



BAB 1

PENDAHULUAN

1.1. Latar Belakang

Pesatnya perkembangan dunia teknik sipil menuntut bangsa Indonesia untuk dapat menghadapi segala kemajuan dan tantangan. Hal itu dapat terpenuhi apabila sumber daya yang dimiliki oleh bangsa Indonesia memiliki kualitas pendidikan yang tinggi, Karena pendidikan merupakan sarana utama bagi kita untuk semakin siap menghadapi perkembangan ini.

Dalam hal ini bangsa Indonesia telah menyediakan berbagai sarana guna memenuhi sumber daya manusia yang berkualitas. Sehingga Universitas Sebelas Maret Surakarta sebagai salah satu lembaga pendidikan dalam merealisasikan hal tersebut memberikan Tugas Akhir sebuah perencanaan gedung bertingkat dengan maksud agar menghasilkan tenaga yang bersumber daya dan mampu bersaing dalam dunia kerja.

1.2. Rumusan Masalah

Masalah-masalah yang akan dibahas dalam penulisan Tugas Akhir ini dapat dirumuskan sebagai berikut:

- a. Bagaimana mengetahui konsep-konsep dasar berdasarkan data-data yang diperoleh untuk merencanakan suatu bangunan.
- b. Bagaimana melakukan perhitungan struktur dengan tingkat keamanan yang memadai.

1.3. Tujuan

Dalam menghadapi pesatnya perkembangan jaman yang semakin modern dan berteknologi, serta derasnya arus globalisasi saat ini, sangat diperlukan seorang teknisi yang berkualitas. Khususnya dalam bidang teknik sipil, sangat diperlukan

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teknisi-teknisi yang menguasai ilmu dan keterampilan dalam bidangnya. Fakultas Teknik Universitas Sebelas Maret Surakarta sebagai lembaga pendidikan bertujuan untuk menghasilkan ahli teknik yang berkualitas, bertanggungjawab, kreatif dalam menghadapi masa depan serta dapat mensukseskan pembangunan nasional di Indonesia.

Fakultas Teknik Universitas Sebelas Maret Program D III Jurusan Teknik Sipil memberikan Tugas Akhir dengan maksud dan tujuan :

1. Mahasiswa dapat merencanakan suatu konstruksi bangunan yang sederhana sampai bangunan bertingkat.
2. Mahasiswa diharapkan dapat memperoleh pengetahuan, pengertian dan pengalaman dalam merencanakan struktur gedung.
3. Mahasiswa dapat mengembangkan daya fikirnya dalam memecahkan suatu masalah yang dihadapi dalam perencanaan struktur gedung.

1.4. Metode Perencanaan

Metode perencanaan yang digunakan untuk pembahasan Tugas Akhir ini meliputi:

- a. Sistem struktur.
- b. Sistem pembebanan.
- c. Perencanaan analisa struktur.
- d. Perencanaan analisa tampang.
- e. Penggambaran.

1.5. Kriteria Perencanaan

1. Spesifikasi Bangunan

- | | |
|--------------------|-------------------------|
| a. Fungsi Bangunan | : Kantor Gedung Pajak |
| b. Luas Bangunan | : $\pm 600 \text{ m}^2$ |
| c. Jumlah Lantai | : 2 lantai |
| d. Tinggi Lantai | : 4,0 m |
| e. Konstruksi Atap | : Rangka kuda-kuda baja |
| f. Penutup Atap | : Genteng |

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- g. Pondasi : *Foot Plat*
2. Spesifikasi Bahan
- a. Mutu Baja Profil : BJ 37 ($f_u = 370$ MPa, $f_y = 240$ MPa)
- b. Mutu Beton ($f'c$) : 17,5 MPa
- c. Mutu Baja Tulangan (f_y) : Polos : 240 MPa.
Ulir : 320 MPa.

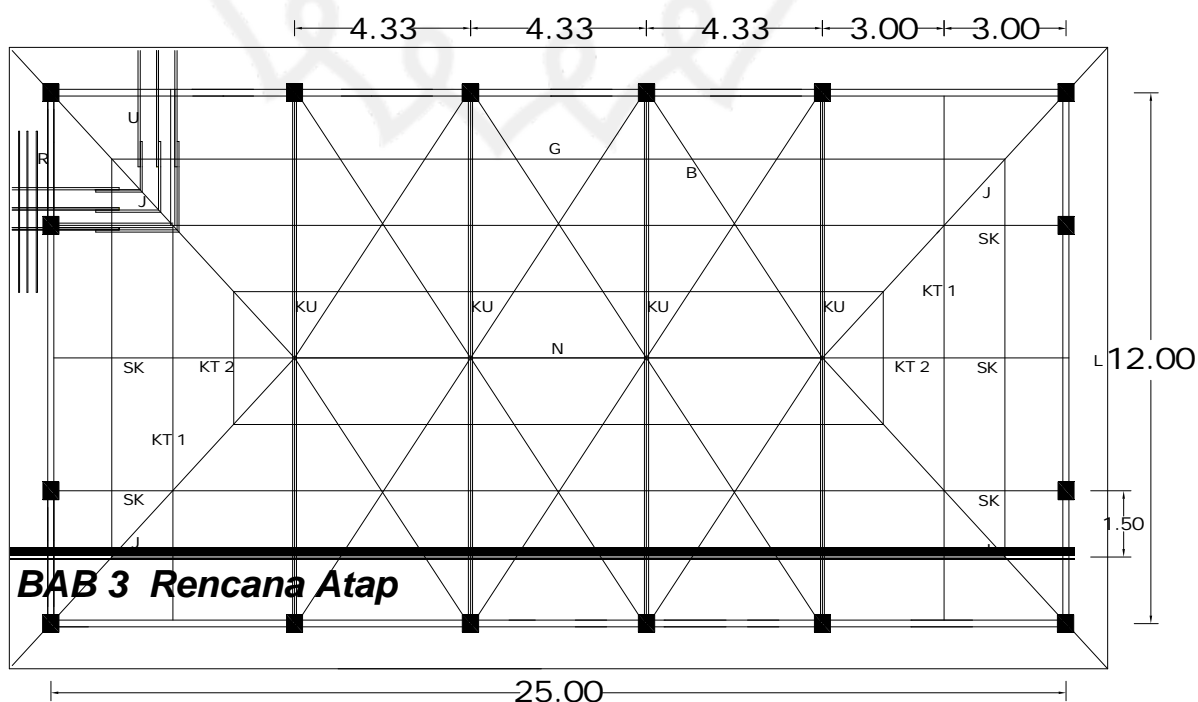
1.6. Peraturan-Peraturan Yang Berlaku

- Standart tata cara perencanaan struktur baja untuk bangunan gedung PPBBI 1984.
- Standart Tata Cara Perhitungan Struktur Beton Untuk Bangunan Gedung SKSNIT – 15 – 1991 – 03.
- Peraturan Beton Bertulang Indonesia 1971.
- Peraturan Pembebanan Indonesia Untuk Gedung 1989 (SNI 03-1727-1989)

Perancangan struktur kantor pajak dua lantai

BAB 3 PERENCANAAN ATAP

3.1. Rencana Atap







Gambar 3.1. Rencana Atap

Keterangan :

- KU = Kuda-kuda Utama
 KT 1 = Kuda-kuda Trapesium 1
 KT 2 = Kuda-kuda Trapesium 2
 SK = Setengah kuda-kuda utama
 J = Jurai
 G = Gording
 B = Bracing
 N = Nok
 L = Lisplank

3.1.1. Dasar Perencanaan

Dasar perencanaan yang dimaksud disini adalah data dari perencanaan atap itu sendiri, seperti perencanaan kuda-kuda dan gording, yaitu :

- a. Bentuk rangka kuda-kuda : seperti tergambar.
- b. Jarak antar kuda-kuda : 4,33 m.
- c. Kemiringan atap (α) : 30°
- d. Bahan gording : baja profil *lip channels* ().
- e. Bahan rangka kuda-kuda : baja profil *double* siku sama kaki ().
- f. Bahan penutup atap : genteng.
- g. Alat sambung : baut-mur.
- h. Jarak antar gording : 1,73 m.
- i. Bentuk atap : limasan.
- j. Mutu baja profil : Bj-37 ($\sigma_{ijin} = 1600 \text{ kg/cm}^2$).

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$$(\sigma_{\text{leleh}} = 2400 \text{ kg/cm}^2).$$

3.2. Perencanaan Gording

3.2.1. Perencanaan Pembebanan

Dicoba menggunakan gording dengan dimensi baja profil tipe *lip channels*/ kanal kait (\square) $200 \times 75 \times 20 \times 3,2$ dengan data sebagai berikut :

- | | | | |
|------------------|------------------------|----------|------------------------|
| a. Berat gording | = 9,27 kg/m. | g. t_b | = 3,2 mm |
| b. I_x | = 721 cm ⁴ | h. Z_x | = 72,1 cm ³ |
| c. I_y | = 87,5 cm ⁴ | i. Z_y | = 16,8 cm ³ |
| d. h | = 200 mm | | |
| e. b | = 75 mm | | |
| f. t_s | = 3,2 mm | | |

Kemiringan atap (α) = 30°

Jarak antar gording (s) = 1,73 m.

