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Sheet

خرسانة مسلحة 1

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Table 1

f'_c, MPa	β_1
$17 \le f'_c \le 28$	0.85
$28 < f'_c < 55$	$0.85 - \dfrac{0.05(f'_c - 28)}{7}$
$f'_c \ge 55$	0.65

For slap

Table 7.3.1.1—Minimum thickness of solid nonprestressed one-way slabs

Support condition	Minimum h[1]
Simply supported	$\ell/20$
One end continuous	$\ell/24$
Both ends continuous	$\ell/28$
Cantilever	$\ell/10$

For beam

Table 2

Support condition	Minimum h
Simply supported	L/16
One end continuous	L/18.5
Both ends continuous	L/21
Cantilever	L/8

Table 3

Bar Designation	Number of Bars								
	2	3	4	5	6	7	8	9	10
#10	142	213	284	355	426	497	568	639	710
#13	258	387	516	645	774	903	1032	1161	1290
#16	398	597	796	995	1194	1393	1592	1791	1990
#19	568	852	1136	1420	1704	1988	2272	2556	2840
#22	774	1161	1548	1935	2322	2709	3096	3483	3870
#25	1020	1530	2040	2550	3060	3570	4080	4590	5100
#29	1290	1935	2580	3225	3870	4515	5160	5805	6450
#32	1638	2457	3276	4095	4914	5733	6552	7371	8190
#36	2012	3018	4024	5030	6036	7042	8048	9054	10 060
#43	2904	4356	5808	7260	8712	10 162	11 616	13 068	14 520
#57	5162	7743	10 324	12 905	15 486	18 067	20 648	23 229	25 810

Table 4

TABLE B.5 Minimum Beam Width (mm) for Beams with Inside Exposure (1995 ACI Metric Code)[a,b,c]

Size of Bars	Number of Bars in Single Layer of Reinforcement							Add for Each Additional Bar
	2	3	4	5	6	7	8	
#13	175	213	251	288	326	364	401	37.7
#16	178	219	260	301	342	383	424	40.9
#19	182	226	270	314	358	402	446	44.1
#22	185	232	279	326	373	421	468	47.2
#25	188	239	290	341	391	442	493	50.8
#29	195	252	310	367	424	482	539	57.4
#32	202	267	331	396	460	525	590	64.6
#36	209	281	353	424	496	567	639	71.6
#43	228	314	400	486	572	658	744	86.0
#57	271	386	501	615	730	844	959	114.6

Table 5

TABLE B.6 Areas of Bars in Slabs (mm^2/m)

Spacing (mm)	Bar Number								
	10	13	16	19	22	25	29	32	36
75	947	1720	2653	3787	5160	6800	8600	10 920	13 413
90	789	1433	2211	3156	4300	5667	7167	9100	11 178
100	710	1290	1990	2840	3870	5100	6450	8190	10 060
115	617	1122	1730	2470	3365	4435	5609	7122	8748
130	546	992	1531	2185	2977	3923	4962	6300	7738
140	507	921	1421	2029	2764	3643	4607	5850	7186
150	473	860	1327	1893	2580	3400	4300	5460	6707
165	430	782	1206	1721	2345	3091	3909	4964	6097
180	394	717	1106	1578	2150	2833	3583	4550	5589
190	374	679	1047	1495	2037	2684	3395	4311	5295
200	355	645	995	1420	1935	2550	3225	4095	5030
225	316	573	884	1262	1720	2267	2867	3640	4471
250	284	516	796	1136	1548	2040	2580	3276	4024
300	237	430	663	947	1290	1700	2150	2730	3353

Table 6

Table 6.3.2.1—Dimensional limits for effective overhanging flange width for T-beams

Flange location	Effective overhanging flange width, beyond face of web	
Each side of web	Least of:	$8h$
		$s_w/2$
		$\ell_n/8$
One side of web	Least of:	$6h$
		$s_w/2$
		$\ell_n/12$

Table 20.5.1.3.1—Specified concrete cover for cast-in-place nonprestressed concrete members

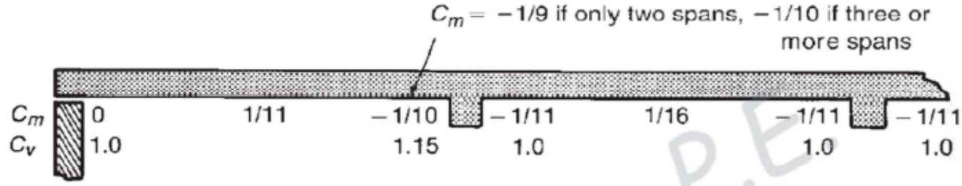
Concrete exposure	Member	Reinforcement	Specified cover, mm
Cast against and permanently in contact with ground	All	All	75
Exposed to weather or in contact with ground	All	No. 19 through No. 57 bars	50
		No. 16 bar, MW200 or MD200 wire, and smaller	40
Not exposed to weather or in contact with ground	Slabs, joists, and walls	No. 43 and No. 57 bars	40
		No. 36 bar and smaller	20
	Beams, columns, pedestals, and tension ties	Primary reinforcement, stirrups, ties, spirals, and hoops	40

