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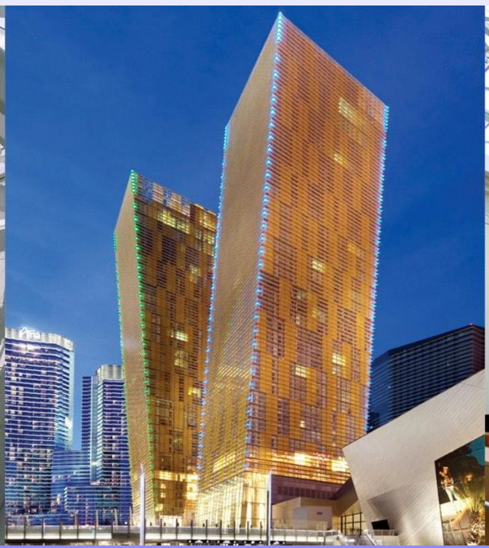
QATAR UNIVERSITY

COLLEGE OF ENGINEERING
DEPARTMENT OF CIVIL & ARCHITECTURAL ENGINEERING

CVEN 320 : Design of Reinforced Concrete Members

Introduction & Loads

WAEL I. ALNAHHAL, Ph. D., P. Eng

Concrete and Reinforced Concrete

Concrete – a mixture of fine aggregate (sand), coarse aggregate (eg, limestone), cement, water, air and admixtures.

Admixtures are materials, other than cement, aggregate and water, that are added to concrete either before or during its mixing to alter its properties, such as workability, curing temperature range, set time or color.

Concrete and Reinforced Concrete

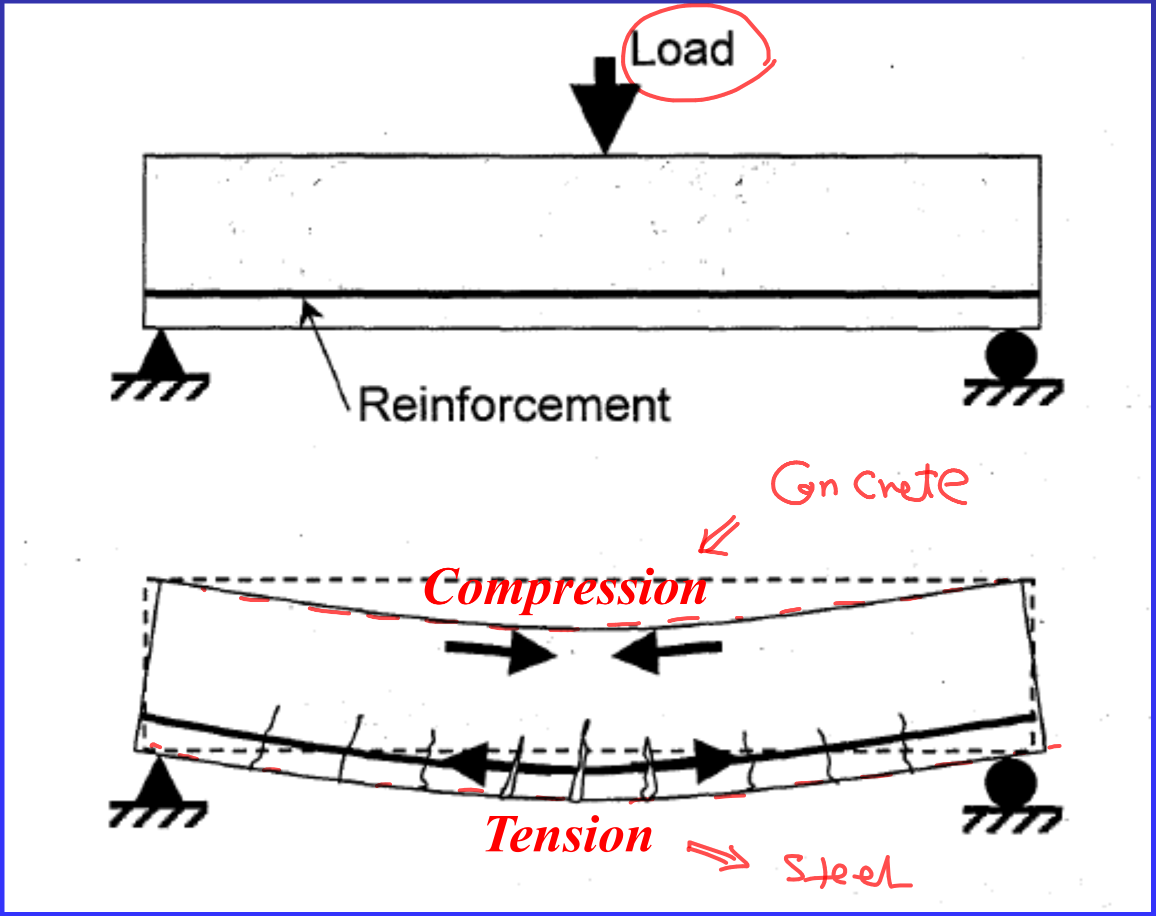
Concrete has high compressive strength and low tensile strength

⇒ steel

Reinforced concrete is a combination of concrete and steel. The reinforcing steel is used to resist tension

Reinforcing steel can also be used to resist compression (columns)

Reinforced Concrete –BEAM EXAPMLE



Codes

Building Code Requirements for Structural Concrete (ACI 318M-14) for SI units

International Building Code (IBC 2015)

Compressive Strength

The specified compressive strength of concrete is denoted by the symbol f'_c

Compressive strength is determined by testing a 6x12 in(150x300 mm) cylinder at an age of 28 days

For most applications, the range of concrete strength is 3,000 to 4,000 psi (21 to 28 MPa)

Compressive Strength

For prestressed concrete, the range of concrete strength is 5,000 to 6,000 psi (35 to 42 MPa)

For columns with high axial loads (lower stories of tall buildings), concrete with strength in the range 9,000 to 10,000 psi (63 to 70 MPa) may be used

Static Modulus of Elasticity

Concrete does not have a single modulus of elasticity

The particular value varies with concrete strength, age, type of loading and proportions of aggregate and cement

ACI Code Section 8.5.1 -

$E_c =$ $0.043\, w_c^{1.5} \sqrt{f_c'}$ $w_c = 1500 \rightarrow 2500$ kg/m3

For concrete weighing about 2320 Kg/m^3 :

$E_c =$ $4700 \sqrt{f_c'}$ E_c f_c' in MPa

Static Modulus of Elasticity

High-strength concrete (> 42 MPa)

$$E_c = \left[3.32\sqrt{f_c^{'}} + 6895\right]\left(\frac{w_c}{2320}\right)^{1.5}$$

Dynamic modulus is about 20 to 40 percent higher than the static modulus

Poisson's Ratio

$0 < \nu < 0.5$

About 0.11 for high strength concrete (>42MPa)

About 0.21 for low strength concrete

Average value is about 0.16

Reinforcing Steel

Bars or welded wire fabric (WWF)

Bars can be plain or deformed

Plain bars are rarely used

Bars are given a number in US units equivalent to one eighth of the diameter in inches and an equivalent SI number that is nearly equal to the diameter in mm

Reinforcing Steel

Important

Table 1.1 Reinforcement Bar Sizes and Areas

Standard inch-pound bars			Soft metric bars		
Bar no.	Diameter (in.)	Area (in.^{2})	Bar no.	Diameter (mm)	Area (mm^2)
3	0.375	0.11	10	9.5	71
4	0.500	0.20	13	12.7	129
5	0.625	0.31	16	15.9	199
6	0.750	0.44	19	19.1	284
7	0.875	0.60	22	22.2	387
8	1.000	0.79	25	25.4	510
9	1.128	1.00	29	28.7	645
10	1.270	1.27	32	32.3	819
11	1.410	1.41	36	35.8	1006
14	1.693	2.25	43	43.0	1452
18	2.257	4.00	57	57.3	2581

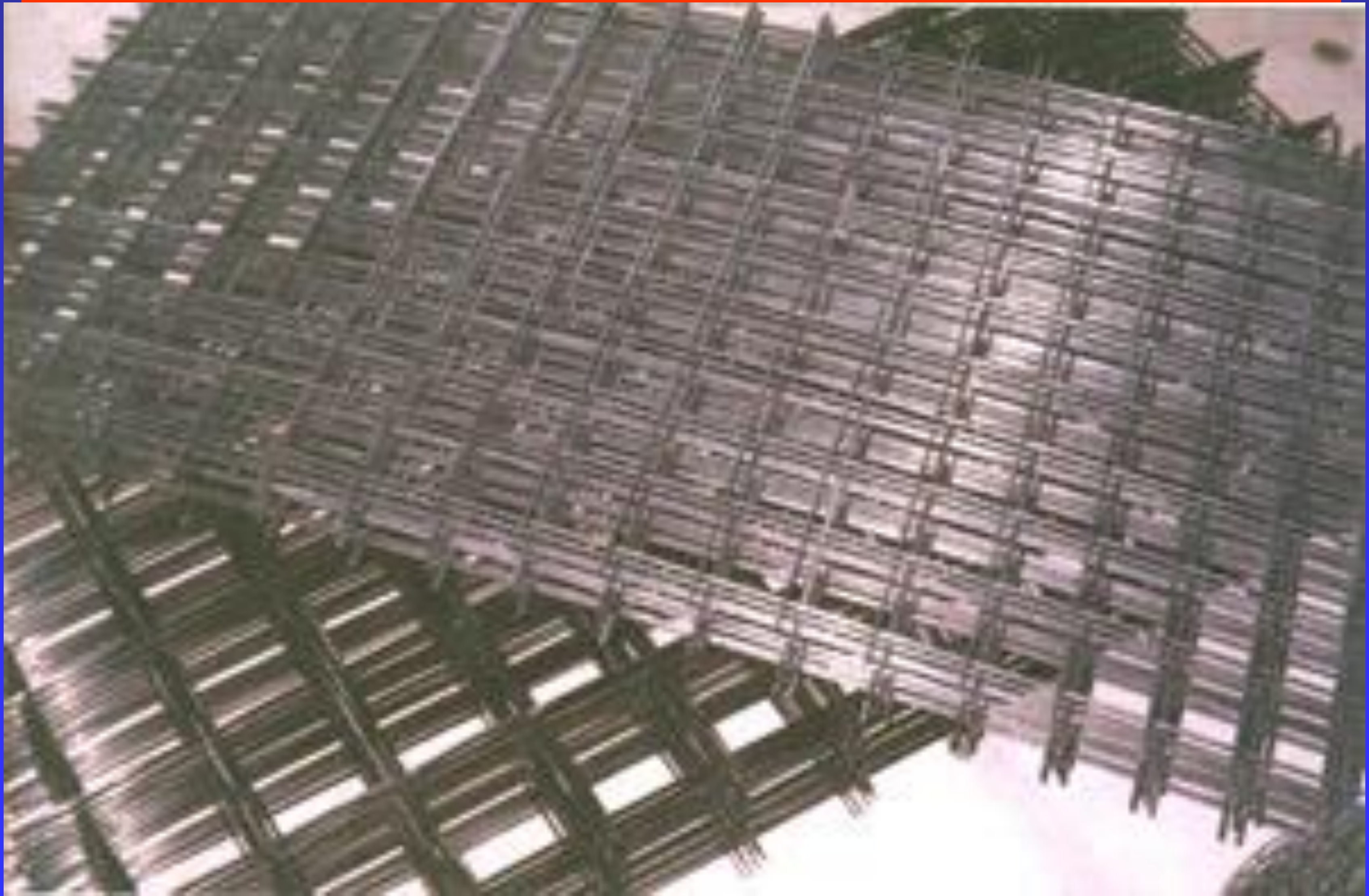
3 # 10

Reinforcing Steel-Qatar Steel Company

Designation	Nominal Dia. (d) (mm)	Nominal Cross Section Area (mm^2)	Unit Mass (kg/m)	Maximum of Average Knot Space (mm)	Height of Knot		Ltgd/Ri Width (mm)	Nominal Mass kg/piece		
					Min (mm)	Max (mm)		6m	9m	12m
D8	08	50.27	0.395	5.6	0.3	0.6	3.14	2.37	3.56	4.74
D10	10	78.54	0.617	7.0	0.4	0.8	3.9	3.7	5.55	7.40
D12	12	113.1	0.888	8.4	0.5	1.0	4.7	5.33	7.99	10.66
D14	14	153.9	1.21	9.8	0.6	1.2	5.5	7.26	10.89	14.52
D16	16	201.1	1.58	11.2	0.7	1.4	6.3	9.48	14.22	18.96
D18	18	254.5	2.00	12.6	0.8	1.6	7.1	12.00	18.00	24.00
D20	20	314.2	2.47	14.0	1.0	2.0	7.9	14.82	22.23	29.64
D22	22	380.1	2.98	15.4	1.1	2.2	8.6	17.88	26.82	35.76
D25	25	490.9	3.85	17.5	1.3	2.6	9.8	23.10	34.65	46.20
D28	28	615.8	4.83	19.6	1.4	2.8	11.0	28.98	43.47	57.96
D30	30	706.9	5.55	21.0	1.5	3.0	11.8	33.30	49.95	66.60
D32	32	804.2	6.31	22.4	1.6	3.2	12.6	37.86	56.79	75.72
D36	36	1017.9	7.990	25.2	1.8	3.6	14.1	47.94	71.99	95.88
D40	40	1256.6	9.864	28.0	2.0	4.0	15.7	59.18	88.78	118.37

ISO 6935-2 B500B-R / ASTM A615 GRADE 60 / SASO 2/1992

Welded Wire Fabric (WWF)



Grades of Reinforcing Steel

Grade	40,	50,	60,	75	
F_y = Yield stress	300,	350,	420,	520	MPa

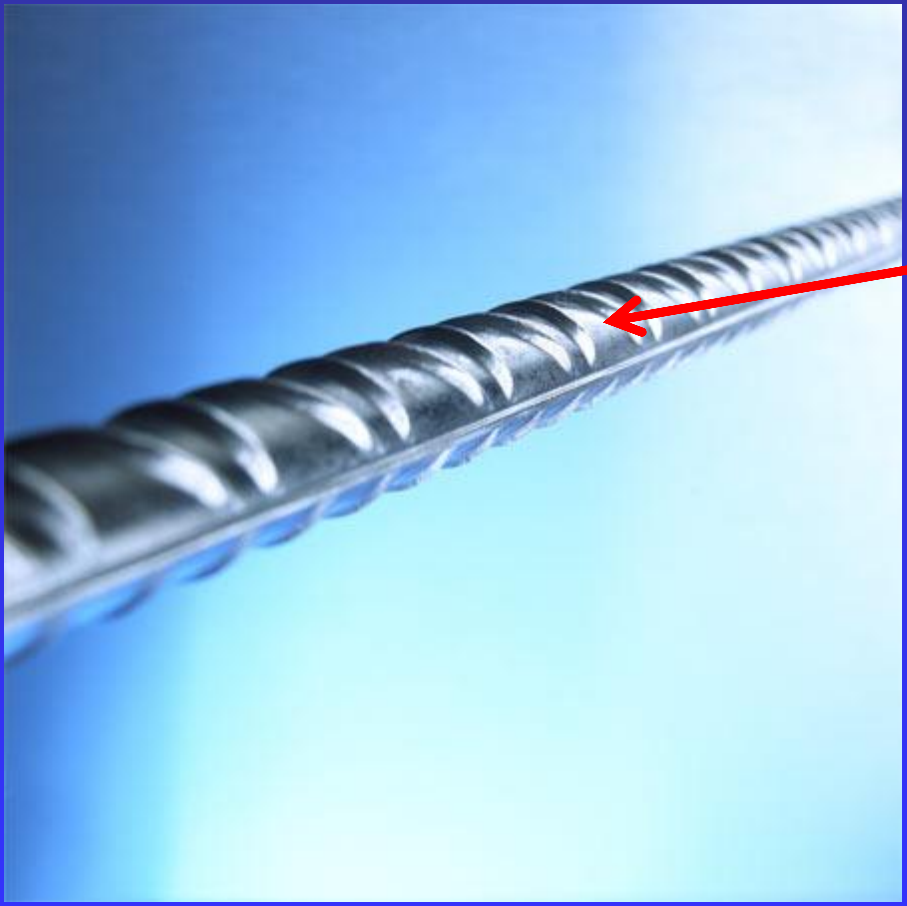
Grade 60 -> 60 ksi yield stress

Grade 60 most commonly used

Grades 40 and 50 intended to be Grade 60 but does not have adequate yield strength

