I. PERHITUNGAN BALOK

A. BALOK ATAP

1. Perhitungan q Ekuivalen Pada Balok Atap

Wu atap = 5,2 kN/m^2

a. Tinjau Plat Tipe I

- Balok AS A (3 – 4)

$$\text{qe trapezium} = \frac{0{,}5*\left(\frac{Ly}{Lx}-0{,}5\right)*Wu*lx^2}{Ly}$$

$$= \frac{0{,}5*\left(\frac{4}{3}-0{,}5\right)*5{,}2*3^2}{4}$$

$$= 4{,}88 \text{ kN/m}$$

- Balok AS 4 (A- B)

qe segitiga = 0,25 * Wu * lx

= 0,25 * 5,2 * 3 = 3,9 kN/m

b. Plat Tipe II

- Balok AS B (3 – 4)

$$\text{qe trapezium plat II} = \frac{0{,}5*\left(\frac{Ly}{Lx}-0{,}5\right)*Wu*Lx^2}{Ly}$$

$$= \frac{0{,}5*\left(\frac{4}{2}-0{,}5\right)*5{,}2*2^2}{4} = 3{,}9 \text{ kN/m}$$

$$\text{qe trapezium plat I} = \frac{0{,}5*\left(\frac{Ly}{Lx}-0{,}5\right)*Wu*Lx^2}{Ly}$$

$$= \frac{0{,}5*\left(\frac{4}{3}-0{,}5\right)*5{,}2*3^2}{4} = 4{,}88 \text{ kN/m}$$

qe total Balok AS B (3 – 4) = qe trapezium plat II + qe trapezium plat I

= 3,9 + 4,88

= 8,78 kN/m

c. Plat Tipe III

- Balok AS 3 (B – C)

  qe segitiga Plat III = 0,25 * Wu * Lx

  = 0,25 * 5,2 * 2 = 2,6 kN/m

  qe segitiga Plat II = 0,25 * Wu * Lx

  = 0,25 * 5,2 * 2 = 2,6 kN/m

  qe total Balok AS 3 (B – C) = qe segitiga Plat III + qe segitiga Plat II

  = 2,6 + 2,6 = 5,2 kN/m

d. Plat Tipe IV

- Balok AS 3 (C – E)

  qe trapezium plat IV $= \frac{0{,}5 * \left(\frac{Ly}{Lx} - 0{,}5\right) * Wu * Lx^2}{Ly}$

  $= \frac{0{,}5 * \left(\frac{3}{2} - 0{,}5\right) * 5{,}2 * 2^2}{3}$ = 3,47 kN/m

  qe segitiga Plat I = 0,25 * Wu * Lx

  = 0,25 * 5,2 * 3 = 3,9 kN/m

  qe total Balok AS 3 (C – E) = qe trapezium plat IV + qe segitiga Plat I

  = 3,47 + 3,9 = 7,37 kN/m

Tabel Hasil Perhitungan q Ekuivalen Balok Atap

Perhitungan q Ekuivalen Plat Atap							
plat	Balok AS	ly (m)	lx (m)	WU (kN/m^2)	qe trapezium (kN/m)	qe segitiga (kN/m)	qe total (kN/m)
I	A 3 – 4	4.00	3.00	5.20	4.88		4.88
I	4 A – B	4.00	3.00	5.20		3.9	3.9
I	3 A – B	4.00	3.00	5.20		3.9	3.9

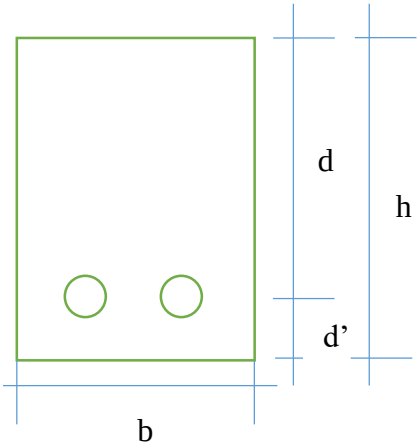
I	B 3 – 4	4.00	3.00	5.20	4.88		8.78
II	B 3 – 4	4.00	2.00	5.20	3.90		
II	4 B – C	4.00	2.00	5.20		2.6	2.6
II	3 B – C	4.00	2.00	5.20		2.6	5.2
III	3 B – C	2.00	2.00	5.20		2.6	
II	C 3 – 4	4.00	2.00	5.20	3.90		8.78
I	C 3 – 4	4.00	3.00	5.20	4.88		
I	4 C – E	4.00	3.00	5.20		3.9	3.9
I	E 3 – 4	4.00	3.00	5.20	4.88		4.88
IV	3 C – E	3.00	2.00	5.20	3.47		7.37
I	3 C – E	4.00	3.00	5.20		3.9	
II	2 B – C	4.00	2.00	5.20		2.6	5.2
III	2 B – C	2.00	2.00	5.20		2.6	
III	C 2 – 3	2.00	2.00	5.20		2.6	5.2
IV	C 2 – 3	3.00	2.00	5.20		2.6	
III	B 2 – 3	2.00	2.00	5.20		2.6	2.6
IV	E 2 – 3	3.00	2.00	5.20		2.6	2.6
IV	2 C – E	3.00	2.00	5.20	3.47		7.37
I	2 C – E	4.00	3.00	5.20		3.9	
I	E 1 – 2	4.00	3.00	5.20	4.88		4.88
I	1 C – E	4.00	3.00	5.20		3.9	3.9
I	C 1 – 2	4.00	3.00	5.20	4.88		8.78
II	C 1 – 2	4.00	2.00	5.20	3.90		
II	1 B – C	4.00	2.00	5.20		2.6	2.6

