BAB III

PERHITUNGAN TANGGA DAN PELAT

3.1. Analisis Beban Gravitasi

Beban gravitasi adalah beban yang bekerja pada portal dan berupa beban mati serta beban hidup.

Bangunan yang akan dianalisis pada penulisan tugas akhir ini merupakan Gedung Kampus di Kota Palembang yang terdiri dari 11 lantai tanpa *basement* dengan atap berbentuk pelat beton. Struktur bangunan menggunakan konstruksi beton bertulang dengan f'c = 25 MPa, baja tulangan pokok fy = 400 MPa untuk penulangan balok dan kolom, serta tulangan pembagi fy = 240 MPa untuk penulangan sengkang.

Berat bahan bangunan dari komponen bangunan yang digunakan pada perancangan ini berdasar SNI 03-1727-1989 adalah sebagai berikut :

1. Beban Mati
    a. Beton Bertulang : 24,00 $^{kN}/_{m^3}$
    b. Dinding pasangan bata merah ½ bata : 2,5 $^{kN}/_{m^2}$
    c. Pasir : 18,00 $^{kN}/_{m^3}$
    d. Adukan semen per cm tebal : 0,21 $^{kN}/_{m^2}$
    e. Penutup lantai (tegel) : 0,24 $^{kN}/_{m^2}$
    f. Plafon + penggantung : 0,18 $^{kN}/_{m^2}$
    g. ME / AC : 0,30 $^{kN}/_{m^2}$
2. Beban Hidup

a. Lantai : 2,50 kN/m^2

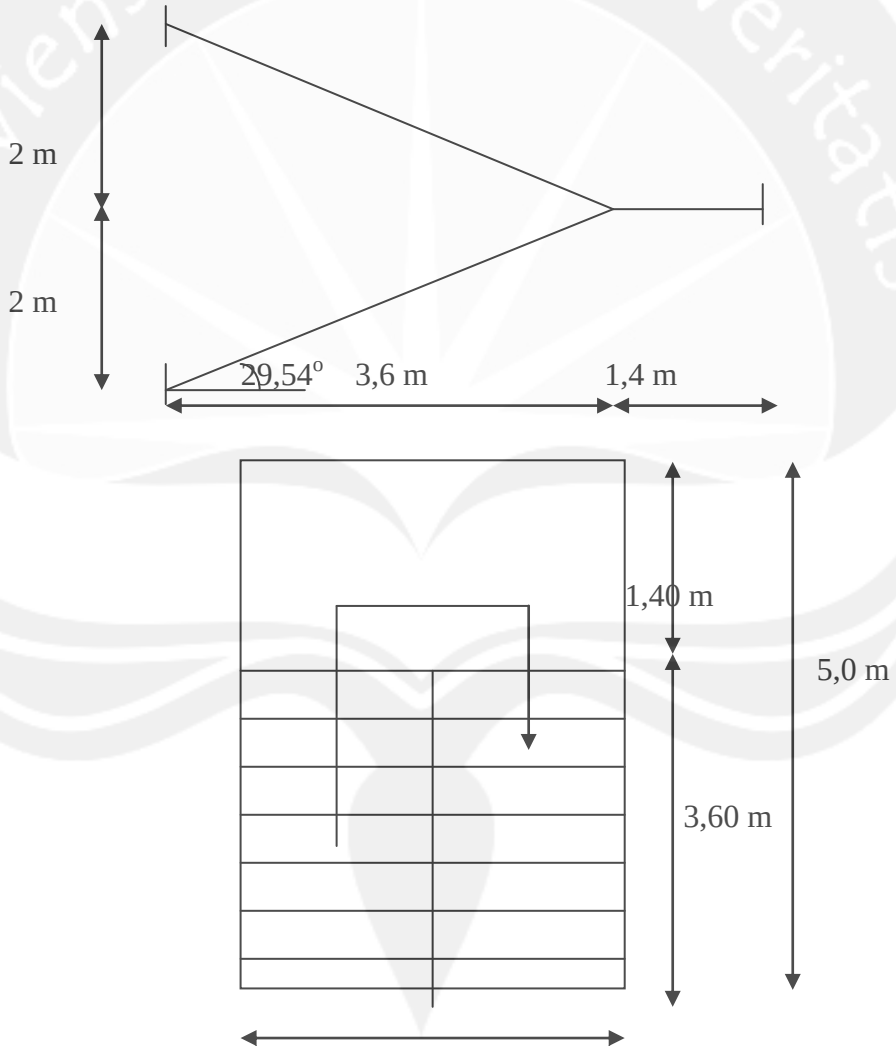
b. Atap : 1,00 kN/m^2

c. Tangga, bordes tangga : 3,00 kN/m^2

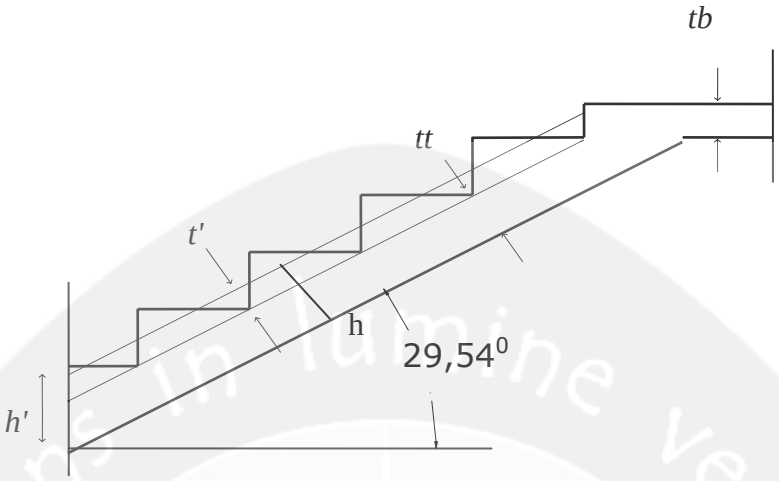
3. Koefisien reduksi beban hidup untuk peninjauan gempa

a. Gedung Sekolah : 0,90 kN/m^2

3.2. Perencanaan Tangga



Gambar 3.1. Ruang Tangga



Gambar 3.2. Penampang Tangga

3.2.1. Hitungan Tangga

Selisih tinggi lantai = 4,0 m

Panjang ruang tangga = 5,0 m

Lebar tangga = 3,0 m

Tinggi anak tangga (*Optrade*) = 17 cm syarat : $16 \leq O \leq 20$

Lebar anak tangga (*Antrade*) = 30 cm syarat : $26 \leq A \leq 30$

Jumlah anak tangga = $\frac{400}{17} - 1 = 22{,}52 \approx 23$ anak tangga

Lebar bordes : b_o = 500 – (12 x 30) = 140 cm

Kemiringan tangga : $\tan \alpha = \frac{O}{A} = \frac{17}{30}$

$$\alpha = 29{,}54^0$$

digunakan tebal pelat tangga (*tt*) = tebal bordes (*tb*) = 12 cm

Tinggi beban merata tangga

$$t' = \frac{(0{,}5.O.A)}{\sqrt{O^2 + A^2}} = \frac{(0{,}5.17.30)}{\sqrt{17^2.30^2}} = 7{,}3951 \text{ cm}$$

h = $tb + t'$

= 12 + 7,3951

= 19,4 cm

$$h' = \frac{tb}{\cos\alpha} + \frac{O}{2} = \frac{12}{\cos 29{,}54^0} + \frac{17}{2}$$

= 22,29 cm = 0,2229 m

1. Pembebanan tangga

Hitungan beban permeter lebar tangga

Beban mati :

beban pelat + anak tangga	= 0,2229 . 24	= 5,3496	$^{kN}/_{m}$
tegel (2 cm)	= 0,02 . 0,24	= 0,0048	$^{kN}/_{m}$
spesi (2 cm)	= 0,02 . 0,21	= 0,0042	$^{kN}/_{m}$
railing		= 0,89	$^{kN}/_{m}$
		+	
		q_{dl} = 6,2486	$^{kN}/_{m}$

Beban hidup : q_{ll} = 3 $^{kN}/_{m}$

Hitungan beban per meter lebar bordes

Beban mati

berat sendiri	= 0,12 . 24	= 2,88	$^{kN}/_{m}$
tegel (2 cm)	= 0,02 . 0,24	= 0,0048	$^{kN}/_{m}$
spesi (2 cm)	= 0,02 . 0,21	= 0,0042	$^{kN}/_{m}$
railing		= 0,89	$^{kN}/_{m}$
		+	
		q_{dl} = 3,779	$^{kN}/_{m}$

