CONSTRUCTION OF BULDINGS

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Buildings :

Is a set of mainly gravity loads of different components of the structure with out neglecting other types of force. •

*types of buildings :

1.Bearing walls

2.Beam – column

3.Combination

1.Bearing wall :

Properties : •

1.load mode :slab>wall>foundation •

2.high cost . •

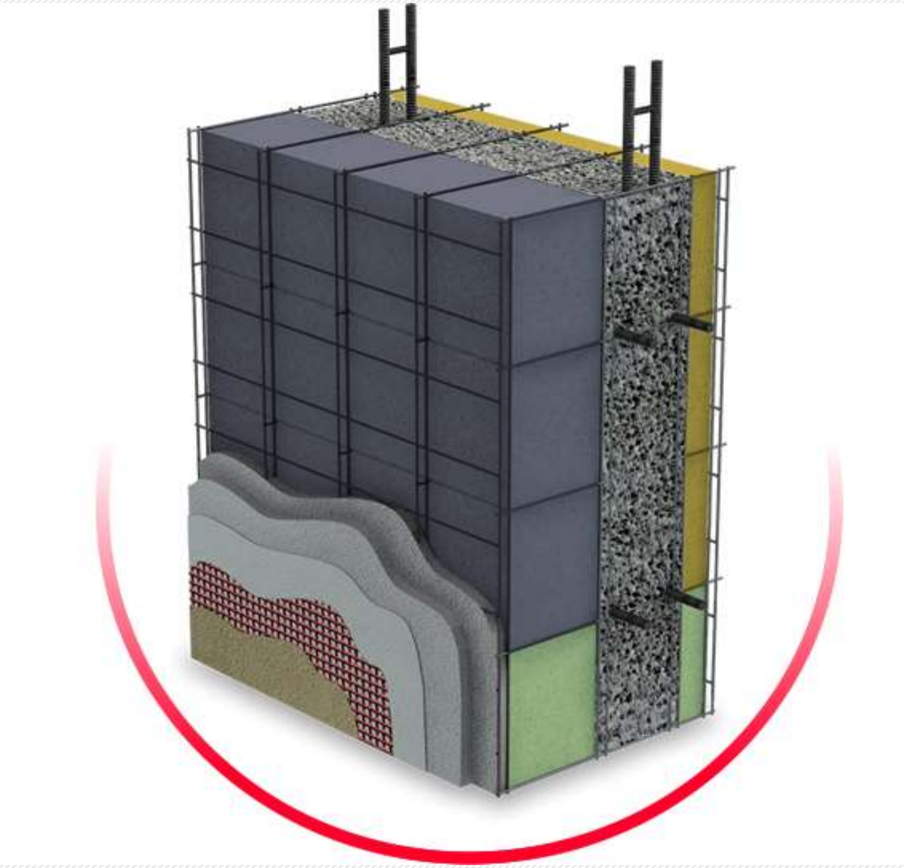
3.high durability •

4.high dead load. •

5. high cost •

6. a lot time and work •

7. Limited for small number of stories • building.



Some illustrations for bearing wall :

Before concrete molding

After

2. Beam – column :

Properties:

1.Load mode :

slab>beam>column>foundation

2.Low cost .

3.Low dead load.

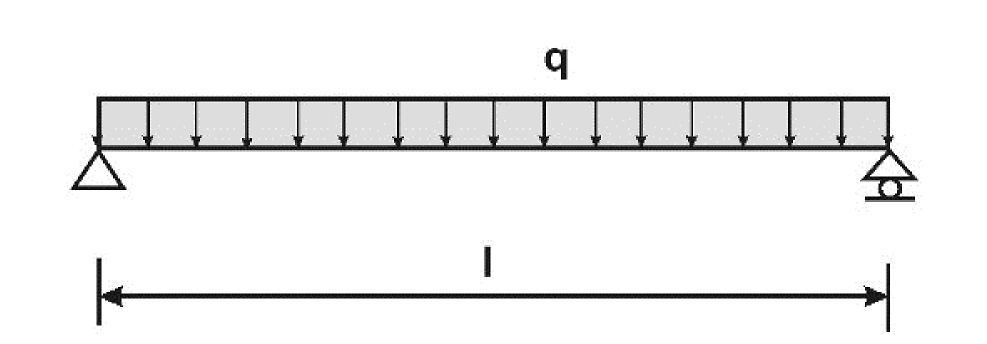
4.Low durability .

Note :

the column and the beam are preferred to be constructed at the same time .

Beam – columns types :

Skelton: small distance with low loads



Fixed: big distance with high loads

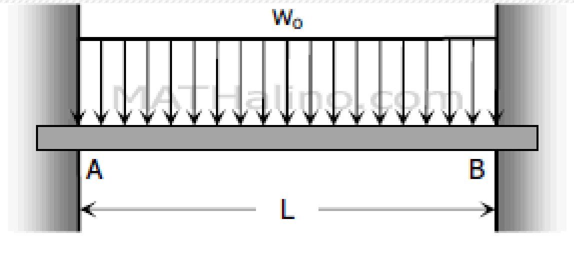


Figure P-735

3. Combination :

*Combines bearing wall + column beam system .
*commonly used in the stair.

Factor of safety :

- There are many equations , the use of each equations varies according to the location of the building and the natural conditions in the surrounding area .

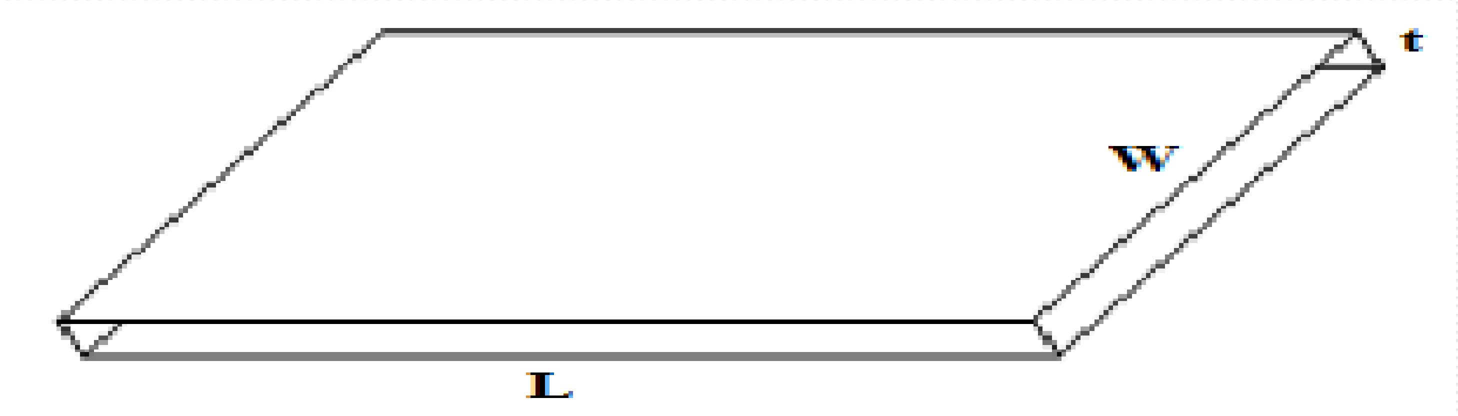
- Factor of safety equation in Jordan :
- Wu=1.2x(Dead load) + 1.6 x (live load)

➢Definition of slab

- **Slab:** is a structural member whose thickness is small compared to its length and width.

- Slab could be: reinforced concrete slab, timber slab or steel slab.

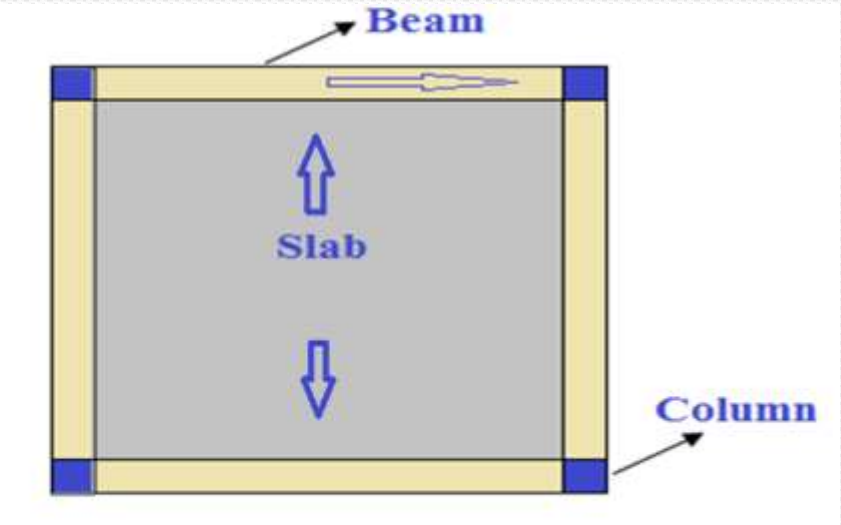
- Slabs are usually used in floors and roofs construction.

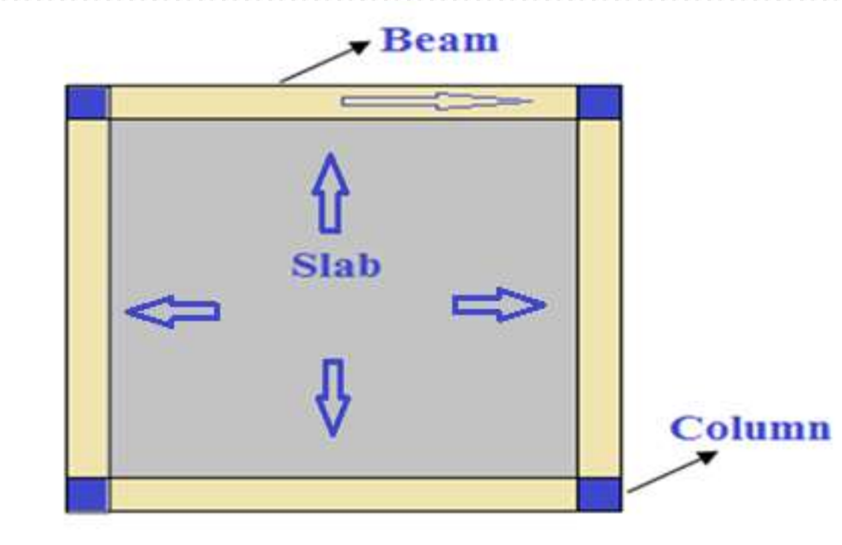


➢Classification of slabs

- According to transferred loads form slab to supporting beams and columns, slabs are classified to two types:

1. One way slab.
2. Two way slab.

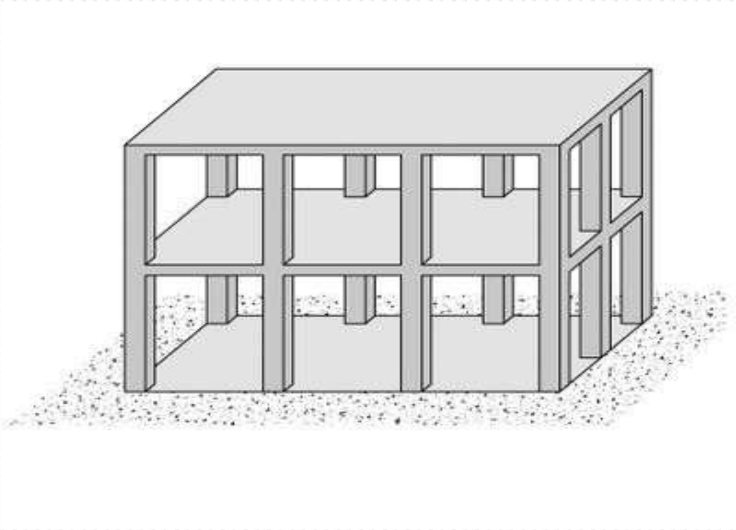




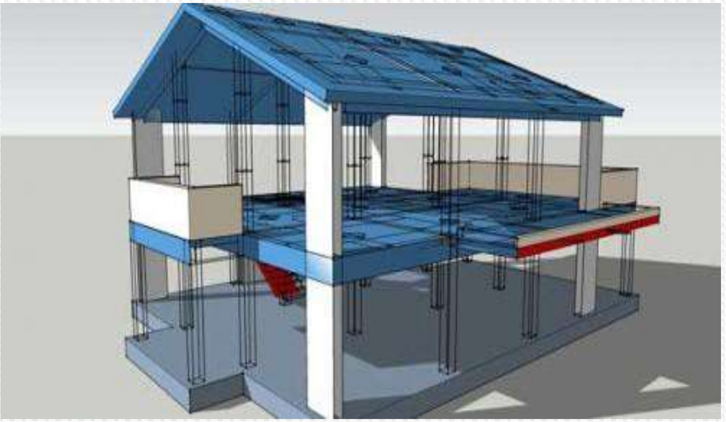
➢Classification of slabs

- According to the shape, slabs are classified to:

1. Flat slab



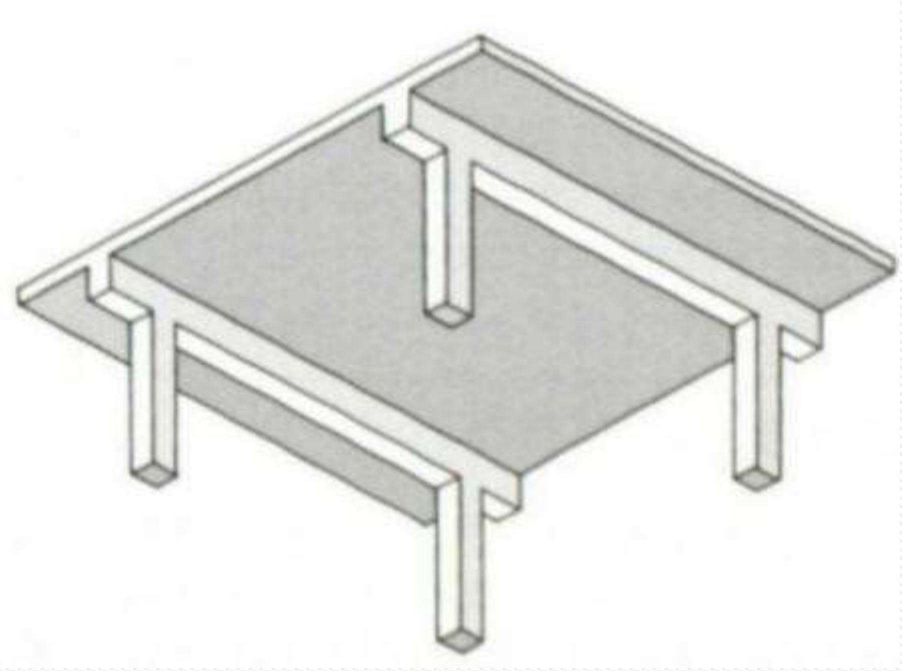
2. Inclined (Roof)
3. Dome

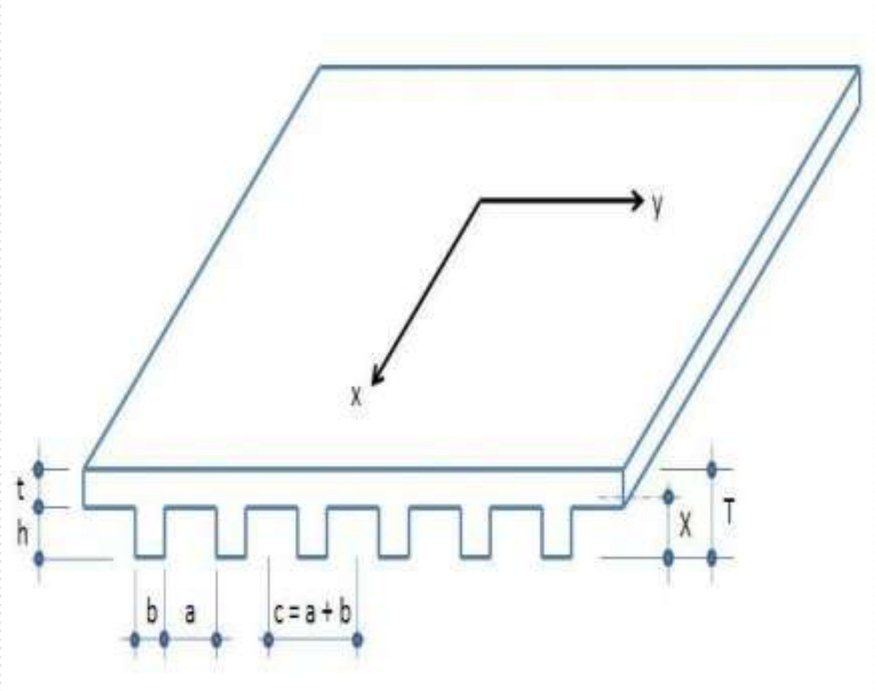


➢Classification of slabs

- Reinforced concrete slabs are classified to main two types:

1. Solid Slab
2. Hollow Slab



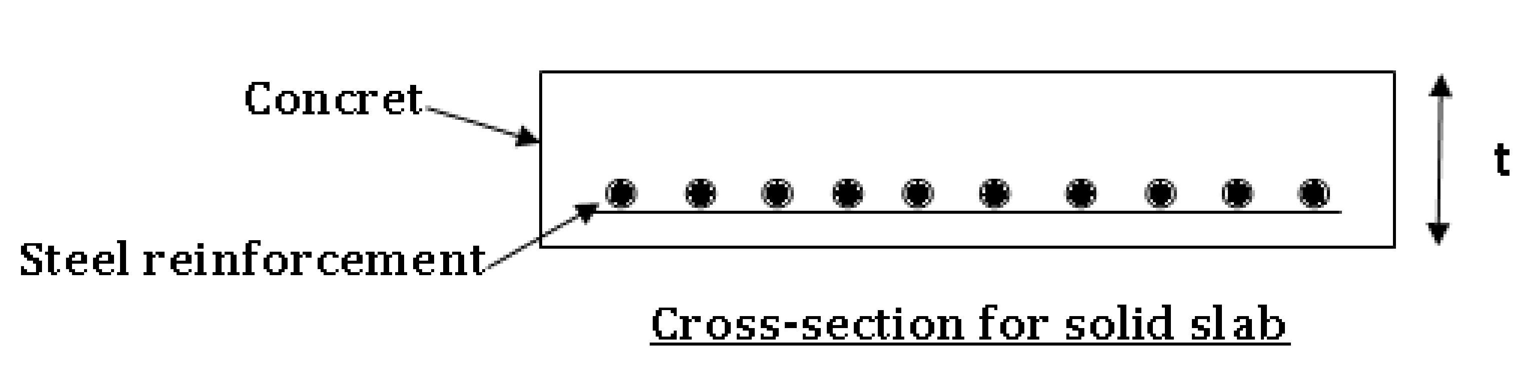


➢Solid Slab

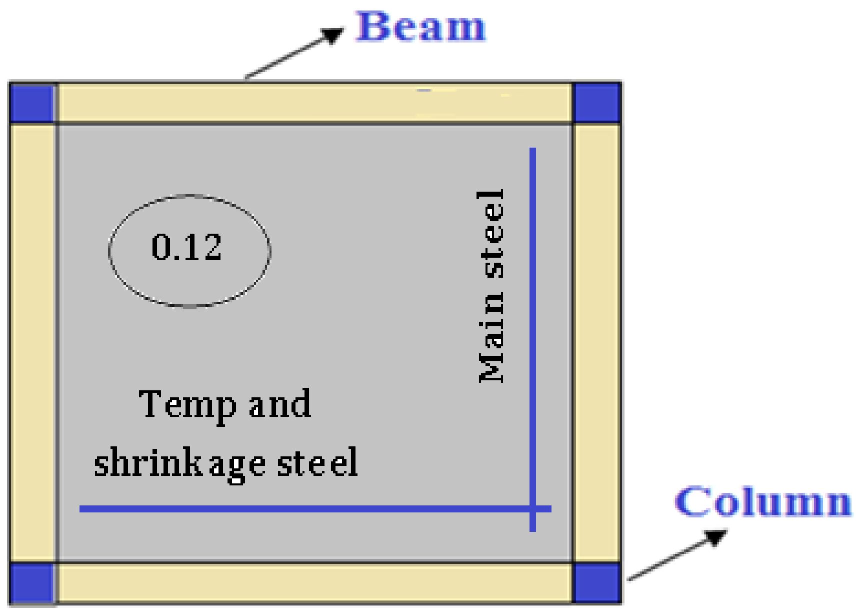
- Solid slab contains totally concrete and steel.

- Thickness of solid slab is a bout 12-15 cm.

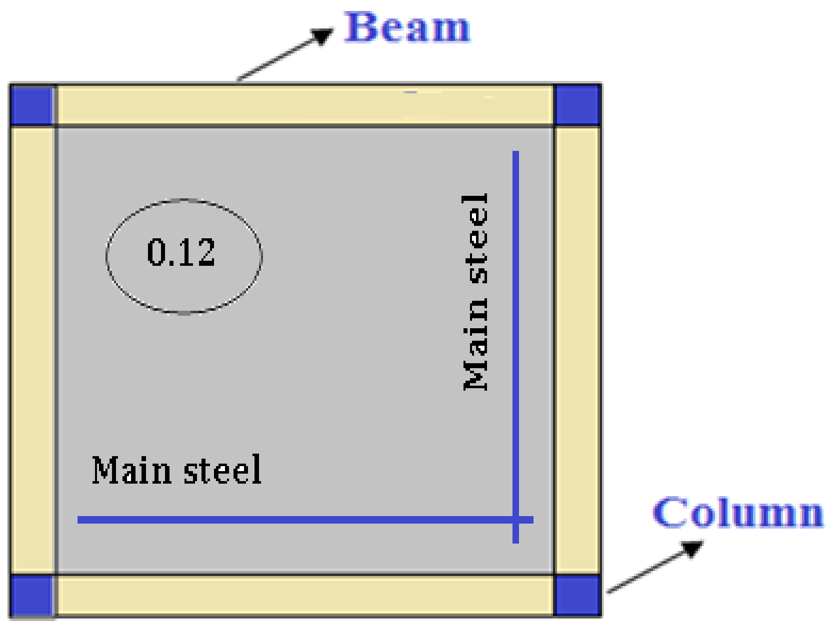
- Solid slab could be: one way slab or two way slab.



➢Solid Slab



Plan view for one way solid slab



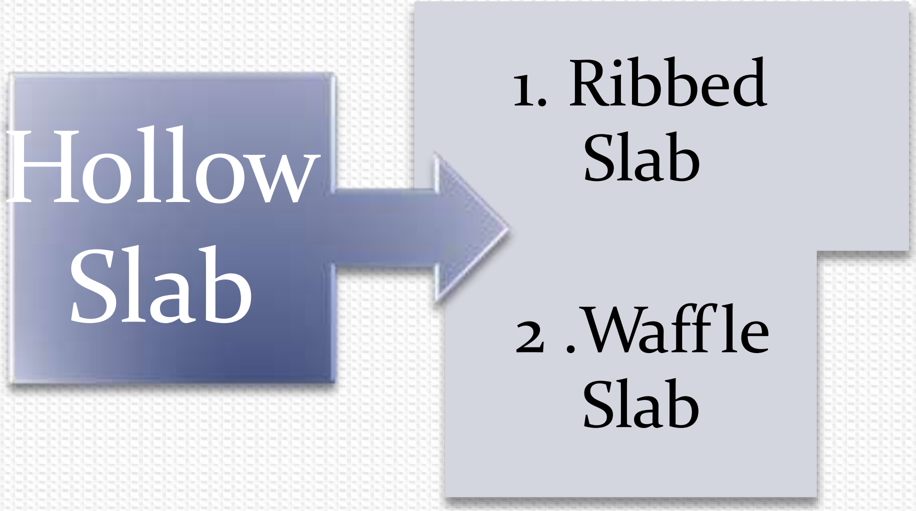
Plan view for two way solid slab

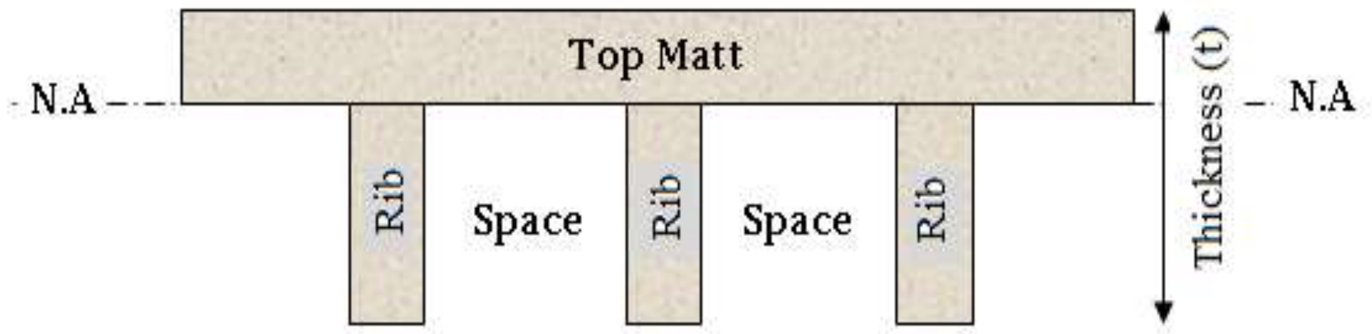
Solid Slab

- Disadvantages of solid slab:

1. High deflection and moment.
2. High own weight of slab with increasing the thickness of slab which cause heavy load from slab.
3. Heat and sound isolation are almost zero.
4. Not good for high rise building because of high dead load according to high own weight.

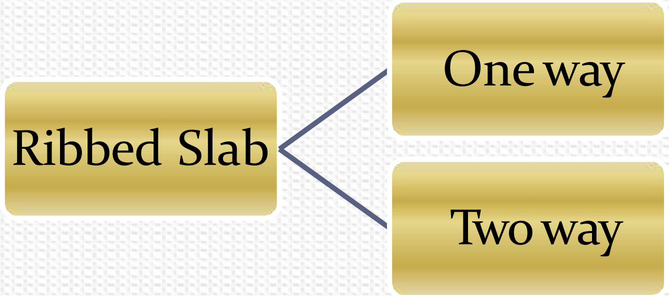
➢Hollow Slab

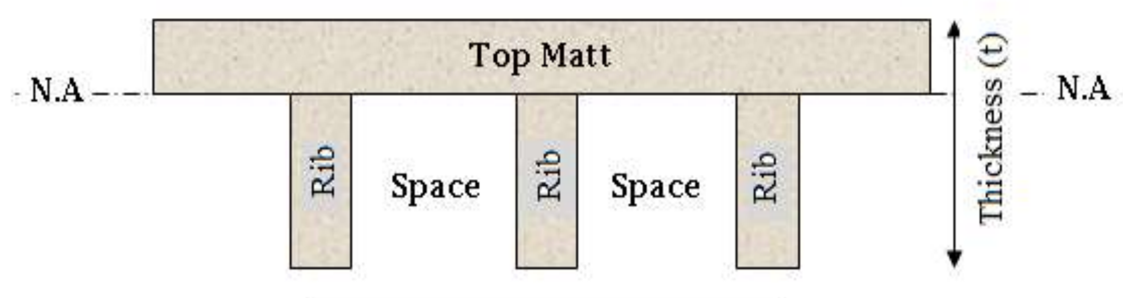




Cross-section for hollow slab

➢Hollow Slab : Ribbed Slab





Cross-section for hollow slab

- Space is filled with hollow block made from: concrete, clay or P.V.C.

- Top matt and rib are reinforced concrete members.

- Thickness of top matt is not standard or designed, it is within range (5-9 cm).

- Thickness of rib equals thickness of hollow block.

- Main reinforcement is placed in rib, and the steel in top matt is shrinkage and temp. reinforcement.

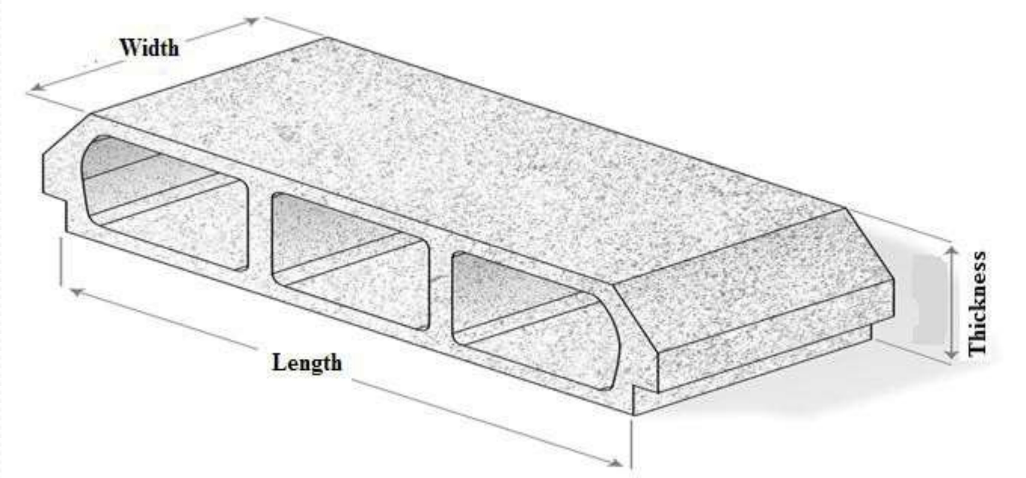
➢Hollow Slab : Ribbed Slab

- Hollow Block in Jordan:

Length = 40cm.

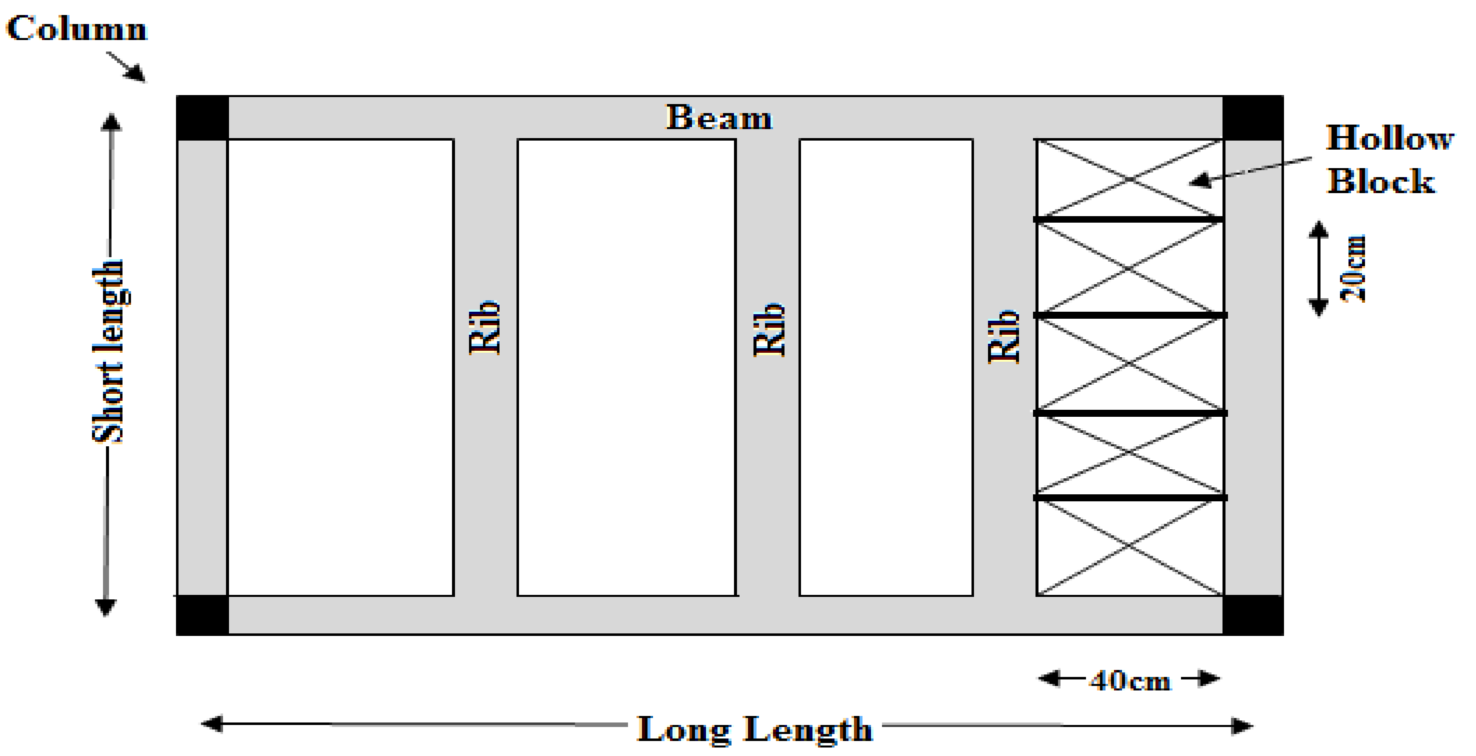
Width = 20cm.

Thickness = 18,24,… cm



➢Hollow Slab : Ribbed Slab

- One way ribbed slab: Ribs are constructed in one direction (short direction).