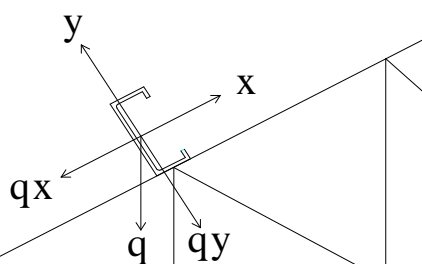
Jarak antar kuda-kuda (L) = 4,33 m.

Pembebanan berdasarkan Tata cara Perhitungan Pembebanan Untuk Bangunan Rumah dan Gedung Revisi SNI 03-1727-1989/Mod SEI/ASCE 7-02, sebagai berikut :

- | | |
|----------------------------------|------------------------|
| a. Berat penutup atap | = 50 kg/m ² |
| b. Beban angin | = 25 kg/m ² |
| c. Berat hidup (pekerja) | = 100 kg |
| d. Berat penggantung dan plafond | = 18 kg/m ² |

3.2.2. Perhitungan Pembebanan

a. Beban mati (titik)





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$$\begin{aligned}
 \text{Berat gording} &= &= &= 9,27 \text{ kg/m} \\
 \text{Berat penutup atap} &= 1,73 \times 50 \text{ kg/m}^2 &= &= 86,5 \text{ kg/m} \\
 q &= 95,77 \text{ kg/m}^+
 \end{aligned}$$

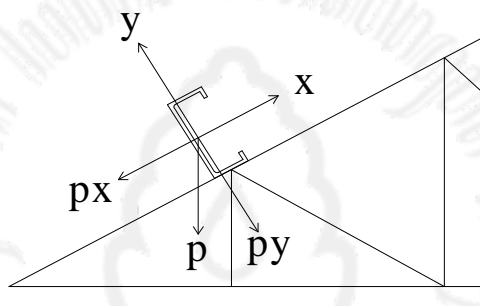
$$q_x = q \times \sin 30^\circ = 95,77 \times \sin 30^\circ = 47,885 \text{ kg/m}$$

$$q_y = q \times \cos 30^\circ = 95,77 \times \cos 30^\circ = 82,939 \text{ kg/m}$$

$$M_{x1} = \frac{1}{8} \times q_y \times L^2 = \frac{1}{8} \times 82,939 \times (4,33)^2 = 194,377 \text{ kgm}$$

$$M_{y1} = \frac{1}{8} \times q_x \times L^2 = \frac{1}{8} \times 47,885 \times (4,33)^2 = 112,224 \text{ kgm}$$

b. Beban hidup



P diambil sebesar 100 kg.

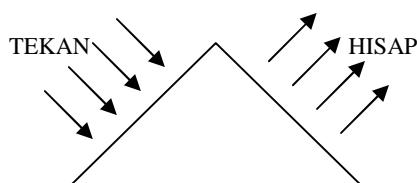
$$P_x = P \times \sin 30^\circ = 100 \times \sin 30^\circ = 50 \text{ kg.}$$

$$P_y = P \times \cos 30^\circ = 100 \times \cos 30^\circ = 87 \text{ kg.}$$

$$M_{x2} = \frac{1}{4} \times P_y \times L = \frac{1}{4} \times 87 \times 4,33 = 94,178 \text{ kgm.}$$

$$M_{y2} = \frac{1}{4} \times P_x \times L = \frac{1}{4} \times 50 \times 4,33 = 54,125 \text{ kgm.}$$

c. Beban angin



Beban angin kondisi normal, minimum = 25 kg/m².

Koefisien kemiringan atap (α) = 30°

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$$1) \text{ Koefisien angin tekan} = (0,02 \alpha - 0,4) = 0,2$$

$$2) \text{ Koefisien angin hisap} = -0,4$$

Beban angin :

$$1) \text{ Angin tekan } (W_1) = \text{koef. Angin tekan} \times \text{beban angin} \times 1/2 (s_1+s_2) \\ = 0,2 \times 25 \times 1/2 \times (1,73 + 1,73) = 8,65 \text{ kg/m.}$$

$$2) \text{ Angin hisap } (W_2) = \text{koef. Angin hisap} \times \text{beban angin} \times 1/2 (s_1+s_2) \\ = -0,4 \times 25 \times 1/2 \times (1,73 + 1,73) = -17,3 \text{ kg/m.}$$

Beban yang bekerja pada sumbu x, maka hanya ada harga M_x :

$$1) M_x (\text{tekan}) = 1/8 \times W_1 \times L^2 = 1/8 \times 8,65 \times (4,33)^2 = 20,272 \text{ kgm.}$$

$$2) M_x (\text{hisap}) = 1/8 \times W_2 \times L^2 = 1/8 \times -17,3 \times (4,33)^2 = -40,544 \text{ kgm.}$$

Tabel 3.1 Kombinasi gaya dalam pada gording

Momen	Beban Mati	Beban Hidup	Beban Angin		Kombinasi	
			Tekan	Hisap	Minimum	Maksimum
M_x	194,377	94,178	20,272	-40,544	268,283	308,827
M_y	112,224	54,125	-	-	166,349	166,349

3.2.3. Kontrol Terhadap Tegangan

➤ Kontrol terhadap tegangan Minimum

$$M_x = 268,283 \text{ kgm} = 26828,3 \text{ kgcm.}$$

$$M_y = 166,349 \text{ kgm} = 16634,9 \text{ kgcm.}$$

$$\sigma = \sqrt{\left(\frac{M_x}{Z_x}\right)^2 + \left(\frac{M_y}{Z_y}\right)^2} \\ = \sqrt{\left(\frac{26828,3}{72,1}\right)^2 + \left(\frac{16634,9}{16,8}\right)^2}$$



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$$= 1057,78 \text{ kg/cm}^2 < \sigma_{\text{ijin}} = 1600 \text{ kg/cm}^2$$

➤ Kontrol terhadap tegangan Maksimum

$$M_x = 308,827 \text{ kgm} = 30882,7 \text{ kgcm.}$$

$$M_y = 166,349 \text{ kgm} = 16634,9 \text{ kgcm.}$$

$$\sigma = \sqrt{\left(\frac{M_x}{Z_x}\right)^2 + \left(\frac{M_y}{Z_y}\right)^2}$$

$$= \sqrt{\left(\frac{30882,7}{72,1}\right)^2 + \left(\frac{16634,9}{16,8}\right)^2}$$

$$= 1078,85 \text{ kg/cm}^2 < \sigma_{\text{ijin}} = 1600 \text{ kg/cm}^2$$

3.2.4 Kontrol Terhadap Lendutan

Di coba profil tipe *lip channels* :

$$\square 200 \times 75 \times 20 \times 3,2$$

$$E = 2,1 \times 10^6 \text{ kg/cm}^2$$

$$I_x = 721 \text{ cm}^4$$

$$I_y = 87,5 \text{ cm}^4$$

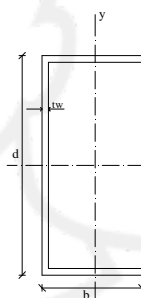
$$q_x = 0,47885 \text{ kg/cm}$$

$$q_y = 0,82939 \text{ kg/cm}$$

$$P_x = 50 \text{ kg}$$

$$P_y = 87 \text{ kg}$$

$$Z_{\text{ijin}} = \frac{1}{180} \times 433$$



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$$= 2,406 \text{ cm}$$

$$Z_x = \frac{5 \times q_x \times L^4}{384 \times E \times I_y} + \frac{P_x \times L^3}{48 \times E \times I_y}$$

$$= \frac{5 \times 0,47885 \times (433)^4}{384 \times 2,1 \times 10^6 \times 87,5} + \frac{50 \times 433^3}{48 \times 2,1 \times 10^6 \times 87,5}$$

$$= 1,653$$

$$Z_y = \frac{5 \times q_y \times l^4}{384 \times E \times I_x} + \frac{P_y \times L^3}{48 \times E \times I_x}$$

$$= \frac{5 \times 0,82939 \times (433)^4}{384 \times 2,1 \times 10^6 \times 721} + \frac{87 \times (433)^3}{48 \times 2,1 \times 10^6 \times 721}$$