Beban hidup : q_{ll} = 3 $^{kN}/_{m}$

2. Reaksi tumpuan

Reaksi perletakan akibat beban mati dan beban hidup

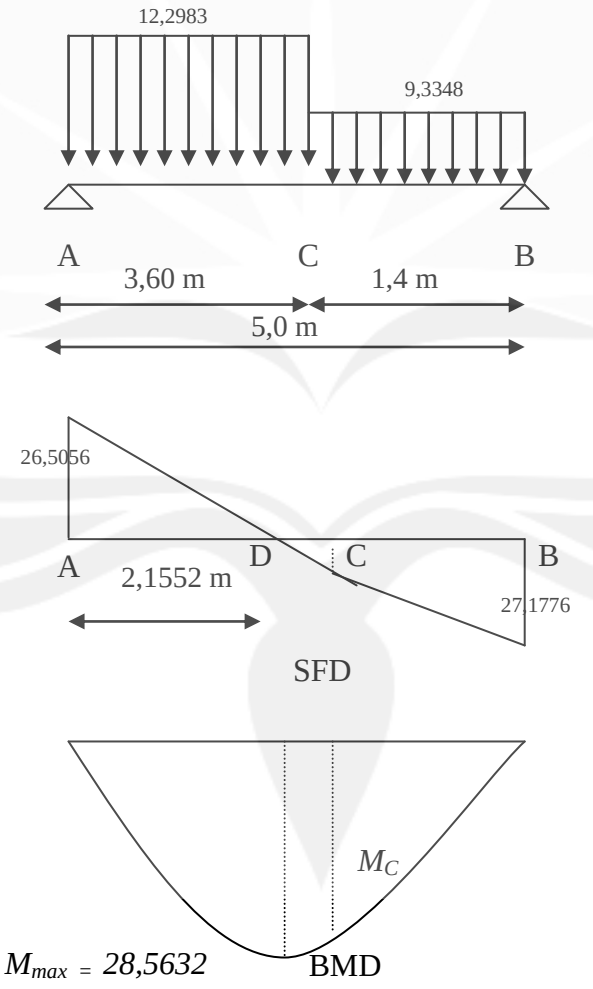
$q_{ult\ tangga}$ = 1,2 q_{dl} + 1,6 q_{ll}

= 1,2 . 6,2486 + 1,6 . 3

= 12,2983 $^{kN}/_{m}$

$q_{ult\ bordes}$ = 1,2 q_{dl} + 1,6 + q_{ll}

= 1,2 . 3,779 + 1,6 . 3 = 9,3348 $^{kN}/_{m}$



Gambar 3.3. Pembebanan Tangga Akibat Beban Mati dan Beban Hidup

$\Sigma M_B = 0$

$$R_A \,.\, 5 - 12{,}2983 \,.\, 3{,}60 \,.\, \left(\frac{3{,}60}{2} + 1{,}4\right) - 9{,}3348 \,.\, 1{,}4 \,.\, \left(\frac{1{,}40}{2}\right) = 0$$

$R_A = 26{,}5056$ kN

$\Sigma M_A = 0$

$$12{,}62376 \,.\, 3{,}60 \,.\, \left(\frac{3{,}60}{2}\right) + 9{,}3348 \,.\, 1.40 \,.\, \left(\frac{1{,}40}{2} + 3{,}60\right) - R_B \,.\, 5 = 0$$

$R_B = 27{,}1776$ kN

$R_C = 26{,}5056 - (12{,}2983 \,.\, 3{,}60)$

$R_C = -17{,}7682$ kN

$26{,}5056.\ (3{,}60 - x) = 17{,}7682.\ x$

$96{,}4201 - 26{,}5065x = 14{,}0734 \,.\, x$

$x = 2{,}1552$ m

$$M_{max} = 26{,}5056.\ 2{,}1552 - 12{,}2983.\ \left(\frac{2{,}1552^{\,2}}{2}\right)$$

$= 28{,}5632$ kNm

3. Penulangan tangga

a. Lapangan dan Tumpuan

M_u = Mmax

= 28,5632 kNm

Data :

Direncanakan tulangan pokok D13

b_w = 1,0 m = 1000 mm

h = t tangga + t'

= 120 + 7,4 = 194

d = h - p – ($^1/_2$. ø)

= 194 -20 - (0,5 . 13) = 168 mm =0,167,5 m

$R_{n\ perlu} = \frac{M_u}{\phi.b_w.d^2} = \frac{28,5632.10^{-3}}{0,9.1,0.0,1675^2} = 1,1311\ {}^{kN}/_{m^2}$

ρ_{min} = 0,018

$\rho_{perlu} = = \frac{0,85.f'_c}{f_y}.\left[1-\sqrt{1-\frac{2.R_n}{0,85.f'_c}}\right]$

$= \frac{0,85.25}{400}.\left[1-\sqrt{1-\frac{2.1,1311}{0,85.25}}\right]$

= 0,9

$\rho_{max} = 0,75\ .\ 0,85\ .\ \beta\ .\ \frac{f'c}{fy}\ .\left[\frac{600}{600+fy}\right]$

$= 0,75x\ 0,85\ x\ 0,85x\ \frac{25}{400}\ .\left[\frac{600}{600+400}\right]$

= 0,0203

ρ_{min} = 0,0018	<	ρ_{perlu} = 0,0029	<	ρ_{max} = 0,0203

As perlu = $\rho\ .\ b_w\ .\ d$ = 0,0029. 1000 . 167,5 = 485,75 mm^2

As min = $\rho\ .\ b_w\ .\ h$ = 0,0018 . 1000 . 194 = 349,2 mm^2

Jarak tulangan = $\frac{1000.0,25.\pi.13^2}{485,75}$ = 273,25 mm ~ 250mm

Digunakan tulangan utama D13 - 250 (*As* = 530,92 mm^2)

$A_{s\ pakai} = \frac{1000.0{,}25.\pi.13^2}{250} = 530{,}92$

Check : As pakai > *As* perlu ..... Aman

b. Tulangan susut

As min $= \rho_{min} \cdot b_w \cdot h$

$= 0{,}002 \cdot 1000 \cdot 194$

$= 388\ mm^2$

Digunakan tulangan P10

Jarak tulangan S = $\frac{1000.0{,}25.\pi.10^2}{388} = 202{,}42$ mm

Digunakan tulangan P10 – 200 (*As* = 392,69 mm^2)

$A_{s\ pakai} = \frac{1000.0{,}25.\pi.10^2}{200} = 392{,}69$

Check : As pakai > *As* perlu ..... Aman

c. Kontrol geser

$V_u = SFA = 26{,}5056$ kN

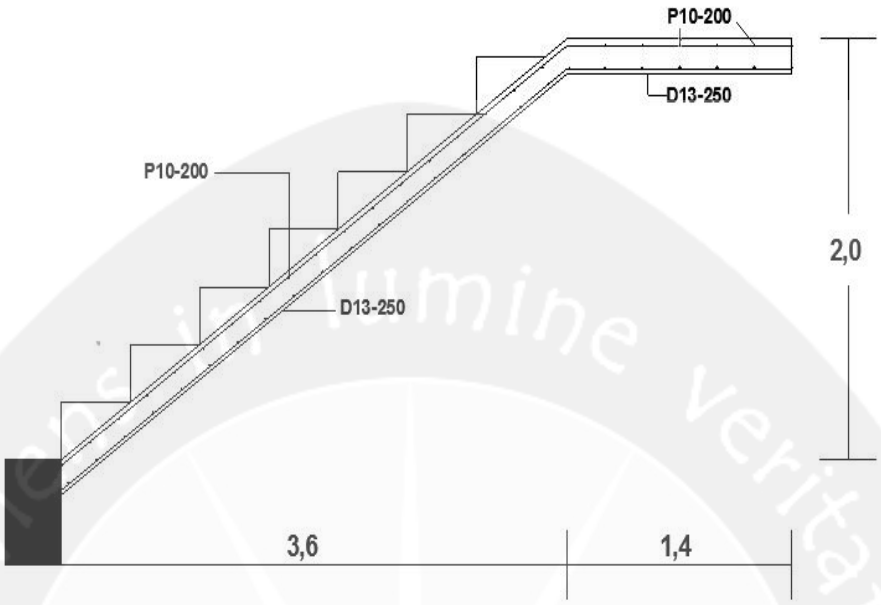
$V_C = 1/6 \sqrt{f'_c} \cdot b \cdot d$

$= (1/6. \sqrt{25} \cdot 1000 \cdot 168). 10^{-3}$

$= 140$ kN

$V_U < \phi V_C = 26{,}5056 < 0{,}75 \cdot 140$

26,5056 < 105.....Aman (Tidak perlu tulangan geser)



