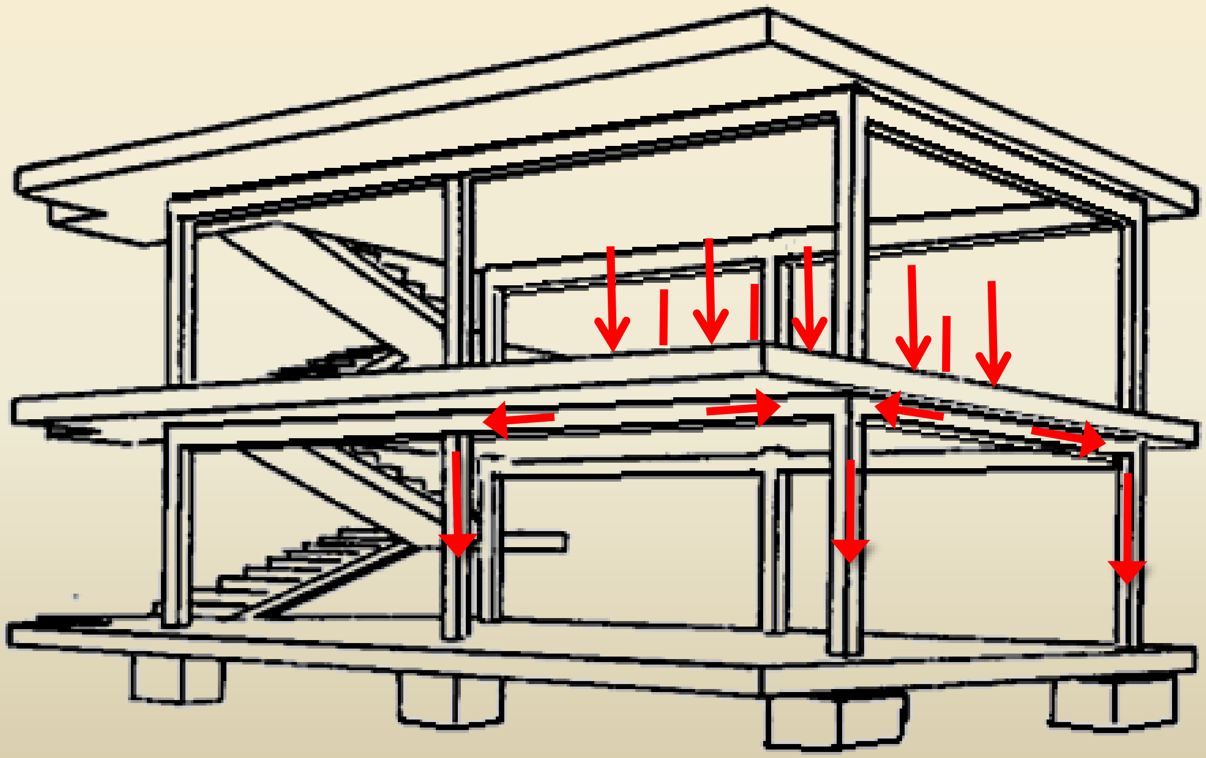
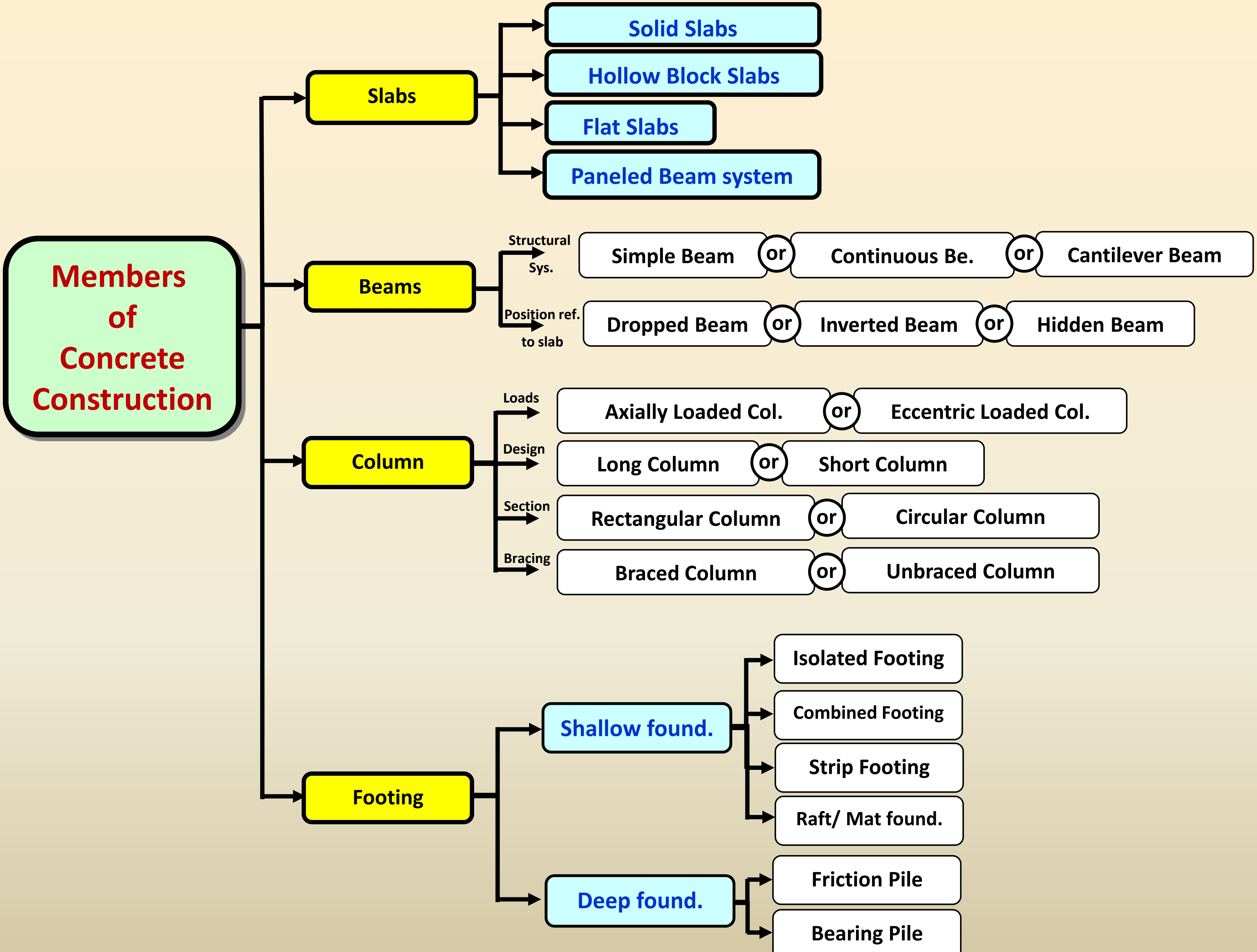
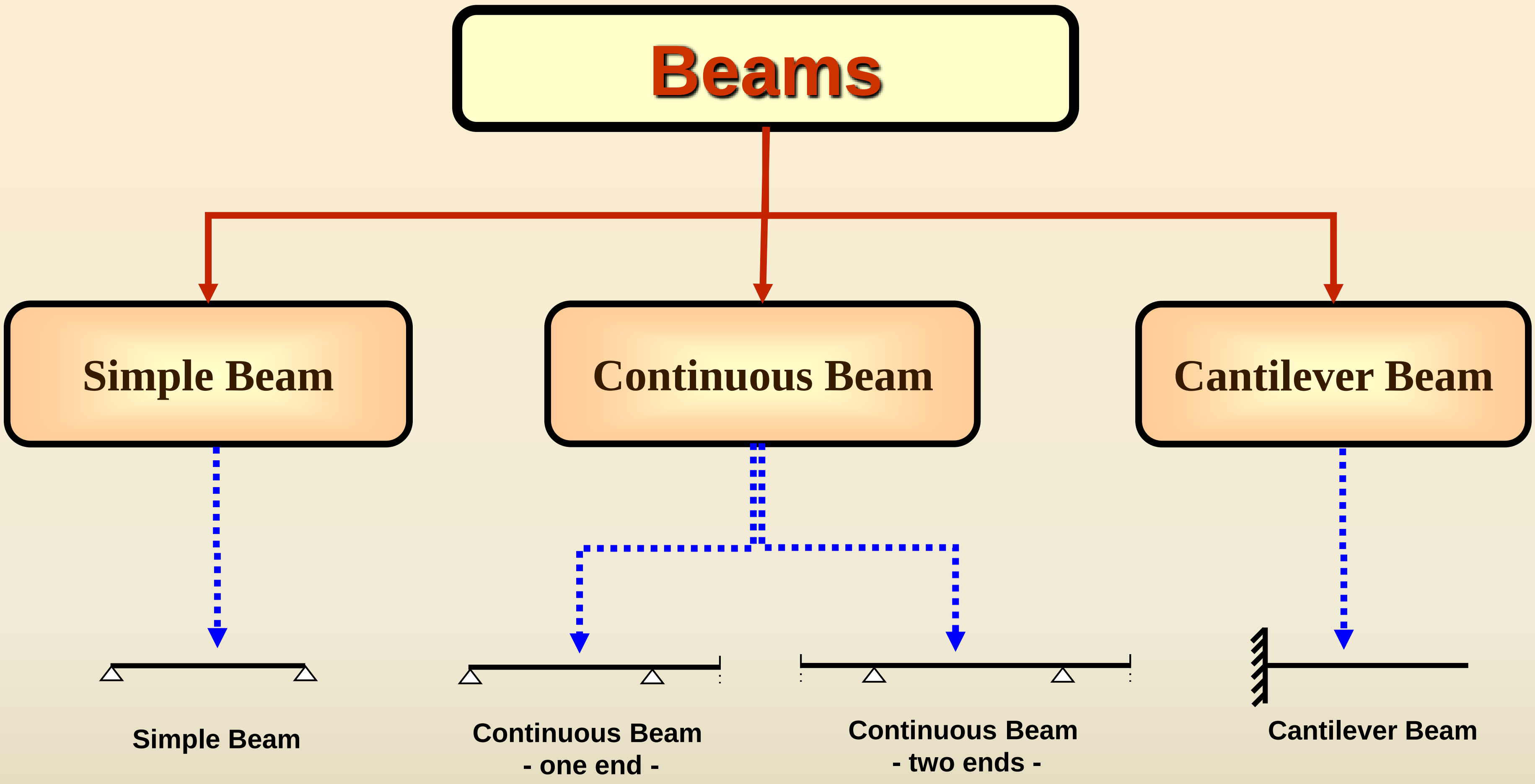
Beams

هى الاعضاء الانشائية المسئولة عن حمل وتثبيت البلاطات والحوائط
ونقل احمالها الى الاعمدة التى تنقلها بدورها الى الاساسات




Members of Concrete Construction
Slabs
Solid Slabs
Hollow Block Slabs
Flat Slabs
Paneled Beam system
Beams
Structural Sys.
Simple Beam
or
Continuous Be.
or
Cantilever Beam
Position ref. to slab
Dropped Beam
or
Inverted Beam
or
Hidden Beam
Column
Loads
Axially Loaded Col.
or
Eccentric Loaded Col.
Design
Long Column
or
Short Column
Section
Rectangular Column
or
Circular Column
Bracing
Braced Column
or
Unbraced Column
Footing
Shallow found.
Isolated Footing
Combined Footing
Strip Footing
Raft/ Mat found.
Deep found.
Friction Pile
Bearing Pile


Beams
Simple Beam
Continuous Beam
Cantilever Beam
Simple Beam
Continuous Beam
- one end -
Continuous Beam
- two ends -
Cantilever Beam

قطاعات الكمرات
Cross Sections of Beams

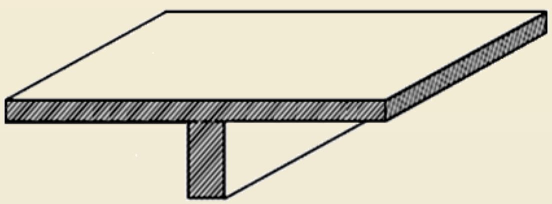
Beams

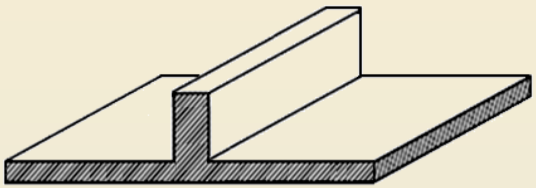
Referring to its position comparing to slabs

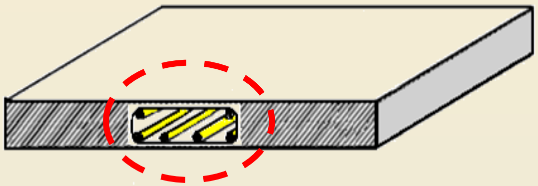
Dropped Beam

Inverted Beam

Hidden Beam







هى كمرة عمقها لاسفل

هى كمرة ترتفع لاعلى

هى كمرة تنفذ بنفس سمك البلاطة
يصمم لها العرض b والتسليح

لجميع الكمرات يتم حساب الاحمال لها وتصميمها ورسم تفاصيل التسليح الرئيسى والثانوى ووضعية الكانات لها بنفس الكيفية والطريقة
الفرق الوحيد هو: وضعية كل منها بالنسبة للبلاطة slab ووضع تسليح البلاطة بالنسبة لها

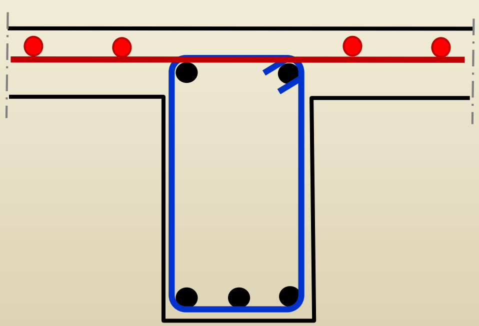
Beams

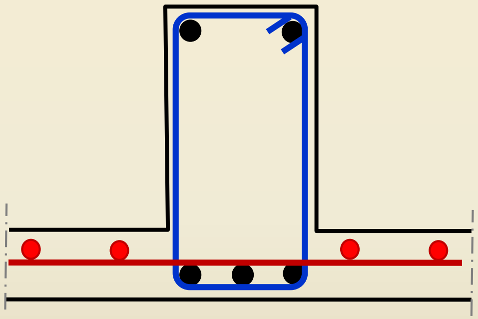
Referring to its position comparing to slabs

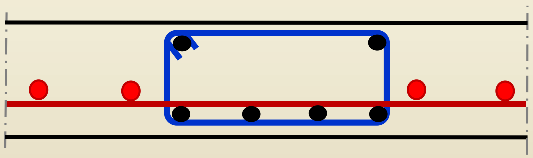
Dropped Beam

Inverted Beam

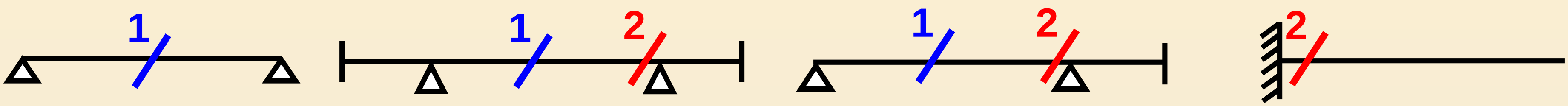
Hidden Beam

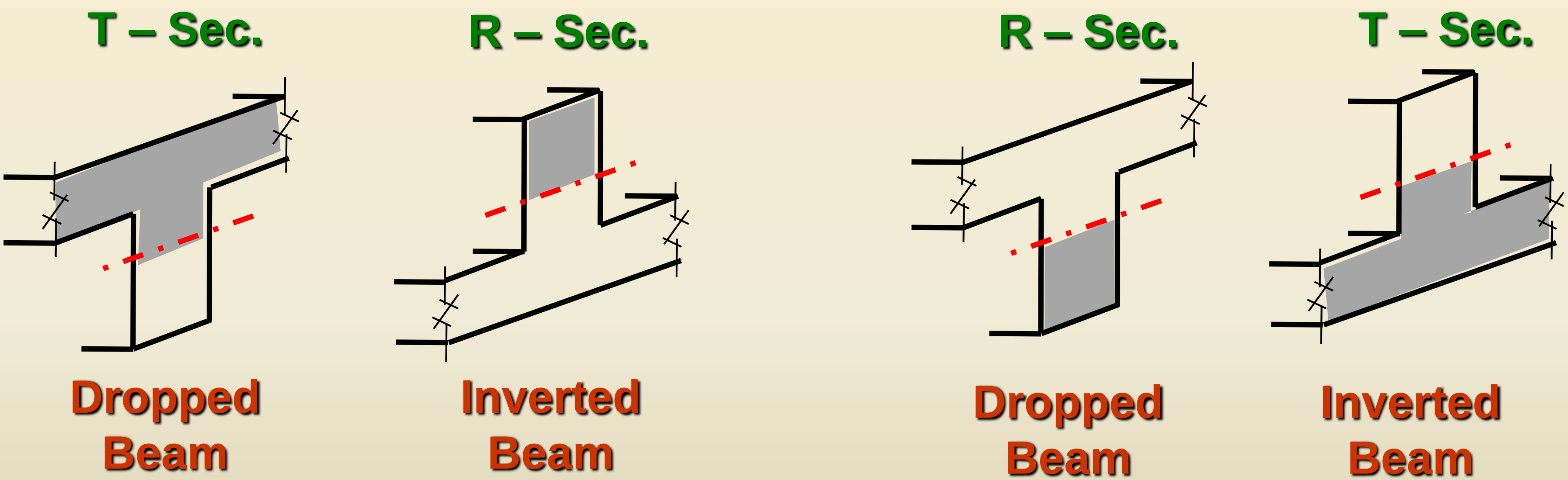






Intermediate Beam

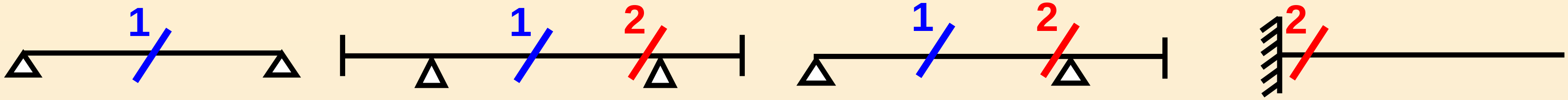


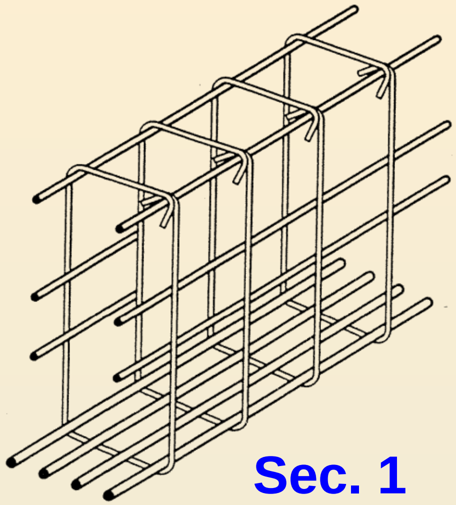


Sec. 1

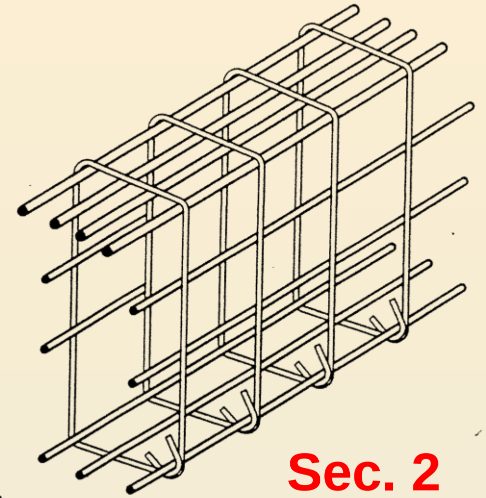
Sec. 2

Internal Beam

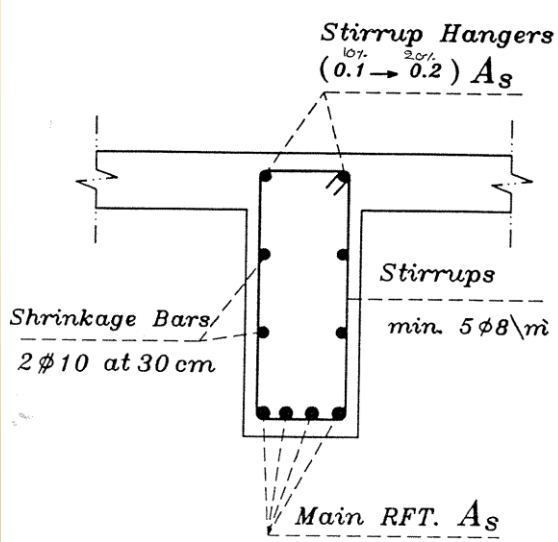




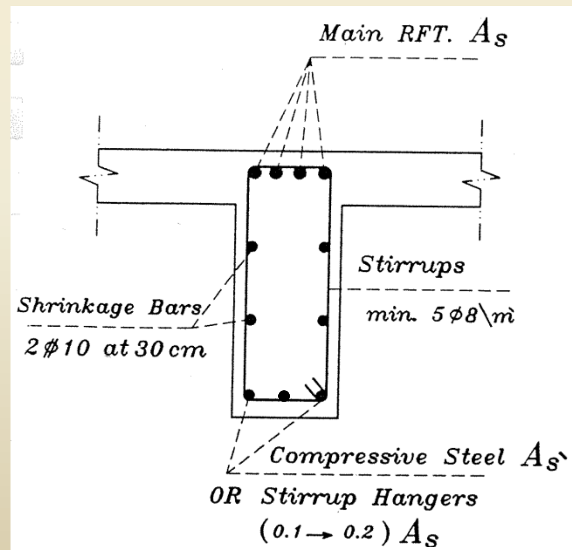
Sec. 1



Sec. 2

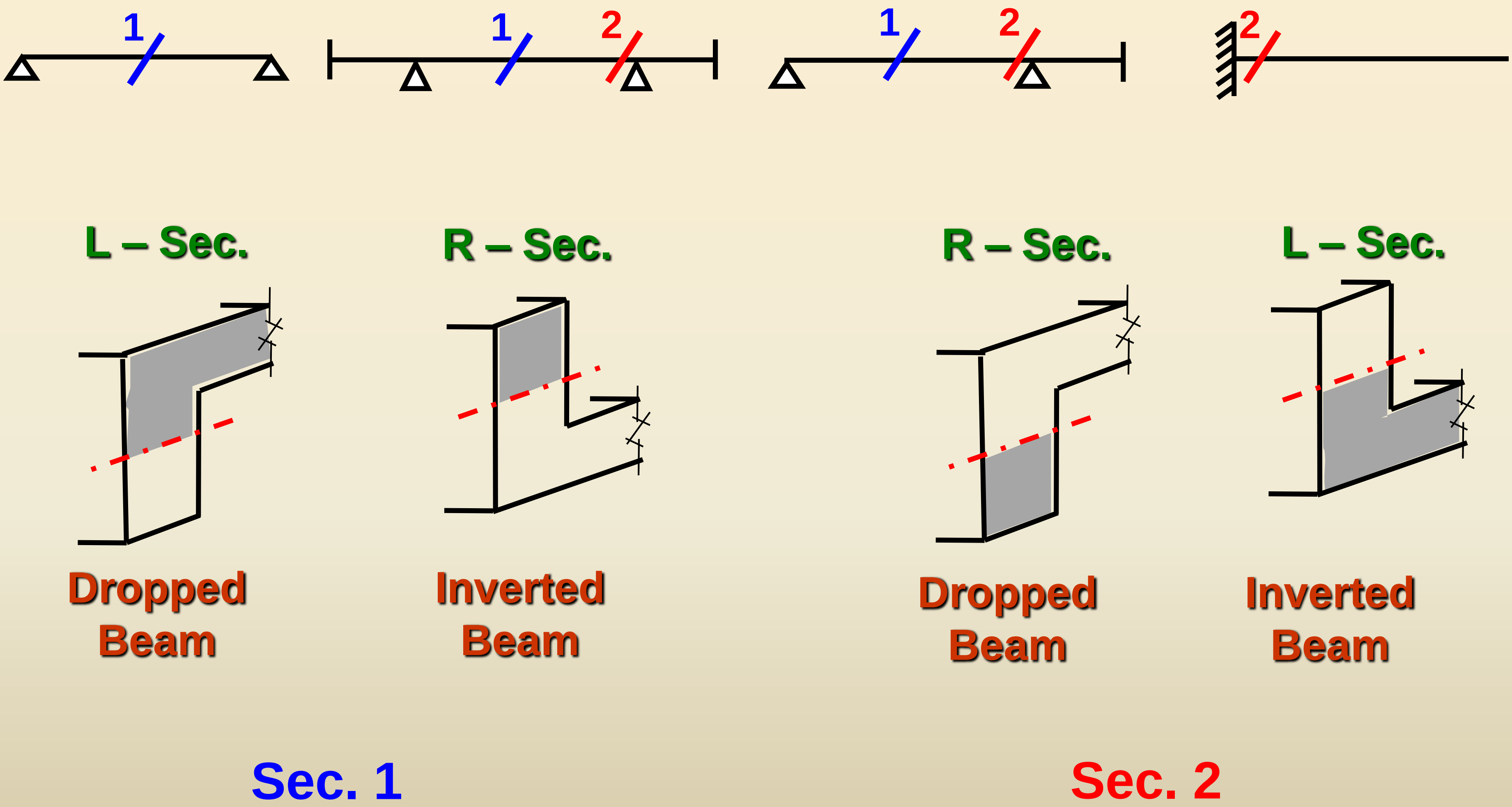


(T – Sec.)

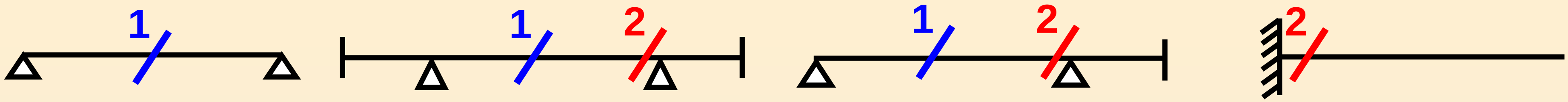


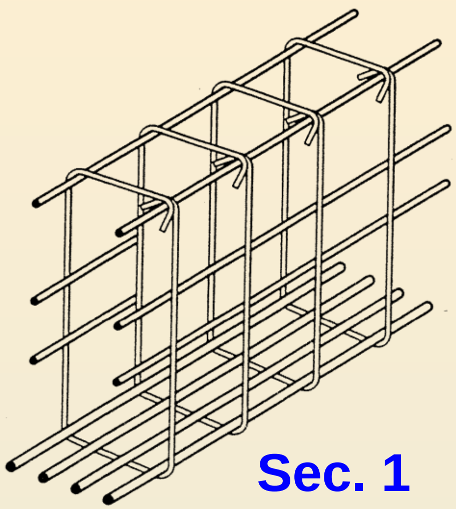
(R – Sec.)