Table 7

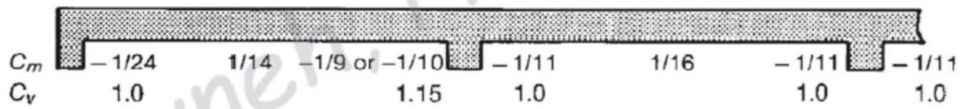
Loading cases

$$M_u = C_m \left(w_u \ell_n^2 \right)$$

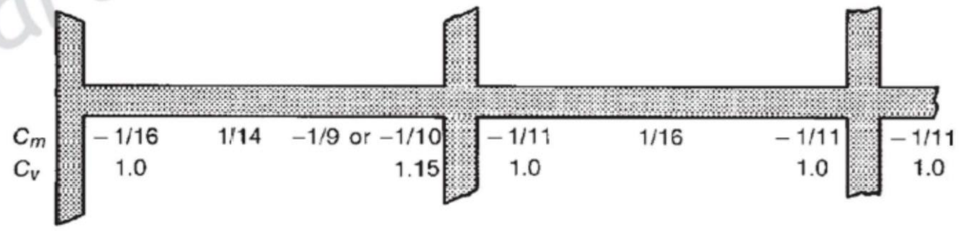
$$V_u = C_v \left(\frac{w_u \ell_n}{2} \right)$$



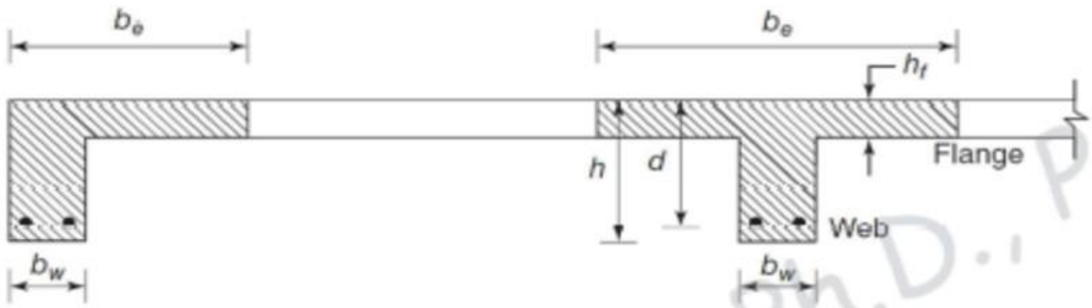
Moment and shear coefficients—Discontinuous end unrestrained.

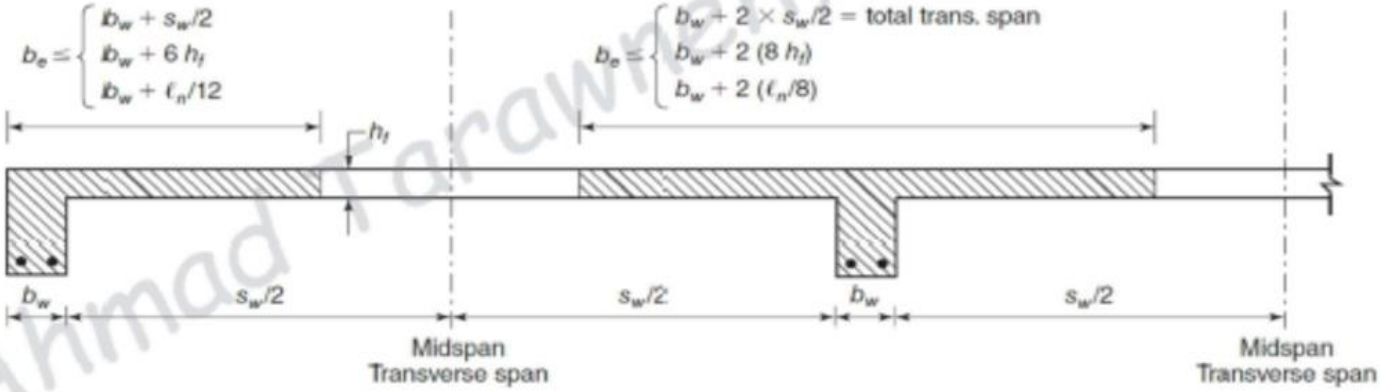


Moment and shear coefficients—Discontinuous end integral with support where support is a spandrel girder.



Moment and shear coefficients—Discontinuous end integral with support where support is a column.

