Beam Analysis

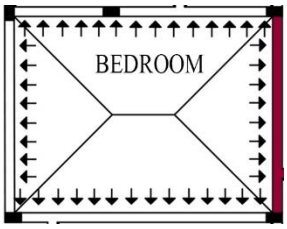
Load Distribution Diagram

Identify One-Way Slab or Two-Way Slab (to identify the distribution of load from slab to beam).

L_y= longer side of slab L_x= shorter side of the slab

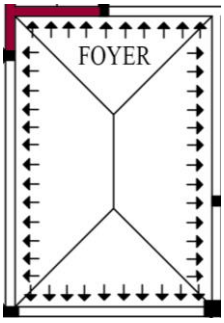
When $L_y / L_x > 2$, it is a one-way slab.

When $L_y / L_x < 2$ or $=2$, it is a two-way slab.



1. Bedroom (D-E1/ 1-3)
   L_y / L_x= 4.785/ 3.6
   = 1.329 (two-way slab)

2. Staircase (D-F/ 3-4)
   L_y / L_x= 5.325/ 1.65
   = 3.227 (one-way slab)

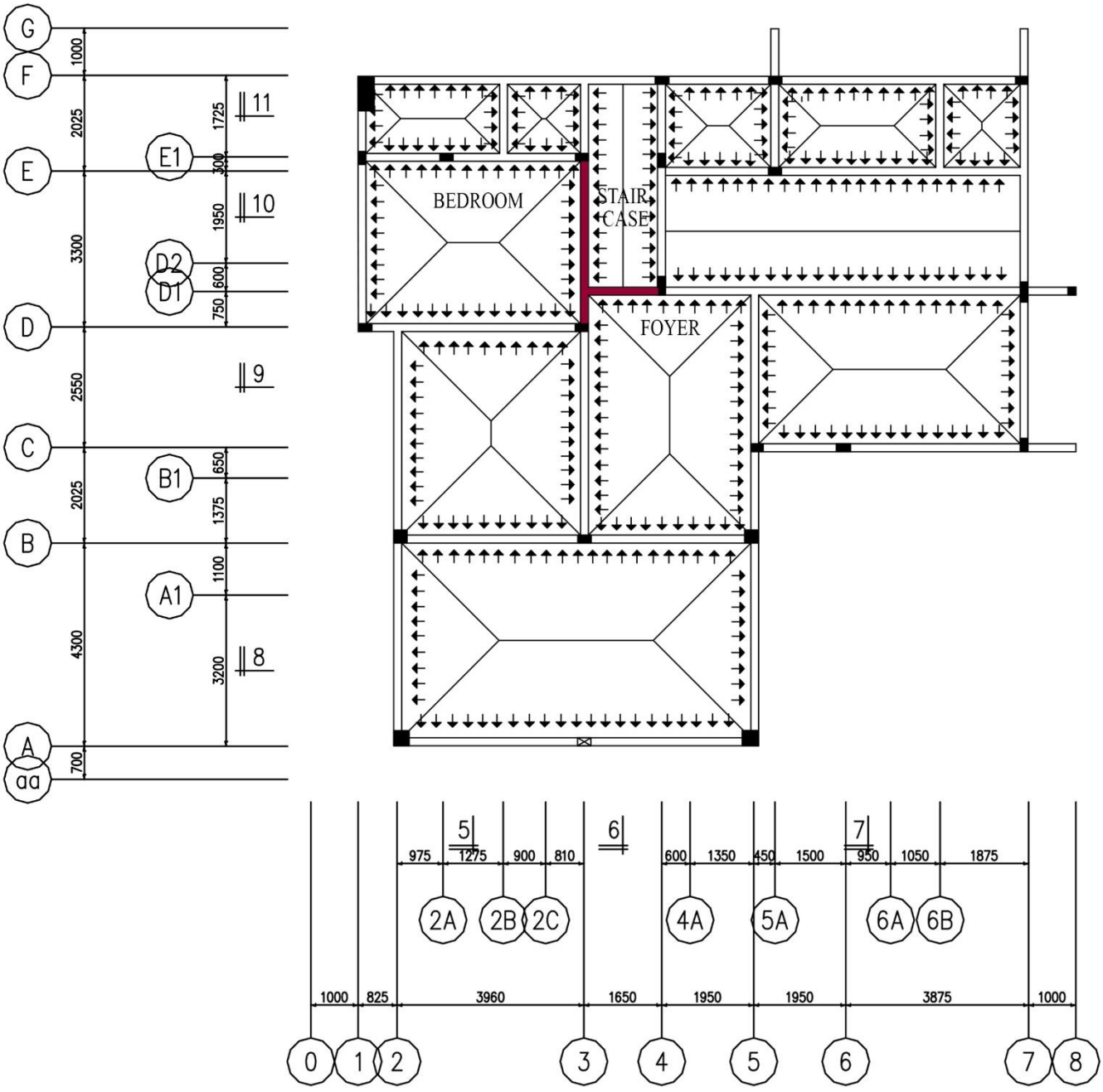


3. Foyer (B-D1/ 3-5)
   L_y / L_x= 5.325/ (1.65 + 1.95)
   = 1.479 (two-way slab)

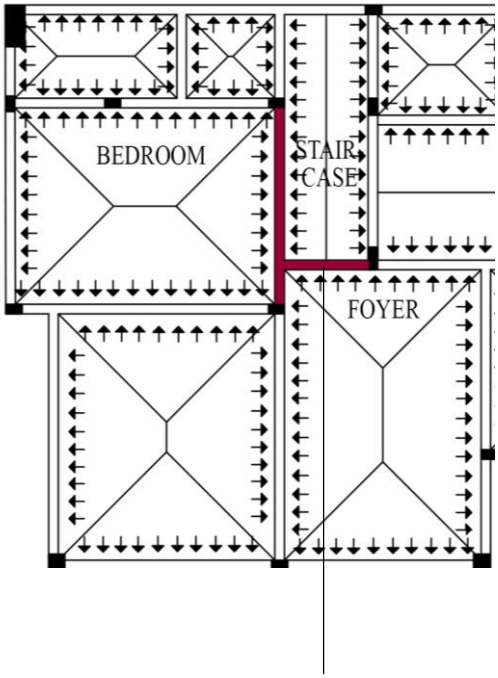
Live Load of spaces according to UBBL

- A/V Room: 1.92kN/m^2
- Balcony: 1.5 kN/m^2
- Bathroom: 2.0 kN/m^2
- Bedroom: 2.0 kN/m^2
- Car porch: 5.0 kN/m^2
- Dining Room: 2.0 kN/m^2
- Dressing Room: 2.0 kN/m^2
- Dry Kitchen: 3.0 kN/m^2
- Family Room: 1.92 kN/m^2
- Foyer: 2.0 kN/m^2
- Living Room: 2.0 kN/m^2
- Roof: 0.5 kN/m^2
- Stairs: 2.0 kN/m^2
- Study Room: 2.0 kN/m^2
- Utility Room: 2.0 kN/m^2
- Passage: Based on the room passage is leading to.

Analysis on beam **D1/ 3-4**



LOAD DISTRIBUTION DIAGRAM- GROUND FLOOR
(NTS)

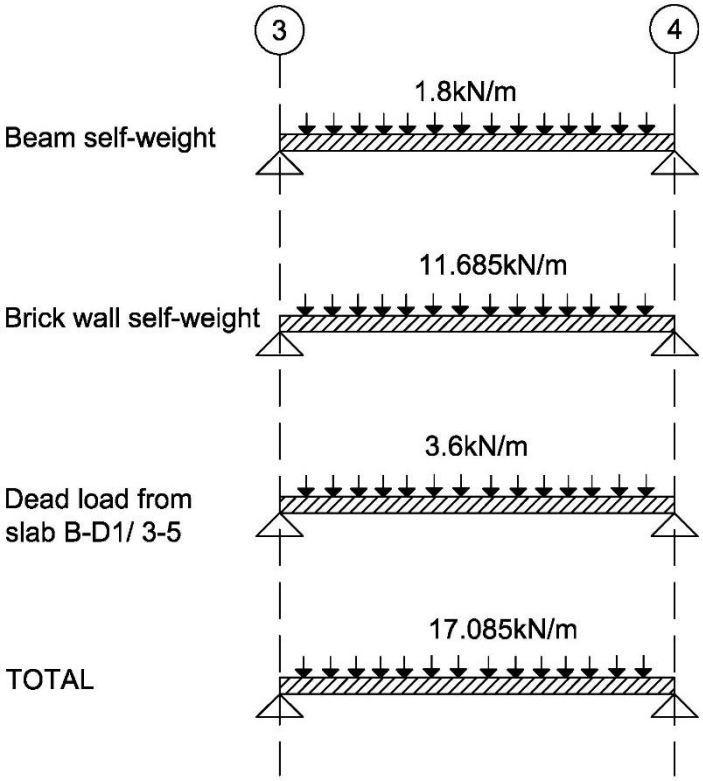


Beam D1/ 3-4 (only loads from foyer is acting on it)

<u>Dead loads acting on beam D1/ 3-4</u>

1. Slab self-weight
   = Slab thickness x concrete density
   = 0.125m x 24kN/m^3
   = 3kN/ m^2
2. Beam self-weight
   = Beam size x concrete density
   = (0.15m x 0.5m) x 24kN/m^3
   = 1.8kN/m
3. Brick wall self-weight
   = Wall height x thickness x density
   = 4.1m x 0.15m x 19kN/m^3
   = 11.685kN/m
4. Dead load from the slab B-D1/ 3-5
   = 3kN/m^2 x (L_x/2) x (2/3)
   =3kN/m^2 x (3.6/2) x (2/3)
   = 3.6kN/m
5. Total dead load
   = 1.8 + 11.685 + 3.6
   = 17.085 kN/m

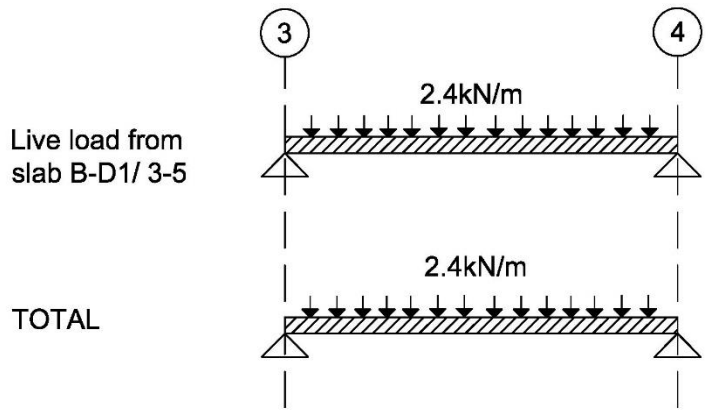
Total Dead Load Diagram



Live loads acting on beam D1/ 3-4

1. Live load on beam D1/ 3-4
   = live load from foyer x
   (L_x/ 2) x (2/3)
   = 2kN/m^2 x (3.6m/ 2) x (2/3)
   = 2.4kN/m
2. Total live load
   = 2.4kN/m

Total Live Load Diagram



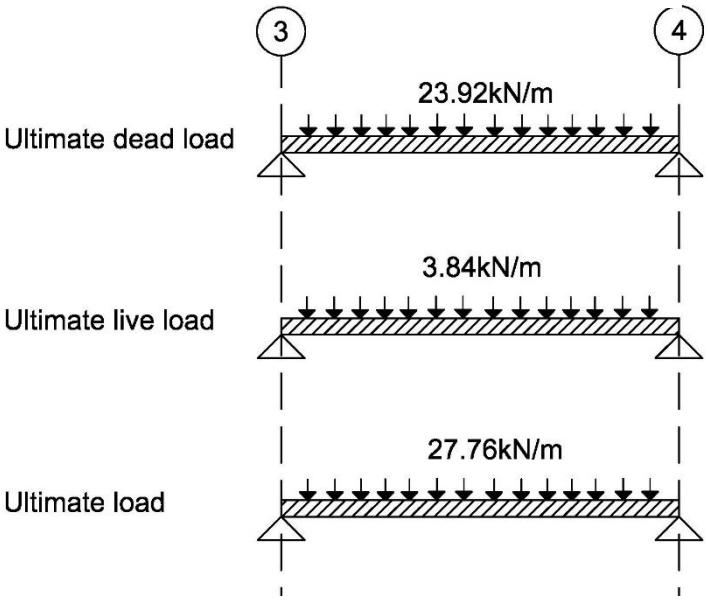
Ultimate Load

Dead load factor= 1.4

Live load factor= 1.6

1. Ultimate dead load
   = 17.085kN/m x 1.4
   = 23.92kN/m
2. Ultimate live load
   = 2.4kN/m x 1.6
   = 3.84kN/m
3. Ultimate load
   = 23.92kN/m + 3.84kN/m
   = 27.76kN/m