II	B 1 – 2	4.00	2.00	5.20	3.90		3.90

2. Perencanaan Penulangan Balok Atap

a. Tinjau Balok AS 4 (A – B)

- L = 3 m
- Tinggi balok (h) = (1/10 sd1/12)*L
  = 1/12 * 3 = 0,25 m
- Tebal balok (b) > 0,5* h
  = 0,5 * 0,25 = 0,125 m ≈ 0,15 m
- d’ = 0,05 m
- d = h – d’
  = 0,25 – 0,05 = 0,20 m



- q Berat Sendiri Balok = 1,2 * b * h * Bj.beton
  = 1,2 * 0,15 * 0,25 * 24 kN/m^3
  = 1,08 kN/m
-
- q total = q E total + q berat sendiri balok
  = 3,9 + 1,08 = 4,98 kN/m
- Mu = $\frac{1}{12} * q\ total * L^2$
  = $\frac{1}{12} * 4{,}98 * 3^2$ = 3,74 kN m
- Mn = Mu / Φ
  = 3,74 / 0,8 = 4,67 kN m
- Rn = $\frac{Mn}{b*d^2}$
  = $\frac{4{,}67 \text{ x } 10^6 \text{N mm}}{150*200^2}$ = 0,78 N/mm^2
- m = $\frac{fy'}{0{,}85\ x\ fc'}$ = $\frac{240}{0{,}85\ x\ 30}$
  = 9,41
- ρ perlu = $\frac{1}{m}\ (1 - \sqrt{1 - \frac{2*m*Rn}{fy}})$

$$= \frac{1}{9{,}41}\left(1 - \sqrt{1 - \frac{2*9{,}41*0{,}78}{240}}\right) \quad = 0{,}0033$$

- ρ min = 1,4 / fy'

  = 1,4 / 240 = 0,0058

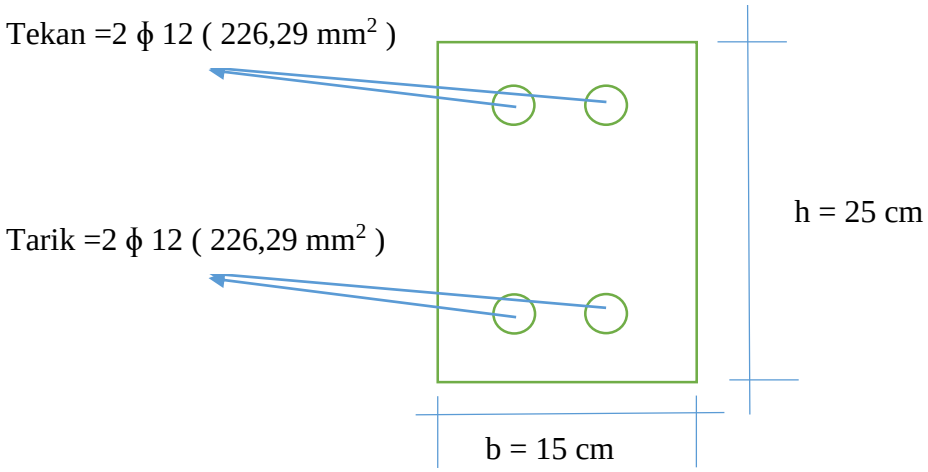
- ρ max = $0{,}75 * \frac{(0{,}85 * fc' * \beta 1)}{fy'} * \left(\frac{600}{600+fy'}\right)$

  = $0{,}75 * \frac{(0{,}85 * 30 * 0{,}85)}{240} * \left(\frac{600}{600+240}\right)$ = 0,0484

- Syarat (ρ min < ρ perlu < ρ max) karena ρ perlu kurang dari ρ min maka, ρ yang digunakan adalah ρ min yaitu = 0,0058 untuk menghitung luas tulangan balok atap
- As = ρ min * b * d

  = 0,0058 * 150 * 200 = 174 mm^2
- As' = 0,5 * As

  = 0,5 * 175 = 87,5 mm^2
- Tulangan Tarik = 2 ϕ 12 (226,29 mm^2)
- Tulangan Tekan = 2 ϕ 12 (226,29 mm^2)



