

I. PERHITUNGAN PLAT

A. PLAT ATAP

1. Penentuan Tebal Plat Atap

Syarat batas tebal plat (h) adalah ($h_{\min} < h < h_{\max}$) berdasarkan syarat lendutan

Direncanakan Mutu Beton $f_c' = 30 \text{ Mpa}$ ($\beta_1 = 0,85$)

Mutu Baja $f_y' = 240 \text{ Mpa}$

a) Tinjau Tipe Plat I

$$l_n = 4 \text{ m}$$

$$\beta = l_y/l_x = 4/3$$

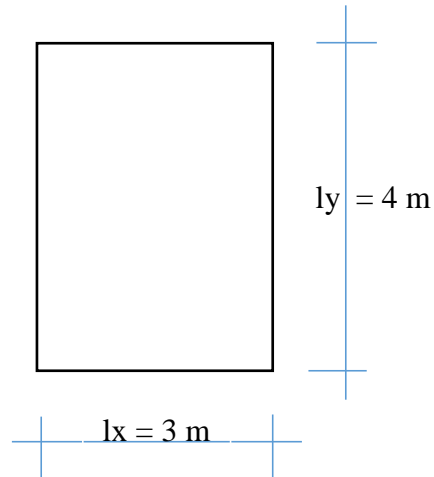
$$= 1,33$$

$$h_{\min} > \frac{0,8 + \frac{f_y}{1500}}{36 + 9\beta} \times l_n$$

$$\frac{0,8 + \frac{240}{1500}}{36 + 9 \times 1,33} \times 4 = 0,08 \text{ m}$$

$$h_{\max} < \frac{0,8 + \frac{f_y}{1500}}{36} \times l_n$$

$$\frac{0,8 + \frac{240}{1500}}{36} \times 4 = 0,11 \text{ m}$$



Tabel Perhitungan Tebal Plat Atap

Tabel Tebal Plat Atap						
Tipe plat	ly(m)	lx (m)	ln	β	h min (m)	h max (m)
I	4.00	3.00	4.00	1.33	0.08	0.11
II	4.00	2.00	4.00	2.00	0.07	0.11
III	2.00	2.00	2.00	1.00	0.04	0.05
IV	3.00	2.00	3.00	1.50	0.06	0.08
rata-rata					0.07	0.09
tebal plat diambil syarat minimal					0.10	

Jadi untuk tebal plat atap dipilih syarat minimal yaitu = 10 cm

2. Pembebanan Plat Atap

beban mati (WD)

Brt. plat (bj.beton*tbl plat = $2.400 \text{ kg/m}^3 * 0,10 \text{ m}$)	240.00	kg/m ²
Lapisan waterproof	2.00	kg/m ²
Brt. plafond + penggantung ($11 + 7 \text{ kg/m}^2$)	18.00	kg/m ²
total WD	260.00	kg/m ²

beban hidup (WL)

Beban atap sesuai SNI	100.00	kg/m ²
Brt. air hujan (Bj.air * tbl. Maks genangan = $1.000 \text{ kg/m}^3 * 0,03 \text{ m}$)	30.00	kg/m ²
total WL	130.00	kg/m ²

- $WU = 1,2*WD + 1,6*WL$

$$= 1,2 \cdot 260 + 1,6 \cdot 130 = 520 \text{ kg/m}^2$$

$$= 5,2 \text{ kN/m}^2$$

3. Perencanaan Tulangan Plat Atap

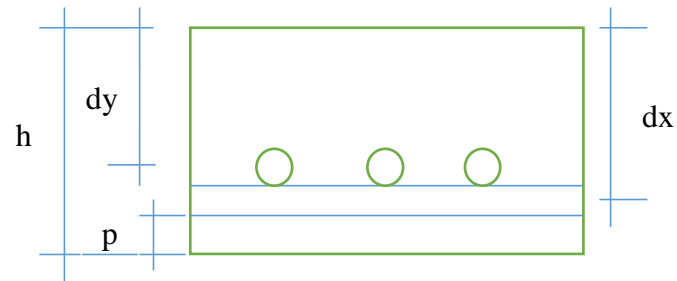
- Tebal plat (h) = 0,1 m = 100 mm
- WU Atap = 5,2 kN/m²
- Direncanakan Diameter Tulangan Ø D = 8 mm
- Selimut beton (p) = 20 mm
- Tinggi Efektif