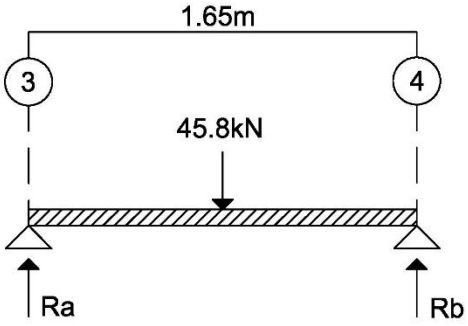
Ultimate Load Diagram



Reaction

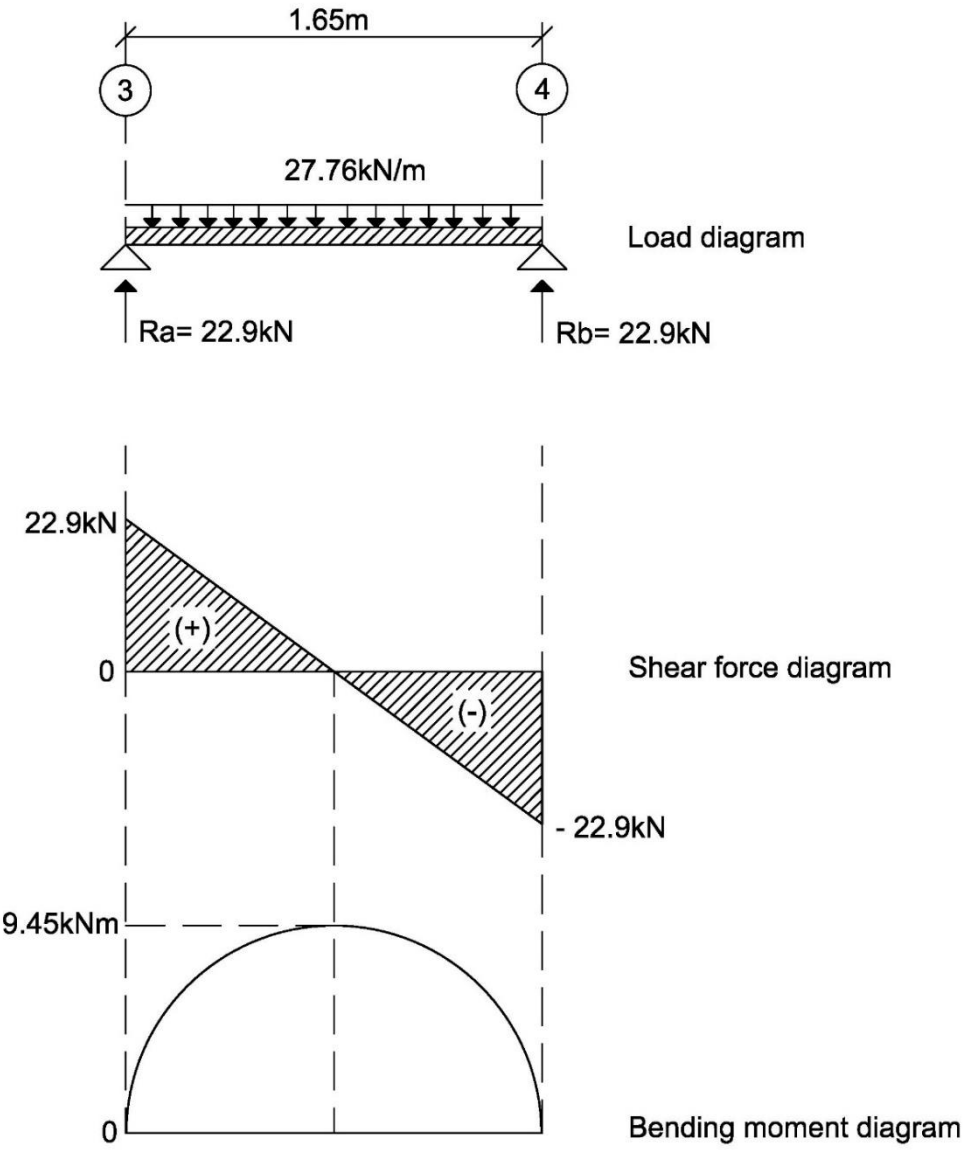
The ultimate load (UDL) is converted into point load before resolving the reaction forces of the beam D1/ 3-4.

27.76kN/m x 1.65m = 45.8kN



Assuming ∑M= 0,
[45.8kN x (1.65m/ 2)] – (R_b x 1.65m) = 0
(45.8kN x 0.825m) – 1.65R_b = 0
37.785kNm – 1.65R_b = 0
-1.65R_b = -37.785kNm
R_b = 37.785kNm/ 1.65m
R_b = 22.9kN

Assuming ∑F= 0,
45.8kN – R_a – R_b = 0
45.8kN – 22.9kN – R_a = 0
R_a = 45.8kN – 22.9kN
R_a = 22.9kN



Shear force diagram

At point 3, 22.9kN of R_a is acting upwards.

From 3 to 4, there is a UDL of 27.76kN/m acting downwards, therefore

27.76kN/m x 1.65m = 45.8kN

22.9kN – 45.8kN = -22.9kN

At point 4, another 22.9kN of R_b acting upwards, making the beam balance.

Bending moment diagram

Positive area – negative area in shear force diagram

(+ve)

= (1/2) x 22.9 x 0.825

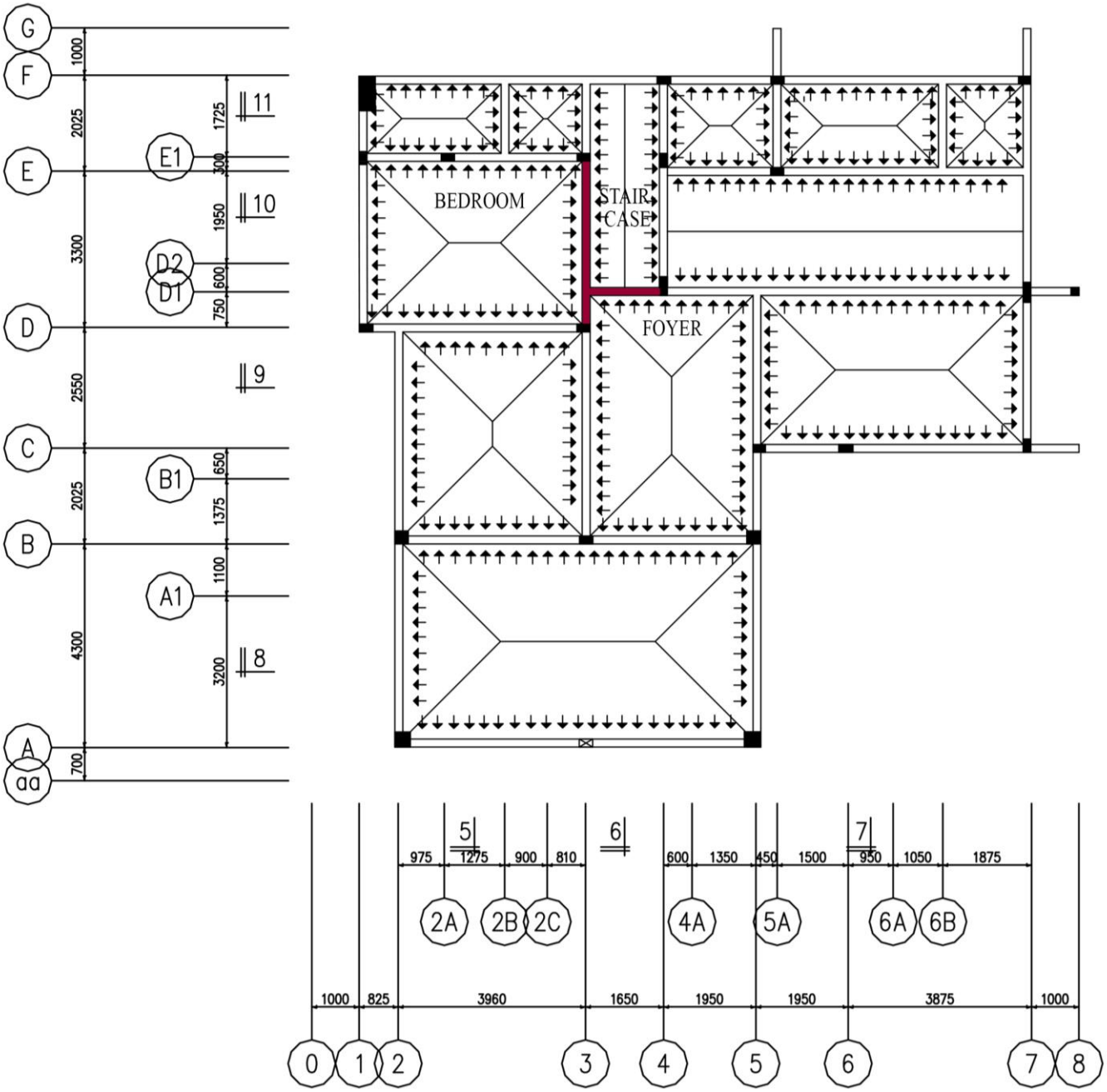
= 9.45

(-ve)

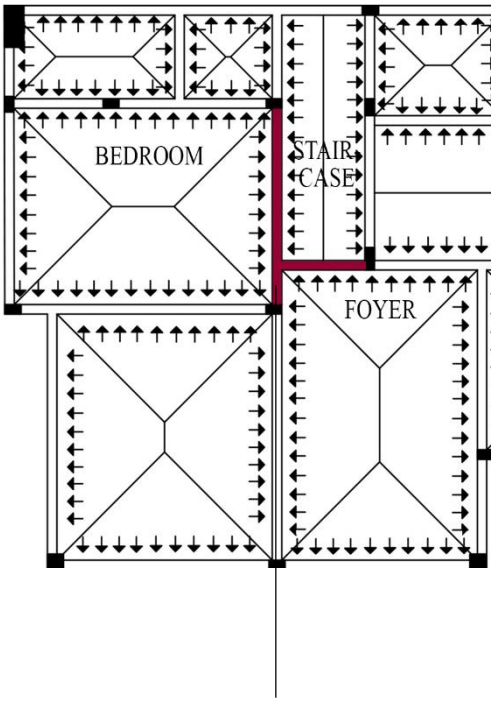
= (1/2) x (-22.9) x 0.825

= -9.45

Analysis on beam **3/ D- E1**



LOAD DISTRIBUTION DIAGRAM- GROUND FLOOR
(NTS)

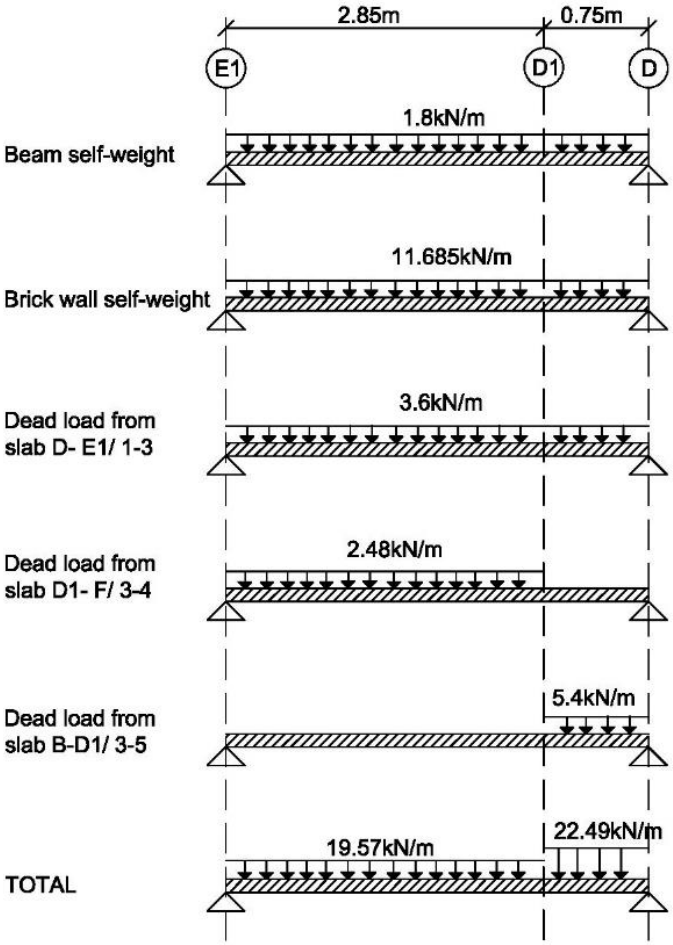


Beam 3/ D- E1 (loads from bedroom, staircase and foyer are acting on it)

<u>Dead loads acting on beam 3/ D- E1</u>

1. Slab self-weight
   = Slab thickness x concrete density
   = 0.125m x 24Kn/m^3
   = 3kN/ m^2
2. Beam self-weight
   = Beam size x concrete density
   = (0.15m x 0.5m) x 24kN/m^3
   = 1.8kN/m
3. Brick wall self-weight
   = Wall height x thickness x density
   = 4.1m x 0.15m x 19kN/m^3
   = 11.685kN/m
4. Dead load from the slab D- E1/ 1-3
   = 3kN/m^2 x (L_x/2) x (2/3)
   = 3kN/m^2 x (3.6/2) x (2/3)
   = 3.6kN/m
5. Dead load from the slab D1- F/ 3-4
   = 3kN/m^2 x (L_x/2)
   = 3kN/m^2 x (1.65/2)
   = 2.48kN/m
6. Dead load from the slab B- D1/ 3-5
   = 3kN/m^2 x (L_x/2)
   = 3kN/m^2 x (3.6/2)
   = 5.4kN/m

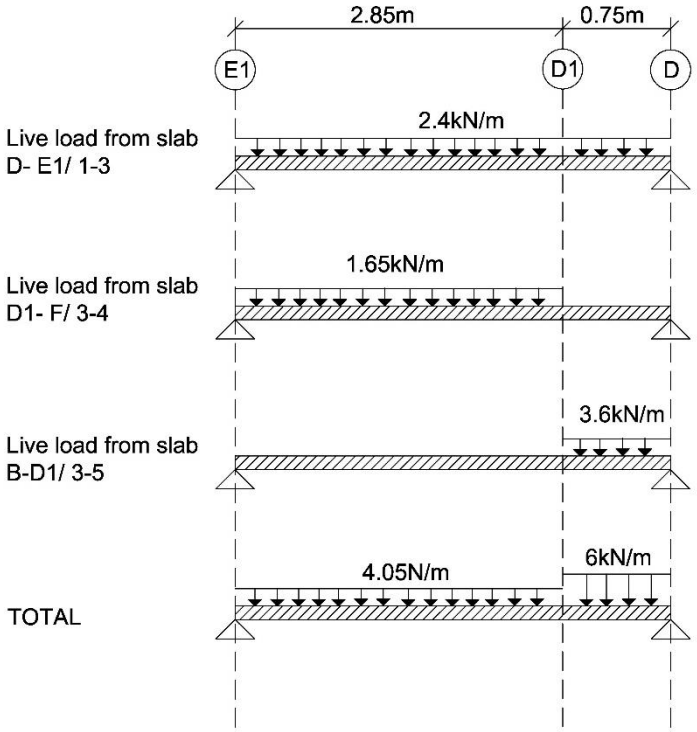
Total Dead Load Diagram



Live loads acting on beam 3/ D- E1

1. Live load from slab D- E1/ 1-3
   = live load of bedroom x (L_x/ 2) x (2/3)
   = 2kN/m^2 x (3.6m/ 2) x (2/3)
   = 2.4kN/m
2. Live load from slab D1- F/ 3-4
   = live load of staircase x (L_x/ 2)
   = 2kN/m^2 x (1.65m/ 2)
   = 1.65kN/m
3. Live load from slab B- D1/ 3-5
   = live load of foyer x (L_x/ 2)
   = 2kN/m^2 x (3.6m/ 2)
   = 3.6kN/m

