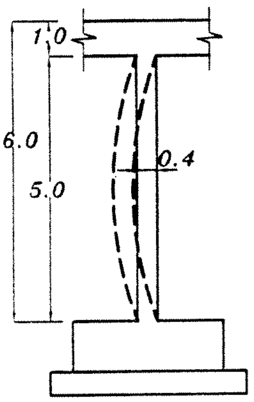
$N = 8.88 + 7.12 = 16.0\ t$

(From the reaction of S.F.D. of the beam)

$M_{ext.} = 7.24 + 5.78 = 13.026\ m.t.\ \downarrow$

(From the reaction of T.M.D. of the beam)

① Inside Plan.

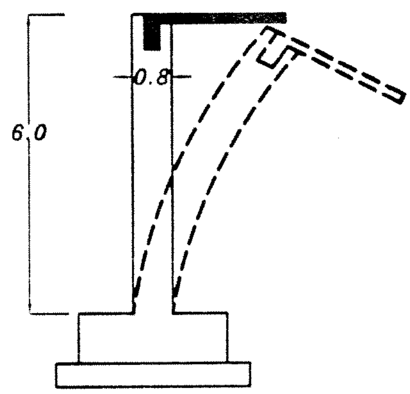


pper Condition Case ①
ower Condition Case ①
} k = 1.2

$H_\circ = 5.30\ m$

$$\lambda_b = \frac{1.2 * 5.0}{0.4} = 15.0 > 10$$

② Outside Plan.



Upper Condition Case ④
Lower Condition Case ①
} k = 2.2

$H_\circ = 6.0\ m$

$$\lambda_b = \frac{2.2 * 6.0}{0.80} = 16.5 > 10$$

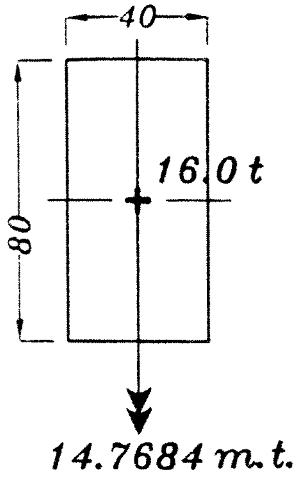
Take the bigger $\lambda_b = 16.5$ (Outside Plan)

$$\delta = \frac{(\lambda_b)^2 * t}{2000} = \frac{16.5^2 * 0.80}{2000} = 0.1089\ m$$

$$M_{add.} = N * \delta = 16.0 * 0.1089 = 1.7424\ m.t.\ \downarrow$$

$$M_{Total} = M_{ext.} + M_{add.} = 13.026 + 1.7424 = 14.7684\ m.t.\ \downarrow$$

$$e = \frac{M}{N} = \frac{14.7684}{16.0} = 0.92\ m \qquad \frac{e}{t} = \frac{0.92}{0.80} = 1.153 > 0.5$$



$$e_s = e + \frac{t}{2} - c = 0.92 + \frac{0.80}{2} - 0.05 = 1.27\ m$$

$$M_s = N * e_s = 16.0 * 1.27 = 20.32\ m.t.$$

$$75 = C_1\sqrt{\frac{20.32 * 10^5}{250 * 40}} \longrightarrow C_1 = 5.26 \longrightarrow J = 0.826$$

$$A_s = \frac{M_s}{J F_y d} - \frac{N}{F_y \backslash \delta_s} = \frac{20.32 * 10^5}{0.825 * 3600 * 75} - \frac{16.0 * 10^3}{3600 \backslash 1.15} = 4.0\ cm^2$$

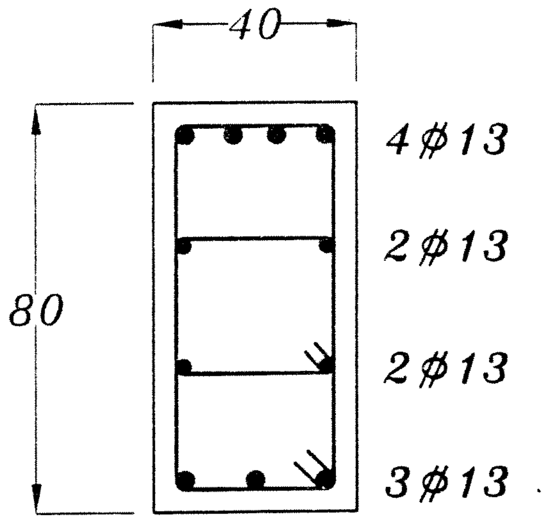
$$A_{s\,min} = \frac{11}{3600}(40)(75) = 9.166$$