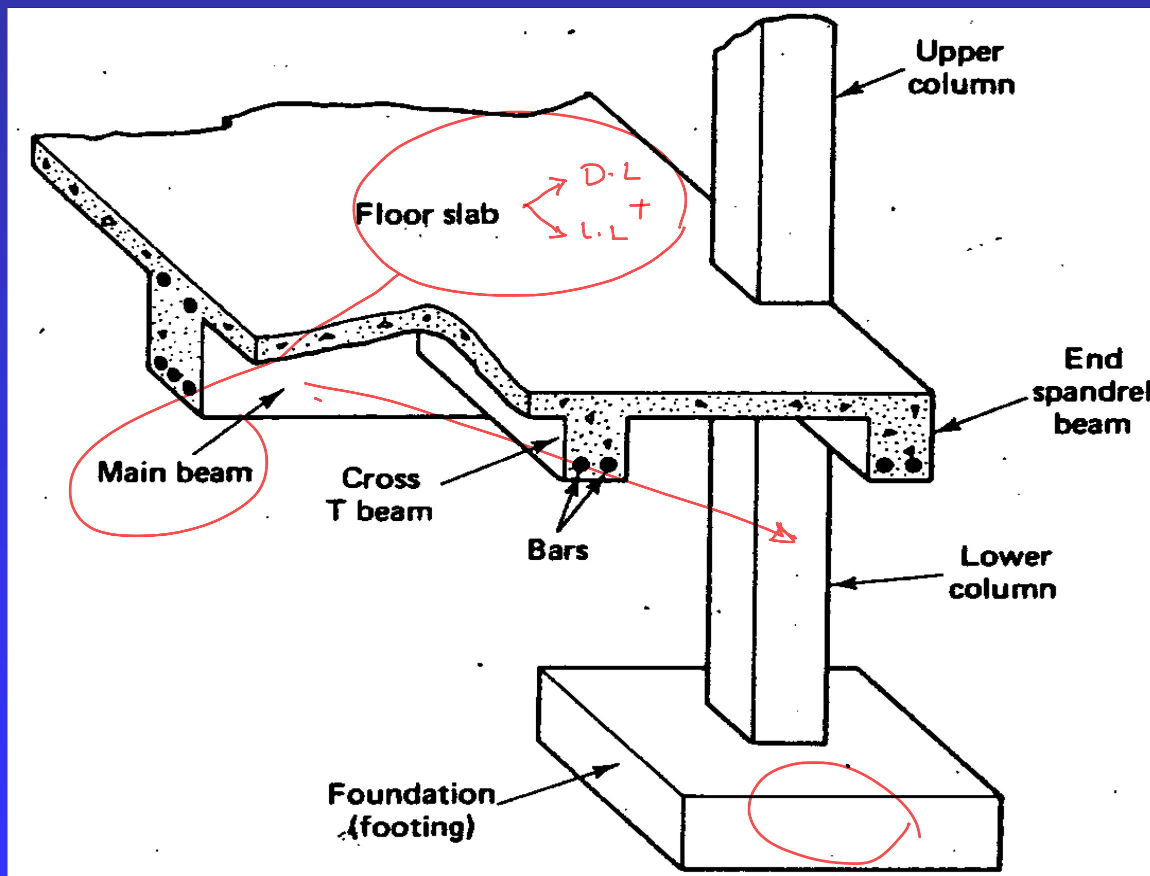
Deformed Rebars

Deformed Rebar



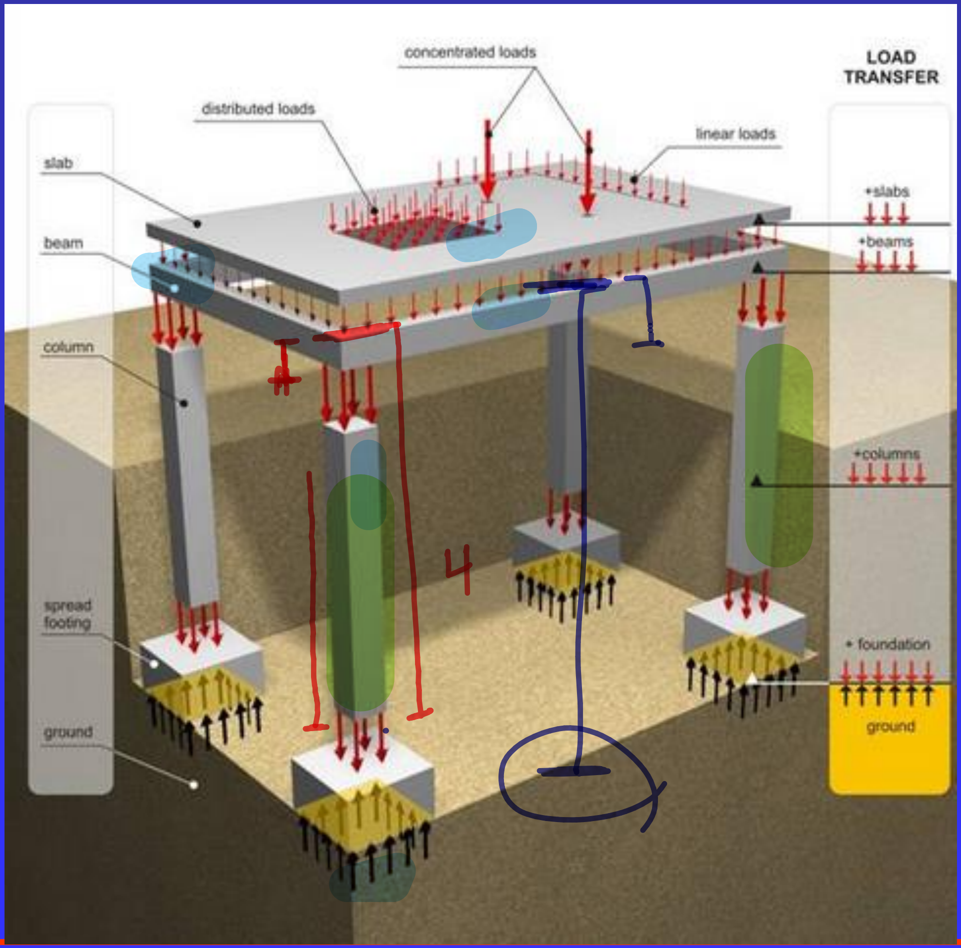
Ribs

Structural System



Slab
↓
beam
↓
Column
↓
Foundation
↓
Soil

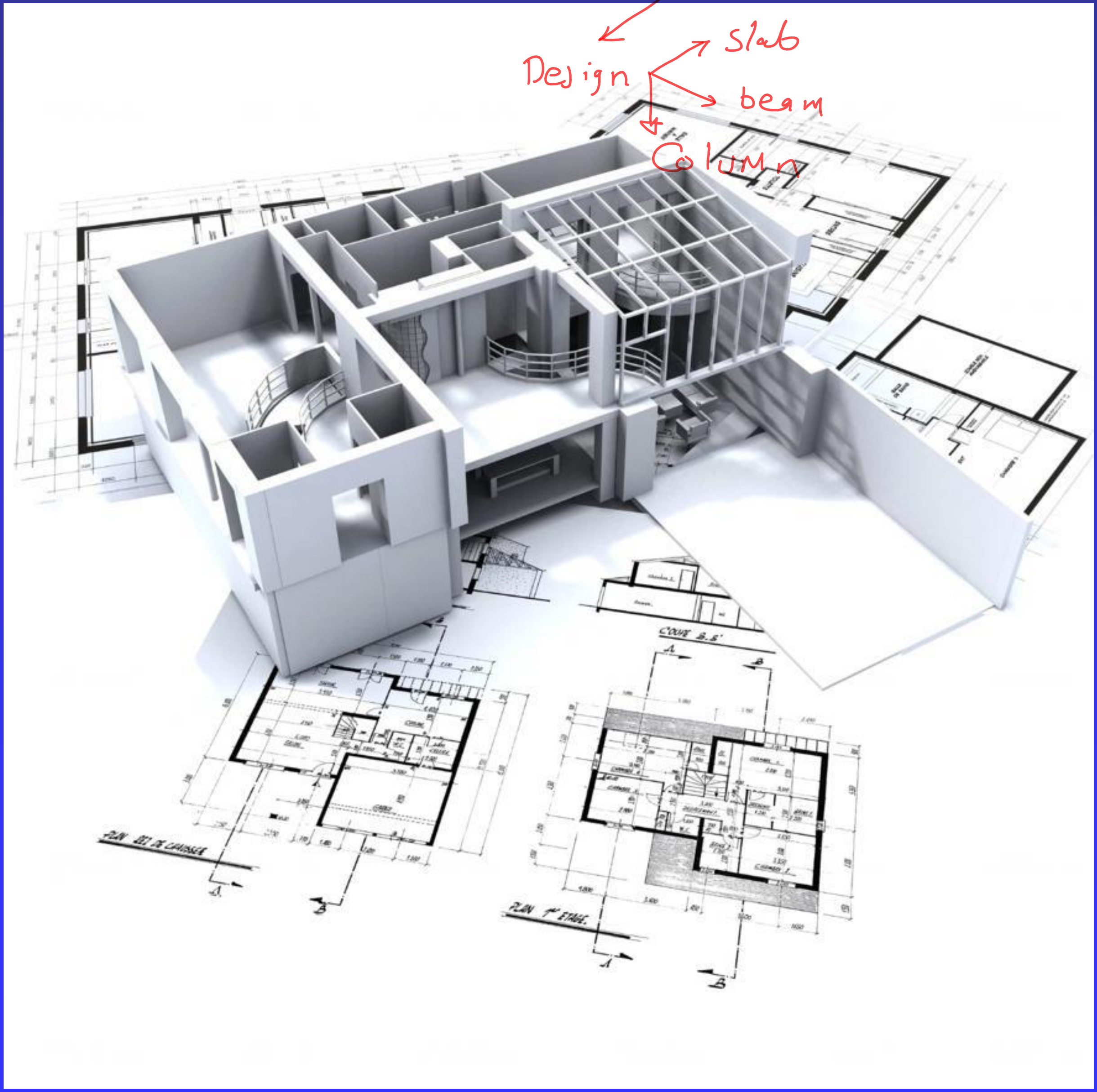
LOAD PATHS IN STRUCTURES



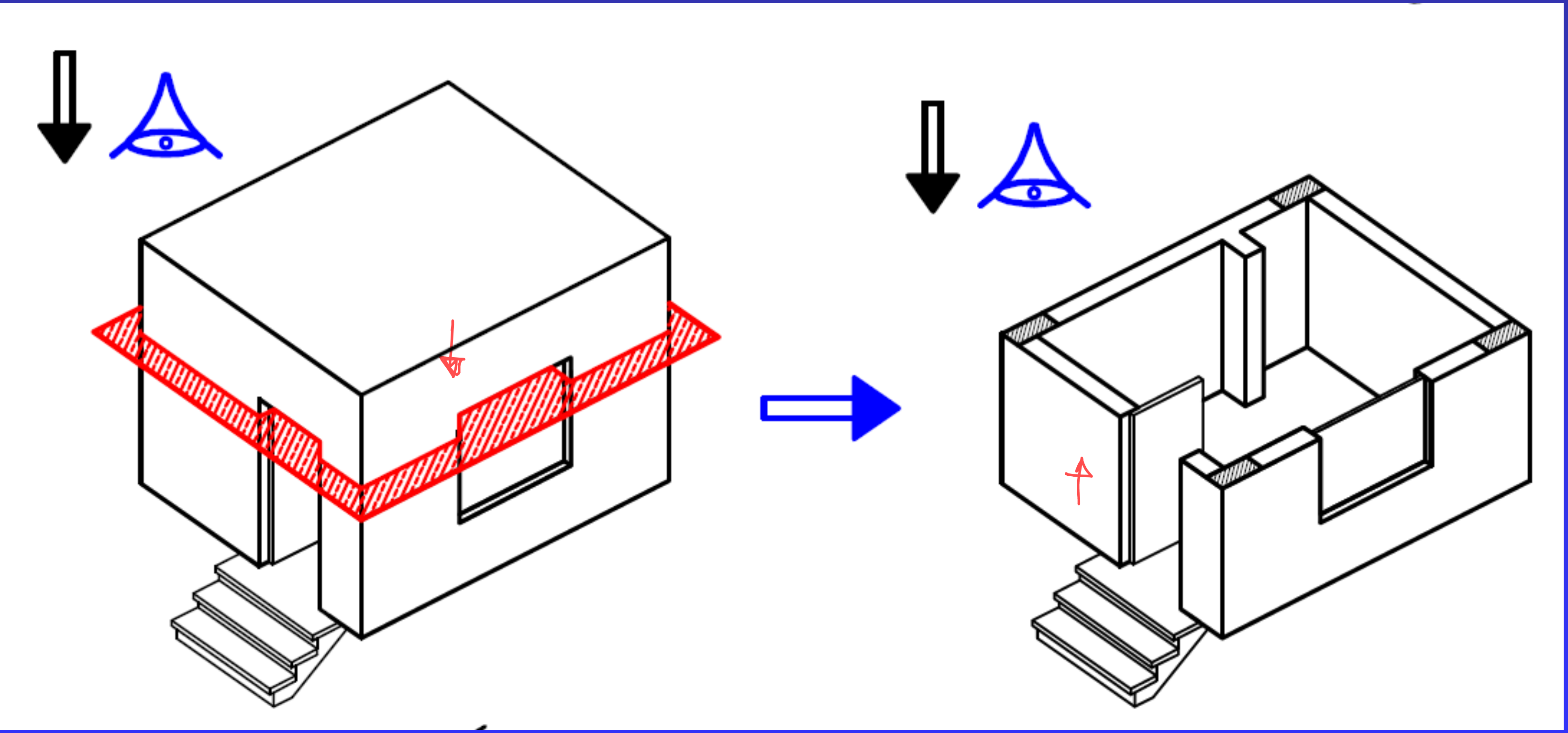
ARCH. DWGS vs. STR. DWGs

Finishing

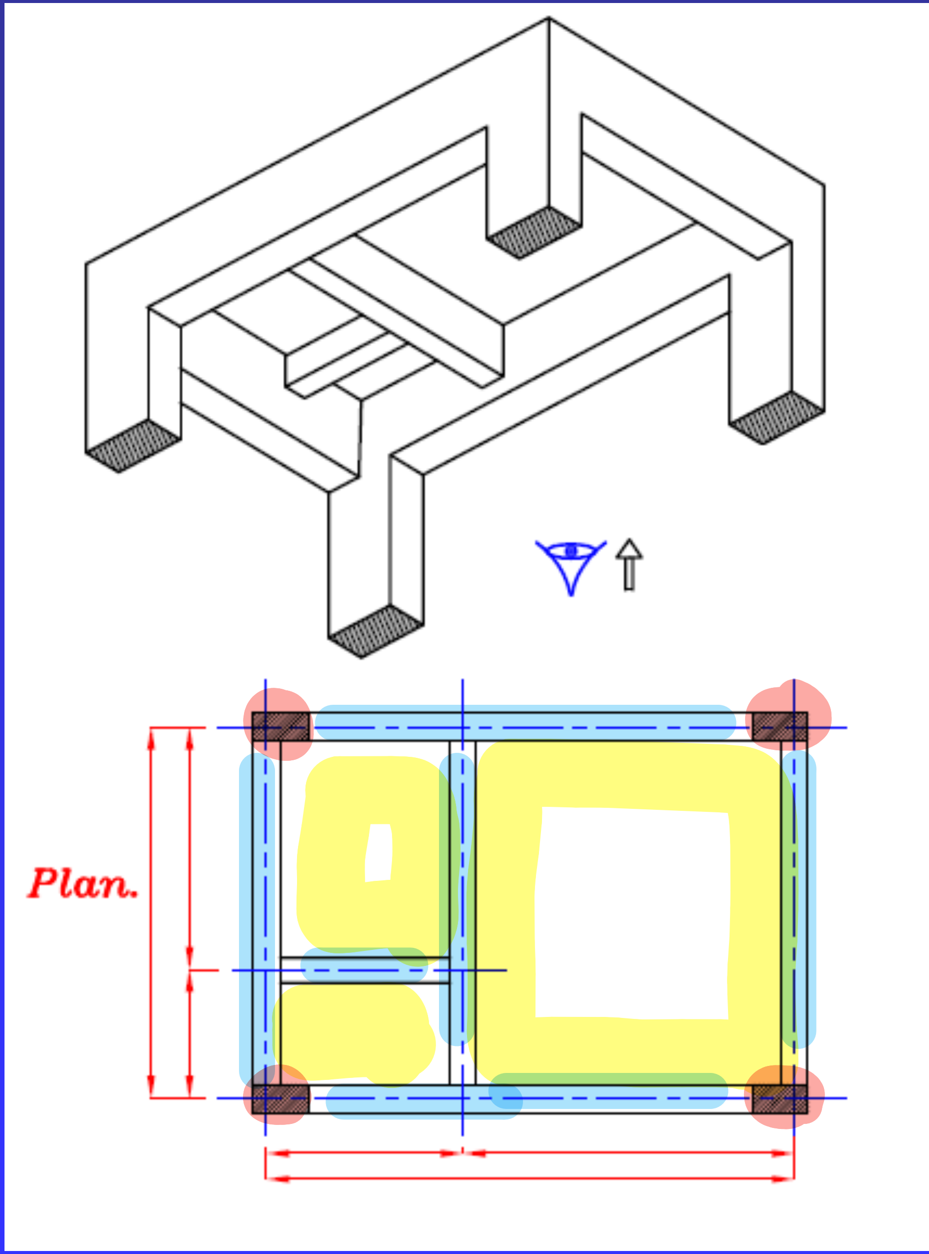
Design
slab
beam
Column



ARCH. DWGS



STR. DWGS

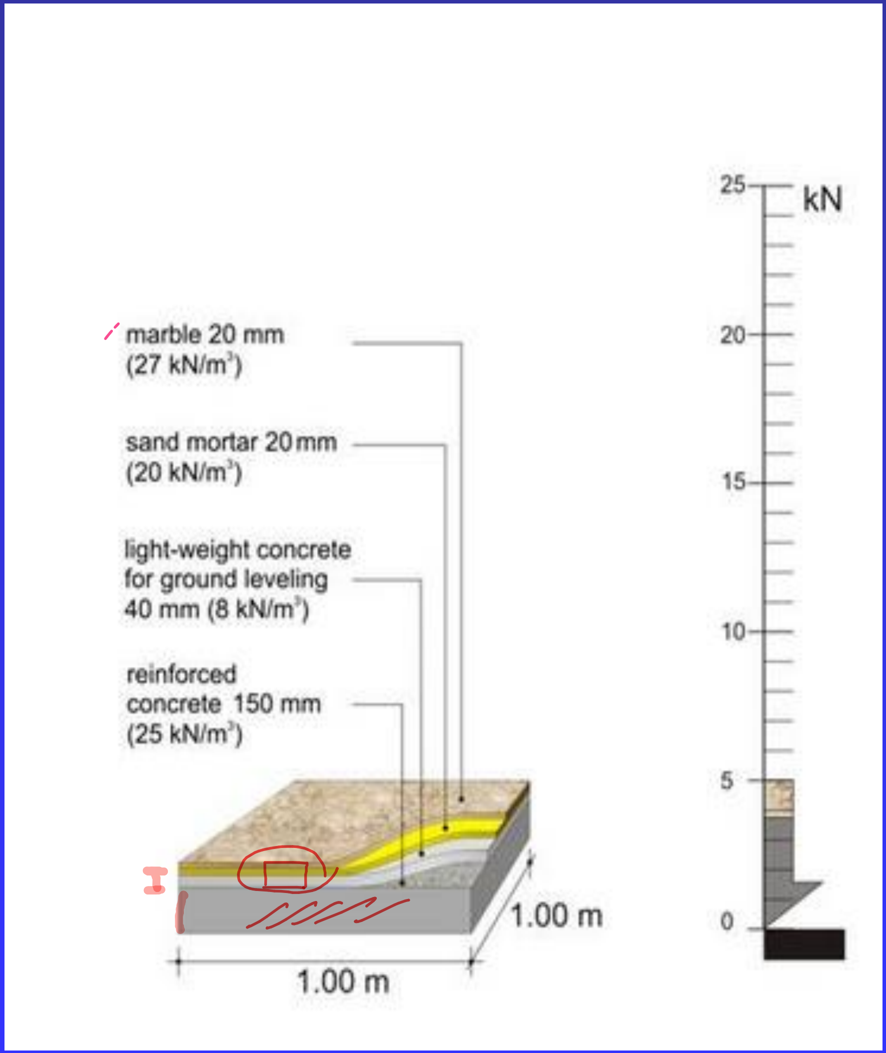


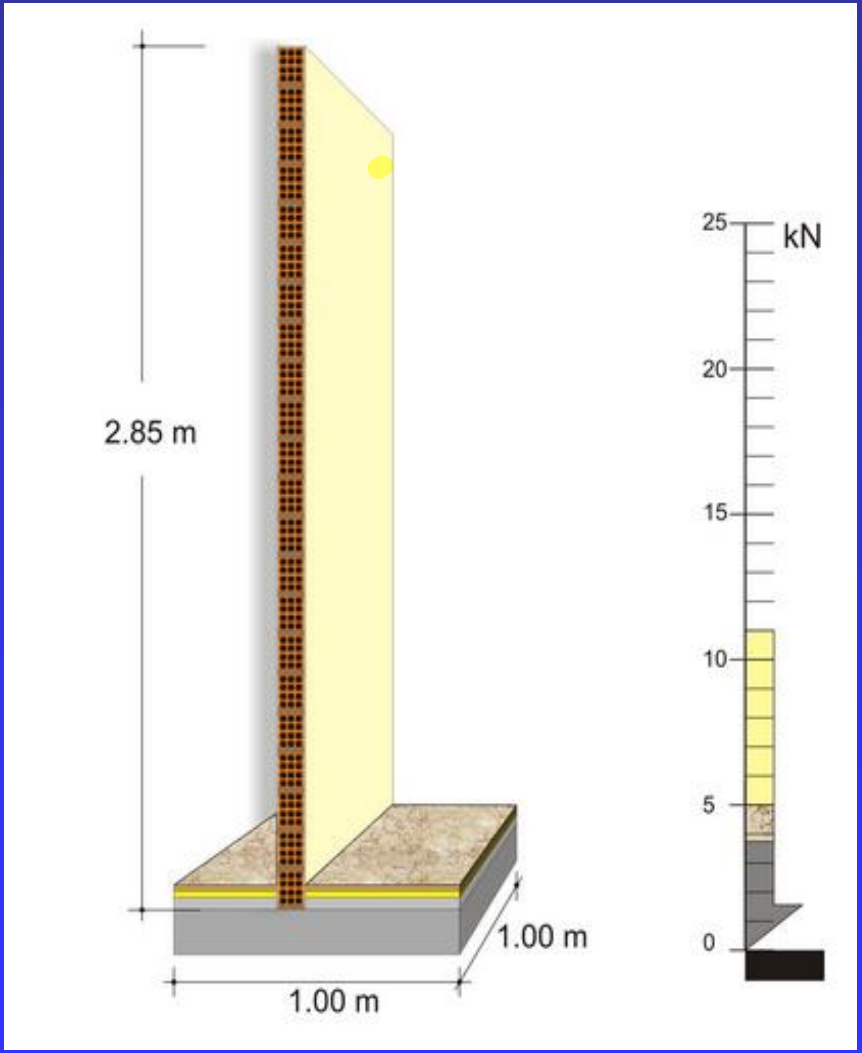
Loads and Load Effects

Types of loads encountered when designing reinforced concrete: dead, live, roof live, snow and ice, rain, temperature, wind and seismic

Loads produce load effects (axial force, shear, moment and torsion)

DEAD LOAD


marble 20 mm
(27 kN/m³)
sand mortar 20 mm
(20 kN/m³)
light-weight concrete
for ground leveling
40 mm (8 kN/m³)
reinforced
concrete 150 mm
(25 kN/m³)
1.00 m
1.00 m
25
20
15
10
5
0
kN


2.85 m
1.00 m
1.00 m
25
20
15
10
5
0
kN

DEAD LOAD (CONT'D)

TABLE 1–2 Minimum Densities for Design Loads from Materials*

	lb/ft^3	kN/m^3
Aluminum	170	26.7
Concrete, plain cinder	108	17.0
Concrete, plain stone	144	22.6
Concrete, reinforced cinder	111	17.4
Concrete, reinforced stone	150	23.6
Clay, dry	63	9.9
Clay, damp	110	17.3
Sand and gravel, dry, loose	100	15.7
Sand and gravel, wet	120	18.9
Masonry, lightweight solid concrete	105	16.5
Masonry, normal weight	135	21.2
Plywood	36	5.7
Steel, cold-drawn	492	77.3
Wood, Douglas Fir	34	5.3
Wood, Southern Pine	37	5.8
Wood, spruce	29	4.5

*Reproduced with permission from American Society of Civil Engineers *Minimum Design Loads for Buildings and Other Structures*, ASCE/SEI 7-10. Copies of this standard may be purchased from ASCE at www.pubs.asce.org.