$$= 0,510$$

$$Z = \sqrt{Z_x^2 + Z_y^2}$$

$$= \sqrt{1,653^2 + 0,510^2} = 1,730$$

$$Z \leq Z_{ijin}$$

$$1,730 \leq 2,406 \quad \dots\dots\dots \text{aman !}$$

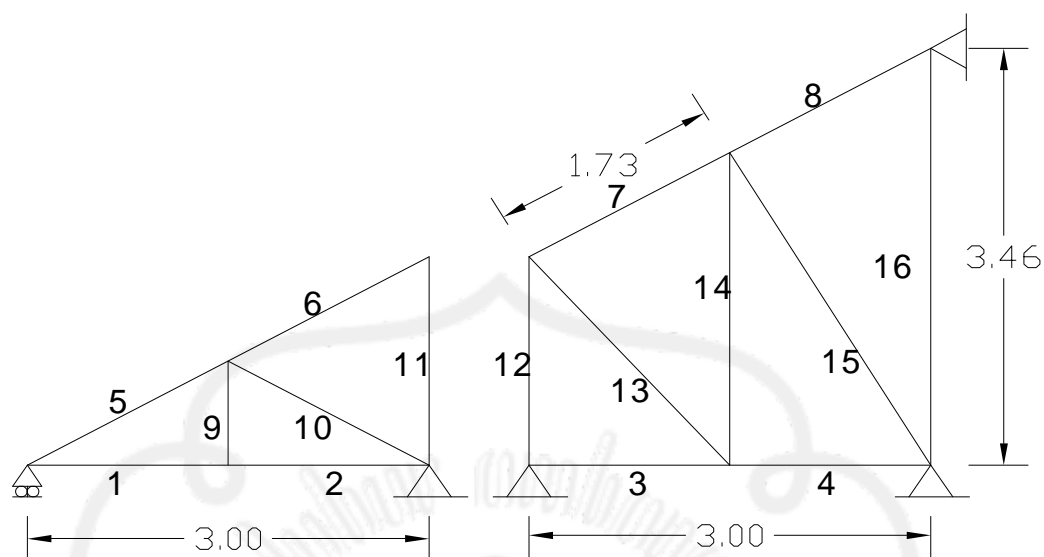
Jadi, baja profil *lip channels* (\square) dengan dimensi $200 \times 75 \times 20 \times 3,2$ aman dan mampu menerima beban apabila digunakan untuk gording.



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3.3. Perencanaan Setengah Kuda-kuda



Gambar 3.2. Panjang Batang Setengah Kuda- Kuda

3.3.1. Perhitungan Panjang Batang Setengah Kuda-kuda

Perhitungan panjang batang selanjutnya disajikan dalam tabel dibawah ini :

Tabel 3.2. Perhitungan panjang batang pada setengah kuda-kuda

Nomor Batang	Panjang Batang (m)
1	1,50
2	1,50
3	1,50
4	1,50
5	1,73
6	1,73
7	1,73
8	1,73
9	0,87
10	1,73
11	1,73
12	1,73
13	2,29
14	2,60
15	3,00
16	3,46

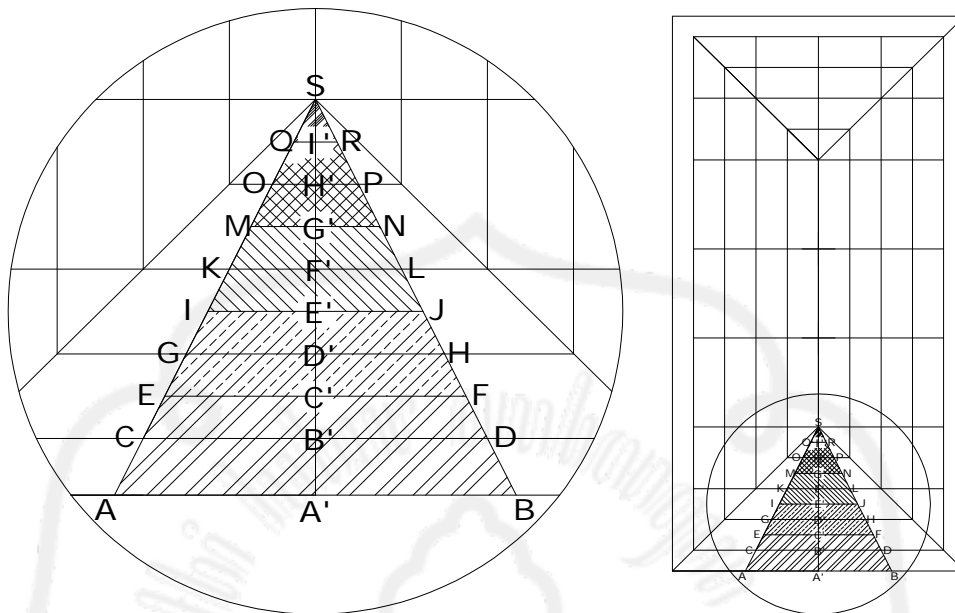


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3.3.2. Perhitungan Luasan

a. Setengah kuda-kuda



Gambar 3.3. Luasan Atap Setengah Kuda-Kuda

$$\text{Panjang SA}' = (4 \times 1,73) + 1,15 = 8,07 \text{ m}$$

$$\text{Panjang AB} = 7,00 \text{ m}$$

$$\text{Panjang CD} = 6,00 \text{ m}$$

$$\text{Panjang GH} = \frac{SD' \times AB}{SA'} = 4,5 \text{ m}$$

$$\text{Panjang KL} = \frac{SF' \times AB}{SA'} = 3,0 \text{ m}$$

$$\text{Panjang OP} = \frac{SH' \times AB}{SA'} = 1,5 \text{ m}$$

$$\text{Panjang EF} = 5,25 \text{ m}$$

$$\text{Panjang IJ} = 3,75 \text{ m}$$

$$\text{Panjang MN} = 2,25 \text{ m}$$

$$\text{Panjang QR} = 0,75 \text{ m}$$



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$$\begin{aligned}\text{Luas ABEF} &= \frac{AB + EF}{2} \times A'C' = \frac{7 + 5,25}{2} \times 1,865 \\ &= 11,423 \text{ m}^2\end{aligned}$$

$$\text{Panjang A'C'} = (0,5 \times 1,73) + 1,00 = 1,865 \text{ m}$$

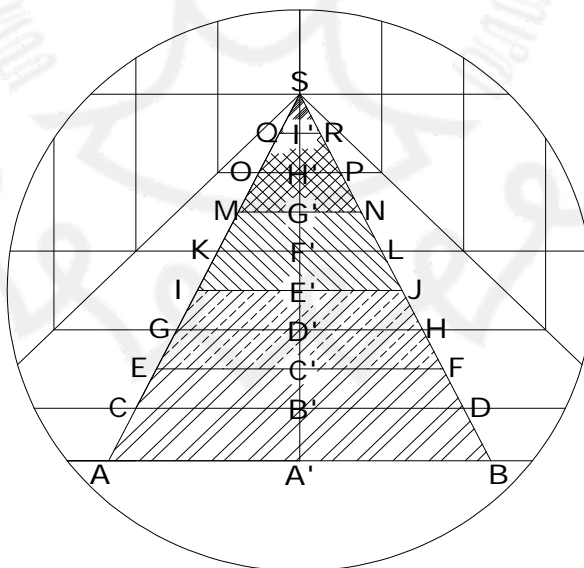
$$\begin{aligned}\text{Luas EFIJ} &= \frac{EF + IJ}{2} \times CE = \frac{5,25 + 3,75}{2} \times 1,73 \\ &= 7,785 \text{ m}^2\end{aligned}$$

$$\begin{aligned}\text{Luas IJMN} &= \frac{IJ + MN}{2} \times E'G' = \frac{3,75 + 2,25}{2} \times 1,73 \\ &= 5,19 \text{ m}^2\end{aligned}$$

$$\begin{aligned}\text{Luas MNQR} &= \frac{MN + QR}{2} \times G'I' = \frac{2,25 + 0,75}{2} \times 1,73 \\ &= 2,595 \text{ m}^2\end{aligned}$$

$$\begin{aligned}\text{Luas SQR} &= \frac{QR \times I'S}{2} \times = \frac{0,75 \times 0,865}{2} \\ &= 0,324 \text{ m}^2\end{aligned}$$

b. Plafon setengah kuda-kuda



Gambar 3.4. Luasan Plafon Setengah Kuda-Kuda

$$\text{Panjang SA}' = (1,50 \times 4) + 1 = 7,00 \text{ m}$$

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$$\text{Panjang AB} = 7,00 \text{ m}$$

$$\text{Panjang CD} = 6,00 \text{ m}$$

$$\text{Panjang GH} = \frac{SD' \times AB}{SA'} = 4,5 \text{ m}$$

$$\text{Panjang KL} = \frac{SF' \times AB}{SA'} = 3,0 \text{ m}$$

$$\text{Panjang OP} = \frac{SH' \times AB}{SA'} = 1,5 \text{ m}$$

$$\text{Panjang EF} = 5,25 \text{ m}$$

$$\text{Panjang IJ} = 3,75 \text{ m}$$

$$\text{Panjang MN} = 2,25 \text{ m}$$

$$\text{Panjang QR} = 0,75 \text{ m}$$

$$\begin{aligned} \text{Luas ABEF} &= \frac{AB + EF}{2} \times A'C' = \frac{7 + 5,25}{2} \times 1,750 \\ &= 10,719 \text{ m}^2 \end{aligned}$$

$$\text{Panjang A'C'} = (0,5 \times 1,50) + 1,00 = 1,75 \text{ m}$$

$$\begin{aligned} \text{Luas EFIJ} &= \frac{EF + IJ}{2} \times CE = \frac{5,25 + 3,75}{2} \times 1,50 \\ &= 6,750 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \text{Luas IJMN} &= \frac{IJ + MN}{2} \times E'G' = \frac{3,75 + 2,25}{2} \times 1,50 \\ &= 4,500 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \text{Luas MNQR} &= \frac{MN + QR}{2} \times G'I' = \frac{2,25 + 0,75}{2} \times 1,50 \\ &= 2,250 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \text{Luas SQR} &= \frac{QR \times I'S}{2} = \frac{0,75 \times 0,75}{2} \\ &= 0,281 \text{ m}^2 \end{aligned}$$