$$= 1.3\ (4.0\ ) = 5.20 \quad \Big\} 5.20$$

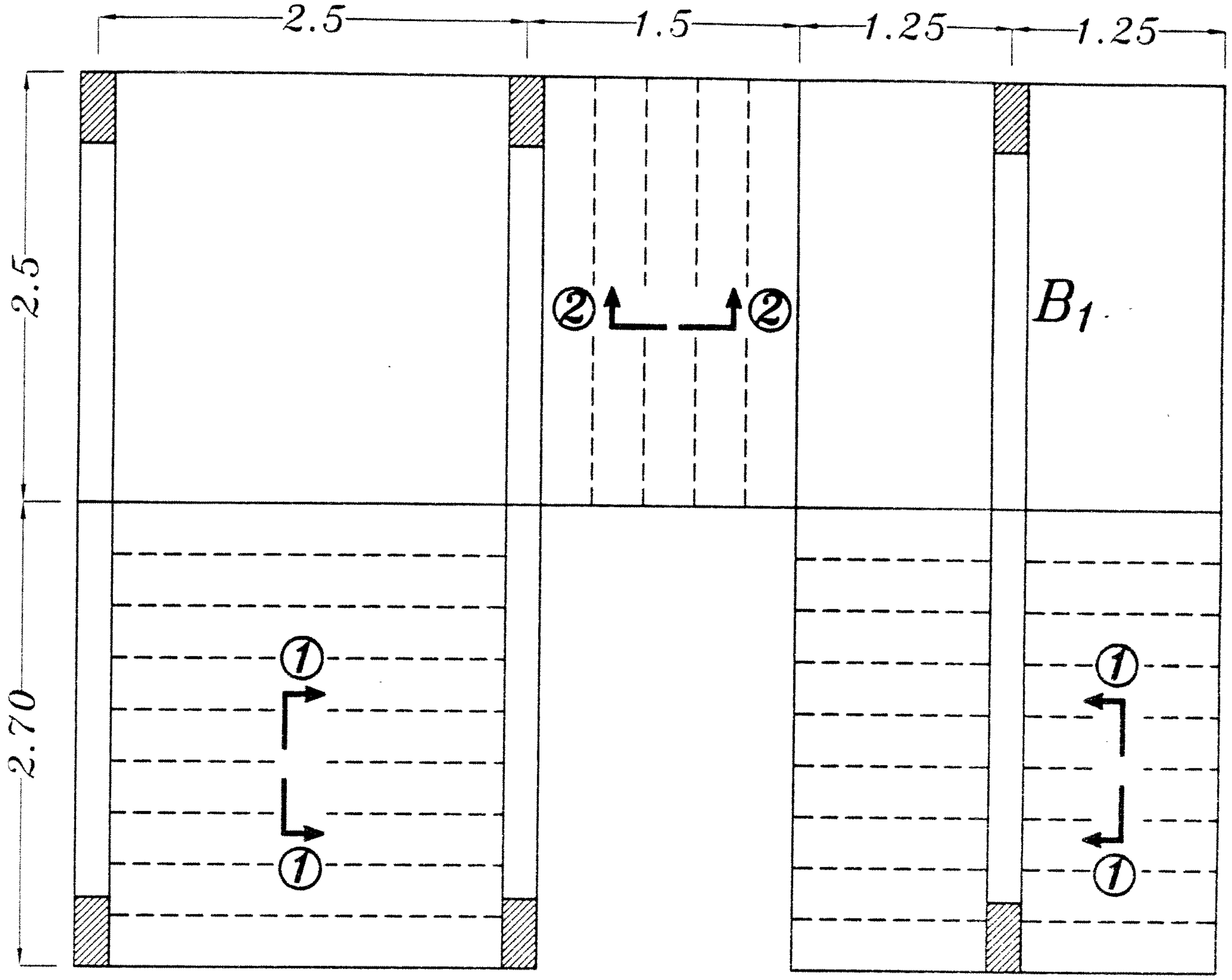
$$\frac{0.15}{100}(40)(75) = 4.50$$

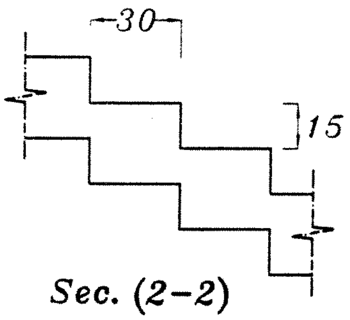
$$\Bigg\} = 5.20\ cm^2$$

4 ϕ 13

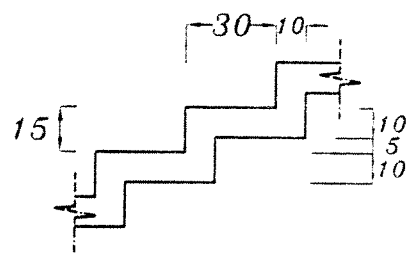


Example.





Sec. (2-2)



Sec. (1-1)

Data.

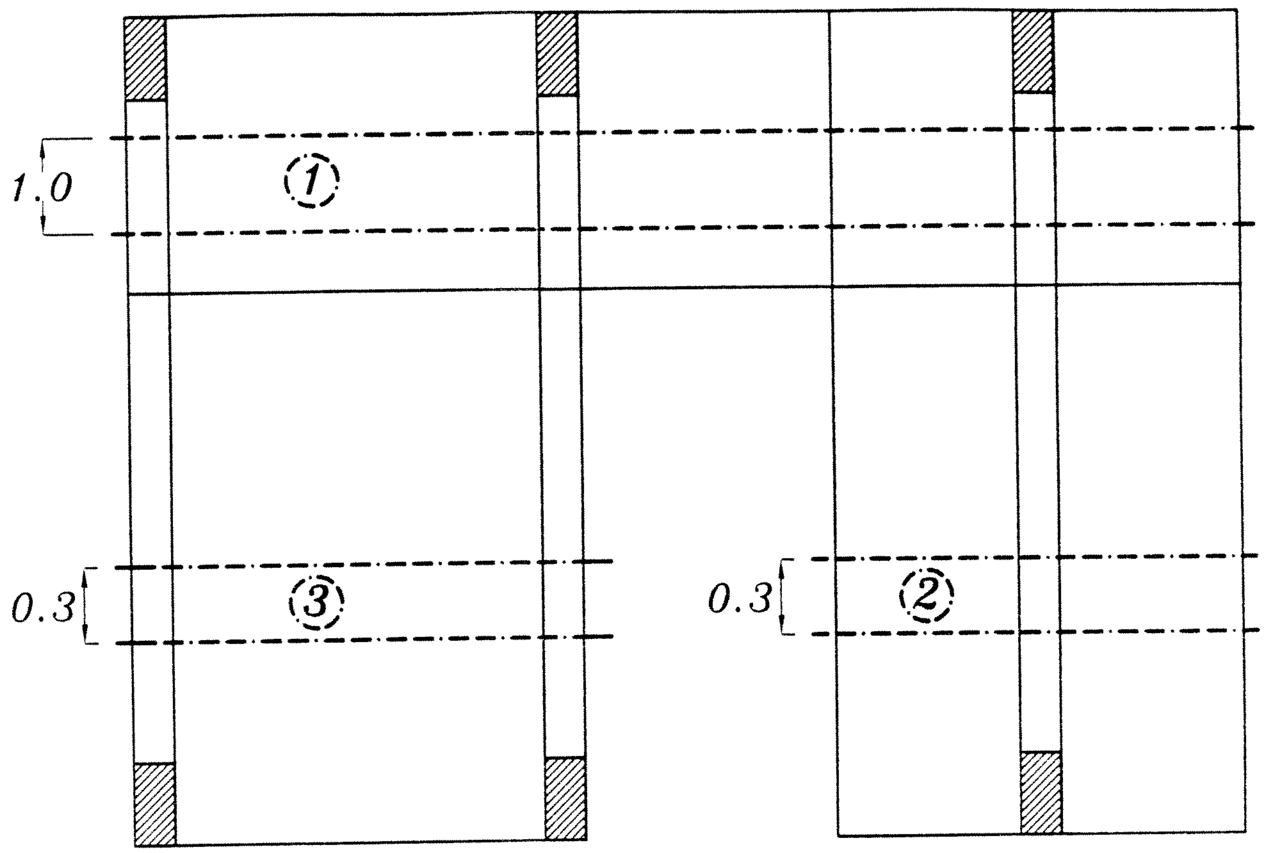
$F_{cu} = 300\ kg\backslash cm^2$ $F_y = 3600\ kg\backslash cm^2$

$L.L. = 400\ kg\backslash m^2$ $F.C. = 200\ kg\backslash m^2$

Req.