Total Live Load Diagram



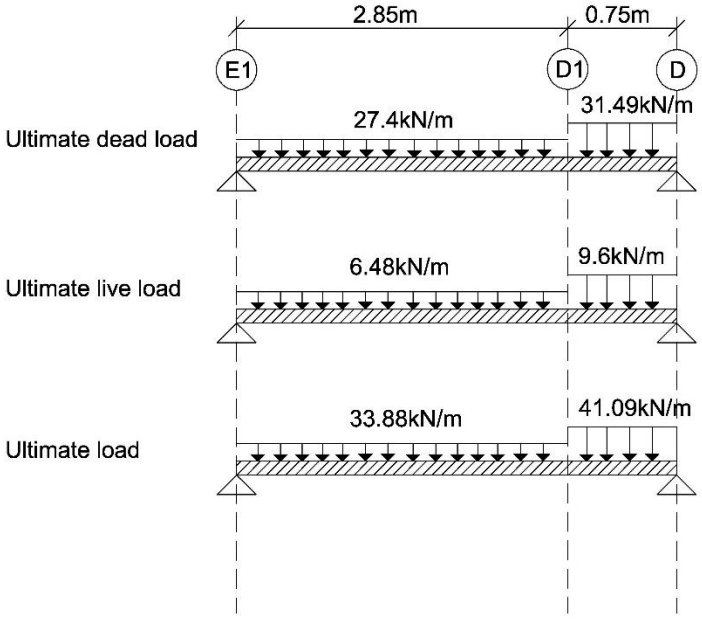
Ultimate Load

Dead load factor= 1.4

Live load factor= 1.6

1. Ultimate dead load at D1- E1
   = 19.57kN/m x 1.4
   = 27.4kN/m
   Ultimate dead load at D- D1
   = 22.49kN/m x 1.4
   = 31.49kN/m
2. Ultimate live load at D1- E1
   = 4.05kN/m x 1.6
   = 6.48kN/m
   Ultimate live load at D- D1
   = 6kN/m x 1.6
   = 9.6kN/m
3. Ultimate load at D1- E1
   = 27.4kN/m + 6.48kN/m
   = 33.88kN/m
   Ultimate load at D- D1
   = 31.49kN/m + 9.6kN/m
   = 41.09kN/m

Ultimate Load Diagram



Reaction

The ultimate load (UDL) is converted into point load before resolving the reaction forces of the beam 3/ D- E1.

Ultimate load at D1- E1

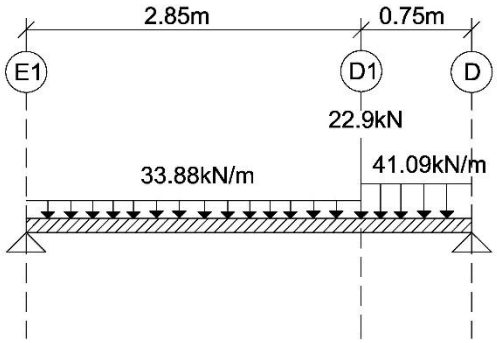
= 33.88kN/m x 2.85m = 96.56kN

Ultimate load at D- D1

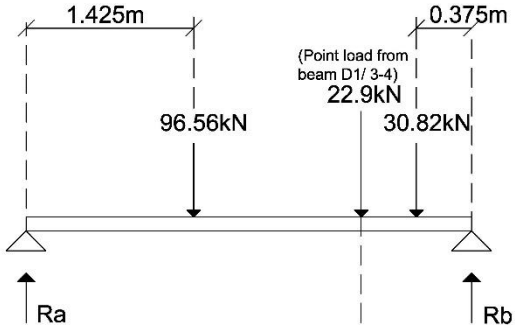
= 41.09kN/m x 0.75m = 30.82kN

Reaction force, R_a of beam D1/ 3-4 acting on this beam is taken as the point load which is 22.9kN.

Ultimate load



Reaction



Assuming ∑M= 0,

(96.56kN x 1.425m) + (22.9kN x 2.85m) + (30.82kN x 3.225m) – (R_b x 3.6m) = 0

137.598kNm + 65.265kNm + 99.39kNm – 3.6R_b = 0

302.253kNm – 3.6R_b = 0

-3.6R_b = -302.253kNm

R_b = 302.253kNm/ 3.6m

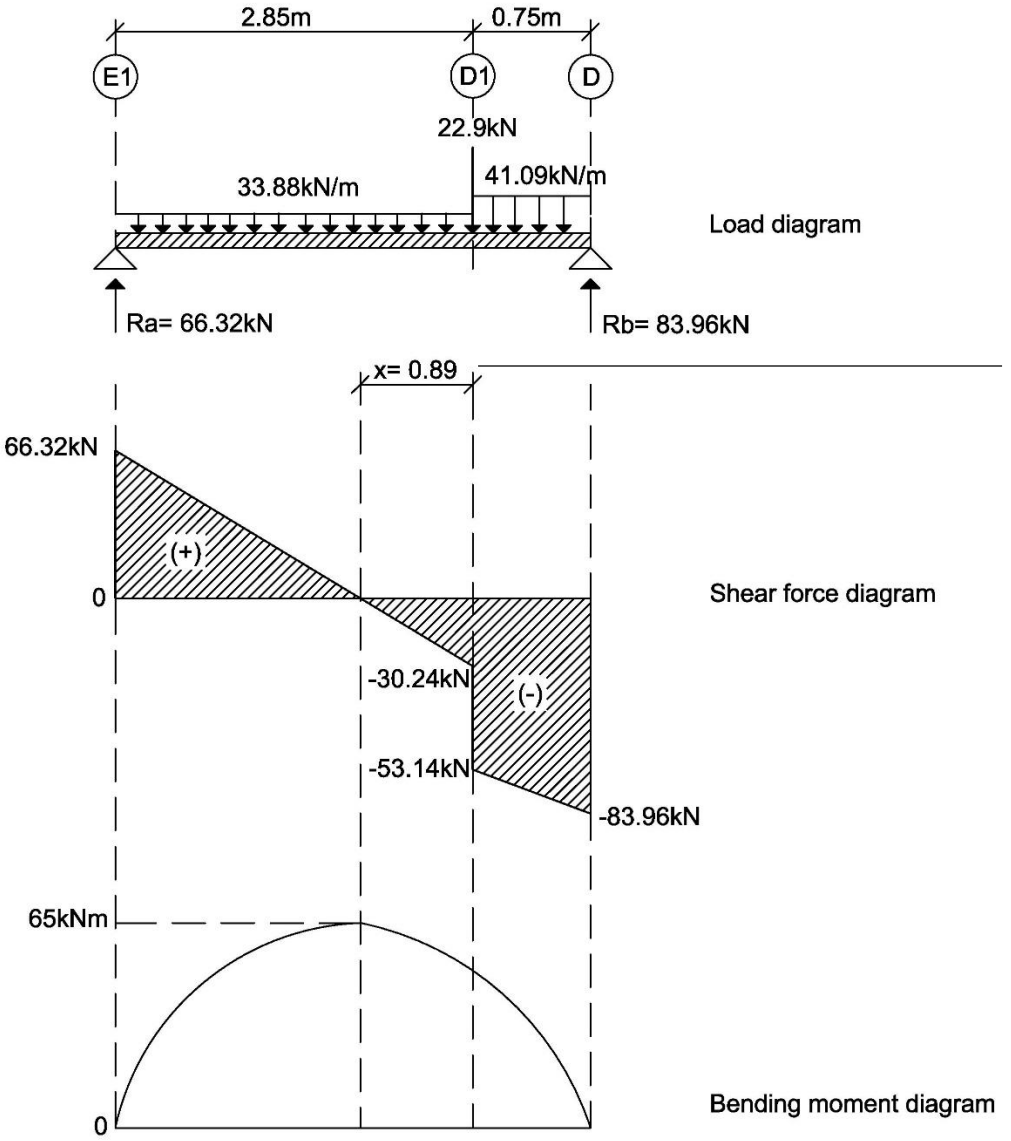
R_b = 83.96kN

Assuming ∑F= 0,

96.56kN + 22.9kN + 30.82kN – R_a – R_b = 0

150.28kN – 83.96kN – R_a = 0

R_a = 66.32kN



(x/ 2.85) = [30.24/
(30.24 + 66.32)]
(x/ 2.85) = 0.31317
X = 0.31317 x 2.85
X = 0.89

Shear force diagram

At point E1, 66.32kN of R_a is acting upwards.

From E1 to D1, there is a UDL of 33.88kN/m acting downwards, therefore
33.88kN/m x 2.85m = 96.558kN
66.32kN – 96.558kN = -30.24kN

At point D1, there is a point load of 22.9kN (R_a of beam D1/ 3-4) acting downwards, therefore
-30.24kN – 22.9kN = -53.14kN

From D1 to D, there is a UDL of 41.09kN/m acting downwards, therefore
41.09kN/m x 0.75m = 30.8175kN
-53.14kN – 30.8175kN = -83.96kN
Which is then resolved by R_b of 83.96kN that is acting upwards.

Bending moment diagram

Positive area – negative area in shear force diagram

(+ve)

= (1/2) x 66.32 x (2.85 – 0.89)

= (1/2) x 66.32 x 1.96

= 64.99 ≈ 65

(-ve)

= [(1/2) x -30.24 x 0.89] + [(1/2) x [(-53.14) + (-83.96)] x 0.75]

= -13.46 + 51.41

= -64.87 ≈ -65

Load Distribution Diagram

Identify One-Way Slab or Two-Way Slab (to identify the distribution of load from slab to beam).

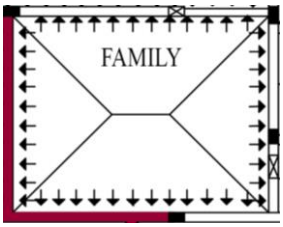
L_y= longer side of slab L_x= shorter side of the slab

When $L_y / L_x > 2$, it is a one-way slab.

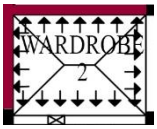
When $L_y / L_x < 2$ or $=2$, it is a two-way slab.

1. Staircase (D-E1/ 1-2A)
   L_y / L_x
   = 3.7/ 1.8
   = 2.1 (one-way slab)

5. Wardrobe 1 (C-D/ 2C-4A)
   L_y / L_x
   = 3.06/ 2.55
   = 1.2 (two-way slab)



2. Family (D-E1/ 2A-4)
   L_y / L_x
   = 4.635/ 3.6
   = 1.2875 (two-way slab)



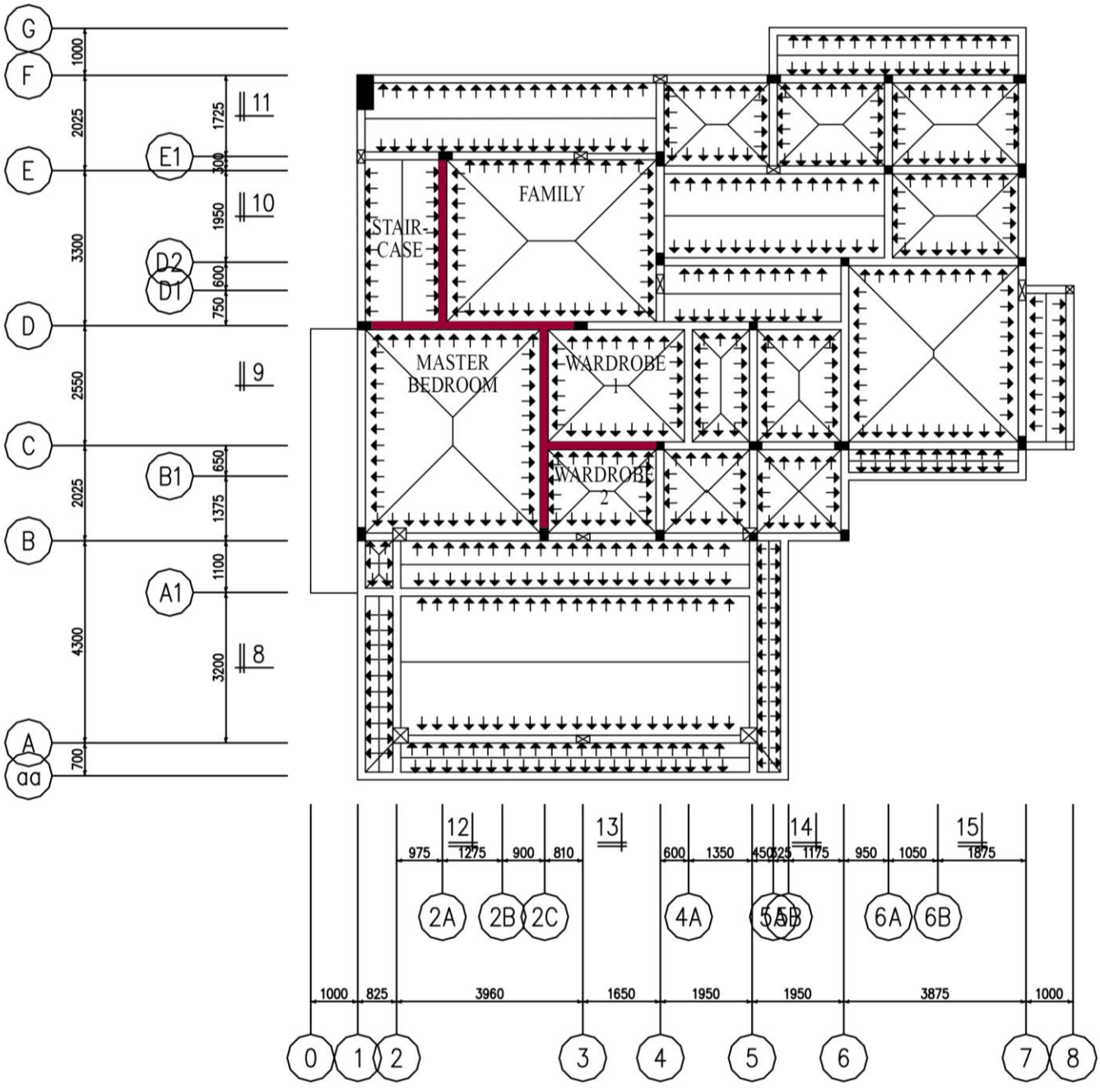
6. Wardrobe 2 (B-C/ 2C-4)
   L_y / L_x
   = 2.46/ 2.025
   = 1.215 (two-way slab)

3. Master Bedroom (B-D/ 1-2C)
   L_y / L_x
   = 4.575/ 3.975
   = 1.15 (two-way slab)

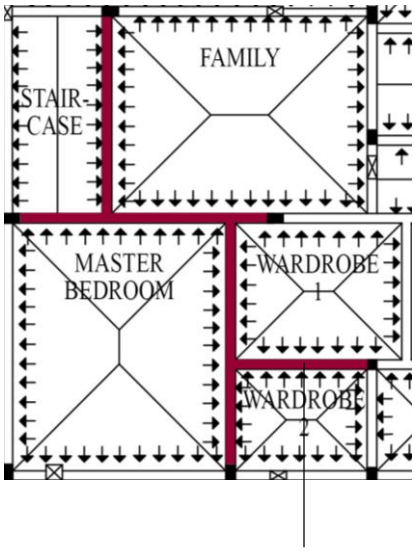
Live Load of spaces according to UBBL

- A/V Room: 1.92kN/m
- Balcony: 1.5kN/m
- Bathroom: 2.0 kN/m
- Bedroom: 2.0 kN/m
- Car porch: 5.0kN/m
- Dining Room: 2.0 kN/m
- Dressing Room: 2.0kN/m
- Dry Kitchen: 3.0 kN/m
- Family Room: 1.92kN/m
- Foyer: 2.0kN/m
- Living Room: 2.0kN/m
- Roof: 0.5kN/m
- Stairs: 2.0kN/m
- Study Room: 2.0kN/m
- Utility Room: 2.0kN/m
- Passage: Based on the room passage is leading to.