Edge Beam

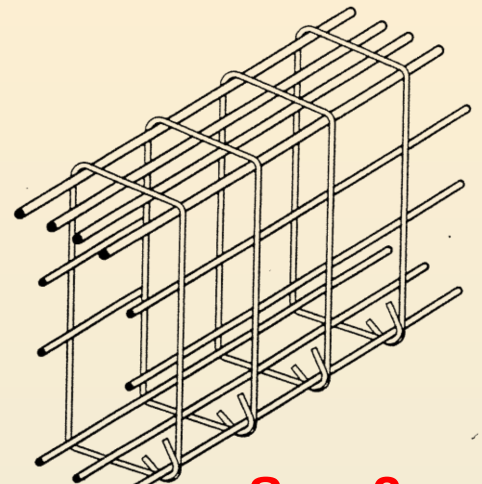

1
1
2
1
2
2
L – Sec.
R – Sec.
R – Sec.
L – Sec.
Dropped Beam
Inverted Beam
Dropped Beam
Inverted Beam
Sec. 1
Sec. 2

Edge Beam

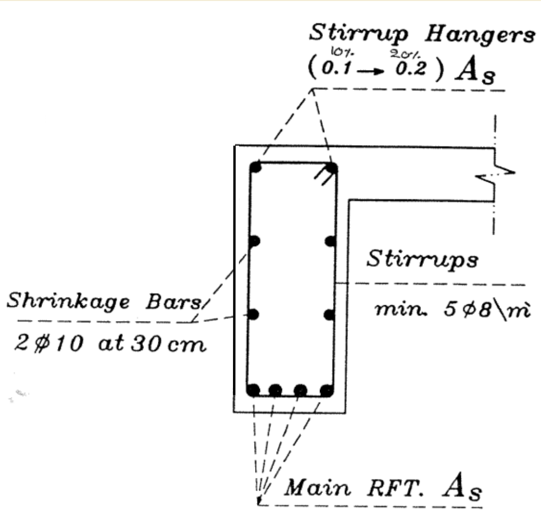




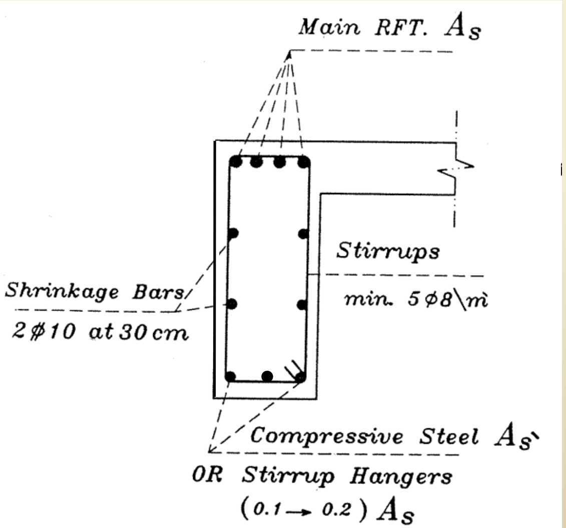
Sec. 1



Sec. 2

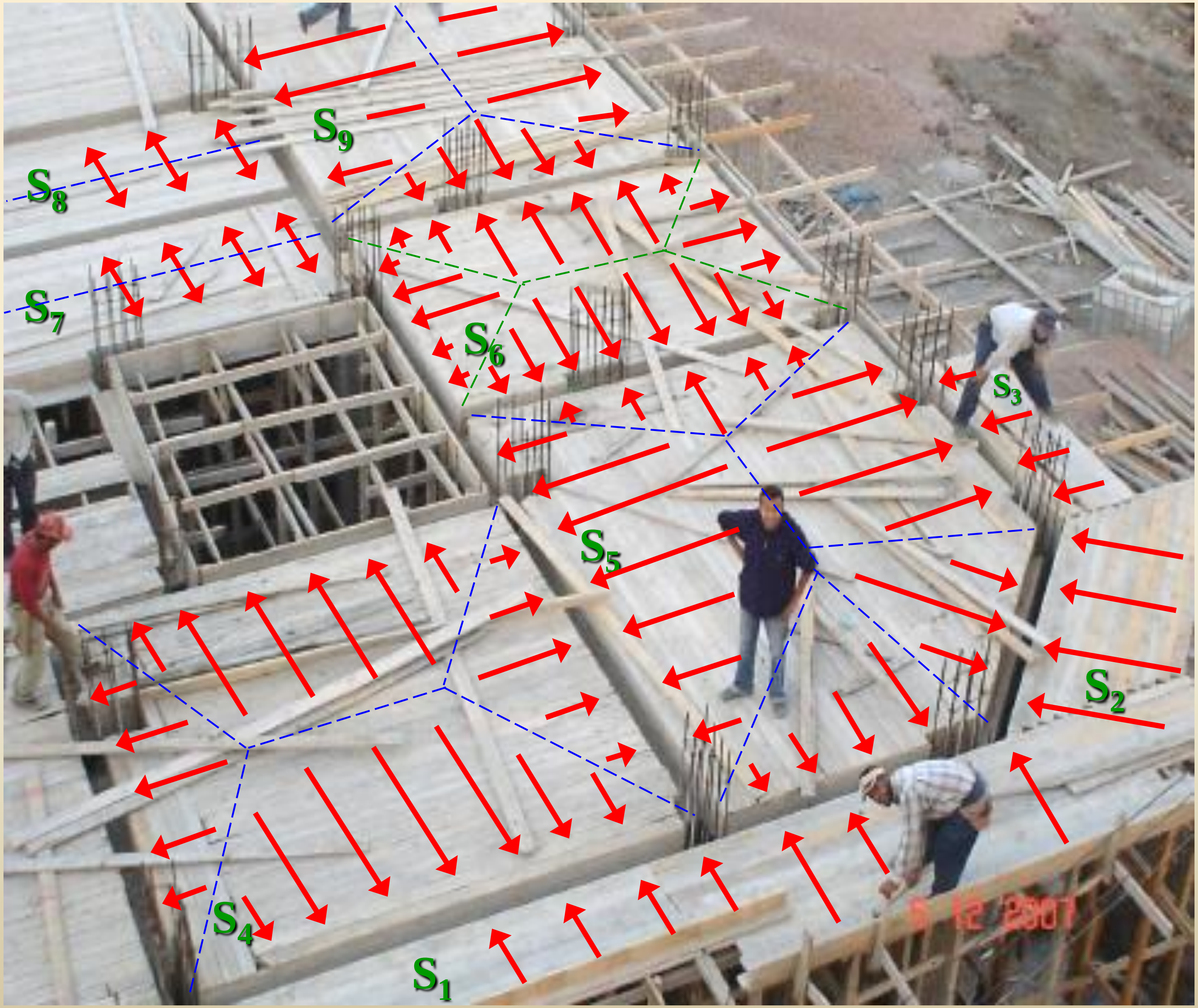


(L – Sec.)

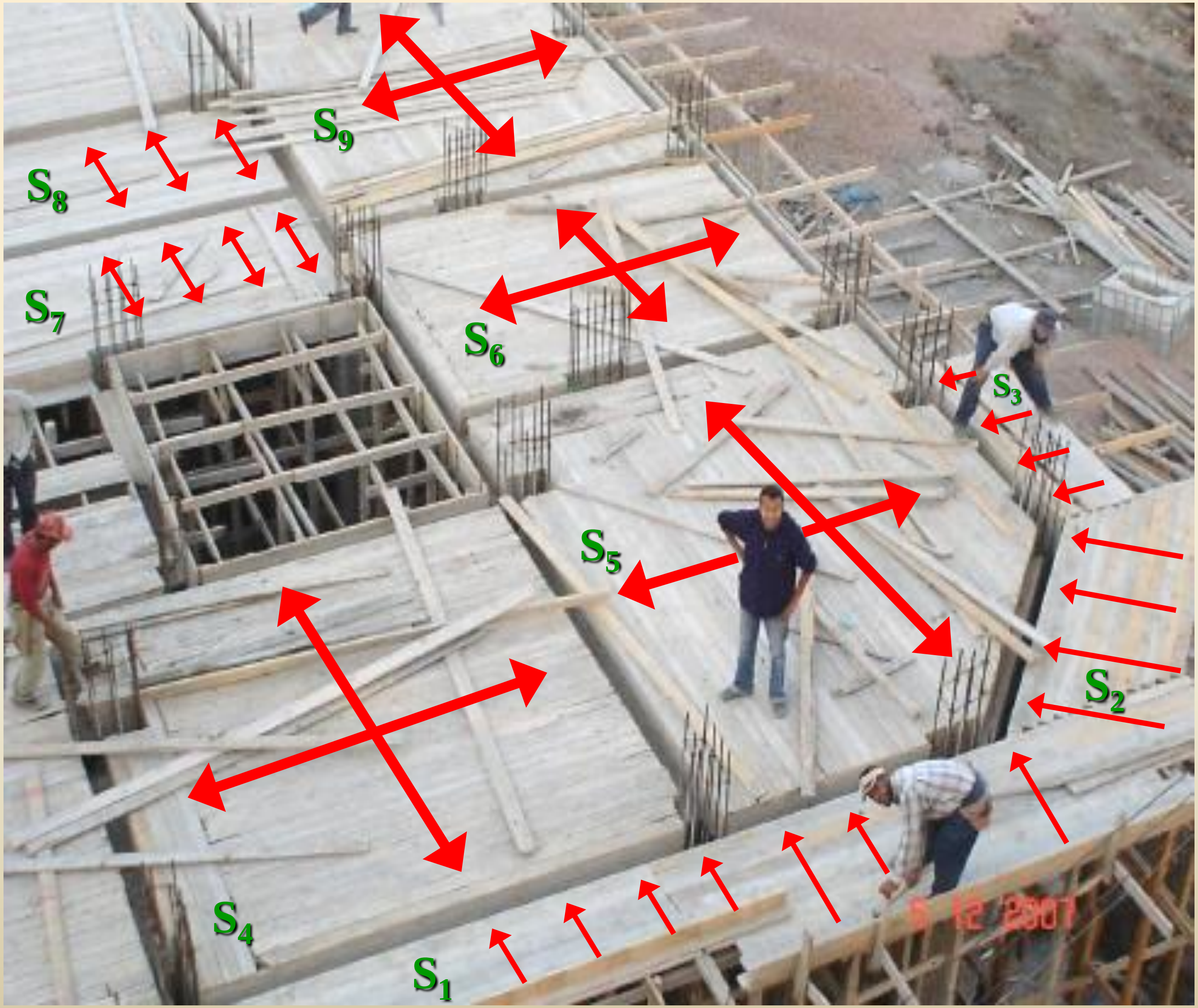


(R – Sec.)

توزيع احمال البلاطات على الكمرات
Load Distribution

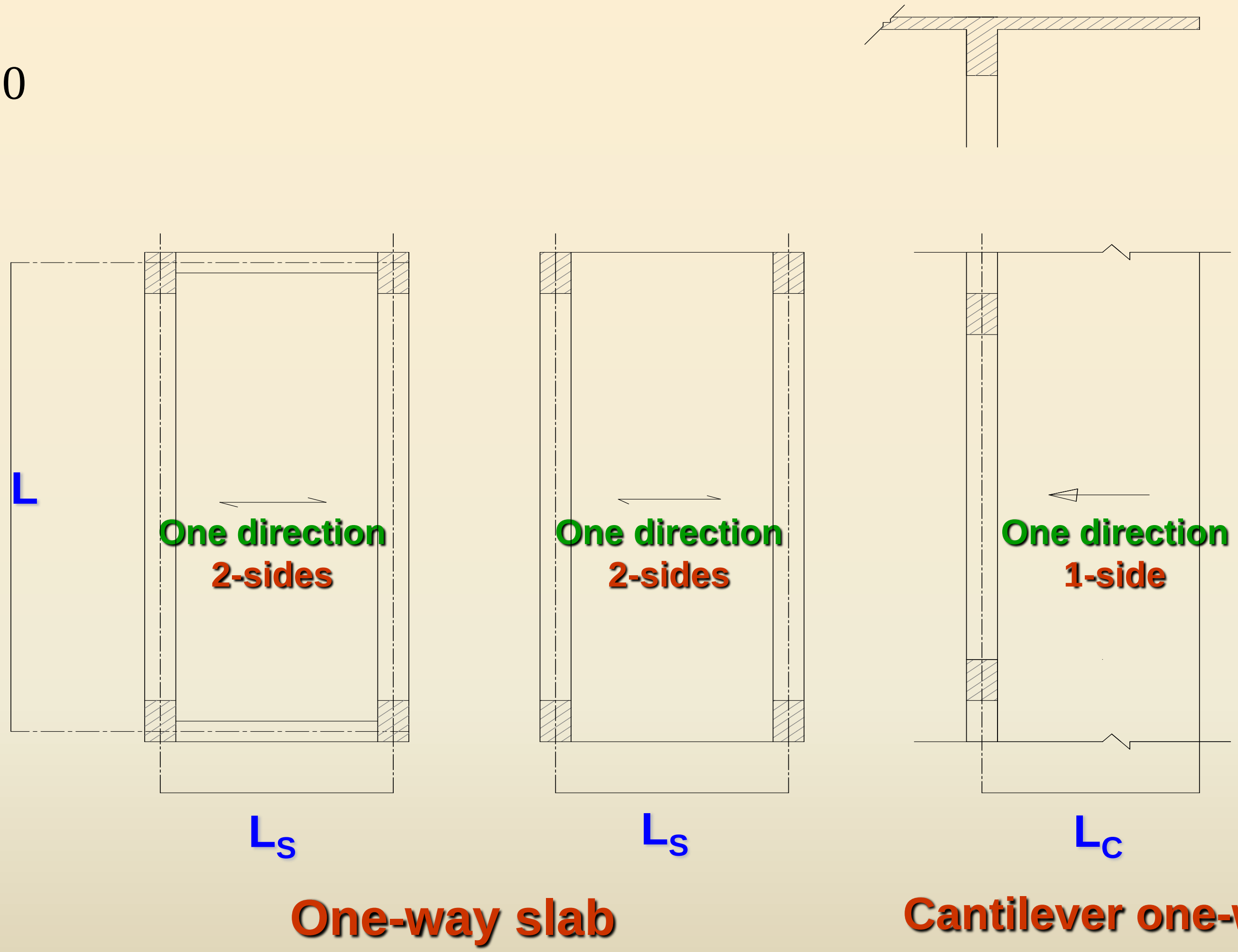


توزيع احمال البلاطات المصمتة



Load Distribution from one-way slab

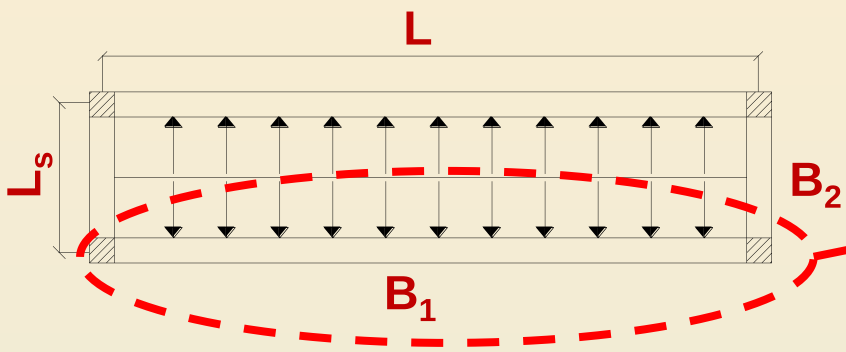
$$\frac{L}{L_S} \geq 2.0$$



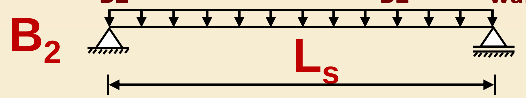
Different Cases for One-way Slab

Load Distribution from one-way slab

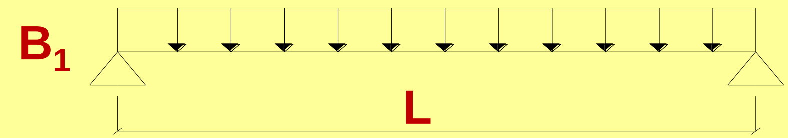
One-way S. Slab $\frac{L}{L_S} \geq 2.00$

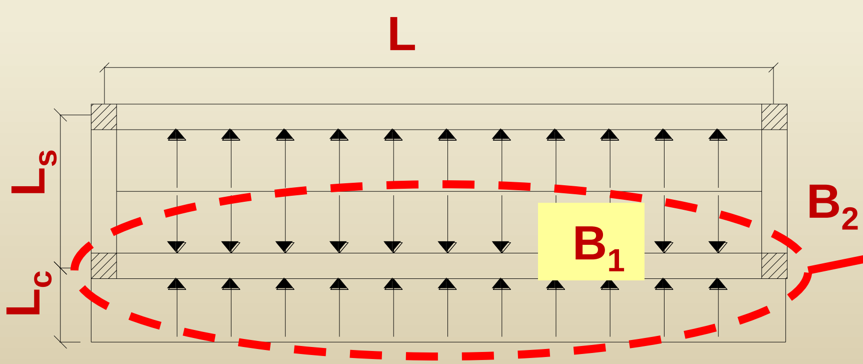


$W_{B2} = 1.4\,(O.\,Wt_{B2} + W_{wall})$ t/m'



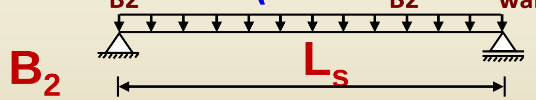
$$W_{B1} = \left[Wu_S \text{ x } \frac{L_S}{2}\right] + \left(1.4 \text{ x} \left[O.Wt_{B1} + W_{Wall}\right]\right)$$



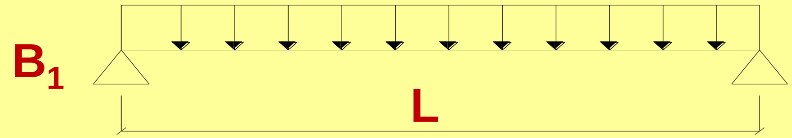


Cantilever Slab

$W_{B2} = 1.4\,(O.\,Wt_{B2} + W_{wall})$ t/m'

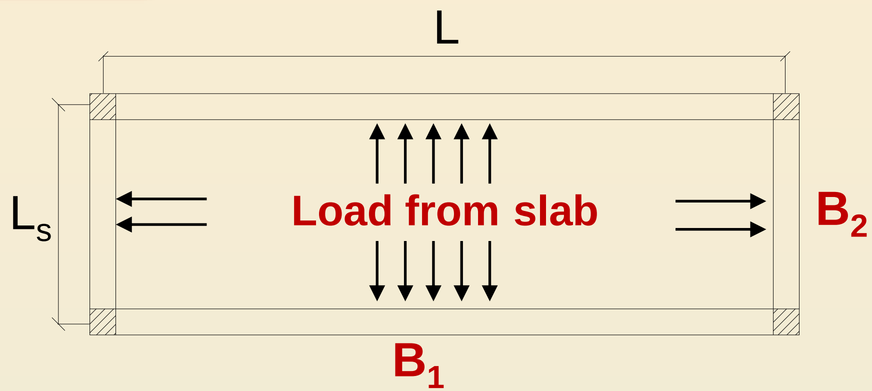


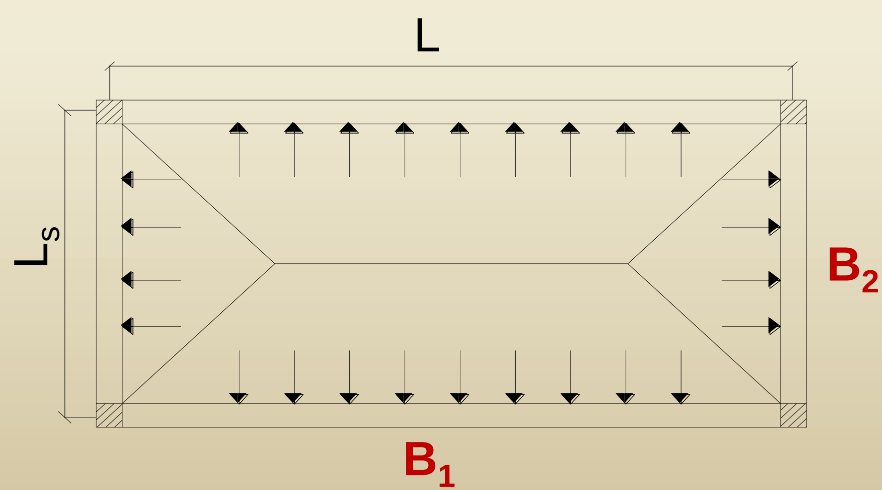
$$W_{B1} = \left[Wu_S \text{ x } \frac{L_S}{2}\right] + \left[Wu_S \text{ x } L_C\right] + \left(1.4 \text{ x} \left[O.Wt_{B1} + + W_{Wall}\right]\right)$$



Load Distribution from two-way slab

Two-way S. Slab $\frac{L}{L_s} < 2.00$





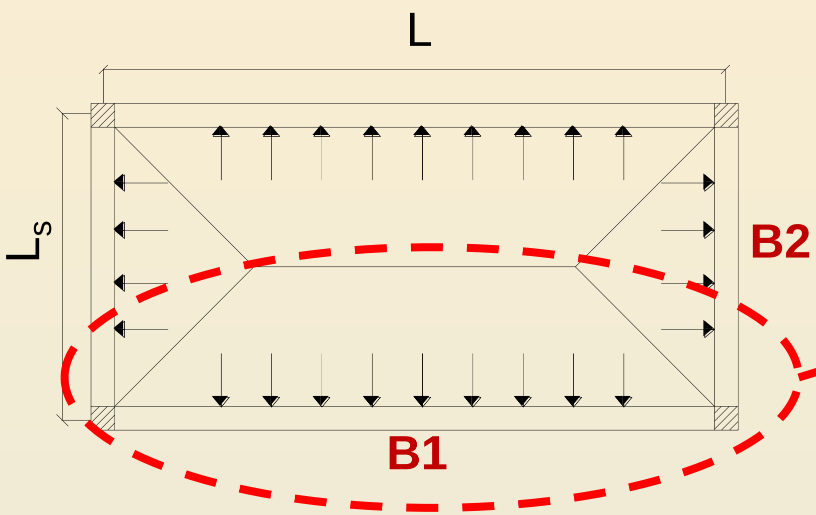
Load Distribution from two-way slab

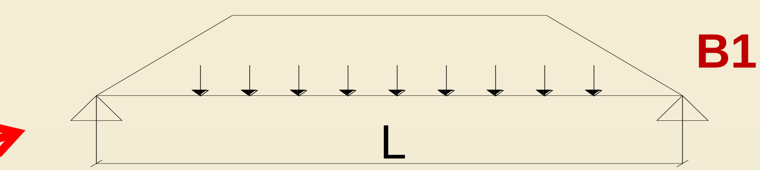
Two-way S. Slab $\frac{L}{L_s} < 2.00$

$$\beta = C_a = \left(1 - \frac{1}{2}\left(L_s / L\right)\right) \text{ for Shear}$$

$$\alpha = C_e = \left(1 - \frac{1}{3}\left(L_s / L\right)^2\right) \text{ for Moment}$$

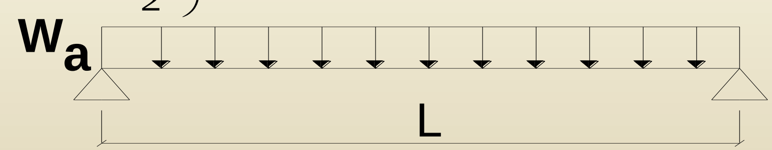
for Trapezoidal Load only





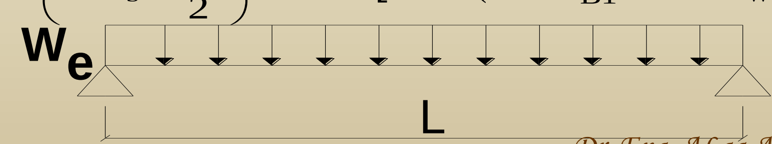
$$Wa_{B1} = \left(Wu_s \times \frac{L_s}{2}\right) \times Ca + \left[1.4 \times \left(O.Wt_{B1} + O.Wt_{wall}\right)\right] \ t/m'$$

Equivalent load for Shear (W_a or W_β)



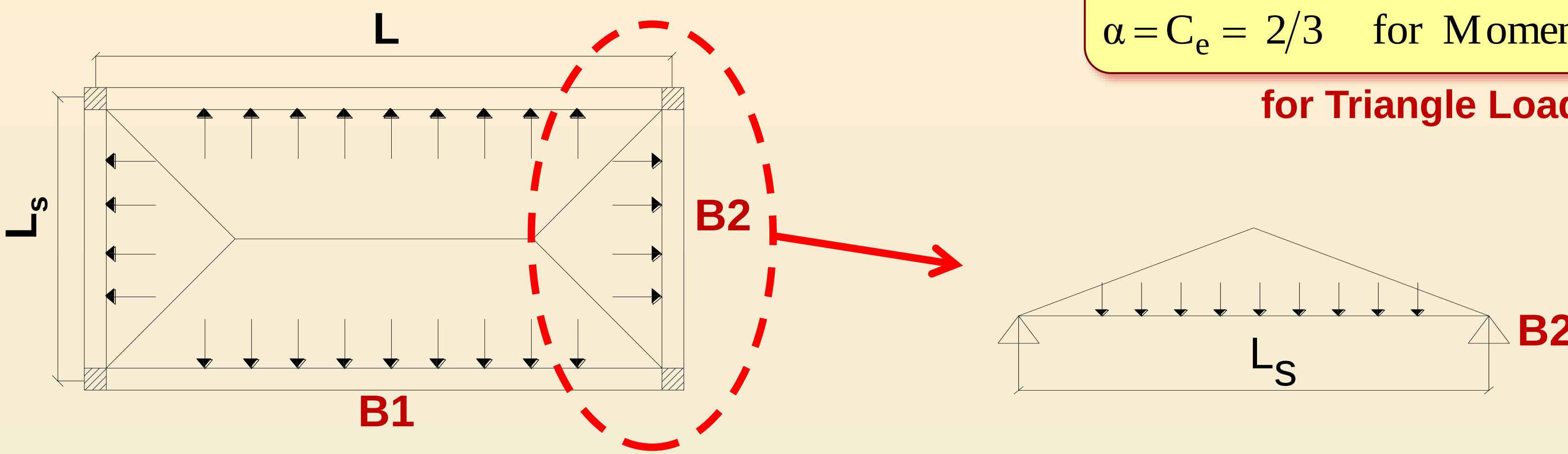
$$We_{B1} = \left(Wu_s \times \frac{L_s}{2}\right) \times Ce + \left[1.4 \times \left(O.Wt_{B1} + O.Wt_{wall}\right)\right] \ t/m'$$