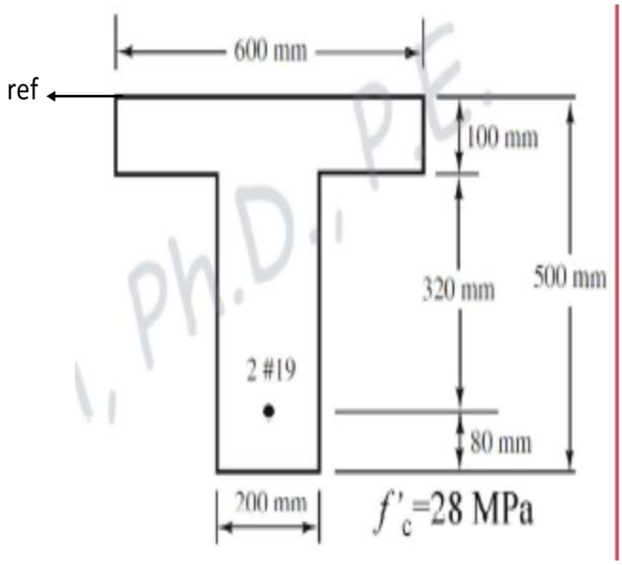




ℓ_n = clear length of beam span (longitudinal span)

s_w = clear transverse span between webs

Calculate the cracking moment (Mc)?



1. Find $\bar{y} = \frac{A1\,y1 + A2\,y2}{A1 + A2}$

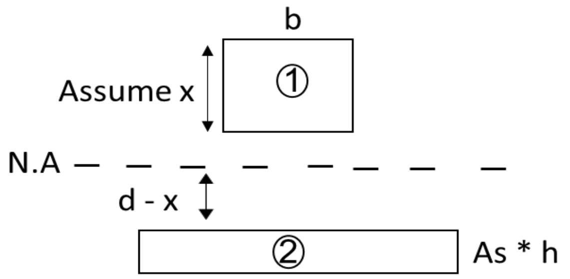
2. $I1 = \frac{1}{12} bh^3 + Ad^2 \longrightarrow d = \bar{y} - \bar{y}1$

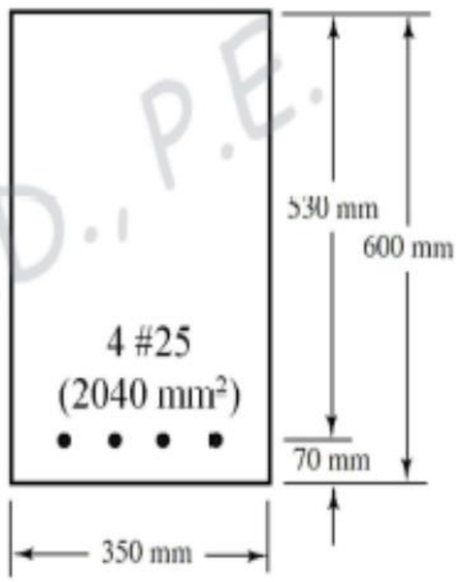
   $I2 = \frac{1}{12} bh^3 + Ad^2 \longrightarrow d = \bar{y} - \bar{y}2$

3. Find $fr = 0.62\lambda\sqrt{f`_c}$

4. $Mcr = \frac{fr\, Ig}{yt}$

Compute the flexural stress?





1. use 1st moment: for find (x)

Area 1 × $\bar{y}1$ = Area 2 × $\bar{y}2$ $\longrightarrow$ $\bar{y}1 = x/2$, $\bar{y}2 = d - x$

2. find i1 , i2

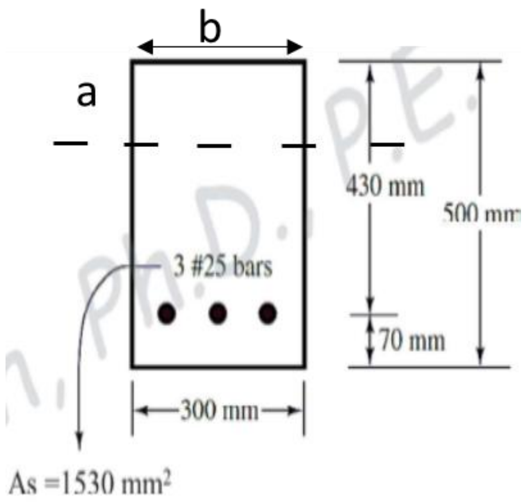
$i1 = \frac{1}{12} bh^3 + Ad^2 \longrightarrow d = x$

$i2 = Ad^2 \longrightarrow d = d - x$

3. stress concrete = $\frac{m\,y}{i} \longrightarrow Y = x$

4. Stress steel = $\frac{m\,y}{i} \times n \longrightarrow Y = d - x$

Ultimate flexural moment (Mn) ?