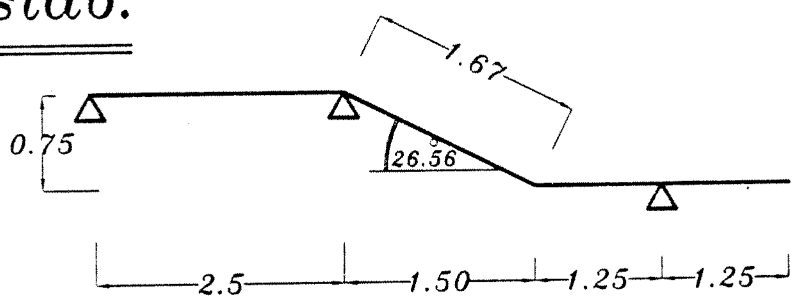
1- Design The slab as solid slab & draw Details of RFT.in plan & cross Sections

2- Design The Beam. B_1 & draw Details of RFT.in elevation.

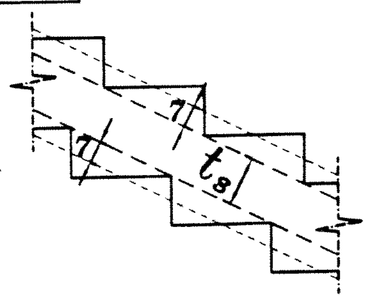


Design The slab.

Strip ①



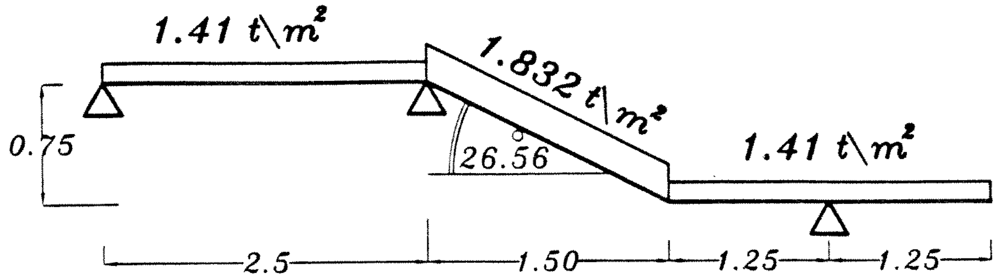
$$t_s = \frac{250}{20} = 12.5 \text{ cm.}$$
$$= \frac{167+125}{28} = 10.4 \text{ cm.}$$
$$= \frac{125}{15} + 2 = 10.3 \text{ cm.}$$
$$= 14.0 \text{ cm.} \qquad \boxed{t_s = 14.0 \text{ cm.}}$$

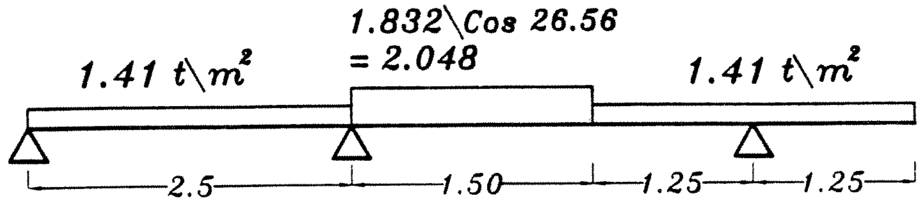


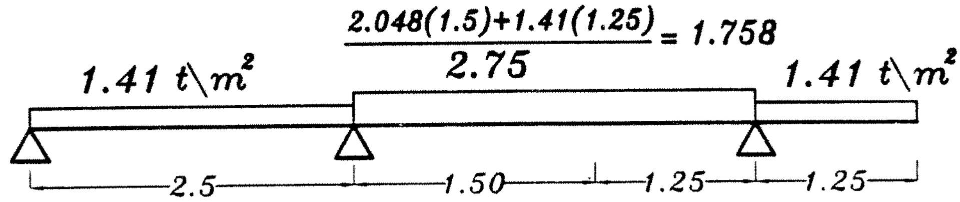
$$(w_{sh}) = 1.4\,(0.14 * 2.5 + 0.20) + 1.6\,(0.4) = 1.41 \ t\backslash m^2$$

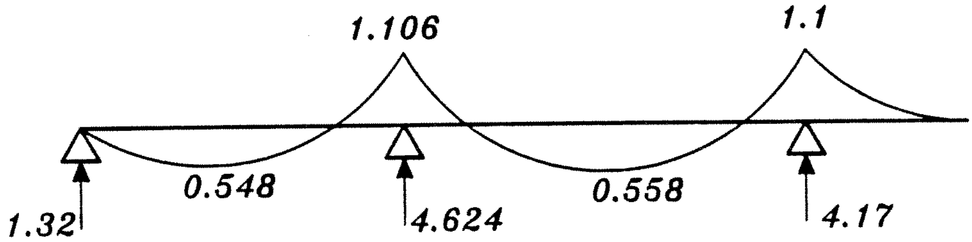
$$t_{av.} = t_s + 7.0 + 7.0 = 28.0 \text{ cm.}$$

$$(w_{si}) = 1.4\,(0.28 * 2.5 + 0.20) + 1.6\,(0.4)\,\text{Cos}\,26.565^\circ = 1.832 \ t\backslash m^2$$

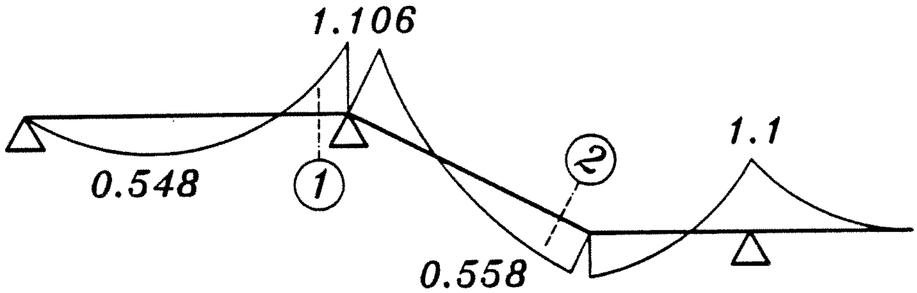








B.M.D.