$$\text{Arah sumbu x (dx)} = h - p - 1/2 \text{ØD}_x$$

$$= 100 - 20 - 1/2 \cdot 8 = 76 \text{ mm}$$

$$\text{Arah sumbu y (dy)} = h - p - \text{ØD}_x - 1/2 \text{ØD}_y$$

$$= 100 - 20 - 8 - 1/2 \cdot 8 = 68 \text{ mm}$$



a. Tinjau Plat Tipe I

$$l_y/l_x = 4/3$$

$$= 1,33 \text{ (lihat tabel penyaluran beban berdasarkan metode amplop) didapat } Cl_x = 38$$

$$Ctx = 67,5$$

$$Cly = 20 \quad Cty = 54,5$$

Tabel penyaluran beban plat atap berdasarkan metode amplop

tipe plat	ly/lx	Clx	Cly	Ctx	Cty
I	1.33	38.00	20.00	67.50	54.50
II	2.00	58.00	15.00	82.00	53.00
III	1.00	25.00	25.00	51.00	51.00
IV	1.50	45.50	16.50	76.50	54.50

Moment per meter lebar tipe plat I

- $M_{lx} = 0,001 * W_u * l_x^2 * C_{lx} = 0,001 * 5,2 * 3^2 * 38 = 1,78 \text{ kN m}$
- $M_{ly} = 0,001 * W_u * l_x^2 * C_{ly} = 0,001 * 5,2 * 3^2 * 20 = 0,94 \text{ kN m}$
- $M_{tx} = -0,001 * W_u * l_x^2 * C_{tx} = -0,001 * 5,2 * 3^2 * 67,5 = -3,16 \text{ kN m}$
- $M_{ty} = -0,001 * W_u * l_x^2 * C_{ty} = -0,001 * 5,2 * 3^2 * 54,5 = -2,55 \text{ kN m}$

Tabel perhitungan moment per meter lebar plat atap

Tipe plat	Moment (kN m)			
	lx	ly	tx	ty
I	1.78	0.94	-3.16	-2.55
II	1.21	0.31	-1.71	-1.10
III	0.52	0.52	-1.06	-1.06
IV	0.95	0.34	-1.59	-1.13

Moment maximum $M_{ux} = 1.78 \text{ kN m}$

$M_{uy} = 0.94 \text{ kN m}$

$$M_{tx} = 3.16 \text{ kN m}$$

$$M_{ty} = 2.55 \text{ kN m}$$

- $M_{nx} = M_{tx} / \Phi = 1.78 / 0.8 = 2.22 \text{ kN m}$
- $M_{ny} = M_{ty} / \Phi = 0.94 / 0.8 = 1.17 \text{ kN m}$
- $M_{tx} = M_{tx} / \Phi = 3.16 / 0.8 = 3.95 \text{ kN m}$
- $M_{ty} = M_{ty} / \Phi = 2.55 / 0.8 = 3.19 \text{ kN m}$

- $$R_{nx} = \frac{M_{nx}}{b \cdot d x^2}$$

$$= \frac{2.22 \times 10^6 \text{ N mm}}{1000 \times 76^2} = 0.38 \text{ N/mm}^2$$

- $$R_{ny} = \frac{M_{ny}}{b \cdot d y^2}$$

$$= \frac{1.17 \times 10^6 \text{ N mm}}{1000 \times 68^2} = 0.25 \text{ N/mm}^2$$

- $$R_{tx} = \frac{M_{tx}}{b \cdot d x^2}$$

$$= \frac{3.95 \times 10^6 \text{ N mm}}{1000 \times 76^2} = 0.68 \text{ N/mm}^2$$