Equivalent load for Moment (W_e or W_α)



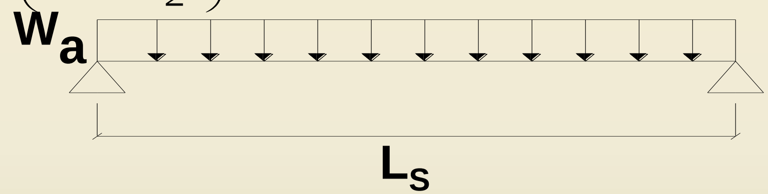
$$\beta = C_a = 1/2 \quad \text{for Shear}$$
$$\alpha = C_e = 2/3 \quad \text{for Moment}$$

for Triangle Load only



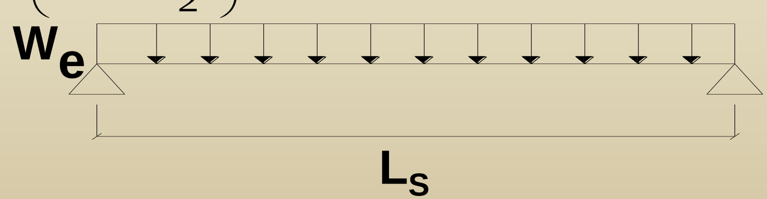
$$Wa_{B2} = \left(Wu_s x \frac{L_s}{2} \right) x\, Ca + \left[1.4\, x \left(O.Wt_{B2} + O.Wt_{wall} \right) \right] \ \text{t/m}^{\backslash}$$

Equivalent load for Shear (W_a or W_β)



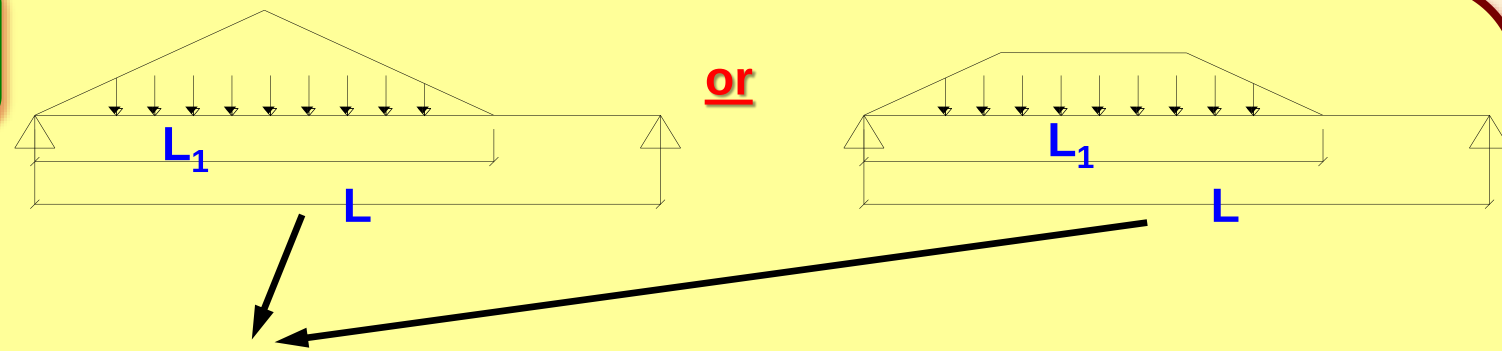
$$We_{B2} = \left(Wu_s x \frac{L_s}{2} \right) x\, Ce + \left[1.4\, x \left(O.Wt_{B2} + O.Wt_{wall} \right) \right] \text{t/m}^{\backslash}$$

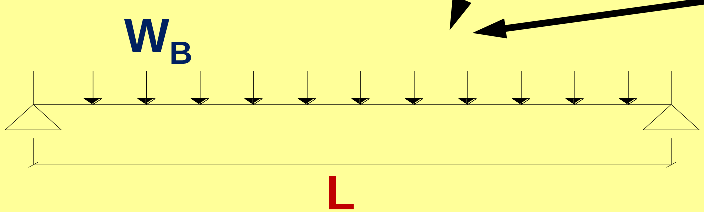
Equivalent load f or Moment (W_e or W_α)



Special Cases of Loading

1. $L_1 > \frac{L}{2}$

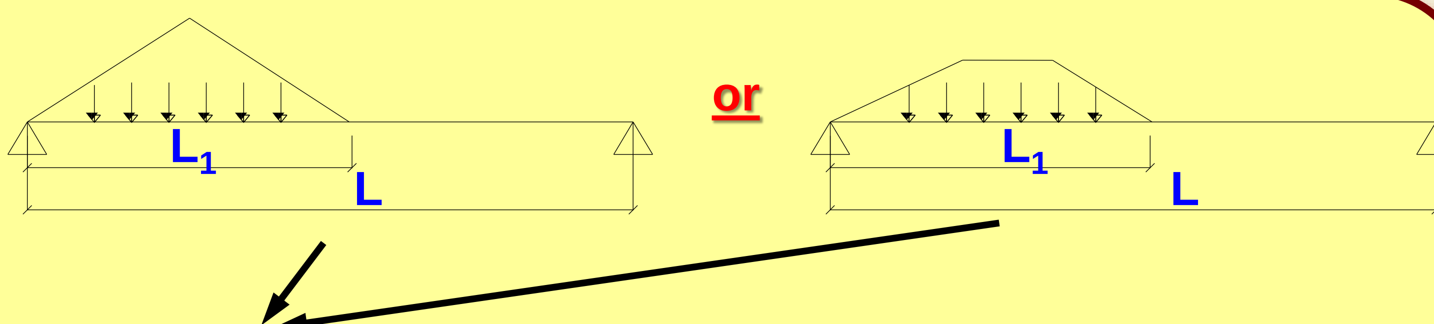


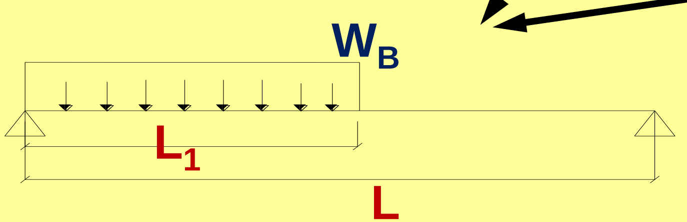


$$W_B = \text{Load for Moment} = \text{Load for Shear}$$

$$= \left(\frac{Area}{L} \text{ x } Wu_s\right) + \left[1.4 \text{ x } \left(O.Wt_B + W_{wall}\right)\right]$$

2. $L_1 < \frac{L}{2}$

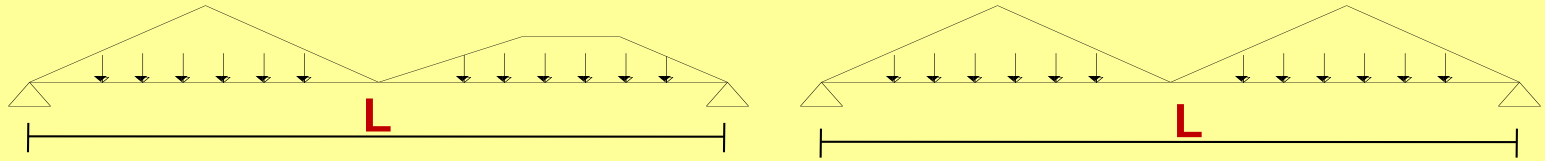




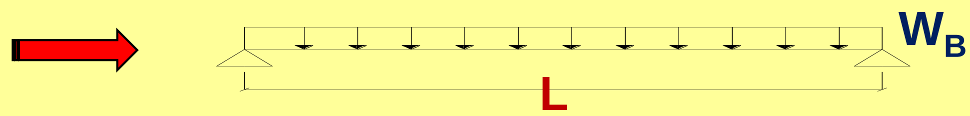
$$W_B = \text{Load for Moment} = \text{Load for Shear}$$

$$= \left(\frac{Area}{L_1} \text{ x } Wu_s\right) + \left[1.4 \text{ x } \left(O.Wt_B + W_{wall}\right)\right]$$

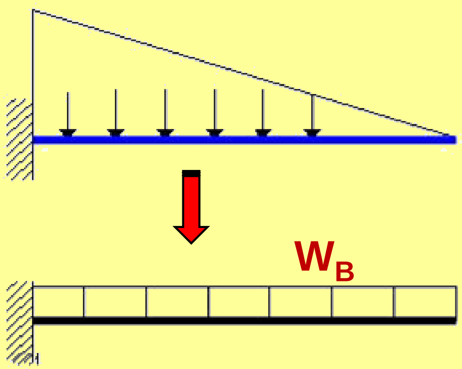
3.



$$W_B = \text{Load for Moment} = \text{Load for Shear} = \frac{\sum \text{Area}}{\text{Span}} \times Wu_s + \left[1.4 \times \left(O.Wt_{beam} + W_{wall}\right)\right]$$

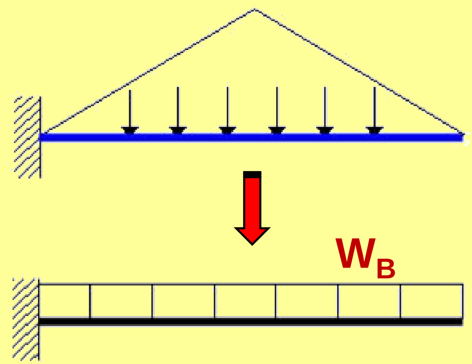


4.



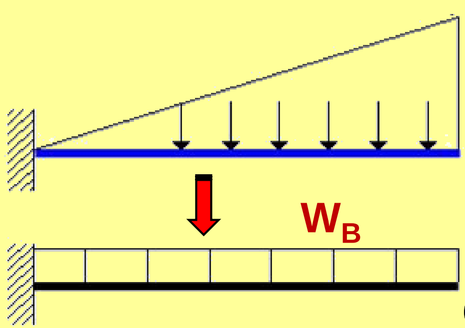
$C_a = 1/2$

$C_e = 1/3$



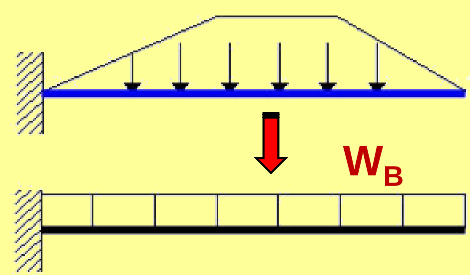
$C_a = 1/2$

$C_e = 1/2$



$C_a = 1/2$

$C_e = 2/3$



$$\frac{\text{Area}}{\text{Span}} \times Wu_s$$

الكمرات الرئيسية والثانوية

Main and Secondary Beams

Beams

Main Beam

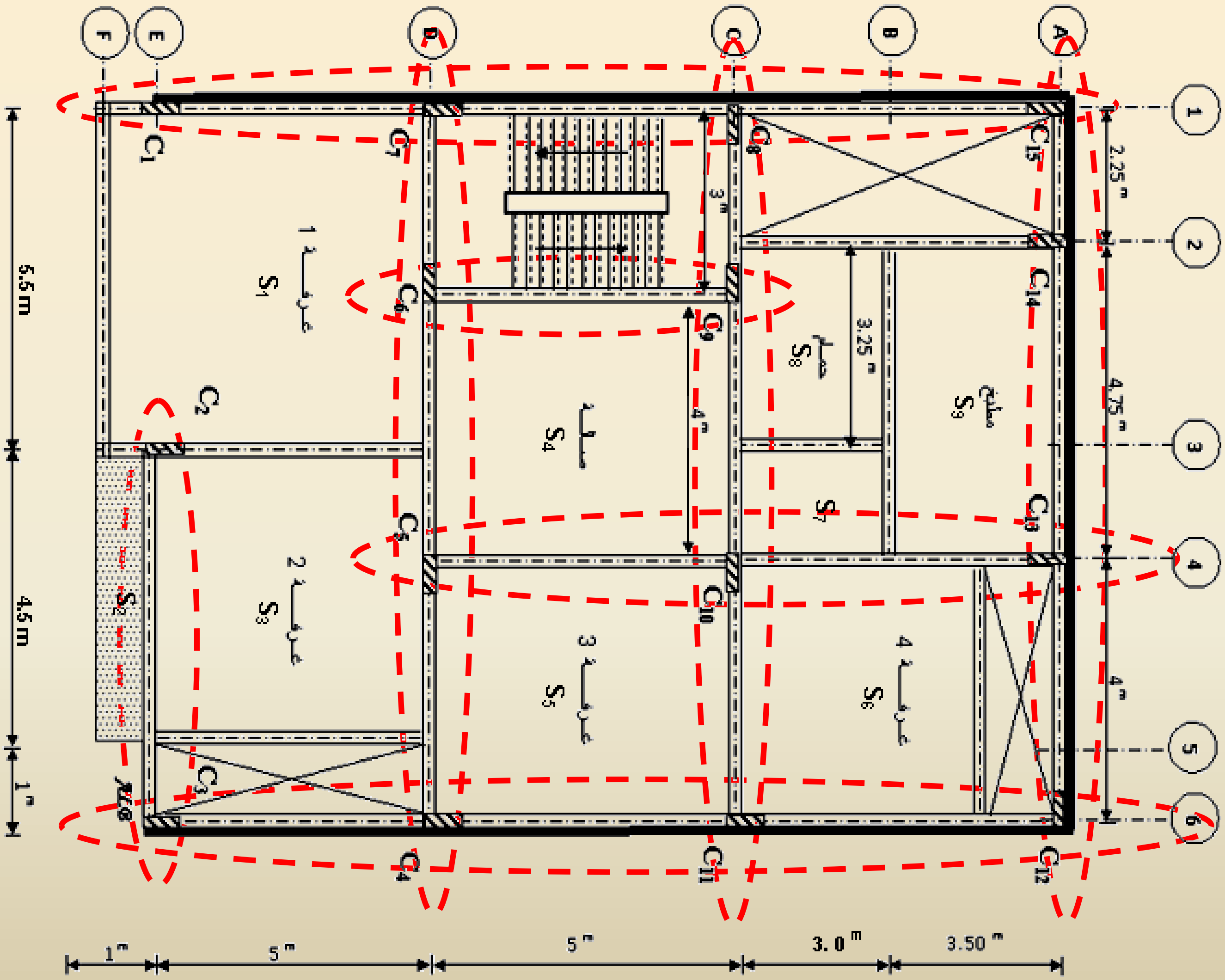
هى الكمرات الرئيسية
وترتكز مباشرة على الاعمدة

Secondary Beam

هى كمرة احد ركائزها
او كلاهما كمرات

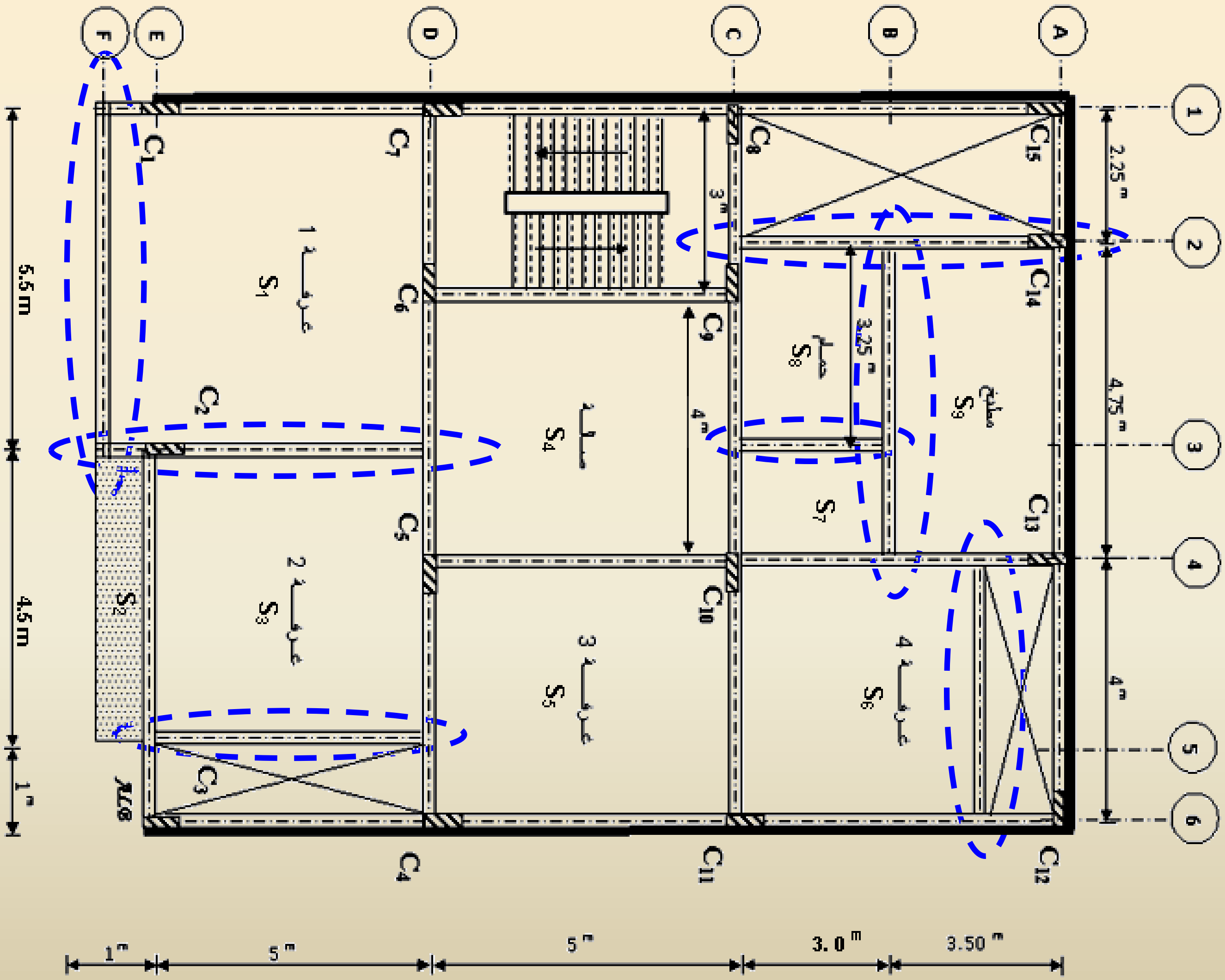
Main Beams

Main Beam

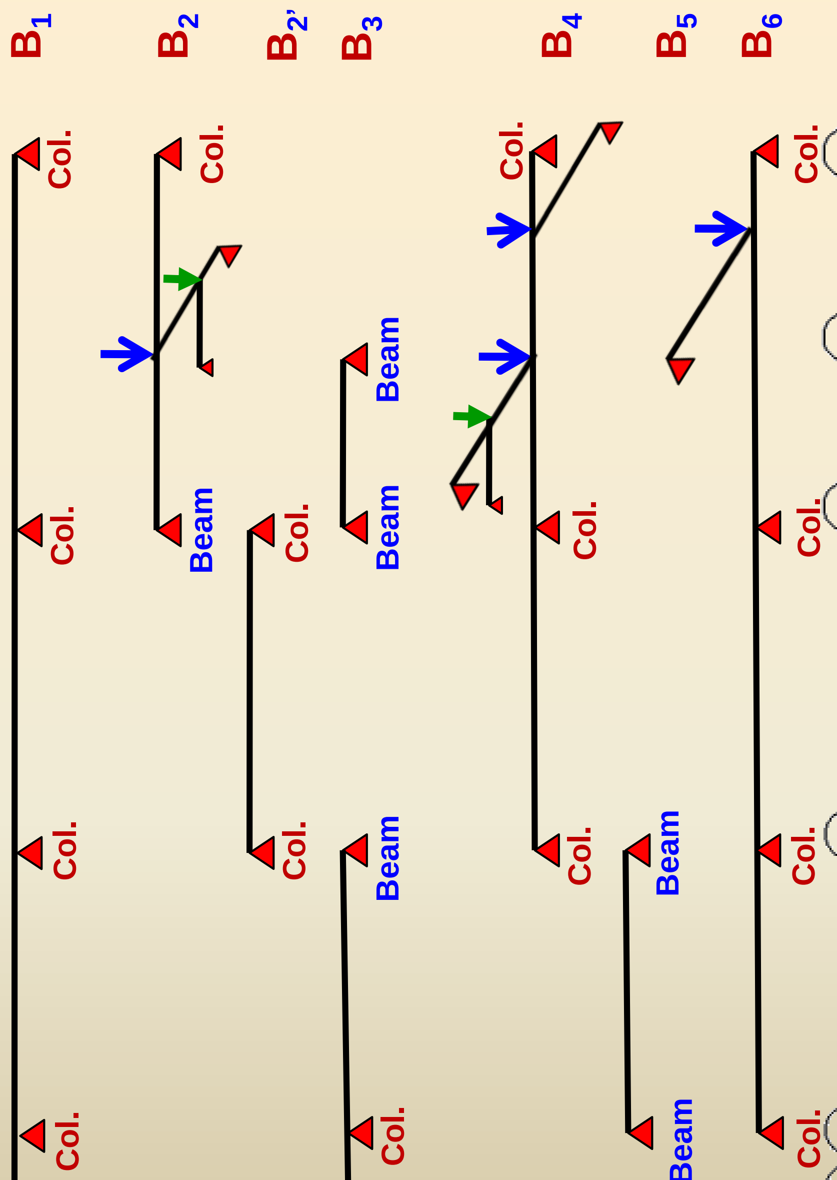


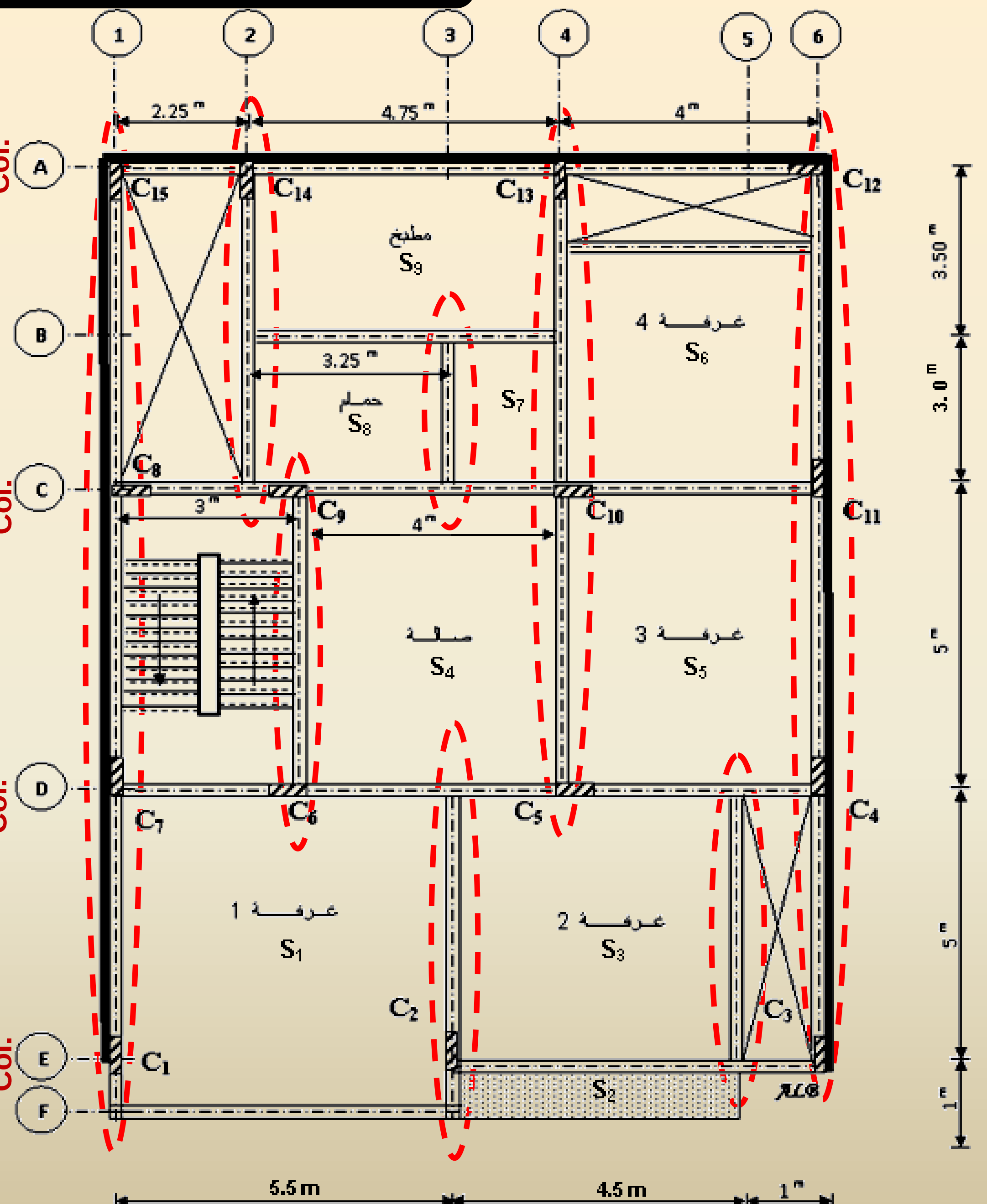
Secondary Beams

Secondary Beam

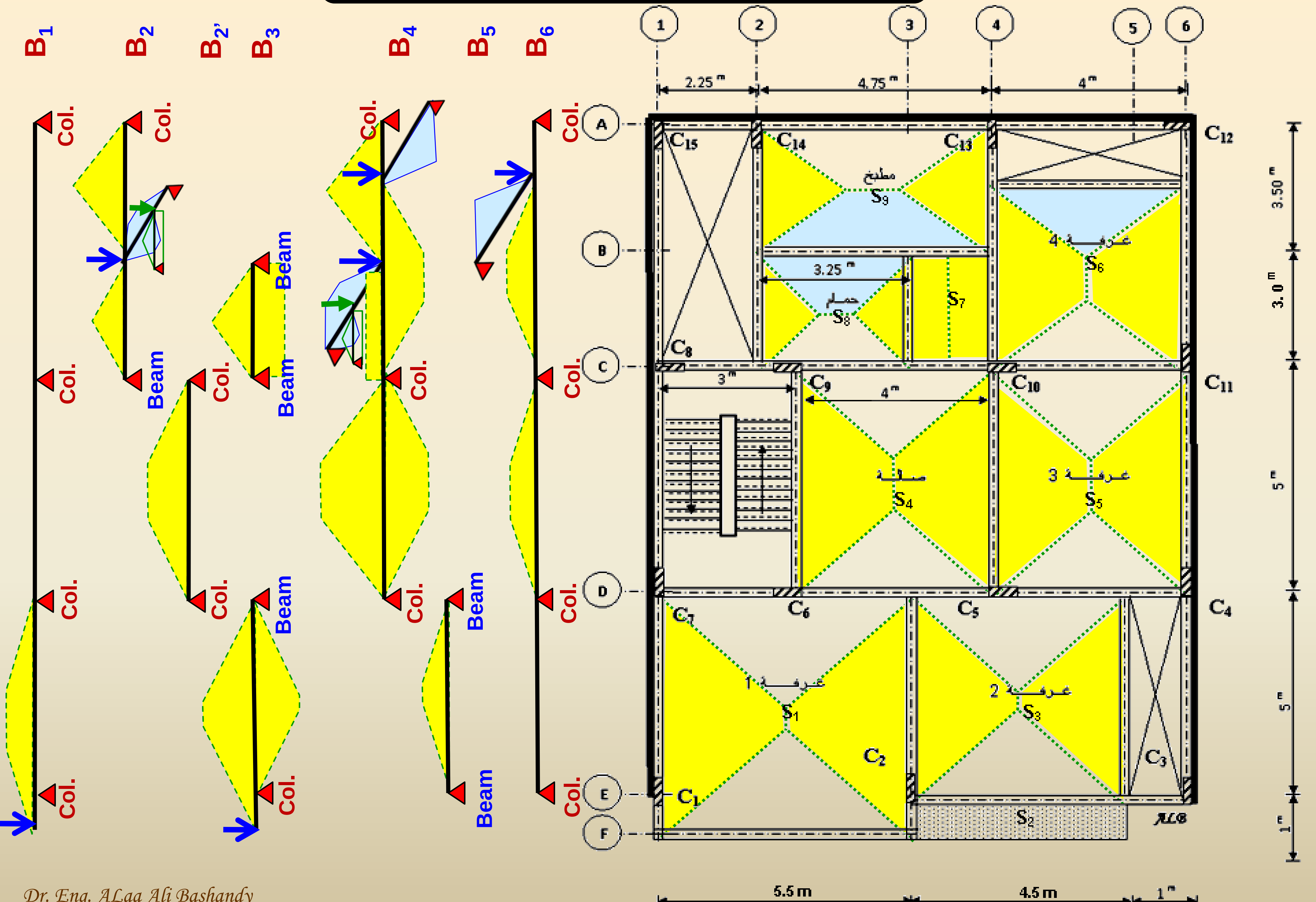


Main and Secondary Beams





Load from Slabs on Beams



تصميم الكمرات
Design of Beams

Load Values

1. Dead Load (D.L)

From Slab

1- Own weight of slab (O.Wt)