Analysis on beam **C/ 2C-4**



LOAD DISTRIBUTION DIAGRA- FIRST FLOOR
(NTS)

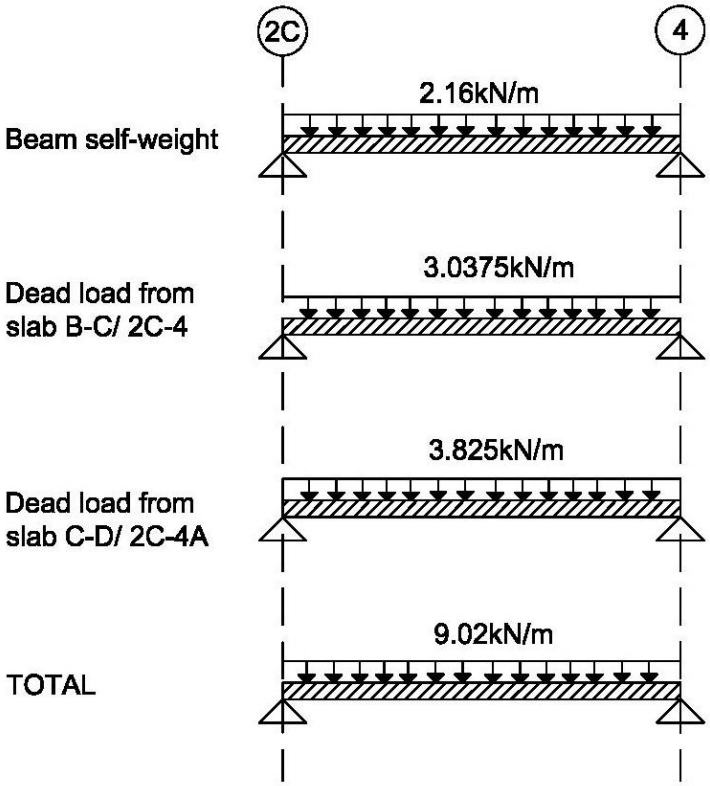


Beam C/ 2C- 4 (loads from wardrobe 1 and wardrobe 2 are acting on it)

<u>Dead loads acting on beam C/ 2C- 4</u>

1. Slab self-weight
   = Slab thickness x concrete density
   = 0.125m x 24Kn/m^3
   = 3kN/ m^2
2. Beam self-weight
   = Beam size x concrete density
   = (0.15m x 0.6m) x 24kN/m^3
   = 2.16kN/m
3. Dead load from the slab B- C/ 2C-4
   = 3kN/m^2 x (L_x/2)
   = 3kN/m^2 x (2.025/2)
   = 3.0375kN/m
4. Dead load from the slab C- D/ 2C-4A
   = 3kN/m^2 x (L_x/2)
   = 3kN/m^2 x (2.55/2)
   = 3.825kN/m
5. Total dead load
   = 2.16kN/m + 3.0375kN/m + 3.825kN/m
   = 9.02kN/m

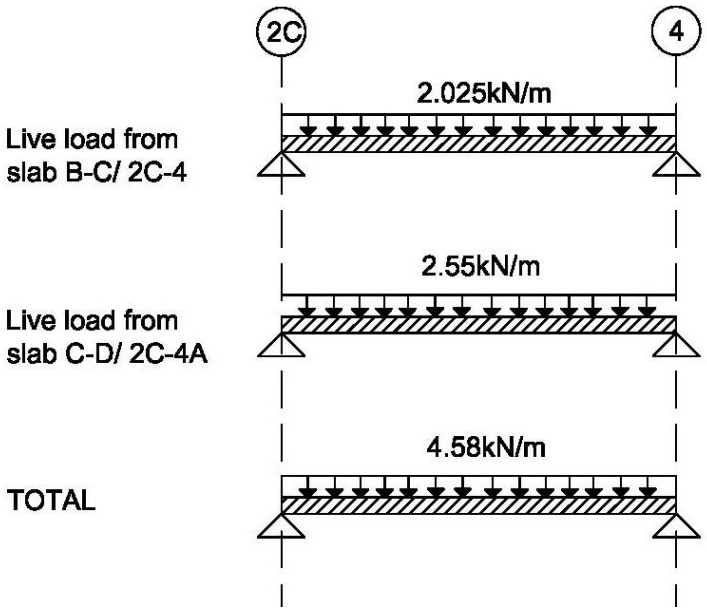
Total Dead Load Diagram



Live loads acting on beam C/ 2C- 4

1. Live load from slab B- C/ 2C-4
   = live load of wardrobe x (L_x/ 2)
   = 2kN/m^2 x (2.025m/ 2)
   = 2.025kN/m
2. Live load from slab C- D/ 2C-4A
   = live load of wardrobe x (L_x/ 2)
   = 2kN/m^2 x (2.55m/ 2)
   = 2.55kN/m
3. Total live load
   = 2.025kN/m + 2.55kN/m
   = 4.58kN/m

Total Live Load Diagram



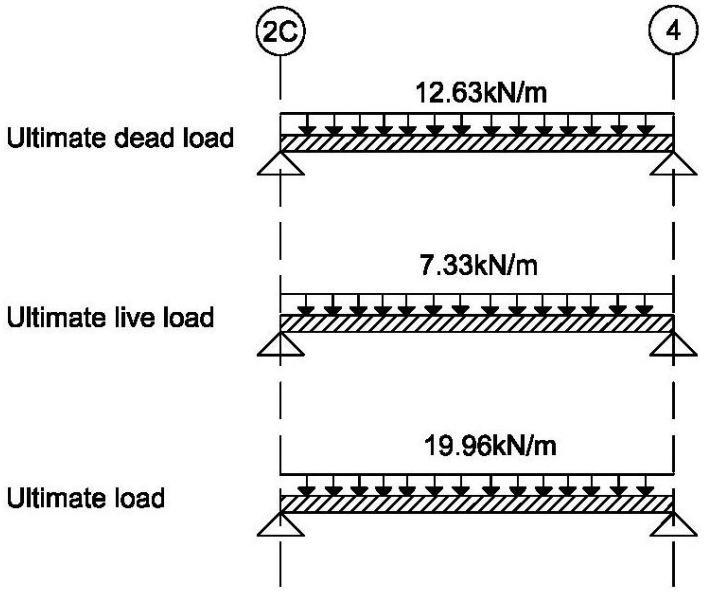
Ultimate Load

Dead load factor= 1.4

Live load factor= 1.6

1. Ultimate dead load
   = 9.02kN/m x 1.4
   = 12.63kN/m
2. Ultimate live load
   = 4.58kN/m x 1.6
   = 7.33kN/m
3. Ultimate load
   = 12.63kN/m + 7.33kN/m
   = 19.96kN/m

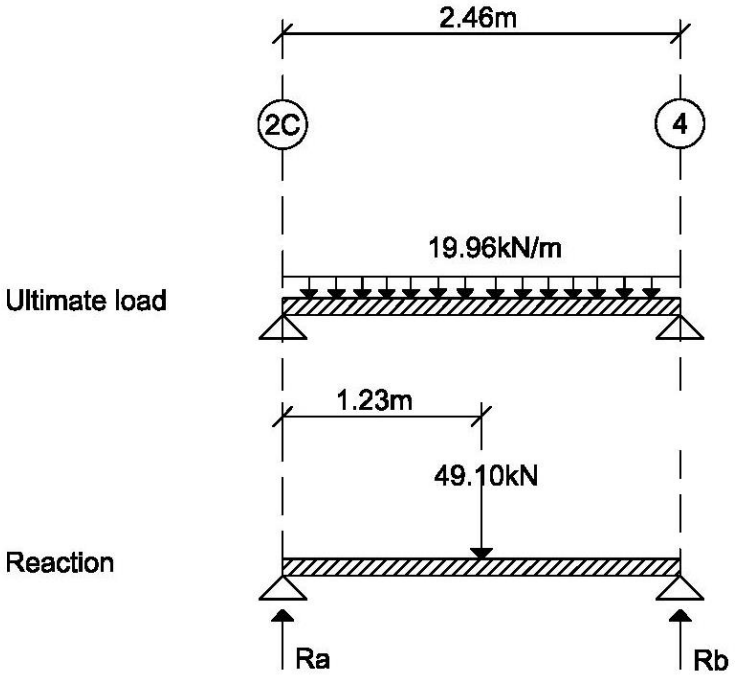
Ultimate Load Diagram



Reaction

The ultimate load (UDL) is converted into point load before resolving the reaction forces of the beam C/ 2C- 4.

Ultimate load
= 19.96kN/m x 2.46m = 49.10kN



Assuming ∑M= 0,
(49.1kN x 1.23m) – (R_b x 2.46m) = 0
60.393kNm – 2.46R_b = 0
-2.46R_b = -60.393kNm
R_b = 60.393kNm/ 2.46m
R_b = 24.55kN

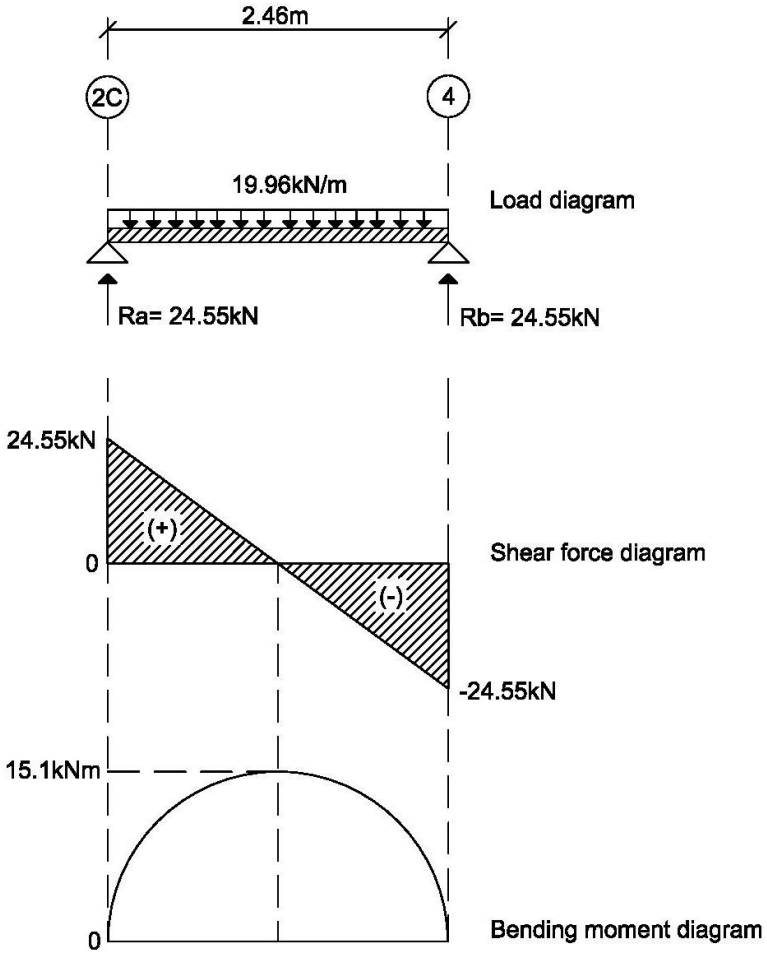
Assuming ∑F= 0,
49.1kN – R_a – R_b = 0
49.1kN – 24.55kN – R_a = 0
R_a = 24.55kN

Shear force diagram

At point 2C, 24.55kN of R_a is acting upwards.

From 2C to 4, there is a UDL of 19.96kN/m acting downwards, therefore
19.96kN/m x 2.46m = 49.1016kN
24.55kN – 49.1016N = -24.55kN

At point 4, another 24.55kN of R_b acting upwards, thus making the beam balance.