Gambar 3.4. Penulangan Tangga

3.2.2. Penulangan Balok Bordes

Digunakan balok bordes ukuran 25/40

Beban mati

Beban dinding	= 1,2 . 5	= 6	$^{kN}/_{m}$
berat sendiri	= 1,2 . 0,25 . 0,4 . 24 . 1	= 2,88	$^{kN}/_{m}$
Reaksi tangga per m lebar (R_B)		= 27,1776	$^{kN}/_{m}$
		+	
		= 36,0576	$^{kN}/_{m}$
Beban hidup bordes (q_l) =	1,6 . 3	= 4,8	$^{kN}/_{m}$

qu = qd + ql

= 36,0576 + 4,8 = 40,8576

1. Penulangan lentur tumpuan

Keterangan : h = 400 m

$ø_{sengkang}$ = 10 mm

$ø_{tulangan}$ = 13 mm

p = 40 mm

Direncanakan ø tulangan pokok = D13

d = 400 – 40 – 10 - (½ . 13) =343,5 mm

a. Penulangan negatif

Mu = 1/11 . qu . L^2

= 1/11 . 40,8576 . 3^2

= 33,4289

$$R_{n\,perlu} = \frac{M_u}{\phi.b_w.d^2} = \frac{33{,}4289.10^{-3}}{0{,}9.0{,}25.0{,}3435^2} = 1{,}2591 \ {}^{kN}/_{m^2}$$

$$\rho_{perlu} = \frac{0{,}85.f'_c}{f_y}.\left[1-\sqrt{1-\frac{2.R_n}{0{,}85.f'_c}}\right]$$

$$= \frac{0{,}85.25}{400}.\left[1-\sqrt{1-\frac{2.1{,}2591}{0{,}85.25}}\right]$$

= 0,00324

$$\rho_{max\ 1} = 0{,}75 \,.\, 0{,}85 \,.\, \beta \,.\, \frac{f'c}{fy} \,.\left[\frac{600}{600+fy}\right]$$

$$= 0{,}75x\ 0{,}85\ x\ 0{,}85x\ \frac{25}{400}\ .\left[\frac{600}{600+400}\right]$$

= 0,0203

$\rho_{max\ 2}$ =0,025

ρ_{max} yang digunakan adalah 0,0203

$$\rho_{min1} = \frac{0{,}25\sqrt{f'_c}}{f_y}$$

$$= \frac{0{,}25\sqrt{25}}{400}$$

$$= 0{,}0031$$

$$\rho_{min2} = \frac{1{,}4}{f_y}$$

$$= \frac{1{,}4}{400}$$

$$= 0{,}0035$$

ρ_{min} yang digunakan adalah 0,0035

$\rho_{perlu} = 0{,}00324$	<	$\rho_{min} = 0{,}0035$	< $\rho_{max} = 0{,}0203$

Gunakan $\rho_{min} = 0{,}0035$

As perlu $= \rho \cdot b_w \cdot d$

$= 0{,}0035 \cdot 250 \cdot 343{,}5 = 300{,}56 \text{ mm}^2$

Jumlah tulangan $= \frac{300{,}56}{0{,}25.\pi.13^2} = 2{,}26 \sim 3$ Batang

Digunakan tulangan utama 3 D-13 (As = 398,1968 mm^2)

$A_{s\ pakai} = 3.0{,}25.\pi.12^2$

$= 398{,}1968 \text{ mm}^2$

Check : As pakai > As perlu ..... Aman

Pemeriksaan momen nominal

a $= \dfrac{As.fy}{0{,}85.f'c.b_w}$

$= \dfrac{398{,}1968 \ .400}{0{,}85.25.250}$

= 29,9818

ϕ Mn $= \phi \ As.fy \ (d - \dfrac{a}{2})$

$= 0{,}9. \ 398{,}1968 \ .400 \ (343{,}5 - \dfrac{29{,}9818}{2})$

= 47092058 = 47,09 kN

ϕ Mn > Mu

47,09 > 33,4289 ..... OK

b. Penulangan positif

Mu = 0,5 . ϕ Mn

= 0,5 . 47,09

= 23,545

$$R_{n\,perlu} = \frac{M_u}{\phi.b_w.d^2} = \frac{23{,}545.10^{-3}}{0{,}9.0{,}25.0{,}3435^2} = 0{,}8868 \ {}^{kN}/_{m^2}$$

$$\rho_{perlu} = \frac{0{,}85.f'_c}{f_y}.\left[1 - \sqrt{1 - \frac{2.R_n}{0{,}85.f'_c}}\right]$$

$$= \frac{0{,}85.25}{400}.\left[1 - \sqrt{1 - \frac{2.0{,}8868}{0{,}85.25}}\right]$$

= 0,00226

$$\rho_{max\ 1} = 0{,}75 \ . \ 0{,}85 \ . \ \beta \ . \ \frac{f'c}{fy} \ . \left[\frac{600}{600 + fy}\right]$$

$$= 0{,}75x\ 0{,}85\ x\ 0{,}85x\ \frac{25}{400}\ .\left[\frac{600}{600+400}\right]$$

$$= 0{,}0203$$

$\rho_{max\ 2}$ =0,025

ρ_{max} yang digunakan adalah 0,0203

$$\rho_{min1} = \frac{0{,}25\sqrt{f'_c}}{f_y}$$

$$= \frac{0{,}25\sqrt{25}}{400}$$

$$= 0{,}0031$$

$$\rho_{min2} = \frac{1{,}4}{f_y}$$

$$= \frac{1{,}4}{400}$$

$$= 0{,}0035$$ $= \rho_{min}$ yang digunakan adalah 0,0035

$\boxed{\rho_{min} = 0{,}0035}$ > $\boxed{\rho_{perlu} = 0{,}00226}$ < $\boxed{\rho_{max} = 0{,}0203}$

Gunakan $\rho_{min} = 0{,}0035$

As perlu $= \rho\ .\ b_w\ .\ d$

$= 0{,}0035\ .\ 250\ .\ 343{,}5\ =\ 300{,}5625\ mm^2$

Jumlah tulangan $= \frac{300{,}5625}{0{,}25.\pi.13^2} =$ 2,26~ 3 Batang

Digunakan tulangan utama 3 P-12 (*As* = 398,196 mm^2)

$A_{s\ pakai}$ $= 3.0{,}25.\pi.12^2$

$= 398{,}196\ mm^2$

Pemeriksaan momen nominal

$$a = \frac{As.fy}{0{,}85.f'c.b_w}$$

$$= \frac{398{,}196\ .400}{0{,}85.25.250}$$

$$= 29{,}9818$$

$$\phi Mn = \phi\ As.fy\ \left(d - \frac{a}{2}\right)$$

$$= 0{,}9.\ 398{,}1968\ .400\ \left(343{,}5 - \frac{29{,}9818}{2}\right)$$

$$= 47092058 = 47{,}09\ kN$$

$$\phi Mn > Mu$$

$$47{,}09 > 23{,}545 \text{..... OK}$$

2. Penulangan lentur lapangan

a.Penulangan Posifif Lapangan

$Mu = 1/16\ .\ qu\ .\ L^2$

$= 1/16\ .\ 40{,}8576\ .\ 3^2$

$= 22{,}9824$

digunakan dengan syarat $Mu > 0{,}25\ .\ \phi Mn^-$

$22{,}9824 > 0{,}25.\ 40{,}45$

$22{,}9824 > 10{,}1125$

Digunakan $Mu^+ = 22{,}9824$

$$R_{n\,perlu} = \frac{M_u}{\phi.b_w.d^2} = \frac{22{,}9824.10^{-3}}{0{,}9.0{,}25.0{,}3435^2} = 0{,}8656 \ {}^{kN}/_{m^2}$$

$$\rho_{perlu} = \frac{0{,}85.f'_c}{f_y}.\left[1-\sqrt{1-\frac{2.R_n}{0{,}85.f'_c}}\right]$$