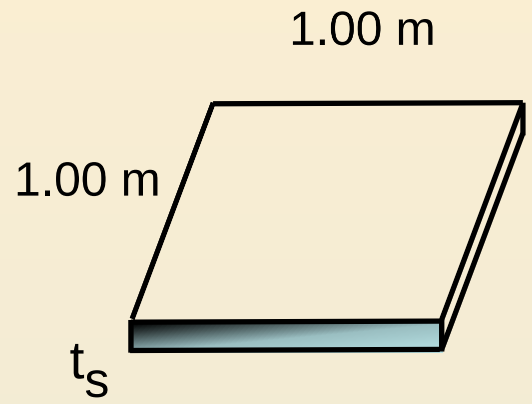
$$W = V_{Concrete} \times \gamma_{R.Concrete}$$

$$= t_s \times 1.0 \times 1.0 * \gamma_{R.C}$$

$\gamma_{R.C} = 2.5\ t/m^3$ & $\gamma_{P.C} = 2.2\ t/m^3$

2- floor cover (F.C)

$$FL.C. = 150\ kg/m^2 = 0.15\ t/m^2$$



From Beam

1- Own weight of Beam ($W_{B\,O.Wt}$)

$$W_{B\,O.Wt} = V_{Concrete} \times \gamma_{R.Concrete} = t_B \times b \times \gamma_{R.C}$$

From Walls

$$W_{wall} = V_{wall} \times \gamma_{Wall} = (t_w \times b_w \times h) \times \gamma_{Wall}$$

$\gamma_{Wall} = 1200 \rightarrow 1500\ t/m^3$ $b_w = 12 \rightarrow 25\ cm$

2. Live Load (L .L)

according to code

3. Total Load (T.L)

$$W_{Beam}\ (t/m') = (\text{Wall Wt.} + \text{O. Wt.}_{Beam}) \times 1.4 + Wu_s\ (\text{From slab})$$

Live Load Values According to Egyptian Code

الأحمال الحية للمباني المختلفة*

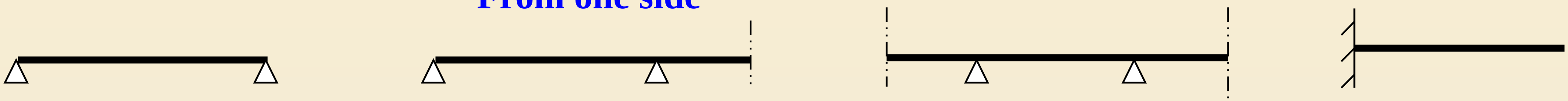
عنصر المبنى	(كجم/م^٢)	كن/م^٢
ب- المباني السكنية:		
١- غرف سكنية	(٢٠٠)	٢
٢- سلالم، مطابخ، حمامات	(٣٠٠)	٣
٣- بلكونات	(٣٠٠)	٣
جـ - المباني الإدارية:		
١- غرف مكاتب	(٢٥٠)	٢,٥
٢- غرف حفظ الملفات فى المكاتب	(٢٠٠/م ارتفاع)	٢/م ارتفاع
٣- أرشـــــيف	(٥٠٠-١٠٠٠)	٥-١٠
٤- ســـــلالم	(٤٠٠)	٤
٥- بلكونات	(٤٠٠)	٤
د - المستشفيات:		
١- غرف علاج المرضى	(٢٥٠)	٢,٥
٢- عنابر علاج المرضى	(٢٥٠)	٢,٥
٣- غرف الجراحة	(٤٠٠ فأكثر)	٤ فأكثر
٤- غرف الأشعة	(٤٠٠ فأكثر)	٤ فأكثر
٥- سلالم وطرقات	(٤٠٠)	٤
٦- بلكونات	(٤٠٠)	٤
هـ - المدارس والجامعات:		
١- فصول	(٣٠٠)	٣
٢- معامل	(٤٠٠ فأكثر)	٤ فأكثر
٣- صالات رياضية	(٥٠٠)	٥
٤- غرف حفظ الكتب ذات أرفف وممرات	(١٠٠٠)	١٠
٥- غرف تخزين الكتب	(٤٠٠/م ارتفاع)	٤/م ارتفاع
٦- المدرجات	(٤٠٠)	٤
٧- سلالم وطرقات	(٤٠٠)	٤

* عند حساب الأحمال على الأسقف ، يتم أخذ حالات التحميل لكل من الأحمال المنتظمة والمركزه الناتجة عن الأحمال الفعلية بحيث تعطى أقصى تأثير على العناصر الإنشائية

Estimation of t_B

t_B **min = 40 cm**

Simple Slab	Continuous Slab From one side	Continuous Slab From tow side	Cantilever Beam



for High Tensile Steel 400/600 (H.T.S)

$t_{B\ min} = L_{eff} / 16$	$L_{eff} / 18$	$L_{eff} / 21$	$L_c / 5$

it is required to check deflection if the span > 10 m

for any other steel type fy / fu

$t_{B\ min}$ = previous values ÷ (0.4 + fy / 650)

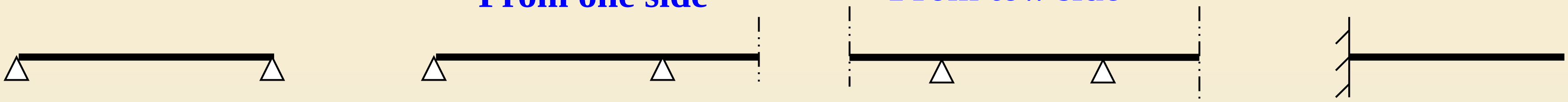
Value of t_B

Simple Slab

Continuous Slab From one side

Continuous Slab From tow side

Cantilever Beam



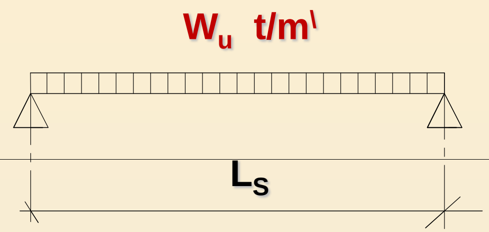
Generally

t_B = span / 10 | span / 12 | L_c / 5

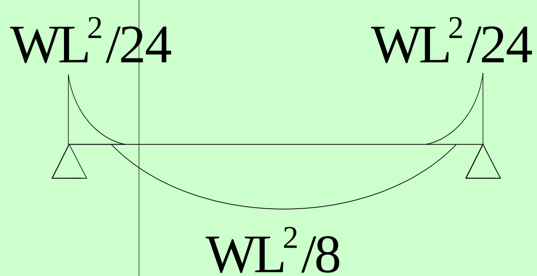
but not less than 40 cm

Moment Values

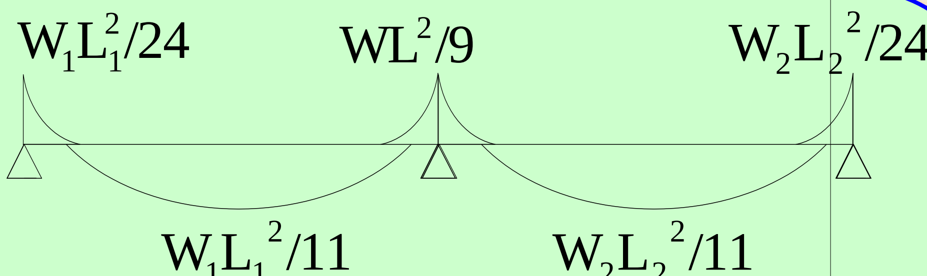
$$\text{min } M_{+ve} = \frac{W_u \times L^2}{8}$$



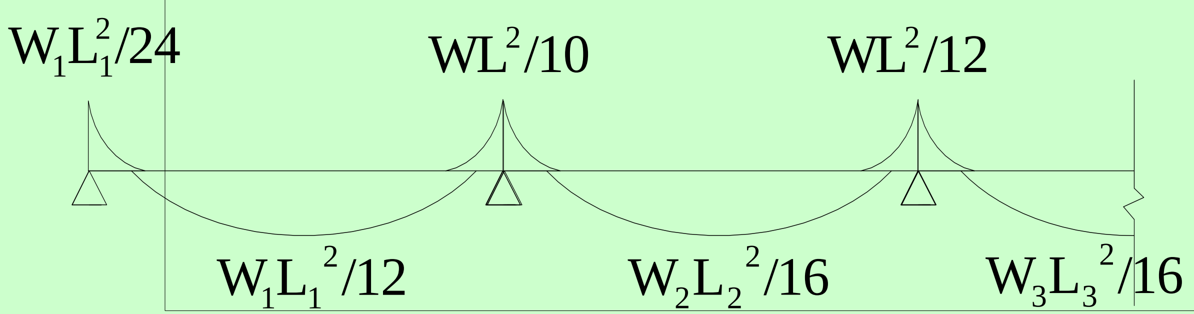
Empirical values for B.M (Max difference in load & span ≤ 20% and D.L >L.L)



Simply supported



continuous two spans



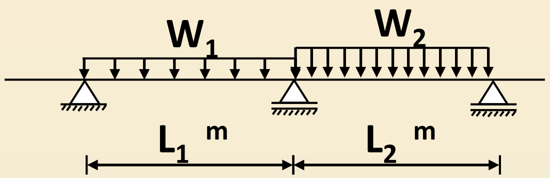
continuous more than two spans

$M_{support}$

In case of: difference in load or span ≥ 20%

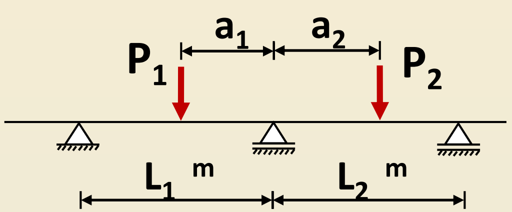
Uniform Load

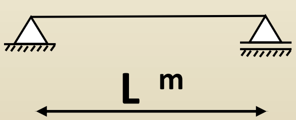
$$M_{support} = \frac{W_1\, L'^{3}_1 + W_2\, L'^{3}_2}{8.5\,(L'_1 + L'_2)}$$



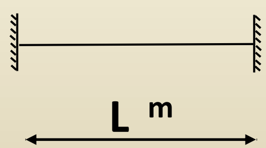
Concentrated Load

$$M_{support} = \frac{k_1\, P_1\, L'^{2}_1 + k_2\, P_2\, L'^{2}_2}{(L'_1 + L'_2)}$$





$L' = L$

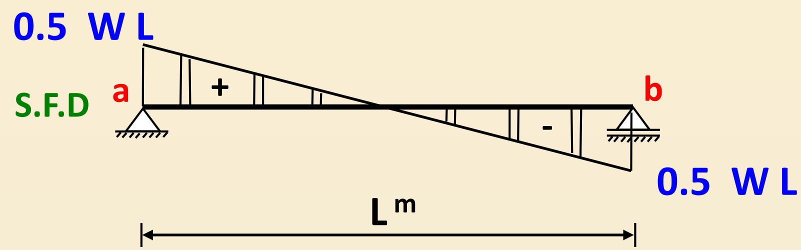


$L' = 0.8L$

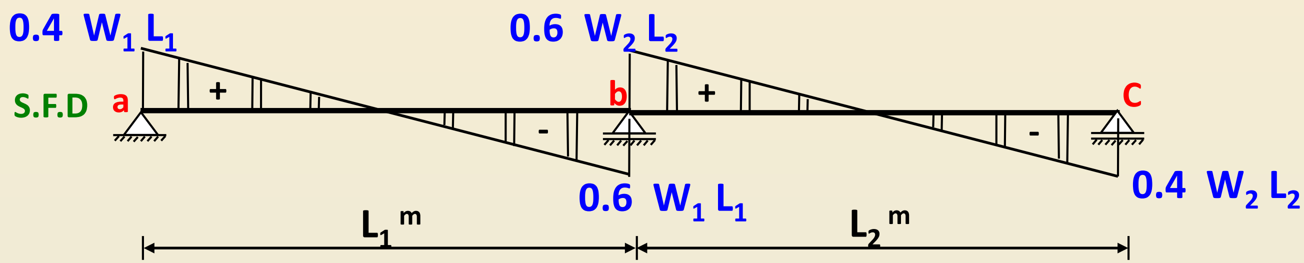
a_1 / L_1 & a_2 / L_2	0.3	0.4	0.5	0.6	0.7
K_1 & k_2	0.168	0.182	0.176	0.158	0.128

Shear Values

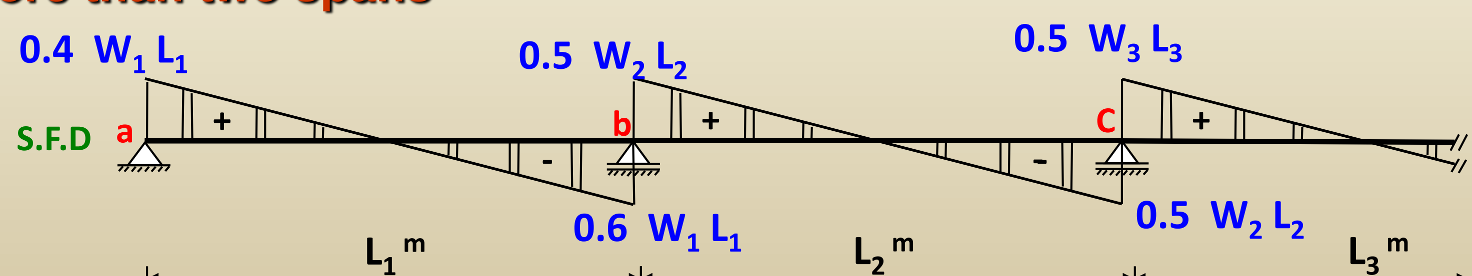
Simply supported beam



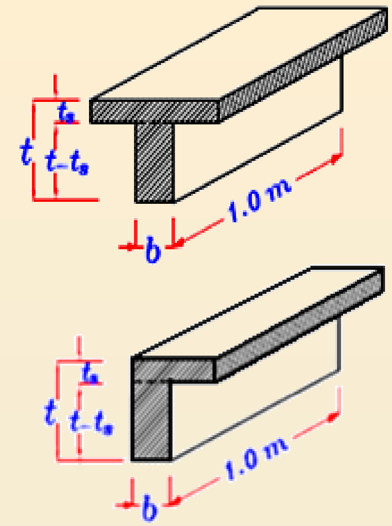
Continuous two spans



Continuous more than two spans



Estimation of b

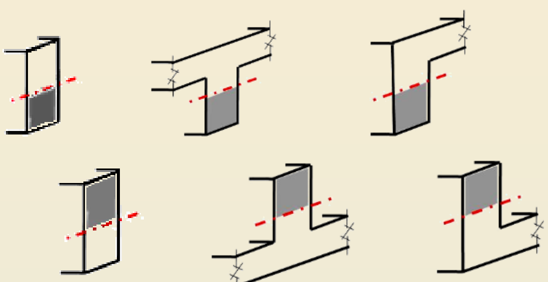


Possible cases of b

- Rectangular section R-sec.
- T - sec. → internal beam
- L - sec. → edge beam

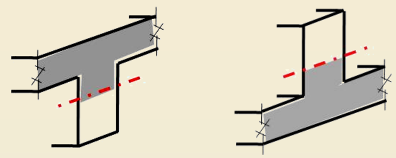
Values of b :

$$d = C_1 \sqrt{\frac{M_u}{F_{cu} \, . \, b}}$$



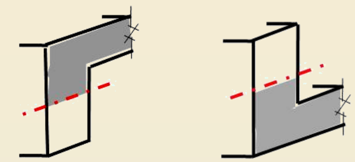
R - sec.

b



T - sec.

Least of :
- CL. to CL.
- $16\, t_s + b$
- $L_2 / 5 + b$

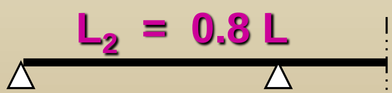


L - sec.

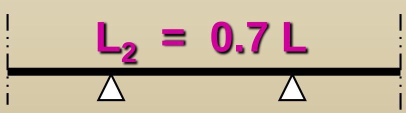
- ½ CL. to CL.
- $6\, t_s + b$
- $L_2 / 10 + b$

$L_2 = L$

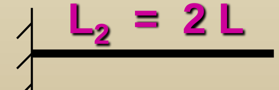
$L_2 = 0.8\,L$



$L_2 = 0.7\,L$



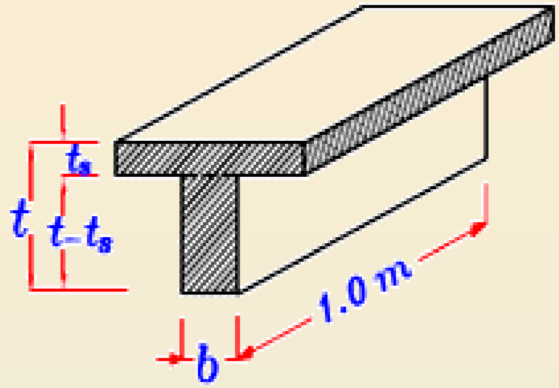
$L_2 = 2\,L$



Design of Section

Given : M_u , t_s , $b = 100$ cm , F_{cu} , F_y

Req. : A_s



$d = t_s - c$ **(cover) c = 20 - 50 mm**

$$d = C_1 \sqrt{\frac{M_u}{F_{cu} \cdot b}} \qquad C_1 = ... \qquad J = ...$$

$$As = \frac{Mu}{J \cdot d \cdot f_y} = ... \quad cm^2/m'$$

A_S min = 0.15 % A_c **H.T.S 360/520**

= 0.25 % A_c **for Mild steel 240/350**

A_S max = 0.4 % A_c ***recommended***

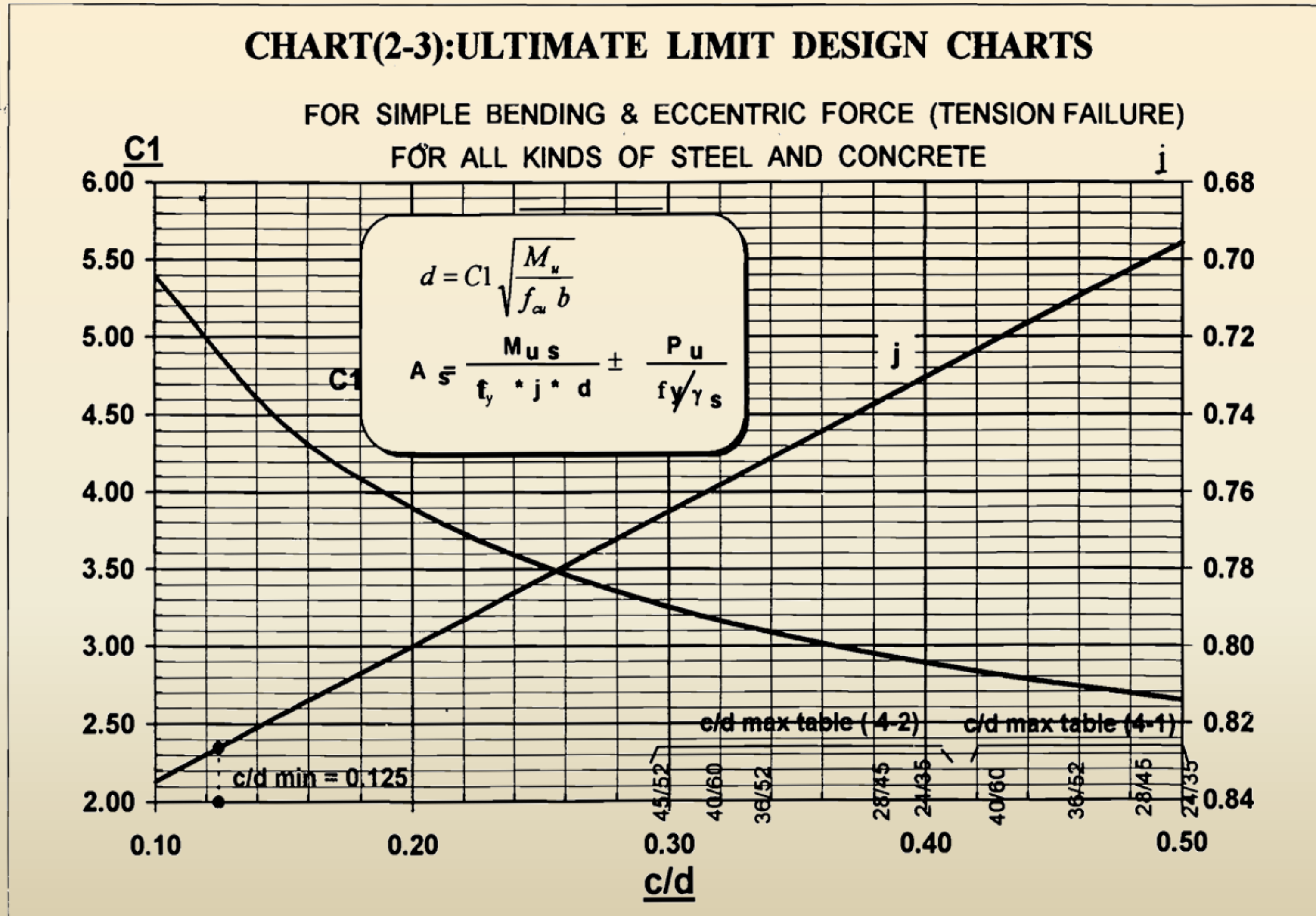
A_c = b x d

C_1 & J

ECCS 203-2001 Design Aids

Flexure Members

c/d	C1	J
0.1250	4.85	0.826
0.1375	4.64	0.821
0.1500	4.46	0.817
0.1625	4.29	0.813
0.1750	4.15	0.808
0.1875	4.02	0.804
0.2000	3.90	0.800
0.2125	3.79	0.795
0.2250	3.70	0.791
0.2375	3.61	0.786
0.2500	3.53	0.782
0.2625	3.45	0.778
0.2750	3.38	0.773
0.2875	3.32	0.769
0.3000	3.26	0.765
0.3125	3.20	0.760
0.3250	3.15	0.756
0.3375	3.10	0.752
0.3500	3.05	0.747
0.3625	3.00	0.743
0.3750	2.96	0.739
0.3875	2.92	0.734
0.4000	2.89	0.730
0.4125	2.85	0.726
0.4250	2.82	0.721
0.4375	2.78	0.717
0.4500	2.75	0.713
0.4625	2.72	0.708
0.4750	2.70	0.704
0.4875	2.67	0.700
0.5000	2.65	0.695