Tabel Hasil Perhitungan Penulangan Balok Atap

PERHITUNGAN PENULANGAN BALOK ATAP																				
No.	balok AS	l (m)	h = 1/12*l (m)	h dipakai (m)	b > 0.5*h (m)	b dipakai (m)	d = h - d' (d'=0.05 m)	q Bs. (kN/m)	qe total (kN/m)	q total (kN/m)	Mu (kN m)	Mn (kN m)	Rn (N / mm2)	ρ perlu	ρ dipakai	As	As'	tulangan tarik	tulangan tekan	As tulangan	S tarik> 25 (mm)
1	A 3 – 4	4.00	0.33	0.30	0.15	0.20	0.25	1.73	4.88	6.60	8.80	11.01	0.88	0.0037	0.0058	291.67	145.83	3 ϕ 12	2 ϕ 12	339.43	54.00
2	4 A – B	3.00	0.25	0.25	0.13	0.15	0.20	1.08	3.90	4.98	3.74	4.67	0.78	0.0033	0.0058	175.00	87.50	2 ϕ 12	2 ϕ 12	226.29	70.00
3	3 A – B	3.00	0.25	0.25	0.13	0.15	0.20	1.08	3.90	4.98	3.74	4.67	0.78	0.0033	0.0058	175.00	87.50	2 ϕ 12	2 ϕ 12	226.29	70.00
4	B 3 – 4	4.00	0.33	0.30	0.15	0.20	0.25	1.73	8.78	10.50	14.00	17.51	1.40	0.0060	0.0060	300.23	150.12	3 ϕ 12	2 ϕ 12	339.43	54.00
5	4 B – C	2.00	0.17	0.20	0.10	0.15	0.15	0.86	2.60	3.46	1.15	1.44	0.43	0.0018	0.0058	131.25	65.63	2 ϕ 10	2 ϕ 10	157.14	74.00
6	3 B – C	2.00	0.17	0.20	0.10	0.15	0.15	0.86	5.20	6.06	2.02	2.53	0.75	0.0032	0.0058	131.25	65.63	2 ϕ 10	2 ϕ 10	157.14	74.00
7	C 3 – 4	4.00	0.33	0.30	0.15	0.20	0.25	1.73	8.78	10.50	14.00	17.51	1.40	0.0060	0.0060	300.23	150.12	3 ϕ 12	2 ϕ 12	339.43	54.00
8	4 C – E	3.00	0.25	0.25	0.13	0.15	0.20	1.08	3.90	4.98	3.74	4.67	0.78	0.0033	0.0058	175.00	87.50	2 ϕ 12	2 ϕ 12	226.29	70.00
9	E 3 – 4	4.00	0.33	0.30	0.15	0.20	0.25	1.73	4.88	6.60	8.80	11.01	0.88	0.0037	0.0058	291.67	145.83	3 ϕ 12	2 ϕ 12	339.43	54.00
10	3 C – E	3.00	0.25	0.25	0.13	0.15	0.20	1.08	7.37	8.45	6.34	7.92	1.32	0.0056	0.0058	175.00	87.50	2 ϕ 12	2 ϕ 12	226.29	70.00
11	2 B – C	2.00	0.17	0.20	0.10	0.15	0.15	0.86	5.20	6.06	2.02	2.53	0.75	0.0032	0.0058	131.25	65.63	2 ϕ 10	2 ϕ 10	157.14	74.00
12	C 2 – 3	2.00	0.17	0.20	0.10	0.15	0.15	0.86	5.20	6.06	2.02	2.53	0.75	0.0032	0.0058	131.25	65.63	2 ϕ 10	2 ϕ 10	157.14	74.00
13	B 2 – 3	2.00	0.17	0.20	0.10	0.15	0.15	0.86	2.60	3.46	1.15	1.44	0.43	0.0018	0.0058	131.25	65.63	2 ϕ 10	2 ϕ 10	157.14	74.00
14	E 2 – 3	2.00	0.17	0.20	0.10	0.15	0.15	0.86	2.60	3.46	1.15	1.44	0.43	0.0018	0.0058	131.25	65.63	2 ϕ 10	2 ϕ 10	157.14	74.00
15	2 C – E	3.00	0.25	0.25	0.13	0.15	0.20	1.08	7.37	8.45	6.34	7.92	1.32	0.0056	0.0058	175.00	87.50	2 ϕ 12	2 ϕ 12	226.29	70.00
16	E 1 – 2	4.00	0.33	0.30	0.15	0.20	0.25	1.73	4.88	6.60	8.80	11.01	0.88	0.0037	0.0058	291.67	145.83	3 ϕ 12	2 ϕ 12	339.43	54.00
17	1 C – E	3.00	0.25	0.25	0.13	0.15	0.20	1.08	3.90	4.98	3.74	4.67	0.78	0.0033	0.0058	175.00	87.50	2 ϕ 12	2 ϕ 12	226.29	70.00
18	C 1 – 2	4.00	0.33	0.30	0.15	0.20	0.25	1.73	8.78	10.50	14.00	17.51	1.40	0.0060	0.0060	300.23	150.12	3 ϕ 12	2 ϕ 12	339.43	54.00
19	1 B – C	2.00	0.17	0.20	0.10	0.15	0.15	0.86	2.60	3.46	1.15	1.44	0.43	0.0018	0.0058	131.25	65.63	2 ϕ 10	2 ϕ 10	157.14	74.00
20	B 1 – 2	4.00	0.33	0.30	0.15	0.20	0.25	1.73	3.90	5.63	7.50	9.38	0.75	0.0032	0.0058	291.67	145.83	3 ϕ 12	2 ϕ 12	339.43	54.00

- ρ min = 1,4 / fy’

  = 1,4 / 240 = 0,0058

- ρ max = $0{,}75 * \frac{(0{,}85 * fc' * \beta 1)}{fy'} * \left(\frac{600}{600+fy'}\right)$