$$= \frac{0{,}85.25}{400}.\left[1-\sqrt{1-\frac{2.0{,}8656}{0{,}85.25}}\right]$$

$$= 0{,}0022$$

$$\rho_{max\ 1} = 0{,}75\ .\ 0{,}85\ .\ \beta\ .\ \frac{f'c}{fy}\ .\left[\frac{600}{600+fy}\right]$$

$$= 0{,}75x\ 0{,}85\ x\ 0{,}85x\ \frac{25}{400}\ .\left[\frac{600}{600+400}\right]$$

$$= 0{,}0203$$

$\rho_{max\ 2}$ =0,025

ρ_{max} yang digunakan adalah 0,0203

$$\rho_{min1} = \frac{0{,}25\sqrt{f'_c}}{f_y}$$

$$= \frac{0{,}25\sqrt{25}}{400}$$

$$= 0{,}0031$$

$$\rho_{min2} = \frac{1{,}4}{f_y}$$

$$= \frac{1{,}4}{400}$$

$$= 0{,}0035$$

ρ_{min} yang digunakan adalah 0,0035

ρ_{min} = 0,0035 > ρ_{perlu}= 0022 < ρ_{max} = 0,0203

Gunakan ρ_{perlu}= 0,0035

As perlu = $\rho \; . \; b_w \; . \; d$

= 0,0035 . 250 . 343,5 = 300,56 mm^2

Jumlah tulangan = $\frac{300,56}{0,25.\pi.13^2}$ = 2,26 ~ 3 Batang

Digunakan tulangan utama 3 D-13 (*As* = 398,19 mm^2)

b.Penulangan Negatif Lapangan

Mu = 0,25 . ϕ Mn$^-$

= 0,25. 40,45

= 10,1125

$R_{n\,perlu} = \frac{M_u}{\phi.b_w.d^2} = \frac{10,1125.10^{-3}}{0,9.0,25.0,3435^2} = 0,3809 \; {}^{kN}/_{m^2}$

$\rho_{perlu} = \frac{0,85.f'_c}{f_y}.\left[1-\sqrt{1-\frac{2.R_n}{0,85.f'_c}}\right]$

$= \frac{0,85.25}{400}.\left[1-\sqrt{1-\frac{2.0,3809}{0,85.25}}\right]$

= 0,00096

$\rho_{max\,1} = 0,75 \; . \; 0,85 \; . \; \beta \; . \; \frac{f'c}{fy} \; . \left[\frac{600}{600+fy}\right]$

$= 0,75x\ 0,85\ x\ 0,85x\ \frac{25}{400}\ .\left[\frac{600}{600+400}\right]$

= 0,0203

$\rho_{max\ 2}$ =0,025

ρ_{max} yang digunakan adalah 0,0203

$$\rho_{min1} = \frac{0,25\sqrt{f'_c}}{f_y}$$

$$= \frac{0,25\sqrt{25}}{400}$$

$$= 0,0031$$

$$\rho_{min2} = \frac{1,4}{f_y}$$

$$= \frac{1,4}{400}$$

$$= 0,0035$$

ρ_{min} yang digunakan adalah 0,0035

$\rho_{min} = 0,0035$	>	$\rho_{perlu} = 0,00096$	<	$\rho_{max} = 0,0203$

Gunakan $\rho_{perlu} = 0,0035$

As perlu $= \rho \cdot b_w \cdot d$

$= 0,0035 \cdot 250 \cdot 343,5 = 300,56\ mm^2$

Jumlah tulangan $= \frac{300,56}{0,25.\pi.13^2} = 2,26 \sim 3$ Batang

Digunakan tulangan utama 3 D-13 (As = 398,19 mm^2)

3. Penulangan Geser

$q_u = q_{u\ dl} + q_{u\ ll}$

= 36,0576 + 4,8 = 40,8576

V_U = 0,5 $q_{u\ dl}$. L+ 0,5 $q_{u\ ll}$. L

= (3 . 36,0576 . 0,5) + (3 . 4,8 . 0,5)

= 108,17 + 14,4

= 61,285

V_C = 1/6 $\sqrt{f'_c}$. b . d

= (1/6. $\sqrt{25}$. 250 . 343,5). 10^{-3} = 71,56 kN

Check :

$V_U > \phi\ V_C$ = 61,1989 > 0,75 . 71,56

= 61,285 > 53,67

gunakan tulangan geser

$V_S = \frac{V_U}{\phi}$

$= \frac{61,285}{0,75}$ = 81,71 kN

Digunakan tulangan P8

As_v = 2 . A_s

As_v = 2 . 0,25 . π . 8^2 = 100,5310 mm^2

$S = \frac{A_v . f_y . d}{V_s}$

$= \frac{100,5310.240.344}{81,71.10^3}$ = 101,42 mm

Menentukan spasi maksimum

Didalam sendi plastis

- spasi maksimum adalah $= d/4$

  $= 343{,}5/4 = 85{,}875$ mm

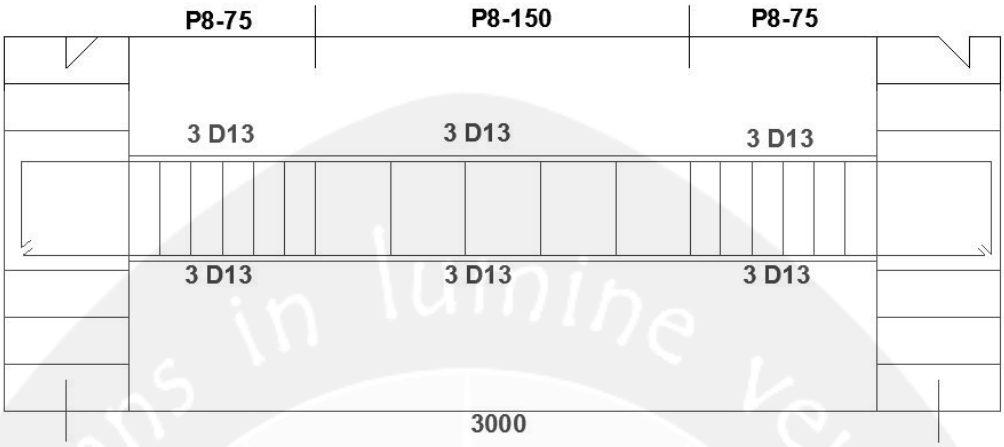
- 6 . D = 6. 13 = 78
- 150 mm
- Pilih 70 mm

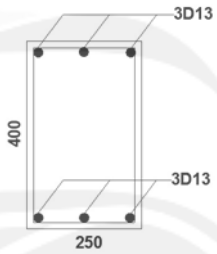
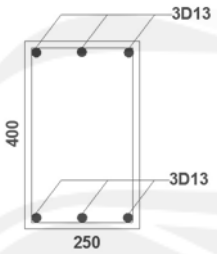
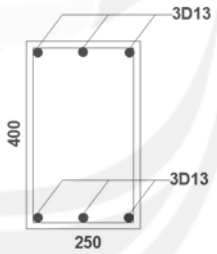
Maka digunakan tulangan geser 2P-8 – 75

Diluar sendi plastis

Smaks $= d/2 = 343{,}5/2$

= 171,75 Maka digunakan tulangan geser 2P8 – 150



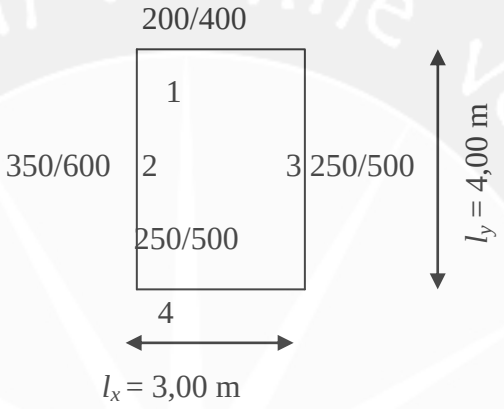
Balok	Bordes		
	Tump. Kanan	Tump. Kanan	Tump. Kanan
Penampang balok			
Tul. Atas	3 D13	3 D13	3 D13
Tul. Bawah	3 D13	3 D13	3 D13
Sengkang	2 P8-75	2 P8-150	2 P8-75
Mutu baja	Tulangan deform BJTD 40, Tulangan Polos BJTP 24		
Mutu Beton	Kuat tekan beton 25MPa,		

Gambar 3.5. Penulangan Balok Bordes

3.3. Perencanaan Pelat

3.3.1. Estimasi Tebal Pelat

Untuk menentukan tebal pelat minimum akan digunakan tebal pelat yang dapat mewakili tebal pelat pada seluruh lokasi pelat.