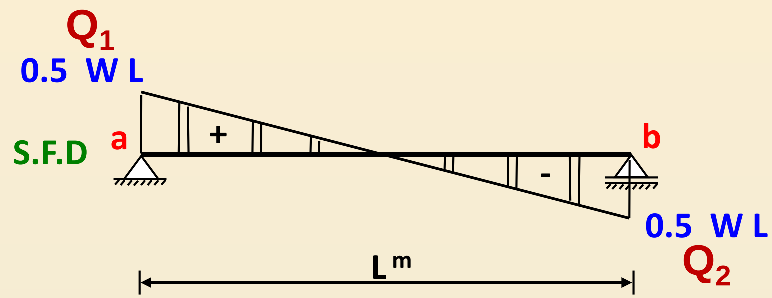
سلوك الكمرات فى القص

Shear Behavior of Beams

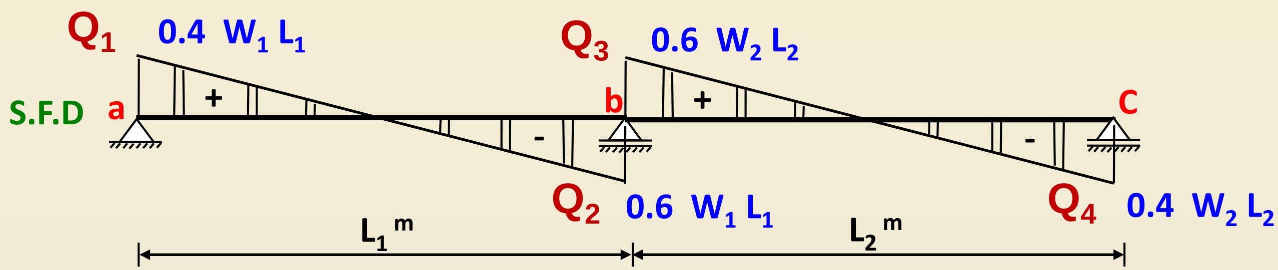
Choice of Shear Values

Chose the larger value of shear along the beam span - axis Q_{max}

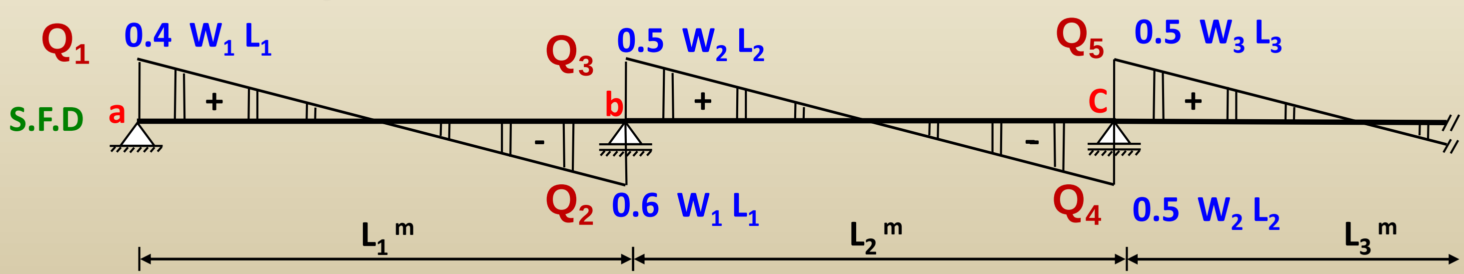
Simply supported beam



Continuous two spans



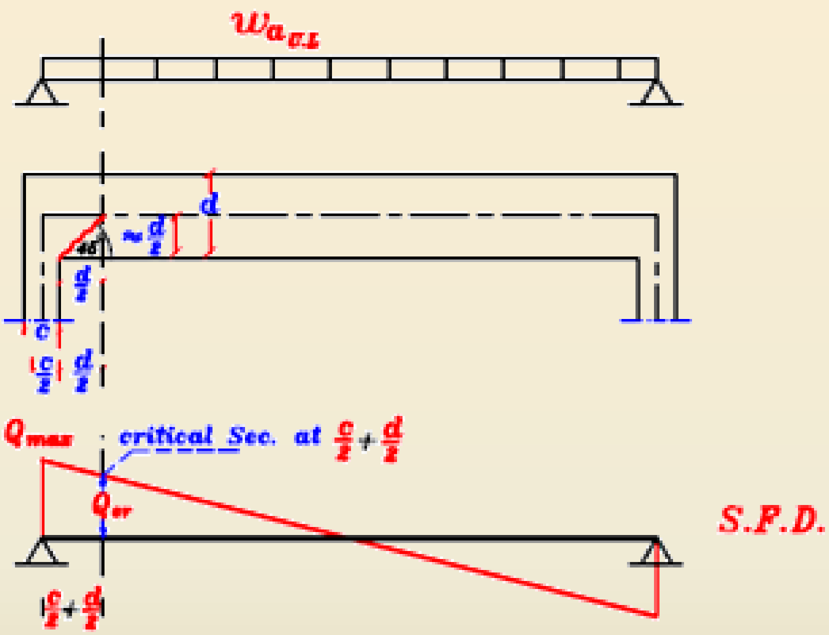
Continuous more than two spans



Critical Sections of Shear

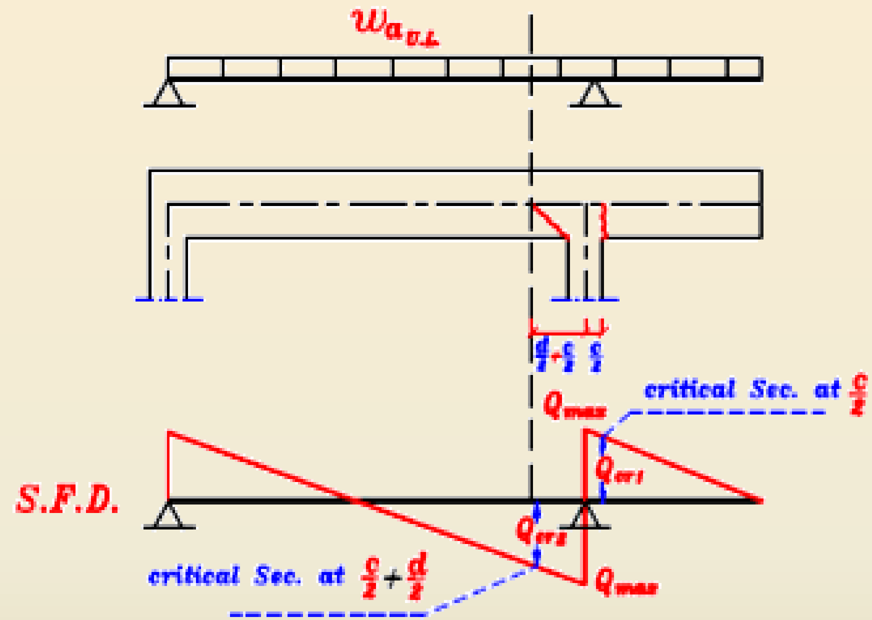
we may use previous values $Q_{max.}$ **(more safe)**

or **take the accurate values $Q_{cr.}$** **(safe)** **as follow:**



$$Q_{cr.} = R - w_a \left(\frac{c}{2} + \frac{d}{2} \right)$$

Simple or Continuous Beam



Cantilever Beam

Check of Shear → at critical sections

Shear Limitations of Beams

Calculate Allowable Shear Stresses

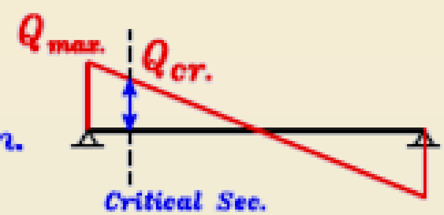
$$q_{cu} = 0.24 \sqrt{\frac{F_{cu}}{\gamma_c}} \quad N\backslash mm^2$$

$$q_{max.} = 0.70 \sqrt{\frac{F_{cu}}{\gamma_c}} \quad N\backslash mm^2$$

Check of Shear

$$\text{Actual Shear Stress} = \quad q_U = \frac{Q_{cr.}}{b\,d} \quad N \backslash mm^2$$

Where:

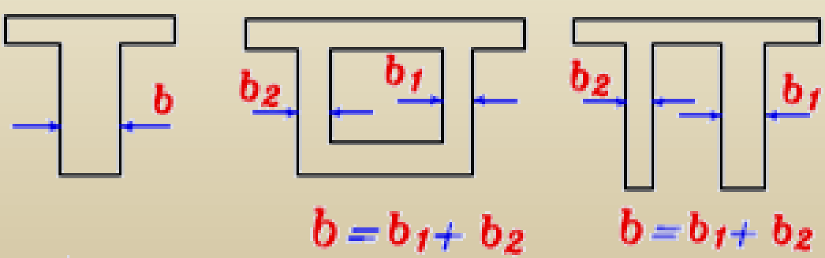


$Q_{cr.}$ (N) = Shear Force at Critical Section.

و عاده تؤخذ Q_{max} للتصميل

d (mm) = Effective depth = $t - 50\ mm$

b (mm) = min. width of the Section.



Cases of q_u

$$q_U = \frac{Q_{cr.}}{b\,d} \quad N\backslash mm^2$$

q_U

$q_U \leqslant q_{cu}$

Use min. Stirrups.

$5 \phi 8 \backslash m$

$q_{cu} < q_U \leqslant q_{Umax.}$

We need Stirrups

More Than $5 \phi 8 \backslash m$

$q_U > q_{Umax.}$

Increase Dim.

b or d

Check of Shear

IF $q_{cu} < q_U < q_{U\,max.}$

We need Stirrups more than $5 \phi 8 \backslash m`$

$$q_{su} = q_u - \frac{q_{cu}}{2} = \frac{n\,A_s (F_y \backslash \delta_s)}{b\;S}$$

Where : q_{su} = Shear Stress Taken by Stirrups only.

q_u = Actual Shear Stress.

$\frac{q_{cu}}{2}$ = Shear Stress Taken by Concrete only.

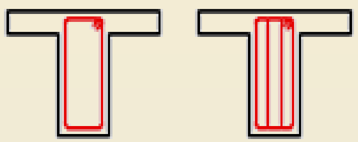
$$IF \quad q_{cu} < q_U < q_{U\,max.}$$

We need Stirrups more than $5\phi 8 \backslash m'$

$$q_{su} = \frac{n\, A_s\, (F_y \backslash \gamma_s)}{b\; S}$$

Where :

n = No. of Branches.



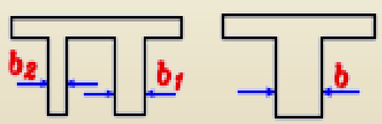
$n = 2$ $\qquad$ $n = 4$

A_s مساحه سطح السيخ الواحد من الكانه

IF using $\phi 8 \longrightarrow A_s = 50.3 \; mm^2$

IF using $\phi 10 \longrightarrow A_s = 78.5 \; mm^2$

b = min. width in the Sec.



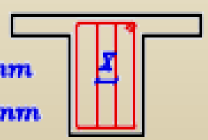
$b = b_1 + b_2$

$F_y = 240 \;\; N\backslash mm^2$ using Mild Steel

S = Spacing between stirrups in the Long Direction.

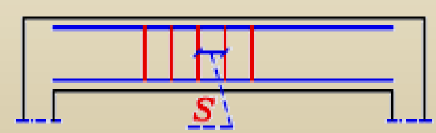
المسافات بين الكانات فى الإتجاه الطولى

IF $b \geq 400$ mm OR $b > t$ Take $n = 4$ $\longrightarrow$ $X \nless 50$ mm, $X \ngtr 250$ mm



$S_{min} = 100$ mm

$S_{max.} = 200$ mm



كيفية ايجاد تسليح القص

$$q_u - \frac{q_{cu}}{2} = \frac{n\, A_s (F_y \backslash \delta_s)}{b\ S}$$

نفرض قيمه كلاً من n , A_s ثم نوجد قيمه S

Assume $n = 2$, $\phi 8$ ⟶ $A_s = 50.3\ mm^2$

IF S:

- IF $S > 200\ mm$
  - Use min. Stirrups. $5 \phi 8 \backslash m$
- IF $100\ mm \leq S < 200\ mm$
  - Take no. of stirrups\m` $= \frac{1000}{S}$
  - Example. $S = 140\ mm$
  - ∴ No. of stirrups\m` $= \frac{1000}{S} = \frac{1000}{140} = 7.14$
  - $= 8 \phi 8 \backslash m$
- IF $S < 100\ mm$
  - ∴ No. of stirrups\m` > 10 Refused
  - ∴ Try another assumption of n , A_s

ترتيب الفروض يكون كالاتى

Assumption No.	n	ϕ
1	2	8
2	2	10
3	4	8
4	4	10

حدود نسبة التسليح المستخدم لمقاومة الـقص

$$\mu = \frac{A_{st}}{b\,S} = \frac{n\,A_s}{b\,S}$$

$$\mu_{min} = \frac{0.4}{F_y}$$

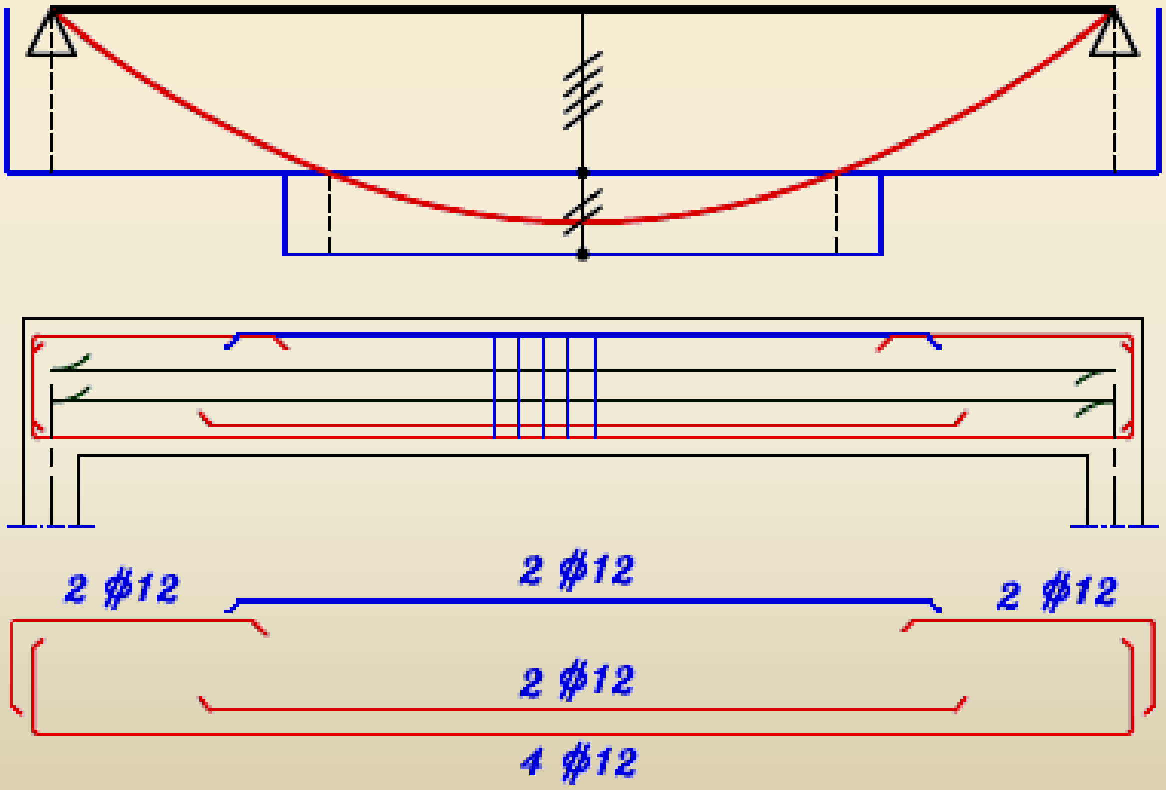
تحديد اماكن بداية ونهاية اسياخ تسليح الكمرات

Reinforcing Rebars

كيفية ايجاد اماكن بداية ونهاية اسياخ التسليح

Simple Beam

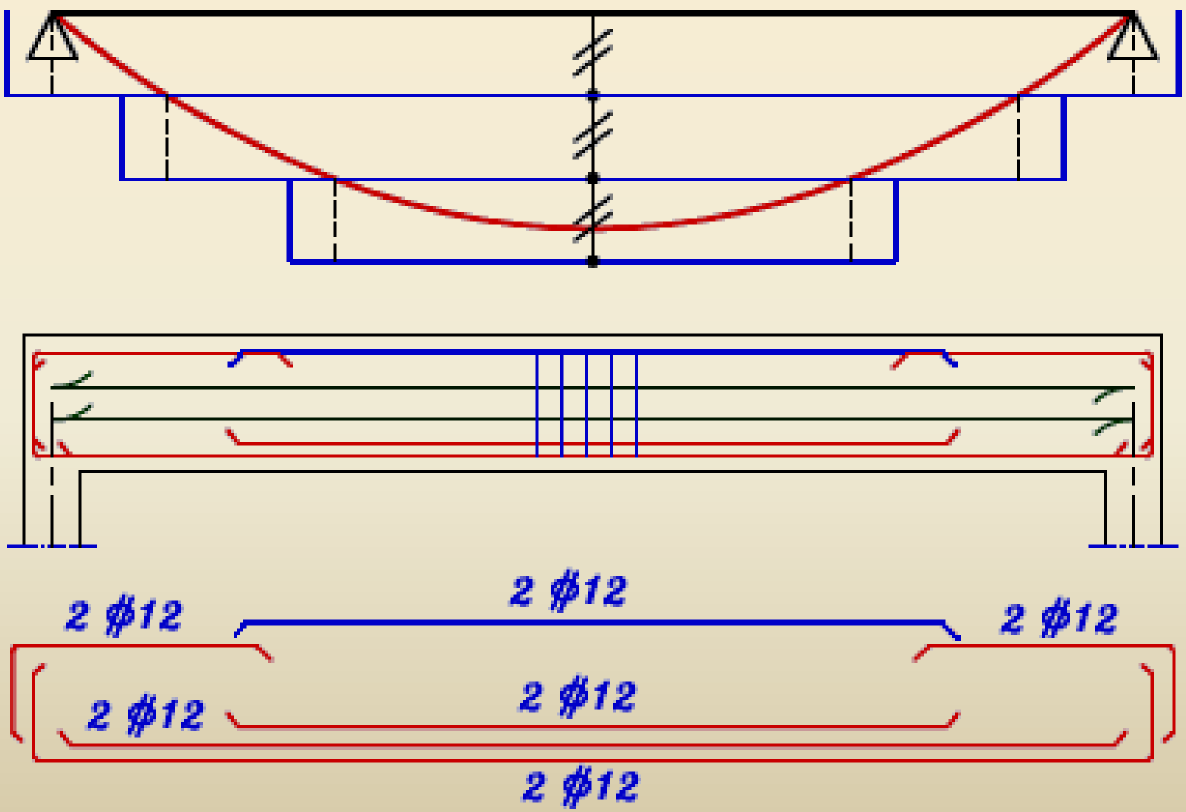
4 + 2



كيفية إيجاد اماكن بداية ونهاية اسياخ التسليح

Simple Beam

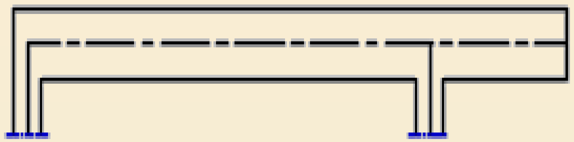
2 + 2 + 2



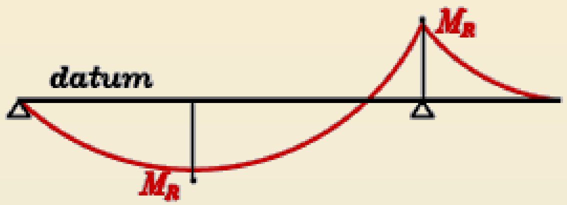
كيفية إيجاد اماكن بداية ونهاية اسياخ التسليح

Simple Beam

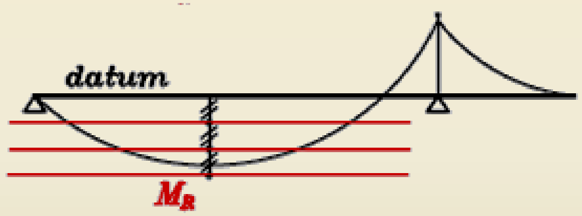
1



2



3



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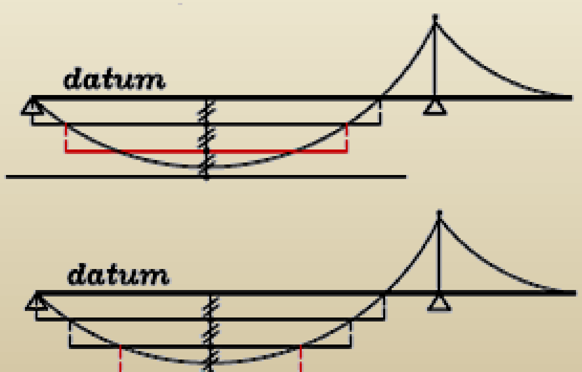

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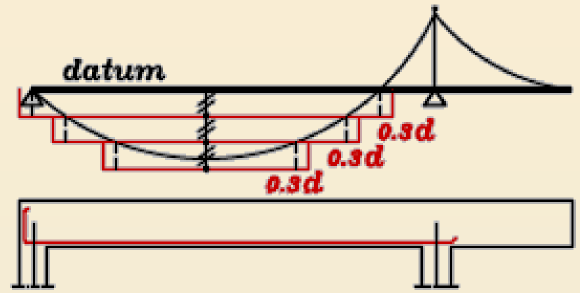

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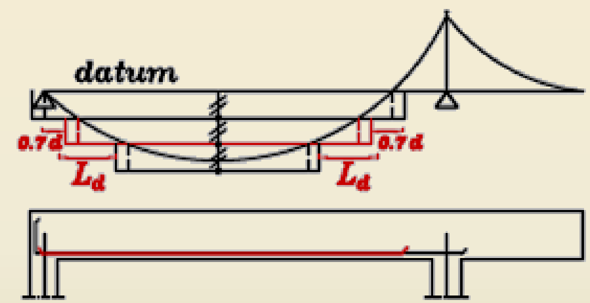

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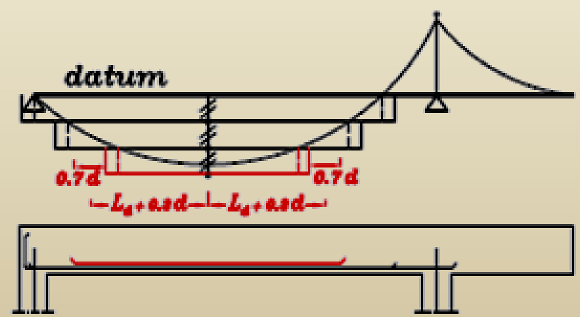
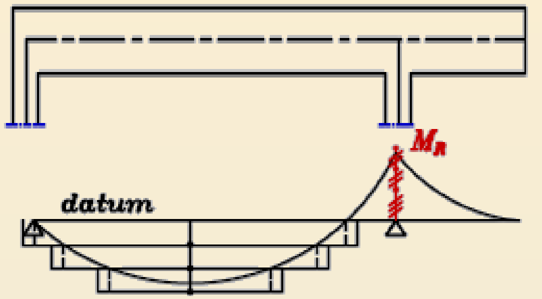


كيفية إيجاد اماكن بداية ونهاية اسياخ التسليح

Cantilever Beam

1



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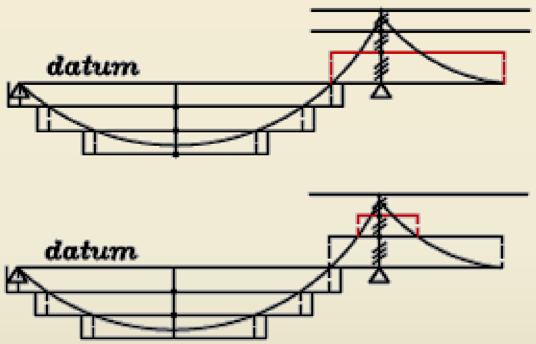

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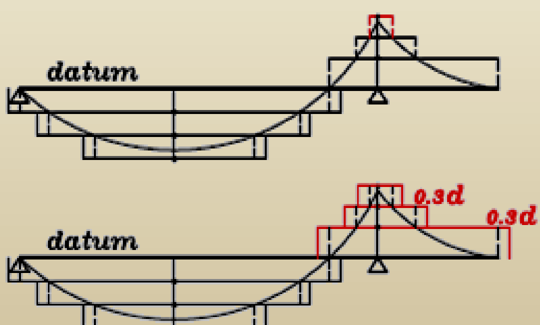

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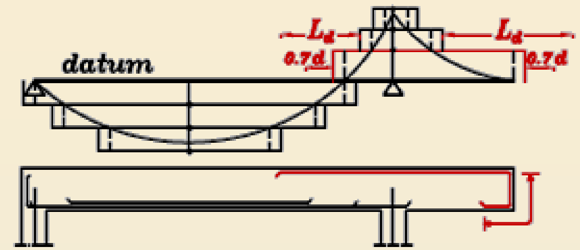

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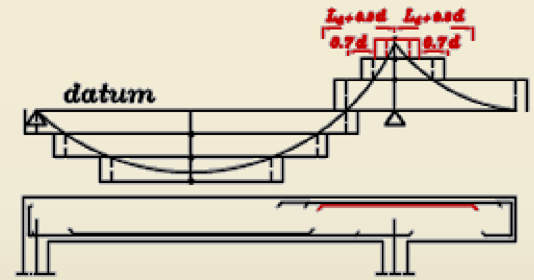
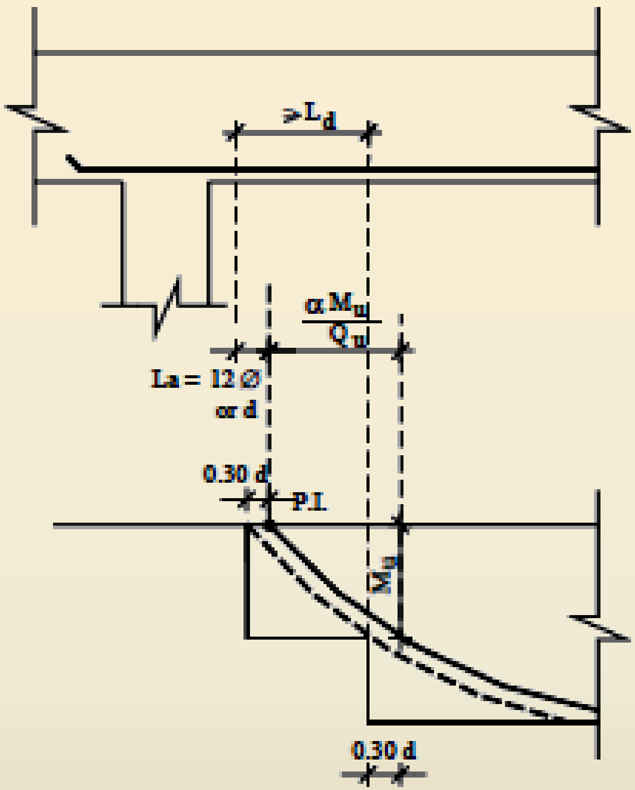
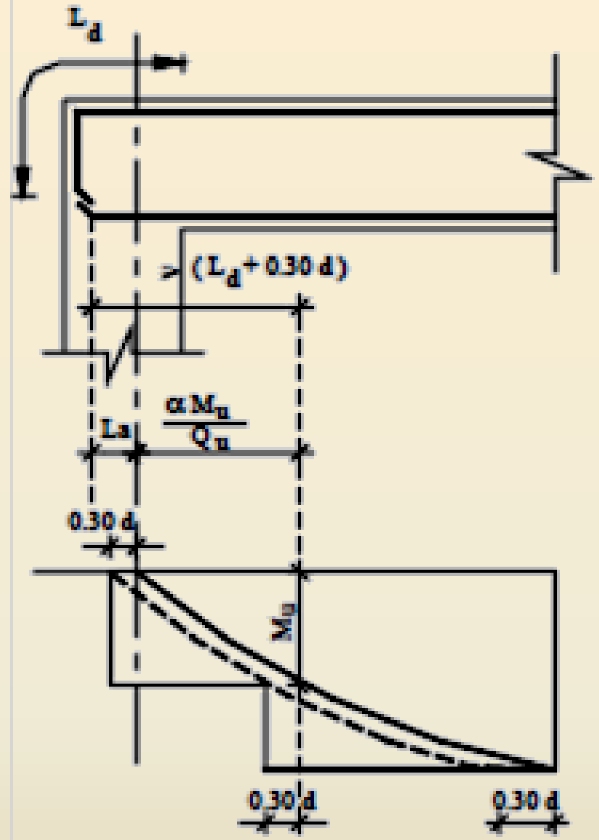