Plan view for one way ribbed

➢Hollow Slab : Ribbed Slab

- One Way Ribbed Slab:

➢Hollow Slab : Ribbed Slab

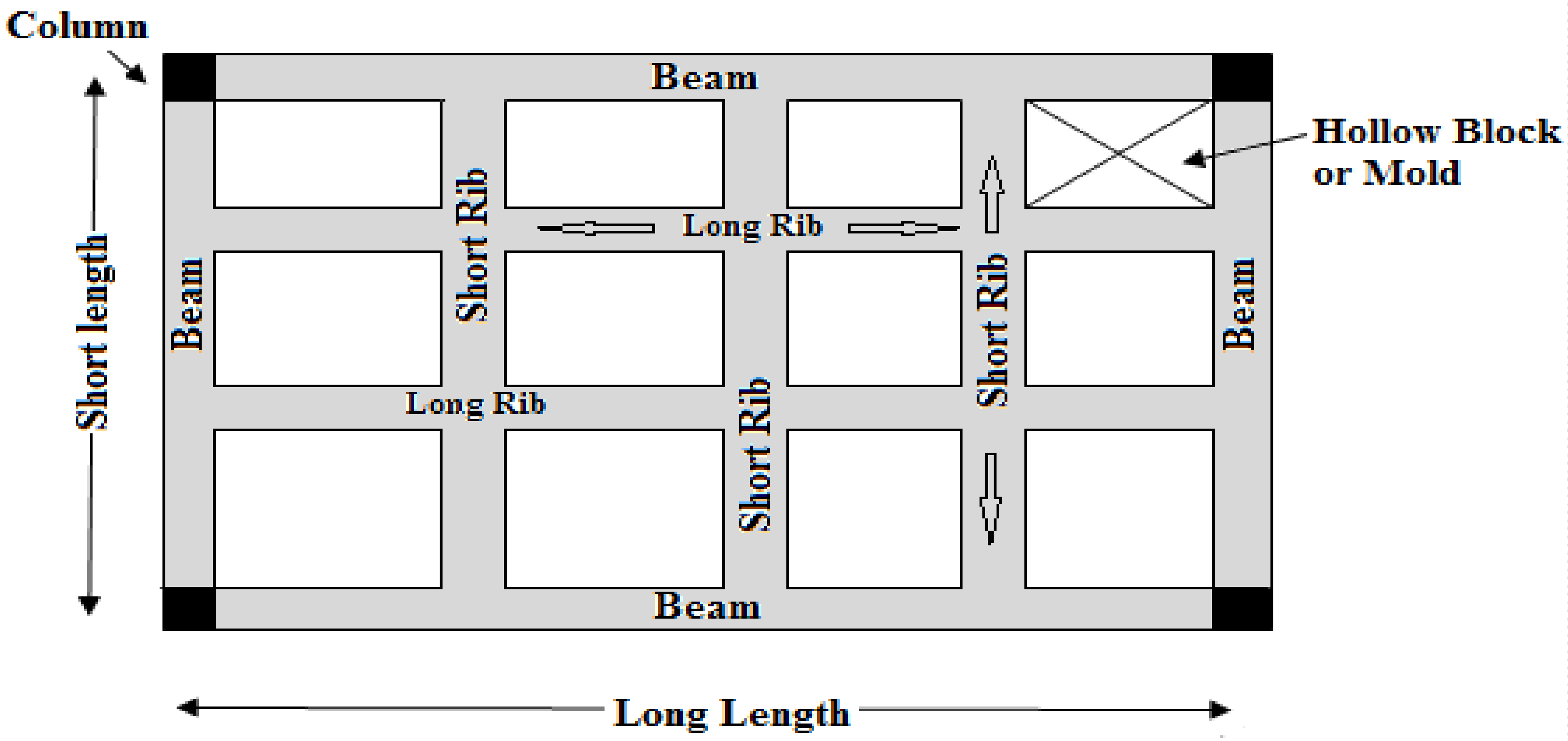
- One Way Ribbed Slab:

➢Hollow Slab : Ribbed Slab

- One Way Ribbed Slab:

➢Hollow Slab : Ribbed Slab

- Two Way Ribbed Slab:



Plan view for two ribbed slab

➢Hollow Slab : Ribbed Slab

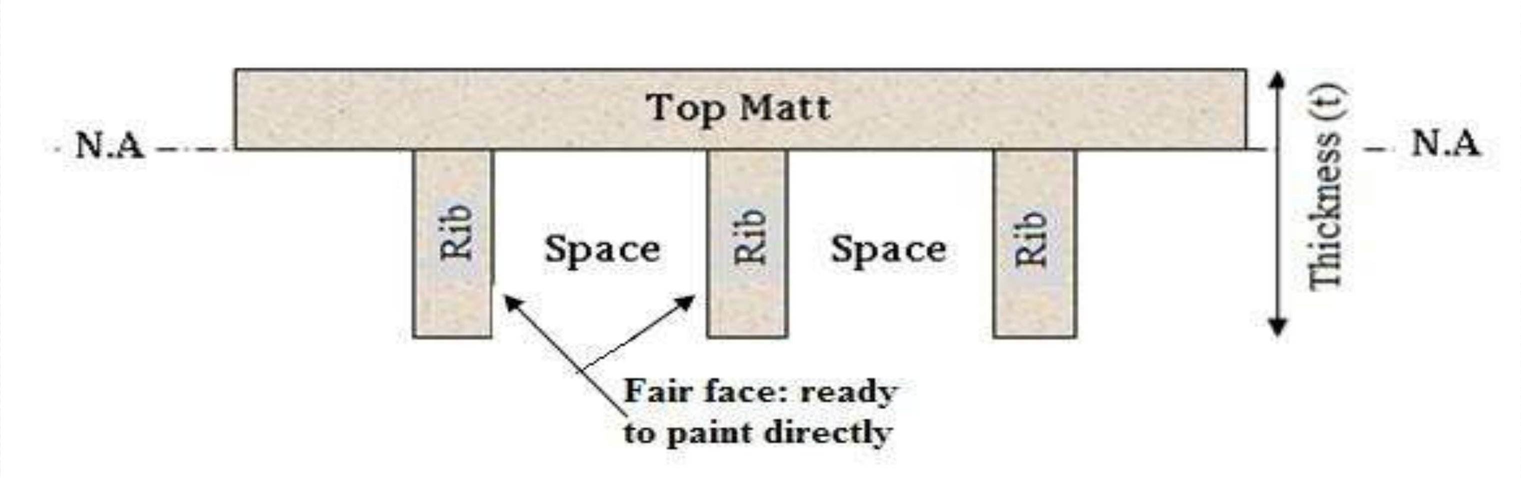
- Two Way Ribbed Slab:

➢Hollow Slab : Ribbed Slab

- Two Way Ribbed Slab:

➢Hollow Slab : Waffle Slab

- This type of slabs is two way hollow slab and used for big places for spans (9 – 30m).



- For space, using special molds from metal or polystyrene.

➢Hollow Slab : Waffle Slab

- Waffle slab is suitable for airports, library and any other bid place because of high absorption of sound.

➢Hollow Slab : Waffle Slab

➢Flat Slab

- Flat slab is a slab with constant thickness and it supports on columns directly.

Slab ⇒ Column ⇒ Foundations ⇒ Ground

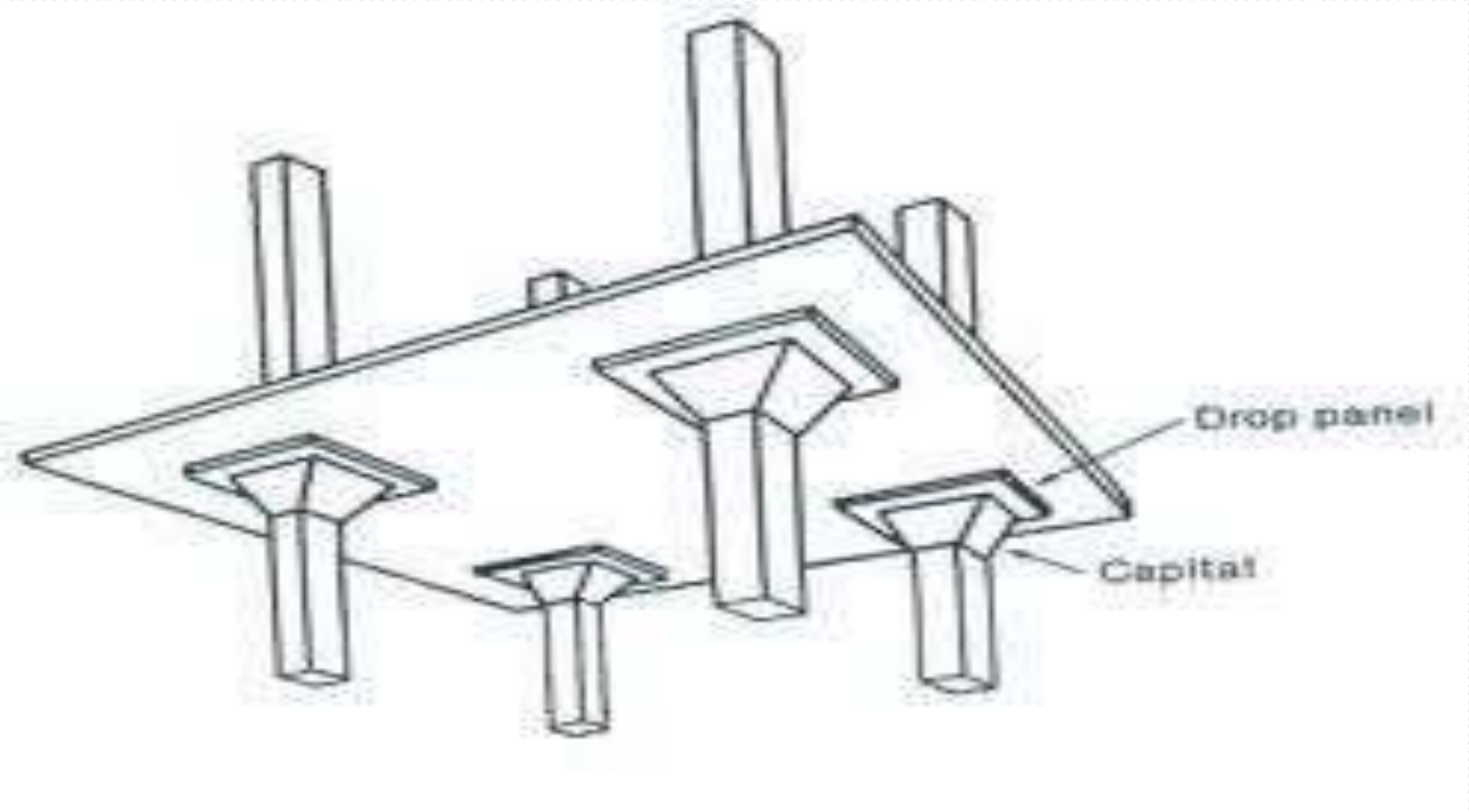
- This type of slabs are used for industrial places or large stories.

- Advantages:

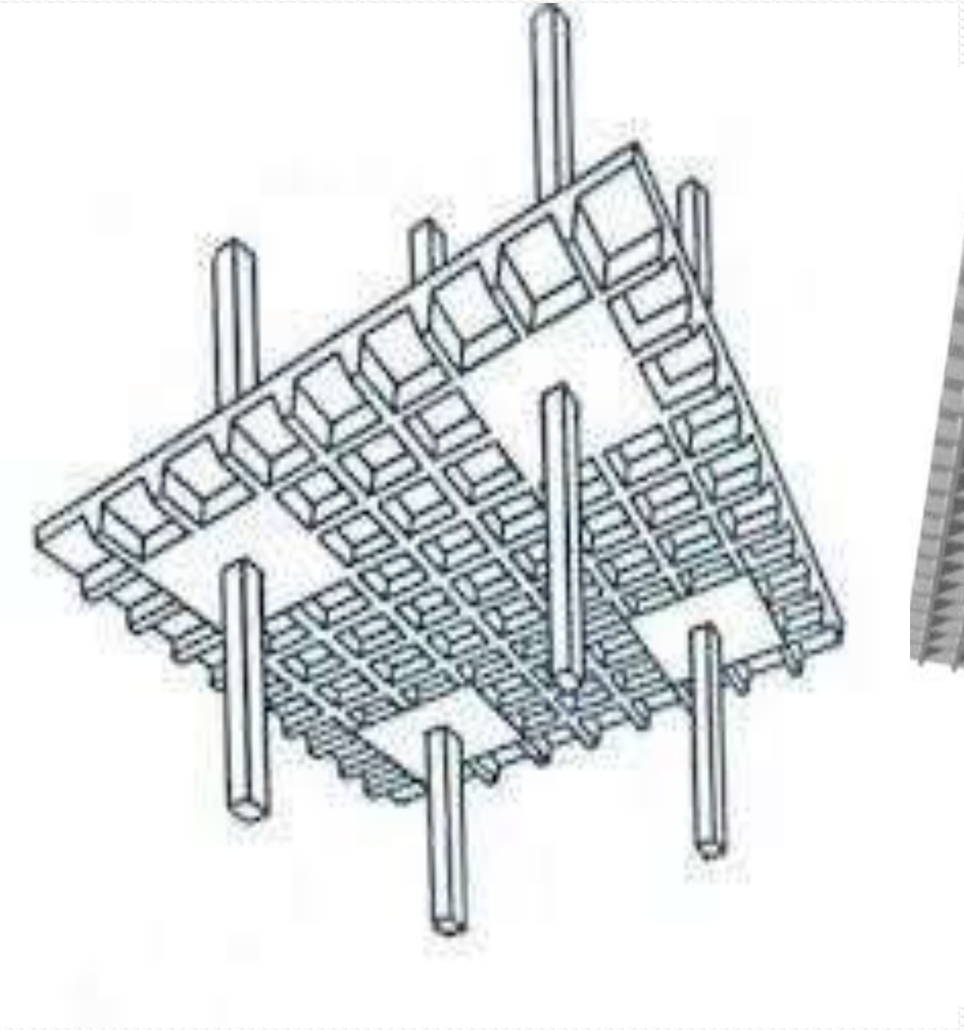
1. Simplified formwork.
2. Better lighting
3. Saving in clear light of the story and uniform surface for suspended sprinkles and head crane rails.

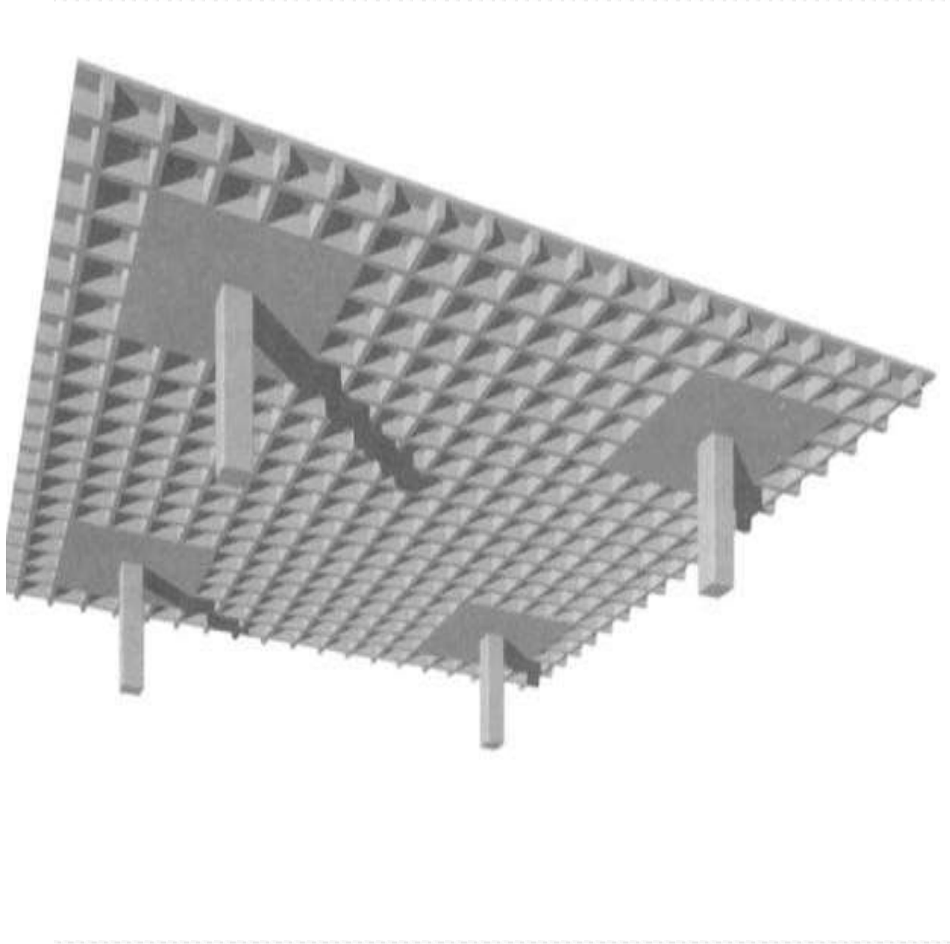
➢Flat Slab

Flat Slab	
Solid slab	Ribbed slab



➢Flat Slab





- Flat Slab

Solid slab :

*Consisting of reinforced concrete .

*of their disadvantages it possesses a high dead load .

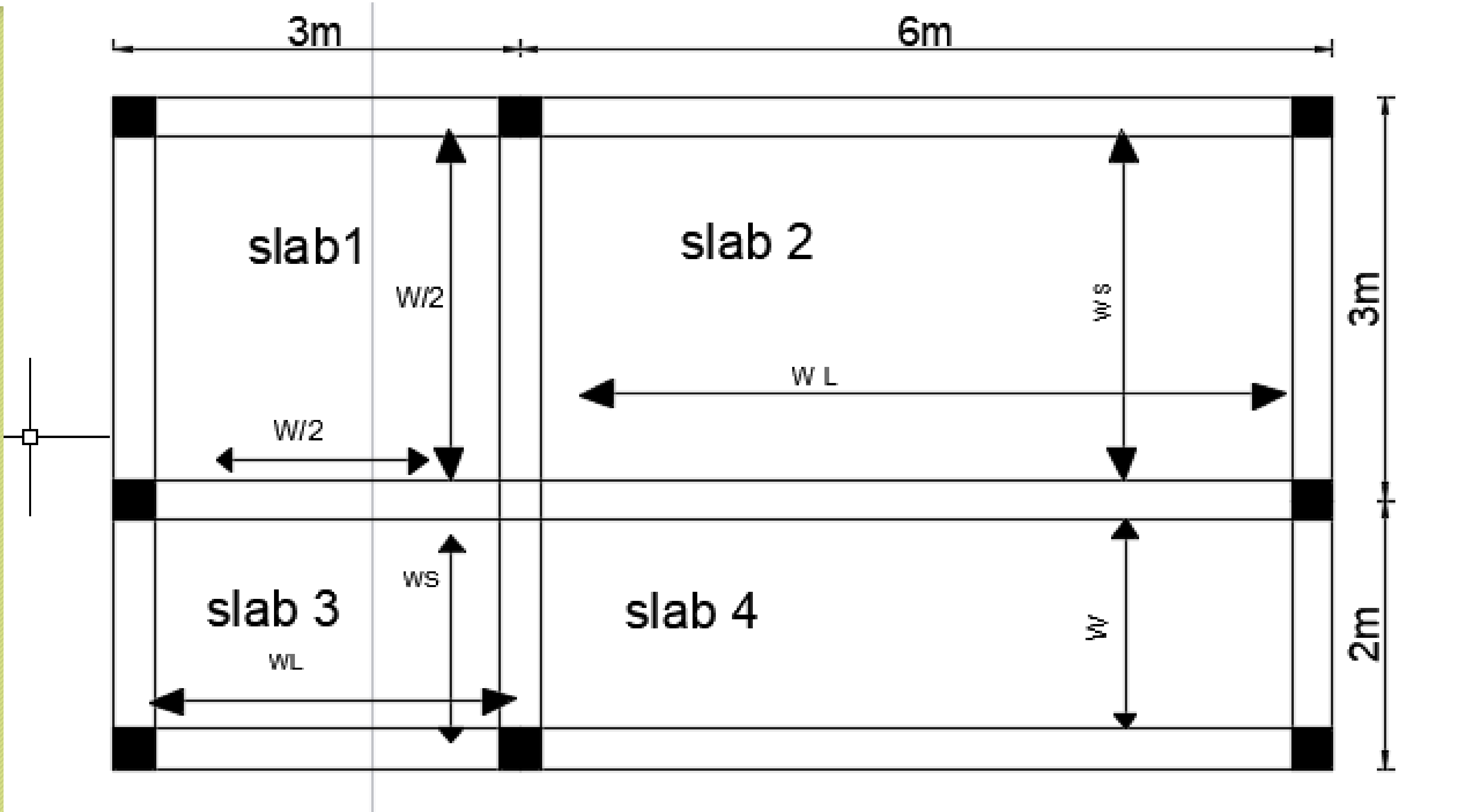
*tow way or one way depend on this equations :

R= Ll/Ls.

If (R>2) , so its one way .

If (R<=2) , so its tow way .

Example 1 : Select the types of slabs in this plane .



Solution :

- Slab 1 : r= LL/LS = (3/3) = 1 <=2
- Slab 1 > two way.

- Slab 2 : r=(6/3)=2<=2 : two way

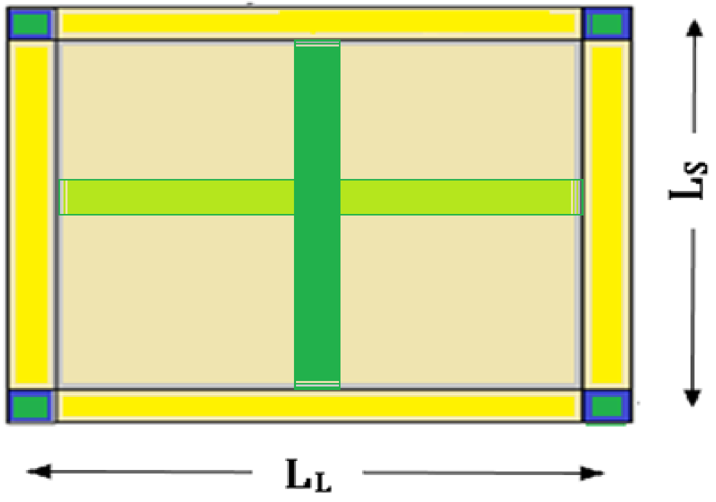
- Slab 3 : r=3/2 =1.5 <=2 : two way

- Slab 4 : r=6/2=3>2 : one way

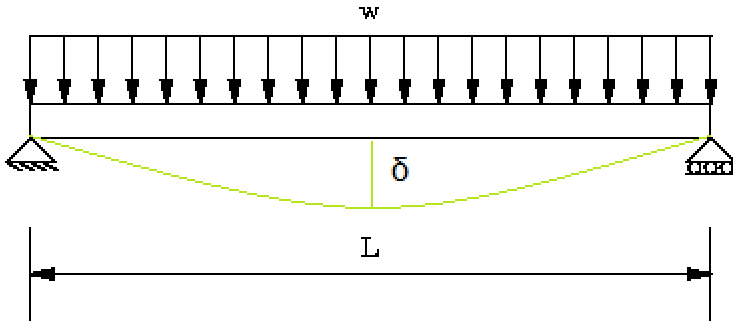
Note : steel bars diameters Ø8, Ø10,Ø12,Ø14 , 16 ,18 , 20.

➢One Way Solid Slab

- For one way solid slab: $r = \dfrac{L_L}{L_s} > 2$



- Max deflection for simply supported span with uniform load: $\delta_{\max} = \dfrac{5wL}{384EI}$



- If we take strip in short direction and another strip in long direction.

$$\delta_{\max(short)} = \delta_{\max(long)}$$

$$\frac{5 w_s L_s^4}{384EI} = \frac{5 w_L L_L^4}{384EI}$$

$$\frac{w_s}{w_L} = \frac{L_L^4}{L_s^4} \Rightarrow w_s = w_L \frac{L_L^4}{L_s^4}$$

➢One Way Solid Slab

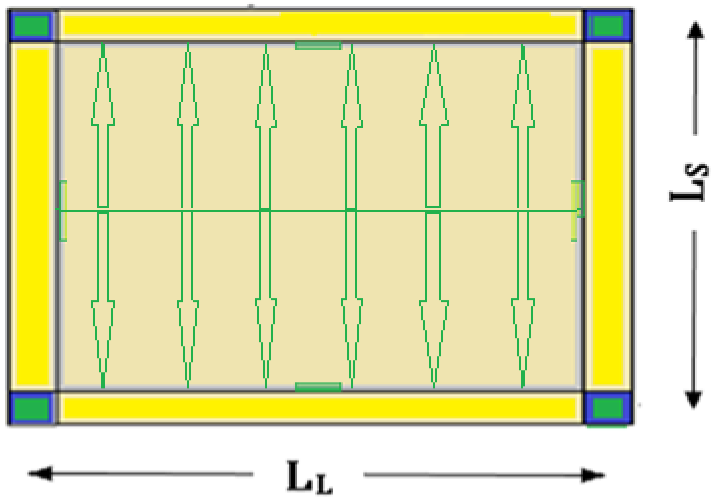
- For one way solid slab the total load transfer from slab to beams in one direction which is short direction.

- Example: for solid slab 15m*5m, determine the load in short direction:

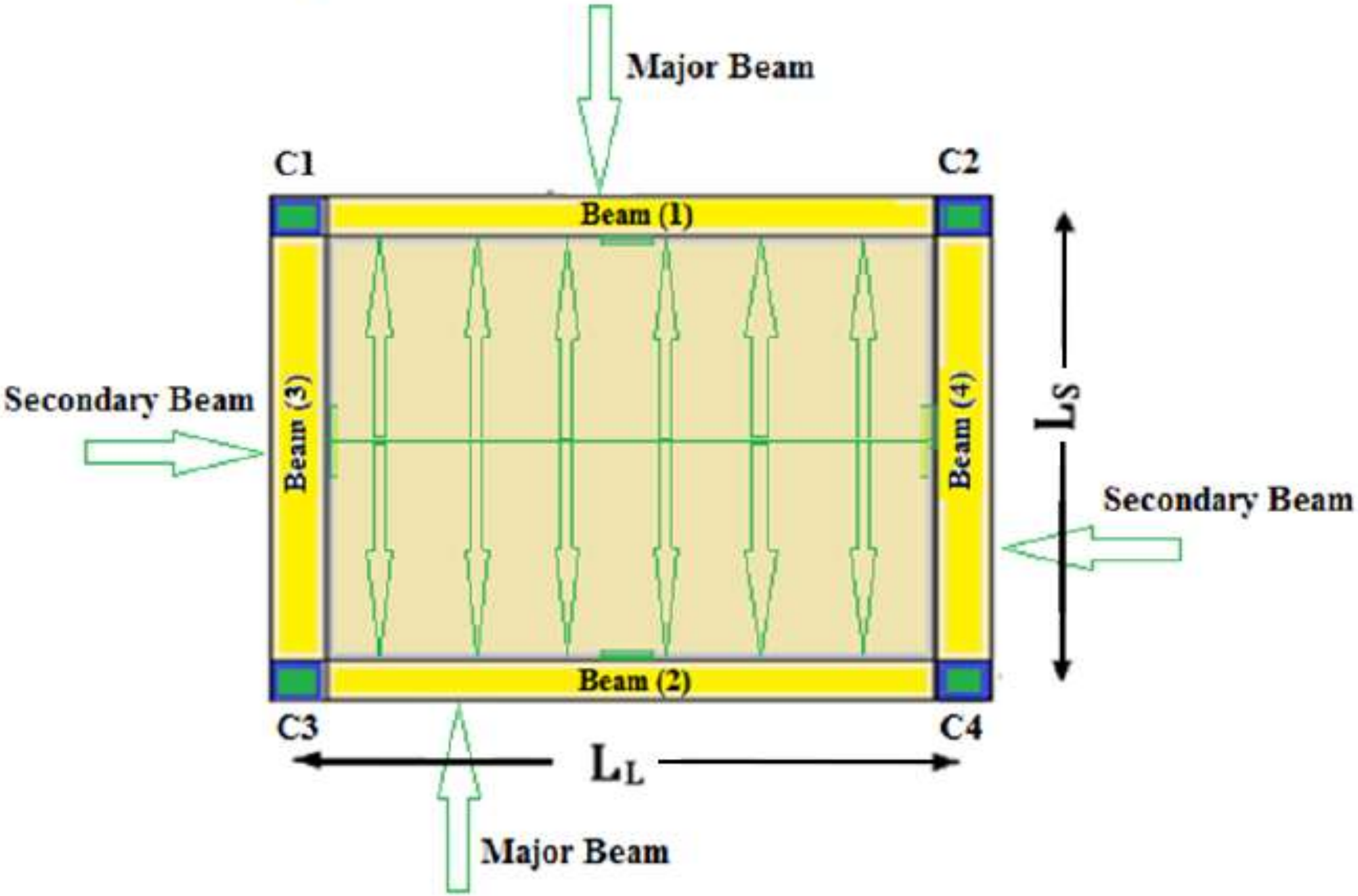
$$w_s = w_L \frac{L_L^4}{L_s^4} = w_L \frac{15^4}{5^4}$$

$$w_s = 81 w_L$$

- **<u>In one way solid slab the load transfer always in short direction :</u>** $w = w_s$



➢One Way Solid Slab

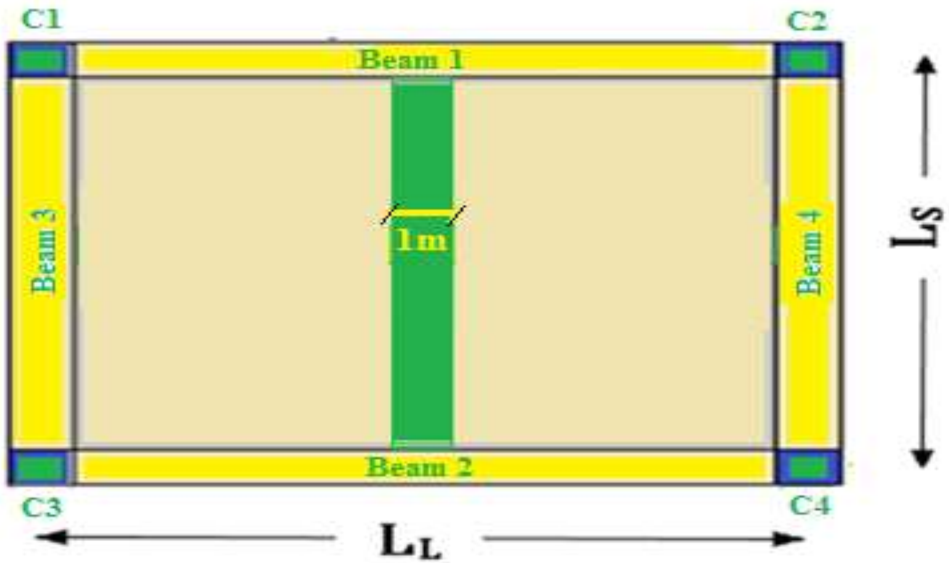


Analysis of One Way Solid Slab

- $r = \dfrac{L_L}{L_s} > 2$ ⟹ one way solid slab ⟹ $w = w_s$

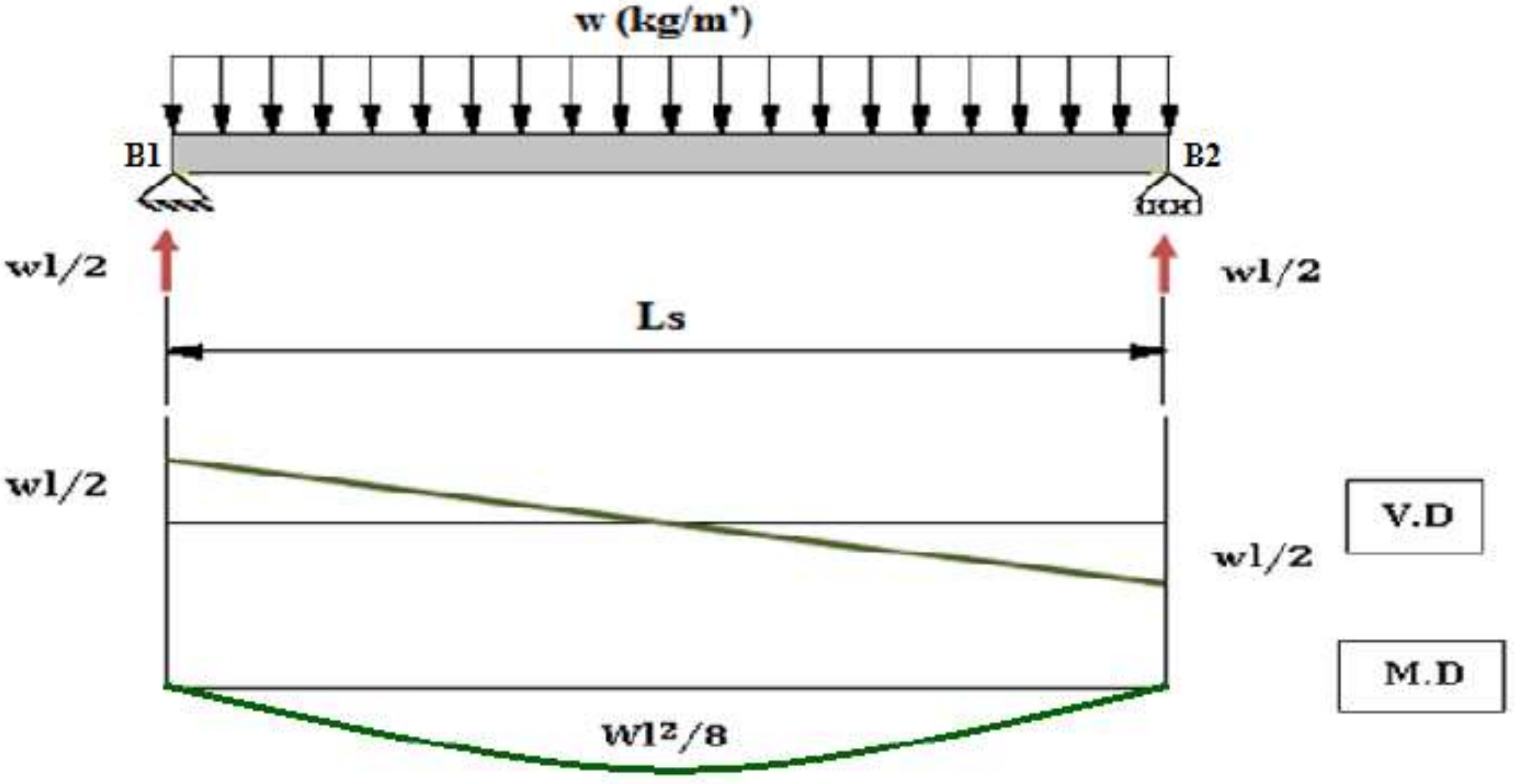
- Slab's Analysis procedure:

1. Take a strip with (1m) width parallel to short direction.
2. Confirm total load on slab (w) (load/area) to distributed load (load/m'): Load/m'= (load/m^2) * (1m)
3. Determine the max. shear and max. moment for simply supported span with distributed.