3.3.3. Perhitungan Pembebanan Setengah Kuda-kuda

Data-data pembebanan :

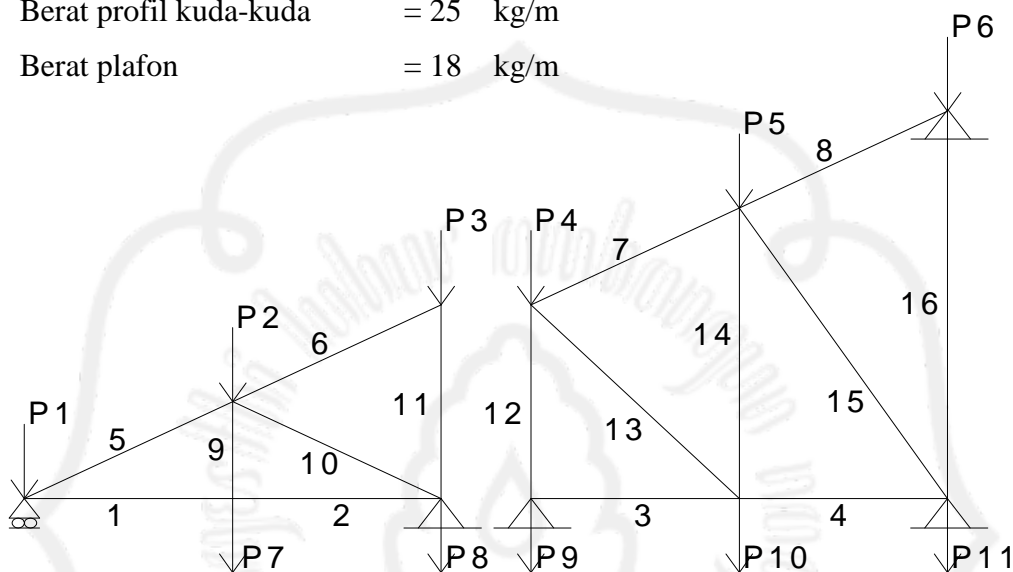
Berat gording = 11 kg/m

Jarak antar kuda-kuda = 4,33 m

Berat penutup atap = 50 kg/m²

Berat profil kuda-kuda = 25 kg/m

Berat plafon = 18 kg/m



Gambar 3.5. Pembebanan Setengah Kuda-Kuda Akibat Beban Mati

a) Perhitungan Beban

➤ Beban Mati

1. Beban P₁

$$\begin{aligned} \text{a). Beban gording} &= \text{Berat profil gording} \times \text{Panjang Gording CD} \\ &= 11 \times 6 = 66 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{b). Beban atap} &= \text{Luasan ABEF} \times \text{Berat atap} \\ &= 11,423 \times 50 = 571,15 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{c). Beban kuda-kuda} &= \frac{1}{2} \times \text{Btg}(1 + 5) \times \text{berat profil kuda-kuda} \\ &= \frac{1}{2} \times (1,5 + 1,73) \times 25 = 40,375 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{d). Beban plat sambung} &= 30 \% \times \text{beban kuda-kuda} \\ &= 30 \% \times 40,375 = 12,1125 \text{ kg} \end{aligned}$$



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-
- e). Beban bracing = $10\% \times \text{beban kuda-kuda}$
 = $10\% \times 40,375 = 4,0375 \text{ kg}$
- f). Beban plafon = Luasan ABEF \times berat plafon
 = $10,719 \times 18 = 192,942 \text{ kg}$
2. Beban P_2
- a). Beban gording = Berat profil gording \times Panjang Gording GH
 = $11 \text{ kg} \times 4,5 = 49,5 \text{ kg}$
- b). Beban atap = Luasan EFIJ \times berat atap
 = $7,785 \times 50 = 389,25 \text{ kg}$
- c). Beban kuda-kuda = $\frac{1}{2} \times \text{Btg}(5 + 6 + 9 + 10) \times \text{berat profil kuda-kuda}$
 = $\frac{1}{2} \times (1,73 + 1,73 + 0,87 + 1,73) \times 25 = 75,75 \text{ kg}$
- d). Beban plat sambung = $30\% \times \text{beban kuda-kuda}$
 = $30\% \times 75,75 = 22,725 \text{ kg}$
- e). Beban bracing = $10\% \times \text{beban kuda-kuda}$
 = $10\% \times 75,75 = 7,575 \text{ kg}$
3. Beban P_3
- a). Beban gording = Berat profil gording \times Panjang Gording KL
 = $\frac{1}{2} (11 \times 3) = 16,5 \text{ kg}$
- b). Beban atap = Luasan IJMN \times berat atap
 = $\frac{1}{2} (5,19 \times 50) = 112,5 \text{ kg}$
- c). Beban kuda-kuda = $\frac{1}{2} \times \text{Btg} (6 + 11) \times \text{berat profil kuda-kuda}$
 = $\frac{1}{2} \times (1,73 + 1,73) \times 25$
 = $30,75 \text{ kg}$
- d). Beban plat sambung = $30\% \times \text{beban kuda-kuda}$
 = $30\% \times 30,75 = 9,225 \text{ kg}$
- e). Beban bracing = $10\% \times \text{beban kuda-kuda}$
 = $10\% \times 30,75 = 3,075 \text{ kg}$
- 3 Beban P_4
- a). Beban gording = Berat profil gording \times Panjang Gording OP
 = $\frac{1}{2} (11 \times 3) = 16,5 \text{ kg}$
-



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Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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- b). Beban atap = Luasan IJMN \times berat atap
 $= \frac{1}{2} (5,19 \times 50) = 112,5 \text{ kg}$
- c). Beban kuda-kuda = $\frac{1}{2}$ Btg (12 + 13 + 7) \times berat profil kuda-kuda
 $= \frac{1}{2} \times (1,73 + 2,29 + 1,73) \times 25 = 71,875 \text{ kg}$
- d). Beban plat sambung = 30 % \times beban kuda-kuda
 $= 30 \% \times 71,875 = 21,563 \text{ kg}$
- e). Beban bracing = 10 % \times beban kuda-kuda
 $= 10 \% \times 71,875 = 7,1875 \text{ kg}$
- 4 Beban P_5
- a). Beban gording = Berat profil gording \times Panjang Gording
 $= 11 \times 1,50 = 16,50 \text{ kg}$
- b). Beban atap = Luasan MNQR \times berat atap
 $= 2,595 \times 50 = 129,75 \text{ kg}$
- c). Beban kuda-kuda = $\frac{1}{2}$ Btg (7 + 8 + 14 + 15) \times berat profil kuda-kuda
 $= \frac{1}{2} \times (1,73 + 1,73 + 2,6 + 3) \times 25 = 113,25 \text{ kg}$
- d). Beban plat sambung = 30 % \times beban kuda-kuda
 $= 30 \% \times 113,25 = 33,975 \text{ kg}$
- e). Beban bracing = 10 % \times beban kuda-kuda
 $= 10 \% \times 113,25 = 11,325 \text{ kg}$
- 5 Beban P_6
- a). Beban gording = Berat profil gording \times Panjang Gording
 $= 11 \times 0 = 0 \text{ kg}$
- b). Beban atap = Luasan SQR \times berat atap
 $= 0,324 \times 50 = 16,2 \text{ kg}$
- c). Beban kuda-kuda = $\frac{1}{2}$ Btg (8 + 16) \times berat profil kuda-kuda
 $= \frac{1}{2} \times (1,73 + 3,46) \times 25 = 64,875 \text{ kg}$
- d). Beban plat sambung = 30 % \times beban kuda-kuda
 $= 30 \% \times 64,875 = 19,463 \text{ kg}$
- e). Beban bracing = 10 % \times beban kuda-kuda
 $= 10 \% \times 64,875 = 6,4875 \text{ kg}$