Gambar 3.6. Pelat Lantai

$$\beta = \frac{l_y}{l_x} = \frac{4{,}00}{3{,}00} = 1{,}33 \leq 2 \Rightarrow \text{ pelat 2 arah}$$

l_n arah l_y = 4,00 – 0,175 – 0,125 = 3,7 m

l_n arah l_x = 3,00 – 0,125 – 0,100 = 2,775 m

$$\beta\,(bentang\ bersih) = \frac{l_y}{l_x} = \frac{3{,}7}{2{,}775} = 1{,}33 < 2 \Rightarrow \text{ pelat 2 arah}$$

Direncanakan tebal pelat 120 mm.

Pemeriksaan tebal pelat berdasarkan syarat lendutan :

$$Ib_1 = \frac{1}{12} \times 20 \times 40^3 = 106666{,}6667\ cm^4$$

$$Ib_2 = \frac{1}{12} \times 35 \times 60^3 = 630000 cm^4$$

$$Ib_3 = lb_4 = \frac{1}{12} \times 25 \times 50^3 = 260416{,}667 cm^4$$

$$Is_1 = Is_4 = \frac{1}{12} \times 300 \times 12^3 = 43200\ cm^4$$

$$Is_2 = Is_3 = \frac{1}{12} \times 400 \times 12^3 = 57600\ cm^4$$

$$\alpha_1 = \frac{Ib_1}{Is_1} = \frac{106666{,}6667}{43200} = 2{,}4691$$

$$\alpha_2 = \frac{Ib_2}{Is_2} = \frac{630000}{57600} = 10{,}9375$$

$$\alpha_3 = \frac{Ib_3}{Is_3} = \frac{260416{,}667}{57600} = 4{,}5211$$

$$\alpha_4 = \frac{Ib_4}{Is_4} = \frac{260416{,}667}{43200} = 6{,}0281$$

$\alpha_{m\,=\,¼}(\alpha_{1\,+}\ \alpha_2 +\ \alpha_{3\,+}\ \alpha_4)$

= ¼ (2,4691 + 10,9375 + 4,5211 + 6,0281) = 5,.9889

$\alpha_{m\,=}\ 5{,}9889\ \geq 2$

Maka :

Syarat tebal pelat jika $\alpha_m \geq 2$:

Tebal pelat tidak boleh kurang dari :

$$h = \frac{ln(0{,}8 + \frac{f_y}{1400})}{36 + 9\beta}$$

dan tidak boleh kurang dari 90mm

$$h = \frac{3700(0{,}8 + \frac{240}{1400})}{36 + (9 \times 1{,}33)} = 74{,}92mm$$

120 mm >74,92 ….. OK !

3.3.2. Perencanaan Pelat Lantai

Pembebanan pada pelat lantai

Beban mati pada atap :

Pelat atap (12 cm)	= 0,12 . 24	= 2,88	$^{kN}/_{m^2}$
Finishing (spesi + water profing)		= 0,21	$^{kN}/_{m^2}$
Plafon dan penggantung		= 0,18	$^{kN}/_{m^2}$
ME dan AC		= 0,3	$^{kN}/_{m^2}$ +
		q_{mati} = 3,57	$^{kN}/_{m^2}$

Beban hujan pada atap : q_{hujan} = 0,03 . 10 kN/m^2 = 0,3 $^{kN}/_{m^2}$

Beban hidup pada atap : q_{hidup} = 1 $^{kN}/_{m^2}$

Beban mati pada tiap lantai

Pelat lantai (12 cm)	= 0,12 . 24	= 2,88	$^{kN}/_{m^2}$
Pasir urug (2 cm)	= 0,02 . 18	= 0,36	$^{kN}/_{m^2}$
Spesi (2 cm)	= 0,02 . 0,21	= 0,0042	$^{kN}/_{m^2}$
Tegel (2 cm)	= 0,02 . 0,24	= 0,0048	$^{kN}/_{m^2}$
Plafon dan penggantung		= 0,18	$^{kN}/_{m^2}$
ME dan AC		= 0,3	$^{kN}/_{m^2}$
		——————— +	
		q_{mati} = 3,729	$^{kN}/_{m^2}$

Beban hidup pada tiap lantai : q_{hidup} = 2,5 $^{kN}/_{m^2}$

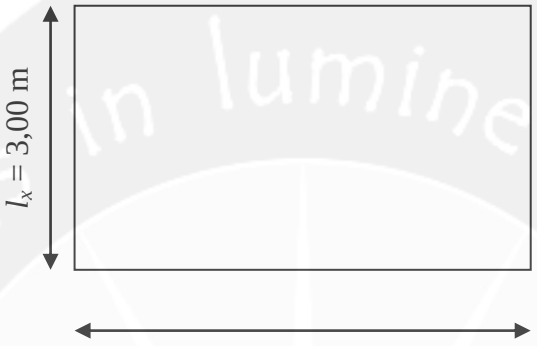
Diperoleh : q_{dl} atap = 3,86 $^{kN}/_{m^2}$

q_{ll} atap = 1,00 $^{kN}/_{m^2}$

q_r atap = 0,3 $^{kN}/_{m^2}$

q_{dl} lantai = 3,729 $^{kN}/_{m^2}$

q_{ll} lantai = 2,50 $^{kN}/_{m^2}$



Gambar 3. 7. Pelat Lantai 2 Arah

q_{dl} lantai = 3,729 $^{kN}/_{m^2}$

q_{ll} lantai = 2,50 $^{kN}/_{m^2}$

$W_u = 1{,}2\ q_d + 1{,}6\ q_l$

$W_u = 1{,}2 \cdot 3{,}729 + 1{,}6 \cdot 2{,}50$

$= 4{,}4748\ ^{kN}/_{m^2}$

$\frac{l_y}{l_x} = \frac{4}{3} = 1{,}33 \le 2{,}00 \Rightarrow$ pelat 2 arah

Berdasarkan Grafik dan Tabel Perhitungan Beton Bertulang (Kusuma, G. H. dan Vis, C. W., 1993), diperoleh :

$x_1 = 33{,}1$ $x_2 = 18{,}3$ $x_3 = 71{,}8$ $x_4 = 57$

$M_{lx} = 0{,}001 \cdot W_u \cdot l_x^2 \cdot x = 0{,}001 \cdot 4{,}4748 \cdot 3{,}0^2 \cdot 33{,}1 = 1{,}333$ kNm

$M_{ly} = 0{,}001 \cdot W_u \cdot l_x^2 \cdot x = 0{,}001 \cdot 4{,}4748 \cdot 3{,}0^2 \cdot 18{,}3 = 0{,}7369$ kNm

M_{tx} = 0,001 . W_u . t_x^2 . x = - 0,001 . 4,4748 . $3,0^2$ .71,8= -2,8916 kNm

M_{ty} = 0,001 . W_u . t_x^2 . x = - 0,001 . 4,4748 . $3,0^2$. 57 = -2,2955 kNm

Tebal pelat 120 mm, diameter tulangan utama 8 mm dan selimut beton 20 mm.

b = 1 m = 1000 mm

f'_c = 25 MPa f_y = 240 MPa

dx = tinggi efektif dalam arah sumbu x

= 120 – p – ½ . $\varnothing_x$ = 120 – 20 – ½ . 8 = 96 mm

dy = tinggi efektif dalam arah sumbu y

= 120 - p - $\varnothing_x$ – ½ . $\varnothing_y$ = 120 – 20 – 8 – ½ 8 =88 mm

Tulangan pelat

a. Momen tumpuan arah x

M_{tx} = 2,8916 kNm

b = 1 m

Syarat penulangan untuk komponen lentur

ρ_{min} = 0,002

$$\rho_b = \frac{0,85.f'_c.\beta}{f_y}.\frac{600}{600+f_y} = \frac{0,85.25.0,85}{240}.\frac{600}{600+240} = 0,0537$$

ρ_{max} = 0,75 . ρ_b = 0,75 . 0,0537 = 0,0402

$$R_{n\,perlu} = \frac{M_u}{\phi.b_w.d^2} = \frac{2,8916.10^{-3}}{0,9.1,0.0,096^2} = 0,3486\ {}^{kN}/_{m^2}$$

$$\rho_{perlu} = \frac{0,85.f'_c}{f_y}.\left[1-\sqrt{1-\frac{2.R_n}{0,85.f'_c}}\right] = \frac{0,85.25}{240}.\left[1-\sqrt{1-\frac{2.0,3486}{0,85.25}}\right]$$