  = $0{,}75 * \frac{(0{,}85 * 30 * 0{,}85)}{240} * \left(\frac{600}{600+240}\right)$ = 0,0484

- Jarak antar tulangan tarik (S) balok AS A (3-4) = $\frac{(b-2p-2\phi\text{sengkang}-\text{n}.\phi\text{tulangan})}{n-1} = \frac{(200-2.20-2.8-3.12)}{3-1}$ = 54 mm

Syarat (ρ min < ρ perlu < ρ mak)

- Jika ρ perlu < ρ min maka untuk menghitung luas tulangan digunakan ρ min
- Jika ρ perlu > ρ min maka untuk menghitung luas tulangan digunakan ρ perlu
- Jika ρ perlu > ρ mak maka dimensi harus diperbesar

B. Balok Lantai Dua

1. Perhitungan q Ekuivalen Pada Balok Lantai Dua

Wu balok lantai dua = 7,924 kN/m^2

a. Tinjau plat tipe II

- Balok AS 4 (B – C)

qe segitiga Plat II = 0,25 * Wu * Lx

= 0,25 * 7,924 * 2

= 3,96 kN/m

q dinding = 1,2 * b * t * Bj.dinding

= 1,2 * 0,15 * 3,5 * 17

= 10,71 kN/m

qe total = qe segitiga Plat II + q dinding

= 3,96 + 10,71

= 14,67 kN/m

- Balok AS C (3 – 4)

qe trapezium Plat II $= \frac{0{,}5 * \left(\frac{Ly}{Lx} - 0{,}5\right) * Wu * Lx^2}{Ly}$

$= \frac{0{,}5 * \left(\frac{4}{2} - 0{,}5\right) * 7{,}924 * 2^2}{4}$ = 5,94 kN/m

qe trapezium Plat I $= \frac{0{,}5 * \left(\frac{Ly}{Lx} - 0{,}5\right) * Wu * Lx^2}{Ly}$

$= \frac{0{,}5 * \left(\frac{4}{3} - 0{,}5\right) * 7{,}924 * 3^2}{4}$ = 7,43 kN/m

qe total = qe trapezium Plat II + qe trapezium Plat I

= 5,94 + 7,43 = 13,37 kN/m

Tabel Hasil Perhitungan q Ekuivalen Balok Lantai Dua

perhitungan q ekuivalen plat lantai								
plat	Balok AS	ly (m)	lx (m)	WU (kN/m^2)	qe trapesium (kN/m)	qe segitiga (kN/m)	qe dinding (kN/m)	qe total (kN/m)
I	A 3 – 4	4.00	3.00	7.924	7.43		10.71	18.14
I	4 A – B	4.00	3.00	7.924		5.94	10.71	16.65
I	3 A – B	4.00	3.00	7.924		5.94	10.71	16.65
I	B 3 – 4	4.00	3.00	7.924	7.43		10.71	24.08
II	B 3 – 4	4.00	2.00	7.924	5.94			
II	4 B – C	4.00	2.00	7.924		3.96	10.71	14.67
II	C 3 – 4	4.00	2.00	7.924	5.94			13.37
I	C 3 – 4	4.00	3.00	7.924	7.43			
I	4 C – E	4.00	3.00	7.924		5.94	10.71	16.65
I	E 3 – 4	4.00	3.00	7.924	7.43		10.71	25.57
I	E 3 – 4	4.00	3.00	7.924	7.43			
I	4 E – F	4.00	3.00	7.924		5.94		5.94
I	F 3 – 4	4.00	3.00	7.924	7.43			7.43
I	3 E – F	4.00	3.00	7.924		5.94		5.94
III	B 2 – 3	2.00	2.00	7.924		3.96	10.71	14.67
II	3 B – C	4.00	2.00	7.924		3.96	10.71	18.63
III	3 B – C	2.00	2.00	7.924		3.96		
III	C 2 – 3	2.00	2.00	7.924		3.96	10.71	17.64
IV	C 2 – 3	2.00	1.00	7.924	2.97			
IV	3 C – D	2.00	1.00	7.924		1.98		7.92
I	3 C – E	4.00	3.00	7.924		5.94		

IV	D 2 – 3	2.00	1.00	7.924	2.97			2.97
IV	2 C – D	2.00	1.00	7.924		1.98		7.92
I	2 C – E	4.00	3.00	7.924		5.94		
II	B 1 – 2	4.00	2.00	7.924	5.94		10.71	16.65
III	2 B – C	2.00	2.00	7.924		3.96		7.92
II	2 B – C	4.00	2.00	7.924		3.96		
II	C 1 – 2	4.00	2.00	7.924	5.94		10.71	24.08
I	C 1 – 2	4.00	3.00	7.924	7.43			
II	1 B – C	4.00	2.00	7.924		3.96	10.71	14.67
I	E 1 – 2	4.00	3.00	7.924	7.43		10.71	18.14
I	1 C – E	4.00	3.00	7.924		5.94	10.71	16.65
VOID	E 2 – 3	2.00					10.71	10.71