Step (1)

➢Analysis of One Way Solid Slab



$V_{max} = wl/2$

$M_{max} = wl^2/8$

Step (3)

➢Analysis of One Way Solid Slab

- Beam's Analysis procedure:

<u>** Analysis of major beams:</u>

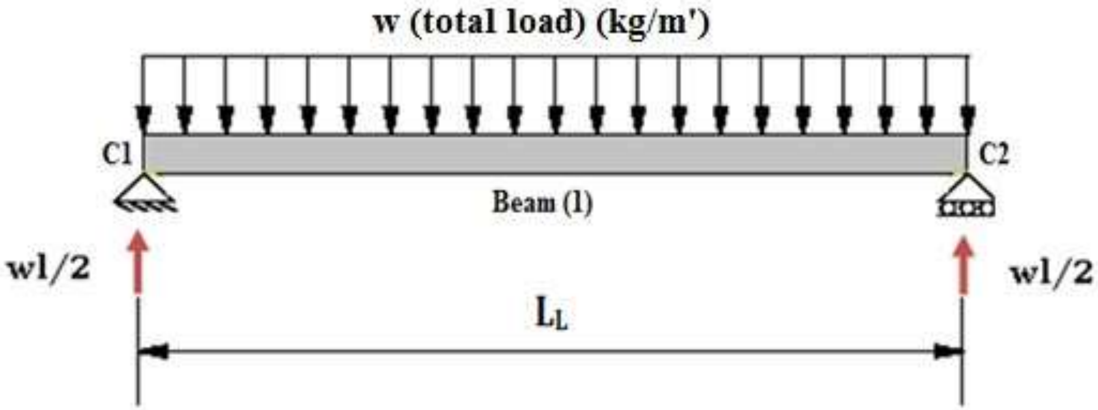
1. Load /m' from slab on beam1, beam2 = $\frac{wL_sL_L}{2L_L}$
2. Total load on beam1, beam2 = own weight of beam+ load from slab.
3. Determine max. shear and max moment:

$$V_{max} = \frac{wL}{2}$$

$$M_{max} = \frac{wL^2}{8}$$

$$where: w = \text{total load}$$

$$L = \text{length of beam}$$



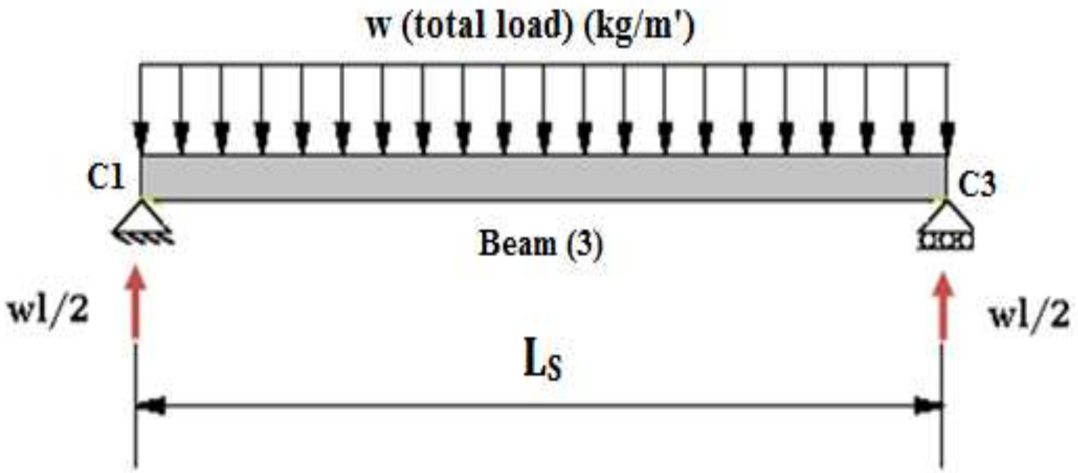
➢Analysis of One Way Solid Slab

- Beam's Analysis procedure:

<u>** Analysis of secondary beams:</u>

1. Total load on beam3, beam4 = own weight of beam

2. Determine max. shear and max moment:



$$V_{max} = \frac{wL}{2}$$

$$M_{max} = \frac{wL^2}{8}$$

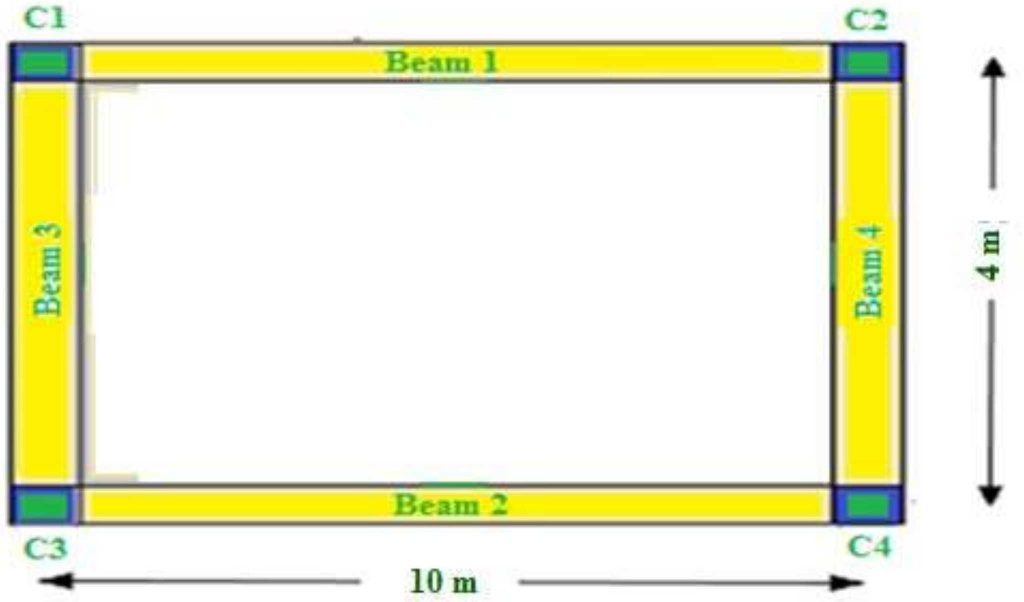
where : w = total load

L = length of beam

➢ Analysis of One Way Solid Slab

- Example: For shown solid slab, load on floor w = 20 (kN/m^2), own weight for each beam = 5 (kN/m'), determine:

1. Max. shear and max. moment in the slab.
2. Max. shear and max. moment in B1.
3. Max. shear and max. moment in B4.
4. Total axial load on C2



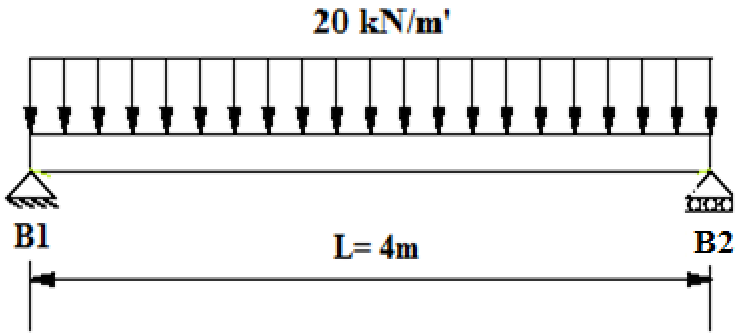
➢ Analysis of One Way Solid Slab

- Solution:

r= 10/4 = 2.5 >2 → one way solid slab

$w_s = w = 20 kN/m^2$: load transfer parallel to short direction.

1. Max. shear and max. moment in the slab.



$$V_{max} = \frac{wL}{2} = \frac{20*4}{2} = 40kN$$

$$M_{max} = \frac{wL^2}{8} = \frac{20*4^2}{8} = 40kN.m$$

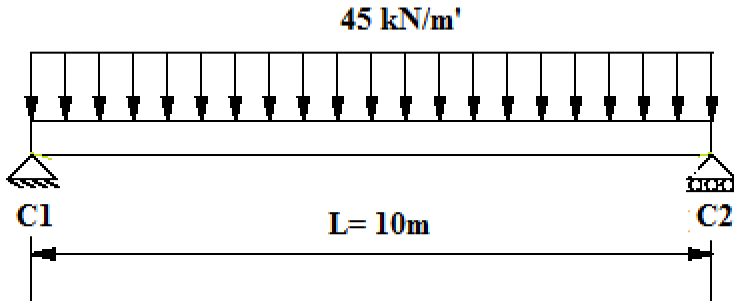
➢ Analysis of One Way Solid Slab

- Solution:

2. Max. shear and max. moment in B1.

Load from slab on Beam (1)= $\dfrac{wL_sL_L}{2L_L} = \dfrac{20*4*10}{2*10} = 40kN/m$

Total load on Beam (1) = 40 + 5 = 45 kN/m'



$$V_{max} = \frac{wL}{2} = \frac{45*10}{2} = 225kN$$

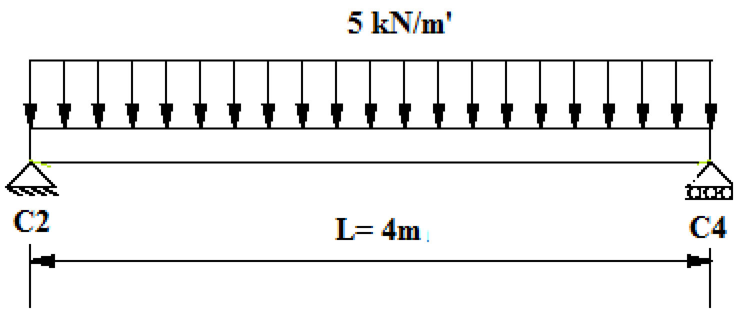
$$M_{max} = \frac{wL^2}{8} = \frac{45*10^2}{8} = 562.5kN.m$$

Analysis of One Way Solid Slab

- Solution:

3. Max. shear and max. moment in B4.

Total load on Beam (4) = 5 kN/m'.



$$V_{max} = \frac{wL}{2} = \frac{5*4}{2} = 10kN$$

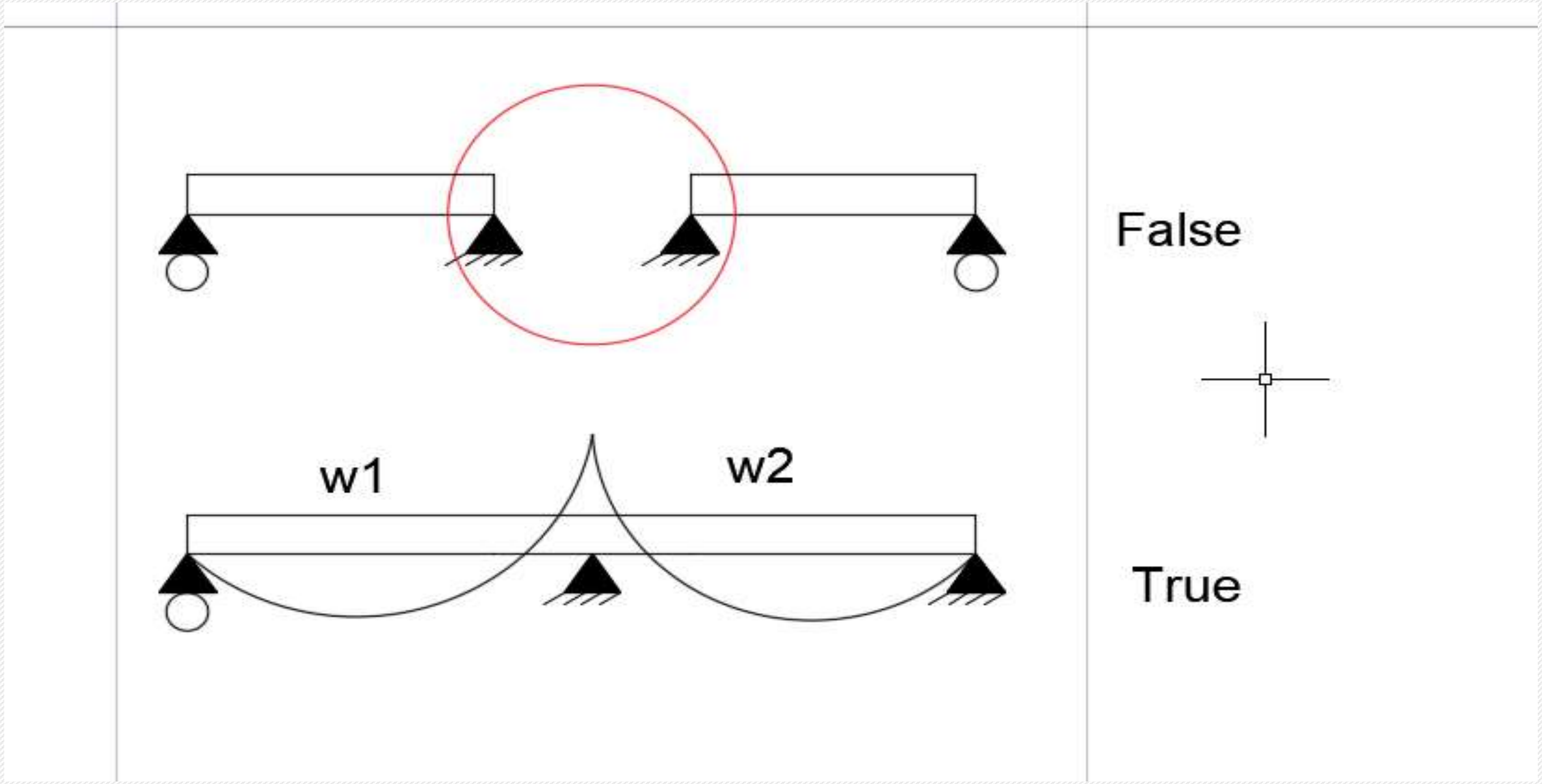
$$M_{max} = \frac{wL^2}{8} = \frac{5*4^2}{8} = 10kN.m$$

4. Total axial load on C2.

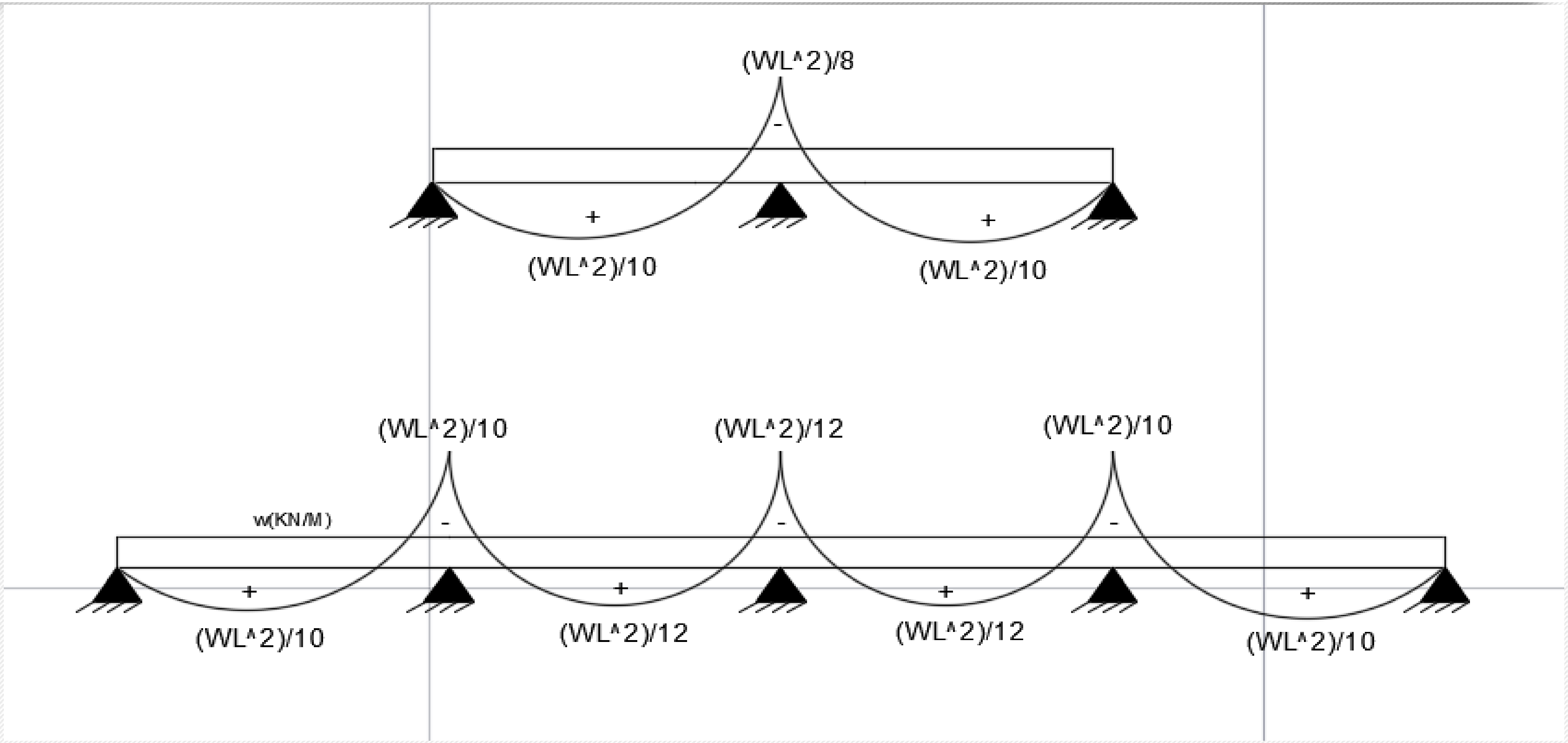
Total axial load on C2 = load from B1 + load from B4

Total axial load on C2 = 225 + 10 = 235 kN.

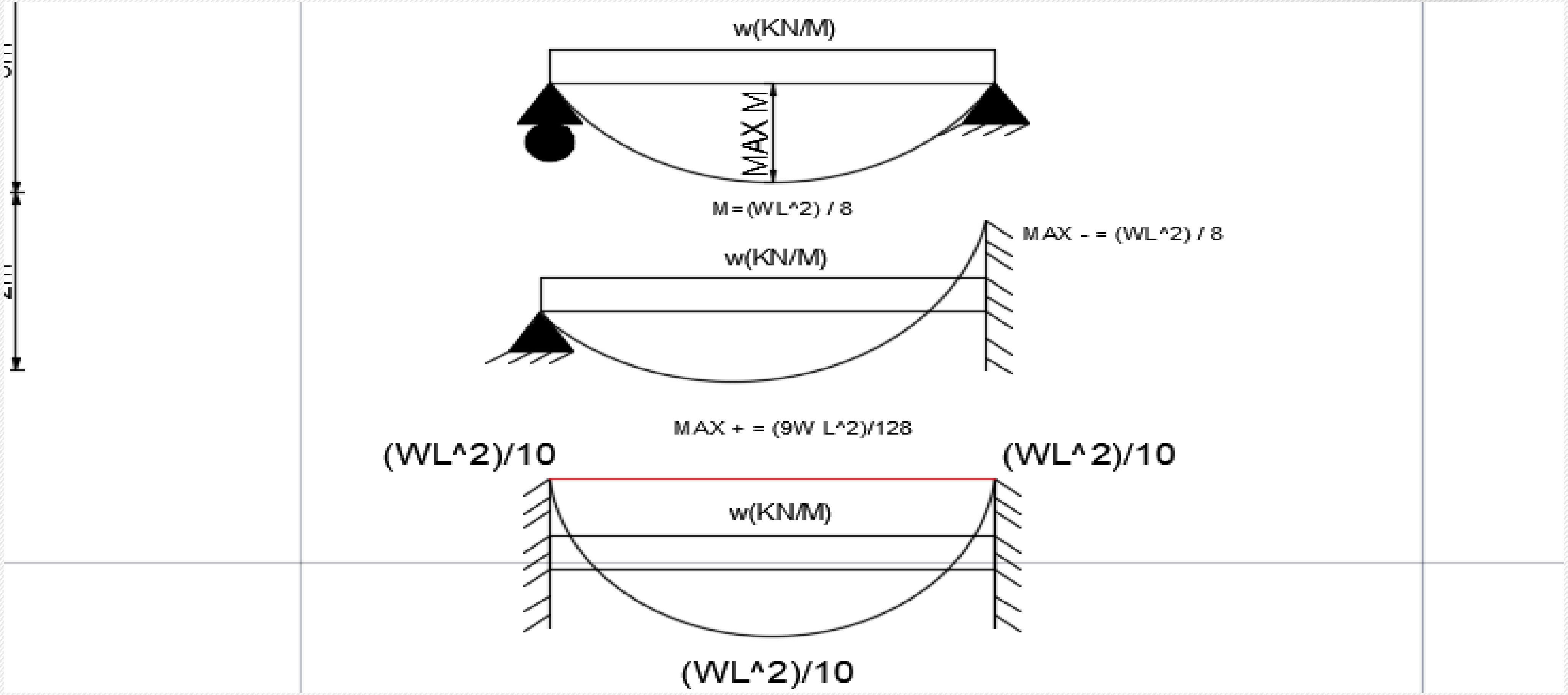
Continuous beam :



Equations to help you to solve problems without structure analysis .



Equations :



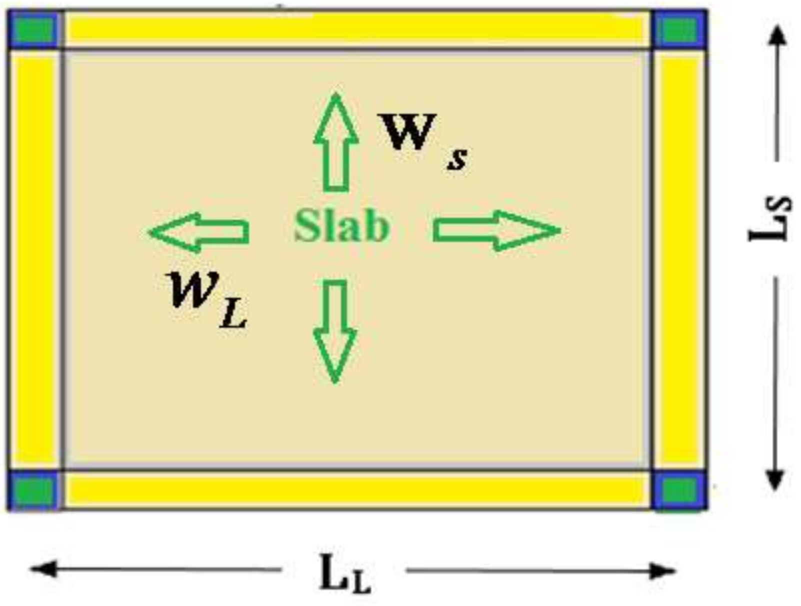
w(KN/M)
MAX M
M=(WL^2) / 8
MAX - = (WL^2) / 8
w(KN/M)
MAX + = (9W L^2)/128
(WL^2)/10
(WL^2)/10
w(KN/M)
(WL^2)/10

➢ Two Way Solid Slab

- For two way solid slab: $r = \dfrac{L_L}{L_s} \leq 2$

- For two-way solid slab: load transfer from slab to beams in two directions.

- All beams in two way solid slab are major beams.



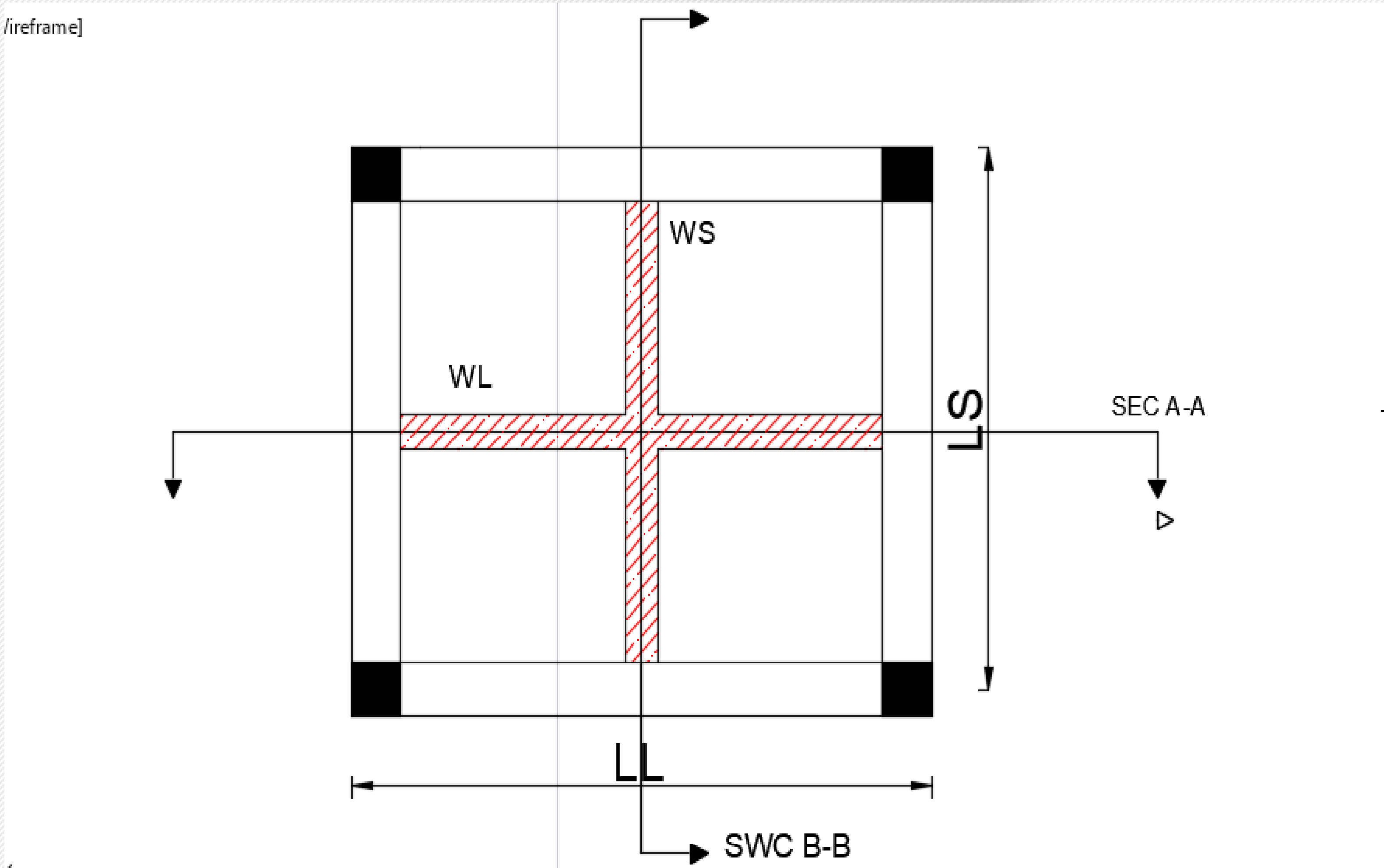
Rankine – Grashoff theory

*we often use in two way case .

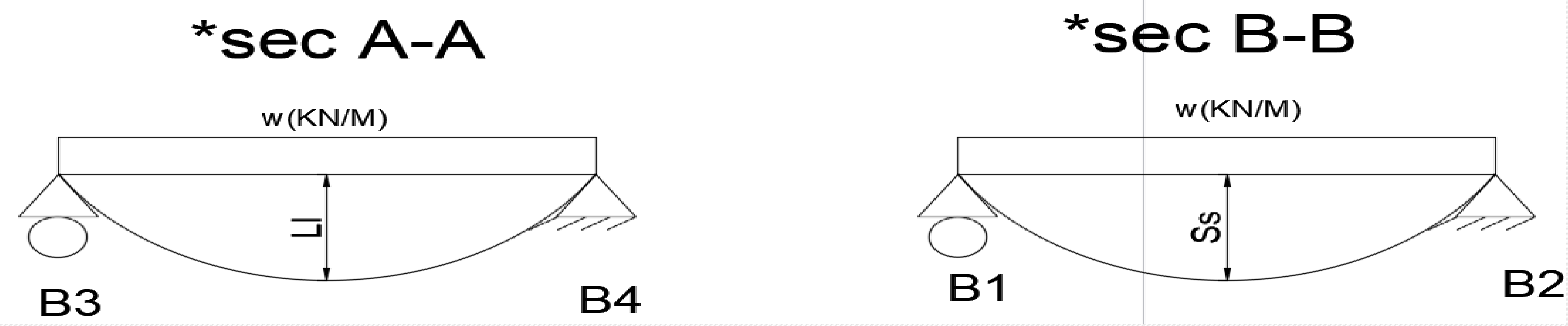
We take a point in the center to make it easier .

At the center of the slab :

$$S_L = S_S$$



Rankine – Grashoff theory :



$$\frac{5Wl\ Ll^4}{384\ EI} = \frac{5WsLs^4}{384\ EI}$$

Wl Ll = Ws Ls

$$\frac{Ws}{Wl} = \frac{Ll^4}{Ls^4} = r^4$$

*Ws>>Wl

Rankine – Grashoff theory :

Derivations :

$W_s = W_l \, r^4$

$W = W_s + W_l$

$W = r^4 \, W_l + W_l$

$W = W_l \, (1 + r^4)$

Load in long (W_l)

- $\dfrac{W}{1+r^4}$

Load on short (W_s)

- $\dfrac{Wr^4}{1+r^4}$

➢Two Way Solid Slab

$$\frac{w_s}{w_L} = \frac{L_L^4}{L_s^4} = \mathrm{r}^4$$

$$w_s = w_L \mathrm{r}^4 \ldots\ldots\ldots.(1)$$

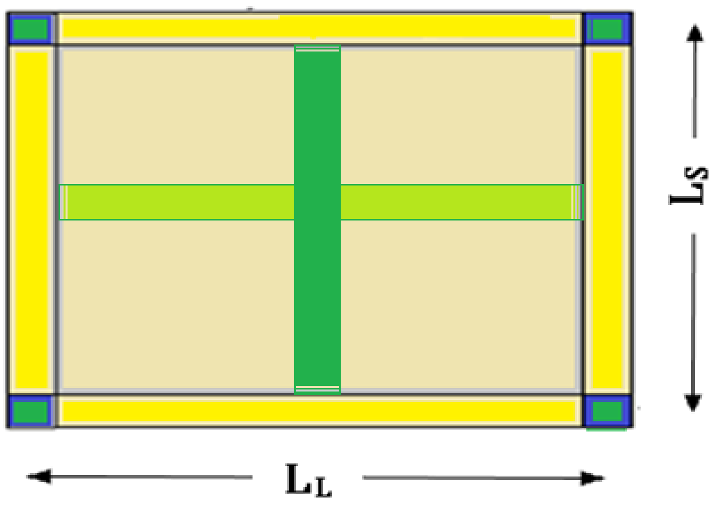
$$w = w_s + w_L \ldots\ldots.(2)$$

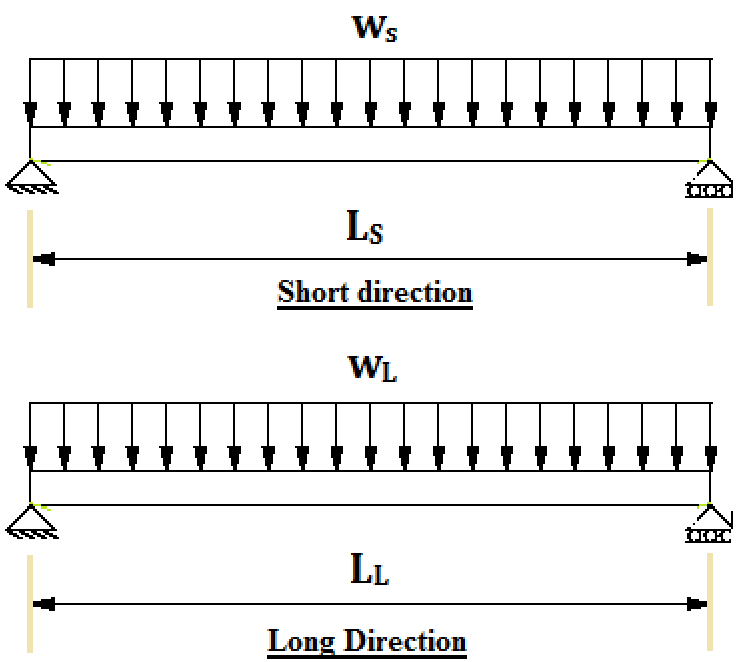
substitute eqn(1) in eqn(2)

$$w = w_L \mathrm{r}^4 + w_L \Rightarrow w = w_L (1 + r^4)$$

$$w_L = \frac{w}{1 + r^4}$$

$$w_s = \frac{wr^4}{1 + r^4}$$





Analysis of Two Way Solid Slab

- Slab's Analysis procedure:

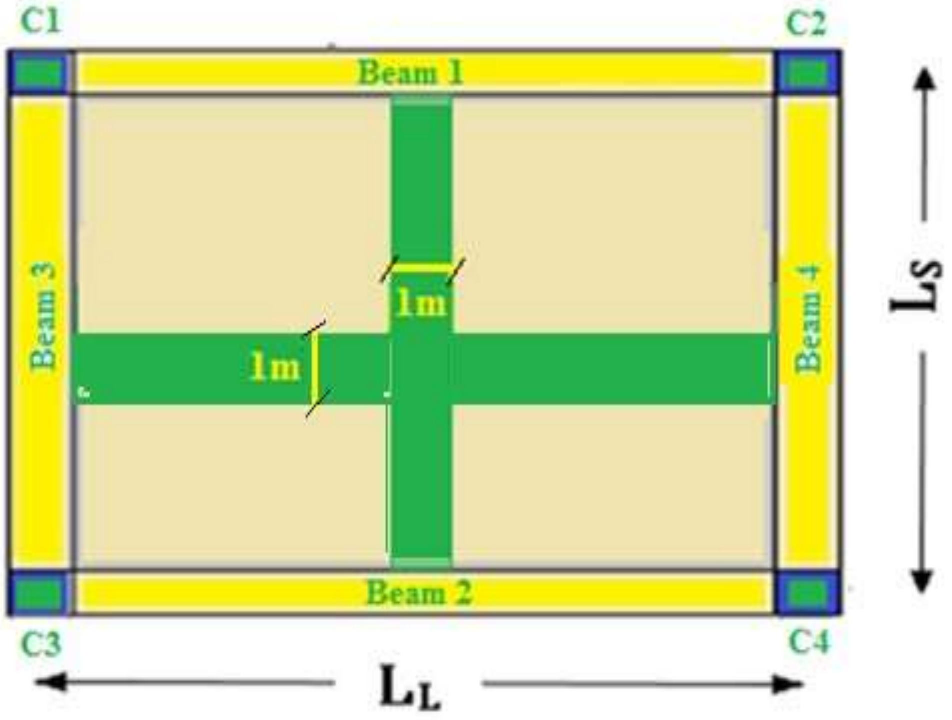
1. Take a strip with (1m) width parallel to short direction or parallel to long direction.
2. Confirm total load on slab (w) (load/area) to distributed load (load/m'): Load/m'= (load/m^2) * (1m) .
3. Determine the max. shear and max. moment for simply supported span with distributed.