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6 Beban P_7

- a). Beban kuda-kuda $= \frac{1}{2} \times \text{Btg} (1 + 9 + 2) \times \text{berat profil kuda-kuda}$
 $= \frac{1}{2} \times (1,5 + 0,87 + 1,5) \times 25 = 48,375 \text{ kg}$
- b). Beban bracing $= 10 \% \times \text{beban kuda-kuda}$
 $= 10 \% \times 48,375 = 4,8375 \text{ kg}$
- c). Beban plafon $= \text{Luasan EFIJ} \times \text{berat plafon}$
 $= 6,75 \times 18 = 121,5 \text{ kg}$
- d). Beban plat sambung $= 30 \% \times \text{beban kuda-kuda}$
 $= 30 \% \times 48,375 = 14,5125 \text{ kg}$

7 Beban P_8

- a). Beban kuda-kuda $= \frac{1}{2} \times \text{Btg} (2 + 10 + 11) \times \text{berat profil kuda-kuda}$
 $= \frac{1}{2} \times (1,5 + 1,73 + 1,73) \times 25 = 62 \text{ kg}$
- b). Beban bracing $= 10 \% \times \text{beban kuda-kuda}$
 $= 10 \% \times 62 = 6,20 \text{ kg}$
- c). Beban plafon $= \text{Luasan IJMN} \times \text{berat plafon}$
 $= \frac{1}{2} (4,50 \times 18) = 40,5 \text{ kg}$
- d). Beban plat sambung $= 30 \% \times \text{beban kuda-kuda}$
 $= 30 \% \times 62 = 18,6 \text{ kg}$

8 Beban P_9

- a). Beban kuda-kuda $= \frac{1}{2} \times \text{Btg} (3 + 12 + 13) \times \text{berat profil kuda-kuda}$
 $= \frac{1}{2} \times (1,5 + 2,29 + 2,6) \times 25 = 79,875 \text{ kg}$
- b). Beban bracing $= 10 \% \times \text{beban kuda-kuda}$
 $= 10 \% \times 79,875 = 7,988 \text{ kg}$
- c). Beban plafon $= \text{Luasan IJMN} \times \text{berat plafon}$
 $= \frac{1}{2} (4,50 \times 18) = 40,5 \text{ kg}$
- d). Beban plat sambung $= 30 \% \times \text{beban kuda-kuda}$
 $= 30 \% \times 79,875 = 23,963 \text{ kg}$

9 Beban P_{10}



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- a) Beban kuda-kuda = $\frac{1}{2} \times \text{Btg} (3 + 13 + 14 + 4) \times \text{berat profil kuda-kuda}$
 = $\frac{1}{2} \times (1,5 + 2,6 + 3 + 1,5) \times 25 = 107,5 \text{ kg}$
- b) Beban bracing = $10 \% \times \text{beban kuda-kuda}$
 = $10 \% \times 107,5 = 10,75 \text{ kg}$
- c) Beban plafon = $\text{Luasan MNQR} \times \text{berat plafon}$
 = $2,25 \times 18 = 40,5 \text{ kg}$
- d) Beban plat sambung = $30 \% \times \text{beban kuda-kuda}$
 = $30 \% \times 107,5 = 32,25 \text{ kg}$

10 Beban P₁₁

- a) Beban kuda-kuda = $\frac{1}{2} \times \text{Btg} (15 + 16 + 8) \times \text{berat profil kuda-kuda}$
 = $\frac{1}{2} \times (3 + 3,46 + 1,73) \times 25 = 102,375 \text{ kg}$
- b) Beban bracing = $10 \% \times \text{beban kuda-kuda}$
 = $10 \% \times 102,375 = 10,238 \text{ kg}$
- c) Beban plafon = $\text{Luasan SQR} \times \text{berat plafon}$
 = $0,281 \times 18 = 5,058 \text{ kg}$
- d) Beban plat sambung = $30 \% \times \text{beban kuda-kuda}$
 = $30 \% \times 102,375 = 30,713 \text{ kg}$

Tabel 3.3. Rekapitulasi Beban Mati Setengah Kuda-kuda

Beban	Beban Atap (kg)	Beban gording (kg)	Beban Kuda-kuda (kg)	Beban Bracing (kg)	Beban Plat Penyambung (kg)	Beban Plafon (kg)	Jumlah Beban (kg)	Input SAP 2000 (kg)
P ₁	571,15	66	40,375	4,0375	12,1125	192,942	886,617	887
P ₂	389,250	49,5	75,75	7,575	22,725	---	544,8	545
P ₃	112,5	16,5	30,75	3,075	9,225	---	172,05	173
P ₄	112,5	16,5	71,875	7,1875	21,563	---	229,623	230
P ₅	129,75	16,50	113,25	11,325	33,975	---	304,8	305
P ₆	16,20	0	64,875	6,4875	19,463	---	107,03	108
P ₇	---	---	48,375	4,8375	14,5125	121,5	189,23	190

BAB 3 Rencana Atap



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Perencanaan Struktur Gedung Kantor Pajak 2 lantai

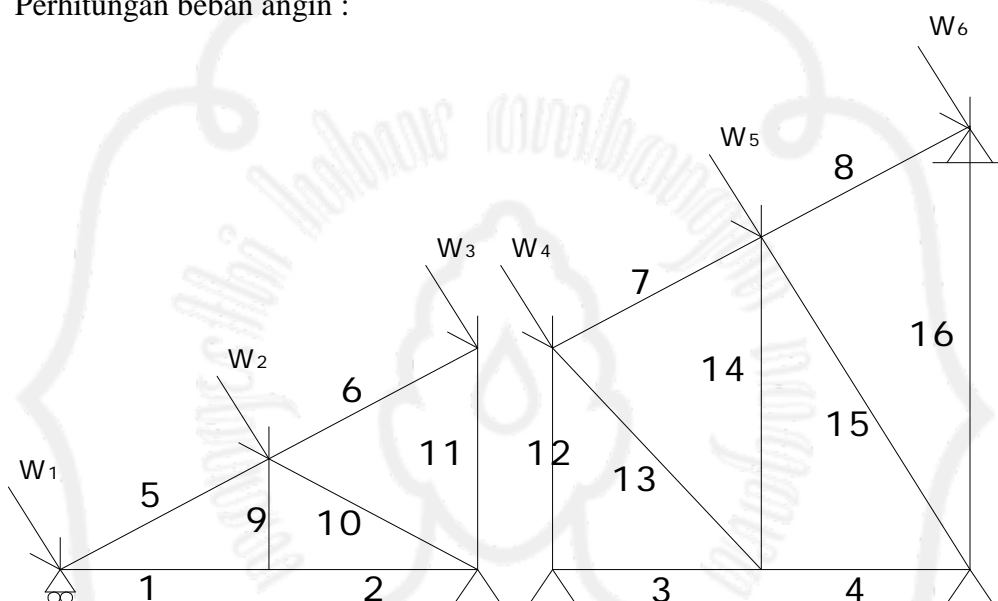
P ₈	---	---	62	6,20	18,6	40,5	127,3	128
P ₉	---	---	79,875	7,988	23,963	40,5	152,33	153
P ₁₀	---	---	107,50	10,75	32,25	40,5	191	191
P ₁₁	---	---	102,375	10,238	30,713	5,058	148,38 4	149

➤ Beban Hidup

Beban hidup yang bekerja pada P₁, P₂, P₅, P₆ = 100 kg/m² dan P₃, P₄ = 50 kg/m²

➤ Beban Angin

Perhitungan beban angin :



Gambar 3.6. Pembebanan Setengah Kuda-kuda akibat beban angin

Beban angin kondisi normal, minimum = 25 kg/m².

$$1) \text{ Koefisien angin tekan} = 0,02\alpha \times 0,40 \\ = (0,02 \times 30) - 0,40 = 0,2$$

$$a). W_1 = \text{luasan ABEF} \times \text{koef. angin tekan} \times \text{beban angin} \\ = 11,423 \times 0,2 \times 25 = 57,115 \text{ kg}$$

$$b). W_2 = \text{luasan EFIJ} \times \text{koef. angin tekan} \times \text{beban angin} \\ = 7,785 \times 0,2 \times 25 = 38,925 \text{ kg}$$

$$c). W_3 = \text{luasan IJMN} \times \text{koef. angin tekan} \times \text{beban angin} \\ = \frac{1}{2} (5,19 \times 0,2 \times 25) = 12,975 \text{ kg}$$

BAB 3 Rencana Atap



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Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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- d). $W_4 = \text{luasan IJMN} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= \frac{1}{2} (5,19 \times 0,2 \times 25) = 12,975 \text{ kg}$
- e). $W_5 = \text{luasan MNQR} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 2,595 \times 0,2 \times 25 = 12,975 \text{ kg}$
- f). $W_6 = \text{luasan SQR} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 0,324 \times 0,2 \times 25 = 1,620 \text{ kg}$