= 0,00146

ρ_{min} = 0,002 > ρ = 0,00146 < ρ_{max} = 0,0402

karena $\rho < \rho_{min}$ maka digunakan $\rho_{min} = 0{,}002$

$A_{s\,min} = A_{s\,perlu} = \rho_{min} \,.\, b \,.\, h = 0{,}002 \,.\, 1000 \,.\, 120 = 240\ mm^2$

Digunakan tulangan P8, maka :

$$S = \frac{1000.0{,}25.\pi.8^2}{240} = 209{,}45\ mm \sim 200\ mm$$

Digunakan tulangan utama P8 - 200

$$A_{s\,pakai} = \frac{1000.0{,}25.\pi.8^2}{200} = 251{,}3\ mm$$

Check : As pakai > *As* perlu ..... Aman

b. Momen tumpuan arah y

$M_{tx} = 2{,}2955$ kNm

$b = 1$ m

Syarat penulangan untuk komponen lentur

$\rho_{min} = 0{,}002$

$$\rho_b = \frac{0{,}85.f'_c.\beta}{f_y}.\frac{600}{600+f_y} = \frac{0{,}85.25.0{,}85}{240}.\frac{600}{600+240} = 0{,}0537$$

$\rho_{max} = 0{,}75 \,.\, \rho_b = 0{,}75 \,.\, 0{,}0537 = 0{,}0402$

$$R_{n\,perlu} = \frac{M_u}{\phi.b_w.d^2} = \frac{2{,}2955.10^{-3}}{0{,}9.1{,}0.0{,}088^2} = 0{,}3293\ {}^{kN}/_{m^2}$$

$$\rho_{perlu} = \frac{0{,}85.f'_c}{f_y}.\left[1-\sqrt{1-\frac{2.R_n}{0{,}85.f'_c}}\right] = \frac{0{,}85.25}{240}.\left[1-\sqrt{1-\frac{2.0{,}3293}{0{,}85.25}}\right]$$

$= 0{,}001386$

$\rho_{min} = 0{,}002 > \rho = 0{,}00138 < \rho_{max} = 0{,}0402$

karena $\rho < \rho_{min}$ maka digunakan $\rho_{min} = 0{,}002$

$A_{s\,min} = A_{s\,perlu} = \rho_{min} . b . h = 0{,}002 . 1000 . 120 = 240\ mm^2$

Digunakan tulangan P8, maka :

$$S = \frac{1000.0{,}25.\pi.8^2}{240} = 209{,}45\ mm \sim 200\ mm$$

Digunakan tulangan utama P8 - 200

$$A_{s\,pakai} = \frac{1000.0{,}25.\pi.8^2}{200} = 251{,}3\ mm$$

Check : As pakai > *As* perlu ..... Aman

c. Momen lapangan arah x

$M_{lx} = 1{,}333$ kNm

$b = 1$ m

Syarat penulangan untuk komponen lentur

$\rho_{min} = 0{,}002$

$$\rho_b = \frac{0{,}85.f'_c.\beta}{f_y}.\frac{600}{600+f_y} = \frac{0{,}85.25.0{,}85}{240}.\frac{600}{600+240} = 0{,}0537$$

$\rho_{max} = 0{,}75 . \rho_b = 0{,}75 . 0{,}0537 = 0{,}0402$

$$R_{n\,perlu} = \frac{M_u}{\phi.b_w.d^2} = \frac{1{,}333.10^{-3}}{0{,}9.1{,}0.0{,}096^2} = 0{,}1607\ {}^{kN}/_{m^2}$$

$$\rho_{perlu} = \frac{0{,}85.f'_c}{f_y}.\left[1-\sqrt{1-\frac{2.R_n}{0{,}85.f'_c}}\right] = \frac{0{,}85.25}{240}.\left[1-\sqrt{1-\frac{2.0{,}1607}{0{,}85.25}}\right]$$

$= 0{,}000664$

$\rho_{min} = 0{,}002 > \rho = 0{,}00066 < \rho_{max} = 0{,}0402$

karena $\rho < \rho_{min}$ maka digunakan $\rho_{min} = 0{,}002$

$A_{s\,min} = A_{s\,perlu} = \rho_{min} . b . h = 0{,}002 . 1000 . 120 = 240\ mm^2$

Digunakan tulangan P8, maka :

$$S = \frac{1000.0{,}25.\pi.8^2}{240} = 209{,}45 \text{ mm} \sim 200 \text{ mm}$$

Digunakan tulangan utama P8 - 200

$$A_{s\ pakai} = \frac{1000.0{,}25.\pi.8^2}{200} = 251{,}3 \text{ mm}$$

Check : As pakai > *As* perlu ..... Aman

d. Momen lapangan arah y

$M_{ly} = 0{,}7369$ kNm

$b = 1$ m

Syarat penulangan untuk komponen lentur

$\rho_{min} = 0{,}002$

$$\rho_b = \frac{0{,}85.f'_c.\beta}{f_y}.\frac{600}{600+f_y} = \frac{0{,}85.25.0{,}85}{240}.\frac{600}{600+240} = 0{,}0537$$

$\rho_{max} = 0{,}75 \cdot \rho_b = 0{,}75 \cdot 0{,}0537 = 0{,}0402$

$$R_{n\ perlu} = \frac{M_u}{\phi.b_w.d^2} = \frac{0{,}7369.10^{-3}}{0{,}9.1{,}0.0{,}088^2} = 0{,}1057\ {}^{kN}/_{m^2}$$

$$\rho_{perlu} = \frac{0{,}85.f'_c}{f_y}.\left[1-\sqrt{1-\frac{2.R_n}{0{,}85.f'_c}}\right] = \frac{0{,}85.25}{240}.\left[1-\sqrt{1-\frac{2.0{,}1057}{0{,}85.25}}\right]$$

$= 0{,}00044$

$\rho_{min} = 0{,}002 > \rho = 0{,}00044 < \rho_{max} = 0{,}0402$

karena $\rho < \rho_{min}$ maka digunakan $\rho_{min} = 0{,}002$

$A_{s\ min} = A_{s\ perlu} = \rho_{min} \cdot b \cdot h = 0{,}002 \cdot 1000 \cdot 120 = 240 \text{ mm}^2$

Digunakan tulangan P8, maka :

$$S = \frac{1000.0{,}25.\pi.8^2}{240} = 209{,}45 \text{ mm} \sim 200 \text{ mm}$$

Digunakan tulangan utama P8 - 200

$$A_{s\ pakai} = \frac{1000.0{,}25.\pi.8^2}{200} = 251,3 \text{ mm}$$

Check : As pakai > *As* perlu ..... Aman

e. Tulangan susut

$As\ min = \rho_{min} \cdot b_w \cdot h$

$= 0{,}002 \cdot 1000 \cdot 120$

$= 240 \text{ mm}^2$

Digunakan tulangan P8

Jarak tulangan $S = \frac{1000.0{,}25.\pi.8^2}{240} = 209{,}43$ mm

Digunakan tulangan P10 – 200 ($As = 251{,}32 \text{ mm}^2$)