- $$R_{ty} = \frac{M_{ty}}{b \cdot d y^2}$$

$$= \frac{3.19 \times 10^6 \text{ N mm}}{1000 \times 68^2} = 0.69 \text{ N/mm}^2$$

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

$$= 9,41$$

$$\begin{aligned} \text{➤ } \rho \text{ perlu lx} &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot Rnlx}{fy}} \right) \\ &= \frac{1}{9,41} \left(1 - \sqrt{1 - \frac{2 \cdot 9,41 \cdot 0,38}{240}} \right) = 0,0016 \end{aligned}$$

$$\begin{aligned} \text{➤ } \rho \text{ perlu ly} &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot Rnly}{fy}} \right) \\ &= \frac{1}{9,41} \left(1 - \sqrt{1 - \frac{2 \cdot 9,41 \cdot 0,25}{240}} \right) = 0,0011 \end{aligned}$$

$$\begin{aligned} \text{➤ } \rho \text{ perlu tx} &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot Rntx}{fy}} \right) \\ &= \frac{1}{9,41} \left(1 - \sqrt{1 - \frac{2 \cdot 9,41 \cdot 0,68}{240}} \right) = 0,0029 \end{aligned}$$

$$\begin{aligned} \text{➤ } \rho \text{ perlu ty} &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot Rnty}{fy}} \right) \\ &= \frac{1}{9,41} \left(1 - \sqrt{1 - \frac{2 \cdot 9,41 \cdot 0,69}{240}} \right) = 0,0029 \end{aligned}$$

$$\rho_{\min} = 1,4 / f_y'$$

$$= 1,4 / 240 = 0,0058$$

$$\rho_{\max} = 0,75 * \frac{(0,85 * f_c' * \beta_1)}{f_y'} * \left(\frac{600}{600 + f_y'} \right)$$

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

Syarat ($\rho_{\min} < \rho_{\text{perlu}} < \rho_{\max}$) karena ρ_{perlu} kurang dari ρ_{\min} , maka ρ yang digunakan adalah ρ_{\min} yaitu = 0,0058 untuk menghitung luas tulangan

$$\circ A_{slx} = \rho_{\min} * b * d_x = 0,0058 * 1000 * 76 = 443,33 \text{ mm}^2$$

$$\circ A_{sly} = \rho_{\min} * b * d_y = 0,0058 * 1000 * 68 = 396,67 \text{ mm}^2$$

$$\circ A_{stx} = \rho_{\min} * b * d_x = 0,0058 * 1000 * 76 = 443,33 \text{ mm}^2$$

$$\circ A_{sty} = \rho_{\min} * b * d_y = 0,0058 * 1000 * 68 = 396,67 \text{ mm}^2$$

Jarak antar tulangan

$$\circ S_{lx} = \frac{0,25 * \pi * \emptyset^2 * 1000}{A_{slx}} = \frac{0,25 * 3,14 * 8^2 * 1000}{443,33} = 113,32 \text{ mm} \approx 100 \text{ mm}$$

$$\circ S_{ly} = \frac{0,25 * \pi * \emptyset^2 * 1000}{A_{sly}} = \frac{0,25 * 3,14 * 8^2 * 1000}{396,67} = 126,66 \text{ mm} \approx 100 \text{ mm}$$

$$\circ S_{tx} = S_{lx} = 100 \text{ mm}$$

$$\circ S_{ty} = S_{ly} = 100 \text{ mm}$$

Dari hasil perhitungan ditentukan untuk tulangan plat atap daerah

- $l_x = \emptyset 8 - 100 \text{ mm}$ ($A_{st} = 503 \text{ mm}^2$)
- $l_y = \emptyset 8 - 100 \text{ mm}$ ($A_{st} = 503 \text{ mm}^2$)
- $t_x = \emptyset 8 - 100 \text{ mm}$ ($A_{st} = 503 \text{ mm}^2$)
- $t_y = \emptyset 8 - 100 \text{ mm}$ ($A_{st} = 503 \text{ mm}^2$)