$\gamma = 24 \ kN/m^3$

DEAD LOAD (CONT'D)

TABLE 1–3 Minimum Design Dead Loads*

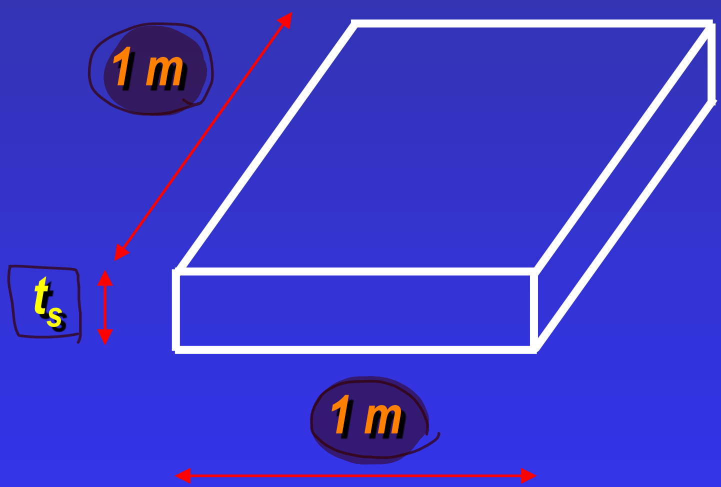
Walls	psf	kN/m^2
4-in. (102 mm) clay brick	39	1.87
8-in. (203 mm) clay brick	79	3.78
12-in. (305 mm) clay brick	115	5.51
Frame Partitions and Walls		
Exterior stud walls with brick veneer	48	2.30
Windows, glass, frame and sash	8	0.38
Wood studs 2 × 4 in., (51 × 102 mm) unplastered	4	0.19
Wood studs 2 × 4 in., (51 × 102 mm) plastered one side	12	0.57
Wood studs 2 × 4 in., (51 × 102 mm) plastered two sides	20	0.96
Floor Fill		
Cinder concrete, per inch (mm)	9	0.017
Lightweight concrete, plain, per inch (mm)	8	0.015
Stone concrete, per inch (mm)	12	0.023
Ceilings		
Acoustical fiberboard	1	0.05
Plaster on tile or concrete	5	0.24
Suspended metal lath and gypsum plaster	10	0.48
Asphalt shingles	2	0.10
Fiberboard, $\frac{1}{2}$-in. (13 mm)	0.75	0.04

*Reproduced with permission from American Society of Civil Engineers *Minimum Design Loads for Buildings and Other Structures*, ASCE/SEI 7-10.

Dead Load - Slabs

D.L
L.L
Given

$$w_D = \gamma_c t_s + SDL \quad \left(\frac{kN}{m^2}\right)$$



w_D = dead load of **1 m²** of the slab

t_s = thickness of slab (m)

γ_c = unit weight of concrete (kN/m^3)

SDL = Superimposed Dead Load (kN/m^2) Given

beam

Dead Load - Beams

⇒ Walls

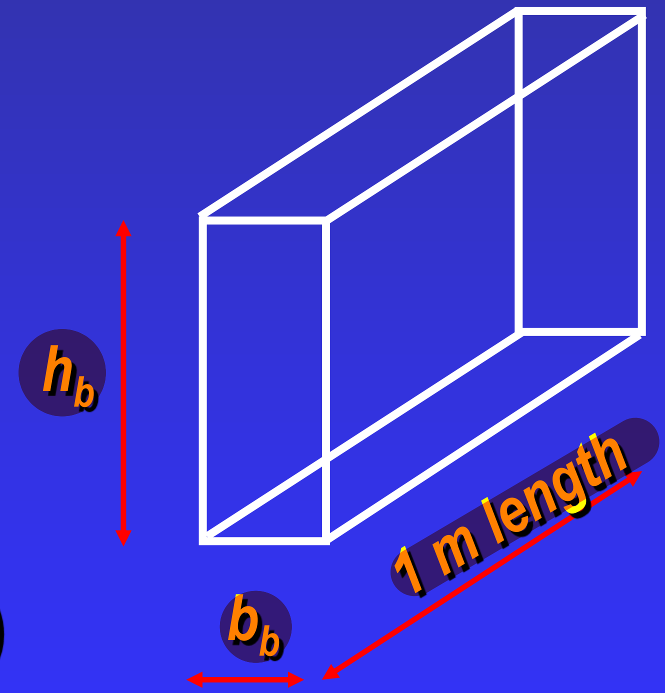
$$o.w_{beam} = b_b \, h_b \, \gamma_c \quad kN/m$$

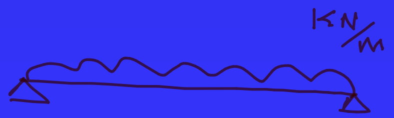
$o.w_{beam}$ = o.w of **1 m length** of the beam

b_b = thickness of beam (m)

h_b = height of beam (m)

γ_c = unit weight of concrete (kN/m^3)





Dead Load - Walls

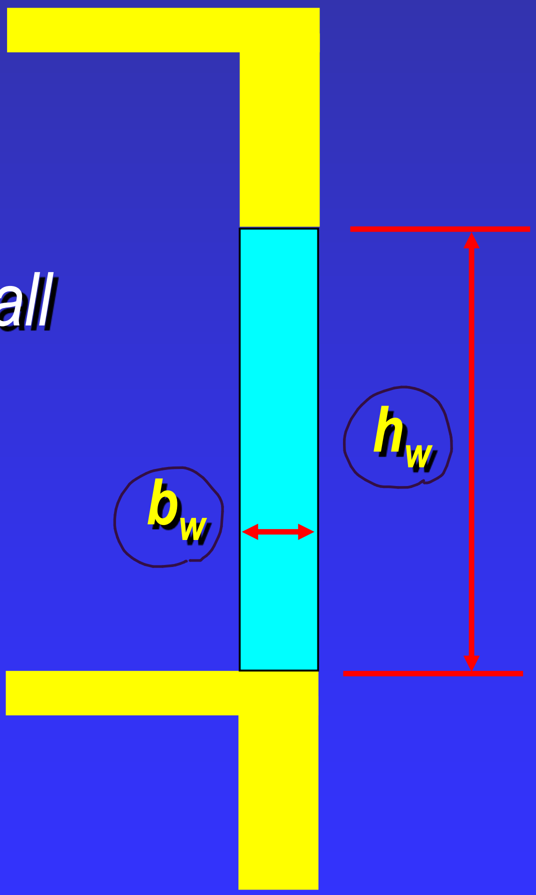
$$O.W_{wall} = b_w \, h_w \, \gamma_w \quad kN/m$$

$o.w_{wall}$ = own weight of **1 m length** of the wall

b_w = thickness of wall (m)

h_w = height of wall (m)

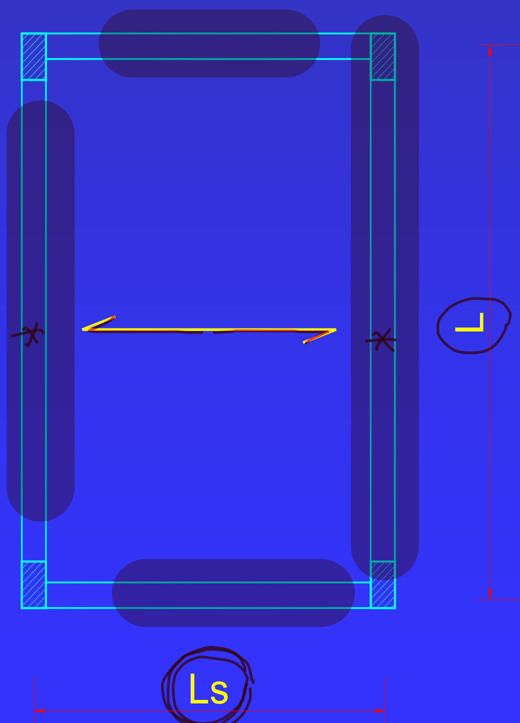
γ_w = unit weight of wall (kN/m^3)

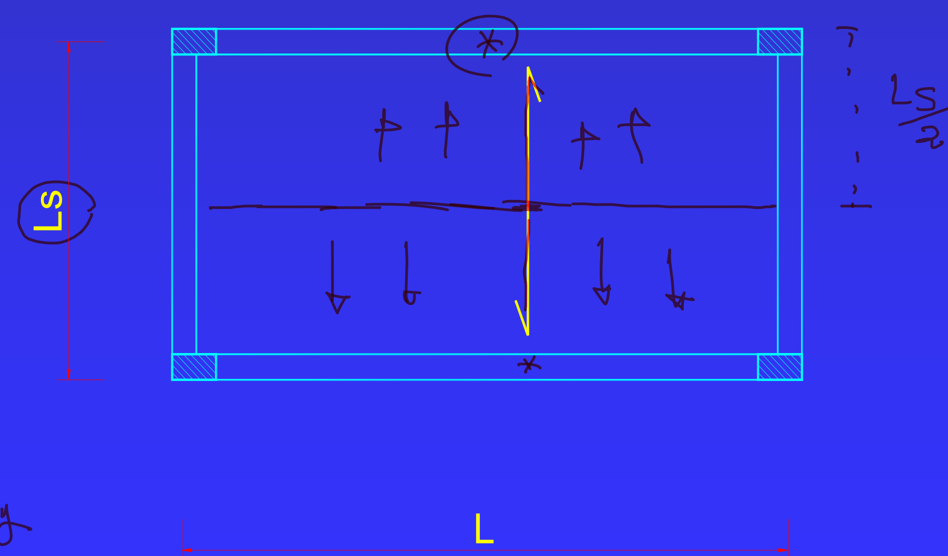


One Way Slabs

✓ Slabs Supported by 4-Beams:

- $L/L_s \geq 2$
- Slab load is carried in **Short Direction** to supporting beams
- Load direction is the Short Direction

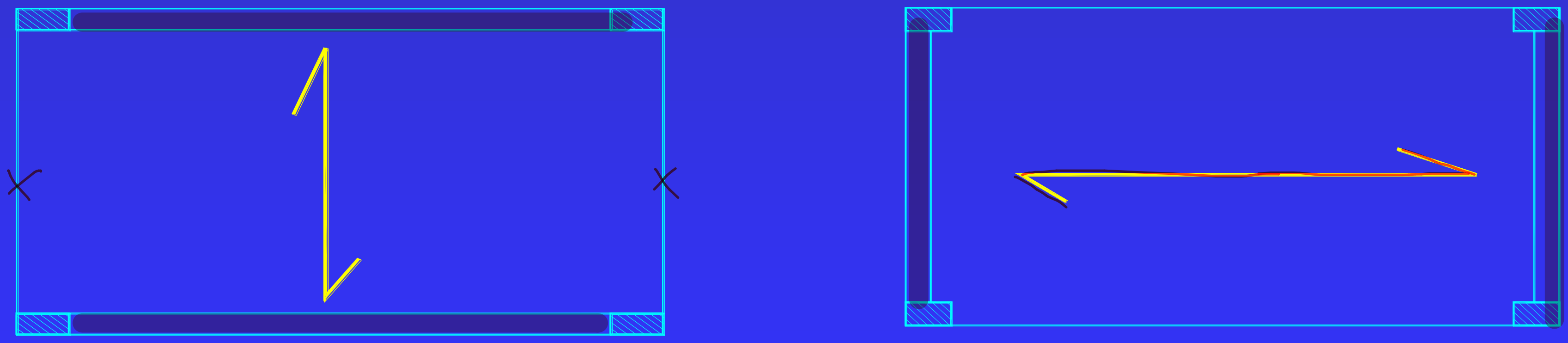


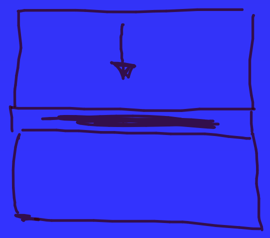


One Way Slabs

✓ **Slabs Supported by 2-Beams on opposite sides:**

- *Slab load is carried in a* ***Direction Perpendicular*** *to* ***Supporting Beams***
- ***Load direction*** *might be short direction* ***OR*** *long direction*





Slab Load

$w_{slab} = w_D + w_L$ (kN/m²)

$w_D = t_s \gamma_c + SDL$

$w_L =$ Given (kN/m²) or table

w_{slab} = Total load of 1 m² of the slab = $w_D + w_L$

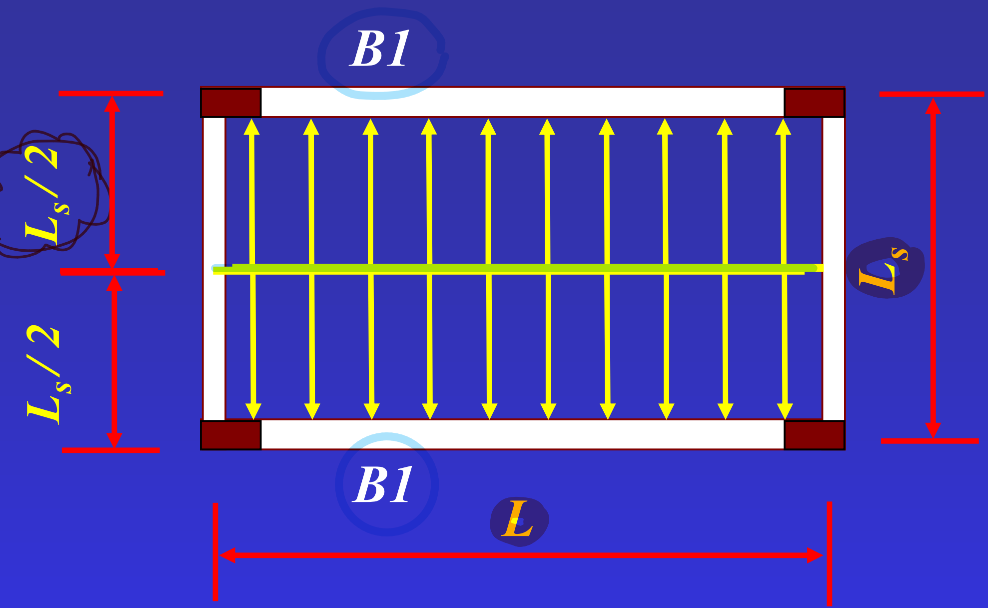
t_s = thickness of slab (m)

γ_c = unit weight of concrete (kN/m³)

SDL = given superimposed dead load (kN/m2)

Load Distribution

One-Way Slabs ($L / L_s \geq 2$)



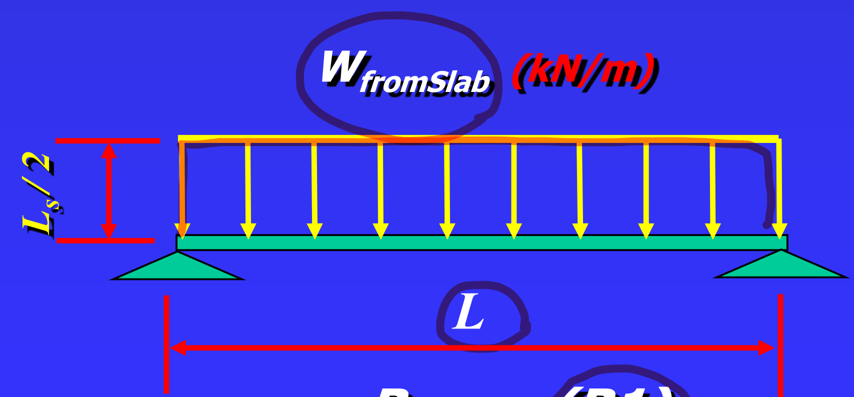
Slab load:

$$w_S = w_D + w_L \qquad kN/m^2$$

- **Slab load transferred to beam**

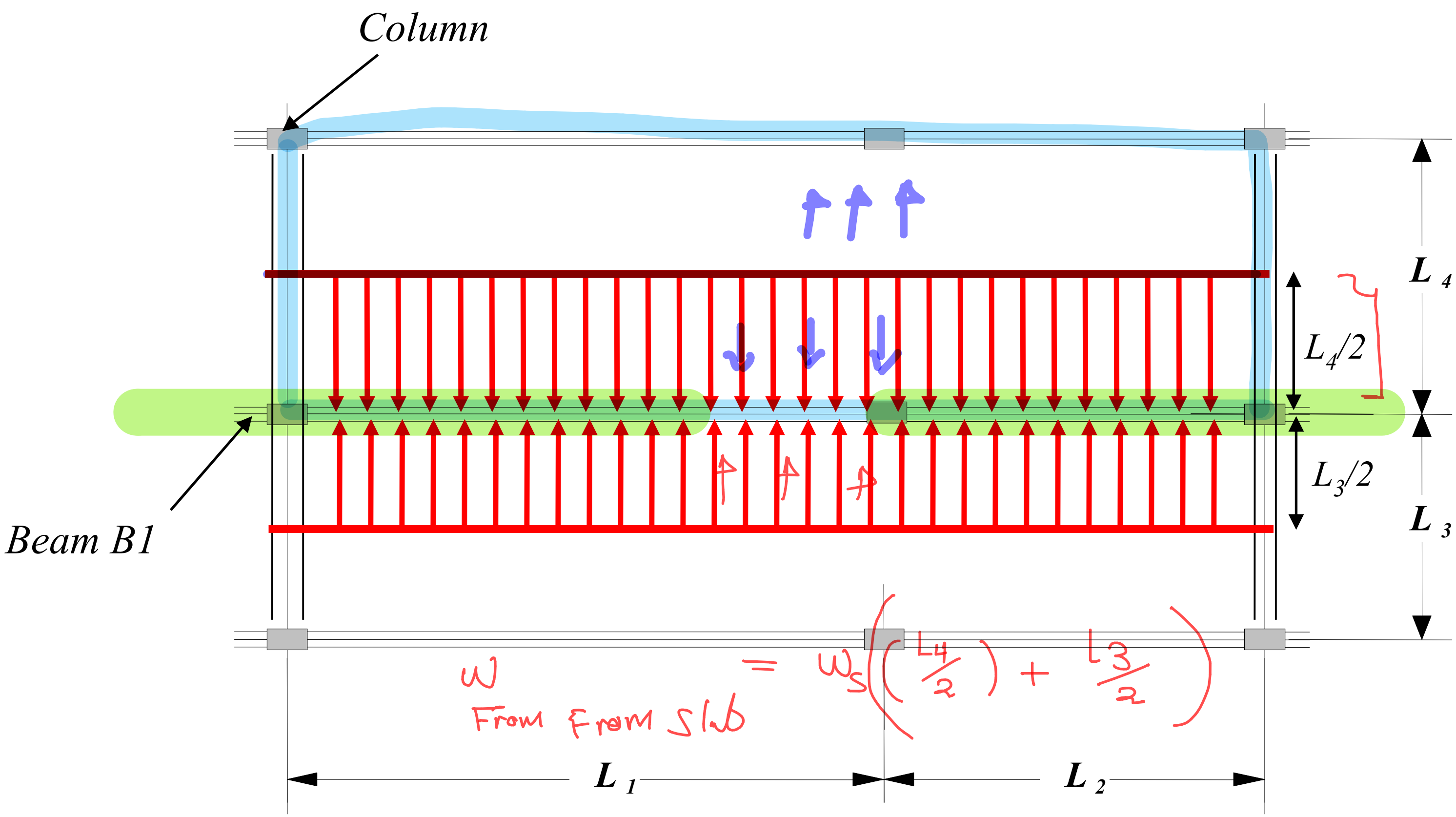
$$W_{From\ slab} = w_{slab} * L_s/2 \qquad (kN/m)$$