$$A_{s\ pakai} = \frac{1000.0{,}25.\pi.8^2}{200} = 251{,}32$$

Check syarat spasi maks

- Smaks < 3 h = 2 . 120 = 360
- Smaks < 450 mm

f. Kontrol geser

$W_u = 1{,}2 \cdot 3{,}729 + 1{,}6 \cdot 2{,}50$

$= 4{,}4748 \ {}^{kN}/_{m^2}$

dx = tinggi efektif dalam arah sumbu x

$= 120 - p - ½ \cdot \varnothing_x = 120 - 20 - ½ \cdot 8 = 96$ mm

$V_u = 0{,}5 \cdot Wu \cdot Lx$

$= 0{,}5 . 4{,}4748 . 3{,}00$

$= 6{,}71$

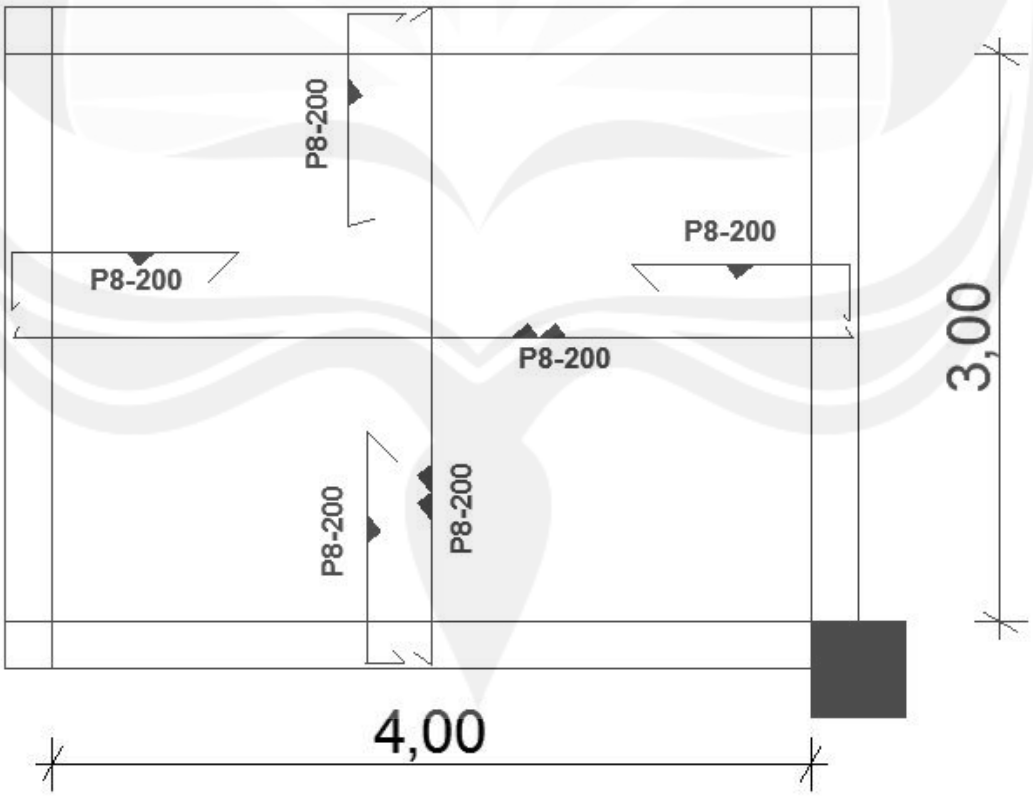
$V_C = 1/6 \sqrt{f'_c} \cdot b \cdot d$

$= (1/6. \sqrt{25} . 1000 . 0{,}96). 10^{-3}$

$= 80$ kN

$V_U < \phi V_C = 6{,}71 < 0{,}75 . 80$

$6{,}71 < 60$.....Aman



Gambar 3.8. Penulangan Plat Lantai

3.3.3. Perencanaan Pelat Atap

Gambar 3.9. Pelat atap 2 arah

q_{dl} atap = 3,57 $^{kN}/_{m^2}$

q_{ll} atap = 1,00 $^{kN}/_{m^2}$

q_r atap = 0,30 $^{kN}/_{m^2}$

$W_u = 1{,}2\ q_d + 1{,}6\ q_l + 0{,}5 q_r$

$W_u = 1{,}2 \cdot 3{,}57 + 1{,}6 \cdot 1{,}00 + 0{,}5.0{,}3$

$= 6{,}034\ ^{kN}/_{m^2}$

$\frac{l_y}{l_x} = \frac{4}{3} = 1{,}33 \le 2{,}00 \Rightarrow$ pelat 2 arah

Berdasarkan Grafik dan Tabel Perhitungan Beton Bertulang (Kusuma, G. H. dan Vis, C. W., 1993), diperoleh :

$x_1 = 33{,}1$ $x_2 = 18{,}3$ $x_3 = 71{,}8$ $x_4 = 57$

$M_{lx} = 0{,}001 \cdot W_u \cdot l_x^2 \cdot x = 0{,}001 \cdot 6{,}034 \cdot 3{,}0^2 \cdot 33{,}1 = 1{,}7975$ kNm

$M_{ly} = 0{,}001 \cdot W_u \cdot l_x^2 \cdot x = 0{,}001 \cdot 6{,}034 \cdot 3{,}0^2 \cdot 18{,}3 = 0{,}9937$ kNm

$M_{tx} = 0{,}001 \cdot W_u \cdot t_x^2 \cdot x = -0{,}001 \cdot 6{,}034 \cdot 3{,}0^2 \cdot 71{,}8 = -3{,}8991$ kNm

$M_{ty} = 0{,}001 \cdot W_u \cdot t_x^2 \cdot x = -0{,}001 \cdot 6{,}034 \cdot 3{,}0^2 \cdot 57 = -3{,}0954$ kNm

Tebal pelat 120 mm, diameter tulangan utama 8 mm dan selimut beton 20 mm.

b = 1 m = 1000 mm

f'_c = 25 MPa f_y = 240 MPa

dx = tinggi efektif dalam arah sumbu x

= 120 – p – ½ . $\varnothing_x$ = 120 – 20 – ½ . 8 = 96 mm

dy = tinggi efektif dalam arah sumbu y

= 120 - p - $\varnothing_x$ – ½ . $\varnothing_y$ = 120 – 20 – 8 – ½ 8 =88 mm

Tulangan pelat

a. Momen tumpuan arah x

M_{tx} = 3,8991 kNm

b = 1 m

Syarat penulangan untuk komponen lentur

ρ_{min} = 0,002

$$\rho_b = \frac{0{,}85.f'_c.\beta}{f_y}.\frac{600}{600+f_y} = \frac{0{,}85.25.0{,}85}{240}.\frac{600}{600+240} = 0{,}0537$$

ρ_{max} = 0,75 . ρ_b = 0,75 . 0,0537 = 0,0402

$$R_{n\,perlu} = \frac{M_u}{\phi.b_w.d^2} = \frac{3{,}8991.10^{-3}}{0{,}9.1{,}0.0{,}096^2} = 0{,}47\ {}^{kN}/_{m^2}$$

$$\rho_{perlu} = \frac{0{,}85.f'_c}{f_y}.\left[1-\sqrt{1-\frac{2.R_n}{0{,}85.f'_c}}\right] = \frac{0{,}85.25}{240}.\left[1-\sqrt{1-\frac{2.0{,}47}{0{,}85.25}}\right]$$

= 0,00197

ρ_{min} = 0,002 > ρ = 0,00197 < ρ_{max} = 0,0402

karena ρ < ρ_{min} maka digunakan ρ_{min} = 0,002

$A_{s\,min}$ = $A_{s\,perlu}$ = ρ_{min} . b . h = 0,002 . 1000 . 120 = 240 mm^2

Digunakan tulangan P8, maka :

$$S = \frac{1000.0{,}25.\pi.8^2}{240} = 209{,}45 \text{ mm} \sim 200 \text{ mm}$$

Digunakan tulangan utama P8 - 200

$$A_{s\ pakai} = \frac{1000.0{,}25.\pi.8^2}{200} = 251{,}3 \text{ mm}$$

Check : As pakai > *As* perlu ..... Aman

b. Momen tumpuan arah y

$M_{ty} = 3{,}2739$ kNm

$b = 1$ m

Syarat penulangan untuk komponen lentur

$\rho_{min} = 0{,}002$

$$\rho_b = \frac{0{,}85.f'_c.\beta}{f_y}.\frac{600}{600+f_y} = \frac{0{,}85.25.0{,}85}{240}.\frac{600}{600+240} = 0{,}0537$$

$\rho_{max} = 0{,}75 \cdot \rho_b = 0{,}75 \cdot 0{,}0537 = 0{,}0402$

$$R_{n\ perlu} = \frac{M_u}{\phi.b_w.d^2} = \frac{3{,}2739.10^{-3}}{0{,}9.1{,}0.0{,}088^2} = 0{,}4697\ {}^{kN}/_{m^2}$$

$$\rho_{perlu} = \frac{0{,}85.f'_c}{f_y}.\left[1-\sqrt{1-\frac{2.R_n}{0{,}85.f'_c}}\right] = \frac{0{,}85.25}{240}.\left[1-\sqrt{1-\frac{2.0{,}4697}{0{,}85.25}}\right]$$

$= 0{,}00197$

$\rho_{min} = 0{,}002 > \rho = 0{,}00197 < \rho_{max} = 0{,}0402$

karena $\rho < \rho_{min}$ maka digunakan $\rho_{min} = 0{,}002$

$A_{s\ min} = A_{s\ perlu} = \rho_{min} \cdot b \cdot h = 0{,}002 \cdot 1000 \cdot 120 = 240 \text{ mm}^2$