**Short direction :

$$V_{max} = \frac{w_s L_s}{2}, M_{max} = \frac{w_s L_s^{\,2}}{8}$$

**Long direction :

$$V_{max} = \frac{w_L L_L}{2}, M_{max} = \frac{w_L L_L^{\,2}}{8}$$



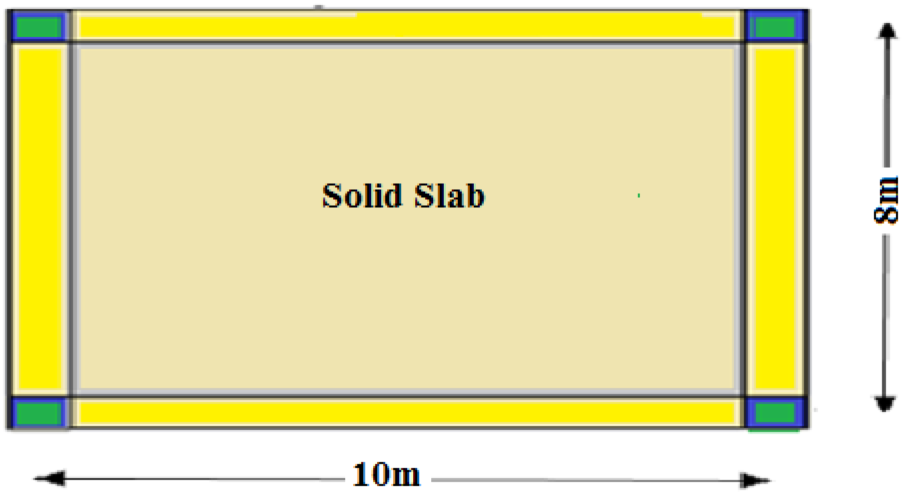
➢Two Way Solid Slab

- **Example:** For shown solid slab with load on floor (w) = 20kN/m². Determine max. shear and max. moment in slab.

$$r = \frac{10}{8} = 1.25 < 2 \Rightarrow Two\ \text{way soild slab}$$

$$w_S = \frac{wr^4}{1+r^4} = \frac{20*1.25^4}{1+1.25^4} = 14.2(kN/m^2)$$

$$w_L = \frac{w}{1+r^4} = \frac{20}{1+1.25^4} = 5.8(kN/m^2)$$



Short Direction:

$$V_{\max} = \frac{wL}{2} = \frac{14.2*8}{2} = 56.8kN$$

$$M_{\max} = \frac{wL^2}{8} = \frac{14.2*8^2}{8} = 113.6kN.m$$

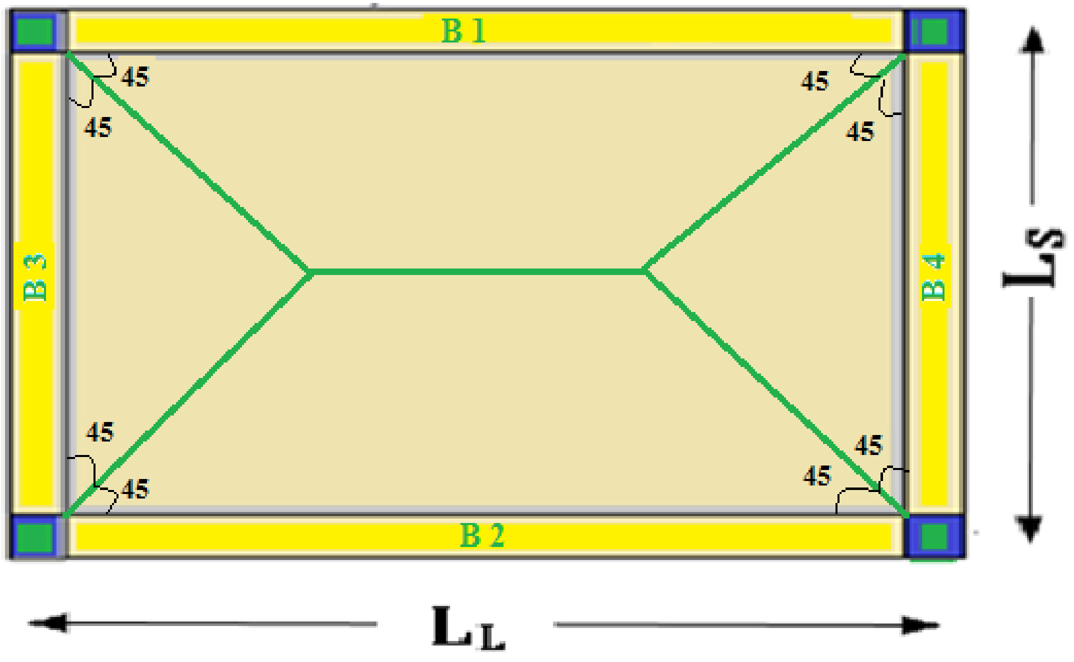
Long Direction:

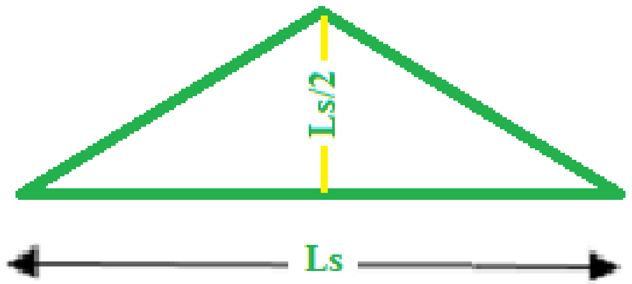
$$V_{\max} = \frac{wL}{2} = \frac{5.8*10}{2} = 29kN$$

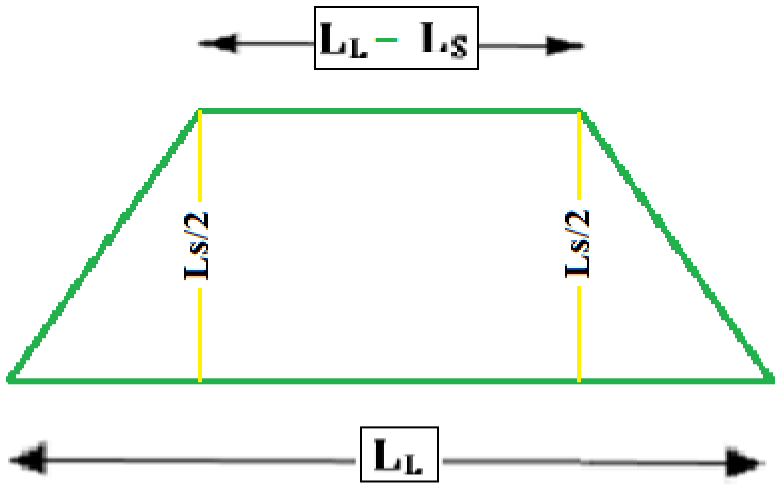
$$M_{\max} = \frac{wL^2}{8} = \frac{5.8*10^2}{8} = 72.5kN.m$$

➢ Analysis of Two Way Solid Slab

- Beam’s Analysis procedure:
  - All beams are major beams with different load.
  - Loads transfer from slab to beams as two triangles and two trapezoids.



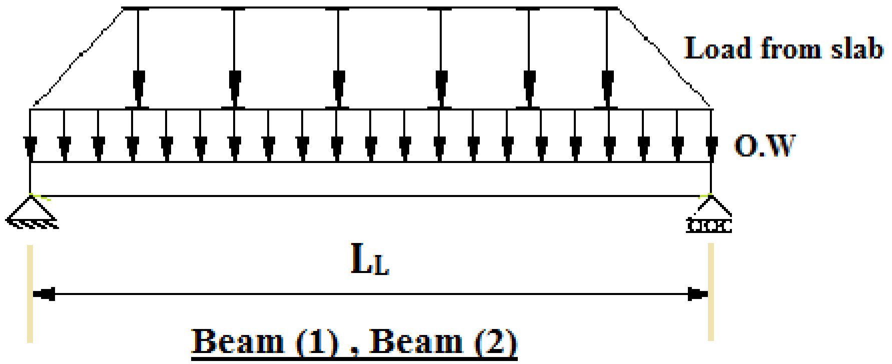




➢Analysis of Two Way Solid Slab

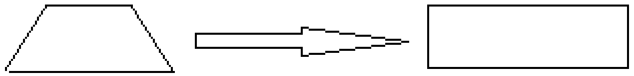
- Beam's Analysis procedure:

** Beam (1) + Beam (2):



$$V_{max} = \frac{(o.w)L_L}{2} + \frac{w * \text{Area of Trapezoid}}{2}$$

$$M_{max} = \frac{(o.w + E.U.D.L) * L^2}{8} \Rightarrow \text{this formula is applicable just for uniform distributed load}$$



For bending moment calculations only :

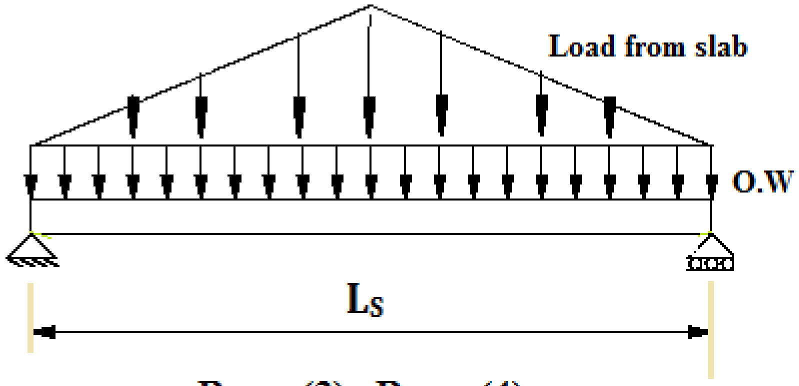
**For Trapezoid

$$\text{Equivalent Uniform Distributed load (E.U.D.L)} = \frac{wL_S r}{2 + r}$$

➢Analysis of Two Way Solid Slab

- Beam's Analysis procedure:

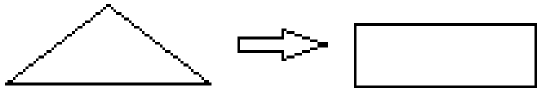
** Beam (3) + Beam (4):



Beam (3) , Beam (4)

$$V_{max} = \frac{(o.w)L_s}{2} + \frac{w * \text{Area of Triangle}}{2}$$

$$M_{max} = \frac{(o.w + E.U.D.L) * L^2}{8} \Rightarrow \text{this formula is applicable just for uniform distributed load}$$



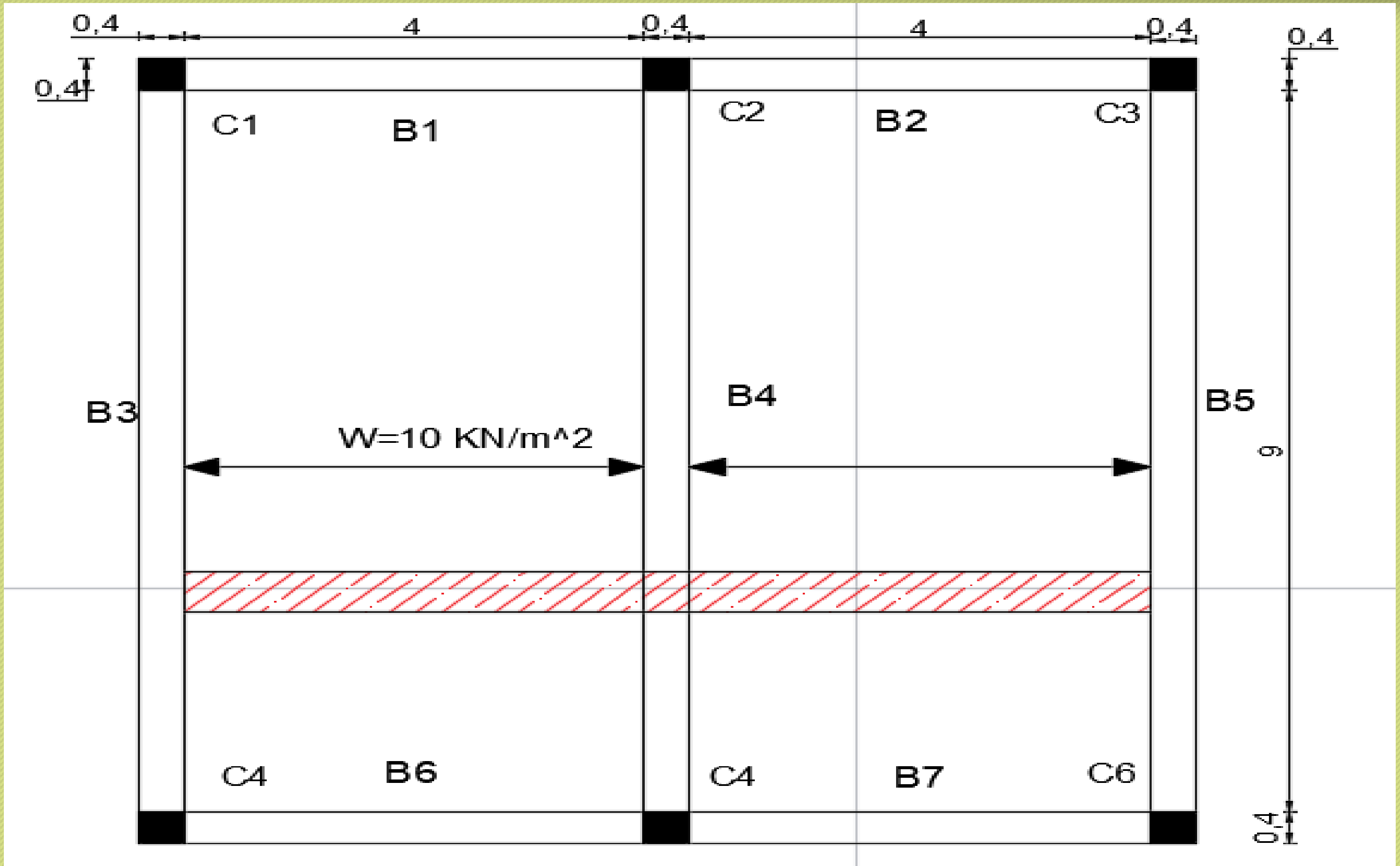
For bending moment calculations only :

**For Triangle

$$\text{Equivalent Uniform Distributed load (E.U.D.L)} = \frac{wL_S}{3}$$

Example 2 : One way solid slab .

1. Max bending moment in the slabs
2. (B4 , B1) , calculate shear and moment . O.W = 4KN/m



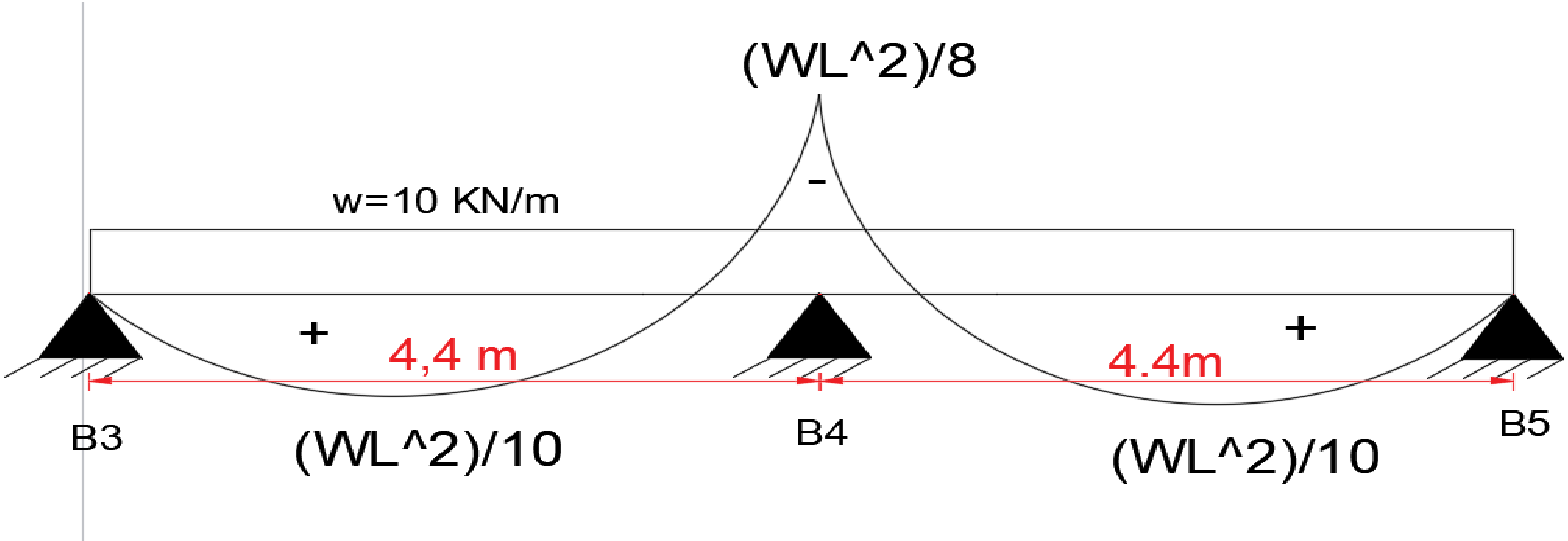
solution:

1. Max bending in slab .

S1: $r = \frac{Ll}{Ls} = \frac{9.4}{4.4} > 2$ (one way)

S2: r>2 (one way)

- MAX +ve B.M $= \frac{W\,L^2}{10} = \frac{10\,(4.4^2)}{10} = 19.36$
- MAX - ve B.M $= \frac{10\,(4.4^2)}{8} = 24.2$
- Unit : KN.m .



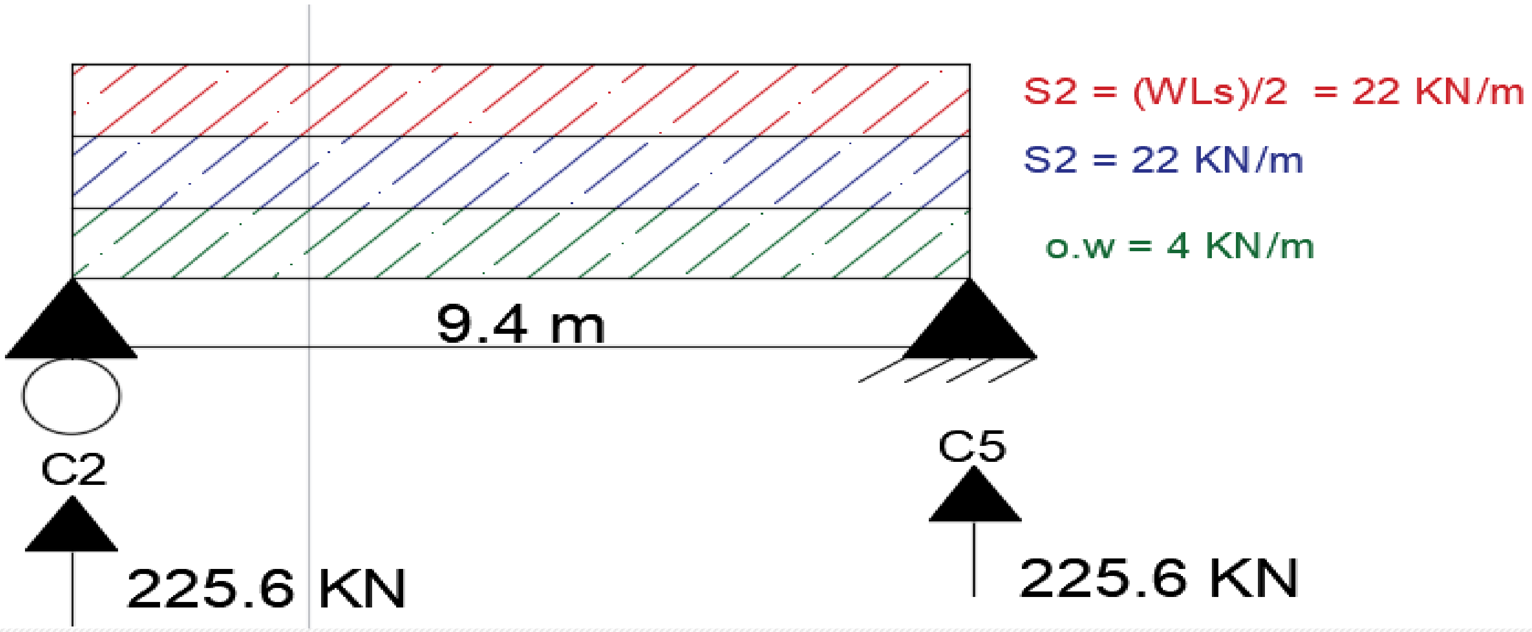
2. Beam 4 (Shear , moment).

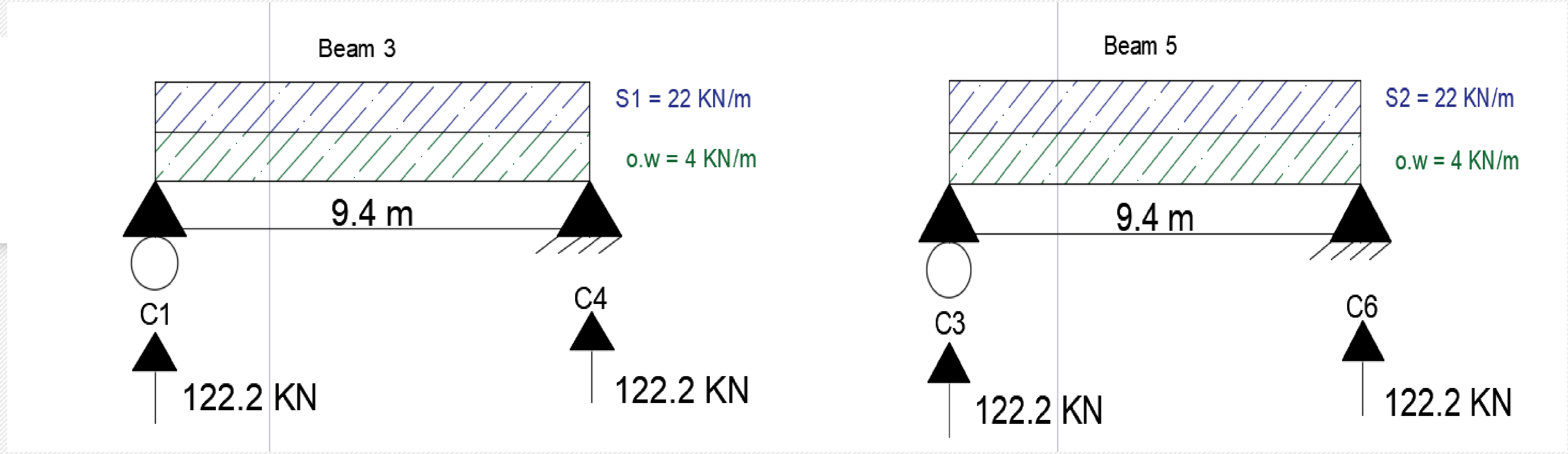
Load from S1 “W” $= \dfrac{4.4\ x\ 9.4\ x10}{2\ x\ 9.4}$ = 22 KN/m or $\dfrac{WLs}{2} = \dfrac{10\ x\ 4.4}{2}$

Load from S2 = load from S1

.Shear V = $\dfrac{(4+22+22)X\ 9.4}{2}$ = 225.6 KN

* Bending moment B.M = $\dfrac{WL^2}{8} = \dfrac{48\ X\ 9.4^2}{8}$ = 530.2 KN.m



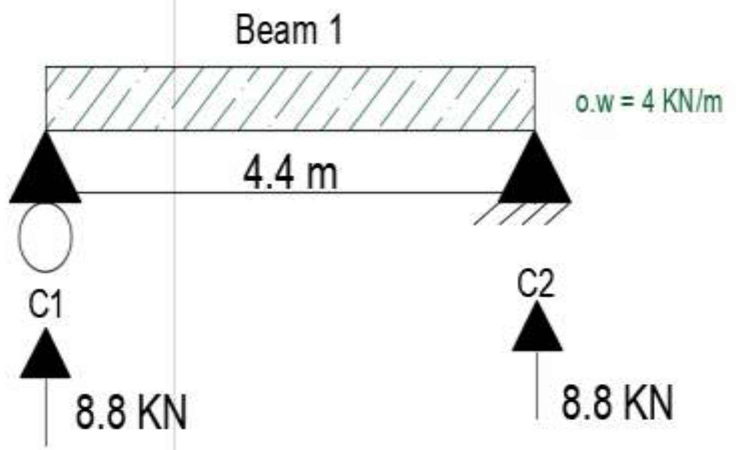


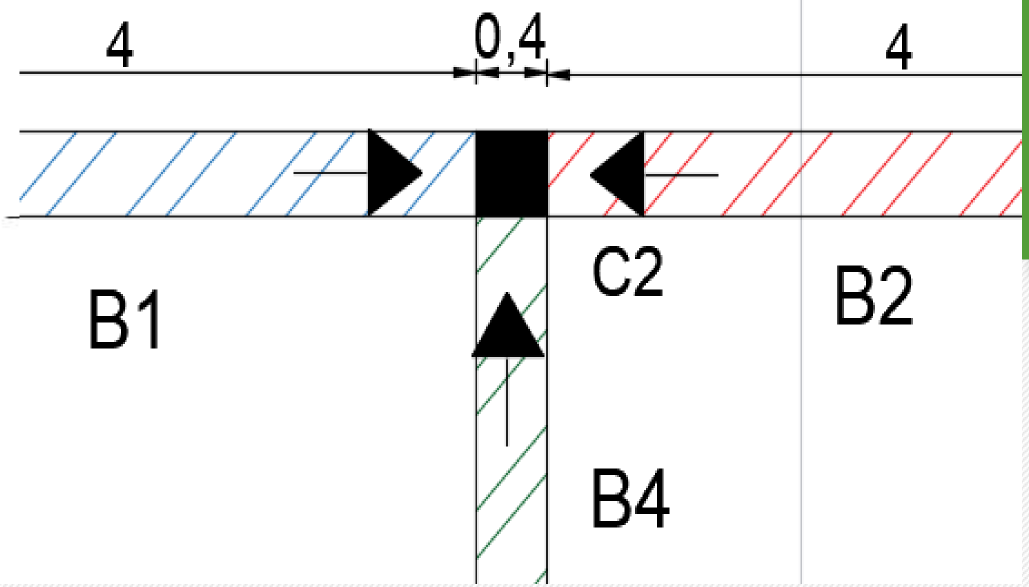
Shear = $\frac{26\ x\ 9.4}{2}$ = **122.2 KN**

B.M= $\frac{26\ X9.4^{\ 2}}{8}$ = **287.17 KN.m**

Shear = $\frac{26\ x\ 9.4}{2}$ = **122.2 KN**

B.M= $\frac{26\ X9.4^{\ 2}}{8}$ = **287.17 KN.m**





Shear V = $\frac{4.4\ x\ 4}{2}$ = 8.8 KN

B.M =$\frac{4\ X\ 4.4^{\ 2}}{8}$ = 9.68 KN.m

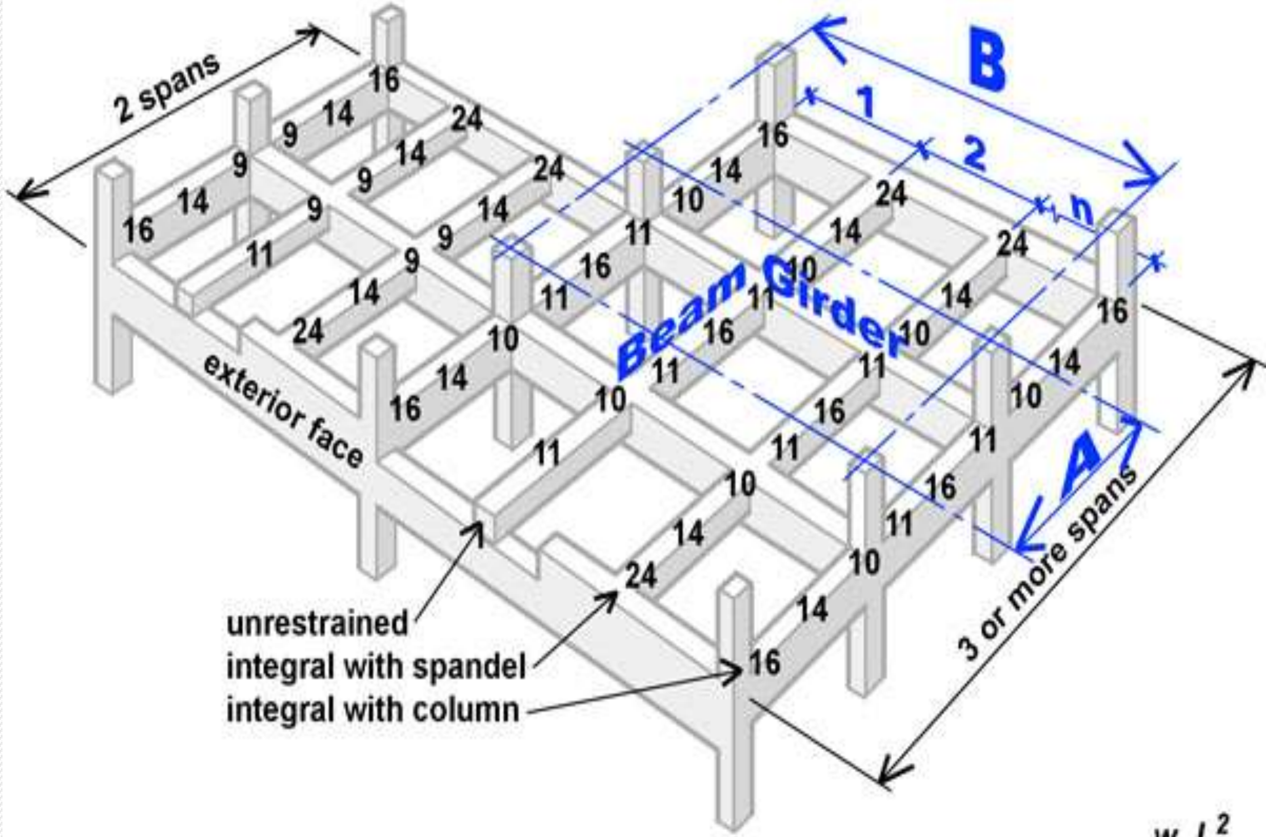
shear in column 2 from three beams (B1+B2+B3).

=225.5 + 8.8 + 8.8 = 243 KN.

Girder :

What is Girder?

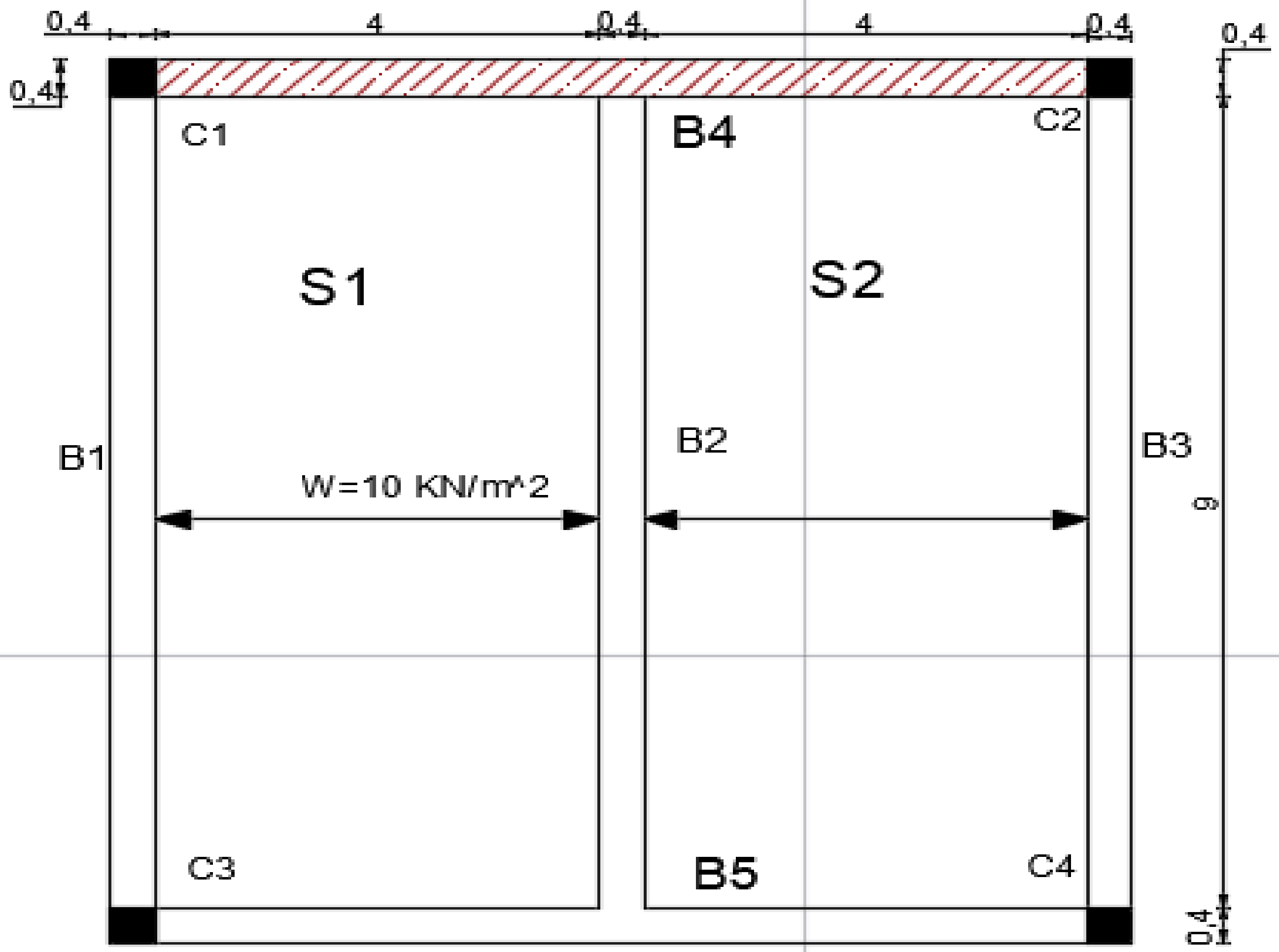
Girder is basically a beam which supports other smaller beams and acts as the main horizontal support of a structure. Unlike beams, girders are designed to support major concentrated loads such as columns or beam reactions and their load bearing capacity is much greater than beams. It can be made from a variety of construction materials such as concrete, stainless steel, or a combination of both. It supports vertical loads and may consist of a single piece or more than one piece bound together.