<u>Sec. ①</u> $M_{U.L.} = 1.106 \ mt\backslash m'$

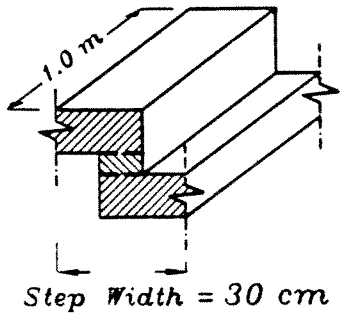
$t_s = 14 \ cm.$, $d = 14 - 1.5 = 12.5 \ cm.$

$$12.5 = C_1\sqrt{\frac{1.106*10^5}{300*100}} \longrightarrow C_1 = 6.51 \longrightarrow J = 0.826$$

$$A_s = \frac{1.106*10^5}{0.826*3600*12.5} = 2.975 \ cm^2/m'$$ (6 Ø8 \m')

<u>Sec. ②</u> $M_{U.L.} = 0.558 \ mt\backslash m'$ (5 Ø8 \m')

Strip ②

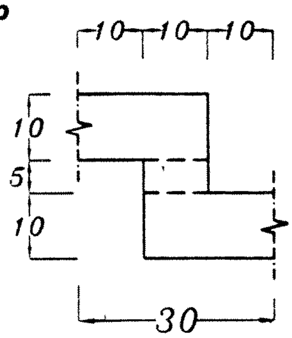


Take the strip width = 30 cm

$o.w. = [2(0.1)(0.2) + (0.05)(0.1)](1.0)(2.5) = 0.1125$ t\step

$(w)_{T.L.} = 1.4\,[o.w.(\text{For step}) + F.C.(S)] + 1.6\,[L.L.(S)]$

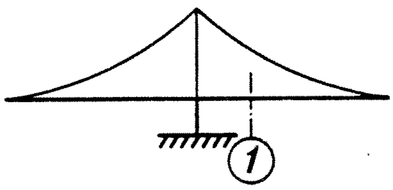
$(w)_{T.L.} = 1.4\,[0.1125 + 0.2(0.30)] + 1.6\,[0.4(0.30)] = 0.433$ t\step

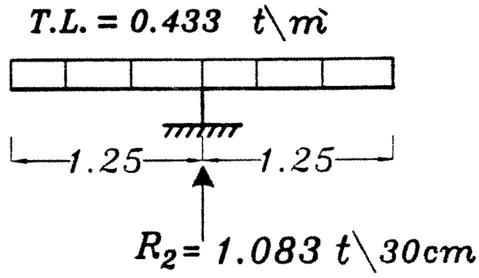


$(w)_{D.L.} = 0.9\,[o.w.(\text{For step}) + F.C.(S)]$

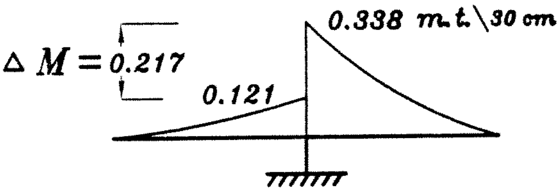
$(w)_{D.L.} = 0.9\,[0.1125 + 0.2(0.30)] = 0.155$ t\step

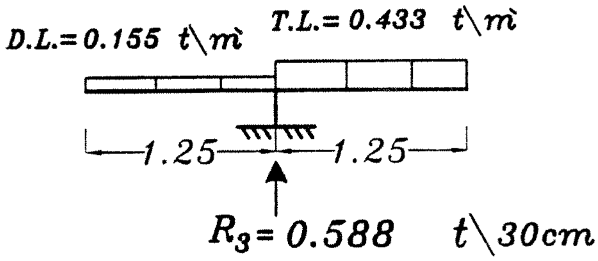
To design the slab.





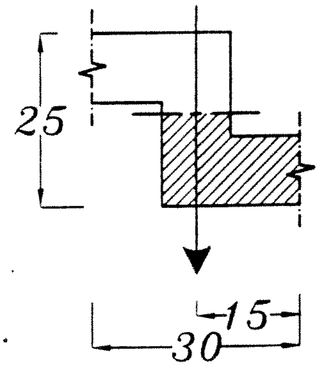
To get the max Torsion.





Sec. ①

Designed as L−Sec. with $B = 15$ cm.



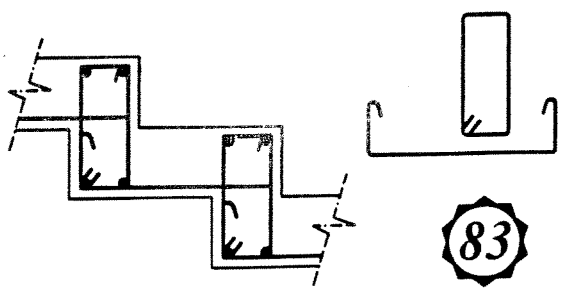
$M_{U.L.} = 0.338$ mt\step

$t = 25$ cm. , $d = 25 - 2.5 = 22.5$ cm.