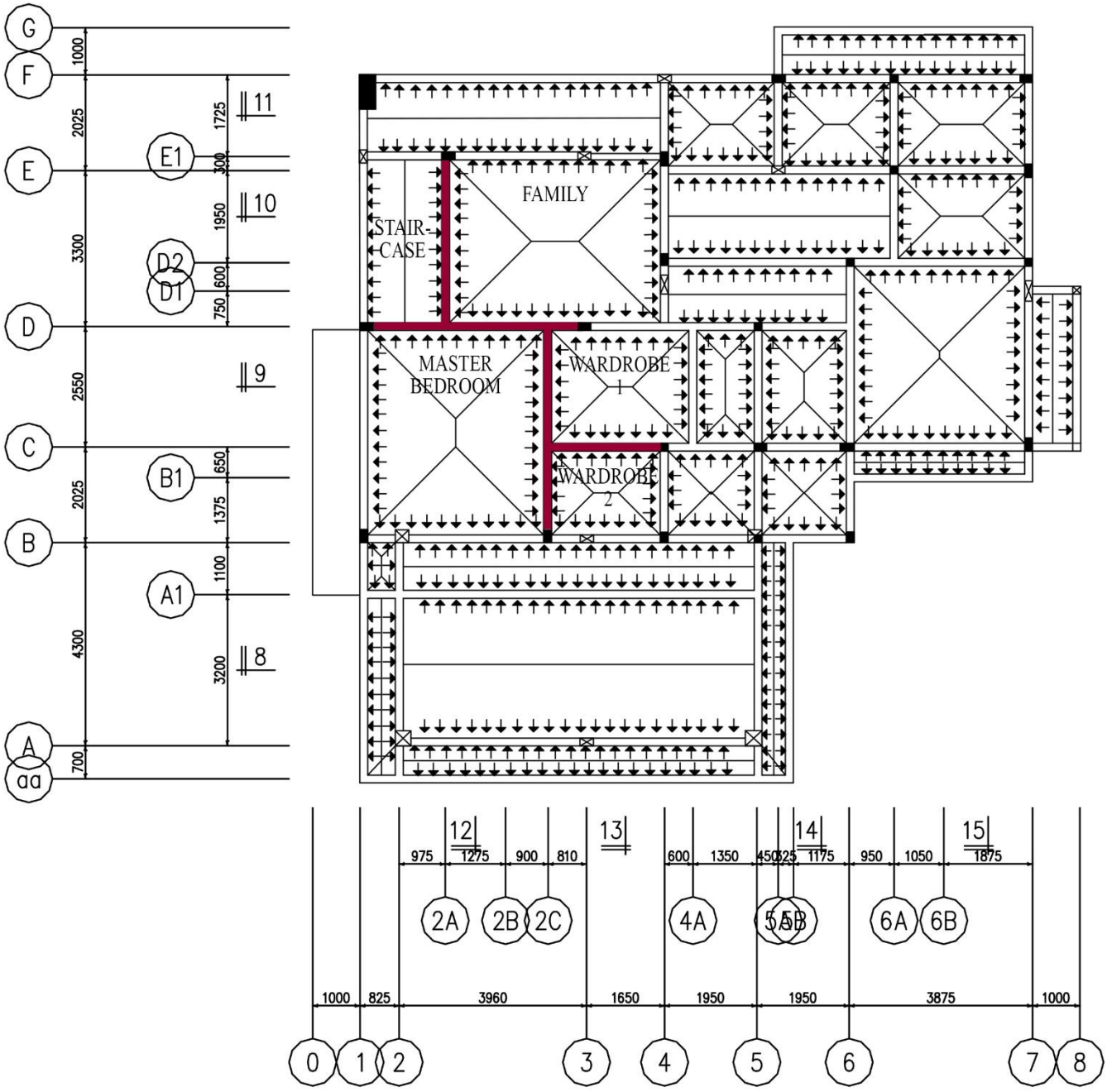


Bending moment diagram

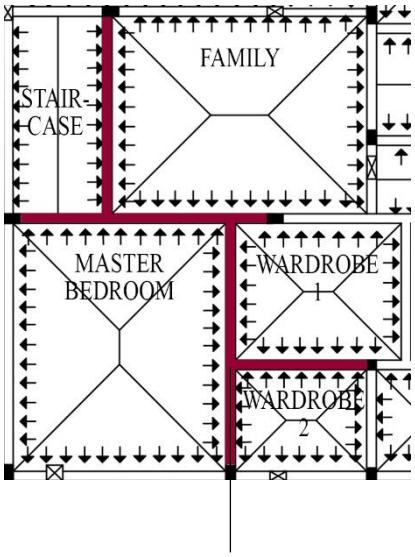
Positive area – negative area in shear force diagram

(+ve)
= (1/2) x 24.55 x (2.46/2)
= (1/2) x 24.55 x 1.23
= 15.1
(-ve)
= (1/2) x (-24.55) x (2.46/2)
= (1/2) x (-24.55) x 1.23
= -15.1

Analysis on beam **2C/ B-D**



LOAD DISTRIBUTION DIAGRA- FIRST FLOOR
(NTS)

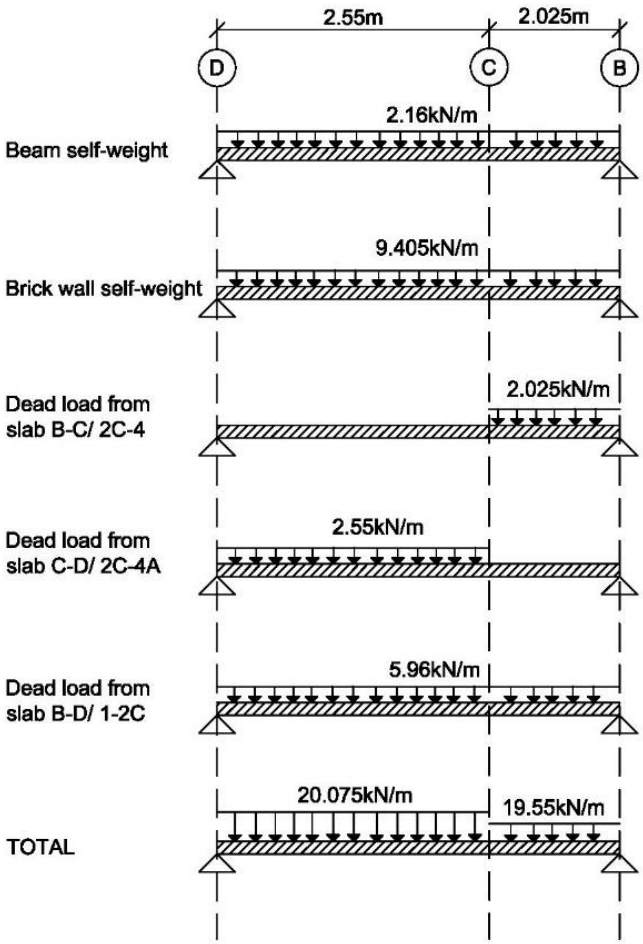


Beam 2C/ B- D (loads from wardrobe 1, wardrobe 2 and master bedroom are acting on it)

<u>Dead loads acting on beam 2C/ B- D</u>

1. Slab self-weight
   = Slab thickness x concrete density
   = 0.125m x 24Kn/m^3
   = 3kN/ m^2
2. Beam self-weight
   = Beam size x concrete density
   = (0.15m x 0.6m) x 24kN/m^3
   = 2.16kN/m
3. Brick wall self-weight
   = Wall height x thickness x density
   = 3.3m x 0.15m x 19kN/m^3
   = 9.405kN/m
4. Dead load from the slab B- C/ 2C-4
   = 3kN/m^2 x (L_x/2) x (2/3)
   = 3kN/m^2 x (2.025/2) x (2/3)
   = 2.025kN/m
5. Dead load from the slab C- D/ 2C-4A
   = 3kN/m^2 x (L_x/2) x (2/3)
   = 3kN/m^2 x (2.55/2) x (2/3)
   = 2.55kN/m
6. Dead load from the slab B- D/ 1-2C
   = 3kN/m^2 x (L_x/2)
   = 3kN/m^2 x (3.975/2)
   = 5.96kN/m

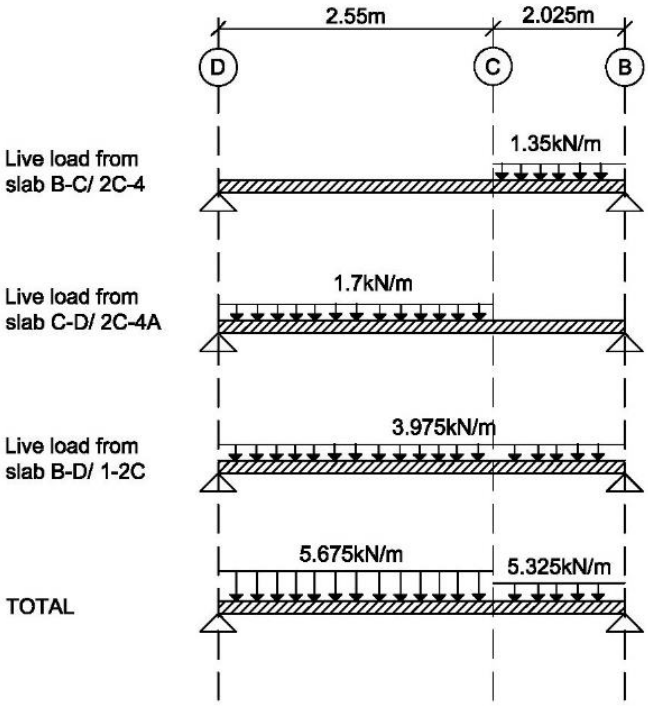
Total Dead Load Diagram



Live loads acting on beam 2C/ B- D

1. Live load from slab B- C/ 2C-4
   = live load of wardrobe 2 x (L_x/ 2) x (2/3)
   = 2kN/m^2 x (2.025m/ 2) x (2/3)
   = 1.35kN/m
2. Live load from slab C- D/ 2C-4A
   = live load of wardrobe 1 x (L_x/ 2) x (2/3)
   = 2kN/m^2 x (2.55m/ 2) x (2/3)
   = 1.7kN/m
3. Live load from slab B- D/ 1-2C
   = live load of master bedroom x (L_x/ 2)
   = 2kN/m^2 x (3.975m/ 2)
   = 3.975kN/m

Total Live Load Diagram



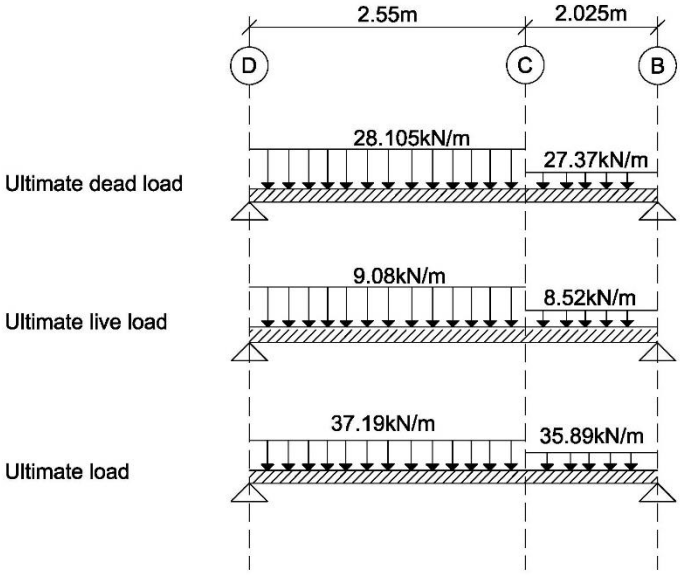
Ultimate Load

Dead load factor= 1.4

Live load factor= 1.6

1. Ultimate dead load at B- C
   = 19.55kN/m x 1.4
   = 27.37kN/m
   Ultimate dead load at C- D
   = 20.075kN/m x 1.4
   = 28.105kN/m
2. Ultimate live load at B- C
   = 5.325kN/m x 1.6
   = 8.52kN/m
   Ultimate live load at C- D
   = 5.675kN/m x 1.6
   = 9.08kN/m
3. Ultimate load at B- C
   = 27.37kN/m + 8.52kN/m
   = 35.89kN/m
   Ultimate load at C- D
   = 28.105kN/m + 9.08kN/m
   = 37.19kN/m

Ultimate Load Diagram

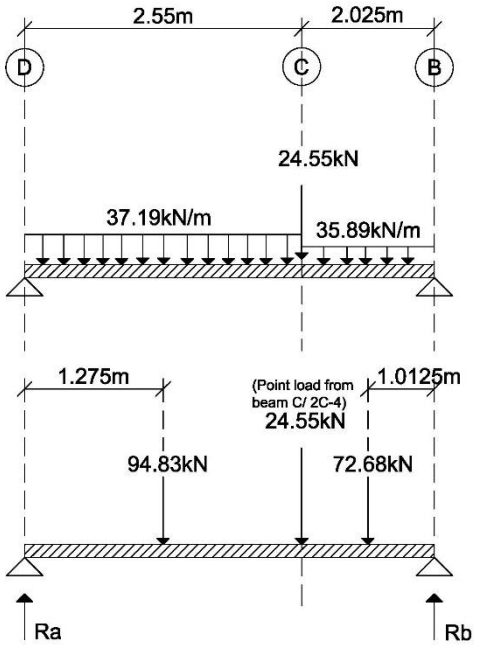


Reaction

The ultimate load (UDL) is converted into point load before resolving the reaction forces of the beam 2C/ B- D.