2. Perhitungan Penulangan Balok Lantai Dua

a. Tinjau Balok AS D 2 – 3

- L = 2 m
- Tinggi balok (h) = (1/10 sd1/12)*L
  = 1/12 * 2 = 0,16 m ≈ 0,20 m
- Tebal balok (b) > 0,5* h
  = 0,5 * 0,20 = 0,10 m ≈ 0,15 m
- d’ = 0,05 m
- d = h – d’
  = 0,20 – 0,05 = 0,15 m
- q Berat Sendiri Balok = 1,2 * b * h * Bj.beton
  = 1,2 * 0,15 * 0,20 * 24 kN/m^3
  = 0,86 kN/m

- q total = qe total + q berat sendiri balok

  = 2,97 + 0,86 = 3,83 kN/m

- Mu $= \frac{1}{12} * q\ total * L^2$

  $= \frac{1}{12} * 3{,}83 * 2^2$ = 1,28 kN m

- Mn = Mu / Φ

  = 1,28 / 0,8 = 1,6 kN m

- Rn $= \frac{Mn}{b*d^2}$

  $= \frac{1{,}6 \text{ x } 10^6 \text{N mm}}{150*150^2}$ = 0,47 N/mm^2

- m = $\frac{fy'}{0{,}85\ x\ fc'} = \frac{240}{0{,}85\ x\ 30}$

  = 9,41

- ρ perlu $= \frac{1}{m}\ (1 - \sqrt{1 - \frac{2*m*Rn}{fy}})$

  $= \frac{1}{9{,}41}\ (1 - \sqrt{1 - \frac{2*9{,}41*0{,}47}{240}})$ = 0,0020

- ρ min = 1,4 / fy'

  = 1,4 / 240 = 0,0058

- ρ max $= 0{,}75 * \frac{(0{,}85*fc'*\beta 1)}{fy'} * (\frac{600}{600+fy'})$

  $= 0{,}75 * \frac{(0{,}85*30*0{,}85)}{240} * (\frac{600}{600+240})$ = 0,0484

- Syarat (ρ min < ρ perlu < ρ max) karena ρ perlu kurang dari ρ min maka ρ digunakan = ρ min (0,0058)

- As = ρ min * b * d

  = 0,0058 * 150 * 150 = 131,25 mm^2

- As' = 0,5 * As

  = 0,5 * 131,25 = 65,63 mm^2

- Tulangan Tarik = 2 ϕ 12 (226,29 mm^2)
- Tulangan Tekan = 2 ϕ 12 (226,29 mm^2)