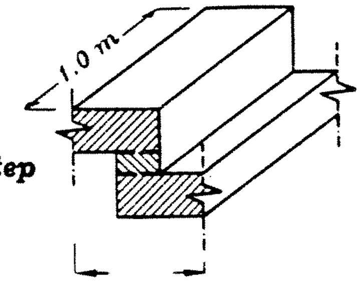
$$22.5 = C_1\sqrt{\frac{0.338 * 10^5}{300 * 15}} \longrightarrow C_1 = 8.21 \longrightarrow J = 0.826$$

$$A_S = \frac{0.338 * 10^5}{0.826 * 3600 * 22.5} = 0.505 \text{ cm}^2/\text{step}$$

2 Ø 8\step



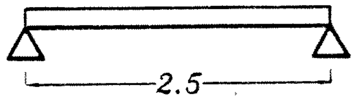
Strip ③



Take the strip width = 30 cm

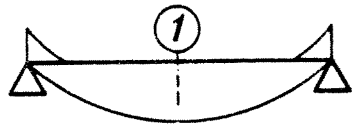
$w_S = 1.4\,[\,0.1125 + 0.2\,(0.30)\,] + 1.6\,[\,0.4\,(0.30)\,] = 0.433\ t\backslash step$

Sec. ①



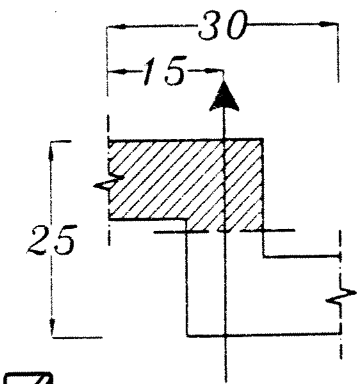
Designed as L−Sec. with $B = 15$ cm.

$M_{U.L.} = 0.338\ mt\backslash step$

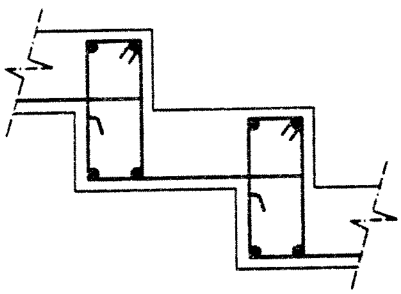


$t = 25$ cm. , $d = 25 - 2.5 = 22.5$ cm.

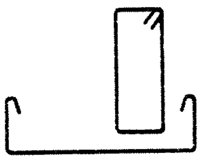
$22.5 = C_1\sqrt{\frac{0.338 * 10^5}{250 * 15}} \longrightarrow C_1 = 7.49 \longrightarrow J = 0.826$