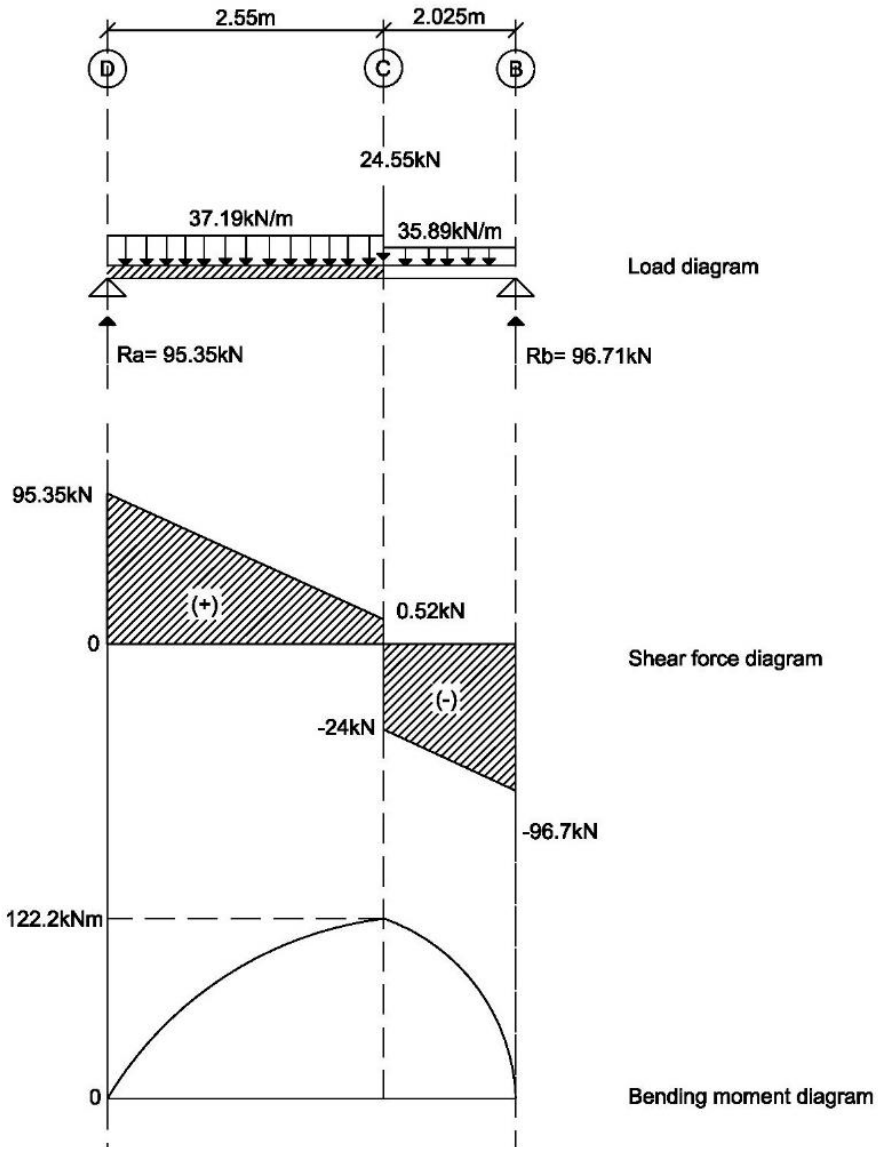
Ultimate load at B- C
= 35.89kN/m x 2.025m = 72.68kN
Ultimate load at C- D
= 37.19kN/m x 2.55m = 94.83kN

Reaction force, R_a of beam C/ 2C-4 acting on this beam is taken as the point load which is 24.55kN.



Assuming ∑M= 0,
(94.83kN x 1.275m) + (24.55kN x 2.55m) + (72.68kN x 3.5625m) – (R_b x 4.575m) = 0
120.91kNm + 65.60kNm + 258.92kNm – 4.575R_b = 0
442.43kNm – 4.575R_b = 0
-4.575R_b = -442.43kNm
R_b = 442.43kNm/ 4.575m
R_b = 96.71kN

Assuming ∑F= 0,
94.83kN + 24.55kN + 72.68kN – R_a – R_b = 0
192.06kN – 96.71kN – R_a = 0
R_a = 95.35kN



Shear force diagram

At point D, 95.35kN of R_a is acting upwards.

From D to C, there is a UDL of 37.19kN/m acting downwards, therefore
37.19kN/m x 2.55m = 94.8345kN
95.35kN – 94.8345kN = 0.52kN

At point C, there is a point load of 24.55kN (R_a of beam C/ 2C-4) acting downwards, therefore
0.52kN – 24.55kN = -24kN

From C to B, there is a UDL of 35.89kN/m acting downwards, therefore
35.89kN/m x 2.025m = 76.677kN
-24kN – 76.677kN = -96.68kN ≈ -96.7kN
Which is then resolved by R_b of 96.71kN that is acting upwards.

Bending moment diagram

Positive area – negative area in shear force diagram

(+ve)

= (1/2) x (95.35 + 0.52) x 2.55

= (1/2) x 95.87 x 2.55

= 122.23 ≈ 122.2

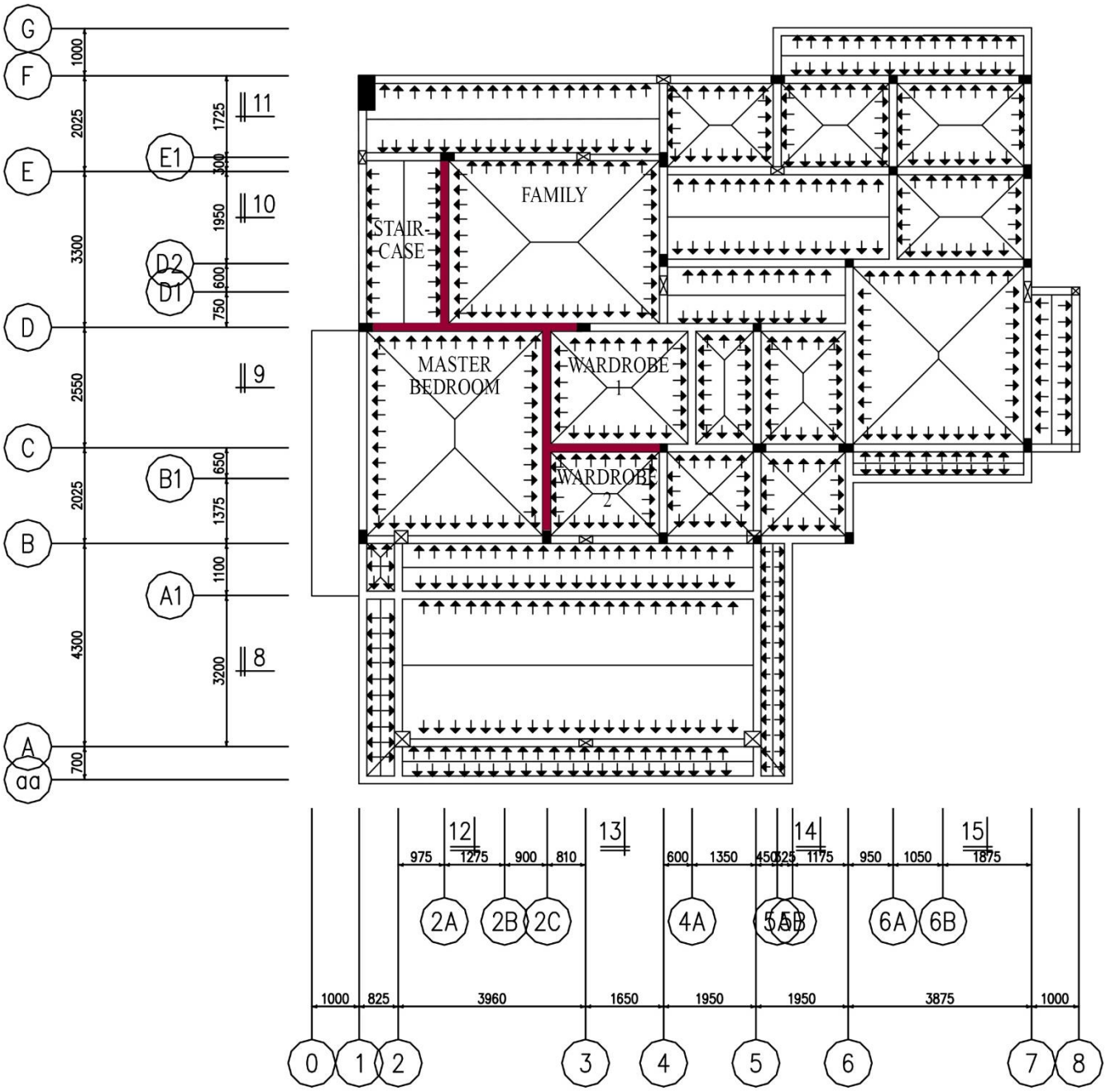
(-ve)

= (1/2) x [(-24) + (-96.7)] x 2.025

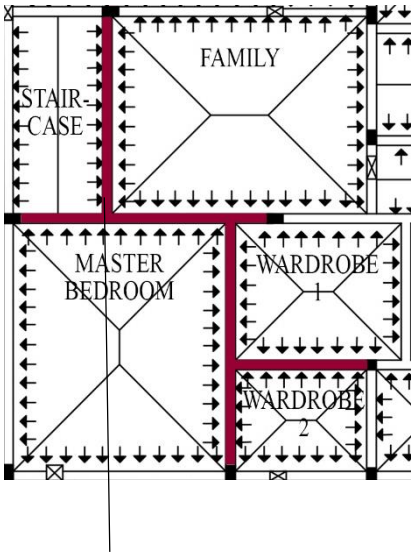
= (1/2) x 120.7 x 2.025

= 122.21 ≈ -122.2

Analysis on beam **2A/ D-E1**



LOAD DISTRIBUTION DIAGRA- FIRST FLOOR
(NTS)

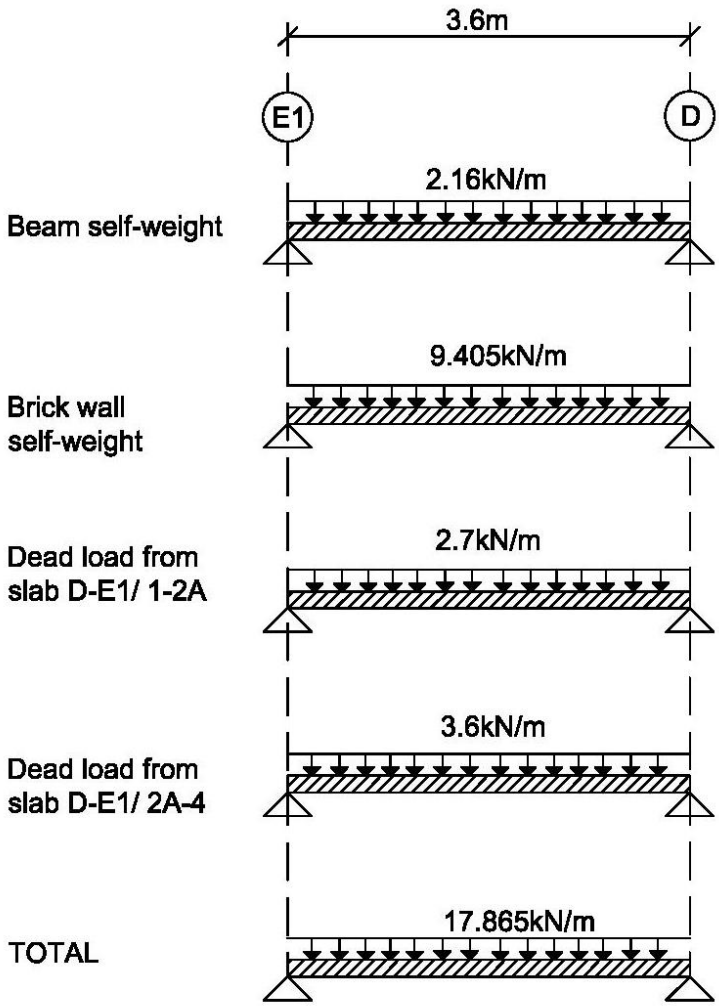


Beam 2A/ D- E1 (loads from staircase and family room are acting on it).

<u>Dead loads acting on beam 2A/ D- E1</u>

1. Slab self-weight
   = Slab thickness x concrete density
   = 0.125m x 24Kn/m^3
   = 3kN/ m^2
2. Beam self-weight
   = Beam size x concrete density
   = (0.15m x 0.6m) x 24kN/m^3
   = 2.16kN/m
3. Brick wall self-weight
   = Wall height x thickness x density
   = 3.3m x 0.15m x 19kN/m^3
   = 9.405kN/m
4. Dead load from the slab D- E1/ 1-2A
   = 3kN/m^2 x (L_x/2)
   = 3kN/m^2 x (1.8/2)
   = 2.7kN/m
5. Dead load from the slab D- E1/ 2A-4
   = 3kN/m^2 x (L_x/2) x (2/3)
   = 3kN/m^2 x (3.6/2) x (2/3)
   = 3.6kN/m
6. Total dead load
   = 2.16kN/m + 9.405kN/m + 2.7kN/m
   +3.6kN/m
   = 17.865kN/m

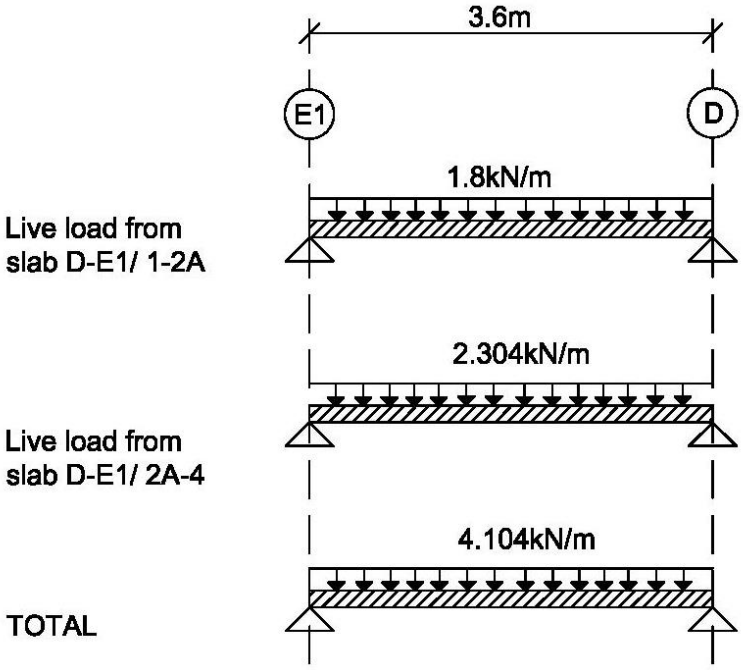
Total Dead Load Diagram



Live loads acting on beam 2A/ D- E1

1. Live load from slab D- E1/ 1-2A
   = live load of staircase x (L_x/ 2)
   = 2kN/m^2 x (1.8m/ 2)
   = 1.8kN/m
2. Live load from slab D- E1/ 2A-4
   = live load of family room x (L_x/ 2) x (2/3)
   = 1.92kN/m^2 x (3.6m/ 2) x (2/3)
   = 2.304kN/m
3. Total live load
   = 1.8kN/m + 2.304kN/m
   = 4.104kN/m