- Reaksi di D2

R D2 $= \frac{1}{2} * qtotal * L$

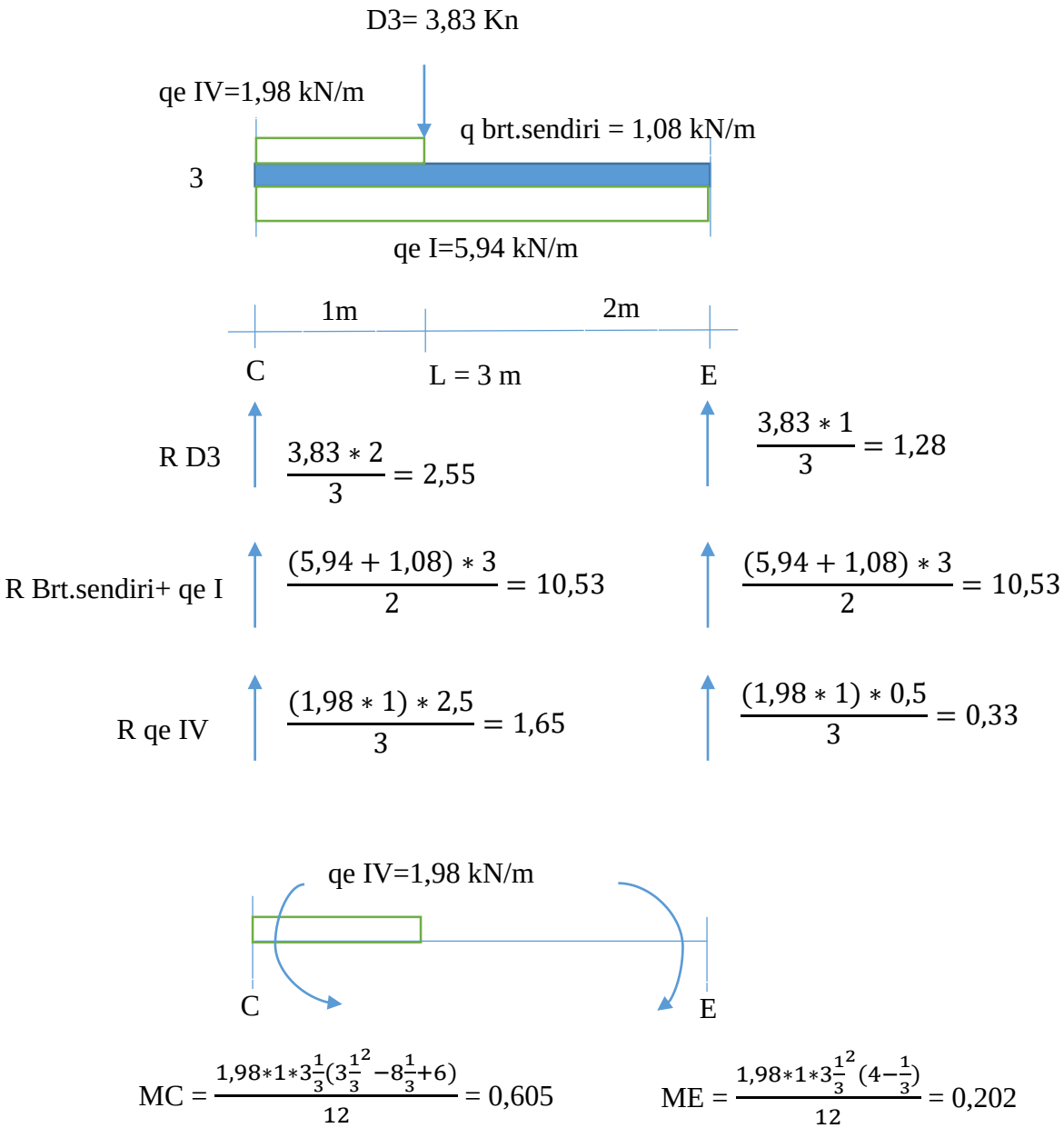
$= \frac{1}{2} * 3{,}83 * 2$ = 3,83 Kn

- Reaksi di D3

R D3 $= \frac{1}{2} * qtotal * L$

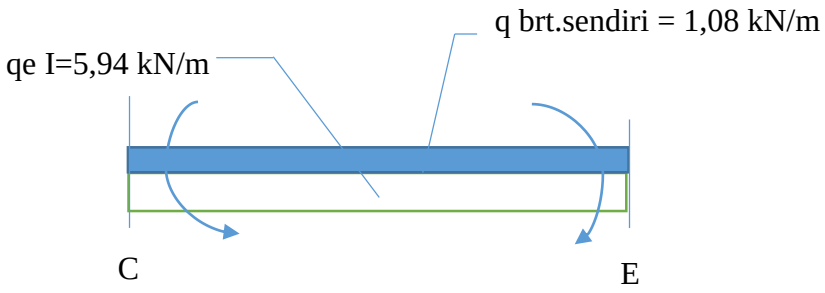
$= \frac{1}{2} * 3{,}83 * 2$ = 3,83 Kn

b. Tinjau Balok AS 3 C – E

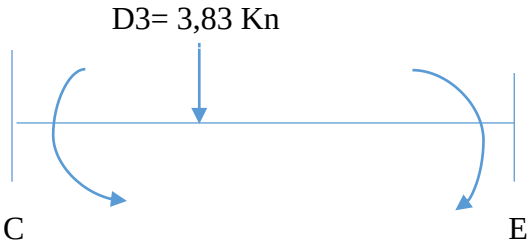


MC = $\frac{1{,}98*1*3\frac{1}{3}(3\frac{1}{3}^2 - 8\frac{1}{3}+6)}{12}$ = 0,605

ME = $\frac{1{,}98*1*3\frac{1}{3}^2 (4-\frac{1}{3})}{12}$ = 0,202



$MC = \frac{(5{,}84+1{,}08)*3^2}{12} = 5{,}265$ $ME = \frac{(5{,}84+1{,}08)*3^2}{12} = 5{,}265$



$MC = \frac{3{,}83 * 1 * 2^2}{3^2} = 1{,}7$ $ME = \frac{3{,}83 * 2 * 1^2}{3^2} = 0{,}85$

$\frac{MC}{L}$ $\frac{1{,}7 + 5{,}265 + 0{,}605}{3} = 2{,}53$ $\frac{1{,}7 + 5{,}265 + 0{,}605}{3} = 2{,}53$

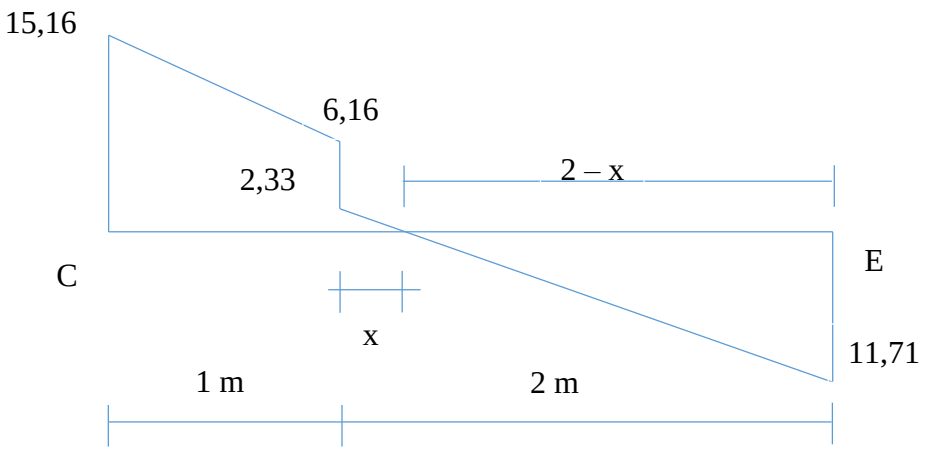
$\frac{ME}{L}$ $\frac{0{,}85 + 5{,}265 + 0{,}202}{3} = 2{,}1$ $\frac{0{,}85 + 5{,}265 + 0{,}202}{3} = 2{,}1$