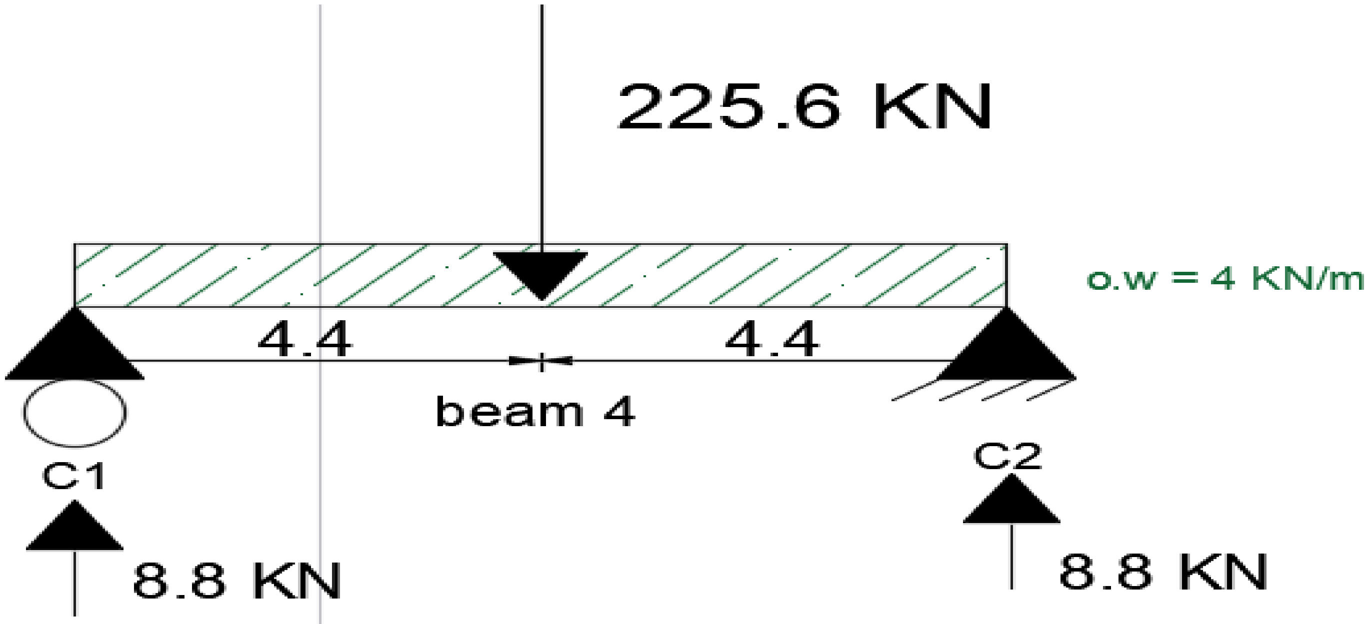


Numbers on beams refer to moment value coefficient, x, in the equation: $M_u = \frac{w_u l_n^2}{x}$

The number, **n**, refers to the *number of spaces* into which the girder span is subdivided by beams.

Example 3 :calculate shear force in C1 & C2 from beam 4 .





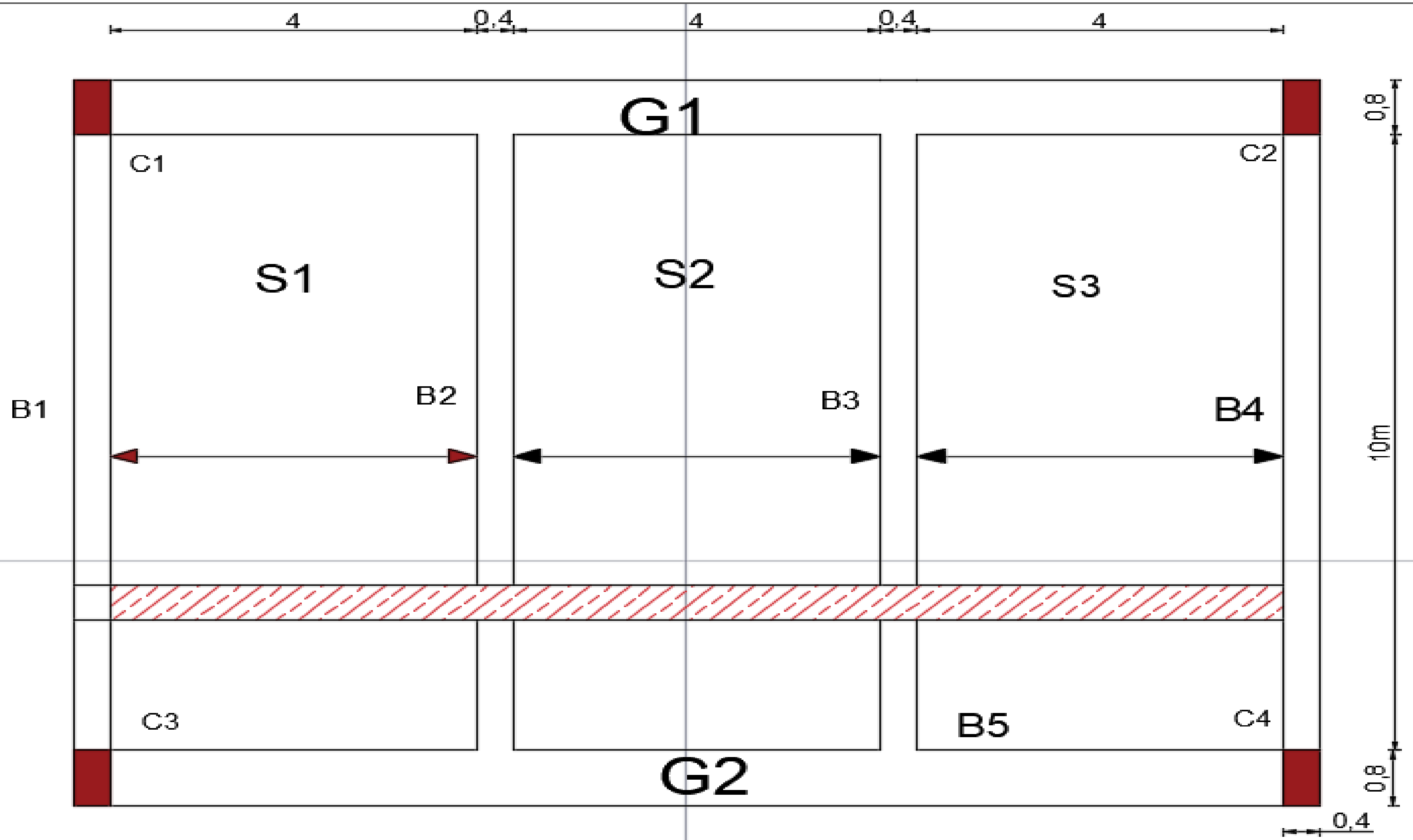
$$C1= \frac{4\ X\ (8.8\ )}{2} + \frac{225.6}{6} = 130.4\ KN$$

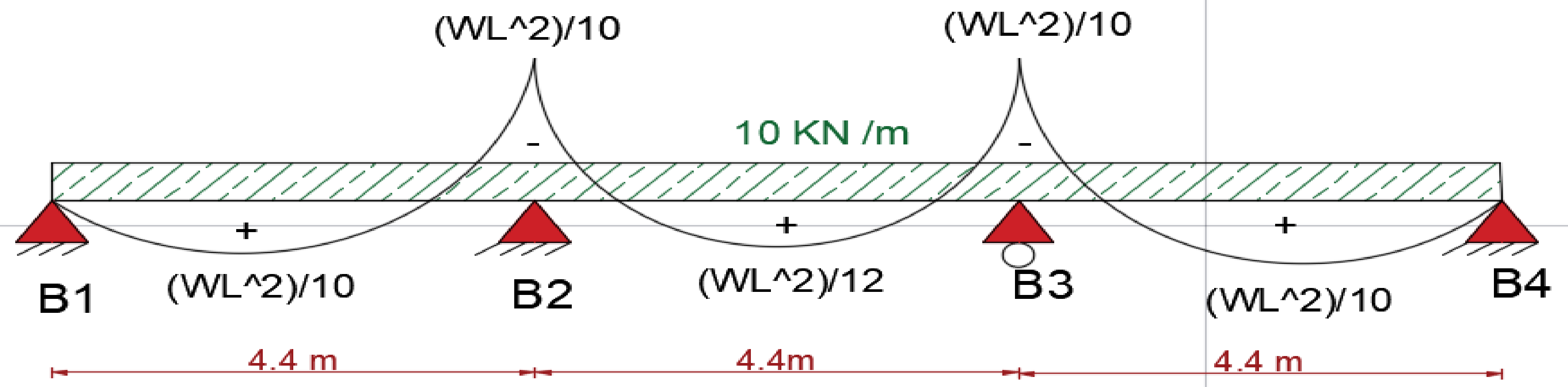
Nature of load :

***from beam to Girder (concentrated)**

***from beam to column (distributed)**

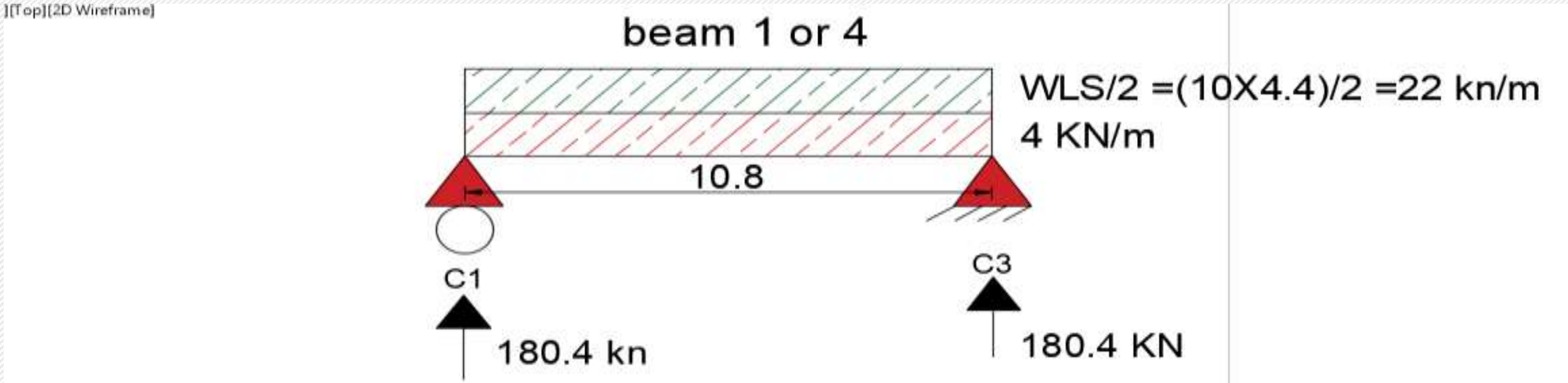
Example 4 :





$$\frac{WL^2}{10} = \frac{10\ X\ 4.4^2}{10} = 19.36 \text{ KN .m}$$

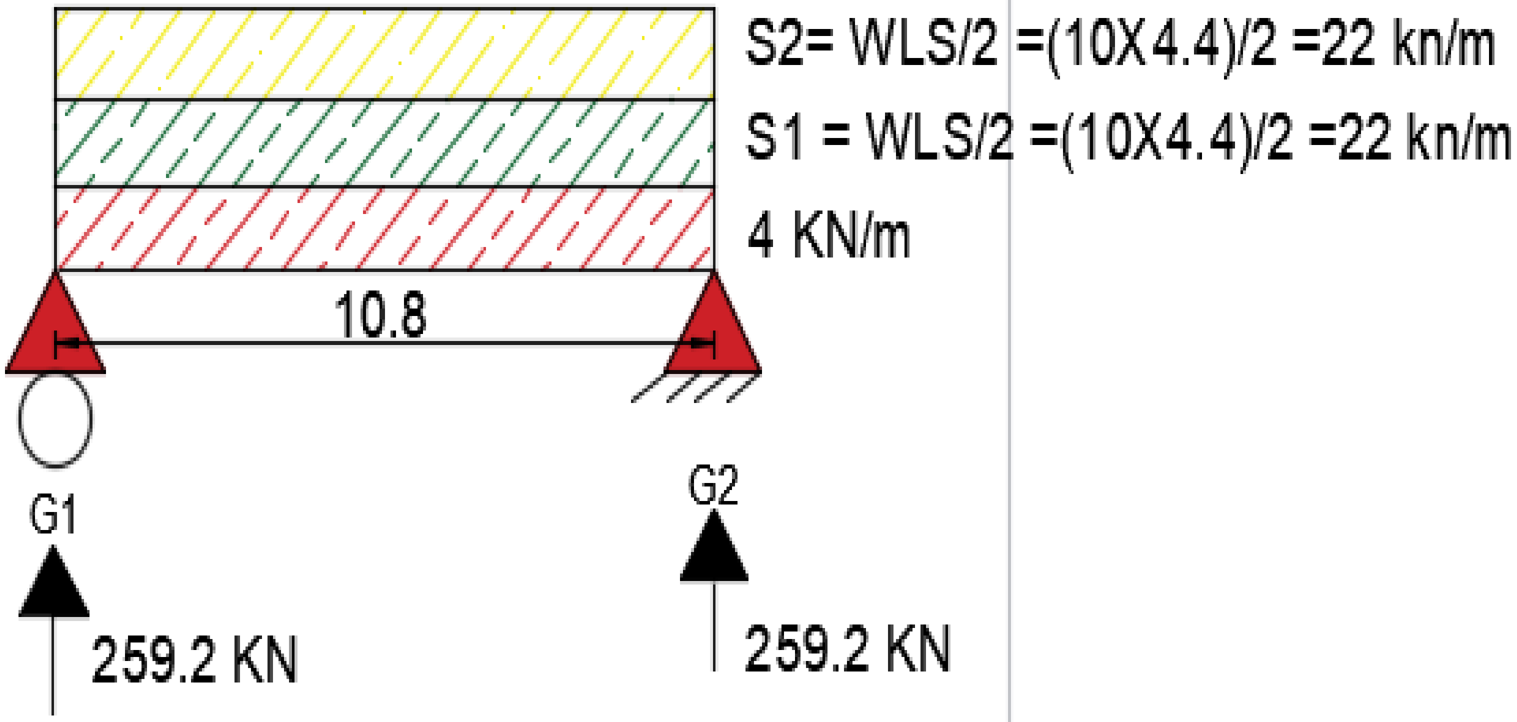
$$\frac{WL^2}{12} = \frac{10\ X\ 4.4^2}{12} = 16.13 \text{ KN .m}$$



V max = axial load on C1 and C3 from B 3= (26x10.8)/2 = 180.4 KN

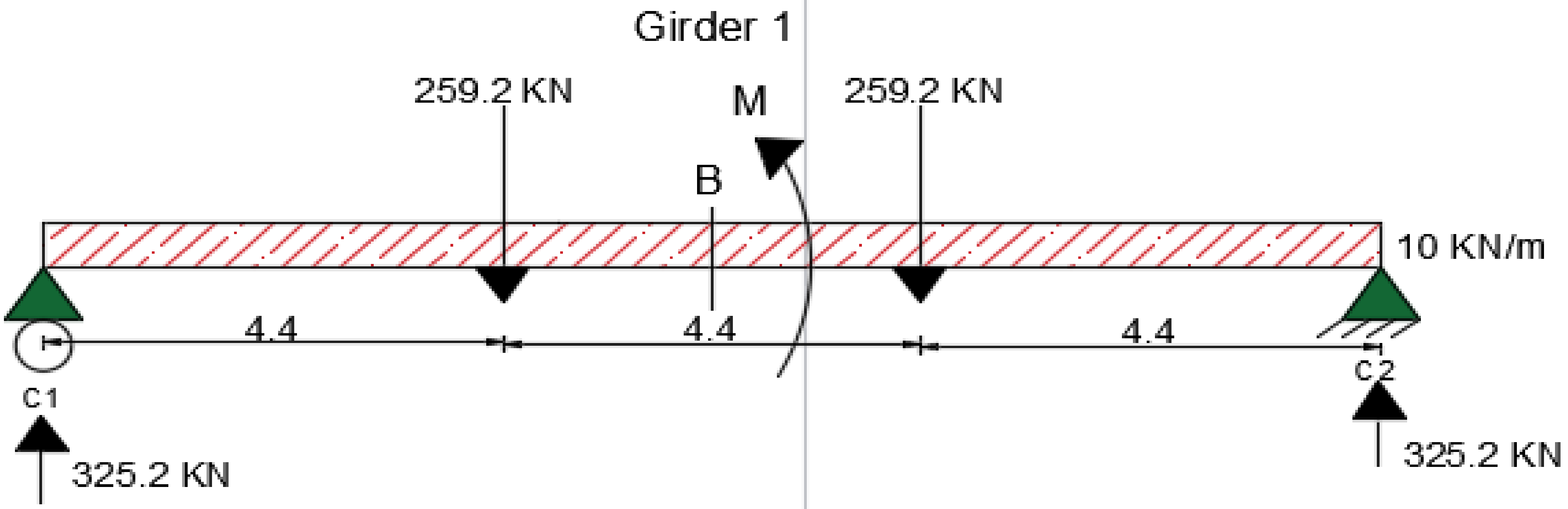
B.M =(26X10.8^2)/8 = 379.08 KN.m

beam 2



V max = (48x10.8)/2 = 259.2 KN

B.M =(48X10.8^2)/8 = 699.84 KN.m



$$\sum M\ c1 = 259.2x(4.4) + 259.2\ (8.8) + 10\ x(13.2)x(13.2/2) = C2(13.2)$$

Reaction C2 = 325.2 = Reaction C1

Total load on C1 = 325.2 + 180.4

$$\sum M\ B = 0 = M - 325.2x(6.6) + 259.2\ (2.2) + (10\ x6.6)x(3.3) = 0$$

$$M = 1358.28\ KN.m$$

One way solid :

W parallel with short direction .

Load transition from slab to the beam $\frac{WL}{2}$.

r = $\frac{L\ long}{L\ short}$ > 2 .

Tow way solid :

r = $\frac{L\ long}{L\ short}$ <= 2

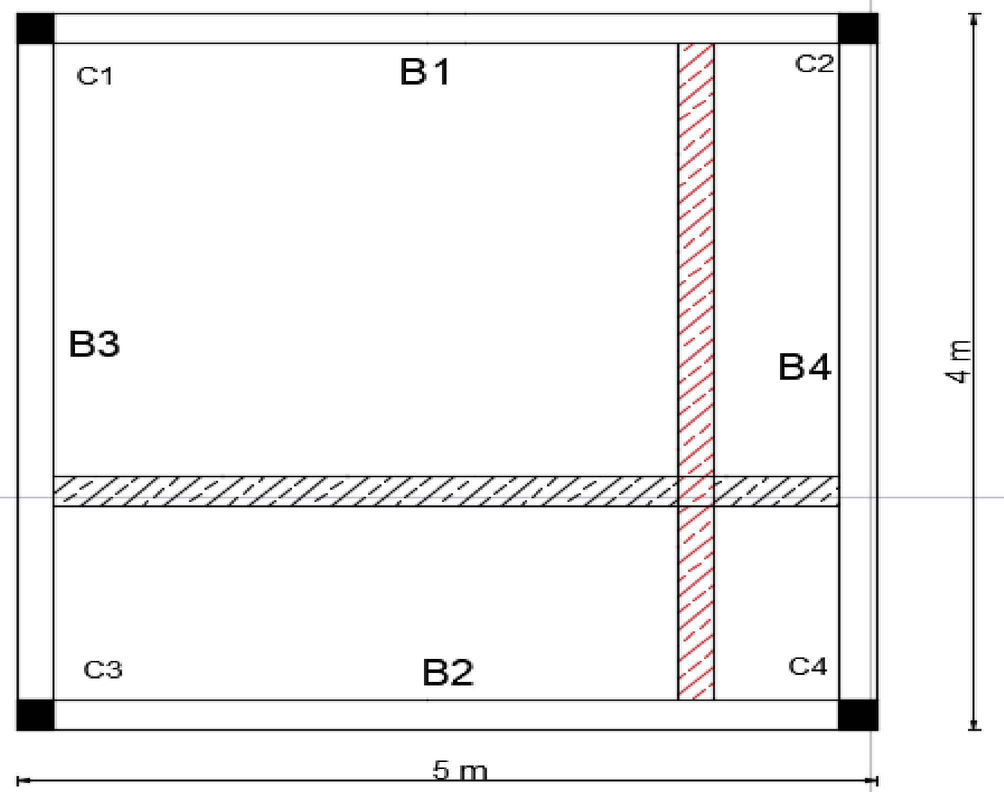
W short = W long x r^4 .

Always : W short >= W long

Example 5 :

1. Select the type of slab.
2. Find Load in short direction and long direction .
3. Analyze loads on beams in tow directions .

W = 20 KN/m^2



- $r = \frac{5}{4} = 1.25 <= 2$ tow way .
- $Ws = \frac{20\,(1.25^4)}{1+\,1.25^4} = 14.2$ KN/m
- $WL = \frac{20}{1+1.25^4} = 5.8$ KN/m
- Ws > WL
- $W = Ws + WL = 20$ KN/m^2

slab tow way solid (r <= 2)

1. $Ws = \frac{W\,r^4}{1+\,r^4}$, $WL = \frac{W}{1+r^4}$
2. $Ms = \frac{Ws\,Ls^2}{8}$, $ML = \frac{WL\,Ll^2}{8}$
3. $Vs = \frac{W\ \ Ls}{3}$, $VL = \frac{W\ \ Ls+r}{2+r}$

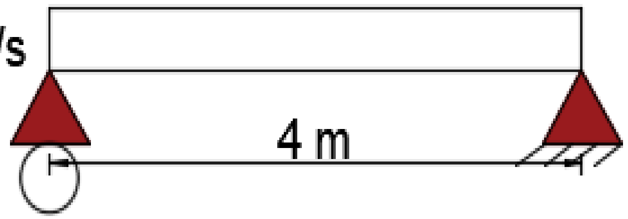
- slab one way solid (r > 2)

1. W Total // short .
2. $M = \frac{W\ Ls^2}{8}$
3. $V = \frac{W\ \ Ls}{2}$

Moment

short

14.2 KN/m = Ws



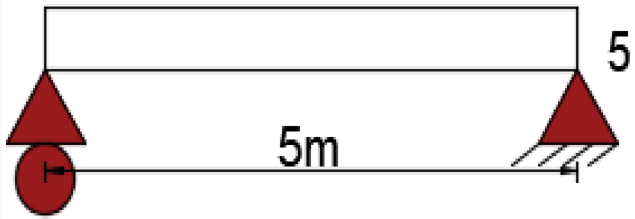
Ms = (Ws x Ls)/8

=(14.2 x 4^2)/8 = 28.4 KN.m

Vs = (W Ls)/3

long

5.8 KN/m = WL

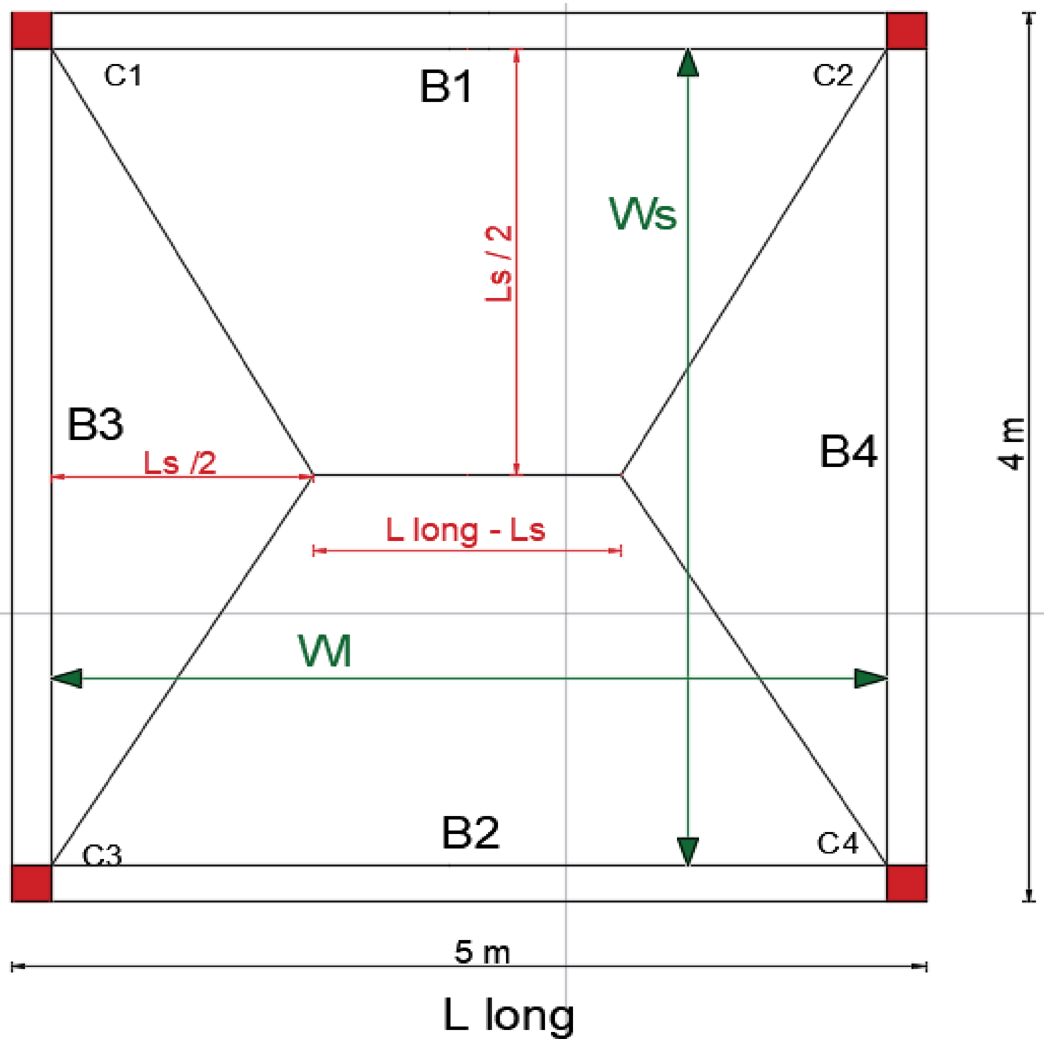


ML = (WL x Ll^2)/8 =

ML = (5.8 x 5^2)/8 = 18.125 KN.m

VL = (W Ls r) / (2+r)

Continue to Example 5 :



L short

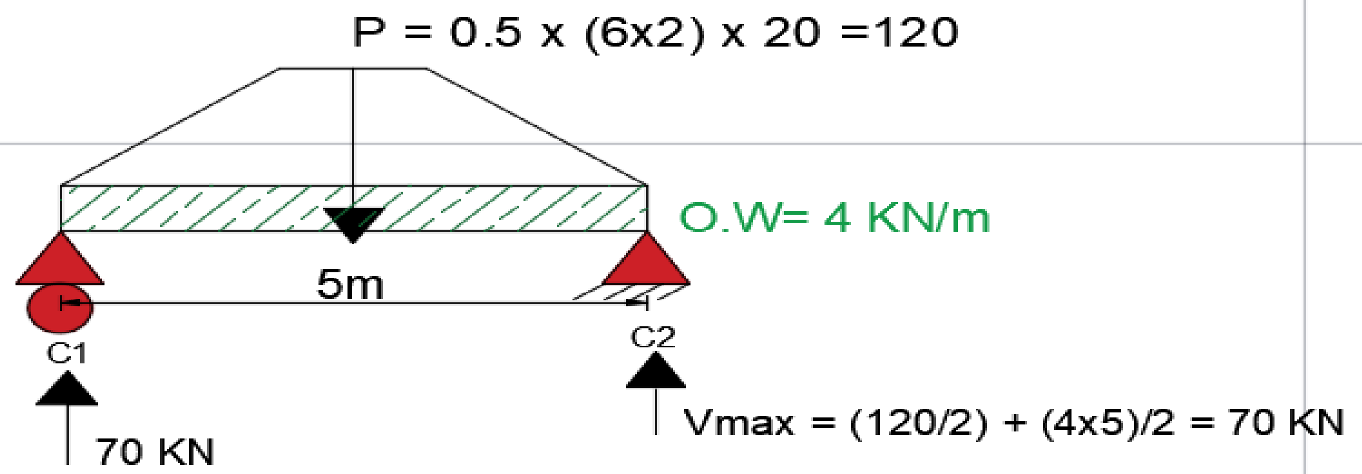
Load on beams in tow way :

Area = tringle area + trapezoidal area .

$= \frac{1}{2}$ (4 x 2) x 2 + $\frac{1}{2}$ (6x2) x 2.

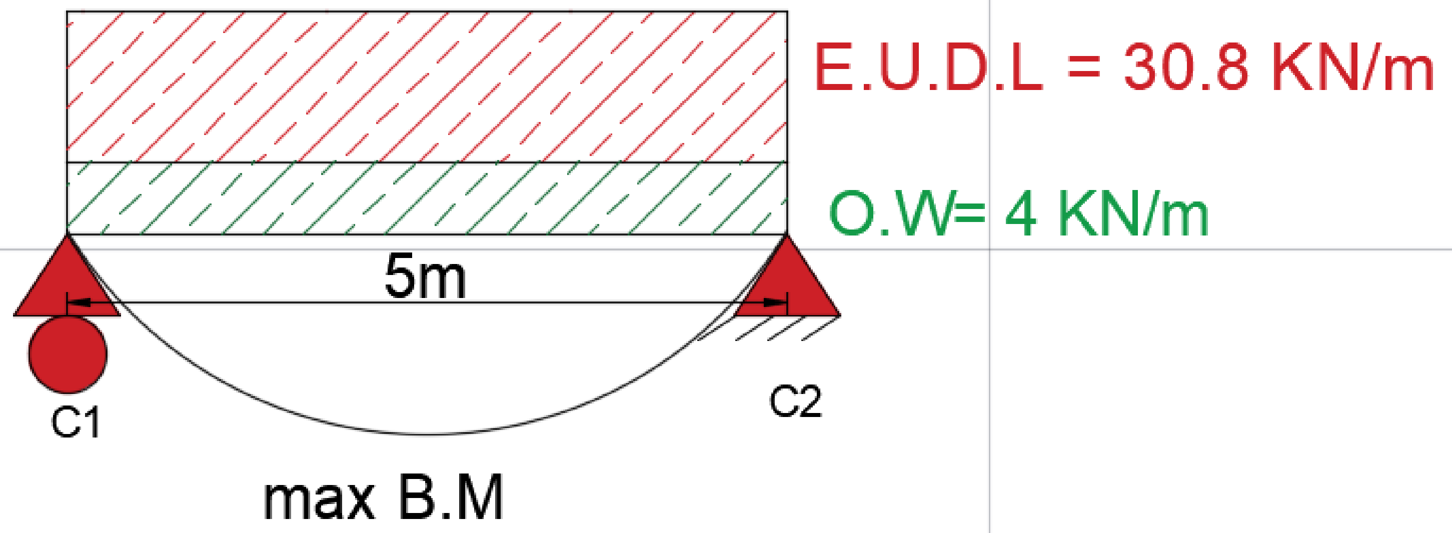
area slab= 8+ 12 = 20 m^2

find shear force on C1&C2 by convert trapezoidal load to concentrated



To find max B.M take the load of the equivalent of the trapezoidal load .

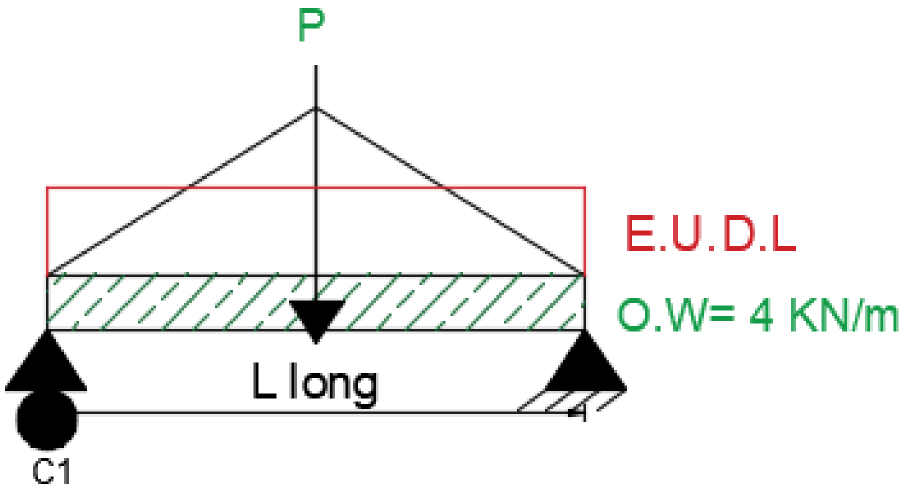
By E.U.D.L = $\frac{W\,Ls\,r}{2+r} = \frac{20\ X\ 4\ X\ 1.25}{2+1.25}$ **= 30.8 KN/m .**

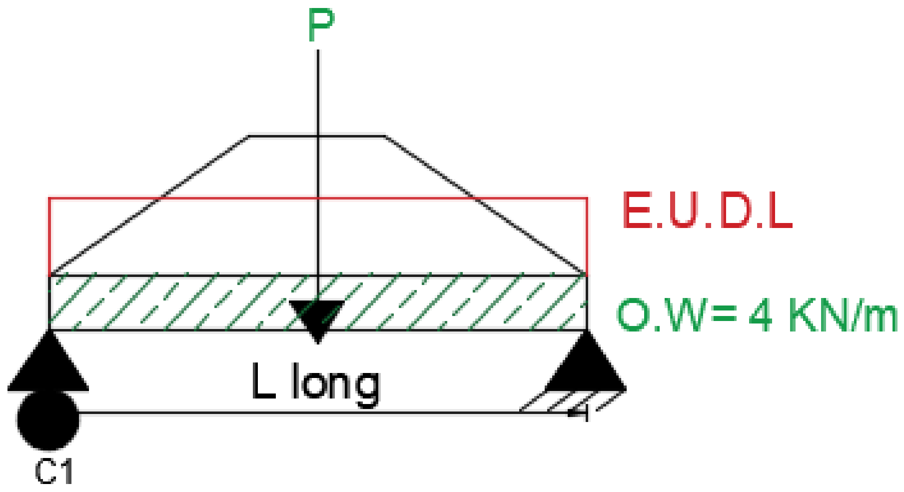


Total weight of slab = area x W =20 x 20 = 400 KN .