Total Live Load Diagram



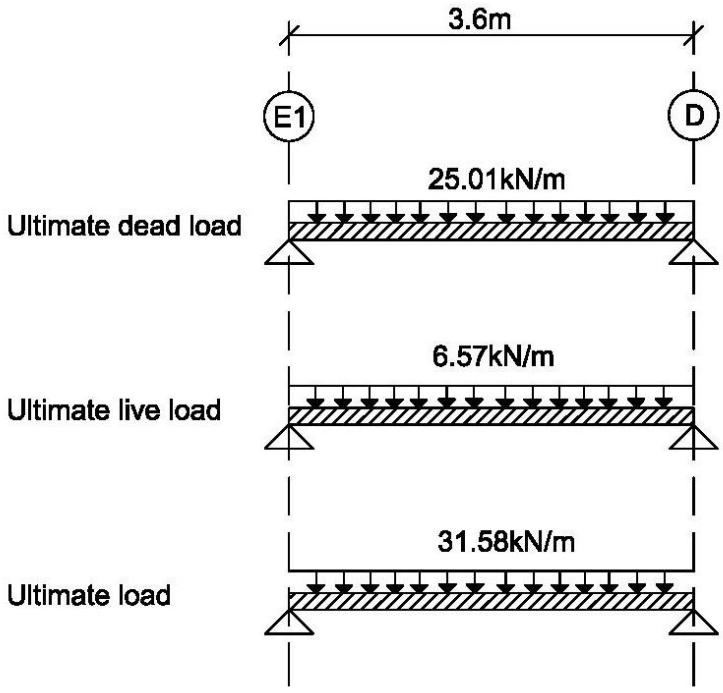
Ultimate Load

Dead load factor= 1.4

Live load factor= 1.6

4. Ultimate dead load
   = 17.865kN/m x 1.4
   = 25.01kN/m
5. Ultimate live load
   = 4.104kN/m x 1.6
   = 6.57kN/m
6. Ultimate load
   = 25.01kN/m + 6.57kN/m
   = 31.58kN/m

Ultimate Load Diagram



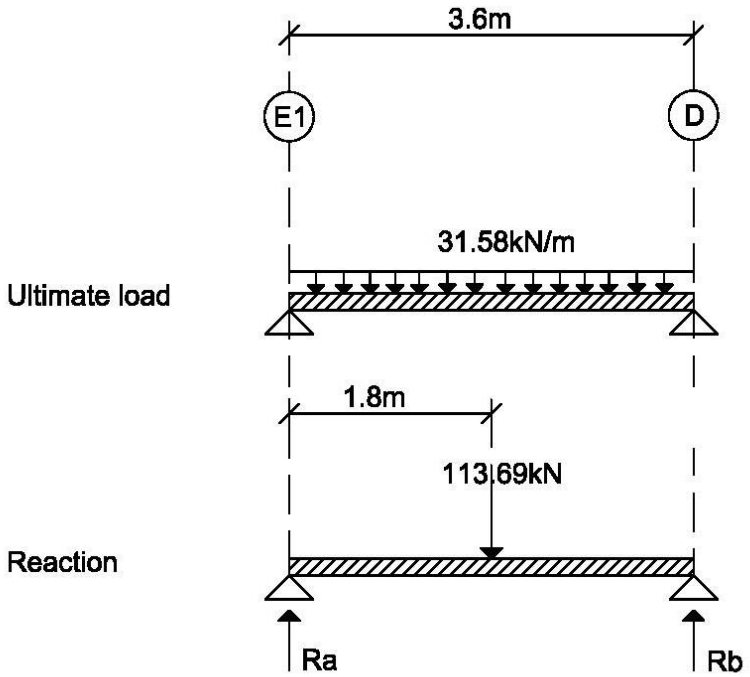
Reaction

The ultimate load (UDL) is converted into point load before resolving the reaction forces of the beam 2A/ D- E1.

Ultimate load
= 31.58kN/m x 3.6m = 113.69kN

Assuming ∑M= 0,
(113.69kN x 1.8m) – (R_b x 3.6m) = 0
204.64kNm – 3.6R_b = 0
-3.6R_b = -204.64kNm
R_b = 204.64kNm/ 3.6m
R_b = 56.85kN

Assuming ∑F= 0,
113.69kN – R_a – R_b = 0
113.69kN – 56.85kN – R_a = 0
R_a = 56.84kN

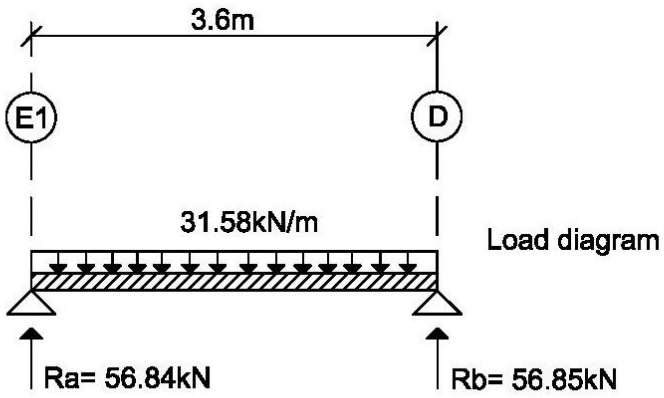


Shear force diagram

At point E1, 56.84kN of R_a is acting upwards.

From E1 to D, there is a UDL of 31.58kN/m acting downwards, therefore
31.58kN/m x 3.6m = 113.688kN
56.84kN – 113.688N = -56.848kN

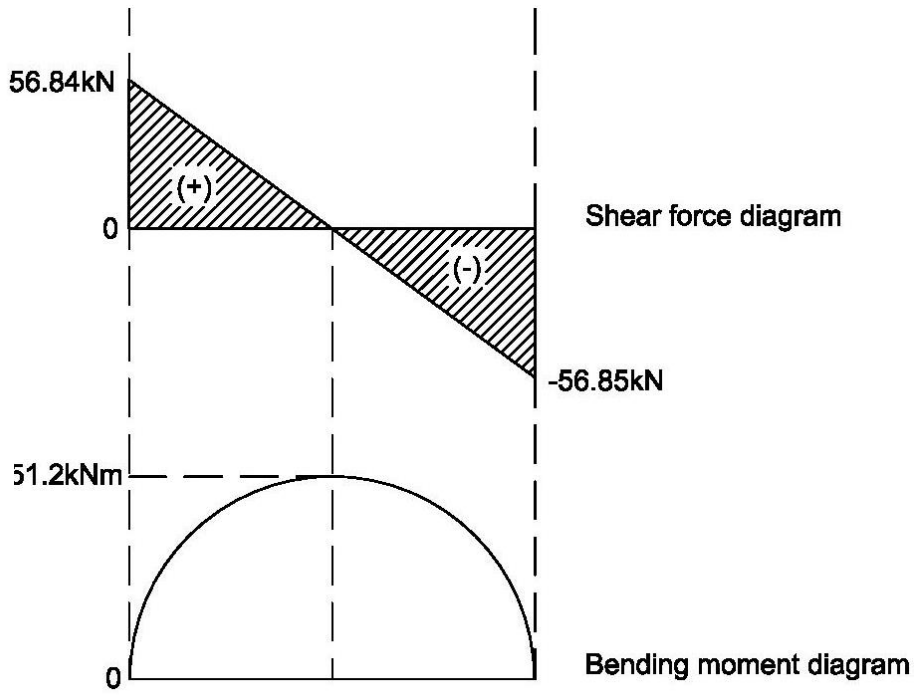
At point D, another 56.85kN of R_b acting upwards,
thus making the beam balance.



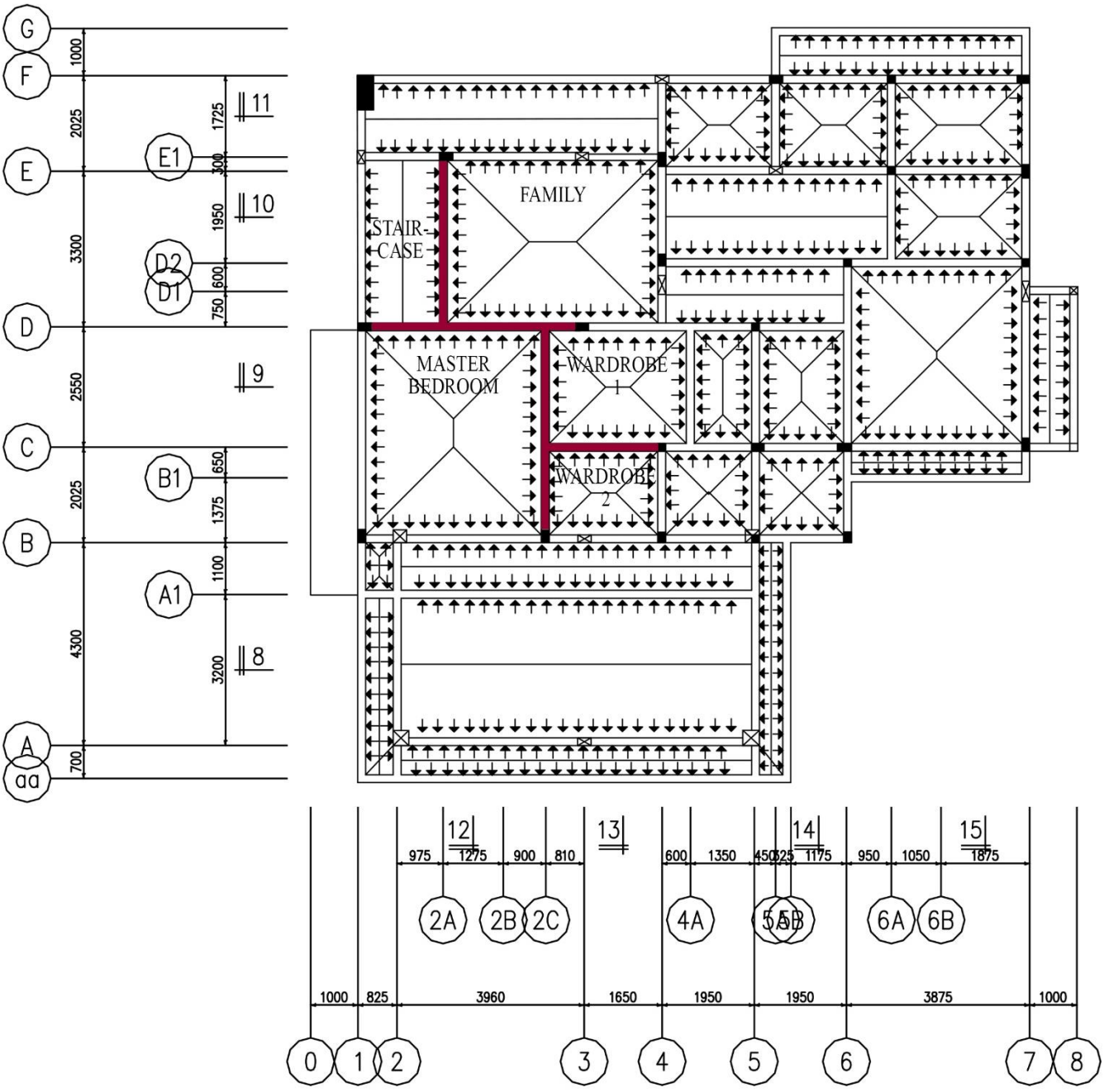
Bending moment diagram

Positive area – negative area in shear force diagram

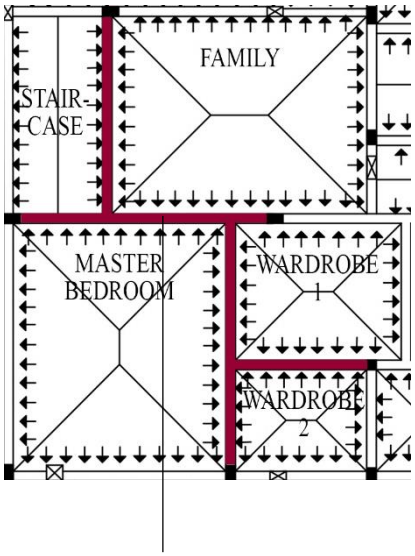
(+ve)
= (1/2) x 56.84 x (3.6/2)
= (1/2) x 56.84 x 1.8
= 51.156 ≈ 51.2
(-ve)
= (1/2) x (-56.85) x (3.6/2)
= (1/2) x (-56.85) x 1.8
= -51.165 ≈ -51.2



Analysis on beam **D/ 1-3**



LOAD DISTRIBUTION DIAGRA- FIRST FLOOR
(NTS)

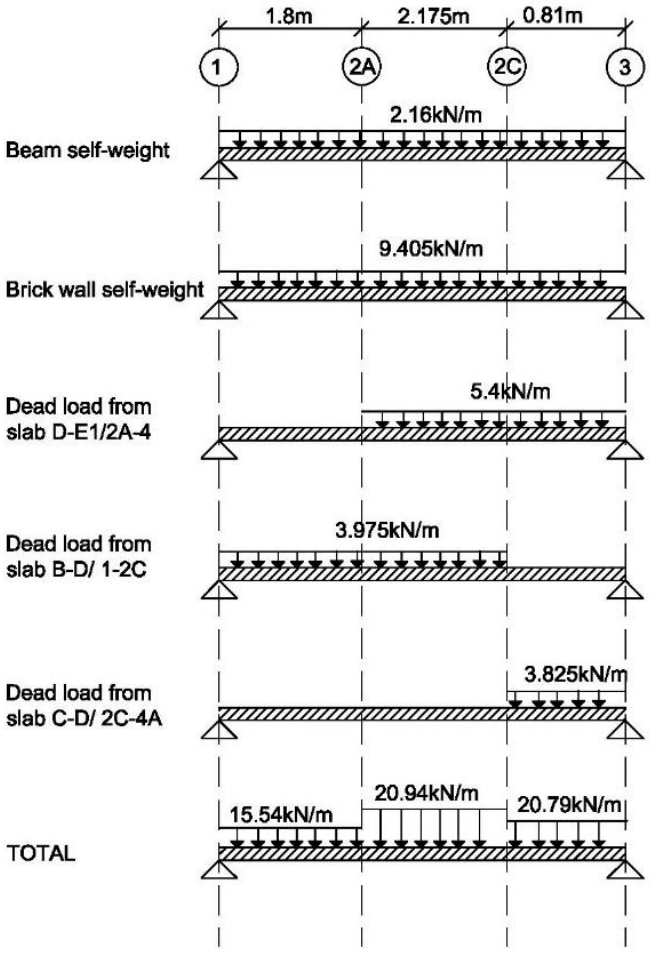


Beam D/ 1-3 (loads from wardrobe 1, family room and master bedroom are acting on it)