Slab height carried by the beam

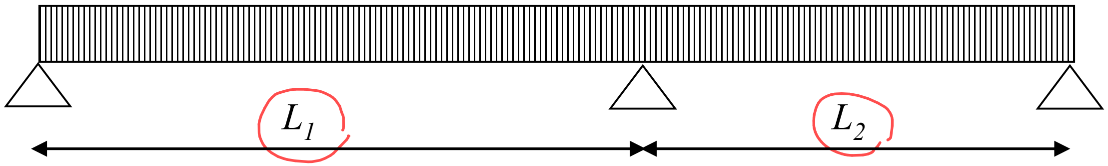


Beam (B1)

Load Distribution



Load from slab (kN/m) = $w_{slab}(L_3/2+L_4/2)$



Beams Loads & System

✓ **Beam own weight**

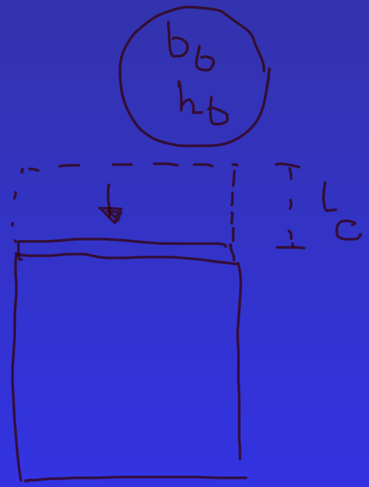
$$o.w_{beam} = b_b\, h_b\, \gamma_c$$ (kN/m)

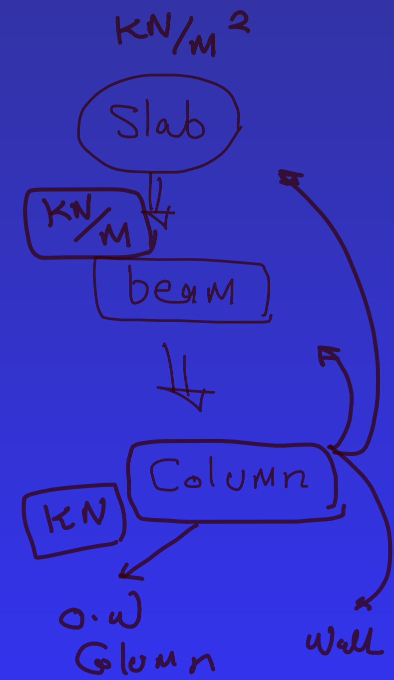
✓ **Wall own weight**

$$o.w_{wall} = b_w\, h_w\, \gamma_w$$ (kN/m)

✓ **Load from slabs**

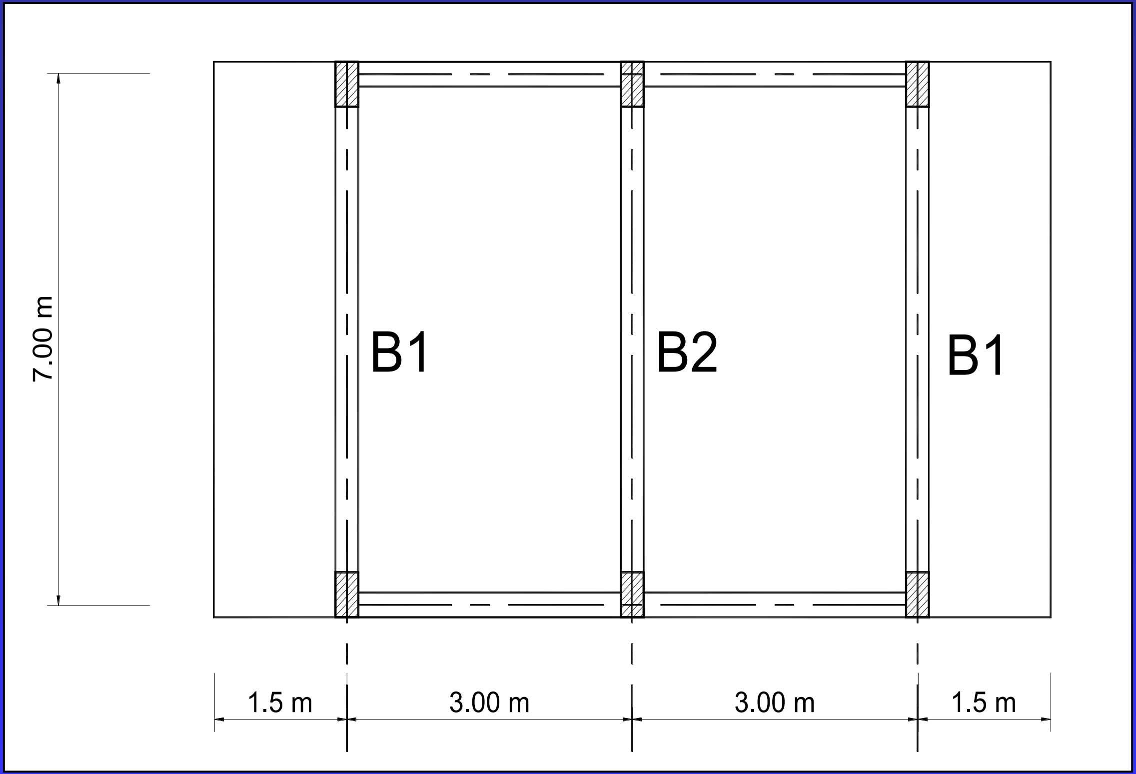
$$w_{From\ slab} = \Sigma\, w_{slab} * \frac{L_s}{2} + w_{slab}\,(L_c)$$ (kN/m)





$$w_{beam} = b_b\, h_b\, \gamma_c + b_w\, h_w\, \gamma_w + \Sigma w_{slab}\,(L_s/2) + w_{slab}\,(L_c)$$ (kN/m)

Example (1)



Given Data:

Slab thickness = 0.2 m

Live Load = 3.0 kN/m^2

Floor cover = 1.5 kN/m^2

Beams 0.25 m x 0.6 m

Walls 0.25 width & 3 m height

γ_c = 25 kN/m^3 & γ_w = 10 kN/m^3

Required:

- Show tributary areas for beams on plan
- Calculate the load carried by beams B1 & B2

Example (1)

Given Data:

Slab thickness = 0.2 m $= t_s$

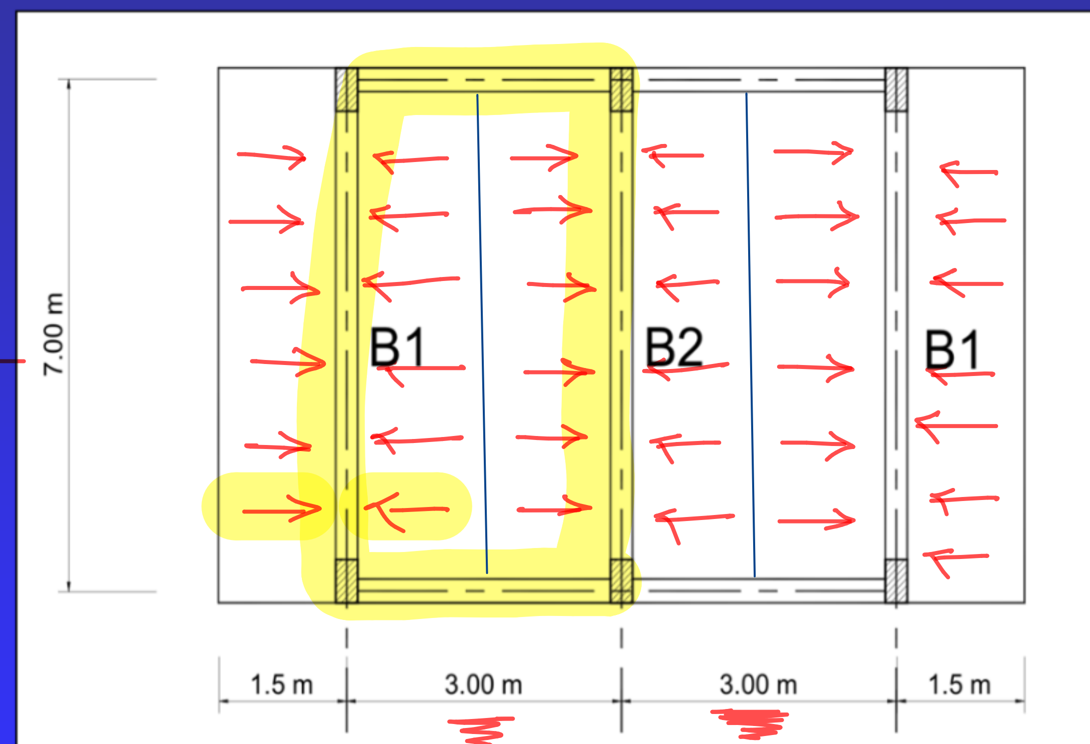
Live Load = 3.0 kN/m² ✓

Floor cover = 1.5 kN/m² = SDL

Beams 0.25 m x 0.6 m (b_b, h_b)

Walls 0.25 width & 3 m height (b_w, h_w)

γ_c = 25 kN/m³ & γ_w = 10 kN/m³



Required:

- Show tributary areas for beams on plan ✓
- Calculate the load carried by beams B1 & B2

$\frac{7}{3} = 2.33 > 2$ one way slab

Beam B_1

$w_{beam} = o.w_{beam} + o.w_{wall} + w_{From\ slab}$

$w_{slab} = w_D + w_L$

$w_D = t_s \gamma_c + SDL$

$= 0.2 * 25 + 1.5 = 6.5$ kN/m²

$w_{slab} = 6.5 + 3 = 9.5$ kN/m²

$o.w_{beam} = b_b h_b \gamma_c$

$= 0.25 * 0.6 * 25 = 3.75$ kN/m

$o.w_{wall} = b_w h_w \gamma_w$

$= 0.25 * 3 * 10 = 7.5$ kN/m

$w_{From\ slab} = w_{slab} * \frac{L_s}{2} + w_{slab} * L_c$

$= 9.5 * \frac{3}{2} + 9.5 * 1.5 = 28.5$ kN/m

$w_{beam} = 3.75 + 7.5 + 28.5 = 39.75$ kN/m

Beam B_2

$w_{beam} = o.w_{beam} + o.w_{wall} + w_{From\ slab}$

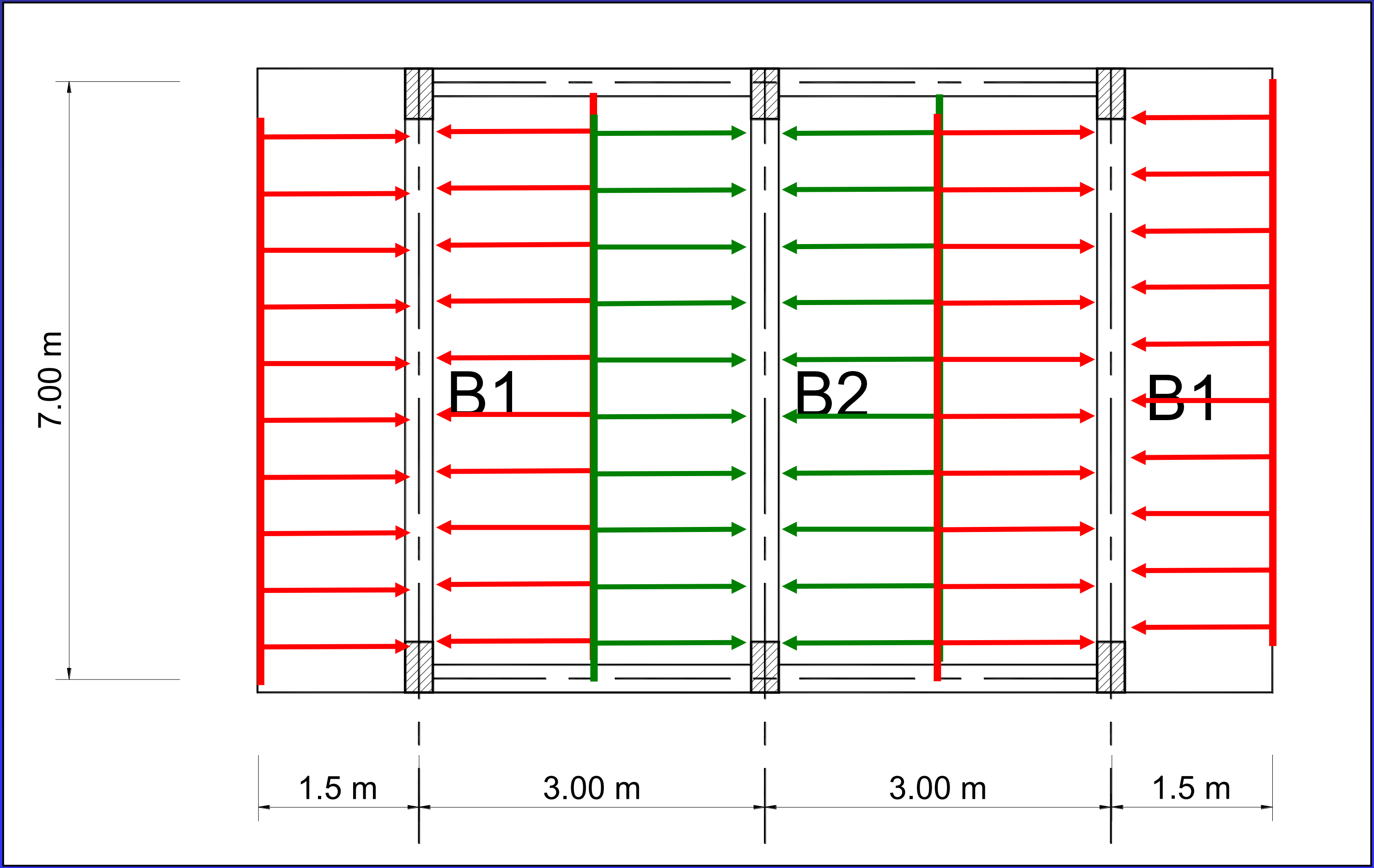
($o.w_{beam}$ = 3.75, $o.w_{wall}$ = 7.5 kN/m)

$w_{From\ slab} = w_s\left(\frac{L_s}{2}\right) + w_s\left(\frac{L_s}{2}\right)$

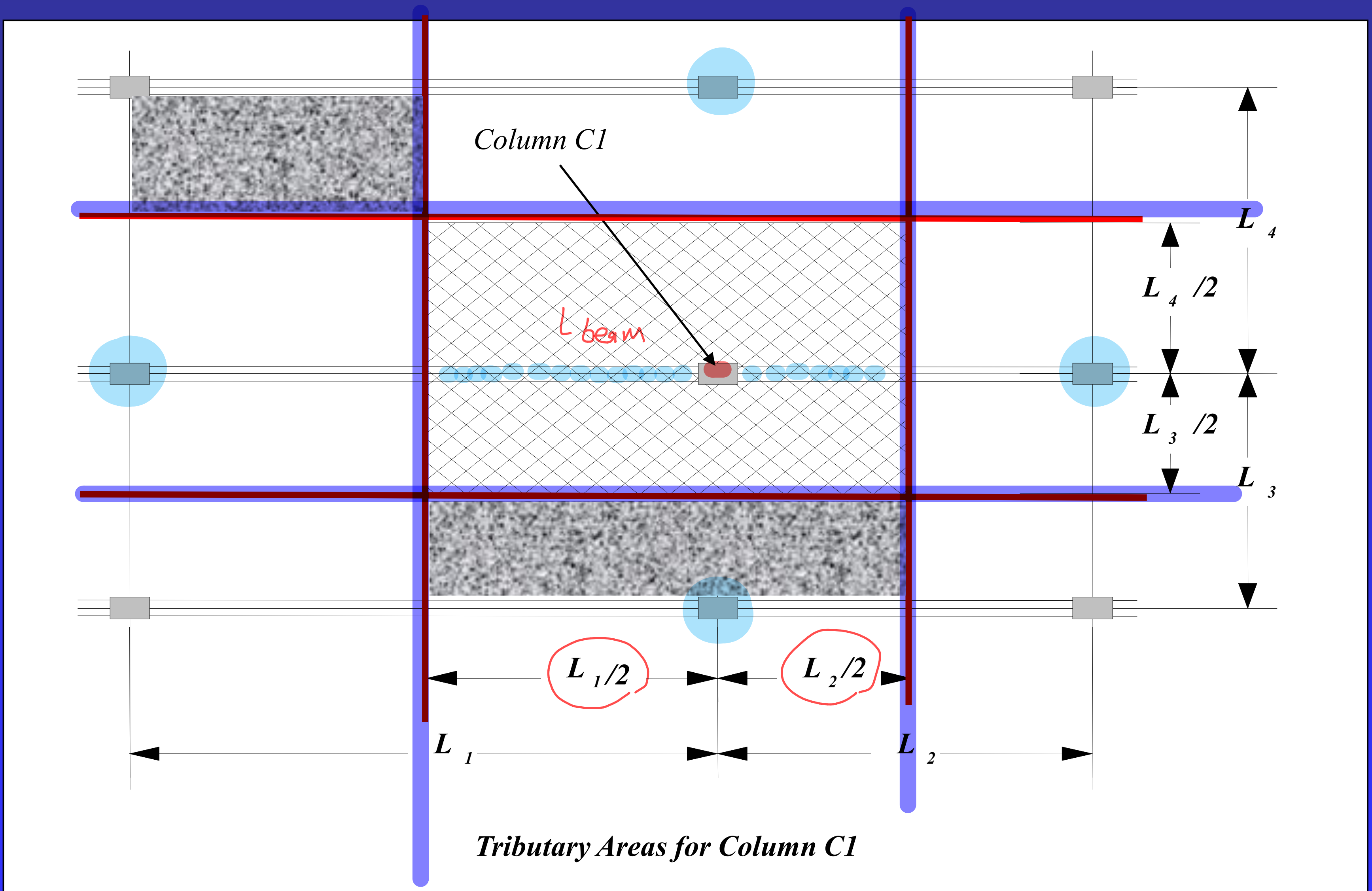
$= 9.5\left(\frac{3}{2}\right) * 2 = 28.5$ kN/m