Case 1 : if rectangular

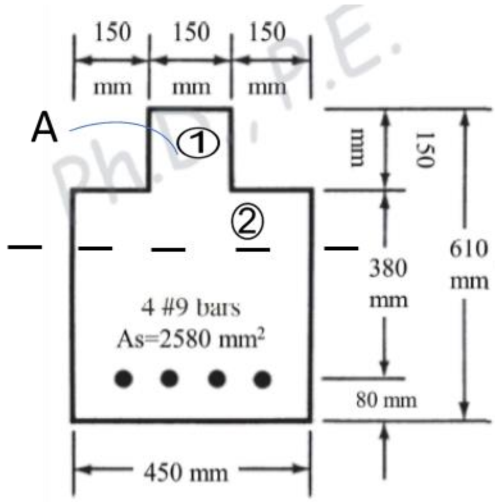
1. T = C

2. $Asfy = 0.85 f`_c ab$

3. $a = \frac{Asfy}{0.85\ f`c\ b}$

4. $Mn = T\left(d - \frac{a}{2}\right) = c\left(d - \frac{a}{2}\right) = Asfy(d - \frac{a}{2})$

Case 2 : if not rectangular



1. T = C

2. $Asfy = 0.85 f`_c bd$

$Asfy = 0.85 f`_c\ Ac$

3. $Ac - A = ??$

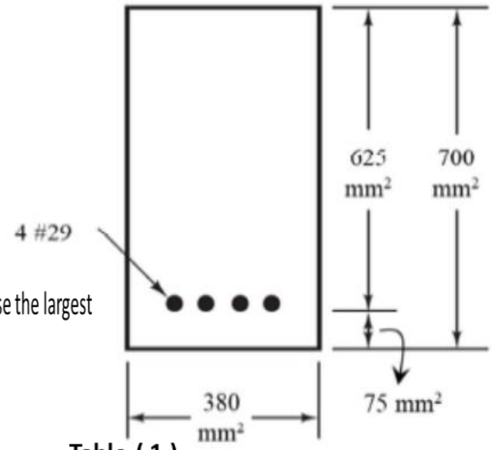
4. $\frac{??}{b}$ = x

5. $\bar{y} = \frac{A1\ y1 + A2\ y2}{A1 + A2} = \frac{A1\ y1 + bx\left(\frac{x}{2} + y1\right)}{A1 + A2}$

6. Mn = T (jd)

= $Asfy$ (d – $\bar{y}$)

Detemine the ACI design moment capacity (Mn × ϕ) ?
Rectangular



1. Find $\rho = \frac{As}{bd}$

2. Find ρ **(min)** → $\rho = \frac{0.25\sqrt{f'c}}{fy}$, $\rho = \frac{1.4}{fy}$ → Choose the largest

Table (1)

3. Find ρ (max) = $\left(\frac{0.85\,\beta_1 f'_c}{f_y}\right)\left(\frac{0.003}{0.003+(\varepsilon_t)}\right)$ 0.005

(should be)

ρ > ρ (min) **ρ < ρ (max)**

4. T = C → **a =** $\frac{As\,fy}{0.85 f'c\, b}$ → **Mn =** $Asfy$ **(d -** $\frac{a}{2}$ **)**

5. C = $\frac{a}{\beta 1}$

6. $\varepsilon_s = \left(\frac{d-c}{c}\right)\varepsilon_{cu}$ 0.003 → If the answer > 0.005 this is tension controlled

7. Mn × ϕ 0.9 → 10^6 اقسم ع

f_c', MPa	β_1
$17 \le f_c' \le 28$	0.85
$28 < f_c' < 55$	$0.85 - \frac{0.05(f_c' - 28)}{7}$
$f_c' \ge 55$	0.65

design Rectangular beam (no dimension) :

1. Find (h) from table 2

   find b = h/2 (preferably increasing 50 mm)

   find Ow (SW) = Unit weight × b × h = ...kn/m

2. Find Wu = 1.2 D + 1.6 L = 1.2 (ow + dd) + 1.6 L

   find Mu = $\frac{wu\,L^2}{8}$ = ... kn/m ^{2}

3. $\rho_{design} = 0.18 \frac{f'_c}{f_y}$

4. $bd^2 = \frac{M_u}{\phi f_y}\left[\frac{1.7\,f'_c}{\rho(1.7f'_c - \rho f_y)}\right]$ → A GOOD d/b RATIO RANGE FROM 1 ½ TO 2
   CHOOSE DIMENSIONS TO THE NEAREST 5 CM
   THE TOTAL BEAM HEIGHT = D + 70 MM !! WHY
   or 65mm

   find rinsed Ow (SW) new = Unit weight × b(new) × h (new)