\+ \+

C3 = 15,16 kN E3 = 11,71 kN

BIDANG D

M Mak terjadi pada D = 0



$$\frac{x}{(2-x)} = \frac{2{,}33}{11{,}71}$$

11,71 x = 4,66 – 2,33 x

14,04 x = 4,66

x = 0,33 m

Mx = 15,16*1,33 – (1/2*9*$1{,}33^2$) – (3,83*0,33)

= 10,94 kN m

b = 0.15 m

h = 0,25 m

d’ = 0,05 m

d = h – d’ = 0,20 m

- Penulangan area lapangan balok AS 3 (C-E)

  - Mn = Mx / Φ

    = 10,94 / 0,8 = 13,68 kN m

  - Rn = $\frac{\text{Mn}}{b*d^2}$

    = $\frac{13{,}68 \text{ x } 10^6 \text{N mm}}{150*200^2}$ = 2,28 N/mm^2

  - m = $\frac{fy'}{0{,}85\ x\ fc'}$ = $\frac{240}{0{,}85\ x\ 30}$

    = 9,41

  - ρ perlu = $\frac{1}{m}\ (1 - \sqrt{1 - \frac{2*m*Rn}{fy}}\ )$

    = $\frac{1}{9{,}41}\ (1 - \sqrt{1 - \frac{2*9{,}41*2{,}28}{240}}\ )$ = 0,0100

  - ρ min = 1,4 / fy’

    = 1,4 / 240 = 0,0058

  - ρ max = 0,75 * $\frac{(\ 0{,}85*fc'*\beta 1\ )}{fy'} * (\frac{600}{600+fy'})$

    = 0,75 * $\frac{(\ 0{,}85*30*\ 0{,}85\ )}{240} * (\frac{600}{600+240})$ = 0,0484

- Syarat (ρ min < ρ perlu < ρ max) karena ρ perlu lebih dari ρ min maka ρ digunakan = ρ perlu (0,0100)

- As = ρ perlu * b * d
  = 0,0100 * 150 * 200 = 300 mm^2
- As' = 0,5 * As
  = 0,5 * 150 = 150 mm^2
- Tulangan Tarik = 2 ϕ 14 (308 mm^2)
- Tulangan Tekan = 2 ϕ 14 (308 mm^2)

▪ Penulangan area tumpuan balok AS 3 (C-E)

MC = 7,57 kN m

ME = 6,317 kN m

Diambil M mak tumpuan = 7,57 kN m

- Mn = M tmak / Φ
  = 7,57 / 0,8 = 9,46 kN m
- Rn = $\frac{Mn}{b*d^2}$
  = $\frac{9{,}46 \text{ x } 10^6 \text{N mm}}{150*200^2}$ = 1,58 N/mm^2
- ρ perlu = $\frac{1}{m}\left(1-\sqrt{1-\frac{2*m*Rn}{fy}}\right)$
  = $\frac{1}{9{,}41}\left(1-\sqrt{1-\frac{2*9{,}41*1{,}58}{240}}\right)$ = 0,0068

- Syarat (ρ min < ρ perlu < ρ max) karena ρ perlu lebih dari ρ min maka ρ digunakan = ρ perlu (0,0068)

- As = ρ perlu * b * d
  = 0,0068* 150 * 200 = 203,64 mm^2
- As' = 0,5 * As
  = 0,5 * 423 = 101,82 mm^2
- Tulangan Tarik = 2 ϕ 12 (226,29 mm^2)
- Tulangan Tekan = 2 ϕ 12 (226,29 mm^2)