For trapezoidal E.U.D.L = $\frac{W\ Ls\ r}{2+r}$

For triangle E.U.D.L = $\frac{W\ Ls}{3}$





V max = P/2 = (Area triangle x W)/2

O.W= 4 KN/m

V max = P/2 = (Area triangle x W)/2

O.W= 4 KN/m

Example 6 :

Wt on slab = 10 KN/m^2 , O.W of beam = 0.4 t/m .

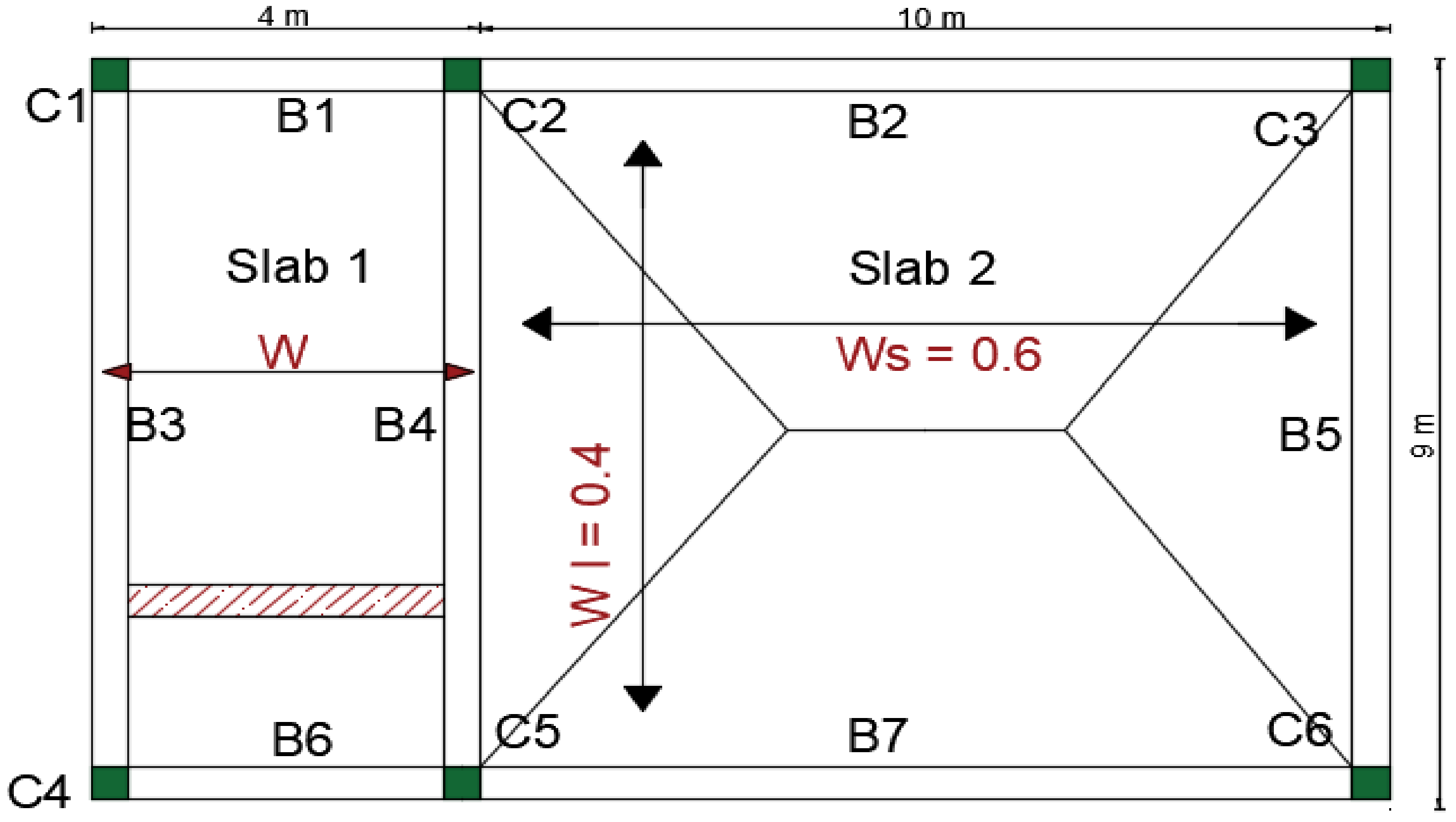
r for slab 1 = $\frac{9}{4}$ > 2 , one way .

r for slab 2 =$\frac{10}{9}$ = 1.11 < 2 , tow way .

- For slab 1 :

V max = $\frac{W\ Ls}{2}$ = $\frac{1\ x\ 4}{2}$ = 2 t .

B.M = $\frac{W\ LS^2}{8}$ = 2 t.m .



For slab 2 :

- Moment “M” :

$$\text{Short} = \frac{Ws\ Ls^2}{8} = \frac{0.6\ x\ 4^2}{8}$$

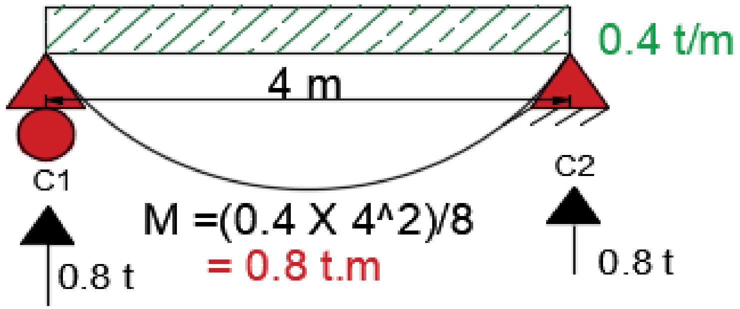
$$\text{Long} = \frac{Wl\ Ll^2}{8} = \frac{0.6\ x\ 10^2}{8}$$

- shear “V” :

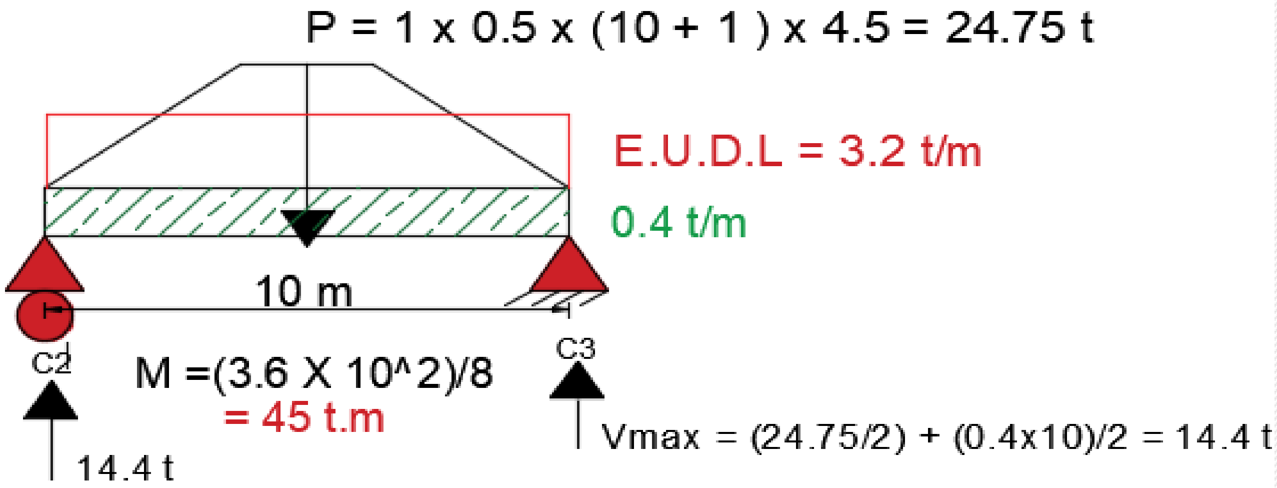
$$\text{short} = \frac{W\ ls}{3} = \frac{1\ x\ 9}{3} = 3\ t/R$$

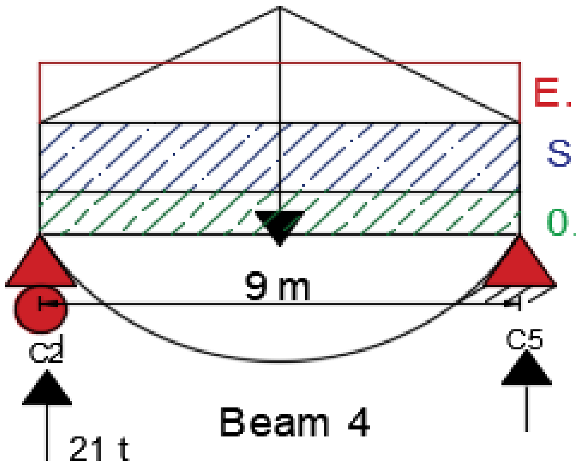
$$\text{long} = \frac{W\ Ls\ r}{2+r} = \frac{1\ X\ 9X\ 1.11}{2+1.11} = 3.21\ t/R$$

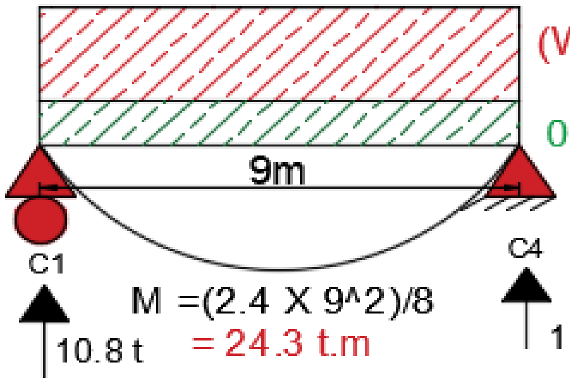
beam 1



beam 2







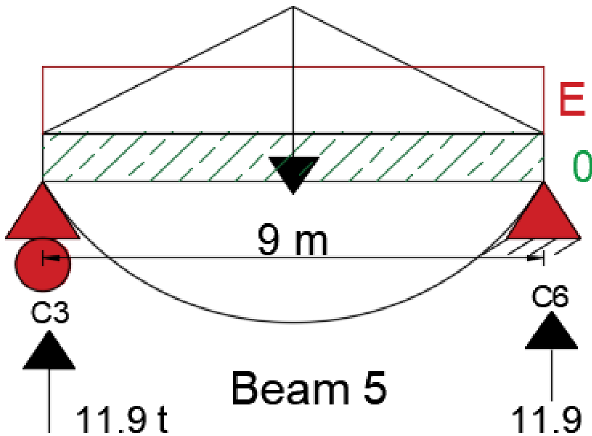
Vmax = (0.4 x 9)/2 + (20.25)/2 +(2 x 9)/2 = 21 t

M = ((3+2+0.4) x 9^2)/8 = 54.7 t.m

total shear force on C1 = 0.8"B1" + 10.8 "B3"= 11.6 t

M = ((3+0.4) x 9^2)/8 = 34.45 t.m

Vmax = (0.4 x 9)/2 + (20.25)/2 =11.9 t



Example 7 :
W = 12 KN/m^2 , o.w = 6 KN/m

r for S1 = (13/4) > 2 , one way .

r for S2 = (8/3) > 2 , one way .

r for S3 (10/8) = 1.25 < 2 , two way .

- For slab 1 :

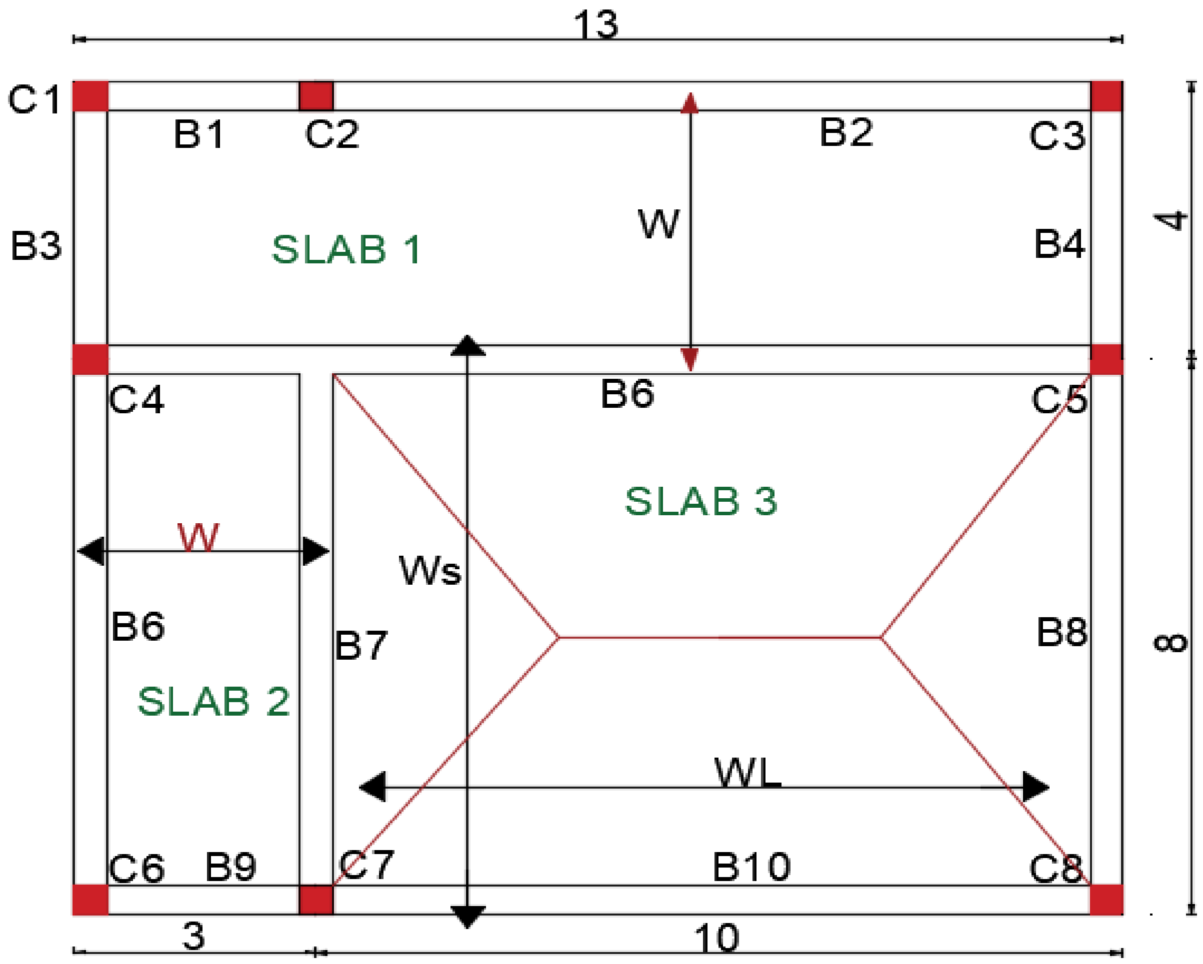
$$M= \frac{W\ Ls^2}{8} = \frac{12\ x\ 4^2}{8} = 24 \text{ KN.m}$$

$$V= \frac{W\ Ls}{2} = \frac{12\ x\ 4}{2} = 24 \text{ KN.}$$

- For slab 2 :

$$M= \frac{W\ Ls\hat{}2}{8} = \frac{12\ x\ 3^2}{8} = 13{,}5 \text{ KN.m}$$

$$V = \frac{12\ X\ 3}{2} = 18 \text{ KN.}$$



for slab 3 :

Max B.M Short = $\frac{Ws\ Ls\text{^}2}{8} = \frac{8.5\ 8^2}{8}$

Max B.M Long = $\frac{Wl\ Ll\text{^}2}{8} = \frac{3.5\ (10)^2}{8}$

Max V short = $\frac{W\ Ls}{3} = \frac{12\ x\ 8}{3}$

Max V long = $\frac{W\ Ls\ r}{2+r} = \frac{12\ x\ 8\ x\ 1{,}25}{2+1.25}$

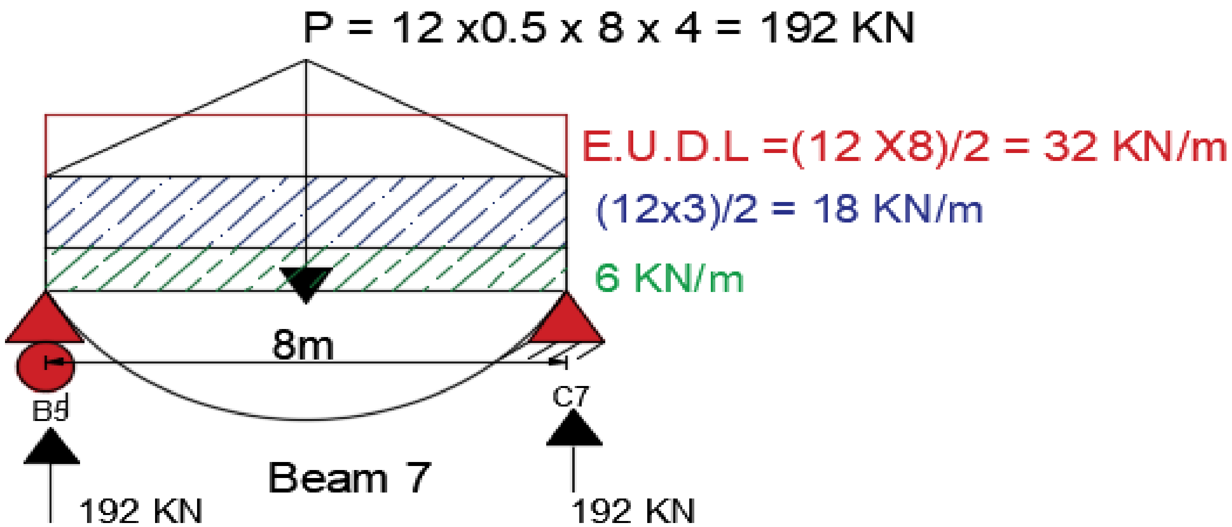
note :

Ws = $\frac{W\ r^4}{1+r^4} = \frac{12\ x\ 1.25^4}{1+1.25^4}$ = 8.51 KN/m

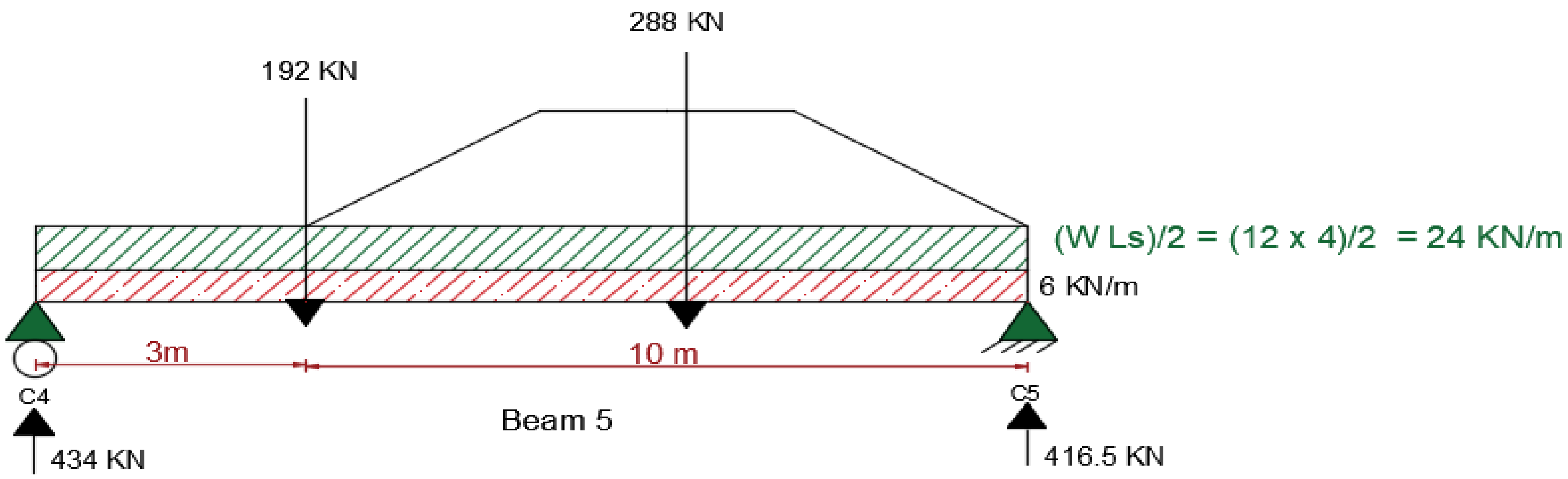
WL = 12 - 8.51 = 3.5 KN/m^2

M = ((32+18+6) x8^2)/8 = 448 KN.m

Vmax = (192)/2 + (24 x 8)/2 = 192 KN



total Load on C7 = 192 + B9(6 x 3)/2 + B10 "174" = 375



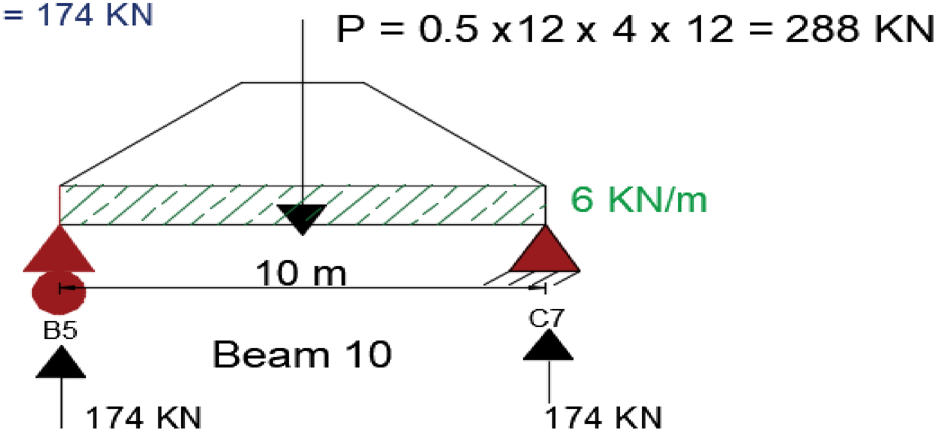
$\sum M$ C4 = 192x(3)+ 288 (8) + 30 x(13)x(13/2) = C5(13)

Reaction C5 = 416.5 KN

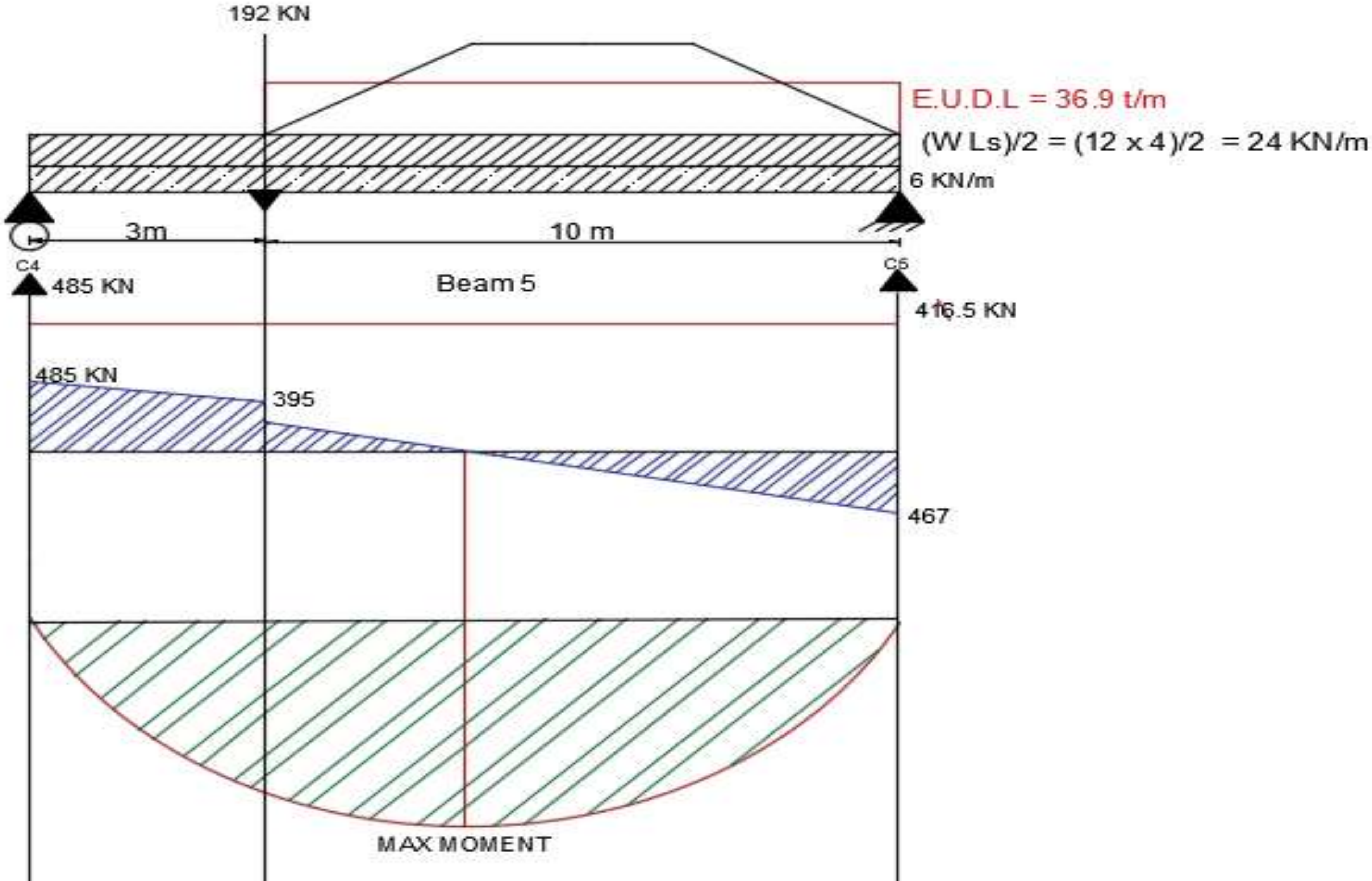
By $\sum Fy$ C4 = 434 KN

* find shaer force on C7 :

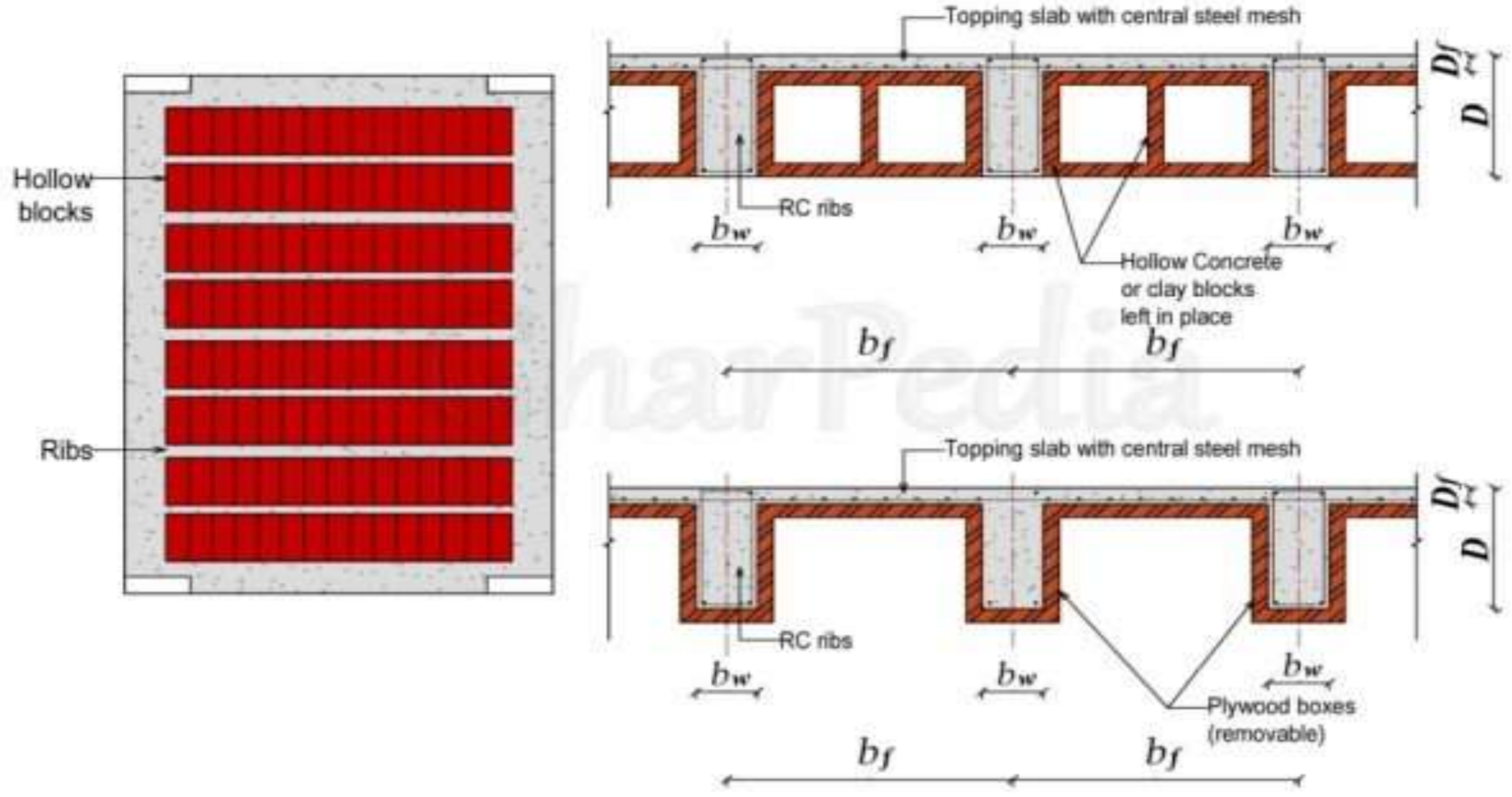
Vmax = (288)/2 + (10 x6)/2 = 174 KN

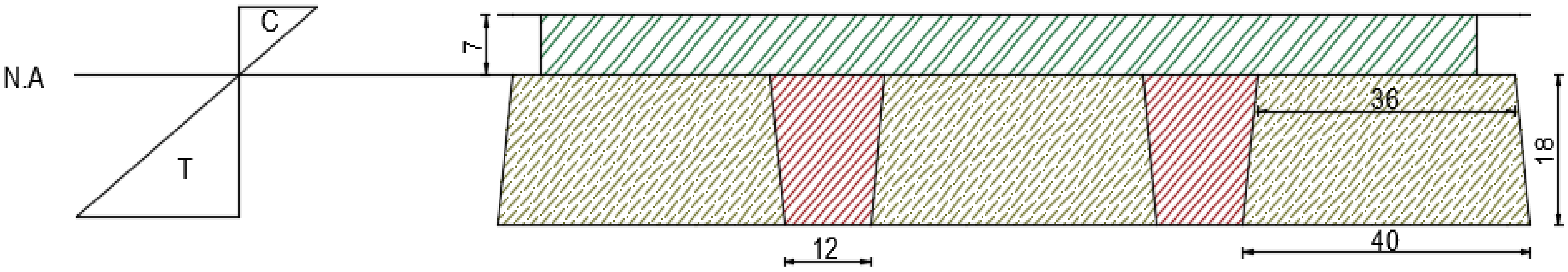


How to find max moment in beam 5:



Hollow slab (one way):





green zone : (TOP mat) reinforced concrete . (7 - 5 cm)

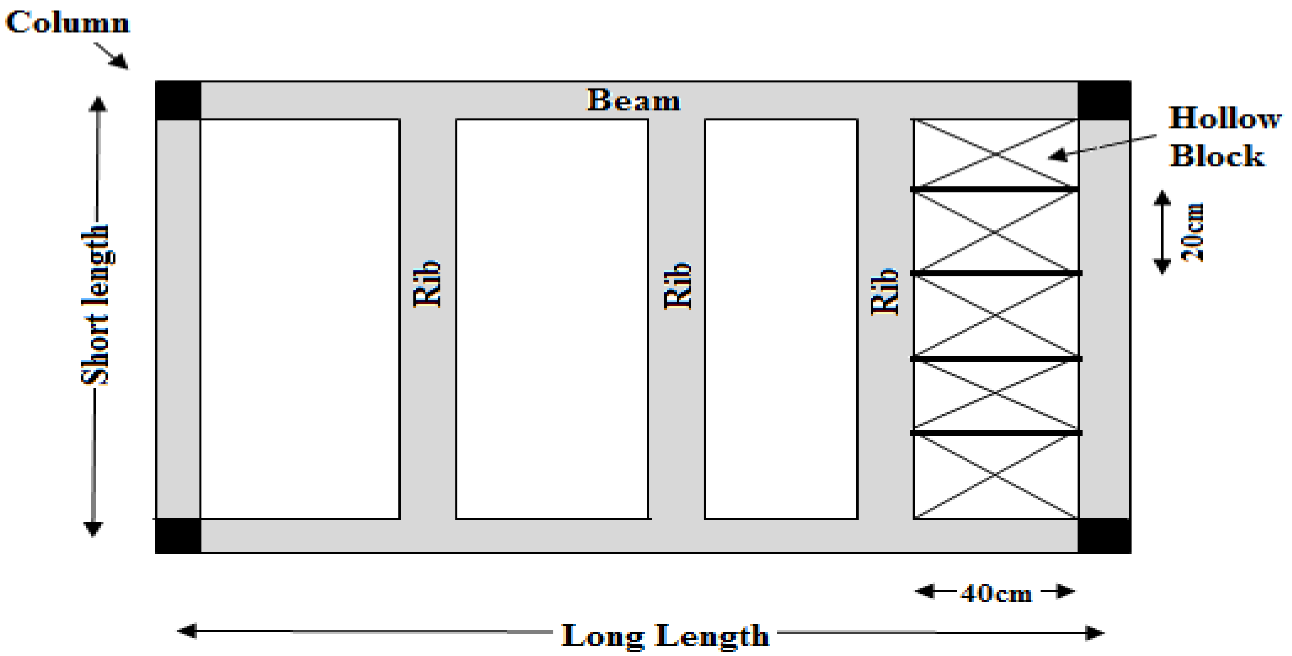
brown zone : blocks (36x40x18) & thickness = 20 cm

red zone : rips (RC)

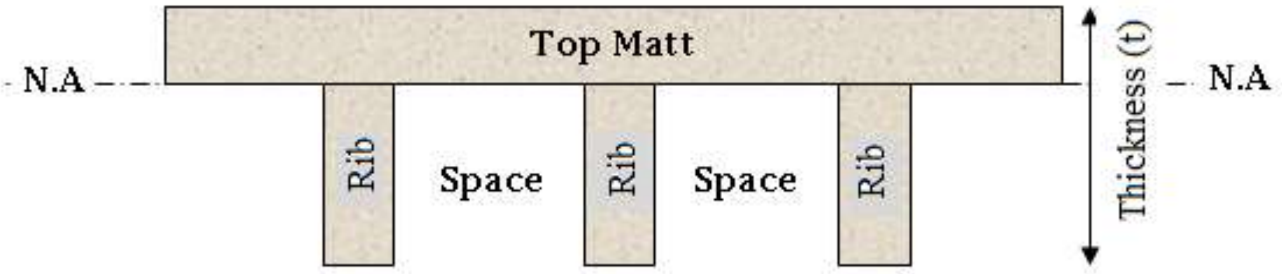
Dimensions vary depending on the code that we use .