5. As = ρ × b(new) × d (new) → Check from table 3

   → d = h-40-10-12.7

6. Analysis

Find

T = C   a = $\frac{As\,fy}{0.85 f'c\, b}$ Mn = Asfy (d - $\frac{a}{2}$)

Mu = $\frac{w\,L^2}{8}$

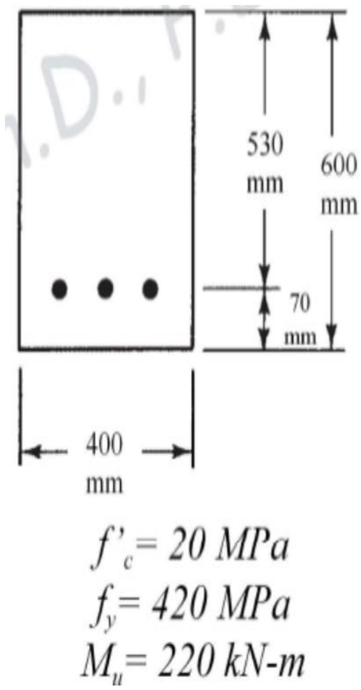
Table (1)

ρ t = $\left(\frac{0.85\,\beta_1 f'_c}{f_y}\right)\left(\frac{0.003}{0.003+(\varepsilon_t)}\right)$ ← 0.005

Mn × ϕ

$\phi Mn \geq Mu$

design Rectangular beam (given dimension) :



1. Find Mn = mu / Ø

2. Find ρ $\rho = \frac{0.85 f'_c}{f_y}\left(1 - \sqrt{1 - \frac{2M_n}{0.85 f'_c\, b\, d^2}}\right)$

3. Find As = ρ × b × d → Check from table 3

4. Check from table 4 (هل مساحة الحديد وعدده بوسع أو لا)

5. Find $a = \frac{As\, fy}{0.85 f'_c\, b}$

6. Find $C = \frac{a}{\beta 1}$

7. Find $\varepsilon_s = \left(\frac{d-c}{c}\right)\varepsilon_{cu}$ ~ 0.003

8. Find **Mn =** $Asfy$ **(d -** $\frac{a}{2}$ **)**

9. Find **Mn × ϕ**

Design one-way slab :

1. Assume b = 1 m

For one-way slab with span up to 3.5 m

$d \approx h - 25mm$

For one-way slab with span over 3.5 m

$d \approx h - 30mm$

find h from table 2

find d →

find Ow (SW) = Unit weight × b × h

find Wu = 1.2 D + 1.6 L = 1.2 (ow + dd) + 1.6 L

find Mu = $\frac{wu\, L^2}{8}$

2. Find $$\rho = \frac{0.85 f'_c}{f_y}\left(1 - \sqrt{1 - \frac{2M_n}{0.85 f'_c\, b\, d^2}}\right)$$

3. As $_{(req)}$ = ρ × b × d

As (min) = 0.0018 bh

اذا كانت As (req) اقل من As (min)
بنوخذ As (min) وبنكمل الحل

4. Choose from table 5
For main steal from As req
For shrinkg from As min

5. Find maxiumm scpacing
Maxiumm spacing should be less than (3h) and 450 mm

$$\frac{380\left(\frac{280}{f_s}\right) - 2.5c_c}{300\left(\frac{280}{f_s}\right)}$$

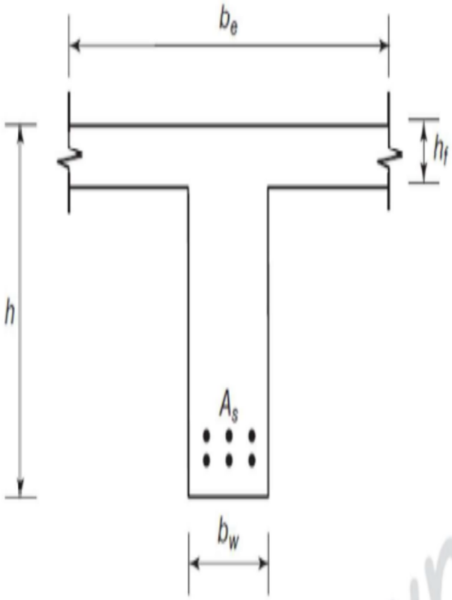
From table 6

f_s as $(2/3)f_y$.