B. PLAT LANTAI DUA

1. Penentuan Tebal Plat Lantai Dua

Syarat tebal minimal untul plat lantai dua adalah 12 cm

Digunakan Beton $f_c' = 30 \text{ MPa}$ ($\beta_1 = 0,85$)

Baja $f_y' = 240 \text{ Mpa}$

a) Tinjau Tipe Plat I

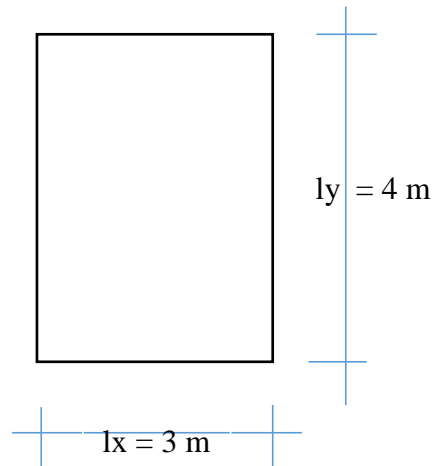
$$l_n = l_y = 4 \text{ m}$$

$$\beta = l_y/l_x = 4/3$$

$$= 1,33$$

$$h_{\min} > \frac{0,8 + \frac{f_y}{1500}}{36 + 9\beta} \times l_n$$

$$\frac{0,8 + \frac{240}{1500}}{36 + 9 \times 1,33} \times 4 = 0,08 \text{ m}$$



$$h_{\max} < \frac{0,8 + \frac{fy}{1500}}{36} \times l_n$$

$$\frac{0,8 + \frac{240}{1500}}{36} \times 4 = 0,11 \text{ m}$$

Tabel hasil perhitungan penentuan tebal plat lantai dua

Hasil perhitungan tebal plat lantai 2						
plat	ly (m)	lx (m)	ln	β	h min (m)	h max (m)
I	4.00	3.00	4.00	1.33	0.08	0.11
II	4.00	.00	4.00	2.00	0.07	0.11
III	2.00	2.00	2.00	1.00	0.04	0.05
IV	2.00	rata-rata	2.00	2.00	0.04	0.05
					0.06	tebal plat diambil

		syarat minimal
	0.12	

Dari hasil perhitungan dengan h min 6 cm dan h maks 8 cm sudah mencukupi, tetapi terlalu tipis maka untuk tebal plat lantai dua diambil syarat minimum yaitu = 12 cm

2. Pembebanan Pada Plat Lantai Dua

Beban Mati (WD)

Brt. plat (bj.beton*tbl plat = $2.400 \text{ kg/m}^3 * 0,12 \text{ m}$)	288.00	kg/m ²
Brt. finishing plat + keramik	21.00	kg/m ²
Brt. plafond + penggantung (11 + 7 kg/m ²)	18.00	kg/m ²
total WD	327.00	kg/m ²

Beban Hidup (WL)

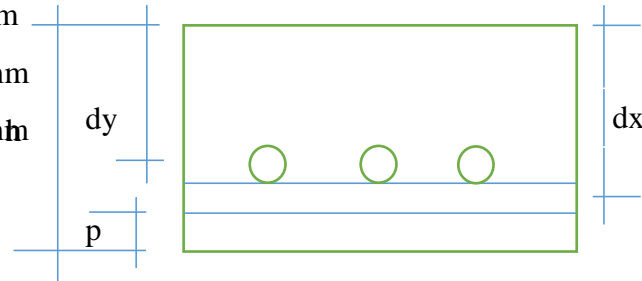
Beban lantai menurut SNI	250.00	kg/m ²
total WL	250.00	kg/m ²

- WU lantai dua = 1,2 WD + 1,6 WL

$$\begin{aligned}
 &= 1,2 * 327 + 1,6 * 250 &&= 792,4 \text{ kg/m}^2 \\
 &&&= 7,924 \text{ Kn/m}^2
 \end{aligned}$$