<u>Dead loads acting on beam D/ 1-3</u>

1. Slab self-weight
   = Slab thickness x concrete density
   = 0.125m x 24Kn/m^3
   = 3kN/ m^2
2. Beam self-weight
   = Beam size x concrete density
   = (0.15m x 0.6m) x 24kN/m^3
   = 2.16kN/m
3. Brick wall self-weight
   = Wall height x thickness x density
   = 3.3m x 0.15m x 19kN/m^3
   = 9.405kN/m
4. Dead load from the slab D- E1/ 2A-4
   = 3kN/m^2 x (L_x/2)
   = 3kN/m^2 x (3.6/2)
   = 5.4kN/m
5. Dead load from the slab B- D/ 1-2C
   = 3kN/m^2 x (L_x/2) x (2/3)
   = 3kN/m^2 x (3.975/2) x (2/3)
   = 3.975kN/m
6. Dead load from the slab C- D/ 2C-4A
   = 3kN/m^2 x (L_x/2)
   = 3kN/m^2 x (2.55/2)
   = 3.825kN/m

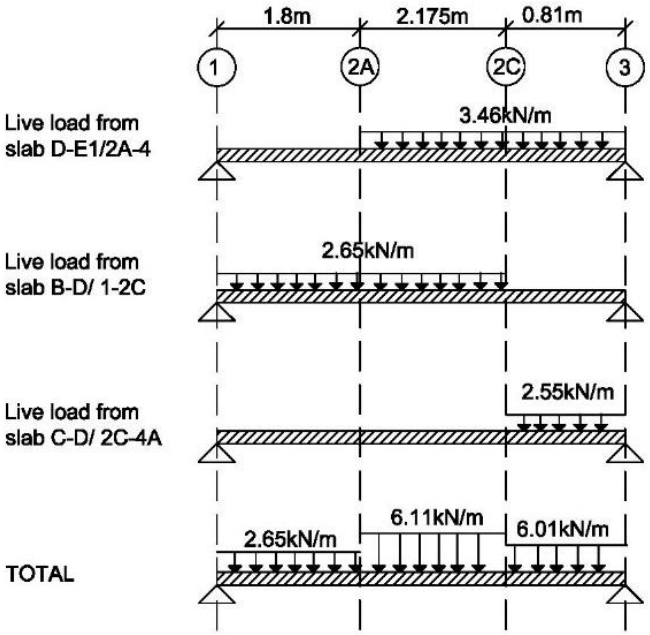
Total Dead Load Diagram



Live loads acting on beam D/ 1-3

1. Live load from slab D- E1/ 2A-4
   = live load of family room x (L_x/ 2)
   = 1.92kN/m^2 x (3.6m/ 2)
   = 3.46kN/m
2. Live load from slab B- D/ 1-2C
   = live load of master bedroom x (L_x/ 2) x (2/3)
   = 2kN/m^2 x (3.975m/ 2) x (2/3)
   = 2.65kN/m
3. Live load from slab C- D/ 2C-4A
   = live load of wardrobe 1 x (L_x/ 2)
   = 2kN/m^2 x (2.55m/ 2)
   = 2.55kN/m

Total Live Load Diagram



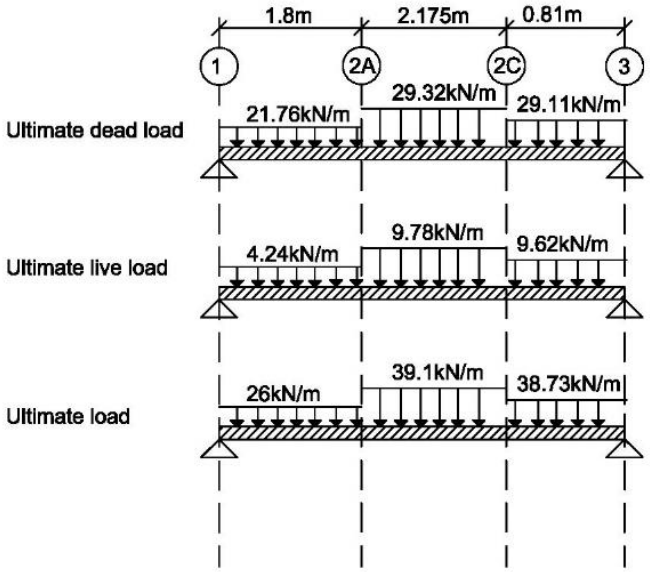
Ultimate Load

Dead load factor= 1.4

Live load factor= 1.6

1. Ultimate dead load at 1- 2A
   = 15.54kN/m x 1.4
   = 21.76kN/m
   Ultimate dead load at 2A- 2C
   = 20.94kN/m x 1.4
   = 29.32kN/m
   Ultimate dead load at 2C- 3
   = 20.79kN/m x 1.4
   = 29.11kN/m
2. Ultimate live load at 1- 2A
   = 2.65kN/m x 1.6
   = 4.24kN/m
   Ultimate live load at 2A- 2C
   = 6.11kN/m x 1.6
   = 9.78kN/m
   Ultimate live load at 2C- 3
   = 6.01kN/m x 1.6
   = 9.62kN/m
3. Ultimate load at 1- 2A
   = 21.76kN/m + 4.24kN/m
   = 26kN/m
   Ultimate load at 2A- 2C
   = 29.32kN/m + 9.78kN/m
   = 39.1kN/m
   Ultimate load at 2C- 3
   = 29.11kN/m + 9.62kN/m
   = 38.73kN/m

Ultimate Load Diagram

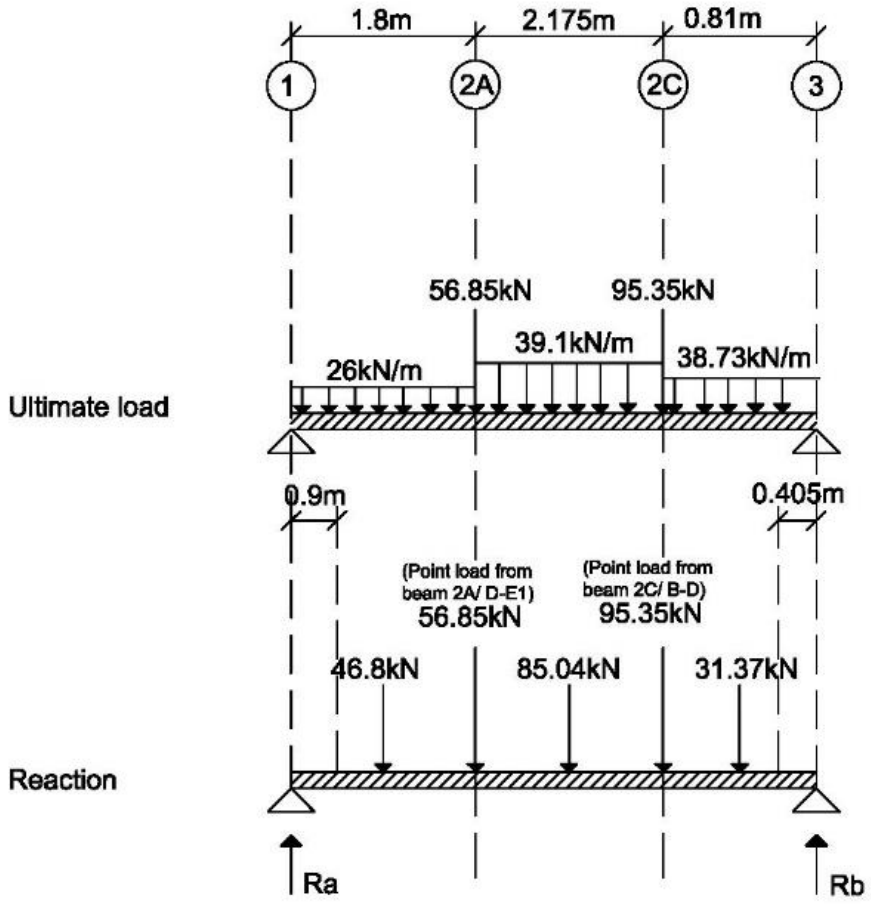


Reaction

The ultimate load (UDL) is converted into point load before resolving the reaction forces of the beam D/1-3.

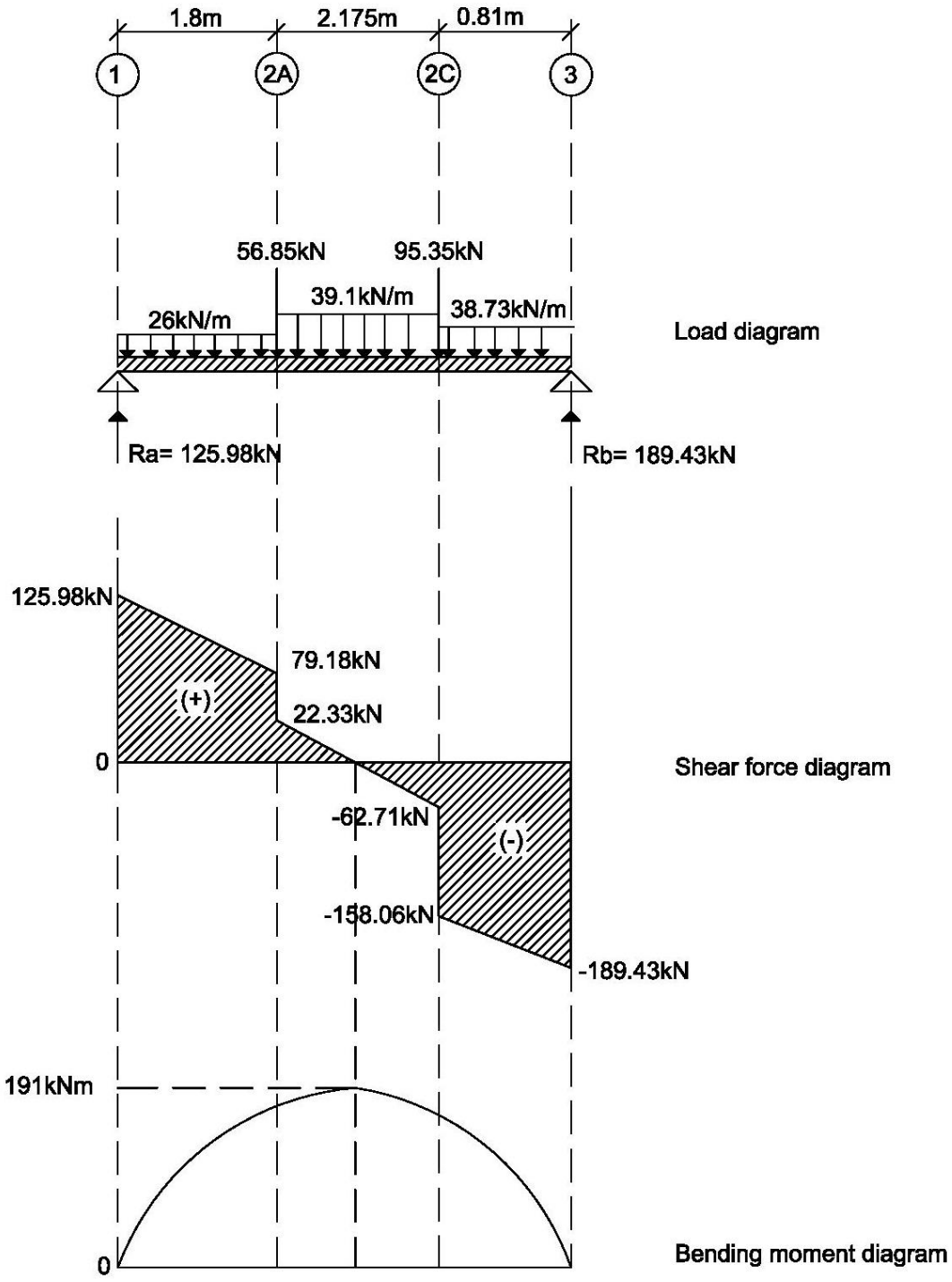
Ultimate load at 1- 2A
= 26kN/m x 1.8m = 46.8kN
Ultimate load at 2A- 2C
= 39.1kN/m x 2.175m = 85.04kN
Ultimate load at 2C- 3
= 38.73kN/m x 0.81m = 31.37kN

Reaction force, R_b of beam 2A/D- E1 acting on this beam is taken as the point load which is 56.85kN, and also reaction force, R_a of beam 2C/B- D which is 95.35kN.



Assuming ∑M= 0,
(46.8kN x 0.9m) + (56.85kN x 1.8m) + (85.04kN x 2.8875m) + (95.35kN x 3.975m) + (31.37kN x 4.38m) – (R_b x 4.785m) = 0
42.12kNm + 102.33kNm + 245.553kNm + 379.02kNm + 137.40kNm– 4.785R_b = 0
906.423kNm – 4.785R_b = 0
-4.785R_b = -906.423kNm
R_b = 906.423kNm/ 4.785m
R_b = 189.43kN

Assuming ∑F= 0,
46.8kN + 56.85kN + 85.04kN + 95.35kN + 31.37kN – R_a – R_b = 0
315.41kN – 189.43kN – R_a = 0
R_a = 125.98kN



Shear force diagram

At point 1, 125.98kN of R_a is acting upwards.

From 1 to 2A, there is a UDL of 26kN/m acting downwards, therefore

26kN/m x 1.8m = 46.8kN

125.98kN – 46.8kN = 79.18kN

At point 2A, there is a point load of 56.85kN (R_b of beam 2A/D-E1) acting downwards, therefore

79.18kN – 56.85kN = 22.33kN

From 2A to 2C, there is a UDL of 39.1kN/m acting downwards, therefore

39.1kN/m x 2.175m = 85.0425kN

22.33kN – 85.0425kN = -62.7125kN

At point 2C, there is another point load of 95.35kN (R_a of beam 2C/ B- D) acting downwards, therefore,

-62.71kN – 95.35kN = -158.0625

From 2C to 3, there is a UDL of 38.73kN/m acting downwards, therefore

38.73kN/m x 0.81m = 31.3713

-158.0625 – 31.3713 = -189.43

Which is then resolved by R_b of 189.43kN that is acting upwards.

Bending moment diagram

Positive area – negative area in shear force diagram

(+ve)

= [(1/2) x (125.98 + 79.18) x 1.8] + [(1/2) x 0.57 x 22.33]

= 184.644 + 6.36

= 191.04 ≈ 191

(-ve)

= [(1/2) x (-62.71) x (2.175 – 0.57)] + [(1/2) x (158.06 + 189.43) x 0.81]

= 50.32 + 140.73

= 191.05 ≈ 191