6. maximum spacing shrinkage should be less than (5h) and 450 mm

Analysis of flanged sections :

N.A in the flanged



1. assume a =ß1 , c ≤ hf

2. assume steel yields ($\varepsilon s \geq \varepsilon y$)

3. calc a = $\frac{As\,fy}{0.85\grave{f}c\,b}$

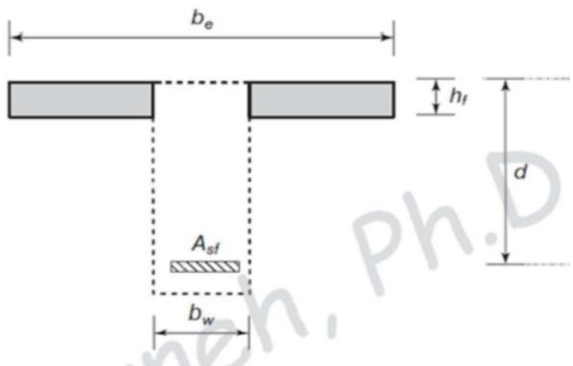
4. if a ≤ hf continue

If not go to case 2 in the web

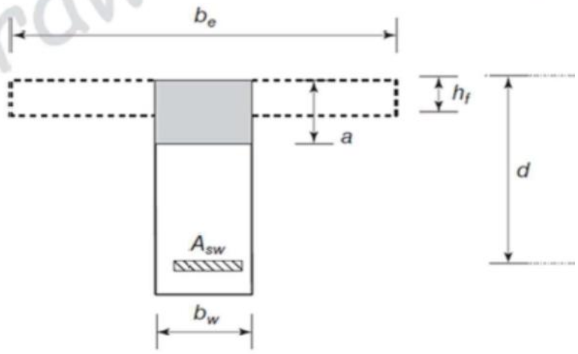
5. confirm that $\varepsilon s \geq \varepsilon y$ and its tension controlled

6. calc Mn = $Asfy$ (d - $\frac{a}{2}$)

N.A in the web : if a > hf



(b) Part 1: Overhanging flange(s) and correspon



1.T = C

2. find Ac …. $Asfy = 0.85f`_c\,Ac$

3. $\frac{Ac - Af}{bw}$ = ??

4. a = $\frac{Ac - Af}{bw}$ + hf …… a > hf

5. C = $\frac{a}{\beta 1}$

6. $\varepsilon s = \left(\frac{d-c}{c}\right) 0.003$

7. $Mn = Ccf\left(d - \frac{hf}{2}\right) + Ccw\left(d - \frac{a}{2}\right)$

$$C_{cf} = 0.85\,f'_c\,(b_e - b_w)h_f$$

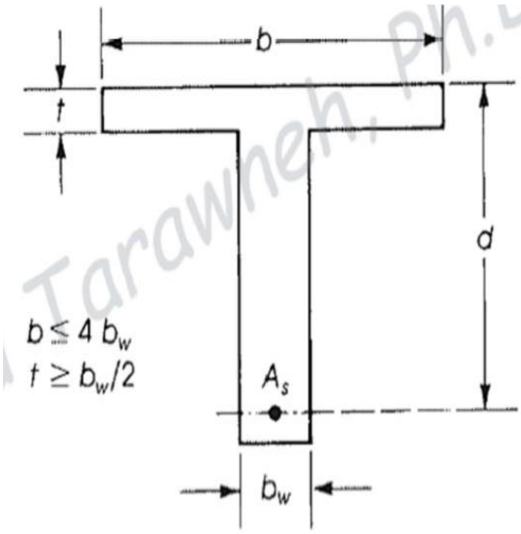
$$C_{cw} = 0.85\,f'_c\,b_w a$$

8. ρ = $\frac{0.25\sqrt{\grave{f}c}}{fy}$

ρ = $\frac{1.4}{fy}$

ρ min = $\frac{As}{bwd}$

Design of T- sections



1. $M_{n,reqd} = Mu/\phi$

2. $$\rho_{reqd} = \frac{0.85f'_c}{f_y}\left(1 - \sqrt{1 - \frac{2M_n}{0.85f'_c bd^2}}\right)$$

3. $$a = \frac{\rho\, d\, f_y}{0.85f'_c}$$ → Check if $a \leq h_f$
   - → **Yes** (rectangular): As req = ρ (design) * bf * d
   - → **No** (T - sec) – continues the steps