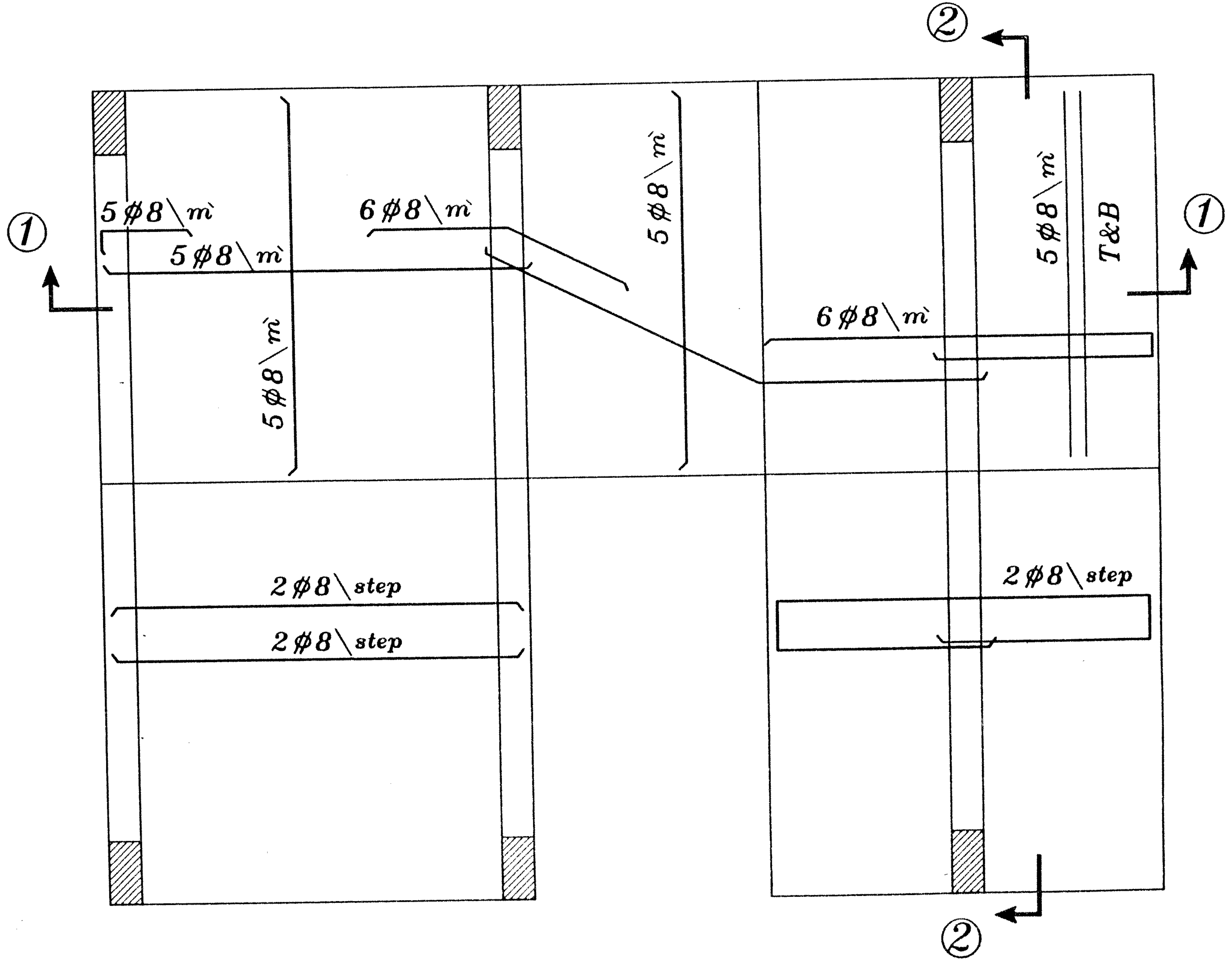


$A_S = \frac{0.338 * 10^5}{0.826 * 3600 * 22.5} = 0.505\ cm^2/step$

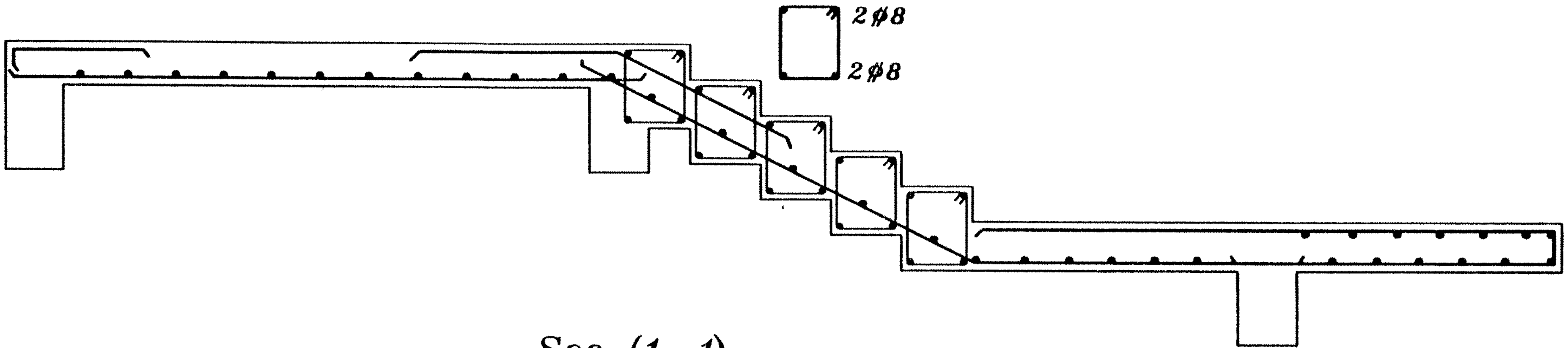


2 ϕ 8 \step

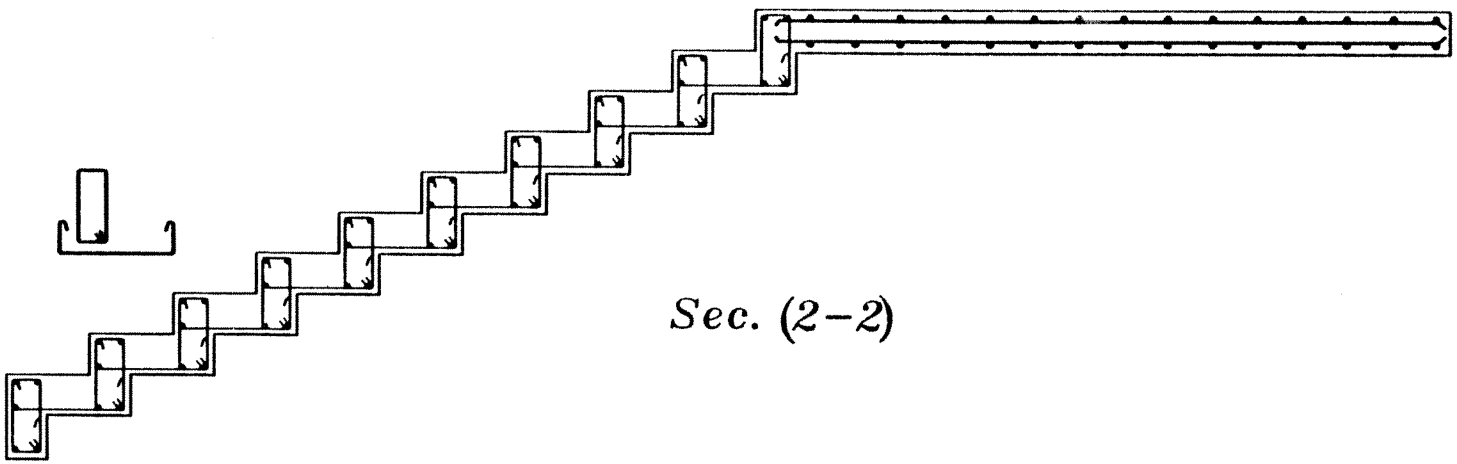




5 φ8 \ m`
5 φ8 \ m`
5 φ8 \ m`
6 φ8 \ m`
5 φ8 \ m`
6 φ8 \ m`
5 φ8 \ m`
T&B
2 φ8 \ step
2 φ8 \ step
2 φ8 \ step
1
1
2
2



Sec. (1–1)

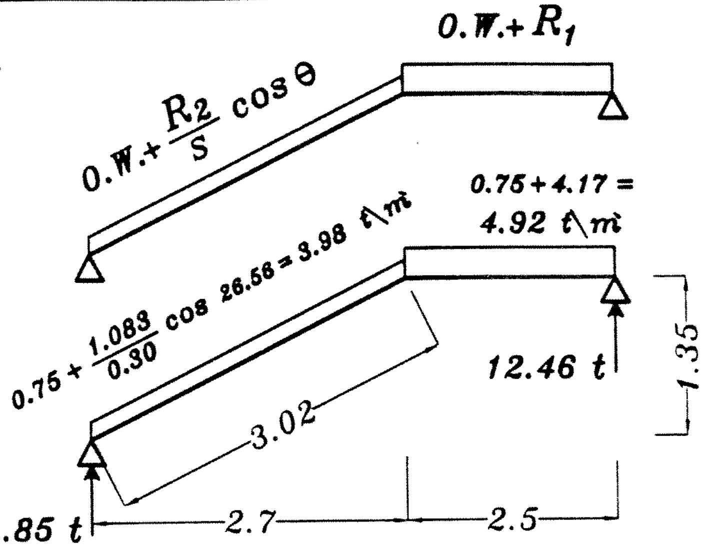


Sec. (2–2)

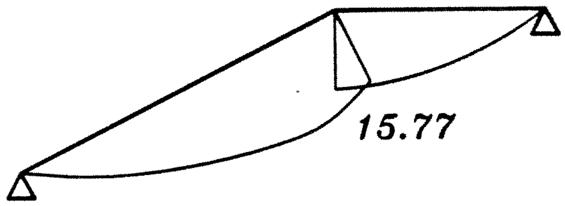
Design The Beam.