Tabel 3.4 Perhitungan Beban Angin Setengah Kuda-kuda

Beban Angin	Beban (kg)	$W \times \cos 30^\circ$ (kg)	Untuk Input SAP2000	$W \times \sin 30^\circ$ (kg)	Untuk Input SAP2000
W_1	57,115	49,463	50	28,558	29
W_2	38,925	33,710	34	19,463	20
W_3	12,975	11,237	12	6,488	7
W_4	12,975	11,237	12	6,488	7
W_5	12,975	11,237	12	6,488	7
W_6	1,620	1,403	2	0,812	1



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Perencanaan Struktur Gedung Kantor Pajak 2 lantai

Dari perhitungan mekanika dengan menggunakan program **SAP 2000** diperoleh gaya batang yang bekerja pada batang setengah kuda-kuda sebagai berikut :

Tabel 3.5 Rekapitulasi gaya batang setengah kuda-kuda

Nomor batang	Tarik (+) (kg)	Tekan (-) (kg)
1	934,88	-
2	924,85	-
3	-	67,4
4	67,4	-
5	-	1116,82
6	11,32	-
7	-	164,5
8	225,51	-
9	239,01	-
10	-	1152,84
11	-	363,43
12	-	648,55
13	186,44	-
14	-	124,39
15	-	719,67
16	-	40,26

3.3.4 Perencanaan Profil Setengah Kuda-kuda

a. Perhitungan profil batang tarik

$$P_{maks} = 934,88 \text{ kg}$$

$$\sigma_{ijin} = 1600 \text{ kg/cm}^2$$

$$F_{netto} = \frac{P_{maks}}{\sigma_{ijin}} = \frac{934,88}{1600}$$

$$= 0,584 \text{ cm}^2$$

$$F_{bruto} = 1,15 \times F_{netto}$$

$$= 1,15 \times 0,584 \text{ cm}^2$$



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$$= 0,788 \text{ cm}^2$$

Dicoba, menggunakan baja profil $\text{—}\text{—}\text{—}$ 50. 50. 5

$$F = 2 \times 4,80 = 9,60 \text{ cm}^2 \text{ (F = Penampang profil)}$$

Kontrol tegangan yang terjadi:

$$\begin{aligned} \sigma &= \frac{P_{maks}}{0,85 \cdot F} \\ &= \frac{934,88}{0,85 \times 9,60} = 114,57 \text{ kg/cm}^2 \end{aligned}$$

$$\sigma \leq 0,75 \sigma_{ijin}$$

$$114,57 \text{ kg/cm}^2 \leq 1200 \text{ kg/cm}^2$$

b. Perhitungan profil batang tekan

$$P_{maks} = 1152,84 \text{ kg}$$

$$lk = 1,73 \text{ m} = 173 \text{ cm}$$

Dicoba, menggunakan baja profil $\text{—}\text{—}\text{—}$ 50. 50. 5

$$i_x = 1,51 \text{ cm}$$

$$F = 2 \times 4,80 = 9,60 \text{ m}^2$$

$$\lambda = \frac{lk}{i_x} = \frac{173}{1,51}$$

$$= 114,57$$

$$\lambda_g = \pi \sqrt{\frac{E}{0,7 \cdot \sigma_{leleh}}} \dots \dots \dots \text{dimana, } \sigma_{leleh} = 2400 \text{ kg/cm}^2$$

$$= \pi \sqrt{\frac{2,1 \times 10^6 \text{ kg/cm}^2}{0,7 \times 2400}}$$

$$= 111,02$$

$$\lambda_s = \frac{\lambda}{\lambda_g} = \frac{114,57}{111,02}$$

$$= 1,032$$

Karena $\lambda_s \geq 1$, maka $\omega = 2,381 \times \lambda_s^2$

$$= 2,536$$



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Kontrol tegangan yang terjadi :

$$\begin{aligned}\sigma &= \frac{P_{maks} \times \omega}{F} \\ &= \frac{1152,84 \times 2,536}{9,60} = 304,542 \text{ kg/cm}^2\end{aligned}$$

$$\sigma \leq 0,75 \sigma_{ijin}$$

$$304,542 \text{ kg/cm}^2 \leq 1200 \text{ kg/cm}^2 \dots\dots\dots \text{aman!!}$$

3.3.5. Perhitungan Alat Sambung

a. Batang Tekan

Digunakan alat sambung baut-mur.

$$\text{Diameter baut } (\varnothing) = 12,7 \text{ mm (1/2 inci)}$$

$$\text{Diameter lubang} = 13,7 \text{ mm}$$

$$\begin{aligned}\text{Tebal pelat sambung } (\delta) &= 0,625 \times d \\ &= 0,625 \times 12,7 \\ &= 7,9 \text{ mm.}\end{aligned}$$

Menggunakan tebal plat 8 mm

➤ Tegangan geser yang diijinkan

$$\begin{aligned}\text{Teg. geser} &= 0,6 \times \sigma_{ijin} \\ &= 0,6 \times 1600 \\ &= 960 \text{ kg/cm}^2\end{aligned}$$

➤ Tegangan tumpuan yang diijinkan

$$\begin{aligned}\text{Teg. tumpuan} &= 1,5 \times \sigma_{ijin} \\ &= 1,5 \times 1600 \\ &= 2400 \text{ kg/cm}^2\end{aligned}$$

➤ Kekuatan baut :

$$\begin{aligned}\text{a) } P_{geser} &= 2 \times \frac{1}{4} \times \pi \times d^2 \times \tau_{geser} \\ &= 2 \times \frac{1}{4} \times \pi \times (1,27)^2 \times 960 = 1914,144 \text{ kg}\end{aligned}$$

$$\begin{aligned}\text{b) } P_{desak} &= \delta \times d \times \tau_{tumpuan} \\ &= 0,8 \times 1,27 \times 2400 = 2438,4 \text{ kg}\end{aligned}$$

P yang menentukan adalah $P_{geser} = 1914,144 \text{ kg}$.

BAB 3 Rencana Atap



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Perhitungan jumlah baut-mur,

$$n = \frac{P_{maks}}{P_{geser}} = \frac{1152,84}{1914,144} = 0,6 \sim 2 \text{ baut}$$

Digunakan : 2 buah baut.

Perhitungan jarak antar baut :

$$a) \quad 1,5 d \leq S_1 \leq 3 d$$

$$\begin{aligned} \text{Diambil, } S_1 &= 2,5 \times d = 2,5 \times 1,27 \\ &= 3,175 \text{ cm} \\ &= 3 \text{ cm} \end{aligned}$$

$$b) \quad 2,5 d \leq S_2 \leq 7 d$$

$$\begin{aligned} \text{Diambil, } S_2 &= 5 \times d = 5 \times 1,27 \\ &= 6,35 \text{ cm} \\ &= 6 \text{ cm} \end{aligned}$$

b. Batang tarik

Digunakan alat sambung baut-mur.

$$\text{Diameter baut } (\varnothing) = 12,7 \text{ mm.}$$

$$\text{Diameter lubang} = 13,7 \text{ mm.}$$

$$\begin{aligned} \text{Tebal pelat sambung } (\delta) &= 0,625 \times d \\ &= 0,625 \times 12,7 = 7,9 \text{ mm.} \end{aligned}$$

Menggunakan tebal plat 8 mm

➤ Tegangan geser yang diijinkan

$$\begin{aligned} \text{Teg. geser} &= 0,6 \times \sigma_{ijin} \\ &= 0,6 \times 1600 = 960 \text{ kg/cm}^2 \end{aligned}$$

➤ Tegangan tumpuan yang diijinkan

$$\begin{aligned} \text{Teg. tumpuan} &= 1,5 \times \sigma_{ijin} \\ &= 1,5 \times 1600 = 2400 \text{ kg/cm}^2 \end{aligned}$$

➤ Kekuatan baut :

$$\begin{aligned} a) \quad P_{geser} &= 2 \times \frac{1}{4} \times \pi \times d^2 \times \tau_{geser} \\ &= 2 \times \frac{1}{4} \times \pi \times (1,27)^2 \times 960 = 1914,144 \text{ kg} \end{aligned}$$



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$$\begin{aligned} \text{b) } P_{\text{desak}} &= \delta \times d \times \tau_{\text{tumpuan}} \\ &= 0,8 \times 1,27 \times 2400 = 2438,4 \text{ kg} \end{aligned}$$

P yang menentukan adalah $P_{\text{geser}} = 1914,144 \text{ kg}$.

Perhitungan jumlah baut-mur,

$$n = \frac{P_{\text{maks}}}{P_{\text{geser}}} = \frac{934,88}{1914,144} = 0,5 \sim 2 \text{ baut}$$

Digunakan : 2 buah baut.