$w_{beam} = 3.75 + 7.5 + 28.5 = 39.75$ kN/m

Example (1) – Tributary Areas for Beams



Columns



Tributary Areas for Column C1

Columns Loads

$$P_{CoL} = w_{slab} \times A_{slab} + \sum o.w_{beam} * L_{beam} + \sum o.w_{wall} * L_{wall} + o.w_{CoL} \quad (kN)$$

- A_{slab} = Slab Tributary area carried by the column (m^2)
- w_{slab} = Uniform total load of the slab (kN/m^2) $= w_D + w_L$, where $w_D = t_s \gamma_c + SDL$
- $o.w_{beam}$ = own weight of beam (kN/m) $= b_b h_b \gamma_c$
- $o.w_{wall}$ = own weight of wall (kN/m) $= b_w h_w \gamma_w$
- $o.w_{col}$ = own weight of column (kN) $= \gamma_c * h_c b_c t_c$
- L_{beam} = length of beams within tributary area (m)
- L_{wall} = length of wall within tributary area (m)

Slab load

- one way: $L_L / L_s \geq 2$
- two way: $L_L / L_s < 2$

W_D — W_L (given)

$$W_D = t_s \cdot \gamma_c + SDL$$

t_s: thickness; SDL (given): Cover, Super Imposed

$$W_{slab} = W_D + W_L \quad (kN/m^2)$$

Walls

$$O.W_{wall} = b_w h_w \gamma_w \quad kN/m$$

(D.L)

Beam

- o.w, beam (D.L)
- o.w, wall
- $\sum W_{slab} * (L_s)$

$$o.w, beam = b_b h_b \gamma_c$$

$$W_{beam} = b_b h_b \gamma_c + b_w h_w \gamma_w + \sum W_{slab} * L_{slab} \quad kN/m$$

Column loads

$$o.w_{Column} + \sum o.w_{beam} \cdot L_{beam} + \sum o.w_{wall} \cdot L_{wall} + W_{slab} \times A_{slab}$$

$$= b_{col} \, t_{col} \, h_{col} \, \gamma_c$$

Columns

Columns Loads:

- ✓ **Loads from slab**

$$P_{from\ slab}\ (KN) = w_{slab}\ (kN/m^2) \times A_{slab}\ (m^2)$$

- ✓ **Loads from beam weight**

$$P_{from\ beam}\ (KN) = \Sigma\ o.w_{beam}\ (kN/m) \times L_{beam}\ (m)$$

- ✓ **Loads from wall weight**

$$P_{from\ wall}\ (KN) = \Sigma\ o.w_{wall}\ (kN/m) \times L_{wall}\ (m)$$

- ✓ **Column own weight**

$$o.w_{col}\ (KN) = (b_{col})\ (t_{col})\ (h_{col})\ (\gamma_c)$$

Example (2)

Given Data:

Slab thickness = 0.2 m

Live Load = 3.0 kN/m^2

Floor cover = 1.5 kN/m^2

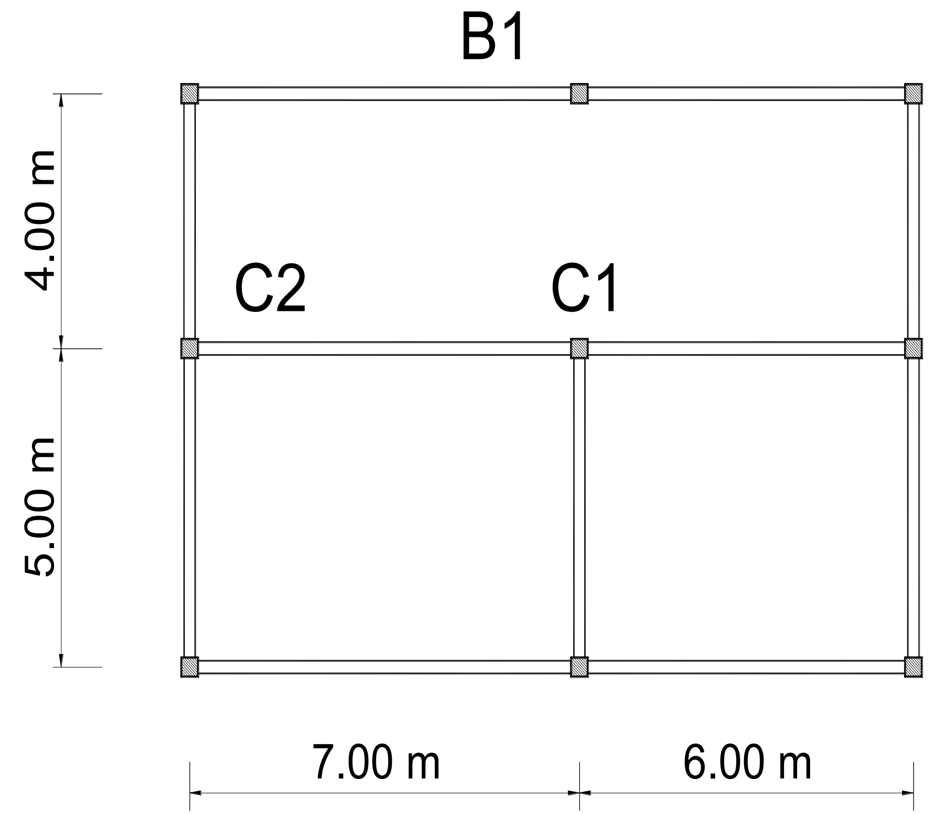
Beams 0.25 m x 0.6 m

Walls 0.25 width & 3 m height

Floor height = 4.0 m

γ_c = 25 kN/m^3 & γ_w = 10 kN/m^3

Column dimensions 0.4 x 0.4 m.



Required:

- *Load carried by the columns C1 & C2 per floor*
- *Load carried by the beam B1*

Example (2)

Given Data:

Slab thickness = 0.2 m $= t_s$

Live Load = 3.0 kN/m² ✓

Floor cover = 1.5 kN/m² ✓

Beams 0.25 m x 0.6 m (b_b, h_b)

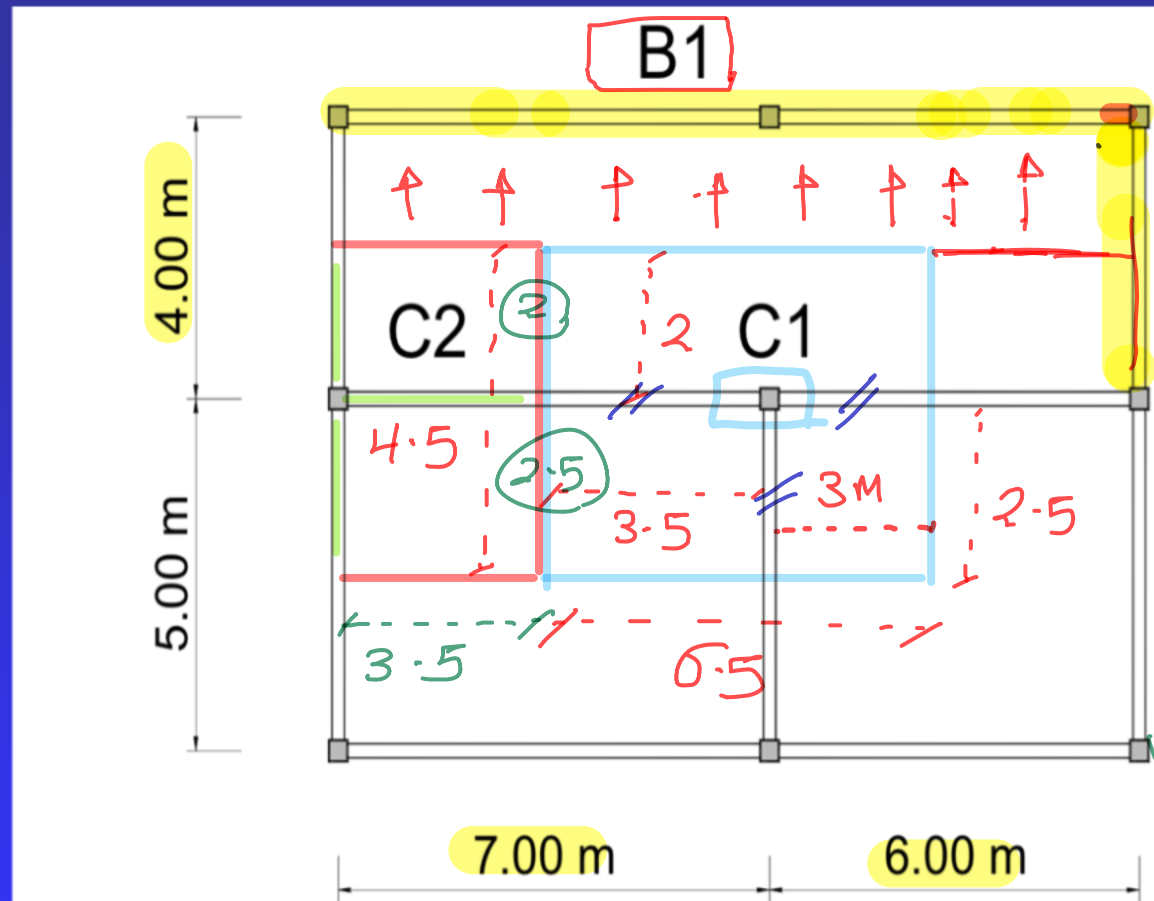
Walls 0.25 width & 3 m height

Floor height = 4.0 m

γ_c = 25 kN/m³ & γ_w = 10 kN/m³

Column dimensions 0.4 x 0.4 m.

$h =$



Required:

- Load carried by the columns C1 & C2 per floor
- Load carried by the beam B1

$w_{slab} = 9.5 \ kN/m^2$

$o.w_{beam} = 3.75 \ kN/m$

$o.w_{wall} = 7.5 \ kN/m$

C1

$P_{From\ slab} = w_{slab} \ A_{slab} = 9.5 * 6.5 * 4.5$

$= 277.875 \ kN$

$P_{From\ beam} = \sum o.w_{beam} * L_{beam}$

$= 3.75 \ (3 + 3.5 + 2.5) = 33.75 \ kN$

$P_{From\ Wall} = 7.5 \ (3 + 3.5 + 2.5) = 67.5 \ kN$

$o.w_{CoL} = \gamma_c \ b_{CoL} \ t_{CoL} \ h_{CoL}$

$= 25 * 0.4 * 0.4 * (4 - 0.6)$

$= 13.6 \ kN$

$P_{CoL} = 277.875 + 33.75 + 67.5 + 13.6$

$= 392.725 \ kN$

C2

$P_{From\ slab} = w_{slab} * A_{slab}$

$= 9.5 * (4.5 * 3.5) = 149.63 \ kN$

$P_{From\ beam} = \sum o.w_{beam} * L_{beam}$

$= 3.75 \ (3.5 + 2 + 2.5) = 30 \ kN$

$P_{From\ wall} = 7.5 \ (3.5 + 2 + 2.5) = 60 \ kN$

$o.w_{CoL} = 13.6 \ kN$

$P_{CoL} = 149.6 + 30 + 60 + 13.6 = 253.23 \ kN$

$\frac{13}{4} > 2$ One way slab

* $O.W_{beam} = 3.75 \ kN/m$

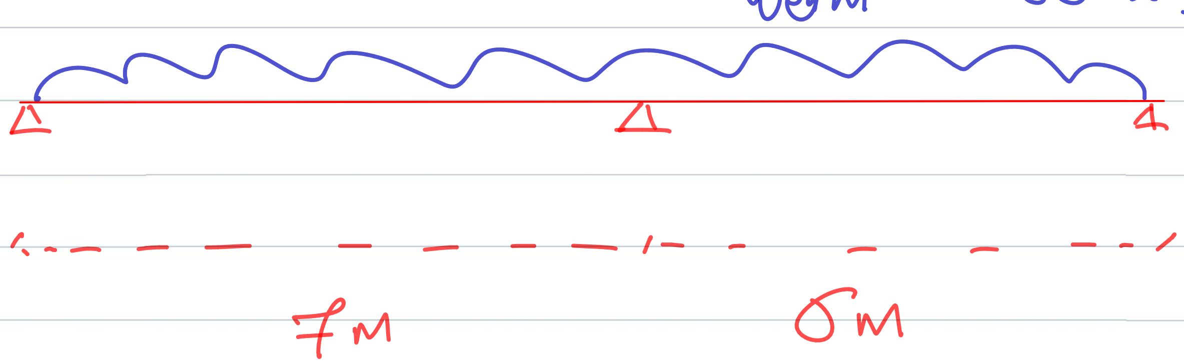
* $O.W_{wall} = 7.5 \ kN/m^2$

* $W_{From\ Slab} = W_{slab} \times \frac{L_s}{2} = 9.5 \times 2$

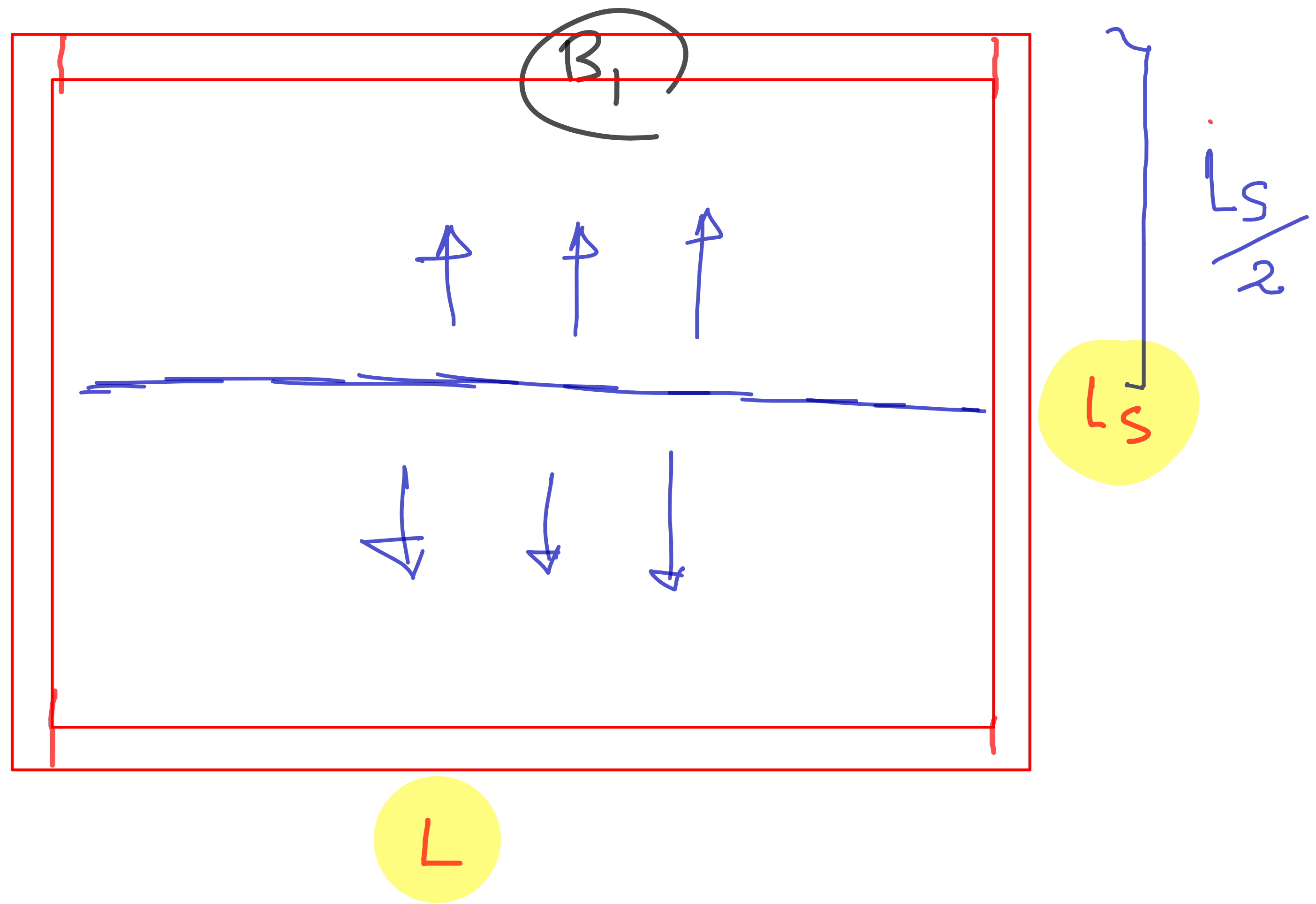
$= 19 \ kN/m$

$$W_{beam} = 3.75 + 7.5 + 19 = 30.25 \ kN/m$$

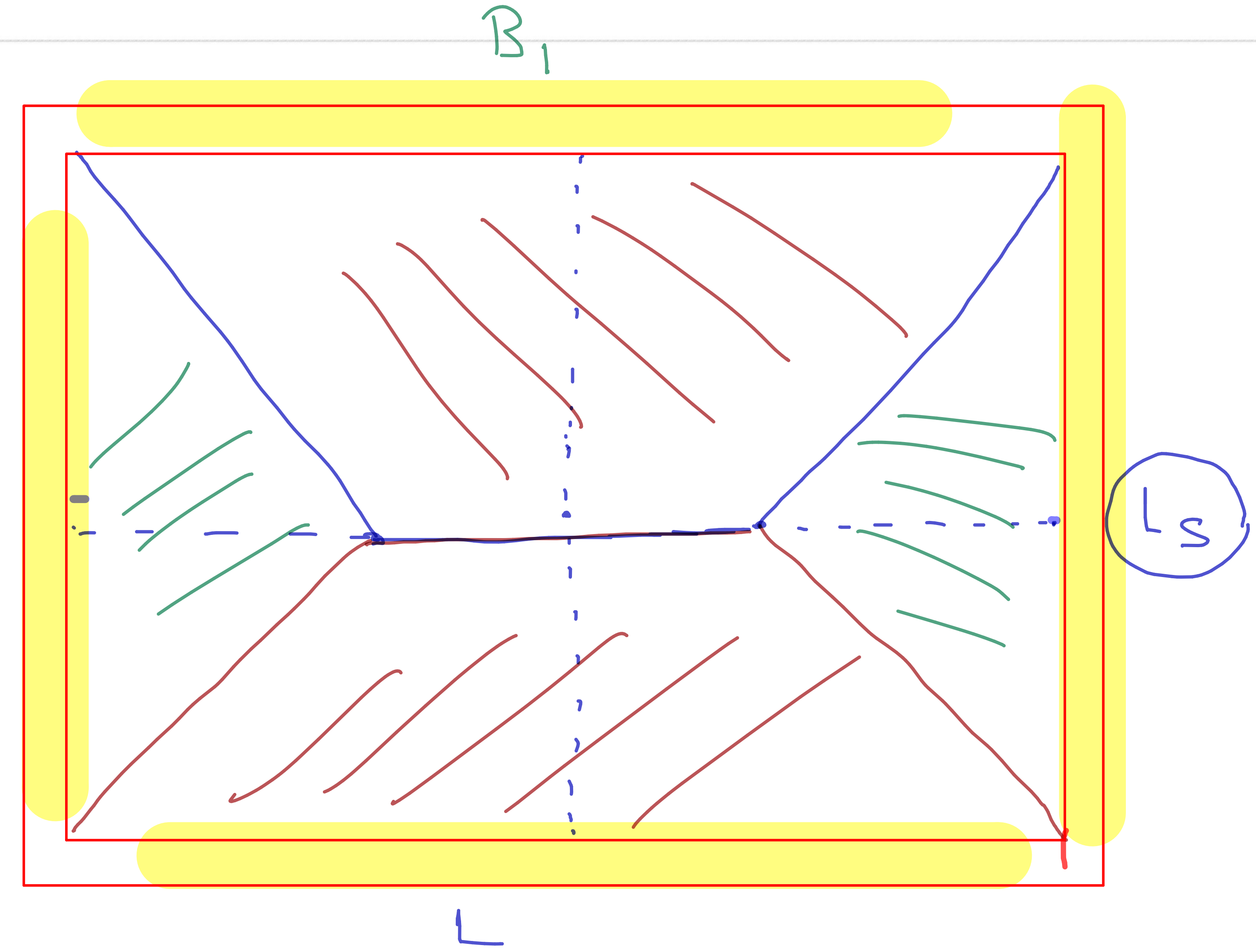
$W_{beam} = 30.25 \ kN/m$



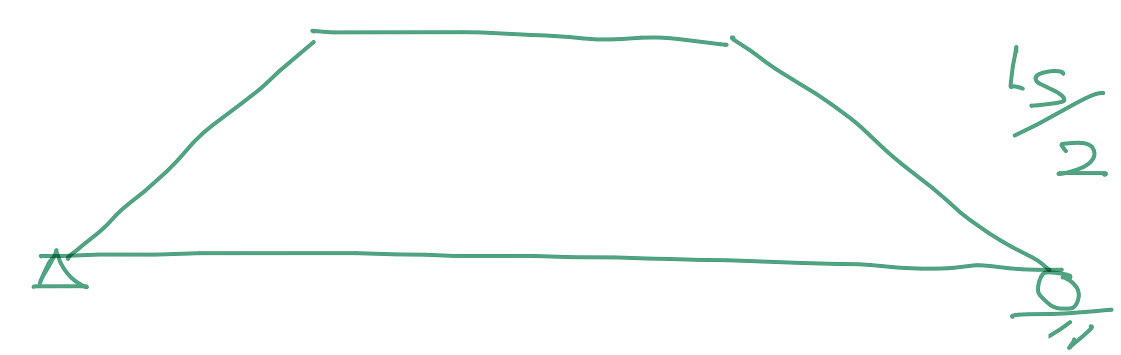
Ch (1) → Ch (2)