Take o.w. of beam
= 0.75 t\m` U.L.

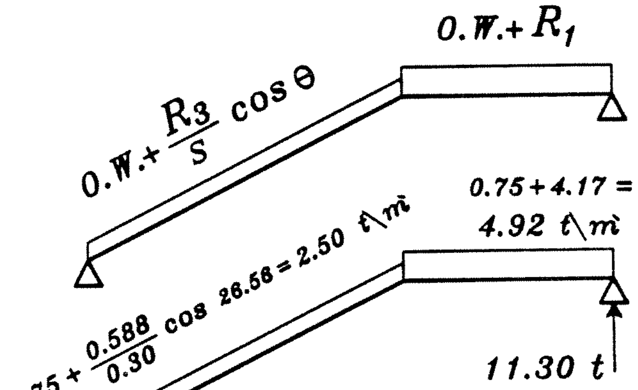
Load For Bending Moment



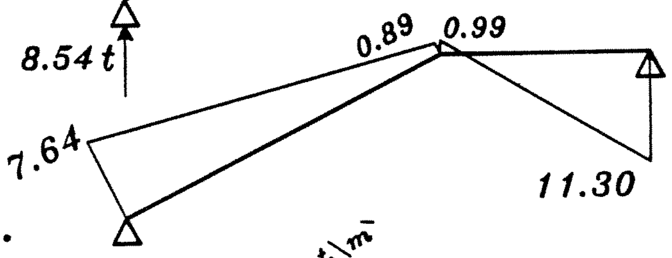
B.M.D.



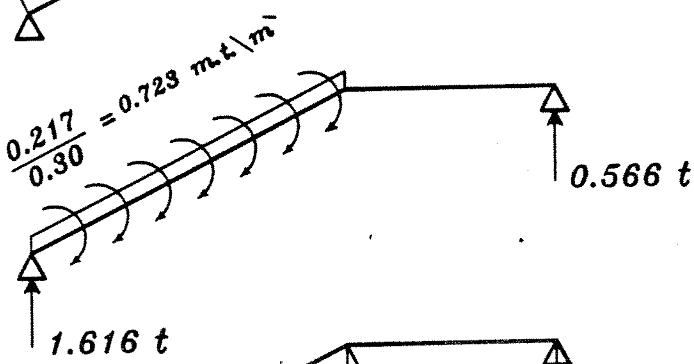
Load For Shear & Torsion



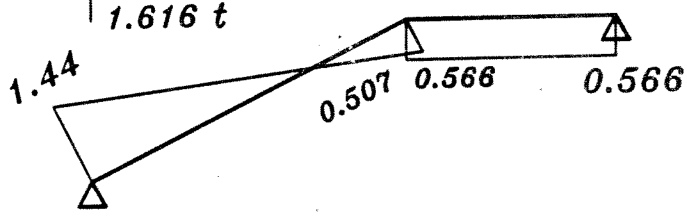
S.F.D.



T.M.



T.M.D.



Dimensions of the Beam.

Take $b = 30$ cm.

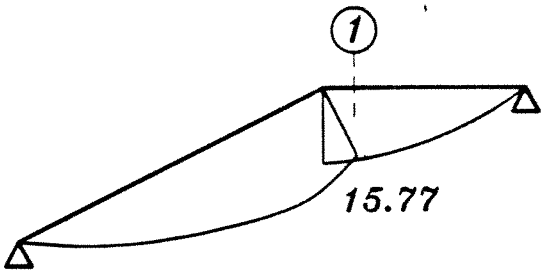
$Q = 11.6$ t $\quad M_t = 1.44$ m.t. $\quad M = 15.77$ m.t.

$$* \; t_{ben.} = 3.50 \sqrt{\frac{M}{F_{cu}\, b}} = 3.50 \sqrt{\frac{15.77 * 10^5}{300 * 30}} = 46.33 \text{ cm.}$$

$$* \; t_{tor.} \simeq \frac{3 M_t}{b^2 \, (15 \rightarrow 17)} = \frac{3 * 1.44 * 10^5}{30^2 * 16} = 30 \text{ cm.}$$

$t = 50$ cm.

Take the Beam $(30 * 50)$



Design due to Bending.

Sec. ① $M_{U.L.} = 15.77$ m.t.

, $t = 50$ cm. , $d = 50 - 5.0 = 45.0$ cm.

$$45 = C_1 \sqrt{\frac{15.77 * 10^5}{300 * 30}} \longrightarrow C_1 = 3.399 \longrightarrow J = 0.774$$

$$A_S = \frac{15.77 * 10^5}{0.774 * 3600 * 45} = 12.57 \text{ cm}^2$$

Design due to Shear + Torsion.

Shear

$$q_s = \frac{Q}{b\,d} = \frac{7.64 * 10^3}{30 * 45} = 5.65 \text{ kg}\backslash\text{cm}^2$$

$$\delta_{si} = \frac{1}{\sqrt{1 + \left(\frac{9.60}{5.65}\right)^2}} = 0.507$$

$$q_{scu} = (0.507)(0.75)\sqrt{\frac{300}{1.5}} = 5.37$$

$$q_{su_{max}} = (0.507)(2.20)\sqrt{\frac{300}{1.5}} = 15.77$$

Torsion

$$q_t = \frac{3 M_t}{b^2\, t} = \frac{3 * 1.44 * 10^5}{30^2 * 50} = 9.60 \text{ kg}\backslash\text{cm}^2$$

$$\delta_{ti} = \frac{1}{\sqrt{1 + \left(\frac{5.65}{9.60}\right)^2}} = 0.861$$

$$q_{tcu} = (0.861)(0.75)\sqrt{\frac{300}{1.5}} = 9.13$$

$$q_{tu_{max}} = (0.861)(2.20)\sqrt{\frac{300}{1.5}} = 26.78$$

$$\because \quad q_{s_{cu}} < q_s < q_{su_{max}} \quad , \quad q_{t_{cu}} < q_t < q_{tu_{max}}$$

$\therefore$ Use RFT. For Shear+Torsion

* Stirrups.

(a) Torsion.