Perhitungan jarak antar baut :

$$\text{a) } 1,5 d \leq S_1 \leq 3 d$$

$$\text{Diambil, } S_1 = 2,5 \times d = 2,5 \times 1,27$$

$$= 3,175 \text{ cm}$$

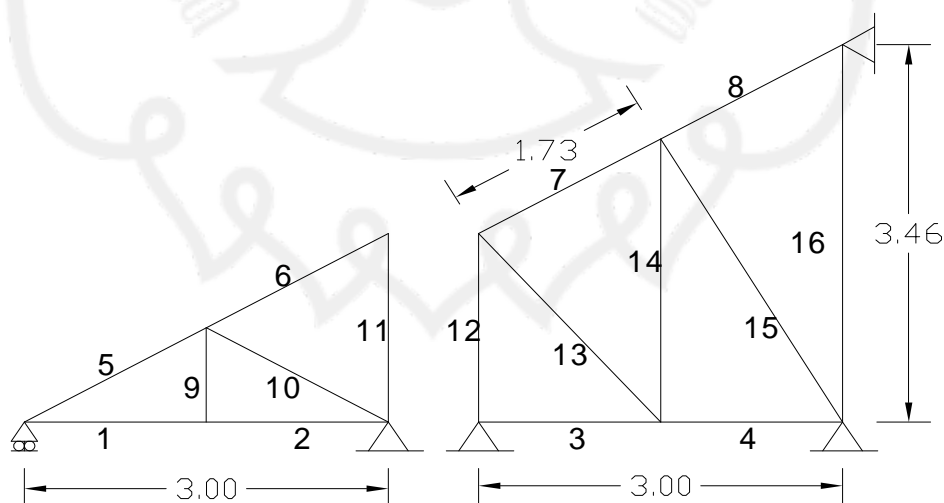
$$= 3 \text{ cm}$$

$$\text{b) } 2,5 d \leq S_2 \leq 7 d$$

$$\text{Diambil, } S_2 = 5 \times d = 5 \times 1,27$$

$$= 6,35 \text{ cm}$$

$$= 6 \text{ cm}$$



Tabel 3.6. Rekapitulasi perencanaan profil setengah kuda-kuda

Nomor Batang	Dimensi Profil	Baut (mm)
--------------	----------------	-----------

BAB 3 Rencana Atap



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1-16	⊥ 50 . 50 . 5	2 Ø 12,7
------	---------------	----------

3.4. Perencanaan Jurai

3.4.1. Perencanaan Pembebanan

Dicoba menggunakan jurai dengan dimensi baja profil tipe *double lip channels*/ kanal kait ganda (\square) $200 \times 150 \times 20 \times 3,2$ dengan data sebagai berikut :

- | | | | |
|----------------|------------------------|----------|-----------------------|
| a. Berat jurai | = 18,5 kg/m | g. t_b | = 3,2 mm |
| b. I_x | = 1432 cm ⁴ | h. Z_x | = 143 cm ³ |
| c. I_y | = 834 cm ⁴ | i. Z_y | = 111 cm ³ |
| d. h | = 200 mm | | |
| e. b | = 150 mm | | |
| f. t_s | = 3,2 mm | | |

Kemiringan atap (α) = 30°

Tinggi kuda-kuda trapesium (s) = 1,73 m.

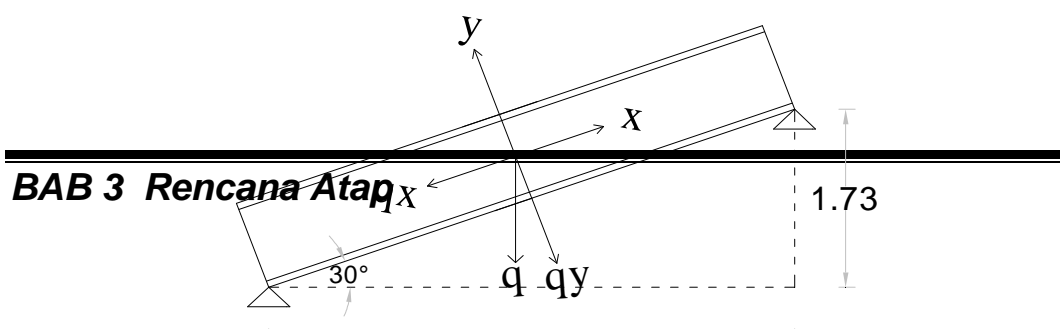
Panjang Jurai (L) = 4,5 m.

Pembebanan berdasarkan Tata cara Perhitungan Pembebanan Untuk Bangunan Rumah dan Gedung Revisi SNI 03-1727-1989/Mod SEI/ASCE 7-02, sebagai berikut :

- | | |
|----------------------------------|------------------------|
| a. Berat penutup atap | = 50 kg/m ² |
| b. Beban angin | = 25 kg/m ² |
| c. Berat hidup (pekerja) | = 100 kg |
| d. Berat penggantung dan plafond | = 18 kg/m ² |

3.4.2. Perhitungan Pembebanan

a. Beban mati





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Berat jurai	=	=	18,5 kg/m
Berat gording	=	=	9,27 kg/m
Berat penutup atap	=	$1,73 \times 50 \text{ kg/m}^2$	= 86,5 kg/m
			q = 114,27 kg/m

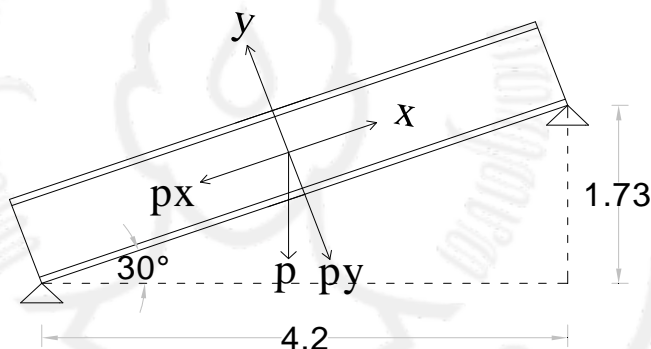
$$q_x = q \times \sin 30^\circ = 114,27 \times \sin 30^\circ = 57,135 \text{ kg/m}$$

$$q_y = q \times \cos 30^\circ = 114,27 \times \cos 30^\circ = 98,961 \text{ kg/m}$$

$$M_{x1} = \frac{1}{8} \times q_y \times L^2 = \frac{1}{8} \times 98,961 \times (4,5)^2 = 250,495 \text{ kgm}$$

$$M_{y1} = \frac{1}{8} \times q_x \times L^2 = \frac{1}{8} \times 57,135 \times (4,5)^2 = 144,623 \text{ kgm}$$

b. Beban hidup



P diambil sebesar 100 kg.

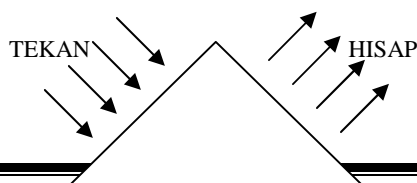
$$P_x = P \times \sin 30^\circ = 100 \times \sin 30^\circ = 50 \text{ kg.}$$

$$P_y = P \times \cos 30^\circ = 100 \times \cos 30^\circ = 87 \text{ kg.}$$

$$M_{x2} = \frac{1}{4} \times P_y \times L = \frac{1}{4} \times 87 \times 4,5 = 97,88 \text{ kgm.}$$

$$M_{y2} = \frac{1}{4} \times P_x \times L = \frac{1}{4} \times 50 \times 4,5 = 56,25 \text{ kgm.}$$

c. Beban angin





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Beban angin kondisi normal, minimum = 25 kg/m^2 .

Koefisien kemiringan atap (α) = 30°

1) Koefisien angin tekan = $(0,02 \alpha - 0,4) = 0,2$

2) Koefisien angin hisap = $-0,4$

Beban angin :

1) Angin tekan (W_1) = koef. Angin tekan \times beban angin $\times 1/2 (s_1+s_2)$
 $= 0,2 \times 25 \times 1/2 \times (1,73 + 1,73) = 8,65 \text{ kg/m.}$

2) Angin hisap (W_2) = koef. Angin hisap \times beban angin $\times 1/2 (s_1+s_2)$
 $= -0,4 \times 25 \times 1/2 \times (1,73 + 1,73) = -17,3 \text{ kg/m.}$

Beban yang bekerja pada sumbu x, maka hanya ada harga M_x :

1) M_x (tekan) = $1/8 \times W_1 \times L^2 = 1/8 \times 8,65 \times (4,5)^2 = 21,90 \text{ kgm.}$

2) M_x (hisap) = $1/8 \times W_2 \times L^2 = 1/8 \times -17,3 \times (4,5)^2 = -43,79 \text{ kgm.}$

Tabel 3.7. Kombinasi gaya dalam pada jurai

Momen	Beban Mati	Beban Hidup	Beban Angin		Kombinasi	
			Tekan	Hisap	Minimum	Maksimum
M_x	250,495	97,88	21,90	-43,79	326,485	370,275
M_y	144,623	56,25	-	-	200,873	200,873