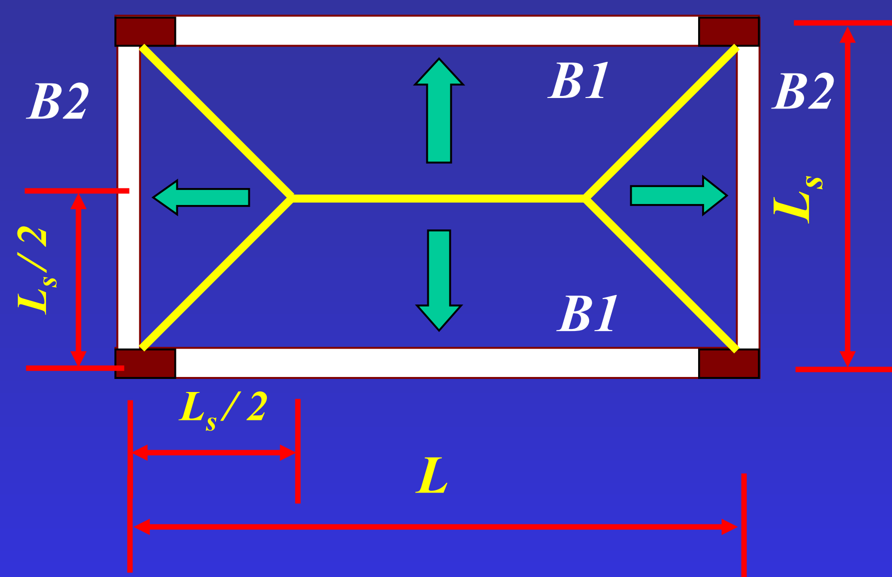
$L/L_s \geq 2$ one-way slab



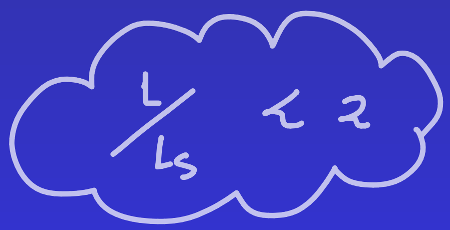
$L/L_s < 2$ two slab



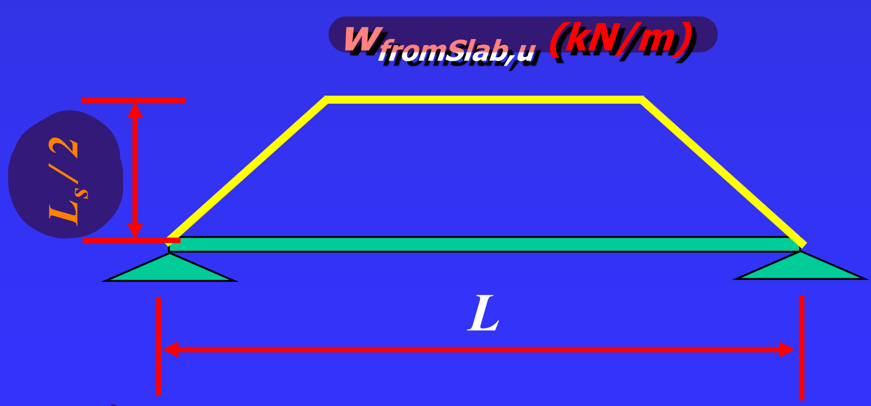
Two-Way Slabs



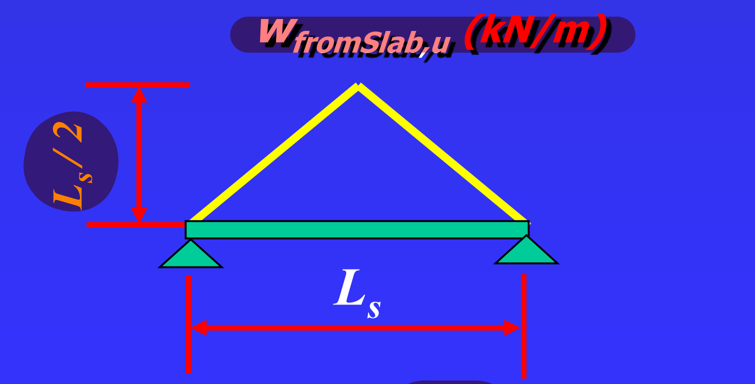
<u>**Two-Way Slabs**</u> **($L / L_s < 2$)**



- <u>***Slab Ultimate load transferred to beam***</u>



BEAM (B1)



BEAM (B2)

Example (3)- In class Activity

• **Given:**

t_s = 0.14 m

F.C. = 1.5 kN/m²

w_L = 1.5 kN/m²

Beam sec = 0.3 x 0.65 m

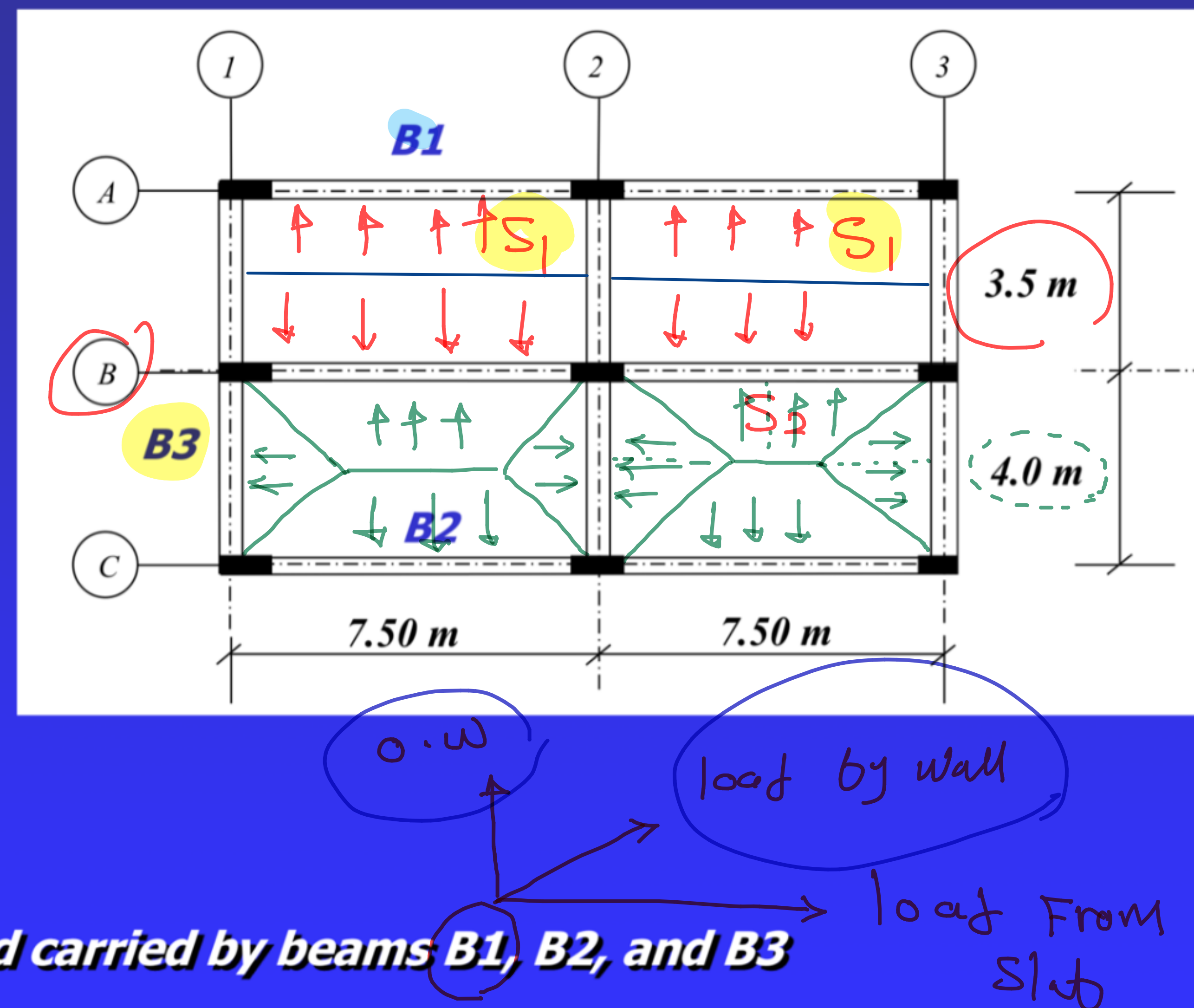
γ_c = 25 kN/m³

Wall density = 10 kN/m³

wall height = 3 m

Wall thickness = 0.25 m

Columns sec. = 0.3 x 0.5 m



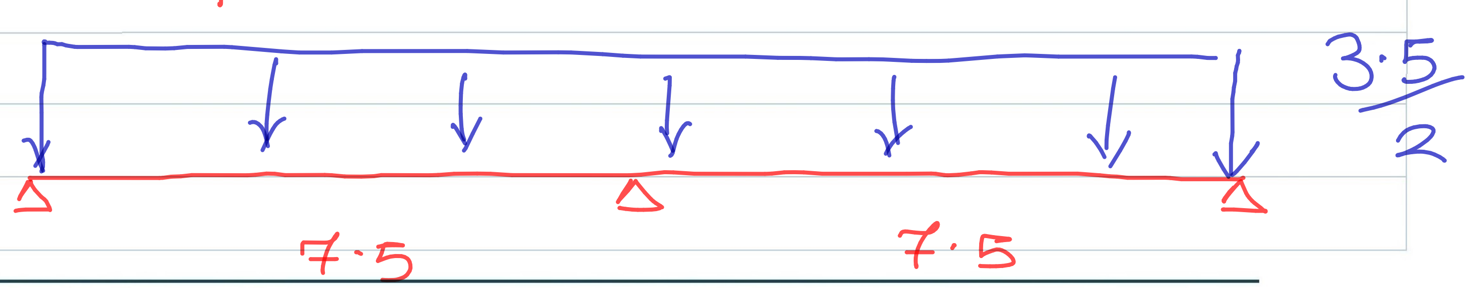
• **Required:**

Calculate Ultimate Load carried by beams B1, B2, and B3

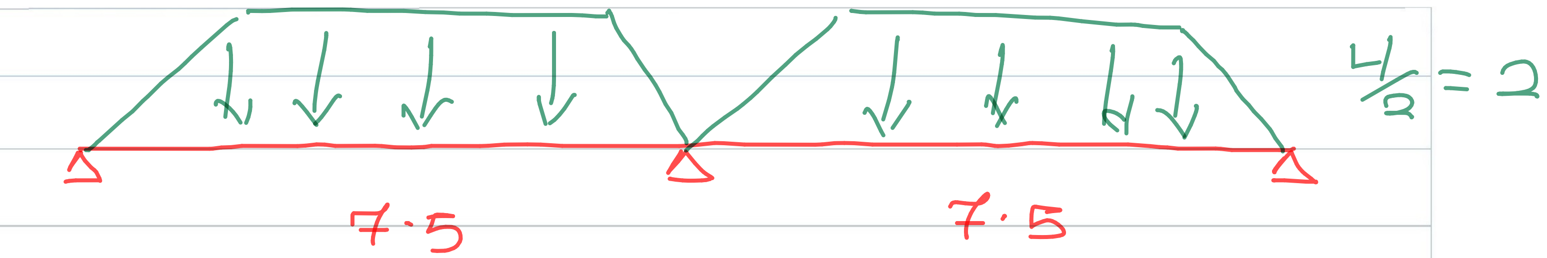
For S_1 $\frac{7.5}{3.5} > 2$ one way slab