$X_1 = 25\ cm$, $y_1 = 45\ cm$ $\quad \alpha_t = \frac{2}{3} + \frac{1}{3}\left(\frac{45}{25}\right) = 1.26 < 1.5$

$$A_{str} = \frac{\left(q_t - \frac{q_{tcu}}{2}\right) S_t\, b^2\, t}{3\, \alpha_t\, X_1\, y_1 \left(\frac{F_y}{\gamma_s}\right)} = \frac{\left(9.60 - \frac{9.13}{2}\right) S_t\, (30)^2\, (50)}{3\, (1.26)(25)(45)(2400/1.15)}$$

$\therefore$ $\boxed{S_t = 39.17 * A_{str}}$

(b) Shear.

$$q_s - \frac{q_{scu}}{2} = \frac{n\, A_s (F_y \backslash \gamma_s)}{b\ S_s} \qquad \therefore\ 5.65 - \frac{5.37}{2} = \frac{n\, A_s\, (2400/1.15)}{(30)\, S_s}$$

$\therefore$ $\boxed{S_s = 23.46 * n\, A_s}$

* Take $n = 2$, $\phi 8 \longrightarrow A_s = A_{str} = 0.503\ cm^2$

$\therefore\ S_t = 39.17 * A_{str} = 39.17 * 0.503 = 19.70\ cm.$

$S_s = 23.46 * n\, A_s = 23.46 * (2 * 0.503) = 23.60\ cm.$

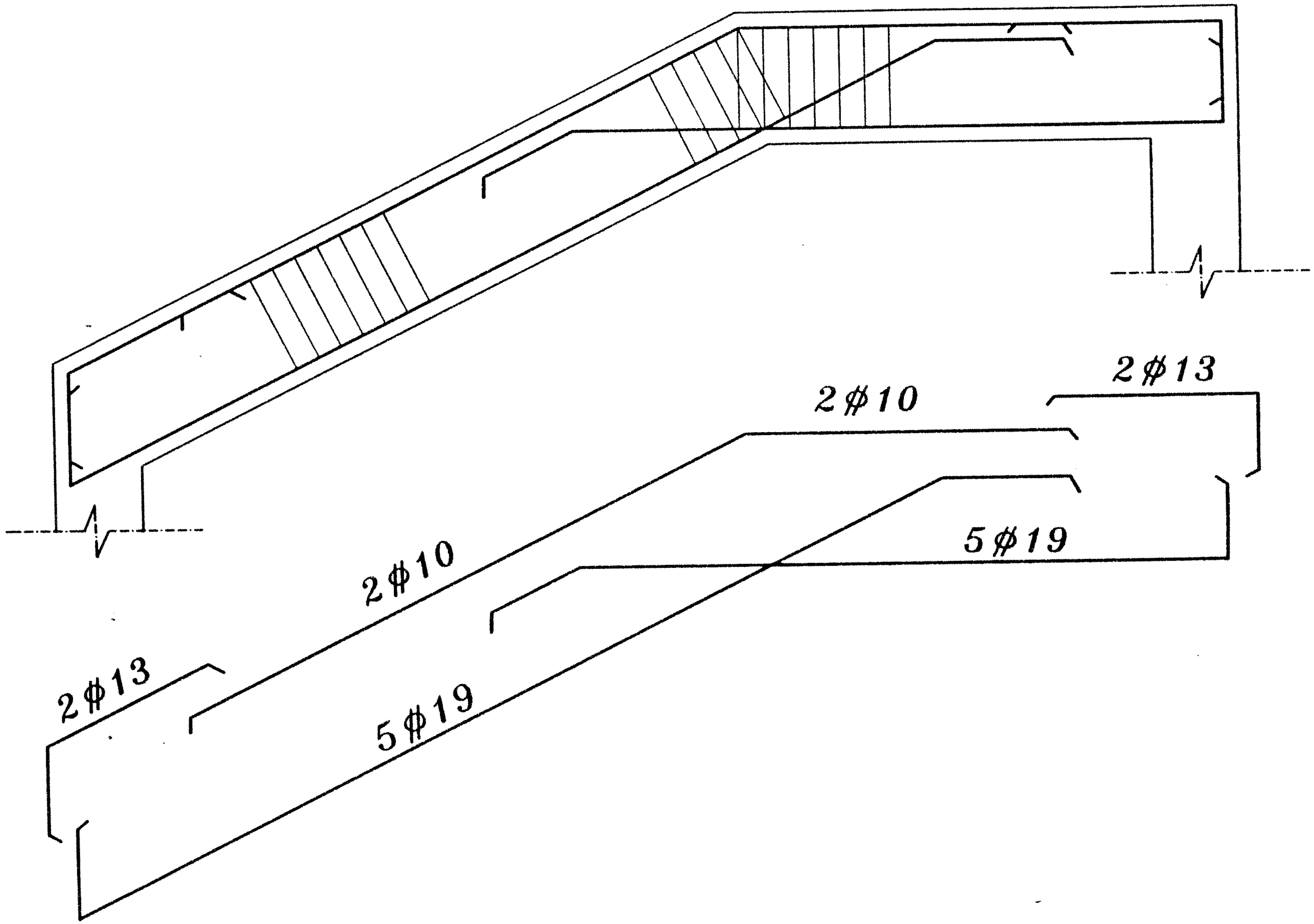
$$\text{No of stirrups} \backslash m' = \frac{100}{S_s} + \frac{100}{S_t} = \frac{100}{23.60} + \frac{100}{19.70} = 9.31 < 10 \backslash m'$$

$\therefore$ Use Closed Stirrups $\boxed{10 \phi 8 \backslash m'}$ 2 branches.

* Longitudinal Bars.

$$A_{sl} = 2\, A_{str} \frac{(X_1 + y_1)}{S_t} \left(\frac{F_{y\,str.}}{F_{y\,L.b.}}\right) = 2\ (0.503)\ \frac{(25 + 45)}{19.70} \left(\frac{2400}{3600}\right)$$

$\therefore\ A_{sl} = 3.37\ cm^2$ $\qquad \therefore\ \frac{A_{sl}}{4} = 0.843\ cm^2$


2Φ13
2Φ10
5Φ19
2Φ10
2Φ13
5Φ19