Hollow block dimension = Width (40 ,36 ,...) x 20 x thickness (18 , 25 ,.....)

One Way Ribbed Slab

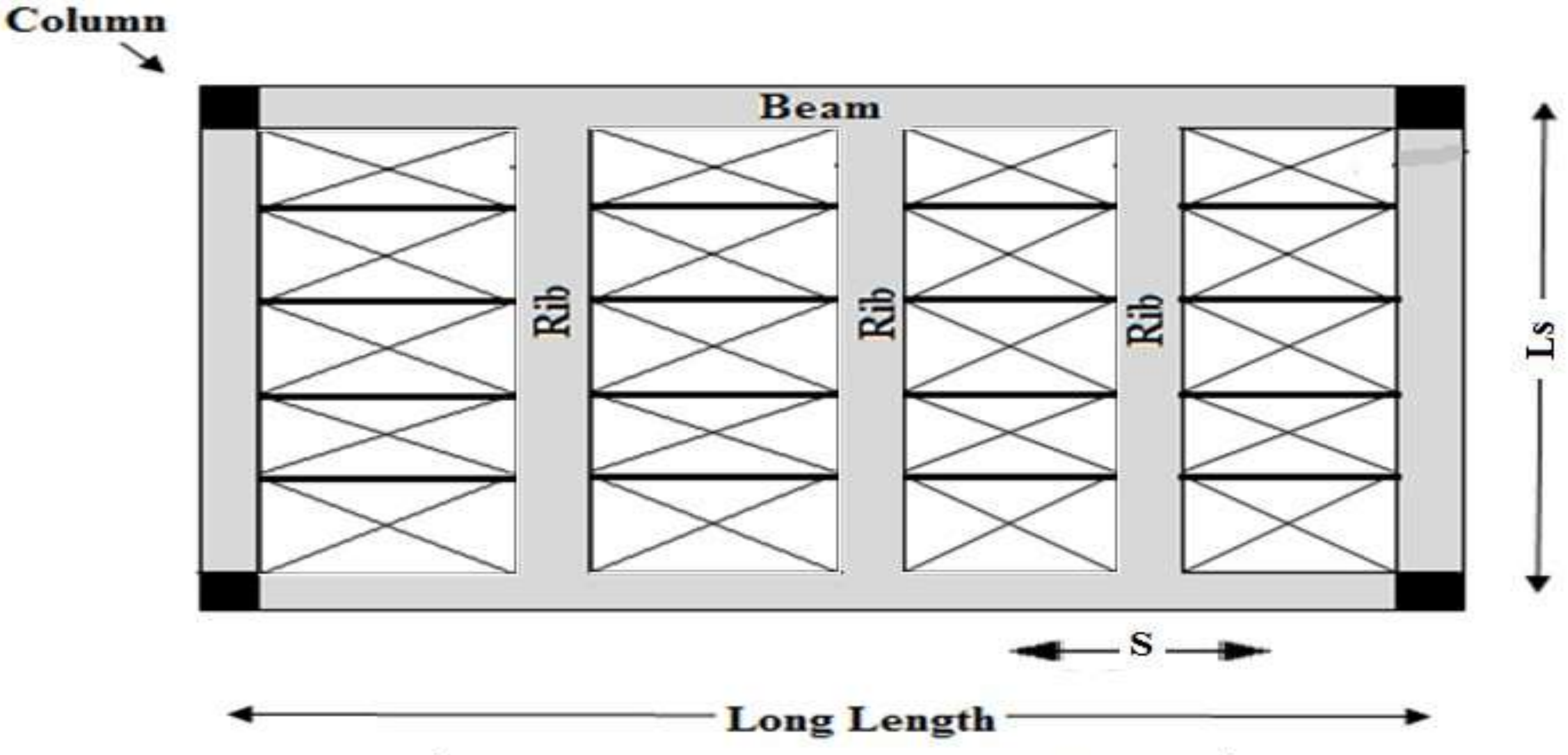


Plan view for one way ribbed



Cross-section for hollow slab

Analysis of One Way Ribbed Slab



Plan view for one way ribbed

- Area supported by one rib = (Ls) (s)
- Load for each rib = (Ls) (s) (w)
- Load / m.R for each rib = $\frac{Ls * s * w}{Ls}$ = ws

Analysis of One Way Ribbed Slab

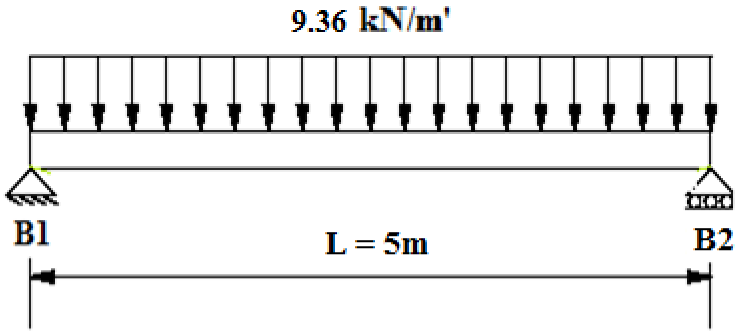
- **Example:** For shown ribbed slab, if load on floor on slab = 18 (kN/m²). Determine max shear and max moment in each rib.

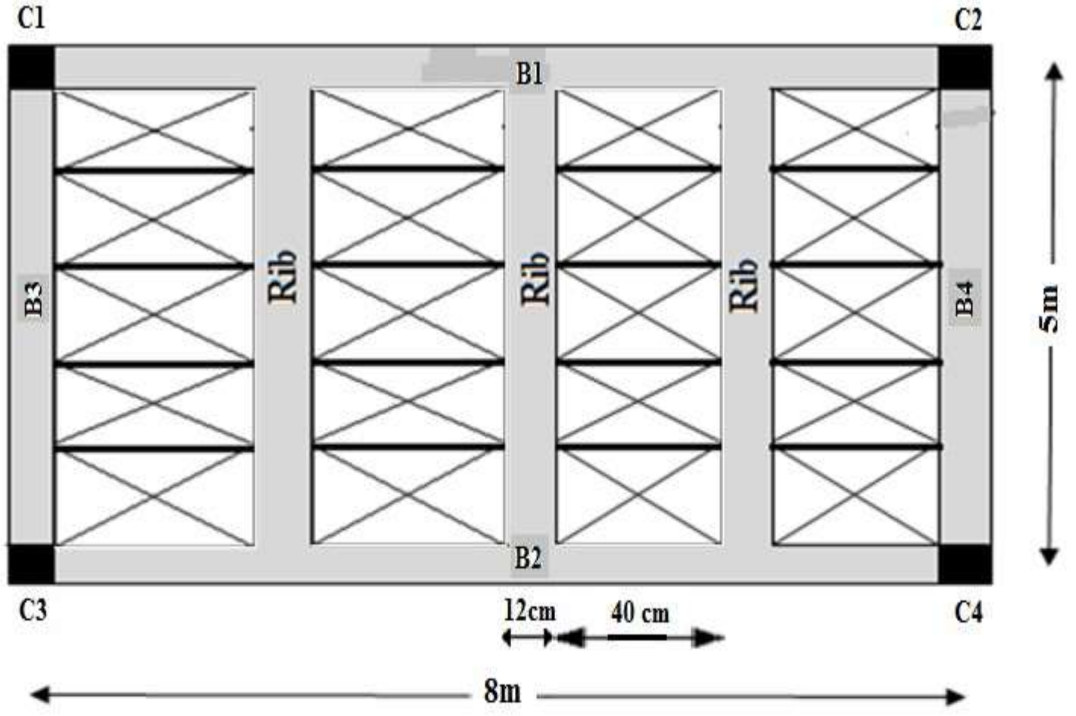
Soln:

- s = 40+12= 52cm = 0.52m

- Load/m.R for each rib = w*s

= 18*0.52 = 9.36 (kN/m)



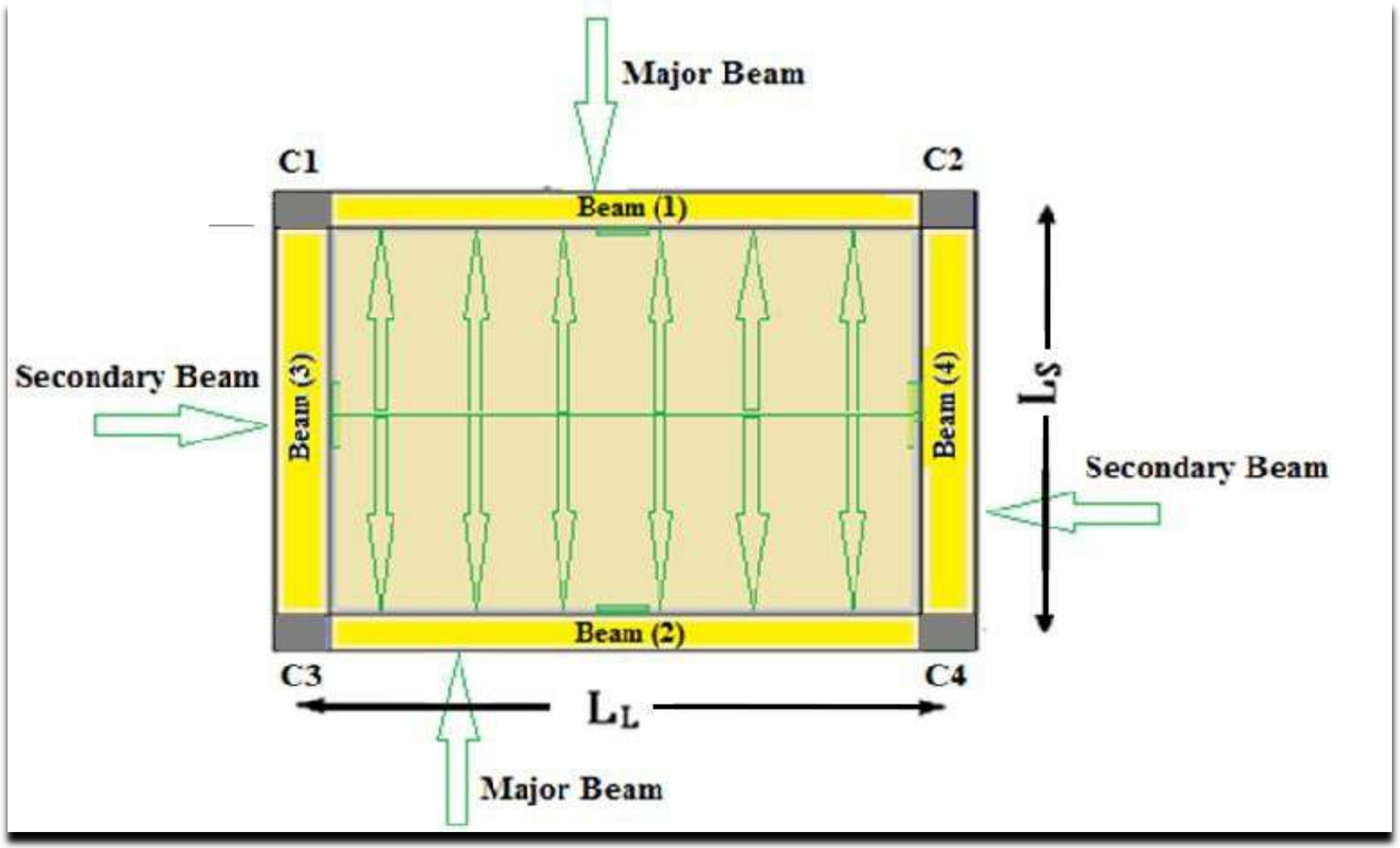


$$V_{max} = \frac{wL}{2} = \frac{9.36*5}{2} = 23.4kN$$

$$M_{max} = \frac{wL^2}{8} = \frac{9.36*5^2}{8} = 29.25kN.m$$

Analysis of One Way Ribbed Slab

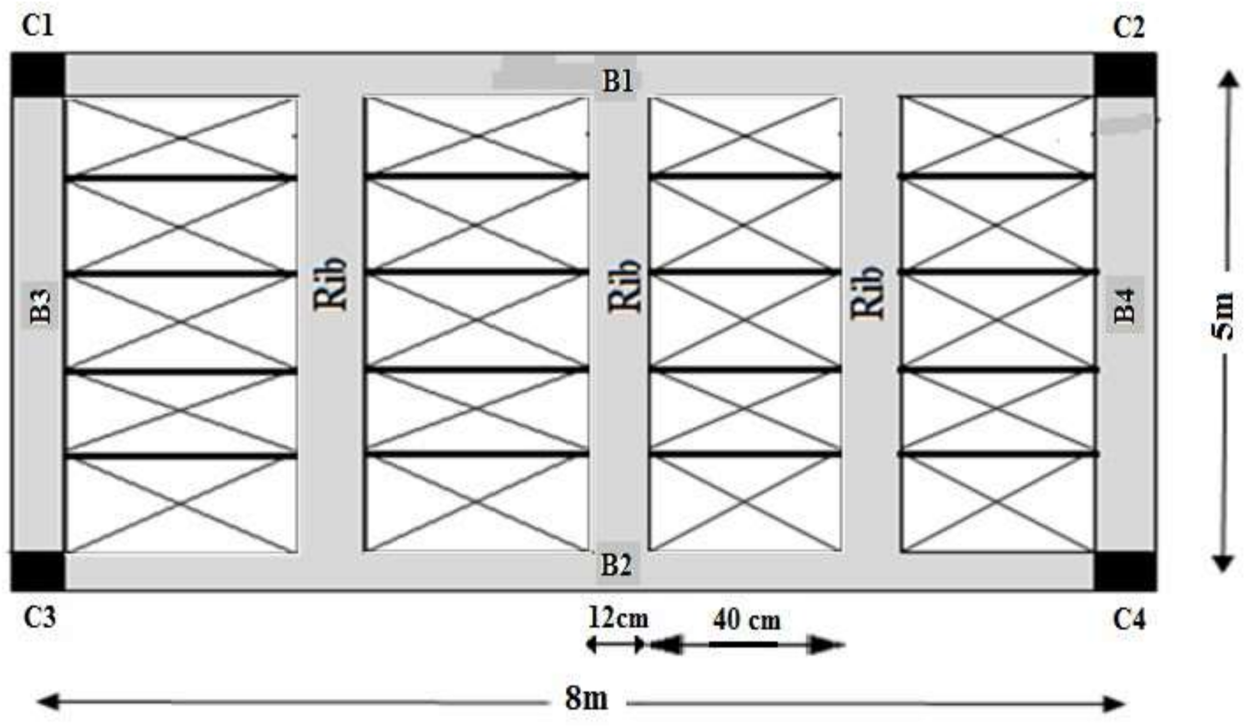
- In one way ribbed slab, the load transfer from slab to beams with same procedure in one way solid slab.



Analysis of One Way Ribbed Slab

- **Example:** For shown ribbed slab, if load on floor on slab = 18 (kN/m²) , own weight for each beam = 4 (kN/m). Determine:

1. Max shear and max moment in B(1).
2. Max shear and max moment in B(3).
3. Total axial load on C1



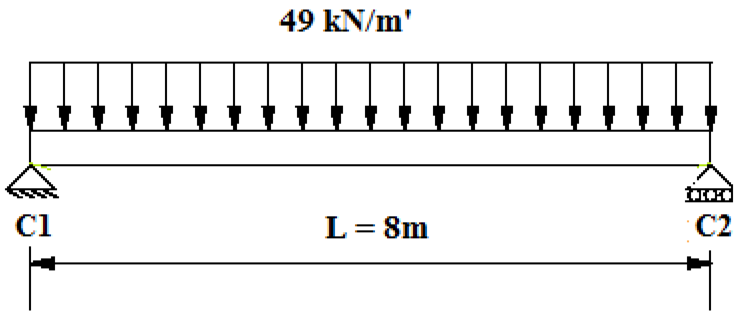
Analysis of One Way Ribbed Slab

- **Solution:**

1. Max shear and max moment in B(1).

Load from slab on Beam (1)= $\dfrac{wL_sL_L}{2L_L} = \dfrac{18*5*8}{2*8} = 45kN/m$

Total load on Beam (1) = 45 + 4 = 49 kN/*m'*.



$$V_{max} = \frac{wL}{2} = \frac{49*8}{2} = 196kN$$

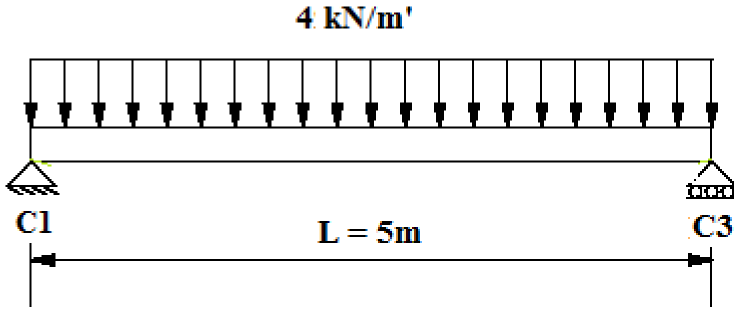
$$M_{max} = \frac{wL^2}{8} = \frac{49*8^2}{8} = 392kN.m$$

Analysis of One Way Ribbed Slab

- **Solution:**

2. Max shear and max moment in B(3).

Total load on Beam (3) = 4 kN/*m*'.



$$V_{max} = \frac{wL}{2} = \frac{4*5}{2} = 10kN$$

$$M_{max} = \frac{wL^2}{8} = \frac{4*5^2}{8} = 12.5kN.m$$

3. Total axial load on C1.

- Total axial load on C1 = 10 + 196 = 206 kN.

- Total axial load on C1 = (1/4) load of slab + (1/2) load of beam

= 0.25*(18*5*8) + 0.5*(4*8) + 0.5*(4*5) = 206 kN.

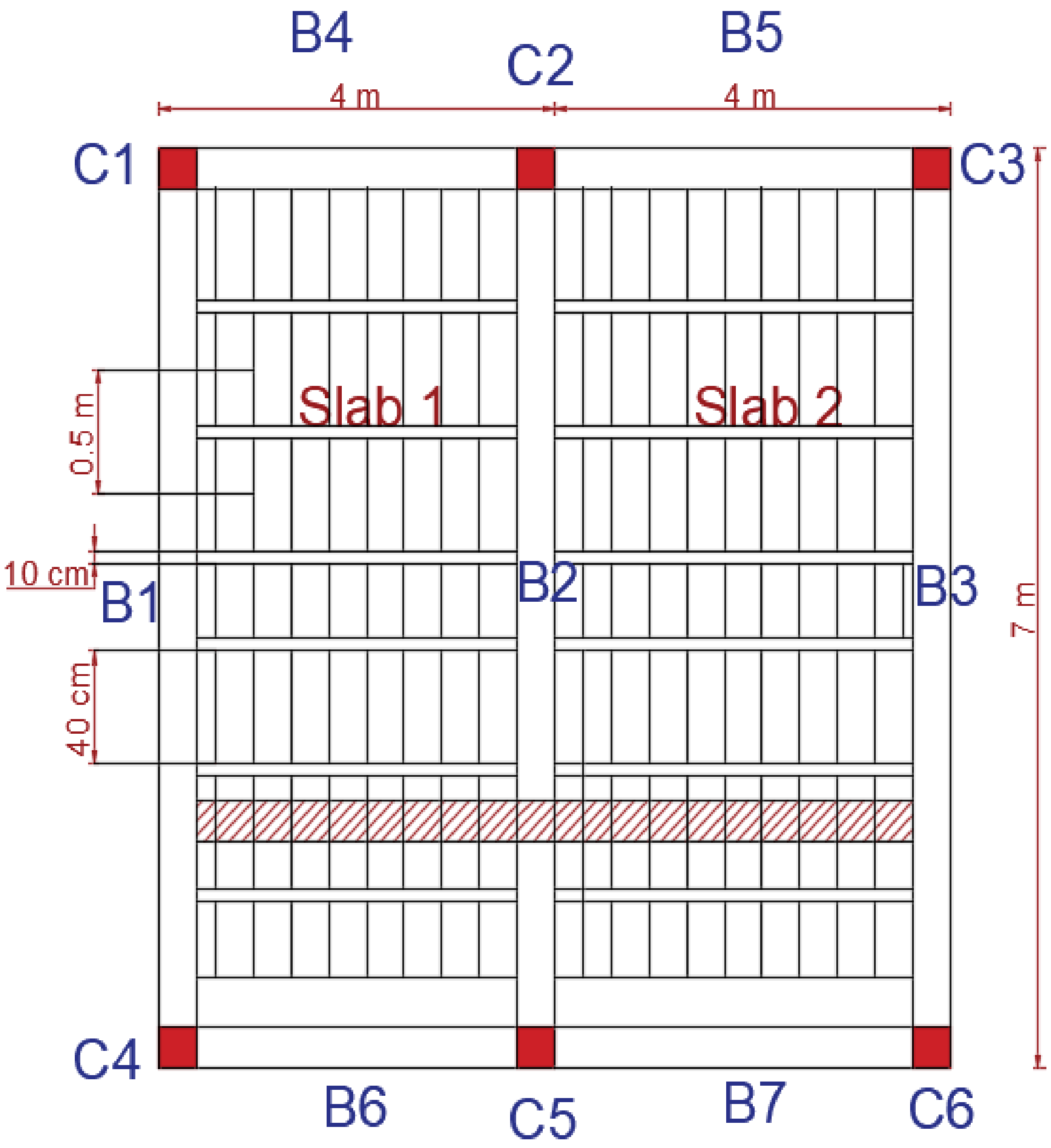
Example 9 :

calculate max V&M in rip and B2

one way hollow slab .

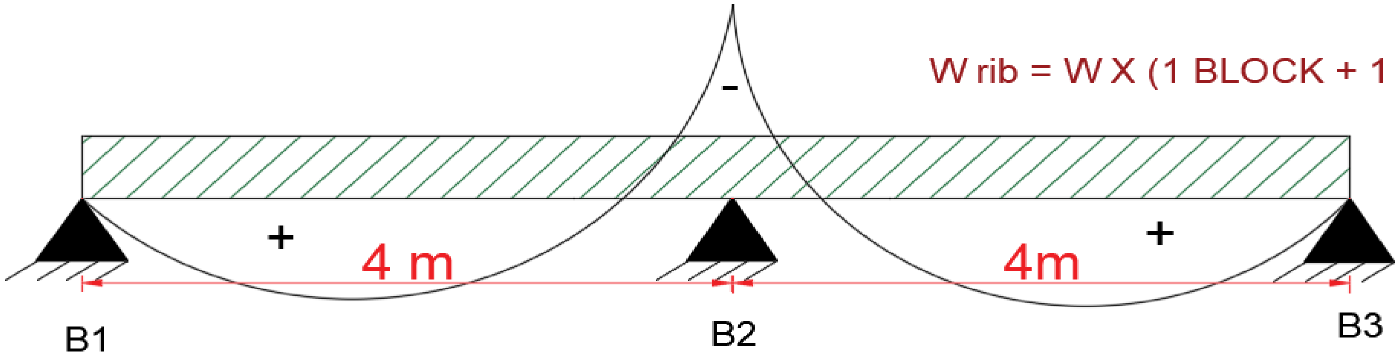
W = 12 KN/m^2 .

o.w of beam = 4 KN/m



Solution :

W rib = W X (1 BLOCK + 1 rib) = 0.5 x 12 = 6 KN/m



Max shear and moment in rip :

max B.M +ve = (W L^2)/10 = (6 X 4^2)/10 = 9.6 KN.m

max B.M -ve = (W L^2) /8 = (6 X 4^2)/8 = 12 KN.m

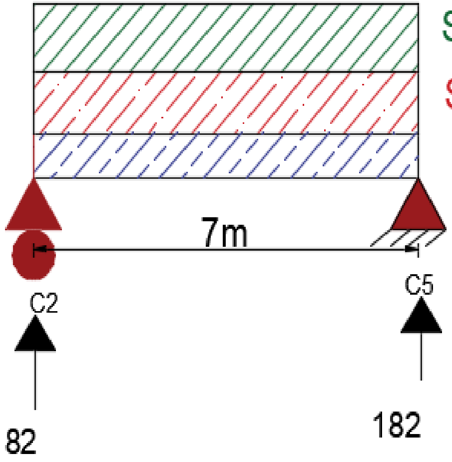
Max shear and moment in beam 2 :

Vmax = (52 x 7)/2 = 182 KN

M max = ((24 + 24 + 4) x7^2) /8 = 318.5 KN.m

total load on C2 = 182 + (4X4)/2 + (4X4)/2 = 198 KN

shear from B5 or B4 = (4 X O.W)/2



S1 = (W Ls)/2 = (12 x4)/2 = 24 KN/m

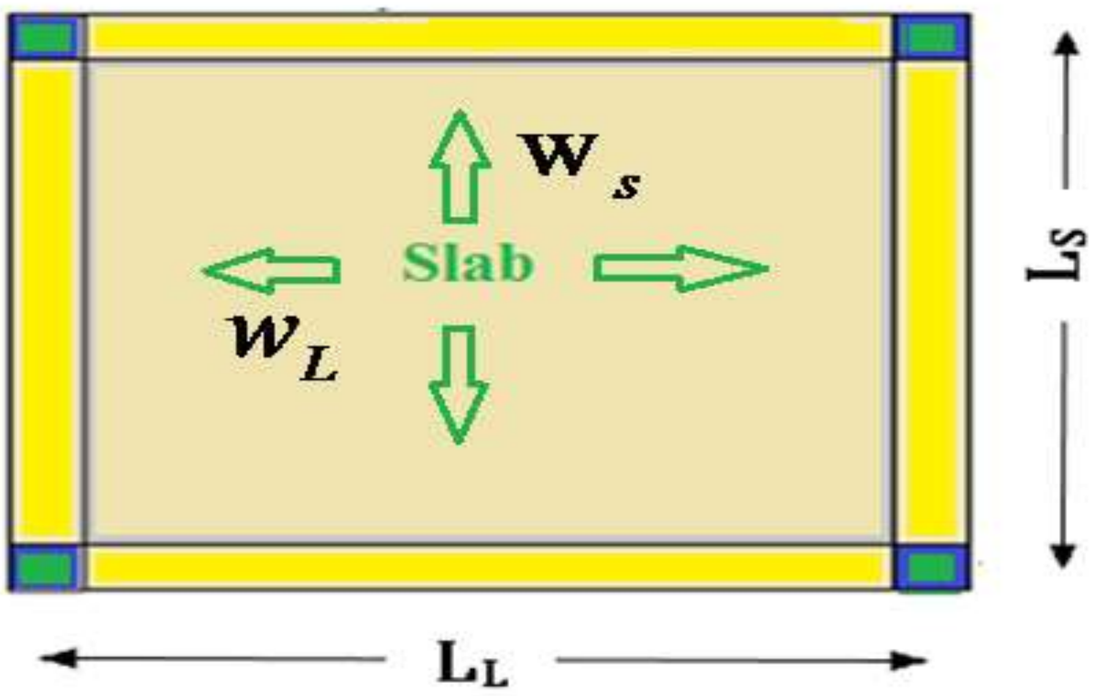
S1 = (W Ls)/2 = (12 x4)/2 = 24 KN/m

o.w = 4 kn/m

Two Way Ribbed Slab

- For two way solid slab: load transfer from slab to beams in two directions.

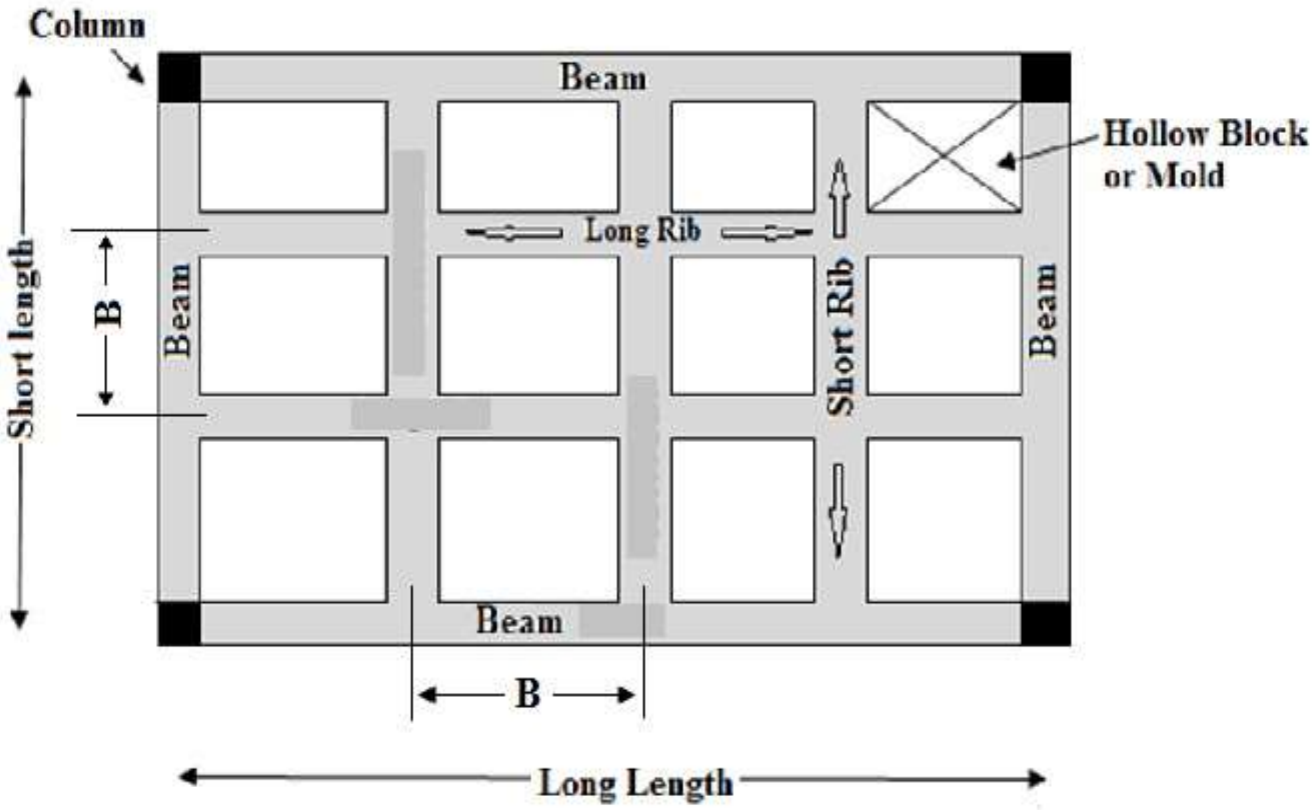
- All beams in two way solid slab are major beams



Two Way Ribbed Slab

$$w_L = \frac{w}{1+r^4}$$

$$w_s = \frac{wr^4}{1+r^4}$$



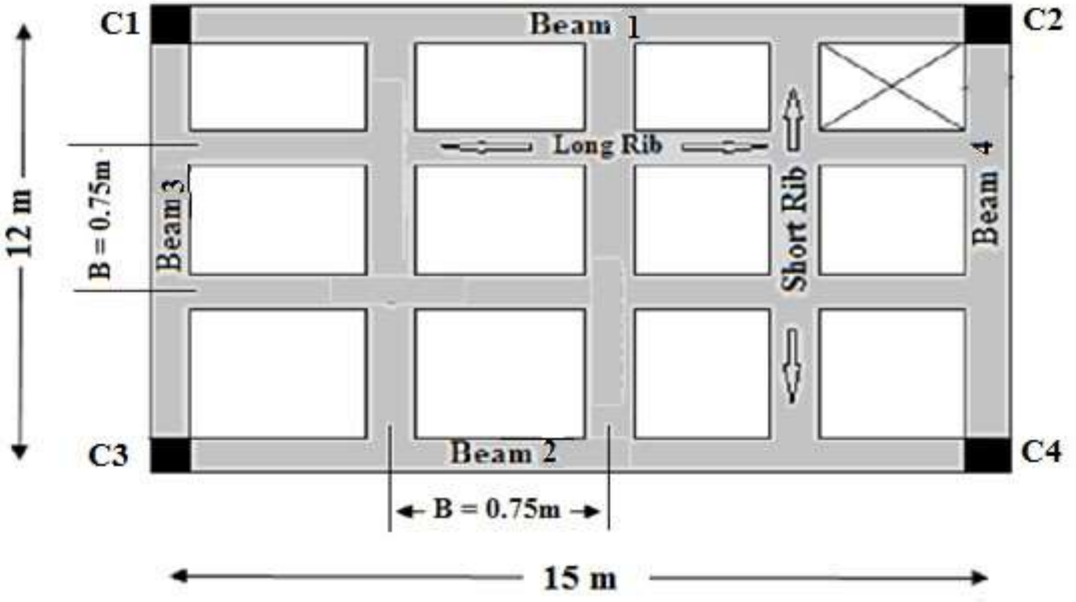
$$**\text{Load / m.R of short rib} = w_s * B * 1$$

$$**\text{Load / m.R of long rib} = w_L * B * 1$$

Two Way Ribbed Slab

- **Example:** For shown ribbed slab with load on floor (w) = 20kN/m², O.W for each beam = 5kN/m. Mold = 65×65 ×65 cm. Rib width = 10cm. Determine:

1. Max. shear and max. moment in slab.
2. Max moment in Beam (1).
3. Total axial load on C2.



$$r = \frac{15}{12} = 1.25$$

$$w_S = \frac{wr^4}{1+r^4} = \frac{20*1.25^4}{1+1.25^4} = 14.2(kN/m^2)$$

$$w_L = \frac{w}{1+r^4} = \frac{20}{1+1.25^4} = 5.8(kN/m^2)$$

$$** \text{Load / m.R of short rib} = 14.2 * 0.75 * 1 = 10.65 \text{ kN/m}$$

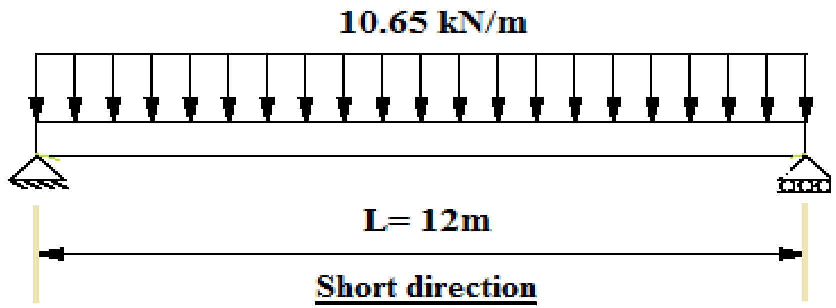
$$** \text{Load / m.R of long rib} = 5.8 * 0.75 * 1 = 4.35 \text{ kN/m}$$

Two Way Ribbed Slab

- **Example (continue):**

1. Max. shear and max. moment in slab.

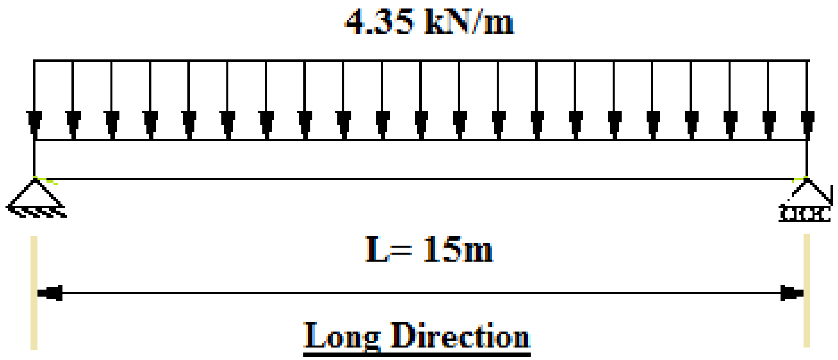
$$**\text{Short Direction}:$$



$$V_{\max} = \frac{wL}{2} = \frac{10.65*12}{2} = 63.9kN$$

$$M_{\max} = \frac{wL^2}{8} = \frac{10.65*12^2}{8} = 191.7kN.m$$

$$**\text{Long Direction}:$$



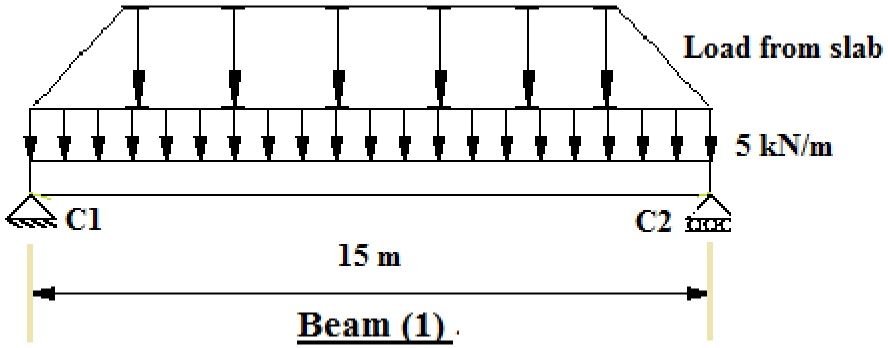
$$V_{\max} = \frac{wL}{2} = \frac{4.35*15}{2} = 32.625kN$$

$$M_{\max} = \frac{wL^2}{8} = \frac{4.35*15^2}{8} = 122.34kN.m$$

Two Way Ribbed Slab

- **Example (continue):**

2. Max moment in Beam (1).



$$* \text{ E.U.D.L } = \frac{wL_s r}{2+r}$$

$$= \frac{20*12*1.25}{2+1.25} = 92.3kN/m$$

$$* \text{ Total Load } = 5 + 92.3 = 97.3\text{kN/m}$$

$$* \text{ Mmax } = \frac{wL^2}{8} = \frac{97.3*15^2}{8} = 2736.56kN-m$$

3. Total axial load on C2.

Total load on C2 = ¼ load of slab + ½ load of beam

= ¼ *(20*12*15) + ½ *(5*15) + ½ *(5*12) = 967.5 kN.

Calculation of Dead load

➢Load on Solid Slab

- $L_{design} = w_u = 1.2D + 1.6\ L + 0.5\ (L_{roof}\ \text{or}\ S)$

- Dead load: own weight of slab + weight of finishing + weight of partitions + another sustained load.

- Live load: depends on type of structure.

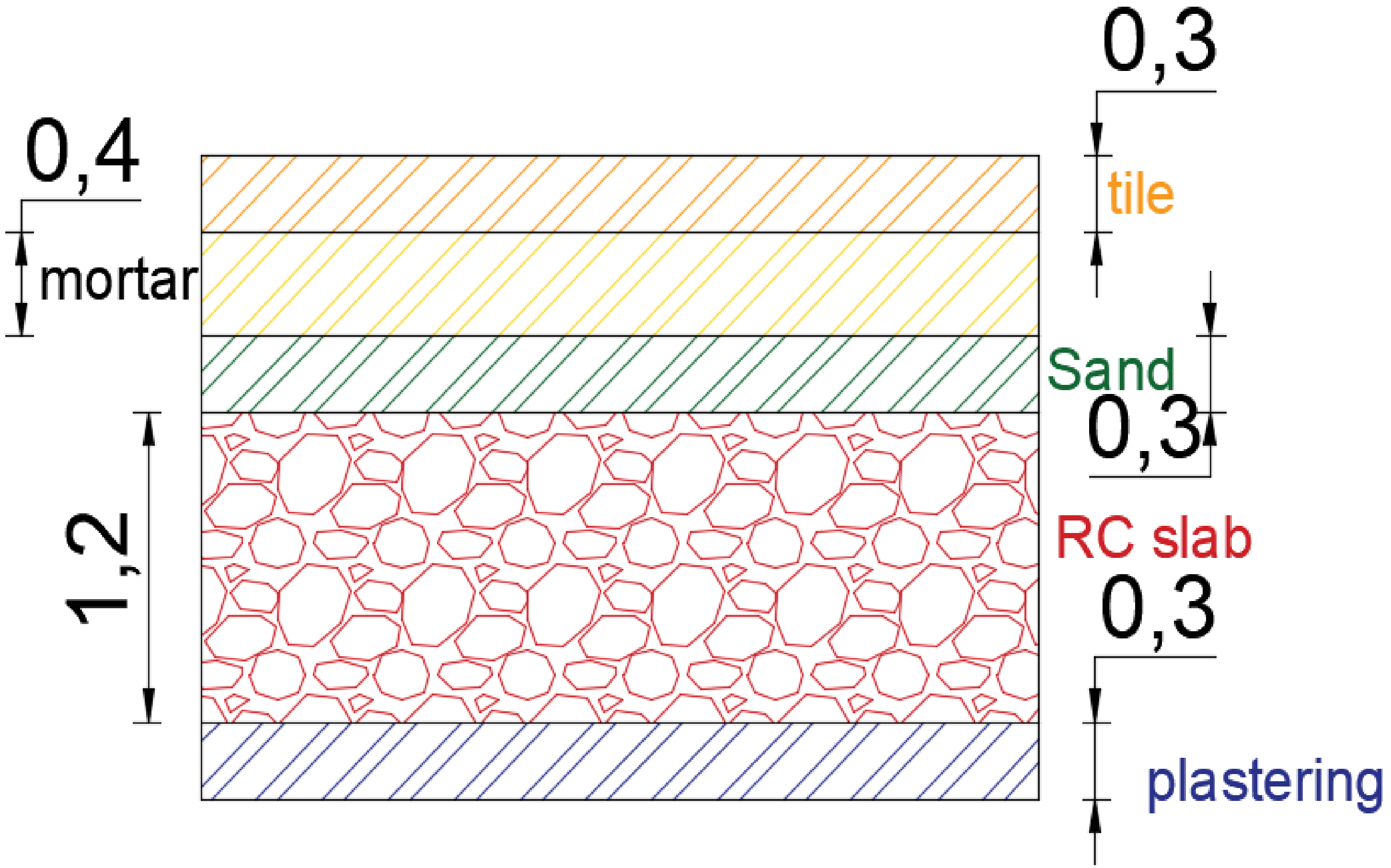
Example: live load for private house = 200 kg/m^2
live load for school = 400 kg/m^2

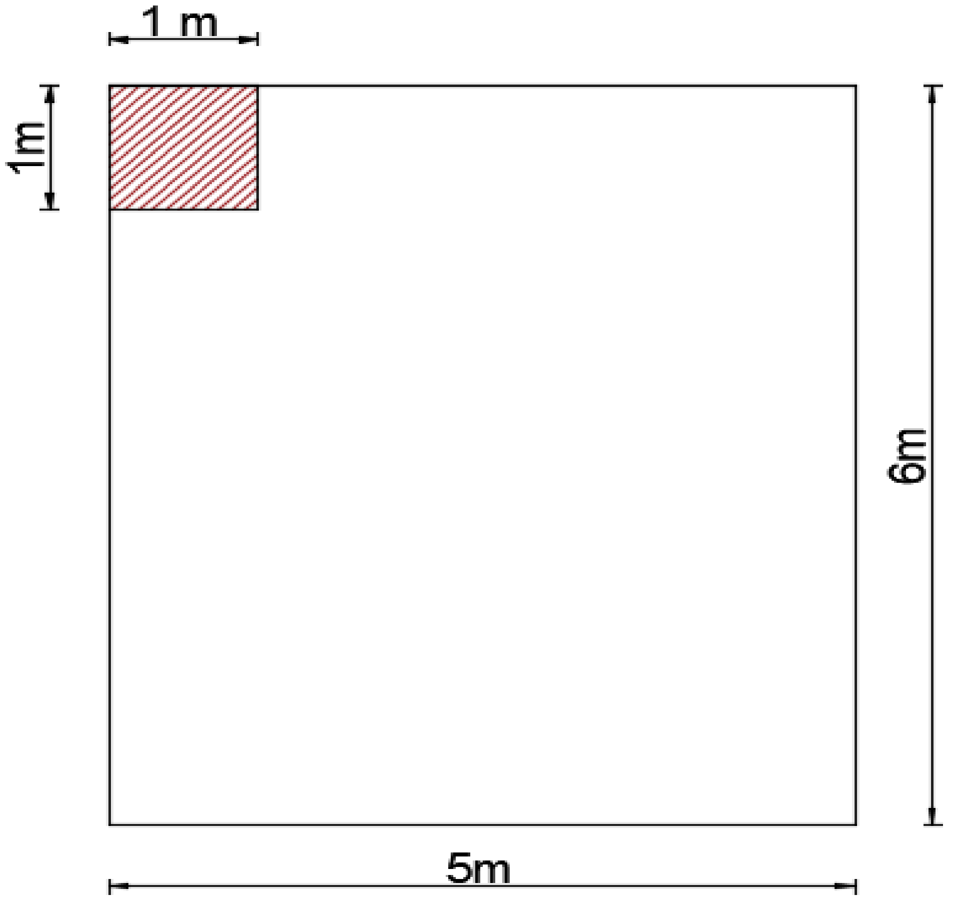
- Intensity of load for slab = force/area = kg/m^2 = kN/m^2 =lb/ft^2 .

1. Dead load for solid slab

Example 12 : calculate dead load for this solid slab .

Study area = 1m x 1m = 1 m^2 .





Solution :

1. plastering :

1cm ⟶ 21 kg/m^2

3cm ⟶ x

$= 21 \times \frac{3\ cm}{1\ cm} = 63\ Kg/m^2 \times 1m^2 = 63$ kg.

2. slab :

$2500 kg/m^3 \times 0.12 = 300\ \frac{kg}{m^2} \times 1m^2 = 300$ kg.

3. Sand :

$1500 kg/m^3 \times 0.03\ m = 45\ kg/m^2$.

4.Mortar :

$2100 kg/m^3 \times 0.04 = 84\ kg/m^2$.

5.Tile :

1cm ⟶ 20 kg/m^2

3cm ⟶ x

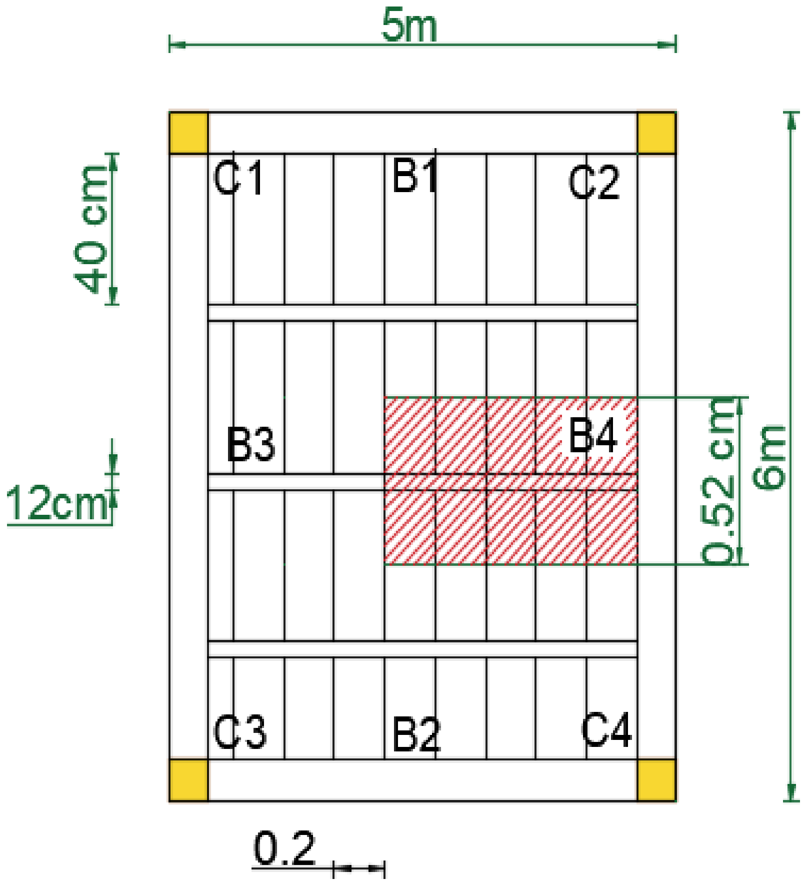
$= 60\ kg/m^2$

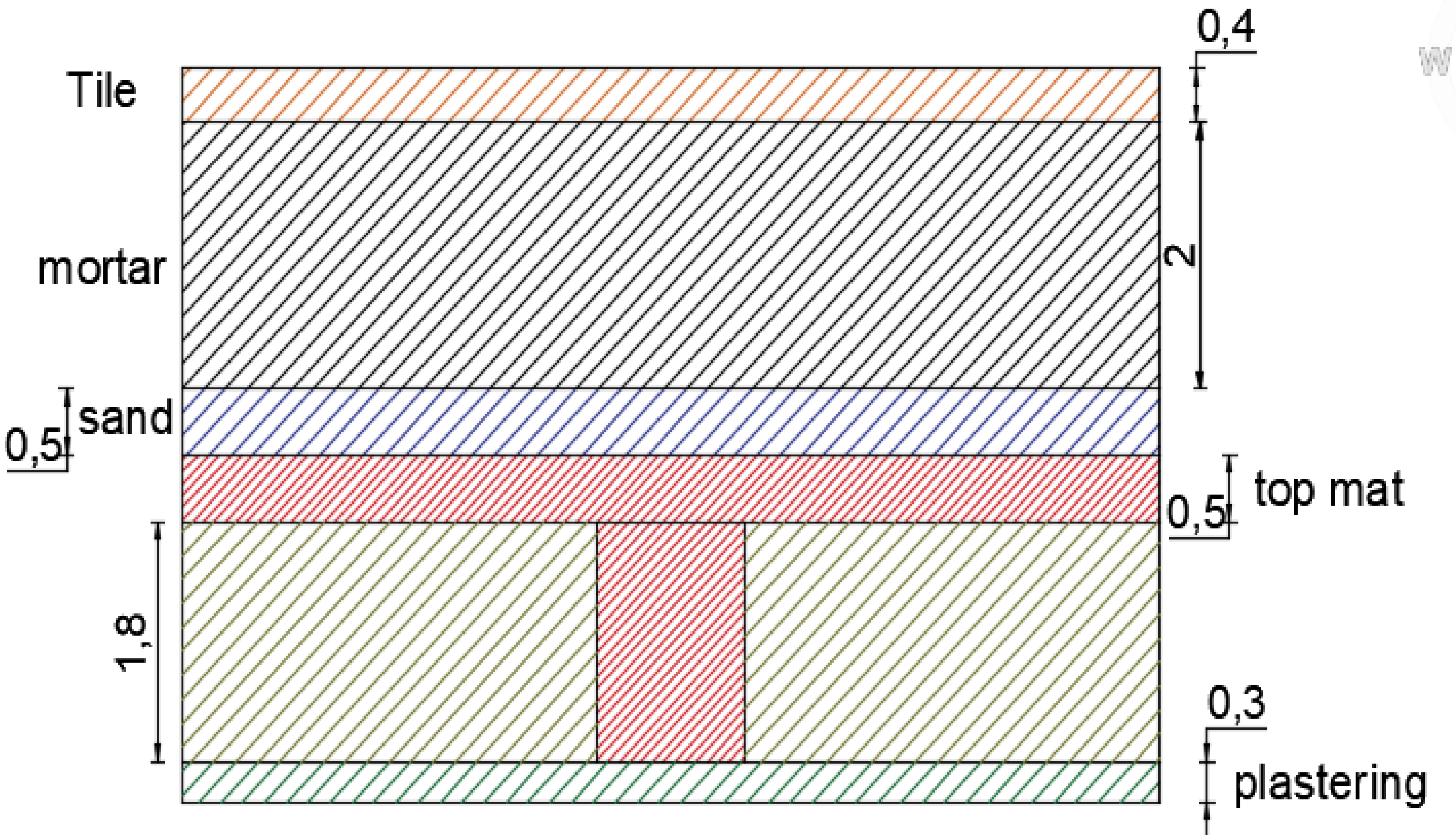
- DL =63 +300 +45 +84+60 =552 kg/m^2

- partition = (100-150) kg/m^2
- Total load = 552 + 100 =652 kg/m^2
- LL = 400 kg/m^2
- Wu = 1.2(652)+ 1.6(400)= 14.22 KN/m^2

2.Hollow slab one way .

Example 13 :





Slab : 5 x 6 m

Block : 40 x 20 x 18

Dead Load (1m^2) :

1. Plastering :

1 cm 21 kg/m

3 cm ?

2.Top mat :

2500 kg/m^3 x 0.05 m = 125 kg/m^2.

3.Sand :

1800 x 0.05 =90 kg/m^2.

4. Mortar :

2100 x 0.02 = 42 kg/m^2.

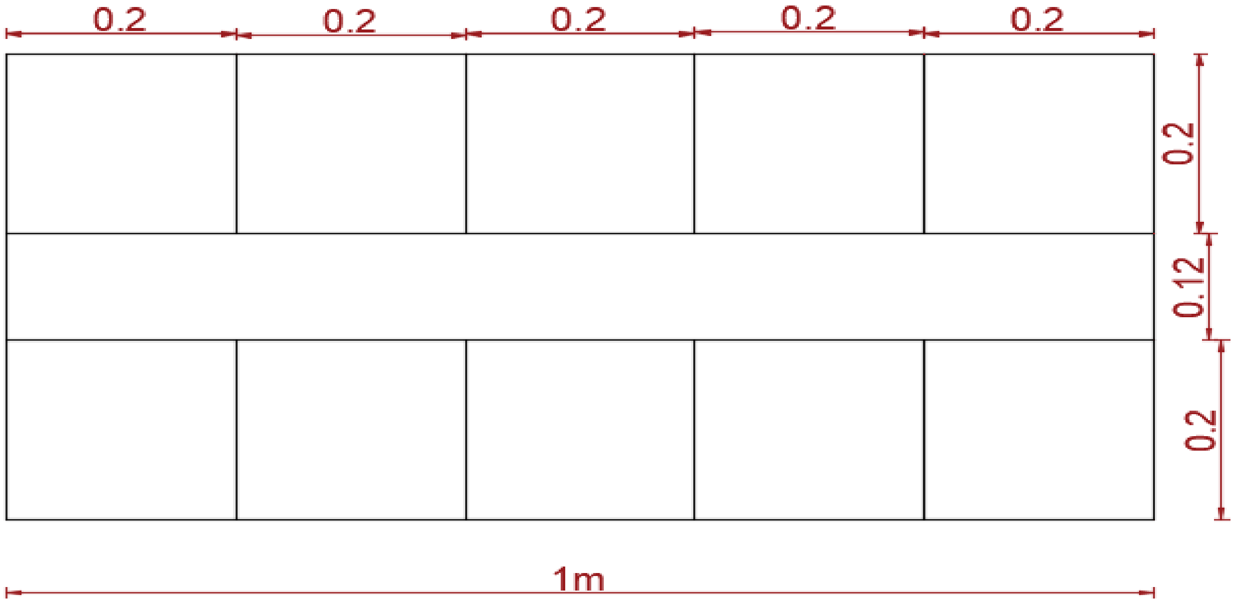
5. Tile :

1 cm 20 kg/m^2

4 cm ?

6. Partition :

=100 kg/m^2



Block and rip calculation :

study area = 0.52 m^2

O.w Block = 5 x 15 kg = 75 kg

0.52 m^2 $\longrightarrow$ 75 kg

1 m^2 $\longrightarrow$? Kg

- = 144.23 kg/m^2
- Or you can take area study one block (0.2 m)
- 0.53 x 0.2 = 0.104 m^2
- block = 1 x 15 = 15 kg
- for 1m^2 = (15/ 0.104) = 144.23 kg/m^2

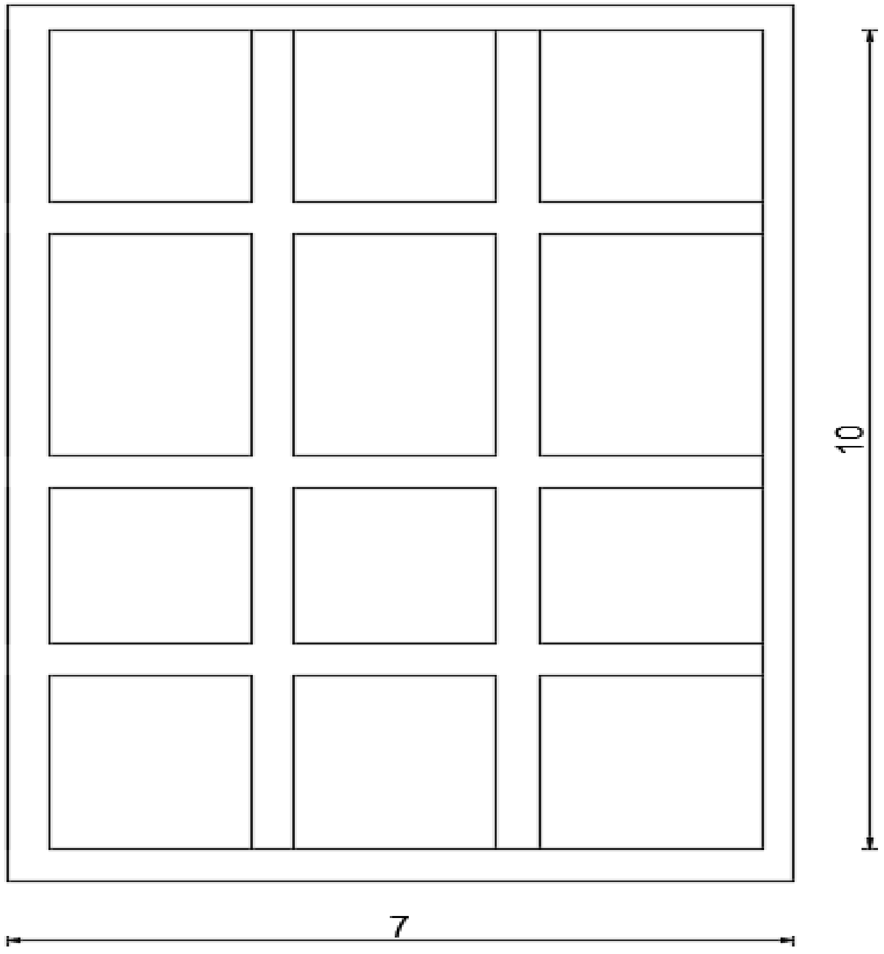
*rib :

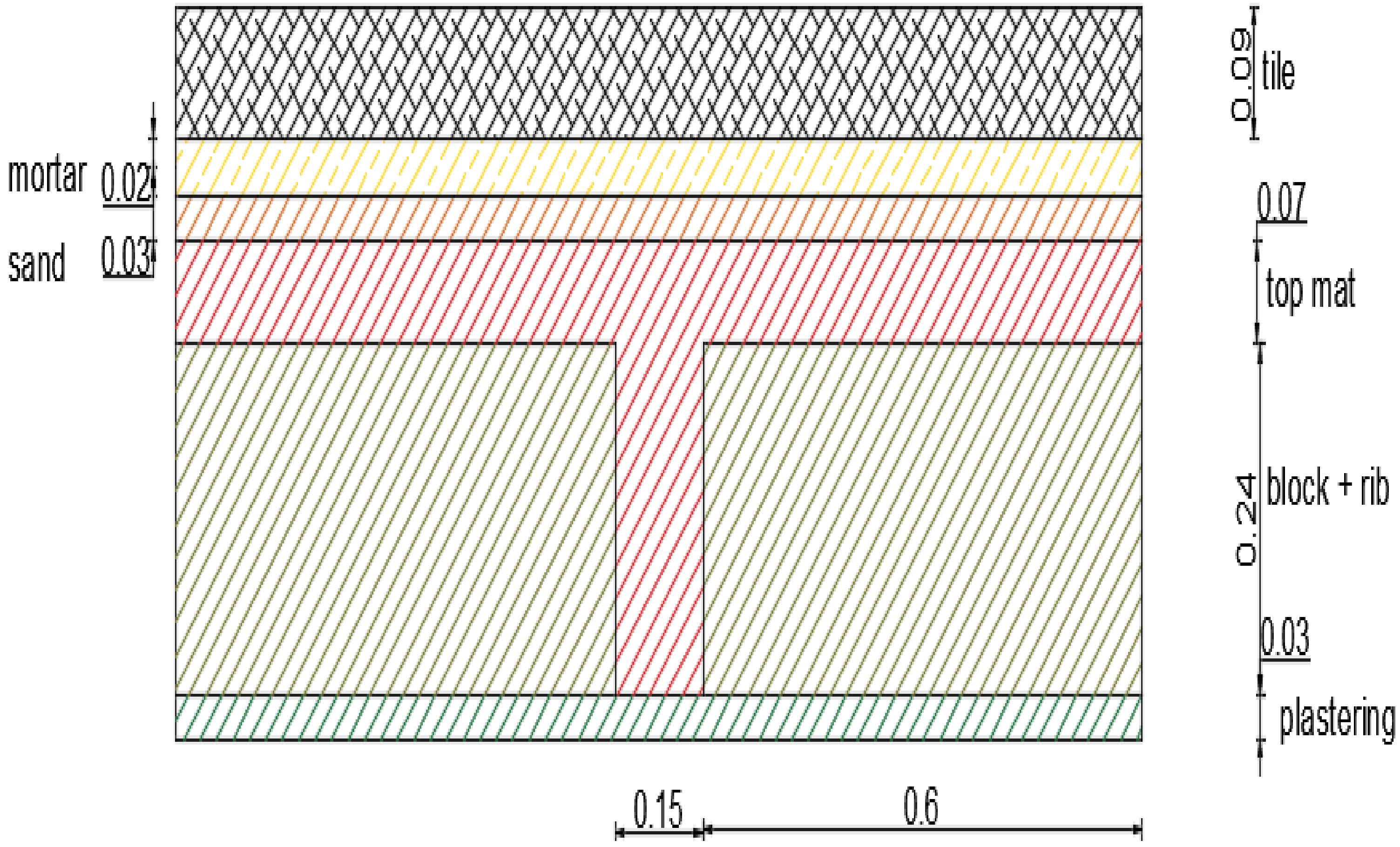
- = 2500 kg/m^3 x 0.18 x 0.12 x 1 = 54kg/m^2
- 54kg $\longrightarrow$ 0.52 m^2
- ? Kg $\longrightarrow$ 1m^2
- = 103.8 kg/m^2

- $\sum DL$ = 63+144.23+103.8+125+90+42+80+100 = 748 kg/m^2
- Wu = 1.2(748) + 1.6 (400) = 1537 kg/m^2

3.Dead load for hollow tow way slab .

Example 15 : H.B = 60 X 60 X24 cm .





Solution:

1.partition = 100 – 150 kg/m^2.

2.plastering :

1 cm $\longrightarrow$ 2kg/m^2

3 cm $\longrightarrow$??

= 63 kg/m^2

3.top mat = 2500 kg/m^2 x 0.07 m = 175 kg/m^2

4.sand = 1800 x 0.03 = 51 kg/m^2

5.mortar = 2100 x 0.04 = 84 kg/m^2

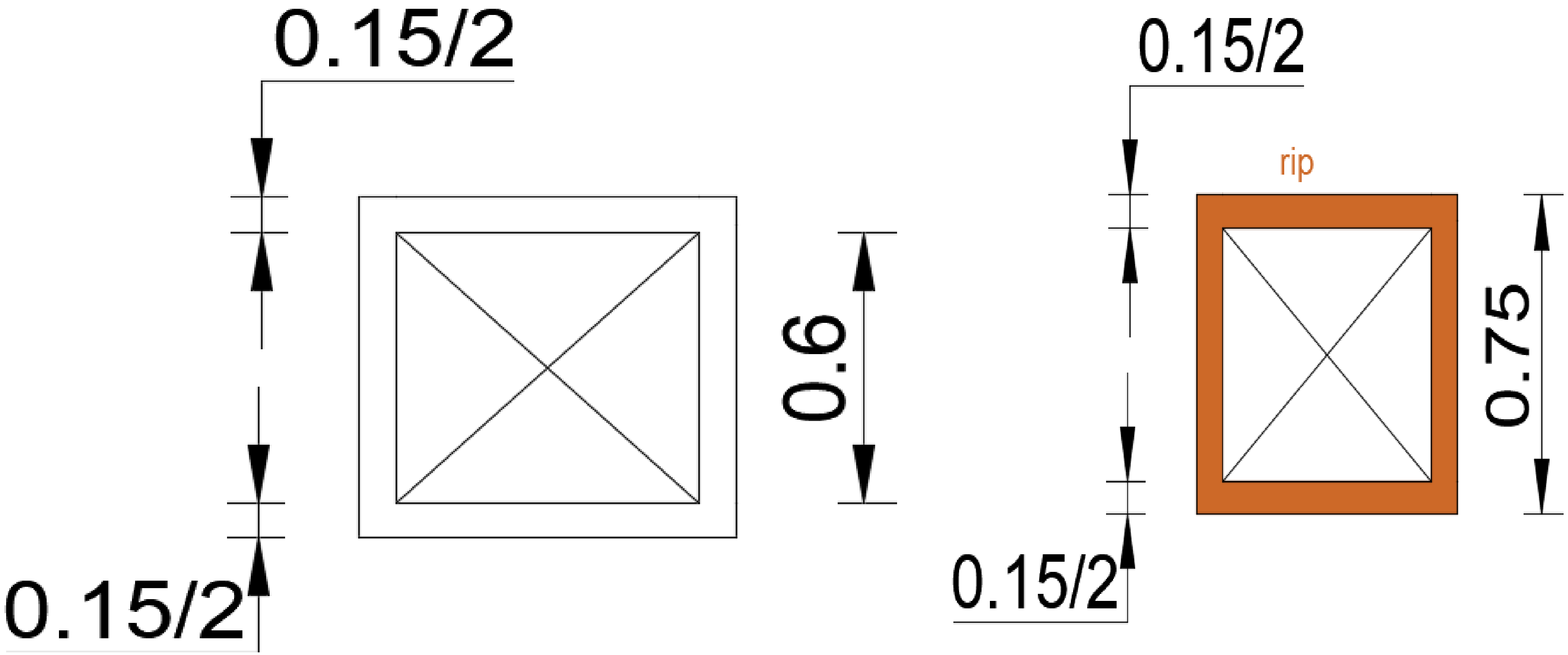
6. tile =

1 cm $\longrightarrow$ 20kg/m^2

4 cm $\longrightarrow$??

= 80 kg/m^2

reframe]



study area = 0.75 x 0.75 = 0.5625 m^2

block = 1 x 17 kg = 17 kg

Block = 1 x17 kg = 17 kg $\longrightarrow$ 0.5625 m^2

?? $\longrightarrow$ $1m^2$

Wt = $\frac{17}{0.5625}$ = 30.20 kg/m^2

rib = 2500kg/ m^2 x 0.24 x (05625 – 0.6^2) = 121.5 kg / 0.5625m^2 = 216 kg/m^2

$\sum DL = (150 + 63 + 216 + 175 + 54 + 84 + 80\ )$ = 852 .2 kg / m^2

Wu = 1.2(852.2) + 1.6 (400) = 1662.7 kg/m^2

Good luck

" The end "