Table hasil perhitungan balok lantai dua

PERHITUNGAN PENULANGAN BALOK LANTAI DUA																				
No.	balok AS	l (m)	h = 1/12* l (m)	h dipakai (m)	b > 0.5*h (m)	b dipakai (m)	d=h-d' (d'=0.05 m)	q Bs. (kN /m)	qe total (kN /m)	q total (kN /m)	Mu (kN m)	Mn (kN m)	Rn (N/ mm2)	ρ perlu	ρ di pakai	As (mm2)	As' (mm2)	tulangan tarik	tulangan tekan	As tulangan	S tarik> 25 (mm)
1	A 3 - 4	4.00	0.33	0.40	0.20	0.20	0.35	2.30	18.14	20.44	27.26	34.07	1.39	0.0060	0.0060	417.32	208.66	3 ϕ 14	2 ϕ 14	462.00	51.00
2	4 A - B	3.00	0.25	0.25	0.13	0.15	0.20	1.08	16.65	17.73	13.30	16.62	2.77	0.0123	0.0123	367.54	183.77	3 ϕ 14	2 ϕ 14	462.00	26.00
3	3 A - B	3.00	0.25	0.25	0.13	0.15	0.20	1.08	16.65	17.73	13.30	16.62	2.77	0.0123	0.0123	367.54	183.77	3 ϕ 14	2 ϕ 14	462.00	26.00
4	B 3 - 4	4.00	0.33	0.40	0.20	0.20	0.35	2.30	24.08	26.39	35.18	43.98	1.79	0.0078	0.0078	543.38	271.69	3 ϕ 16	2 ϕ 16	603.43	48.00
5	4 B - C	2.00	0.17	0.20	0.10	0.15	0.15	0.86	14.67	15.54	5.18	6.47	1.92	0.0083	0.0083	187.14	93.57	2 ϕ 12	2 ϕ 12	226.29	70.00
6	C 3 - 4	4.00	0.33	0.35	0.18	0.20	0.30	2.02	13.37	15.39	20.52	25.65	1.42	0.0061	0.0061	366.75	183.37	3 ϕ 14	2 ϕ 14	462.00	51.00
7	4 C - E	3.00	0.25	0.25	0.13	0.15	0.20	1.08	16.65	17.73	13.30	16.62	2.77	0.0123	0.0123	367.54	183.77	3 ϕ 14	2 ϕ 14	462.00	26.00
8	E 3 - 4	4.00	0.33	0.40	0.20	0.20	0.35	2.30	25.57	27.87	37.16	46.45	1.9	0.0082	0.0082	575.25	278.63	3 ϕ 16	2 ϕ 16	603.43	73.00
9	4 E - F	3.00	0.25	0.25	0.13	0.15	0.20	1.08	5.94	7.02	5.27	6.58	1.10	0.0047	0.0058	175.00	87.50	2 ϕ 12	2 ϕ 12	226.29	70.00
10	F 3 - 4	4.00	0.33	0.35	0.18	0.20	0.30	2.02	7.43	9.44	12.59	15.74	0.87	0.0037	0.0058	350.00	175.00	3 ϕ 14	2 ϕ 14	462.00	51.00
11	3 E - F	3.00	0.25	0.25	0.13	0.15	0.20	1.08	5.94	7.02	5.27	6.58	1.10	0.0047	0.0058	175.00	87.50	2 ϕ 12	2 ϕ 12	226.29	70.00
12	B 2 - 3	2.00	0.17	0.20	0.10	0.15	0.15	0.86	14.67	15.54	5.18	6.47	1.92	0.0083	0.0083	187.14	93.57	2 ϕ 12	2 ϕ 12	226.29	70.00
13	3 B - C	2.00	0.17	0.20	0.10	0.15	0.15	0.86	18.63	19.50	6.50	8.12	2.41	0.0106	0.0106	237.47	118.73	2 ϕ 14	2 ϕ 14	308.00	66.00
14	C 2 - 3	2.00	0.17	0.20	0.10	0.15	0.15	0.86	17.64	18.51	6.17	7.71	2.28	0.0100	0.0100	224.77	112.39	2 ϕ 14	2 ϕ 14	308.00	66.00
15	3 C - E	3.00	0.25	0.25	0.13	0.15	0.20	1.08	7.92	9.00	10.94	13.68	2.28	0.0100	0.0100	298.91	149.46	2 ϕ 14	2 ϕ 14	308.00	66.00
											7.57	9.46	1.58	0.0068	0.0068	203.64	101.82	2 ϕ 12	2 ϕ 12	226.29	70.00
16	D 2 - 3	2.00	0.17	0.20	0.10	0.15	0.15	0.86	2.97	3.84	1.28	1.60	0.47	0.0020	0.0058	131.25	65.63	2 ϕ 12	2 ϕ 12	226.29	70.00
17	2 C - E	3.00	0.25	0.25	0.13	0.15	0.20	1.08	7.92	9.00	10.94	13.68	2.28	0.0100	0.0100	298.91	149.46	2 ϕ 14	2 ϕ 14	308.00	66.00
											7.57	9.46	1.58	0.0068	0.0068	203.64	101.82	2 ϕ 12	2 ϕ 12	226.29	70.00
18	B 1- 2	4.00	0.33	0.40	0.20	0.20	0.35	2.30	16.65	18.96	25.28	31.60	1.29	0.0055	0.0055	386.16	193.08	3 ϕ 14	2 ϕ 14	462.00	51.00
19	2 B - C	2.00	0.17	0.20	0.10	0.15	0.15	0.86	7.92	8.79	2.93	3.66	1.08	0.0046	0.0058	131.25	65.63	2 ϕ 12	2 ϕ 12	226.29	70.00
20	C 1 - 2	4.00	0.33	0.40	0.20	0.20	0.35	2.30	24.08	26.39	35.18	43.98	1.79	0.0078	0.0078	543.38	271.69	3 ϕ 16	2 ϕ 16	603.43	48.00
21	1 B - C	2.00	0.17	0.20	0.10	0.15	0.15	0.86	14.67	15.54	5.18	6.47	1.92	0.0083	0.0083	187.14	93.57	2 ϕ 12	2 ϕ 12	226.29	70.00
22	E 1 - 2	4.00	0.33	0.40	0.20	0.20	0.35	2.30	18.14	20.44	27.26	34.07	1.39	0.0060	0.0060	417.32	208.66	3 ϕ 14	2 ϕ 14	462.00	51.00
23	1 C - E	3.00	0.25	0.25	0.13	0.15	0.20	1.08	16.65	17.73	13.30	16.62	2.77	0.0123	0.0123	367.54	183.77	3 ϕ 14	2 ϕ 14	462.00	26.00
24	E 2 - 3	2.00	0.17	0.20	0.10	0.15	0.15	0.86	10.71	11.57	3.86	4.82	1.43	0.0061	0.0061	137.94	68.97	2 ϕ 12	2 ϕ 12	226.29	70.00