4. $$A_{sf} = \frac{0.85f'_c(b - b_w)h_f}{f_y}$$

5. $$M_{nf} = A_{sf} f_y \left(d - \frac{h_f}{2}\right)$$

6. $$M_{nw} = \frac{Mu - \phi M_{nf}}{\phi}$$

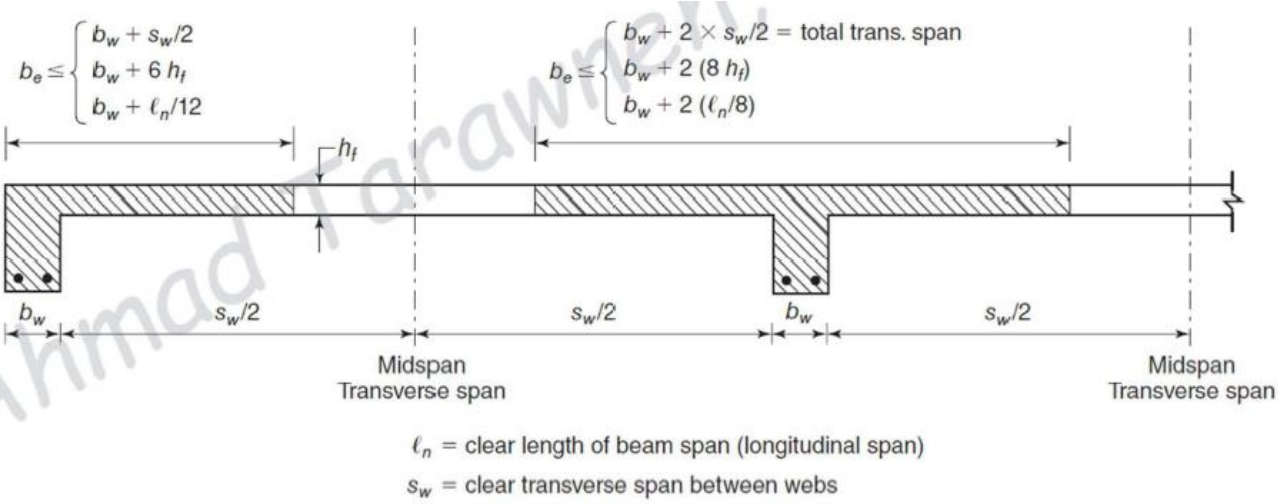
7. $$\rho_{w,reqd} = \frac{0.85f'_c}{f_y}\left(1 - \sqrt{1 - \frac{2M_{nw}}{0.85f'_c b_w d^2}}\right)$$

8. $A_{sw} = \rho_{w,reqd}\, b_w\, d$

9. $A_s = A_{sf} + A_{sw}$

10. Analyses

Design of T- sections



1. find Ow (SW) = Unit weight × b × h = ….kn/m
2. Find Wu = 1.2 D + 1.6 L = 1.2 (ow + dd) + 1.6 L
3. find Mu = $\frac{wu\,L^2}{8}$ = …. kn/m ^{2}
4. Find $M_{n,reqd} = Mu/\ \phi$
5. Find be from chart
6. Find ρf req $\rho = \frac{0.85f'_c}{f_y}\left(1 - \sqrt{1 - \frac{2M_n}{0.85f'_c\, b_e d^2}}\right)$
7. Find a $\boxed{a = \frac{\rho\, d\, f_y}{0.85f'_c}}$

8. $$A_{sf} = \frac{0.85f'_c(b - b_w)h_f}{f_y}$$

9. $$M_{nf} = A_{sf} f_y \left(d - \frac{h_f}{2}\right)$$

10. $$M_{nw} = \frac{Mu - \phi M_{nf}}{\phi}$$

11. $$\rho_{w,reqd} = \frac{0.85f'_c}{f_y}\left(1 - \sqrt{1 - \frac{2M_{nw}}{0.85f'_c b_w d^2}}\right)$$

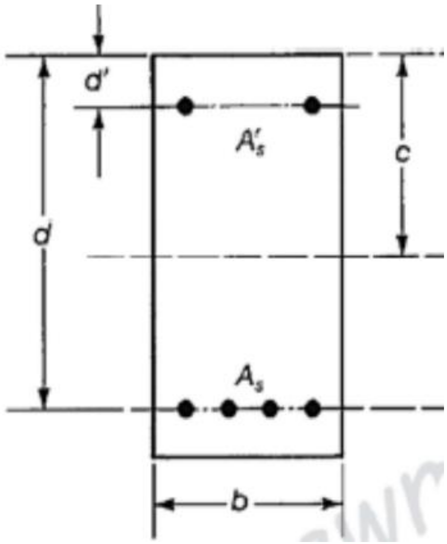
12. $$A_{sw} = \rho_{w,reqd}\, b_w\, d$$

13. $$A_s = A_{sf} + A_{sw}$$

14. analises

Doubly – reinforced sections

Determine the flexural strength



case 1 : *if $\varepsilon'_s > 0.002$ then compression steel yielded*

1. Assume T , C yield

Cc + Cs = T

2. find $a = \frac{(A_s - A'_s)\, f_y}{0.85\, f'_c\, b}$

3. Find C = $\frac{a}{\beta 1}$

4. find $\varepsilon'_s = 0.003\left(\frac{c-d'}{c}\right)$ → If > 0.002 compute steps