7

أماكن توقف اسياخ التسليح



اماكن التوقف بالنسبة للركائز الوسطى



اماكن التوقف بالنسبة للركائز الطرفية

مسافات الوصلات

(ب) أسياخ غير متلاصقة

(أ) أسياخ متلاصقة

(جـ)

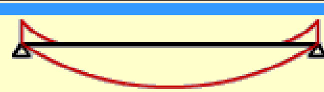
الوصلات بالتراكب

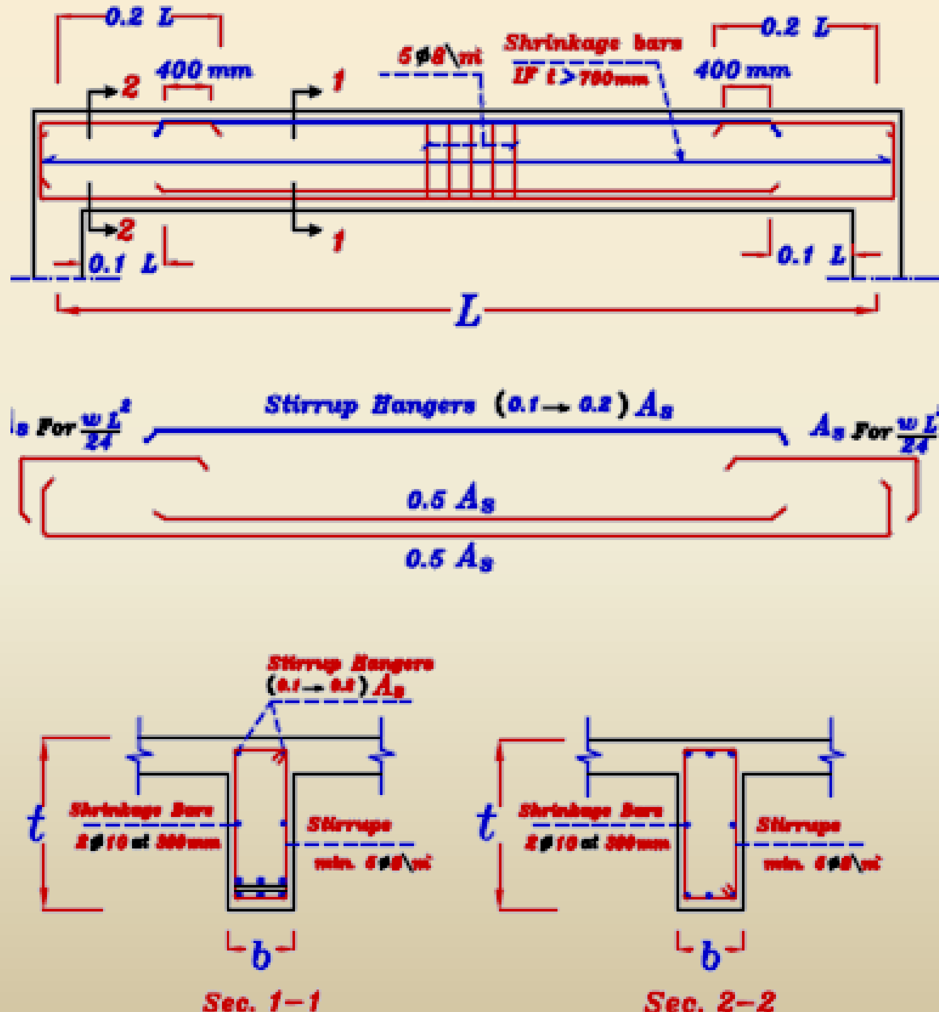
تفاصيل تسليح الكمرات

Reinforcement Detailing

إستخدام اسياخ تسليح عدل
Using Straight Rebars

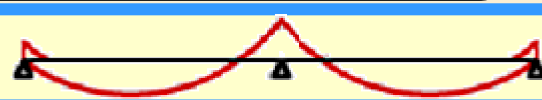
Simple Beam

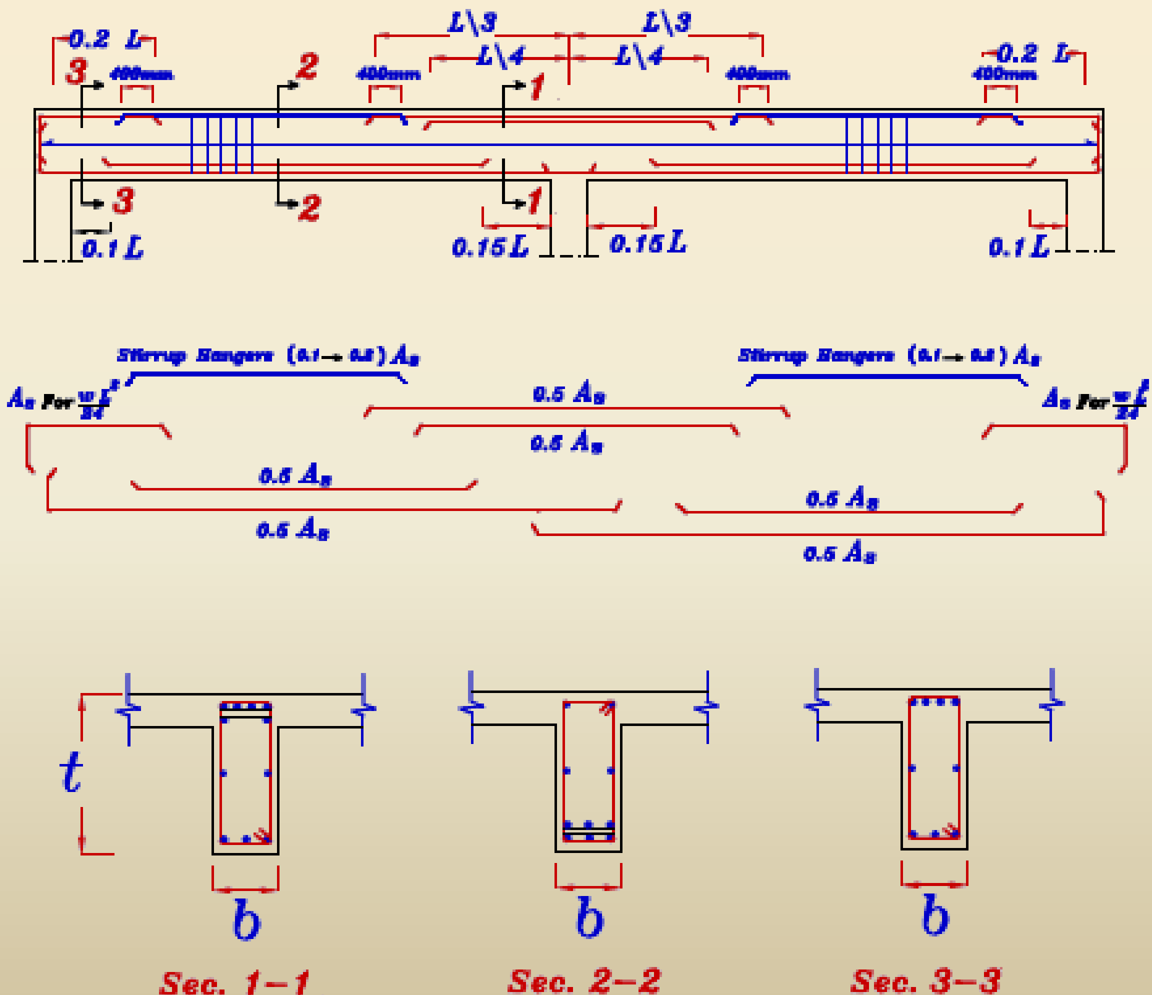




إستخدام اسياخ تسليح عدل
Using Straight Rebars

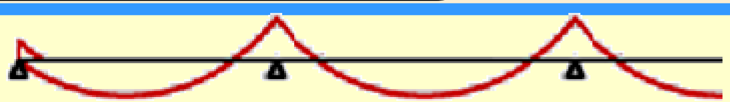
2-spans Beam

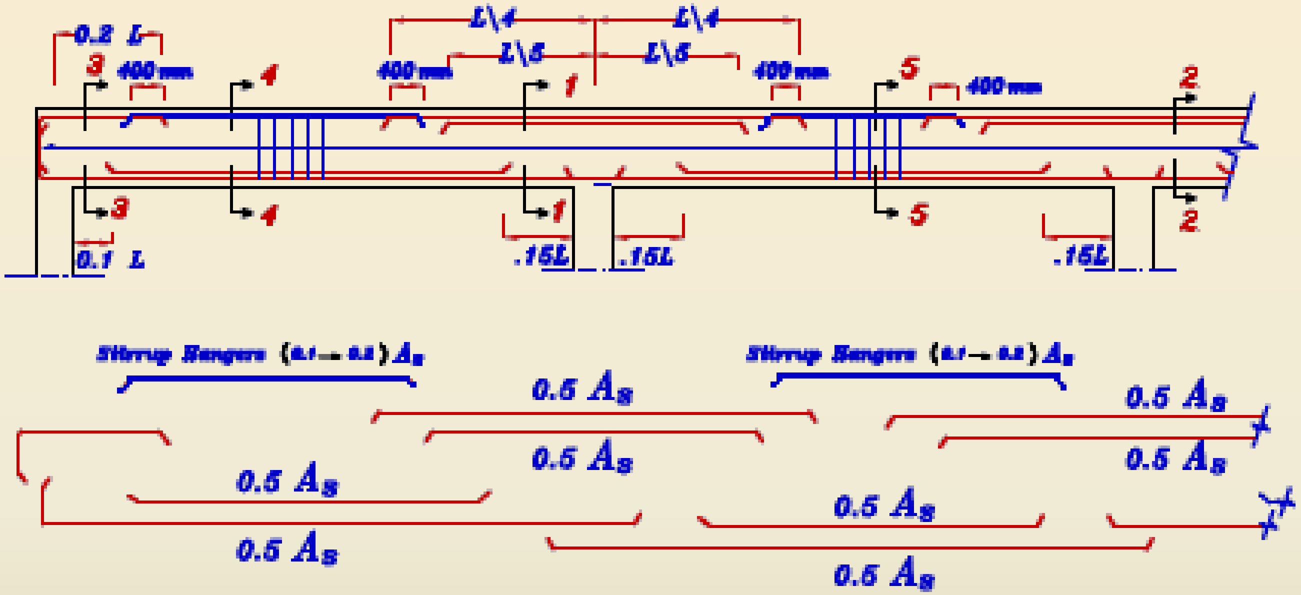


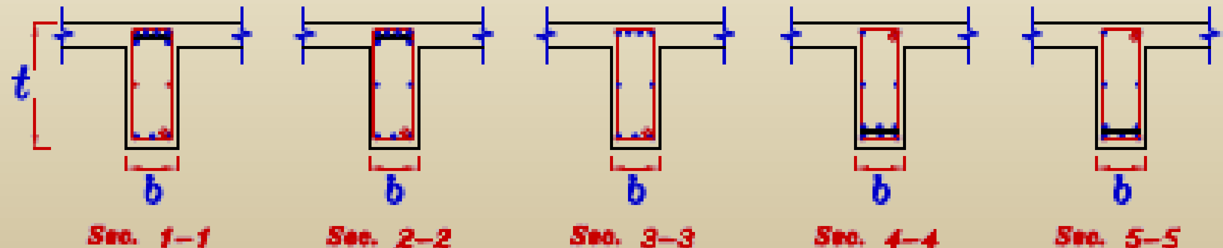


إستخدام اسياخ تسليح عدل
Using Straight Rebars

More than 2-spans Beam

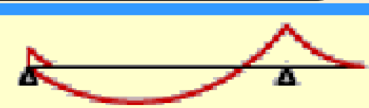


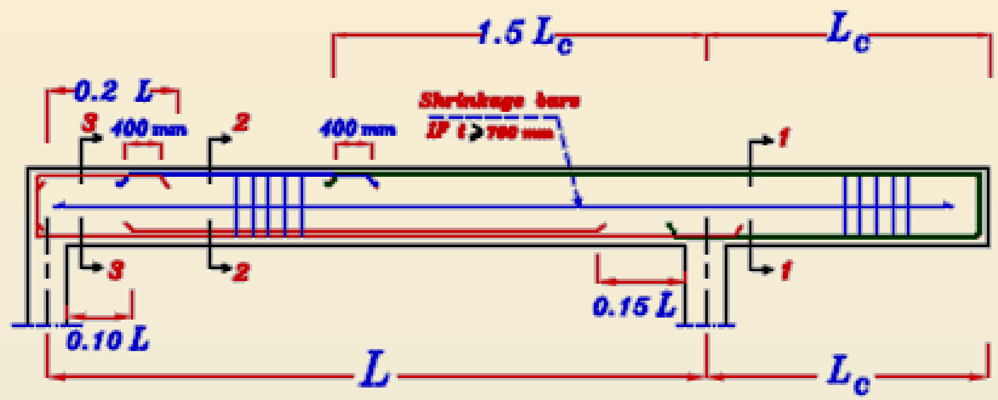


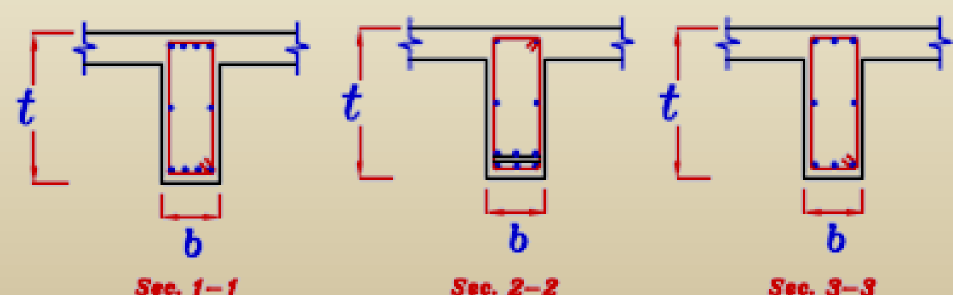


إستخدام اسياخ تسليح عدل
Using Straight Rebars

Over hanging Beam

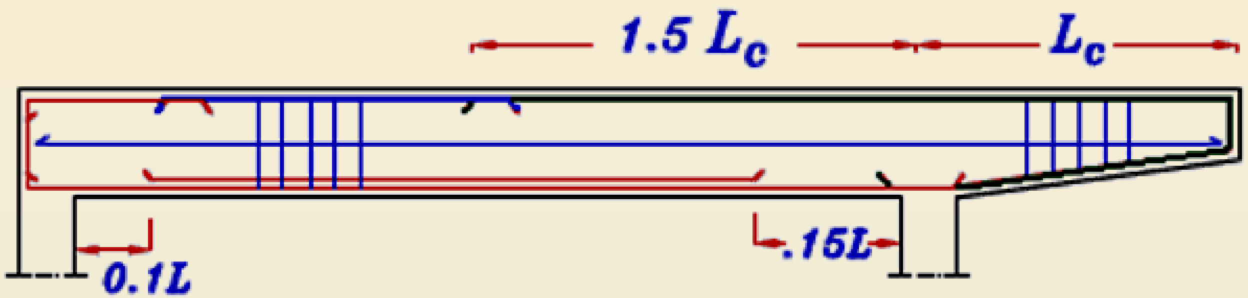


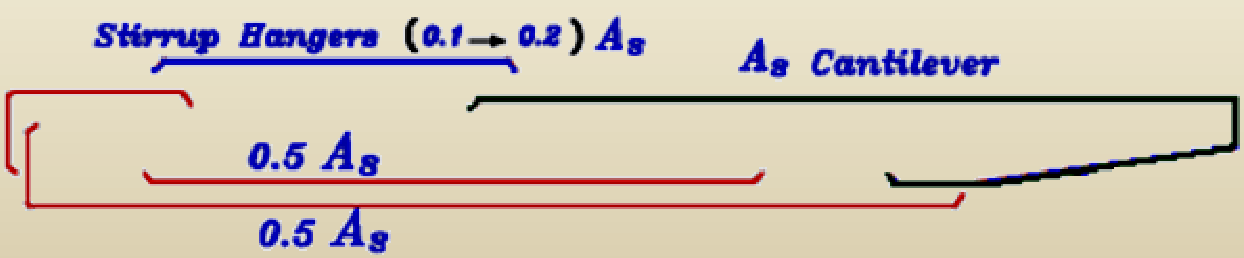




إستخدام اسياخ تسليح عدل
Using Straight Rebars

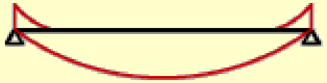
Cantilever Beam

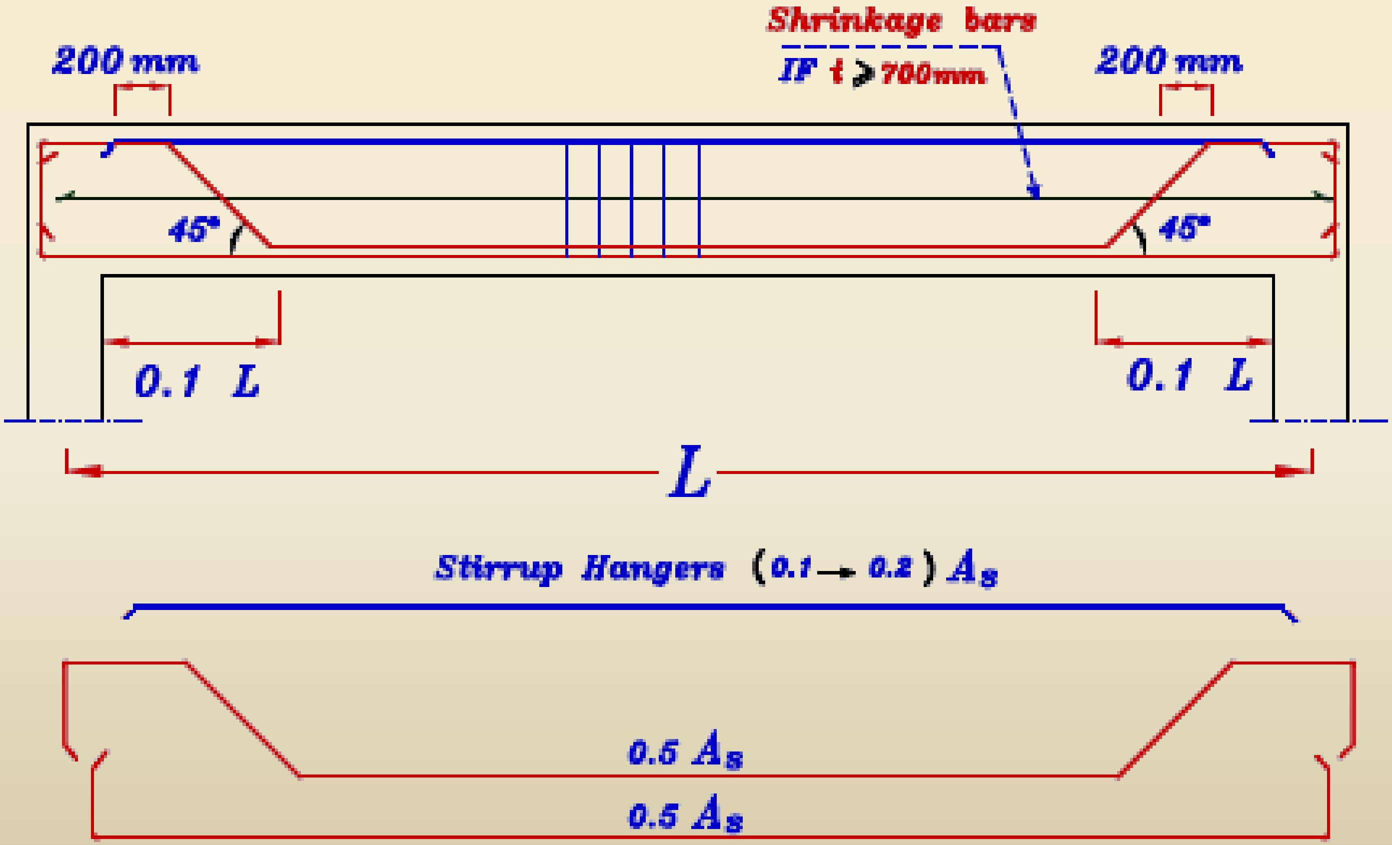




إستخدام اسياخ تسليح مكسحة
Using Bent Rebars

Simple Beam

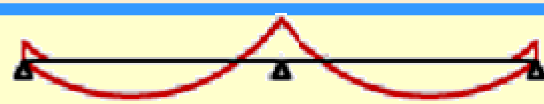


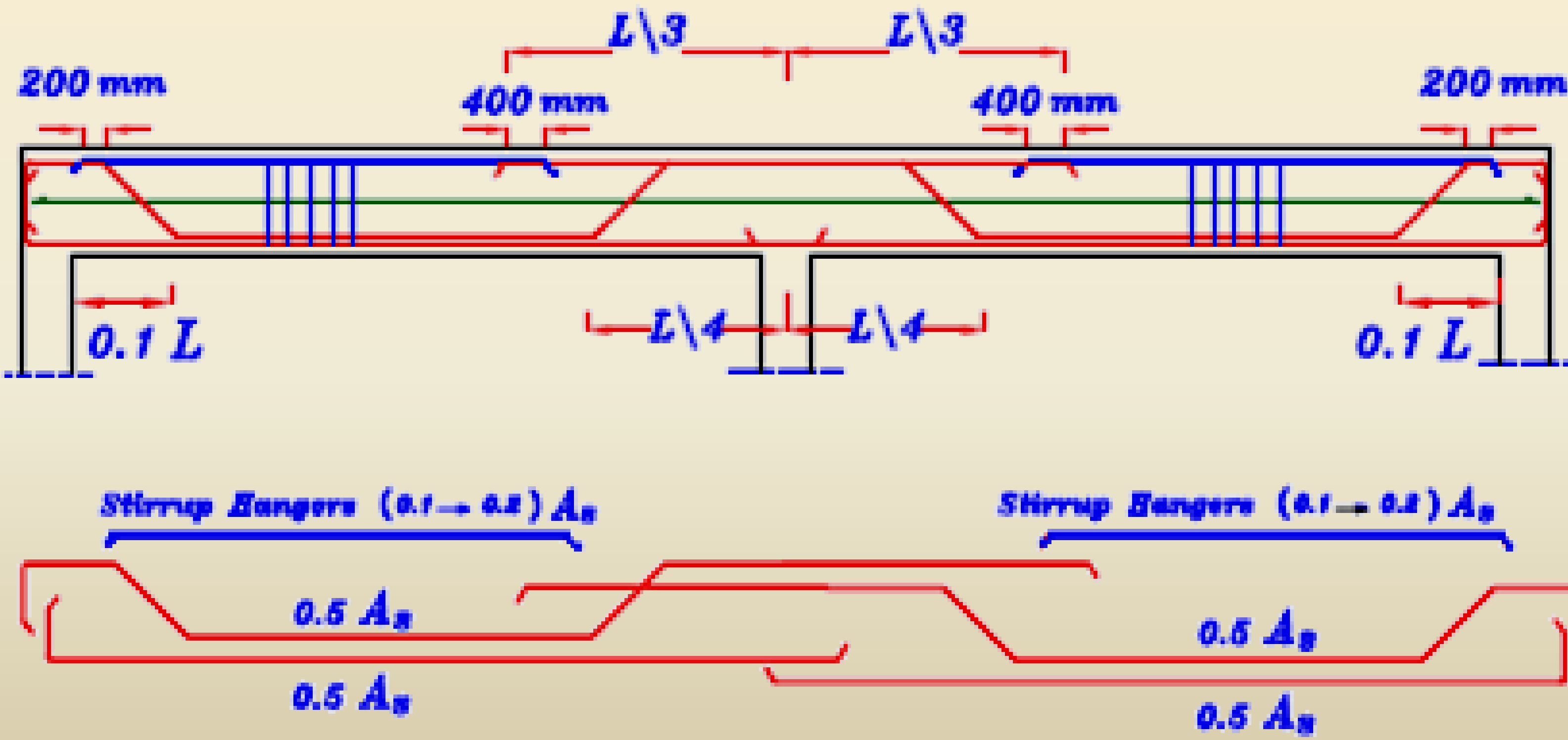


إستخدام اسياخ تسليح مكسحة

Using Bent Rebars

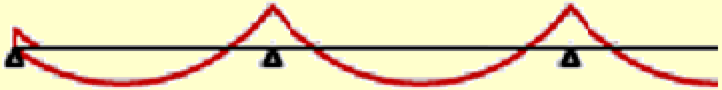
2-spans Beam

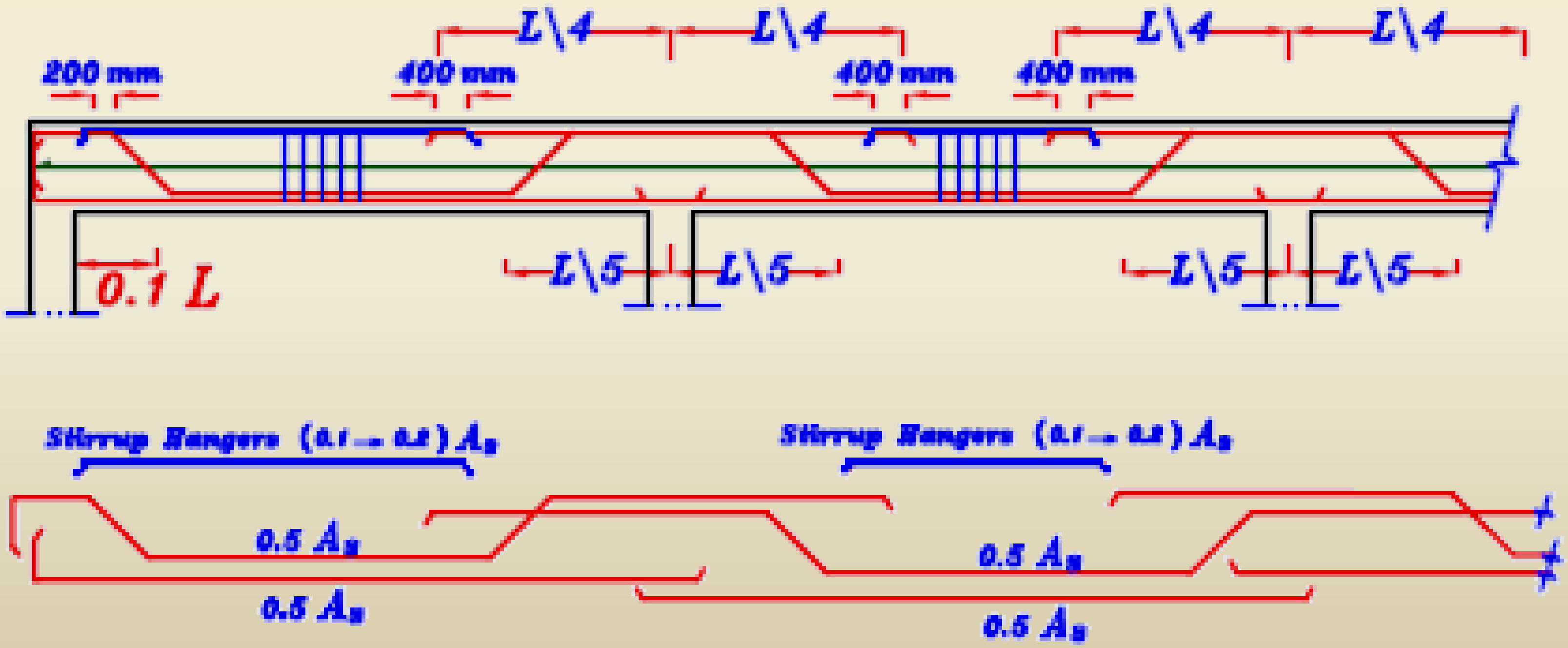




إستخدام اسياخ تسليح مكسحة
Using Bent Rebars

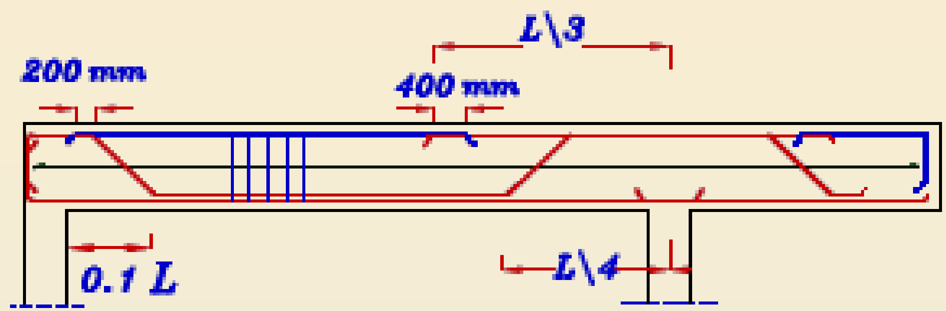
More than 2-spans Beam



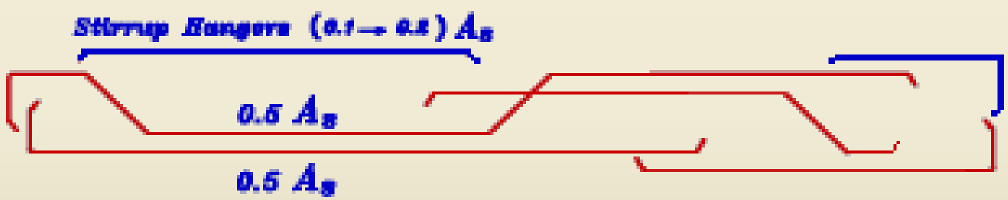


إستخدام اسياخ تسليح مكسحة
Using Bent Rebars

Cantilever Beam

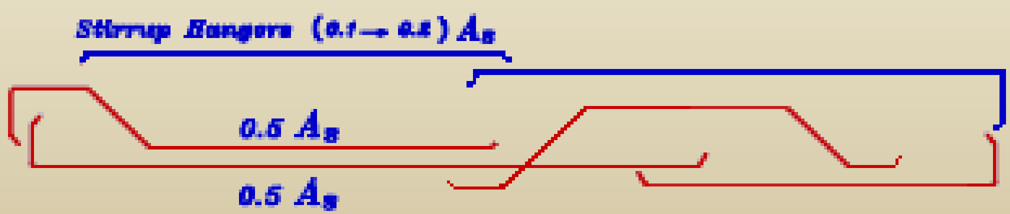


Case 1

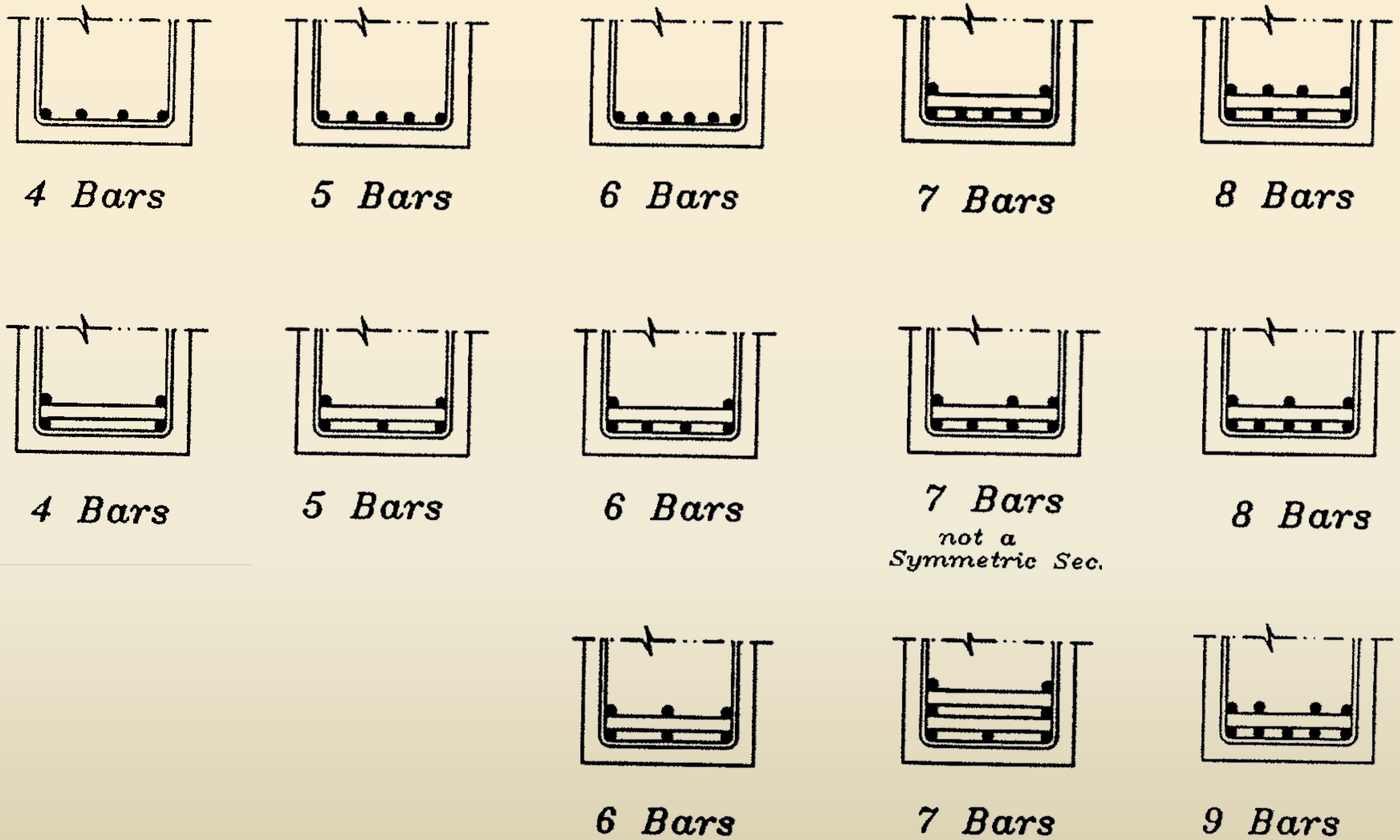


or

Case 2



كيفية وضع اسياخ التسليح داخل قطاع الكمرة



Example:

For the given plan it is required to:

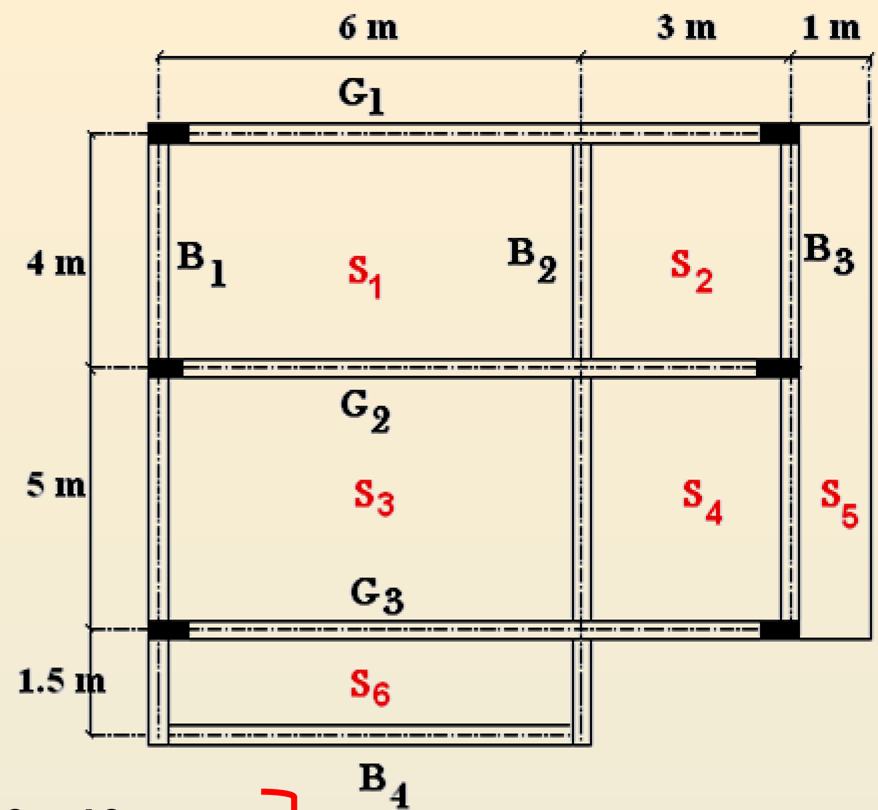
Calculate loads for slabs & Beams

Data:

FL.C = 150 kg/m^2

L.L = 300 kg/m^2

Steel Grade 360/520



Solution:

Slabs

To have slab thickness t_s

$S_1 \rightarrow t_s = 400/40 = 10$ cm

$S_2 \rightarrow t_s = 300/45 = 6.67$ cm

$S_3 \rightarrow t_s = 500/45 = 11.1$ cm

take $t_s = 12$ cm

D.L = (0.12 m * 2.5 t/m^3)+ 0.15 t/m^2 = 0.45 t/m^2

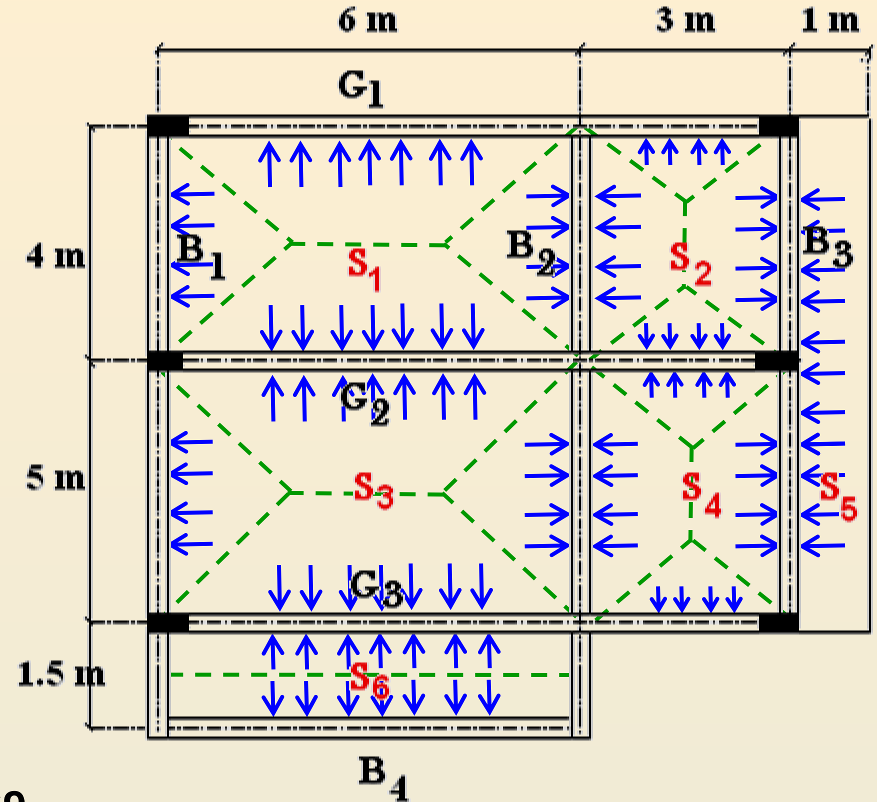
L.L = 0.3 t/m^2

$$Wu_s = 1.4 \times 0.45\ t/m^2 + 1.6 \times 0.3\ t/m^2 = 1.11\ t/m^2$$

For S_1 $r = \frac{6}{4} = 1.5$

→ **trapezoidal** $C_a = 0.67$ & $C_e = 0.85$

→ **triangle** $C_a = 1/2$ & $C_e = 2/3$



For S_2 $r = \frac{4}{3} = 1.33$

→ **trapezoidal** $C_a = 0.63$ & $C_e = 0.81$