3. Perencanaan Tulangan Plat Lantai Dua

- tebal plat (h) = 12 cm
- diameter tulangan (ØD) = 8 mm
- selimut beton (p) = 20 mm
- Tinggi Efektif



$$\begin{aligned} \text{Arah sumbu x (dx)} &= h - p - 1/2\text{ØD}_x \\ &= 120 - 20 - 1/2 \cdot 8 = 96 \text{ mm} \end{aligned}$$

$$\begin{aligned} \text{Arah sumbu y (dy)} &= h - p - \text{ØD}_x - 1/2\text{D}_y \\ &= 120 - 20 - 8 - 1/2 \cdot 8 = 88 \text{ mm} \end{aligned}$$

a. Tinjau Plat Tipe I

$$l_y/l_x = 4/3$$

= 1,33 (lihat tabel penyaluran beban berdasarkan metode amplop)

Untuk tipe plat I didapat $Cl_x = 38$ $Ctx = 67,5$

$Cly = 20$ $Cty = 54,5$

Table penyaluran beban plat lantai dua berdasarkan metode amplop

tipe plat	l_y/l_x	Cl_x	Cly	Ctx	Cty
I	1.33	38.00	20.00	67.50	54.50
II	2.00	58.00	15.00	82.00	53.00
III	1.00	25.00	25.00	51.00	51.00
IV	2.00	58.00	15.00	82.00	53.00

Moment per meter lebar tipe plat I

- $M_{lx} = 0,001 * W_u * l_x^2 * C_{lx} = 0,001 * 7,924 * 3^2 * 38 = 2.71 \text{ kN m}$
- $M_{ly} = 0,001 * W_u * l_x^2 * C_{ly} = 0,001 * 7,924 * 3^2 * 20 = 1.43 \text{ kN m}$
- $M_{tx} = -0,001 * W_u * l_x^2 * C_{tx} = -0,001 * 7,924 * 3^2 * 67,5 = -4.81 \text{ kN m}$
- $M_{ty} = -0,001 * W_u * l_x^2 * C_{ty} = -0,001 * 7,924 * 3^2 * 54,5 = -3.89 \text{ kN m}$

Table perhitungan moment per meter lebar plat lantai dua

Tipe Plat	Moment (kN m)			
	Lx	ly	tx	ty
I	2.71	1.43	-4.81	-3.89
II	1.84	0.48	-2.60	-1.68
III	0.79	0.79	-1.62	-1.62
IV	0.46	0.12	-0.65	-0.42

Moment maximum

$M_{ulx} = 2.71 \text{ kN m}$

$M_{uly} = 1.43 \text{ kN m}$

$M_{utx} = 4.81 \text{ kN m}$

$M_{uty} = 3.89 \text{ kN m}$

- $M_{nlx} = M_{ulx} / \Phi = 2.71 / 0,8 = 3,39 \text{ kN m}$
- $M_{nly} = M_{uly} / \Phi = 1.43 / 0,8 = 1,78 \text{ kN m}$
- $M_{ntx} = M_{utx} / \Phi = 4.81 / 0,8 = 6,02 \text{ kN m}$
- $M_{nty} = M_{uty} / \Phi = 3.89 / 0,8 = 4,86 \text{ kN m}$

$$\begin{aligned}
 \bullet \quad R_{nlx} &= \frac{M_{nlx}}{b * d x^2} \\
 &= \frac{3,39 \times 10^6 \text{ N mm}}{1000 \times 96^2} = 0,37 \text{ N/mm}^2
 \end{aligned}$$

- $R_{nly} = \frac{M_{nly}}{b \cdot d y^2}$
 $= \frac{1,78 \times 10^6 \text{ N mm}}{1000 \times 88^2} = 0,23 \text{ N/mm}^2$

- $R_{ntx} = \frac{M_{ntx}}{b \cdot d x^2}$
 $= \frac{6,02 \times 10^6 \text{ N mm}}{1000 \times 96^2} = 0,65 \text{ N/mm}^2$