For S_2 $\frac{7.5}{4} < 2$ two way slab

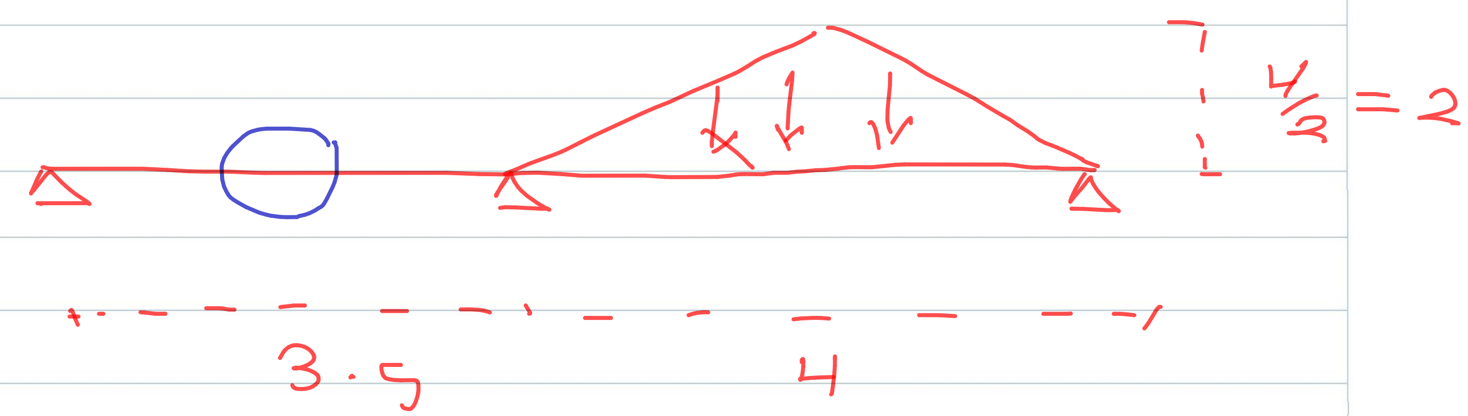
Beam B_1



Beam B_2



Beam B_3



Example (3)- In class Activity

- **Given:**

t_s = 0.14 m

F.C. = 1.5 kN/m^2

w_L = 1.5 kN/m^2

Beam sec = 0.3 x 0.65 m

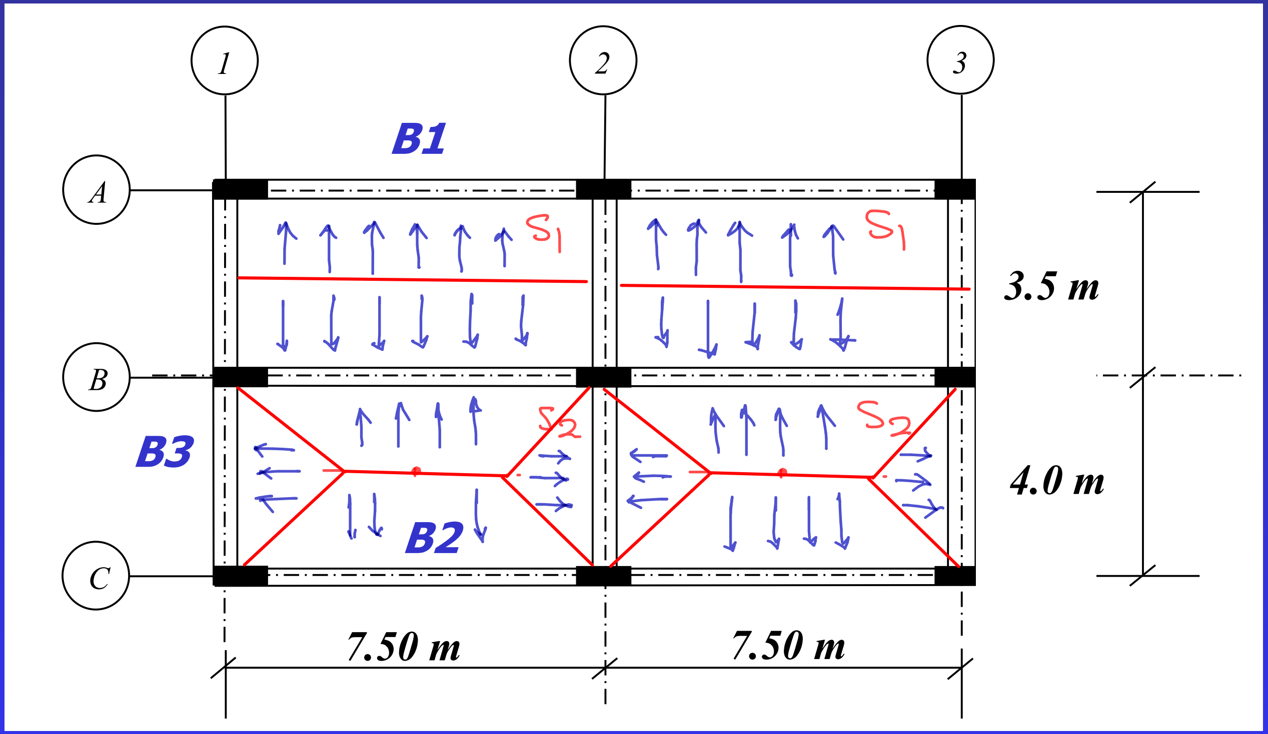
γ_c = 25 kN/m^3

Wall density = 10 kN/m^3

wall height = 3 m

Wall thickness = 0.25 m

Columns sec. = 0.3 x 0.5 m



For S_1 ⇒ $\frac{7.5}{3.5} > 2$ ⇒ one way slab

For S_2 ⇒ $\frac{7.5}{4} < 2$ ⇒ two way slab

- **Required:**

Calculate Ultimate Load carried by beams B1, B2, and B3

Solution Guidelines

STEP 1: Draw tributary areas for beams on plan

STEP 2: Draw Statical System of the beam showing its tributary area

STEP 3: Calculate slab ultimate load transferred to beam

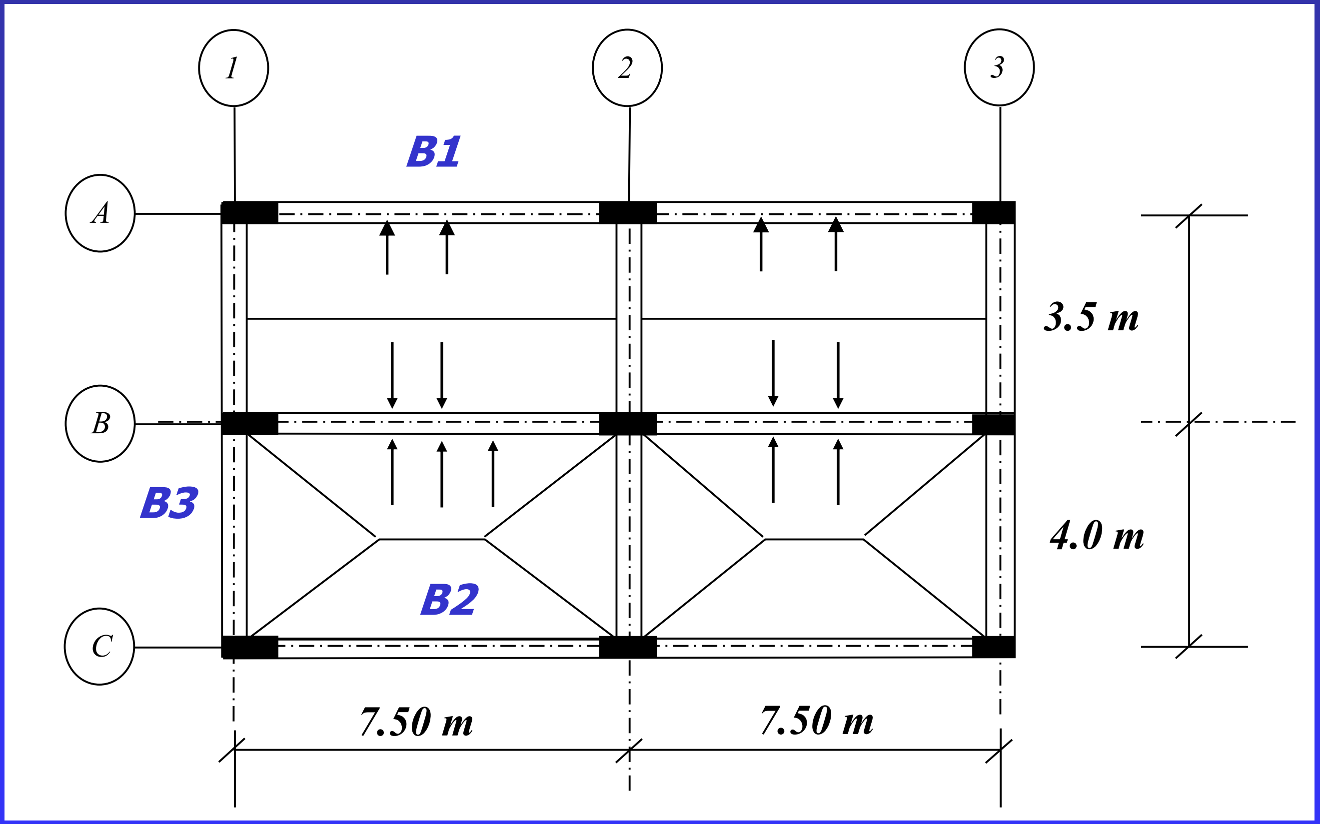
STEP 4: Calculate ultimate beam own weight (dead load)

STEP 5: Calculate ultimate wall weight carried by the beam (dead load)

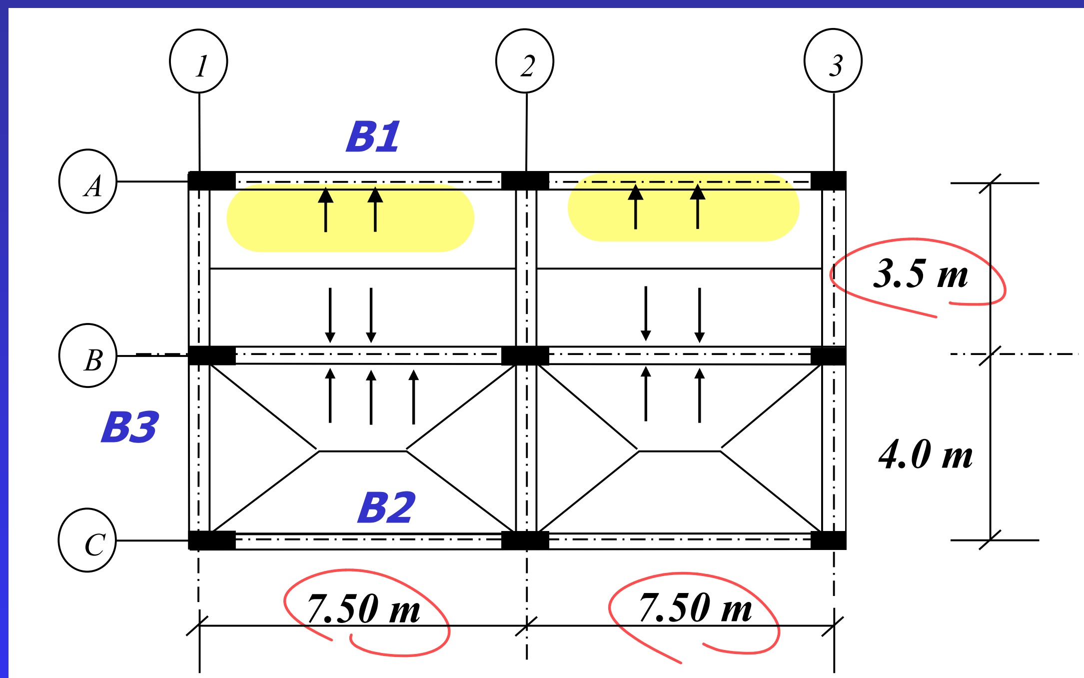
STEP 6: Draw Statical System of the beam showing all ultimate loads

Solution – Tributary Areas

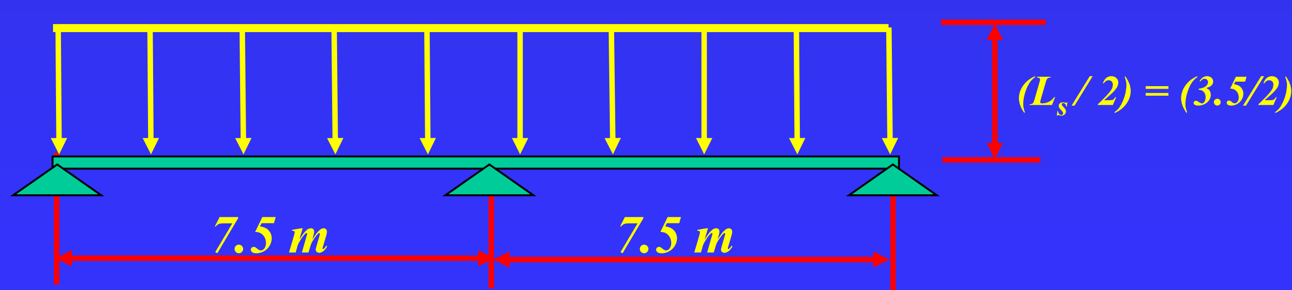
Tributary areas for beams on plan



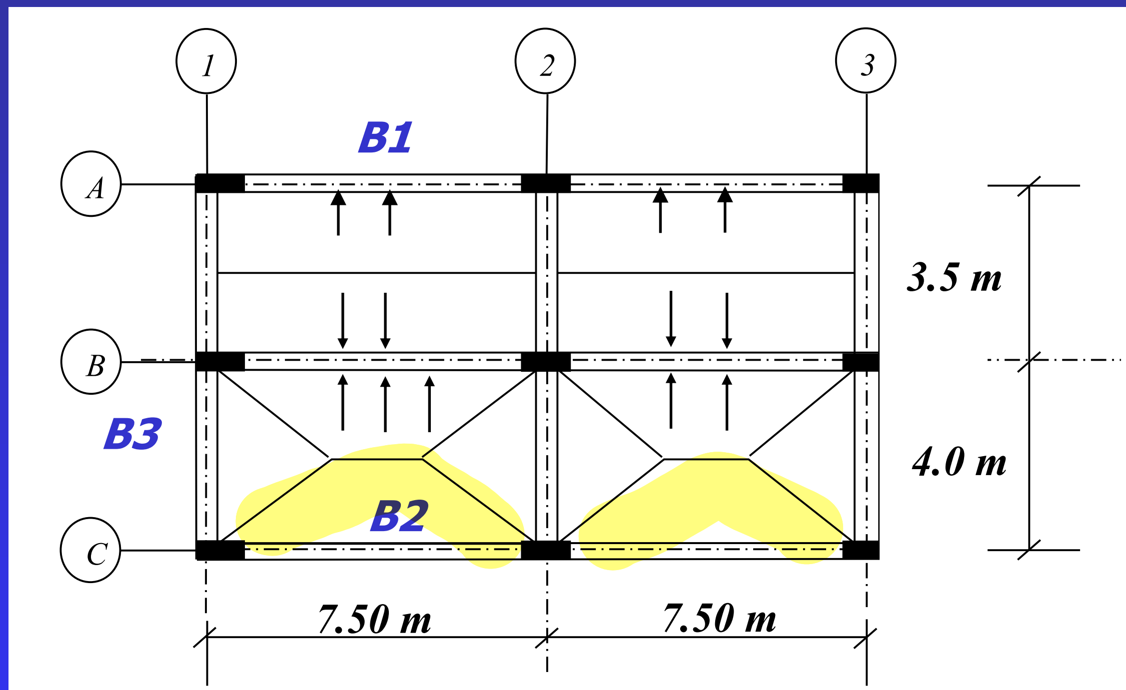
Solution – Beam B1



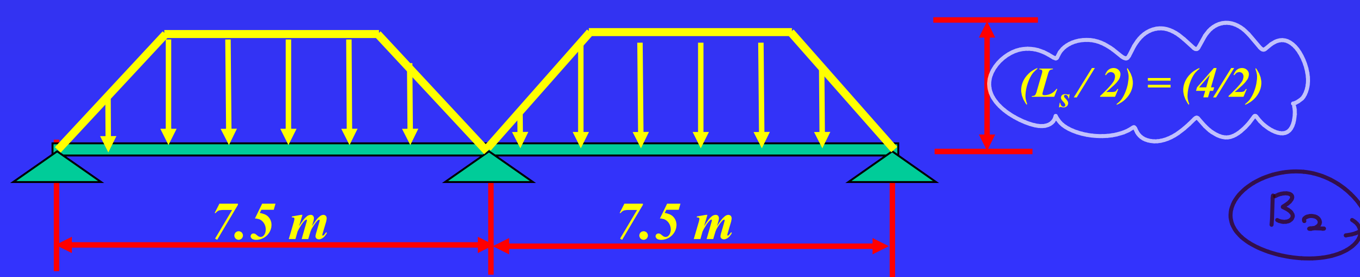
Beam B1



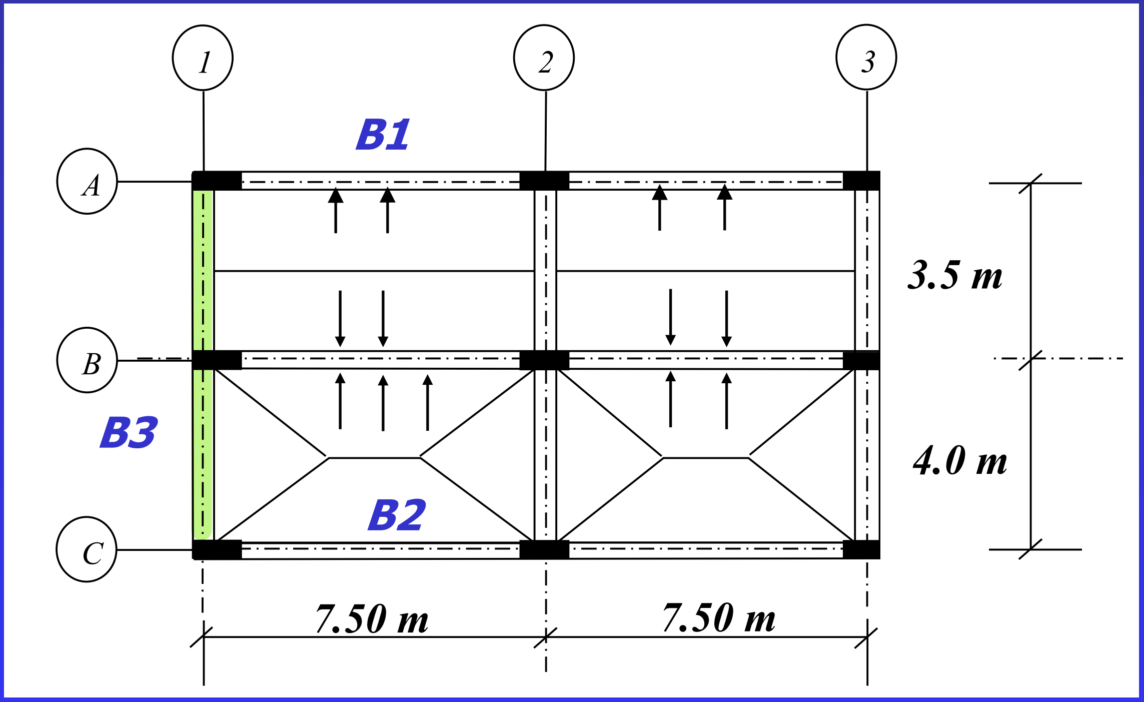
Solution – Beam B2



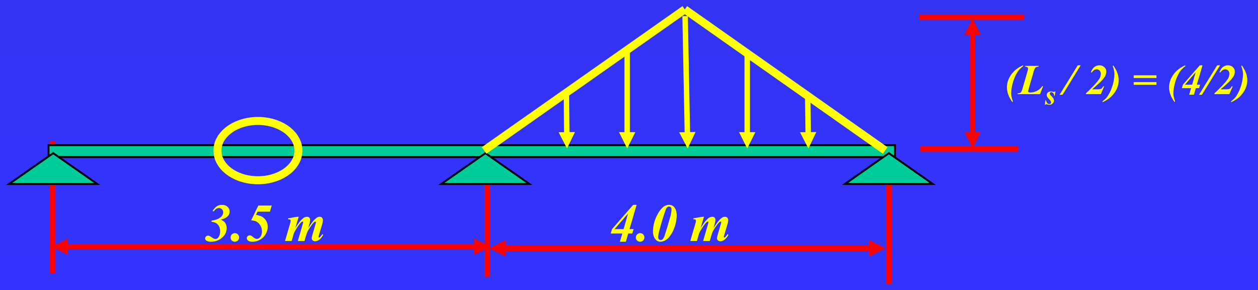
Beam B2



Solution - Beam B3



Beam B3



Example (4) In class Activity

- **Given:**

t_s = 0.14 m

F.C. = 1.5 kN/m^2

w_L = 1.5 kN/m^2

Beam sec = 0.3 x 0.65 m

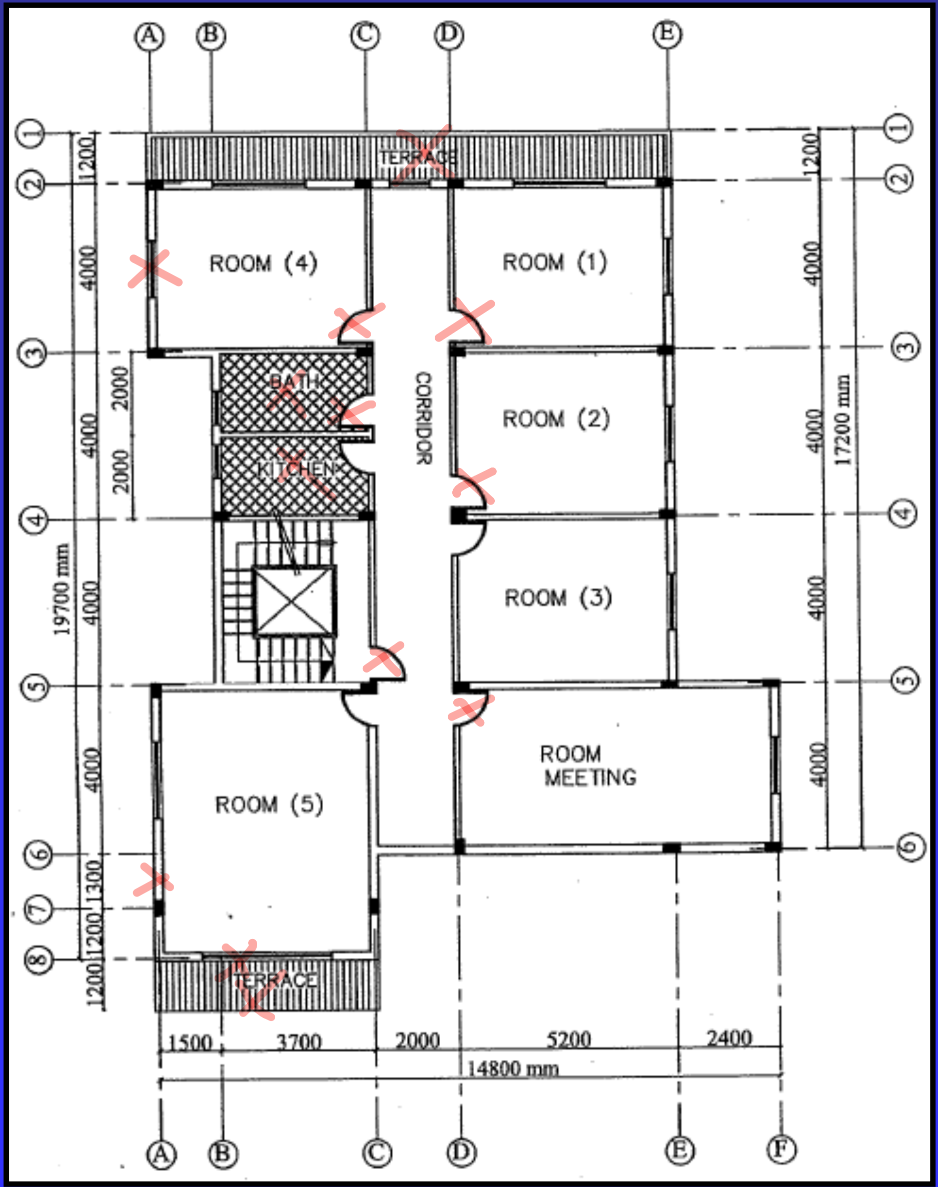
γ_c = 25 kN/m^3

Wall density = 10 kN/m^3

wall height = 3 m

Wall thickness = 0.25 m

Columns sec. = 0.3 x 0.5 m



Example (4) In class Activity

- ***Required:***

The figure shows an architectural plan of a typical story of a building. It is required to:

a- Propose a structural system of the floor as a slab-beam type system.

b- Calculate the Load carried by the beams on axes D, E, and 2.