→ **triangle** $C_a = 1/2$ & $C_e = 2/3$

For S_3 $r = \frac{6}{5} = 1.2$

→ **trapezoidal** $C_a = 0.582$ & $C_e = 0.769$

→ **triangle** $C_a = 1/2$ & $C_e = 2/3$

For S_4 $r = \frac{5}{3} = 1.67$

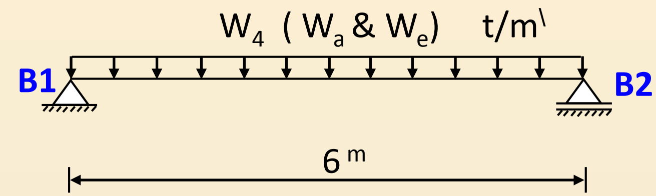
→ **trapezoidal** $C_a = 0.701$ & $C_e = 0.881$

→ **triangle** $C_a = 1/2$ & $C_e = 2/3$

Beams

B4 t_B = span / 10 = 600 / 10 = 60 cm

take t_B = 60 cm

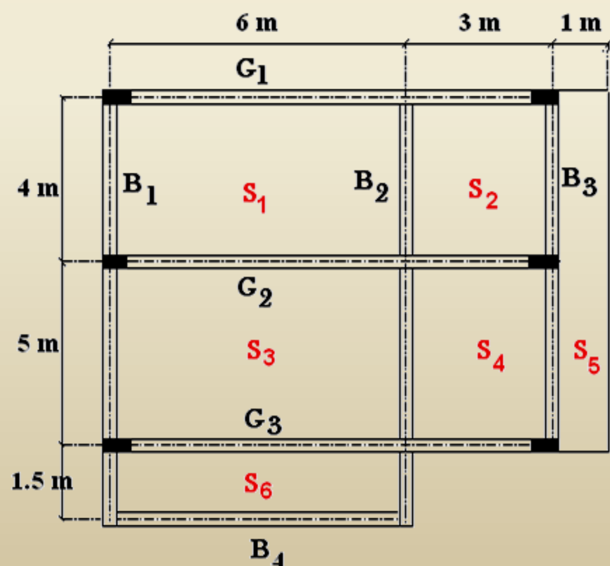


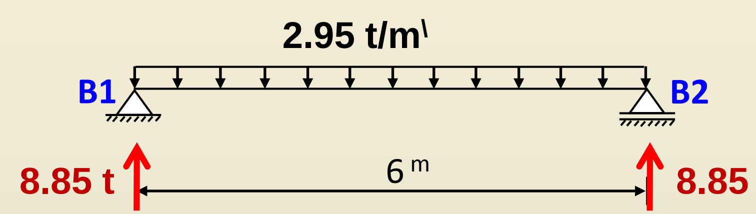
O. wt. of beam = 0.25 x 0.6 x 2.5 t/m³ = 0.375 t/m

Wall weight = W_{wall} = 0.25 (width) x 2.7 (height) x 1.8 (γ_{wall} = 1.2 – 1.8 t/m³) = 1.2 t/m\

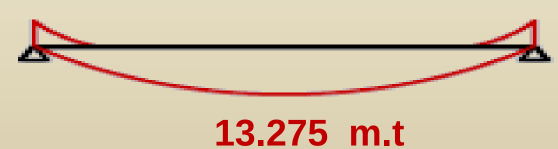
$$W_{a4} = W_{e4} = \left(Wu_s \ x \ \frac{L_s}{2} \right) + (1.4 \, x \, O.wt.) + (1.4 \, x \, W_{wall})$$

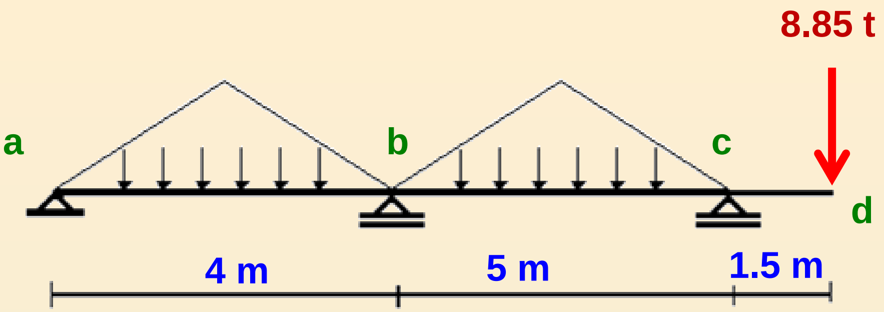
$$= \left(1.11 \, t/m^2 \ x \ \frac{1.5 \, m}{2} \right) + 1.4 \, x \, 0.375 \ t/m + 1.4 \, x \ 1.2 = 2.95 \ t/m'$$





B. M. D.





B1

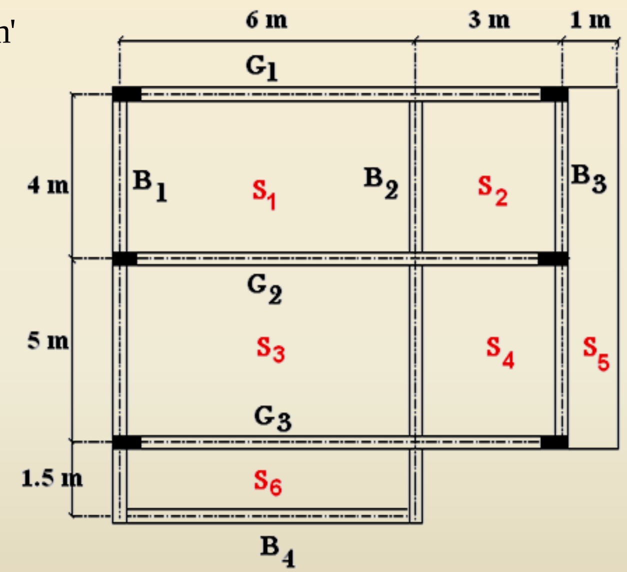
Part ab

$$W_{a1} = \left(Wu_s \ x \ \frac{L_s}{2} \ x \ C_a \right) + (1.4 \ x \ O.wt) + (1.4 \ x \ W_{wall})$$

$$= \left(1.11 \ t/m^2 \ x \ \frac{4 \ m}{2} \ x \ \frac{1}{2} \right) + (1.4 \ x \ 0.3125 \ t/m') + (1.4 \ x \ 1.2) = 3.228 \ t/m'$$

$$W_{e1} = \left(Wu_s \ x \ \frac{L_s}{2} \ x \ C_e \right) + (1.4 \ x \ O.wt) + (1.4 \ x \ W_{wall})$$

$$= \left(1.11 \ t/m^2 \ x \ \frac{4 \ m}{2} \ x \ \frac{2}{3} \right) + (1.4 \ x \ 0.3125 \ t/m') + (1.4 \ x \ 1.2) = 3.605 \ t/m'$$



Part bc

$$W_{a1} = \left(Wu_s \ x \ \frac{L_s}{2} \ x \ C_a \right) + (1.4 \ x \ O.wt) + (1.4 \ x \ W_{wall})$$

$$= \left(1.11 \ t/m^2 \ x \ \frac{5 \ m}{2} \ x \ \frac{1}{2} \right) + (1.4 \ x \ 0.3125 \ t/m') + (1.4 \ x \ 1.2) = 3.505 \ t/m'$$

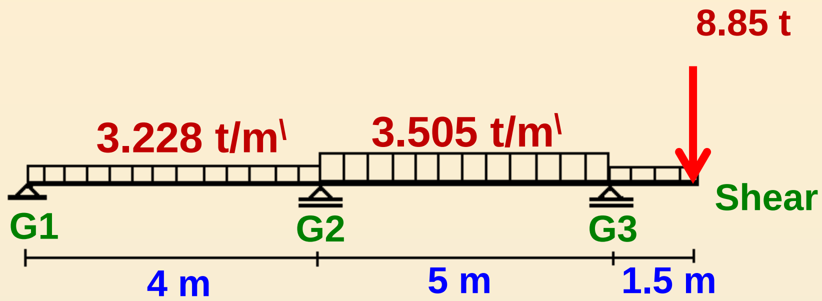
$$W_{e1} = \left(Wu_s \ x \ \frac{L_s}{2} \ x \ C_e \right) + (1.4 \ x \ O.wt) + (1.4 \ x \ W_{wall})$$

$$= \left(1.11 \ t/m^2 \ x \ \frac{5 \ m}{2} \ x \ \frac{2}{3} \right) + (1.4 \ x \ 0.3125 \ t/m') + (1.4 \ x \ 1.2) = 3.977 \ t/m$$

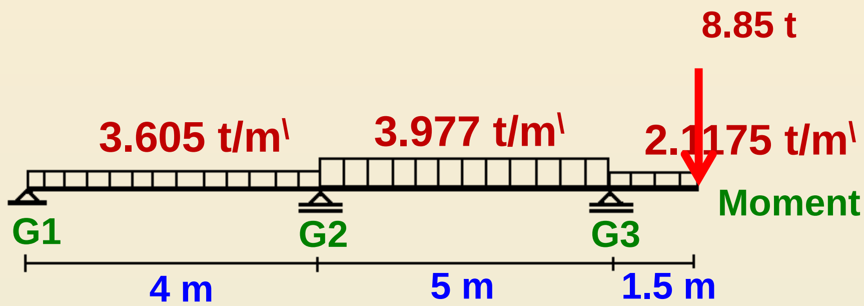
Part cd

$$W_{a3} = W_{e3} = 1.4 \ x \ 0.3125 \ t/m' + 1.4 \ x \ 1.2 = 2.1175 \ t/m'$$

B1



Moment Values of B1



$M_{supp.} = 9.514$ m.t or $W_1L_1^2/9$ $W_2L_2^2/9$

$P \times L_c + W_cL_c^2 / 2 = 15.66$ m.t

$W_cL_c^2 / 2$

B. M. D.

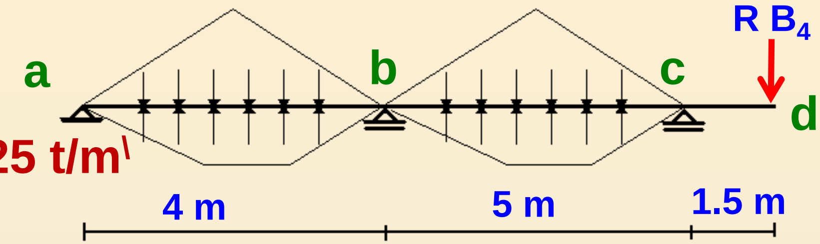
5.244 m.t $W_1L_1^2/11$ $W_2L_2^2/11$ 6.214 m.t

B2

t_B = span / 12 = 500 / 12 = 41.67cm

take $t_B = 50$ *cm*

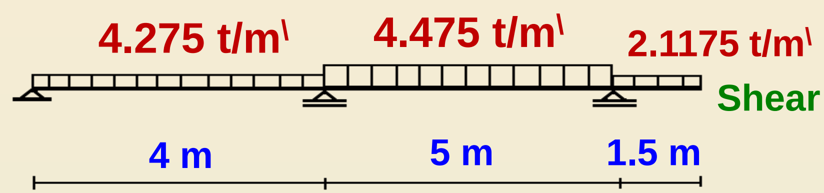
O. wt. of beam = 0.25 x 0.5 x 2.5 t/m³ = 0.3125 t/m\