- $R_{nty} = \frac{M_{nty}}{b \cdot d y^2}$
 $= \frac{4,86 \times 10^6 \text{ N mm}}{1000 \times 88^2} = 0,63 \text{ N/mm}^2$

$$m = \frac{f_{y'}}{0,85 \times f_{c'}} = \frac{240}{0,85 \times 30}$$

$$= 9,41$$

➤ $\rho \text{ perlu lx} = \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot R_{nlx}}{f_y}} \right)$

$$= \frac{1}{9,41} \left(1 - \sqrt{1 - \frac{2 \cdot 9,41 \cdot 0,37}{240}} \right) = 0,0015$$

➤ $\rho \text{ perlu ly} = \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot R_{nly}}{f_y}} \right)$

$$= \frac{1}{9,41} \left(1 - \sqrt{1 - \frac{2*9,41*0,23}{240}} \right) = 0,0010$$

$$\text{➤ } \rho \text{ perlu tx} = \frac{1}{m} \left(1 - \sqrt{1 - \frac{2*m*Rntx}{fy}} \right)$$

$$= \frac{1}{9,41} \left(1 - \sqrt{1 - \frac{2*2,41*0,65}{240}} \right) = 0,0028$$

$$\text{➤ } \rho \text{ perlu ty} = \frac{1}{m} \left(1 - \sqrt{1 - \frac{2*m*Rnty}{fy}} \right)$$

$$= \frac{1}{9,41} \left(1 - \sqrt{1 - \frac{2*9,41*0,63}{240}} \right) = 0,0026$$

$$\rho \text{ min} = 1,4 / f_y'$$

$$= 1,4 / 240 = 0,0058$$

$$\rho \text{ max} = 0,75 * \frac{(0,85*f_c' * \beta_1)}{f_y'} * \left(\frac{600}{600+f_y'} \right)$$

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

Syarat ($\rho \text{ min} < \rho \text{ perlu} < \rho \text{ max}$) karena $\rho \text{ perlu}$ kurang dari $\rho \text{ min}$ maka, ρ yang digunakan adalah $\rho \text{ min}$ yaitu = 0,0058 untuk menghitung luas tulangan plat lantai dua

$$\circ \text{ Aslx} = \rho \text{ min} * b * dx = 0,0058 * 1000 * 96 = 560,00 \text{ mm}^2$$

$$\circ \text{ Asly} = \rho \text{ min} * b * dy = 0,0058 * 1000 * 88 = 513,33 \text{ mm}^2$$

$$\circ A_{stx} = \rho_{min} * b * d_x = 0,0058 * 1000 * 96 = 560,00 \text{ mm}^2$$

$$\circ A_{sty} = \rho_{min} * b * d_y = 0,0058 * 1000 * 88 = 513,33 \text{ mm}^2$$

Jarak antar tulangan

$$\circ S_{lx} = \frac{0,25 * \pi * \emptyset^2 * 1000}{A_{slx}} = \frac{0,25 * 3,14 * 8^2 * 1000}{451,2} = 89,71 \text{ mm} \approx 75 \text{ mm}$$

$$\circ S_{ly} = \frac{0,25 * \pi * \emptyset^2 * 1000}{A_{sly}} = \frac{0,25 * 3,14 * 8^2 * 1000}{413,6} = 97,87 \text{ mm} \approx 75 \text{ mm}$$

$$\circ S_{tx} = S_{lx} = 75 \text{ mm}$$

$$\circ S_{ty} = S_{ly} = 75 \text{ mm}$$

Dari hasil perhitungan ditentukan untuk tulangan plat lantai dua daerah

- $L_x = \emptyset 8 - 75 \text{ mm} (A_{st} = 670 \text{ mm}^2)$
- $L_y = \emptyset 8 - 75 \text{ mm} (A_{st} = 670 \text{ mm}^2)$
- $T_x = \emptyset 8 - 75 \text{ mm} (A_{st} = 670 \text{ mm}^2)$
- $T_y = \emptyset 8 - 75 \text{ mm} (A_{st} = 670 \text{ mm}^2)$