C- Calculate the Load carried by the columns at the intersections of the following axes:

a) 2 and E
b) 3 and D
c) 6 and F

Solution Guidelines

STEP 1: Draw tributary areas for beams and columns on plan

STEP 2: ***Draw Statical System of the beam and column showing their tributary areas***

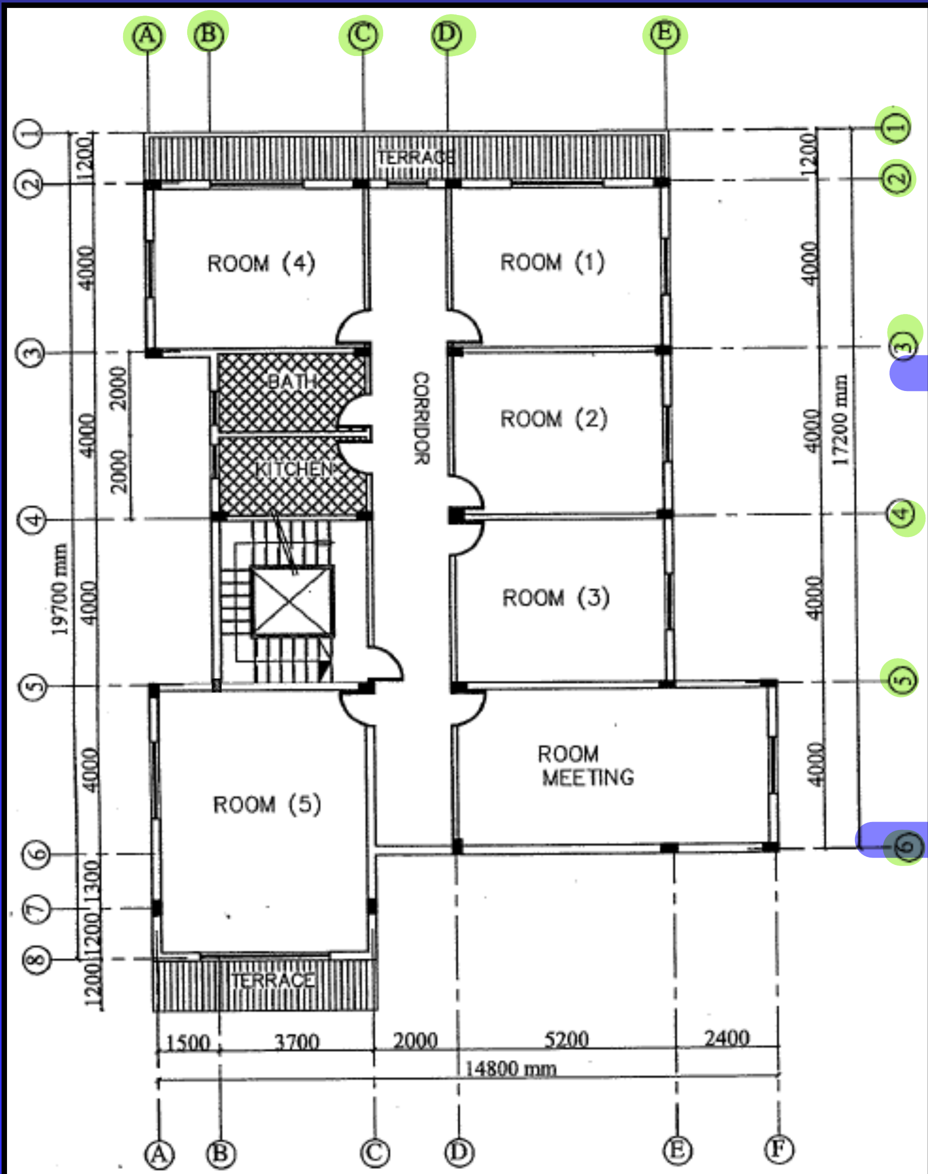
STEP 3: ***Calculate slab ultimate load transferred to beam and column***

STEP 4: ***Calculate ultimate beam and column own weight (dead load)***

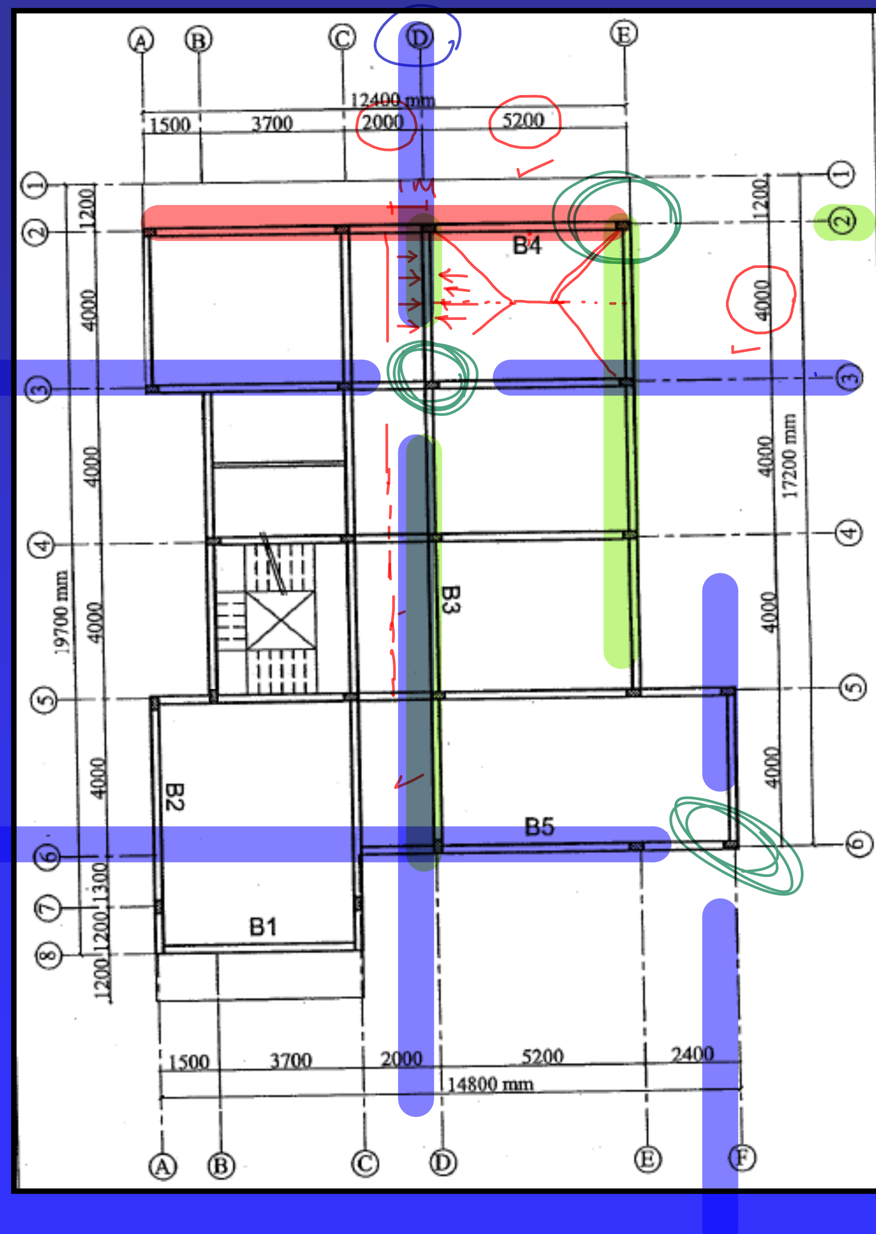
STEP 5: ***Calculate ultimate wall weight carried by the beam and column (dead load)***

STEP 6: ***Draw Statical System of the beam and column showing all ultimate loads***

Solution

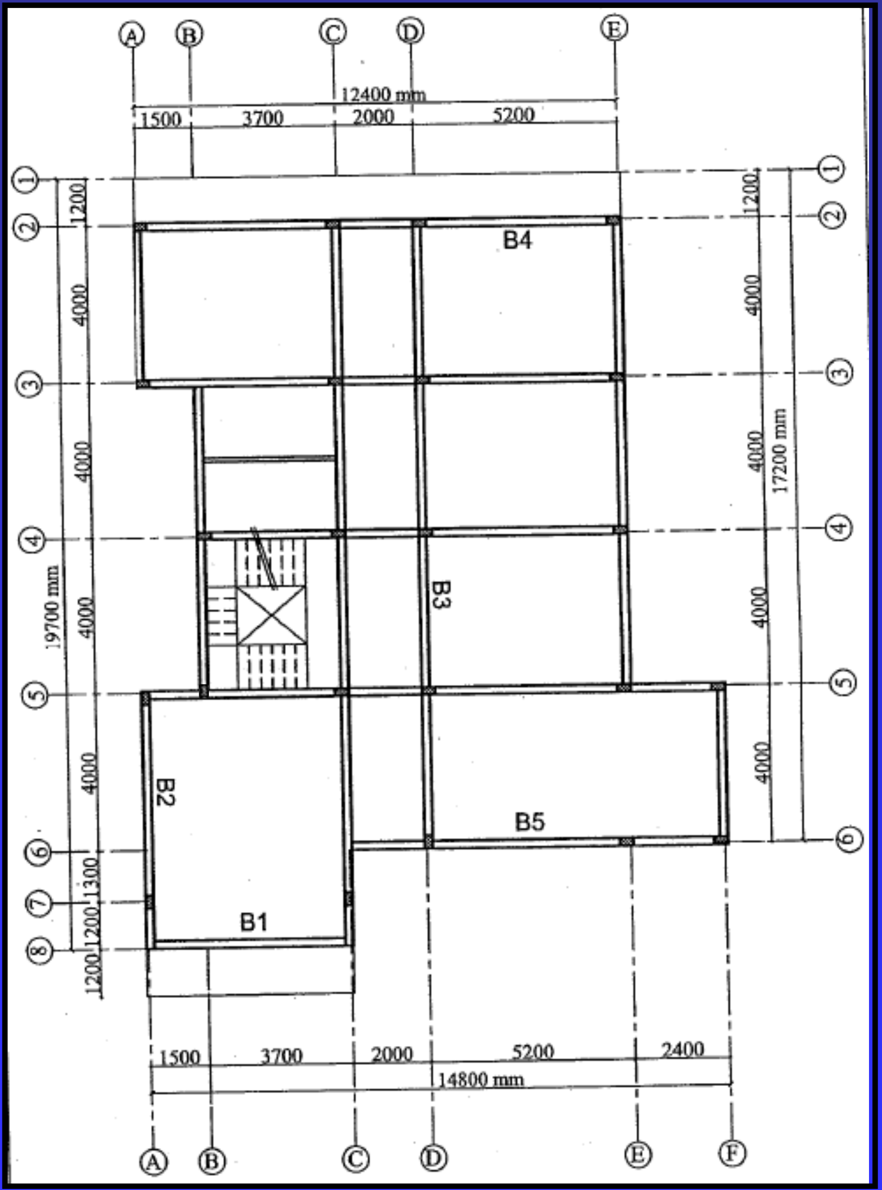


A
B
C
D
E
F
1
2
3
4
5
6
7
8
TERRACE
ROOM (4)
ROOM (1)
BATH
KITCHEN
CORRIDOR
ROOM (2)
ROOM (3)
ROOM (5)
ROOM MEETING
1200
4000
2000
19700 mm
17200 mm
1300
1500
3700
2000
5200
2400
14800 mm

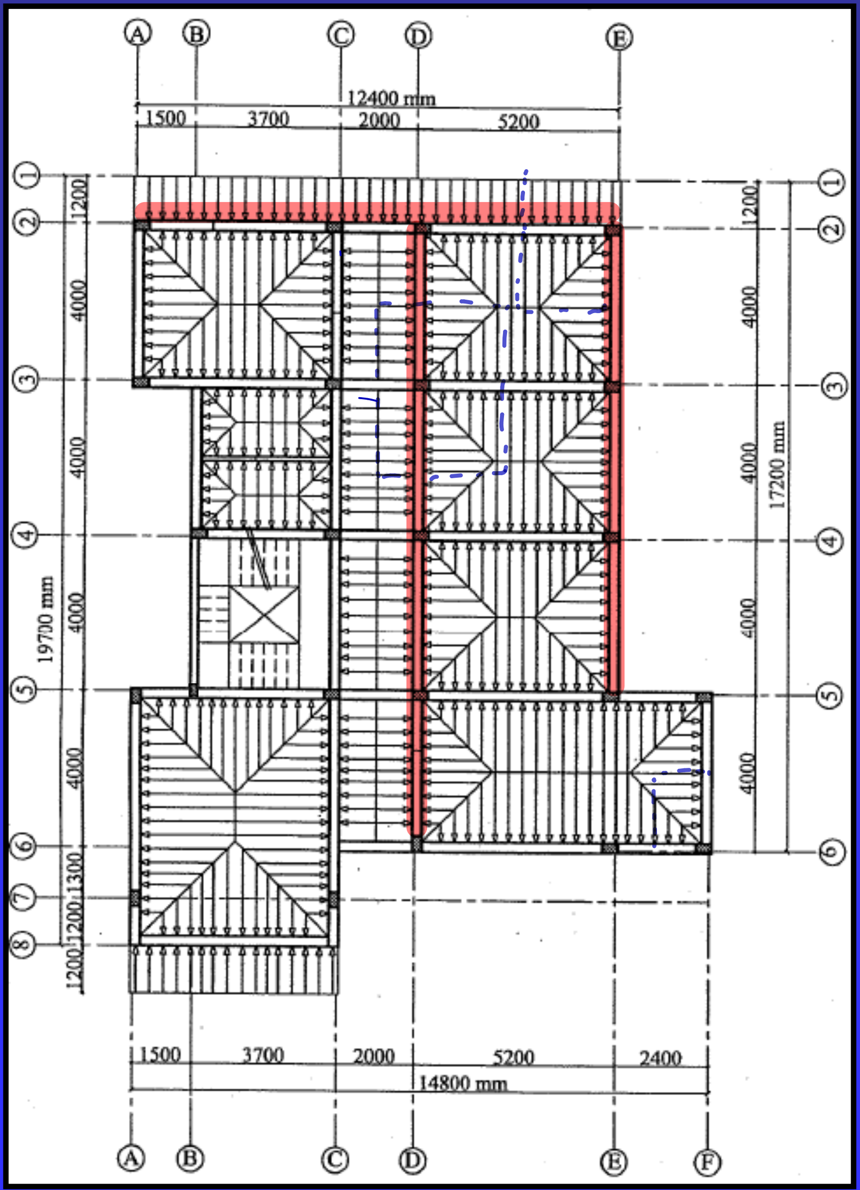


A
B
C
D
E
F
1
2
3
4
5
6
7
8
12400 mm
1500
3700
2000
5200
1200
4000
19700 mm
17200 mm
1300
2400
14800 mm
B1
B2
B3
B4
B5

Solution

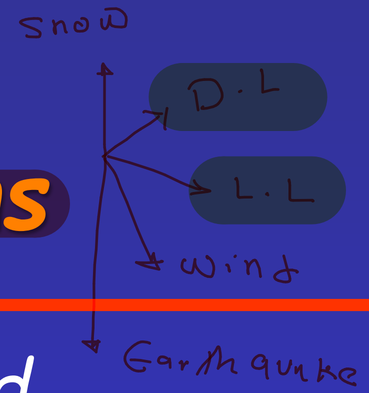


12400 mm
1500
3700
2000
5200
B4
B3
B2
B5
B1
1200
4000
4000
4000
4000
1300
1200
1200
19700 mm
17200 mm
2400
14800 mm



12400 mm
1500
3700
2000
5200
1200
4000
4000
4000
4000
1300
1200
1200
19700 mm
17200 mm
2400
14800 mm

ACI 318 Load Combinations



ACI Code Section 9.2 gives the load combinations to be used in reinforced concrete design

The ACI load combinations deal with load effects, not loads

ACI 318 Load Combinations

$$U = 1.4(D + F)$$

$$U = 1.2(D + F + T) + 1.6(L + H) + 0.5(L_r \text{ or } S \text{ or } R)$$

$$U = 1.2D + 1.6(L_r \text{ or } S \text{ or } R) + (1.0L \text{ or } 0.8W)$$

$$U = 1.2D + 1.6W + 1.0L + 0.5(L_r \text{ or } S \text{ or } R)$$

$$U = 1.2D + 1.0E + 1.0L + 0.2S$$

$$U = 0.9D + 1.6W + 1.6H$$

$$U = 0.9D + 1.0E + 1.6H$$

$U = 1{\cdot}6\,D + 1{\cdot}2\,L$

ACI 318 Load Combinations

D -> dead load
L -> live load
L_r -> roof live load
F -> weight or pressure created by fluids
T -> temperature, creep, shrinkage, differential settlement
S -> snow load
W -> wind load
E -> seismic load
H -> lateral earth pressure, groundwater pressure or pressure from bulk materials

Example.5

The compressive gravity axial load for a building column are: L = 300 k, D = 150 k and L_r = 60 k. The compressive axial force in the column due to other loads are: wind = 70 k, seismic = 50 k. Tensile axial force in the column due to other loads are: wind = 60 k, seismic = 40 k. Determine the critical design loads based on the ACI load combinations . Compressive loads are positive (this is an arbitrary choice).

Example.5

$$(9-1)\quad U = 1.4(150\text{ k} + 0\text{ k}) = 210\text{ k}$$

$$(9-2)\quad U = 1.2(150\text{ k} + 0\text{ k} + 0\text{ k}) +$$

$$1.6(300\text{ k} + 0\text{ k}) + 0.5(60\text{ k}) = 690\text{ k}$$

$$(9-3a)\ U = 1.2(150\text{ k}) + 1.6(60\text{ k}) + 1.0(300\text{ k}) = 576\text{ k}$$

$$(9-3b)\ U = 1.2(150\text{ k}) + 1.6(60\text{ k}) + 0.8(70\text{ k}) = 332\text{ k}$$

$$(9-3c)\ U = 1.2(150\text{ k}) + 1.6(60\text{ k}) + 0.8(-60\text{ k}) = 228\text{ k}$$

$$(9-4a)\ U = 1.2(150\text{ k}) + 1.6(70\text{ k}) + 1.0(300\text{ k}) + 0.5(60\text{ k}) = 622\text{ k}$$

$$(9-4b)\ U = 1.2(150\text{ k}) + 1.6(-60\text{ k}) + 1.0(300\text{ k}) + 0.5(60\text{ k}) = 414\text{ k}$$

Example.5

$$(9-5a) \quad U = 1.2(150\text{ k}) + 1.0(50\text{ k}) + 1.0(300\text{ k}) + 0.2(0\text{ k})$$
$$= 530\text{ k}$$

$$(9-5b) \quad U = 1.2(150\text{ k}) + 1.0(-40\text{ k}) + 1.0(300\text{ k}) + 0.2(0\text{ k})$$
$$= 440\text{ k}$$

$$(9-6a) \quad U = 0.9(150\text{ k}) + 1.6(70\text{ k}) + 1.6(0\text{ k}) = 247\text{ k}$$

$$(9-6b) \quad U = 0.9(150\text{ k}) + 1.6(-60\text{ k}) + 1.6(0\text{ k}) = 39\text{ k}$$

$$(9-7a) \quad U = 0.9(150\text{ k}) + 1.0(50\text{ k}) + 1.6(0\text{ k}) = 185\text{ k}$$

$$(9-7b) \quad U = 0.9(150\text{ k}) + 1.0(-40\text{ k}) + 1.6(0\text{ k}) = 95\text{ k}$$