Part ab

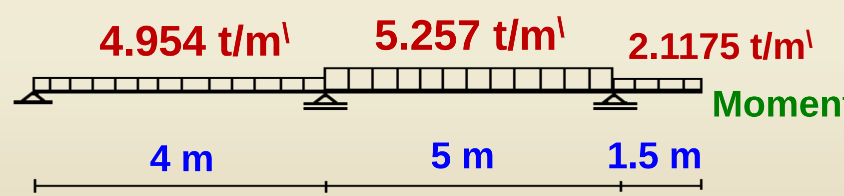
$$W_{a2} = \left(Wu_s \ \text{x} \ \frac{L_s}{2} \ \text{x} \ C_a \right) + \left(1.4 \, \text{x} \, \text{O.wt.} \right) + \left(1.4 \, \text{x} \, W_{wall} \right)$$

$$= \left(1.11 \, t/m^2 \ \text{x} \ \frac{4\,m}{2} \ \text{x} \ \frac{1}{2} \right) + \left(1.11 \ t/m^2 \ \text{x} \ \frac{3\,m}{2} \ \text{x} \ 0.63 \right) + 1.4 \, \text{x} \, 0.3125 \ t/m' + 1.4 \, \text{x} \ 1.2 = 4.276 \ t/m'$$



$$W_{e2} = \left(Wu_s \ \text{x} \ \frac{Ls}{2} \ \text{x} \ C_e \right) + \left(1.4 \ \text{x} \ \text{O.wt} \right) + \left(1.4 \ \text{x} \, W_{wall} \right)$$

$$= \left(1.11 \ t/m^2 \ \text{x} \ \frac{4\,m}{2} \ \text{x} \ \frac{2}{3} \right) + \left(1.11 \, t/m^2 \ \text{x} \ \frac{3\,m}{2} \ \text{x} \, 0.81 \right) + 1.4 \, \text{x} \, 0.3125 \ t/m' + 1.4 \, \text{x} \ 1.2 = 4.954 \ t/m'$$



Part bc

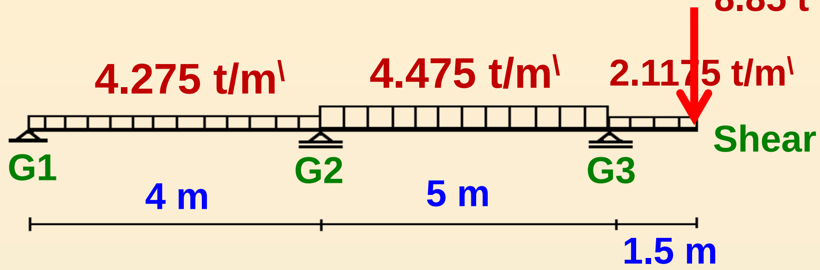
$$W_{a2} = \left(1.11 \, t/m^2 \ \text{x} \ \frac{5\,m}{2} \ \text{x} \ \frac{1}{2} \right) + \left(1.11 \ t/m^2 \ \text{x} \ \frac{3\,m}{2} \ \text{x} \ 0.582 \right) + 1.4 \, \text{x} \, 0.3125 \ t/m' + 1.4 \, \text{x} \ 1.2 = 4.475 \ t/m'$$

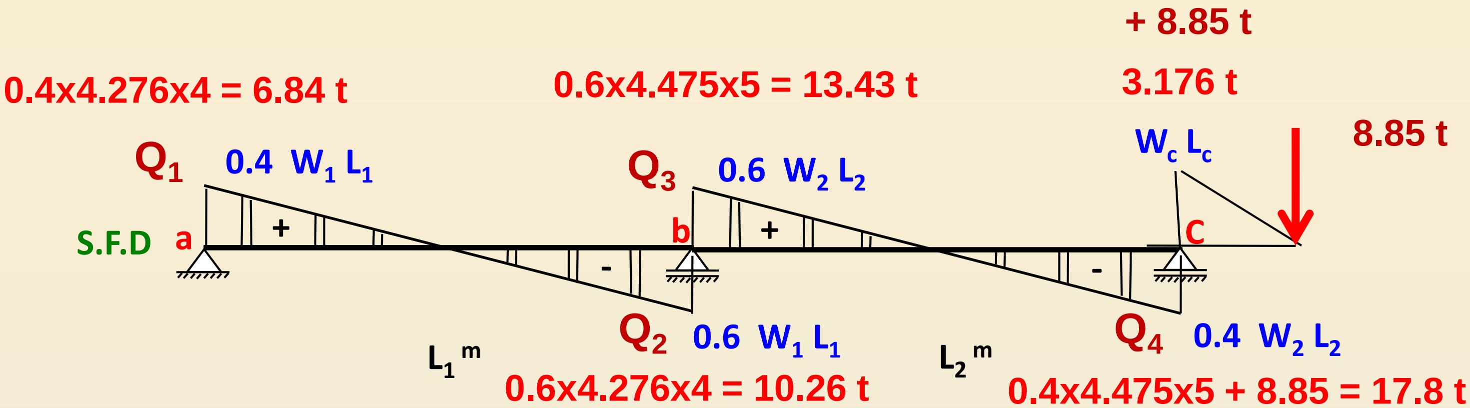
$$W_{e2} = \left(1.11 \ t/m^2 \ \text{x} \ \frac{4\,m}{2} \ \text{x} \ \frac{2}{3} \right) + \left(1.11 \, t/m^2 \ \text{x} \ \frac{3\,m}{2} \ \text{x} \, 0.769 \right) + 1.4 \, \text{x} \, 0.3125 \ t/m' + 1.4 \, \text{x} \ 1.2 = 5.257 \ t/m'$$

Part cd

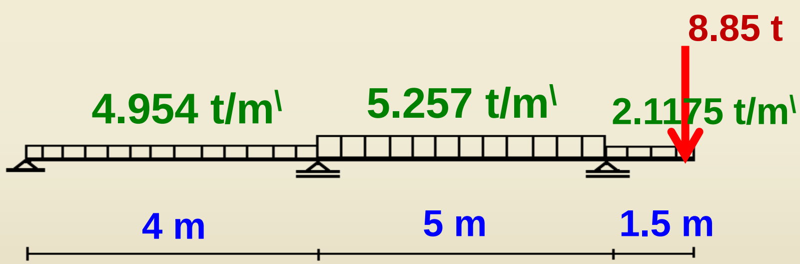
$$W_{a2} = W_{e2} = 1.4 \, \text{x} \, 0.3125 \ t/m + 1.4 \, \text{x} \ 1.2 = 2.1175 \ t/m'$$

B2





Moment Values of **B2**

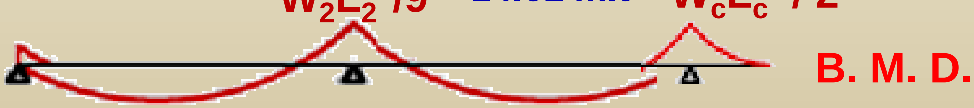


$M_{supp.}$ = 12.734 m.t or $W_1L_1^2/9$ = 8.81 m.t

$W_2L_2^2/9$ = 14.61 m.t

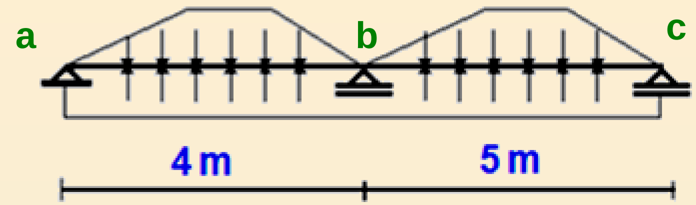
$P \times L_c + W_cL_c^2 / 2$ = 15.66 m.t

$W_cL_c^2 / 2$



6.656 m.t $W_1L_1^2/11$ $W_2L_2^2/11$ 10.67 m.t

B3



Part ab

$$W_{a3\ \text{Left Span}} = \left(Wu_s \ x \ \frac{L_s}{2} \ x \ C_a\right) + (1.4 \, x \, O.wt) + (1.4 \, x \, W_{wall})$$

$$= \left(1.11 \ t/m^2 \ x \ \frac{3\,m}{2} \ x \ 0.63\right) + (1.11 \ t/m^2 \ x \ 1\,m) + (1.4 \, x \, 0.3125 \, t/m') + (1.4 \, x \, 1.2) = 4.276 \ t/m'$$

$$W_{e3\ \text{Left Span}} = \left(Wu_s \ x \ \frac{L_s}{2} \ x \ C_e\right) + (1.4 \, x \, O.wt) + (1.4 \, x \, W_{wall})$$

$$= \left(1.11 \ t/m^2 \ x \ \frac{3\,m}{2} \ x \ 0.81\right) + (1.11 \ t/m^2 \ x \ 1\,m) + (1.4 \, x \, 0.3125 \, t/m') + (1.4 \, x \, 1.2) = 4.576 \ t/m'$$

Part bc

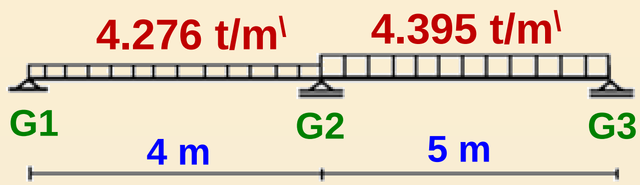
$$W_{a3\ \text{RightSpan}} = \left(Wu_s \ x \ \frac{L_s}{2} \ x \ C_a\right) + (1.4 \, x \, O.wt) + (1.4 \, x \, W_{wall})$$

$$= \left(1.11 \ t/m^2 \ x \ \frac{3\,m}{2} \ x \ 0.701\right) + (1.11 \ t/m^2 \ x \ 1\,m) + (1.4 \, x \, 0.3125 \, t/m') + (1.4 \, x \, 1.2) = 4.395 \ t/m'$$

$$W_{e3\ \text{RightSpan}} = \left(Wu_s \ x \ \frac{L_s}{2} \ x \ C_e\right) + (1.4 \, x \, O.wt) + (1.4 \, x \, W_{wall})$$

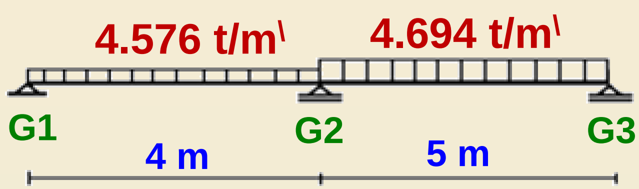
$$= \left(1.11 \ t/m^2 \ x \ \frac{3\,m}{2} \ x \ 0.881\right) + (1.11 \ t/m^2 \ x \ 1\,m) + (1.4 \, x \, 0.3125 \, t/m') + (1.4 \, x \, 1.2) = 4.694 \ t/m'$$

B3



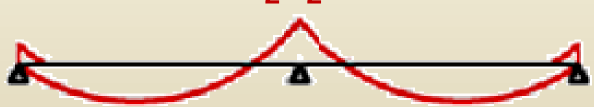
Shear

Moment Values of **B3**



Moment

$W_1L_1^2/9$ or $W_2L_2^2/9$ **13.04 m.t**

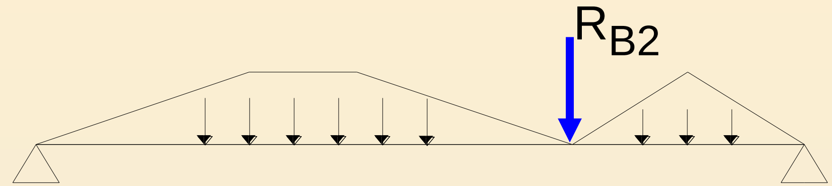


B. M. D.

$W_1L_1^2/11$ **6.656 m.t**

$W_2L_2^2/11$ **10.67 m.t**

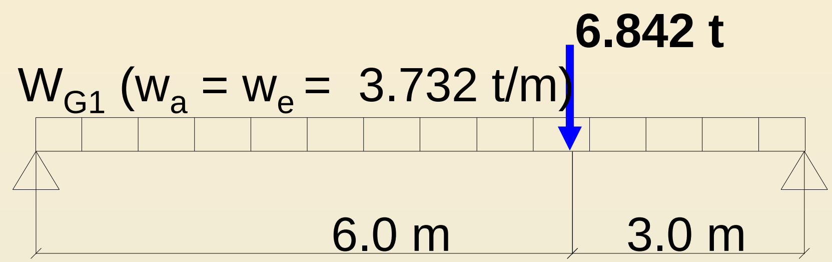
Main Beams (Girders)



t_G = span / 10 = 900 / 10 = 90 cm

take t_G = 90 cm

O. wt. of main beam/ girder = 0.25 x 0.9 x 2.5 t/m³ = 0.5625 t/m



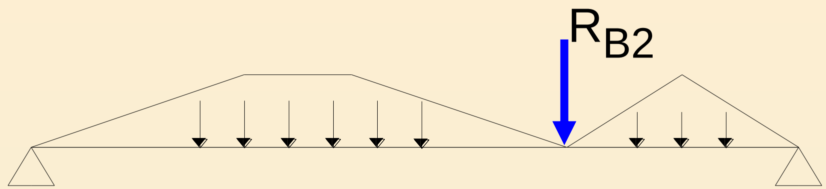
G1

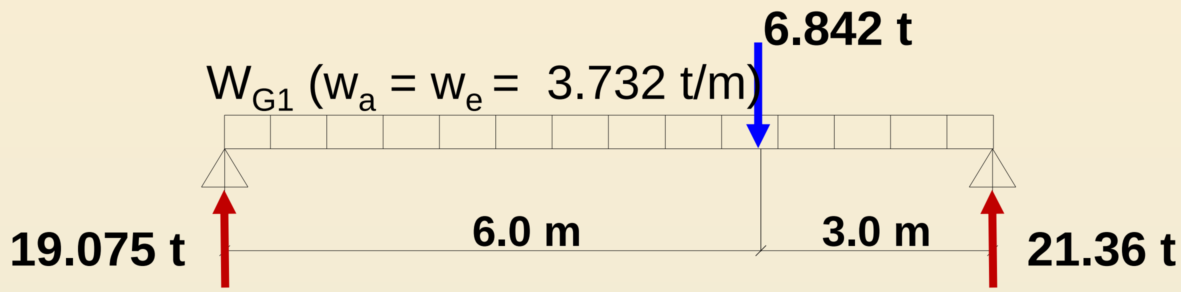
R_{B2} at point a = 0.4 x (4.267 t/m\\ x 4 m) = 6.842 t

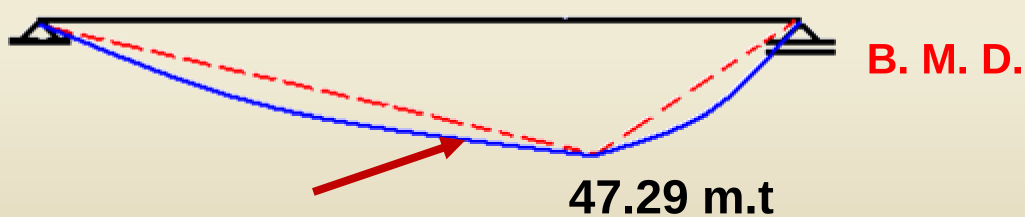
$$W_{G1} = W_{a\,G1} = W_{e\,G1} = \frac{\sum \text{Area}}{\text{Span}} + \left(1.4 \text{ x O. wt}\right) + \left(1.4 \text{ x } W_{wall}\right)$$

$$= \frac{1.11\ t/m^2 \text{ x } \left(\left[\left(\frac{2\,m + 6\,m}{2}\right) \text{ x } 2\,m\right] + \left[\frac{1}{2} \text{ x } 3\,m \text{ x } 1.5\,m\right]\right)}{9\,m} + \left(1.4 \text{ x } 0.5625\ t/m'\right) + \left(1.4 \text{ x } 1.2\right) = 3.732\ t/m'$$

G1

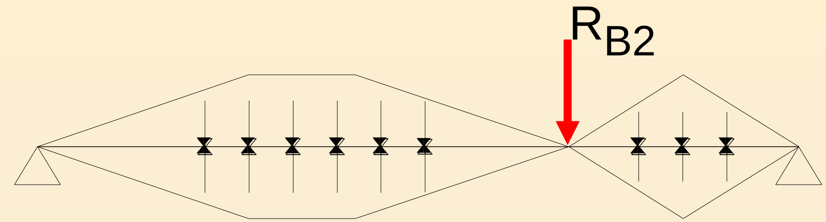


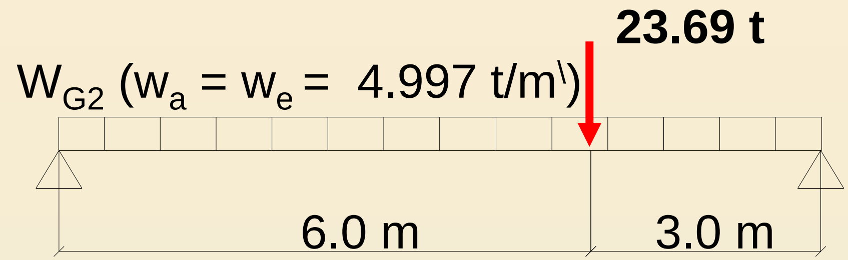




M_{max} = 48.75 m.t

Distance 5.11 m from left supp.





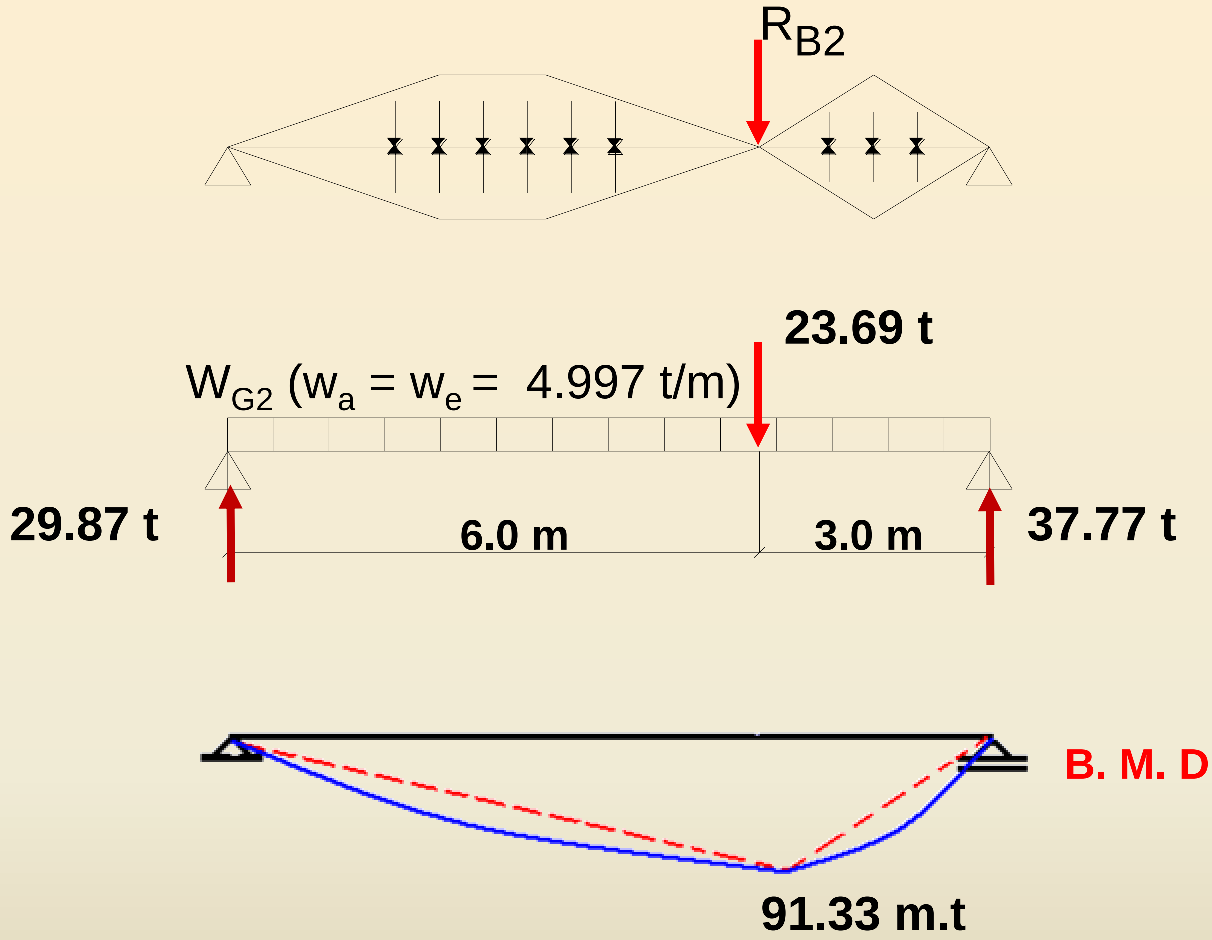
G2

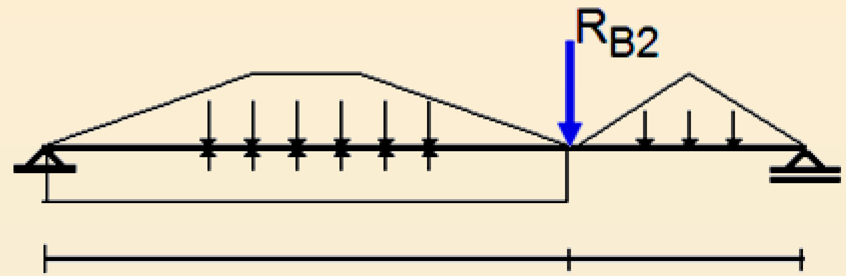
R_{B2} at point b = W_{a2} * L = 4.276 t/m\ x 4 m + 4.475 t/m\ x 5 m = 23.69 t

$$W_{a\,G2} = W_{a\,G2} = W_{e\,G2} = \frac{\sum \text{Area}}{\text{Span}} + \left(1.4 \text{ x O.wt}\right) + \left(1.4 \text{ x } W_{wall}\right)$$

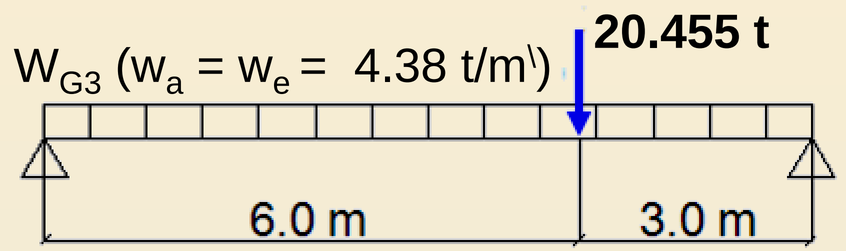
$$= \frac{1.11\ \text{t/m}^2 \text{ x } \left(\left[\left[\left(\left[\frac{2\text{ m}+6\text{ m}}{2}\right] \text{ x } 2\text{ m}\right) + \left[\frac{1\text{ m}+6\text{ m}}{2}\right] \text{ x } 2.5\text{ m}\right] + \left[\left(\frac{1}{2} \text{ x } 3\text{ m x } 1.5\text{ m}\right) \text{x } 2\right]\right]\right)}{9\text{ m}} + \left(1.4 \text{ x } 0.5625\ \text{t/m'}\right) + \left(1.4 \text{ x } 1.2\right) = 4.884\ \text{t/m'}$$

G2





G3



R_{B2} at point c = 0.4 x W L + P + M/L = 6.842 t

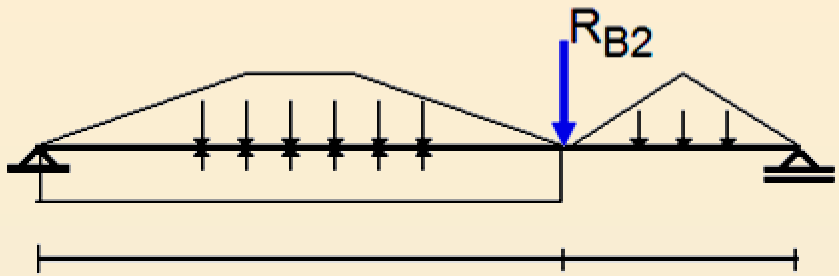
R_{B2} at point c = 0.4 x 4.475 x 5 + 8.85 + (8.85x1.5 + (2.1175 x ($L_c^{\,2}$ /2))/5) = 20.455 t

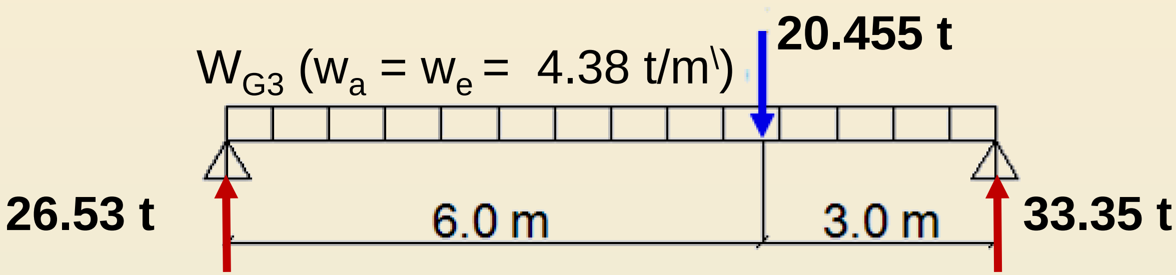
$$W_{G3} = W_{a\,G3} = W_{e\,G3} = \frac{\sum Area}{Span} + (1.4 \text{ x O.wt}) + (1.4 \text{ x } W_{wall})$$

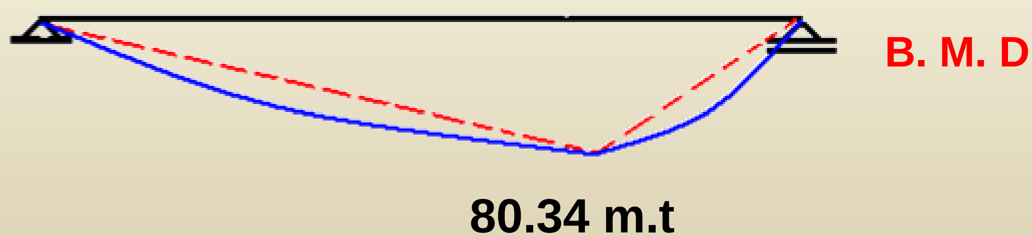
$$= \frac{1.11\, t/m^2 \text{ x } \left(\left[\left(\frac{1\,m + 6\,m}{2} \right) \text{ x } 2.5\,m \right] + \left[\frac{1}{2} \text{ x } 3\,m \text{ x } 1.5\,m \right] + \left[\frac{1.5}{2} \text{ x } 6\,m \right] \right)}{9\,m} + (1.4 \text{ x } 0.5625\ t/m') + (1.4 \text{ x } 1.2)$$

$$= 4.38\ t/m'$$

G3







Moment Values of beams