5. find $\varepsilon_s = 0.003\left(\frac{d-c}{c}\right)$

6. $M_n = C_c\left(d-\frac{a}{2}\right) + C_s(d-d')$

$M_n = 0.85\, f'_c ab\left(d-\frac{a}{2}\right) + A'_s f_y(d-d')$

7. Mn × ϕ

Case 2 : If $\varepsilon'_s < 0.002$

1. Assume T , C yield

Cc + Cs = T

2. find $a = \frac{(A_s - A'_s)\, f_y}{0.85\, f'_c\, b}$

3. Find C = $\frac{a}{\beta 1}$

4. find $\varepsilon'_s = 0.003\left(\frac{c-d'}{c}\right)$ → If < 0.002

5. Use the solver to find C

$0.85\, f'_c ab + A'_s E_s(0.003)\left(\frac{c-d'}{c}\right) = A_s f_y$ → a= c β1

6. $M_n = C_c\left(d-\frac{a}{2}\right) + C_s(d-d')$

$M_n = 0.85\, f'_c ab\left(d-\frac{a}{2}\right) + A'_s E_s(0.003)\left(\frac{c-d'}{c}\right)(d-d')$

7. $\varepsilon_s = 0.003\left(\frac{d-c}{c}\right)$ → C from solver

8. **Mn × ϕ**

Design doubly – reinforced sections (if ε'_s > 0.002)

1. find $\rho_{max} = \left(\frac{0.85\,\beta_1 f'_c}{f_y}\right)\left(\frac{0.003}{0.003 + (\varepsilon_t)}\right)$ ← 0.005 for $f_y = 420\ MPa$

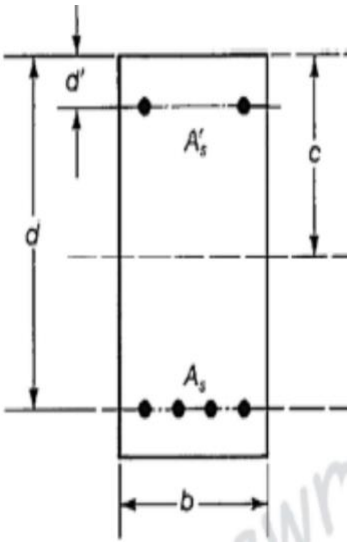
2. find $a = \frac{\rho_{max}\, d\, f_y}{0.85 f'_c}$

3. $\phi M_n = \phi \rho_{max} bd\, f_y \left(d - \frac{a}{2}\right)$ →

If $\phi M_n > M_u$ then compression reinforcement is not needed.

If $\phi M_n < M_u$ then compression reinforcement is needed to carry the extra M_u.

4. $c = \frac{a}{\beta_1}$



5. $\varepsilon'_s = 0.003\left(\frac{c - d'}{c}\right)$ → Assume d' =70 mm if not given

6. $M_{n,2} = \frac{Mu - \phi M_{n1}}{\phi}$

7. $M_{n,2} = A'_s f_y (d - d')$

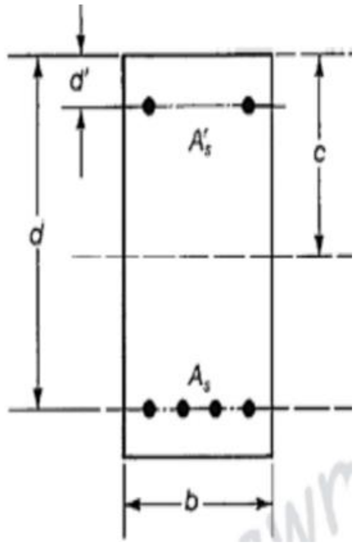
$A'_s = \frac{M_{n,2}}{f_y (d - d')}$ → Remember this amount of reinforcement should be added in both sides!

8. As= ρ_{max} bd + A's

9. chose steal bars & analises

Design doubly – reinforced sections (if $\varepsilon'_s < 0.002$)

1. find $$\rho_{max} = \left(\frac{0.85\,\beta_1 f'_c}{f_y}\right)\left(\frac{0.003}{0.003 + (\varepsilon_t)}\right)$$ $0.005\ for\ f_y = 420\ MPa$



2. find $$a = \frac{\rho_{max}\, d\, f_y}{0.85 f'_c}$$

3. $$\phi M_n = \phi \rho_{max} b d\, f_y \left(d - \frac{a}{2}\right)$$

4. $$c = \frac{a}{\beta_1}$$

5. $$M_{n,2} = \frac{Mu - \phi M_{n1}}{\phi}$$

6. $$\varepsilon'_s = 0.003\left(\frac{c - d'}{c}\right)$$ → Assume d' =70 mm if not given

7. $$f'_s = E\varepsilon'_s$$

8. for top steal $$A'_s = \frac{M_{n,2}}{f'_s(d - d')}$$

9. for additional bottom steal $$A_{s2} = \frac{A'_s\, f'_s}{f_y}$$

Then $As = \rho_{max}\, bd + A'_s$

10. chose steel bars and draw section

11. analyses