Digunakan tulangan P8, maka :

$$S = \frac{1000.0{,}25.\pi.8^2}{240} = 209{,}45 \text{ mm} \sim 200 \text{ mm}$$

Digunakan tulangan utama P8 - 200

$$A_{s\ pakai} = \frac{1000.0{,}25.\pi.8^2}{200} = 251{,}3 \text{ mm}$$

Check : As pakai > *As* perlu ..... Aman

c. Momen lapangan arah x

M_{lx} = 1,7975 kNm

b = 1 m

Syarat penulangan untuk komponen lentur

ρ_{min} = 0,002

$$\rho_b = \frac{0{,}85.f'_c.\beta}{f_y}.\frac{600}{600+f_y} = \frac{0{,}85.25.0{,}85}{240}.\frac{600}{600+240} = 0{,}0537$$

ρ_{max} = 0,75 . ρ_b = 0,75 . 0,0537 = 0,0402

$$R_{n\ perlu} = \frac{M_u}{\phi.b_w.d^2} = \frac{1{,}7975\ .10^{-3}}{0{,}9.1{,}0.0{,}096^2} = 0{,}2167\ {}^{kN}/_{m^2}$$

$$\rho_{perlu} = \frac{0{,}85.f'_c}{f_y}.\left[1-\sqrt{1-\frac{2.R_n}{0{,}85.f'_c}}\right] = \frac{0{,}85.25}{240}.\left[1-\sqrt{1-\frac{2.0{,}2167}{0{,}85.25}}\right]$$

= 0,00090

ρ_{min} = 0,002 > ρ = 0,00095 < ρ_{max} = 0,0402

karena ρ < ρ_{min} maka digunakan ρ_{min} = 0,002

$A_{s\ min} = A_{s\ perlu} = \rho_{min}$. b . h = 0,002 . 1000 . 120 = 240 mm^2

Digunakan tulangan P8, maka :

$$S = \frac{1000.0{,}25.\pi.8^2}{240} = 209{,}45 \text{ mm} \sim 200 \text{ mm}$$

Digunakan tulangan utama P8 - 200

$$A_{s\ pakai} = \frac{1000.0{,}25.\pi.8^2}{200} = 251{,}3 \text{ mm}$$

Check : As pakai > *As* perlu ..... Aman

d. Momen lapangan arah y

M_{ly} = 1,0511 kNm

b = 1 m

Syarat penulangan untuk komponen lentur

ρ_{min} = 0,002

$$\rho_b = \frac{0{,}85.f'_c.\beta}{f_y}.\frac{600}{600+f_y} = \frac{0{,}85.25.0{,}85}{240}.\frac{600}{600+240} = 0{,}0537$$

ρ_{max} = 0,75 . ρ_b = 0,75 . 0,0537 = 0,0402

$$R_{n\ perlu} = \frac{M_u}{\phi.b_w.d^2} = \frac{1{,}0511.10^{-3}}{0{,}9.1{,}0.0{,}088^2} = 0{,}1508\ {}^{kN}/_{m^2}$$

$$\rho_{perlu} = \frac{0{,}85.f'_c}{f_y}.\left[1-\sqrt{1-\frac{2.R_n}{0{,}85.f'_c}}\right] = \frac{0{,}85.25}{240}.\left[1-\sqrt{1-\frac{2.0{,}1508}{0{,}85.25}}\right]$$

= 0,00063

ρ_{min} = 0,002 > ρ = 0,00063 < ρ_{max} = 0,0402

karena ρ < ρ_{min} maka digunakan ρ_{min} = 0,002

$A_{s\ min} = A_{s\ perlu}$ = ρ_{min} . b . h = 0,002 . 1000 . 120 = 240 mm^2

Digunakan tulangan P8, maka :

$$S = \frac{1000.0{,}25.\pi.8^2}{240} = 209{,}45 \text{ mm} \sim 200 \text{ mm}$$

Digunakan tulangan utama P8 - 200

$$A_{s\ pakai} = \frac{1000.0{,}25.\pi.8^2}{200} = 251{,}3 \text{ mm}$$

Check : As pakai > *As* perlu ..... Aman

e. Tulangan susut

$As\ min = \rho_{min} \cdot b_w \cdot h$

$= 0{,}002 \cdot 1000 \cdot 120$

$= 240 \text{ mm}^2$

Digunakan tulangan P8

Jarak tulangan $S = \frac{1000.0{,}25.\pi.8^2}{240} = 209{,}43$ mm

Digunakan tulangan P8 – 200 ($As = 251{,}32 \text{ mm}^2$)

$$A_{s\ pakai} = \frac{1000.0{,}25.\pi.8^2}{200} = 251{,}32$$

Check syarat spasi maks

- Smaks < 3 h = 2 . 120 = 360
- Smaks < 450 mm

f. Kontrol geser

$W_u = 1{,}2 \cdot 3{,}57 + 1{,}6 \cdot 1{,}00 + 0{,}5.0{,}3$

$= 6{,}034\ {}^{kN}/_{m^2}$

dx = tinggi efektif dalam arah sumbu x

$= 120 - p - ½ \cdot \varnothing_x = 120 - 20 - ½ \cdot 8 = 96$ mm

$V_u = 0{,}5 \cdot Wu \cdot Lx$

$= 0{,}5 . 6{,}034 . 3{,}00$

$= 9{,}051$

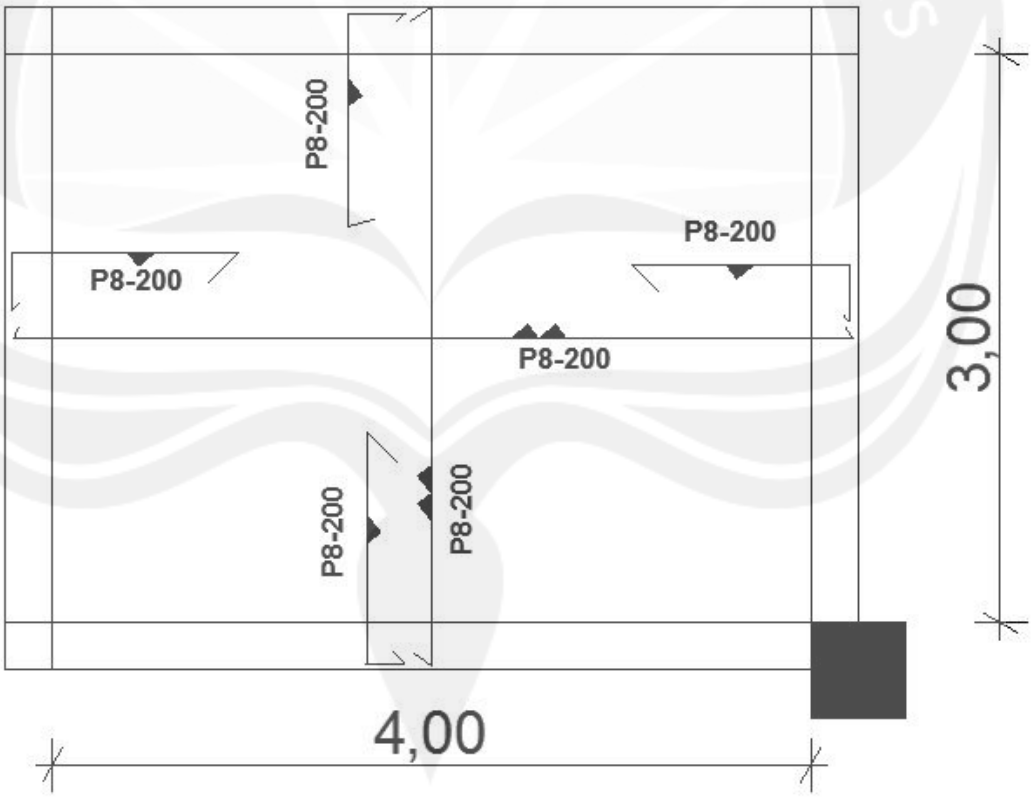
$V_C = 1/6 \sqrt{f'_c} \cdot b \cdot d$

$= (1/6 . \sqrt{25} . 1000 . 0{,}96) . 10^{-3}$

$= 80$ kN

$V_U < \phi V_C = 9{,}573 < 0{,}75 . 80$

$9{,}0513 < 60$.....



Gambar 3.10. Penulangan Plat Atap