Joint Reaksi = 728 kg

3.4.3. Kontrol Terhadap Tegangan

➤ Kontrol terhadap tegangan Minimum

$M_x = 326,49 \text{ kgm} = 32649 \text{ kgcm.}$

$M_y = 200,87 \text{ kgm} = 20087 \text{ kgcm.}$

BAB 3 Rencana Atap



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

$$\begin{aligned}\sigma &= \sqrt{\left(\frac{M_x}{Z_x}\right)^2 + \left(\frac{M_y}{Z_y}\right)^2} \\ &= \sqrt{\left(\frac{32649}{143}\right)^2 + \left(\frac{20087}{111}\right)^2} \\ &= 291,334 \text{ kg/cm}^2 < \sigma_{\text{ijin}} = 1600 \text{ kg/cm}^2\end{aligned}$$

➤ Kontrol terhadap tegangan Maksimum

$$M_x = 370,28 \text{ kgm} = 37028 \text{ kgcm.}$$

$$M_y = 200,87 \text{ kgm} = 20087 \text{ kgcm.}$$

$$\begin{aligned}\sigma &= \sqrt{\left(\frac{M_x}{Z_x}\right)^2 + \left(\frac{M_y}{Z_y}\right)^2} \\ \sigma &= \sqrt{\left(\frac{37028}{143}\right)^2 + \left(\frac{20087}{111}\right)^2} \\ &= 315,906 \text{ kg/cm}^2 < \sigma_{\text{ijin}} = 1600 \text{ kg/cm}^2\end{aligned}$$

3.2.4 Kontrol Terhadap Lendutan

Di coba profil tipe *double lip*

$$\text{channels} : 200 \times 150 \times 20 \times 3,2 \quad q_x = 0,5714 \text{ kg/cm}$$

$$E = 2,1 \times 10^6 \text{ kg/cm}^2 \quad q_y = 0,9896 \text{ kg/cm}$$

$$I_x = 1432 \text{ cm}^4 \quad P_x = 50 \text{ kg}$$

$$I_y = 834 \text{ cm}^4 \quad P_y = 87 \text{ kg}$$

$$\begin{aligned}Z_{\text{ijin}} &= \frac{1}{180} \times 450 \\ &= 2,5 \text{ cm}\end{aligned}$$

BAB 3 Rencana Atap



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Perencanaan Struktur Gedung Kantor Pajak 2 lantai

$$Z_x = \frac{5 \times q_x \times L^4}{384 \times E \times I_y} + \frac{P_x \times L^3}{48 \times E \times I_y}$$

$$= \frac{5 \times 0,5714 \times (450)^4}{384 \times 2,1 \times 10^6 \times 834} + \frac{50 \times 450^3}{48 \times 2,1 \times 10^6 \times 834}$$

$$= 0,228$$

$$Z_y = \frac{5 \times q_y \times l^4}{384 \times E \times I_x} + \frac{P_y \times L^3}{48 \times E \times I_x}$$

$$= \frac{5 \times 0,9896 \times (450)^4}{384 \times 2,1 \times 10^6 \times 1432} + \frac{87 \times (450)^3}{48 \times 2,1 \times 10^6 \times 1432}$$

$$= 0,231$$

$$Z = \sqrt{Z_x^2 + Z_y^2}$$

$$= \sqrt{0,228^2 + 0,231^2} = 0,325$$

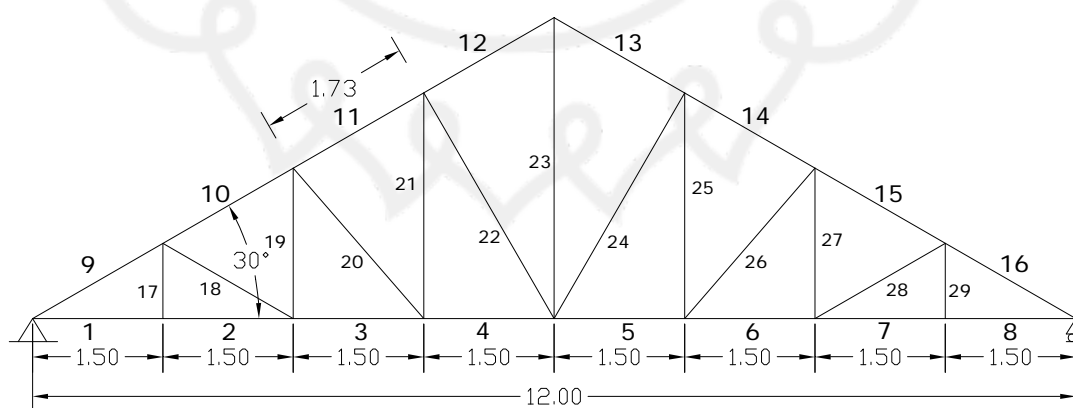
$$Z \leq Z_{ijin}$$

$$0,325 \leq 2,5 \quad \dots\dots\dots \text{aman !}$$

Jadi, baja profil *double lip channels* (□) dengan dimensi 200 × 150 × 20 × 3,2 aman dan mampu menerima beban apabila digunakan untuk jurai.

3.5. Perencanaan Kuda-kuda Utama (KK)

3.5.1. Perhitungan Panjang Batang Kuda-kuda



Gambar 3.12. Panjang batang kuda-kuda



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

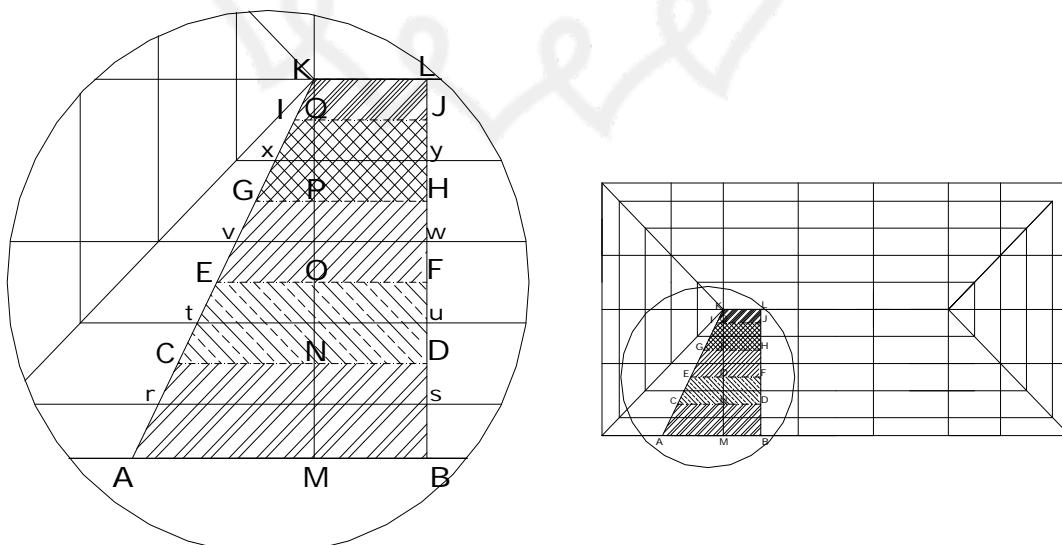
Perhitungan panjang batang selanjutnya disajikan dalam tabel dibawah ini :

Tabel 3.12 Perhitungan panjang batang pada kuda-kuda utama (KK)

Nomor Batang	Panjang Batang (m)	Nomor Batang	Panjang Batang (m)
1	1,5	16	1,73
2	1,5	17	0,87
3	1,5	18	1,73
4	1,5	19	1,73
5	1,5	20	2,30
6	1,5	21	2,60
7	1,5	22	3,00
8	1,5	23	3,46
9	1,73	24	3,00
10	1,73	25	2,60
11	1,73	26	2,30
12	1,73	27	1,73
13	1,73	28	1,73
14	1,73	29	0,87
15	1,73	-	-

3.5.2. Perhitungan Luasan

a. Kuda-kuda Utama





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Perencanaan Struktur Gedung Kantor Pajak 2 lantai

Gambar 3.13. Luasan Atap Kuda-Kuda Utama

$$\text{Panjang KL, MB, OF} = \frac{1}{2} \times 4,33 = 2,17 \text{ m}$$

$$\text{Panjang AB} = \text{AM} + \text{MB} = 5,67 \text{ m}$$

$$\text{Panjang KM, LB} = (4 \times 1,73) + 1,15 = 8,07 \text{ m}$$

$$\text{Panjang LJ} = 0,5 \times 1,73 = 0,87 \text{ m}$$

$$\text{Panjang BD} = (0,5 \times 1,73) + 1,15 = 2,02 \text{ m}$$

$$\text{Panjang DF, FH, HJ} = 1,73 \text{ m}$$

$$\text{Panjang CD} = 4,79 \text{ m}$$

$$\text{Panjang EF} = 4,04 \text{ m}$$

$$\text{Panjang GH} = 3,29 \text{ m}$$

$$\text{Panjang IJ} = 2,54 \text{ m}$$

$$\begin{aligned} \text{Luas ABCD} &= \frac{AB + CD}{2} \times BD \\ &= \frac{5,67 + 4,79}{2} \times 2,02 = 10,56 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \text{Luas CDEF} &= \frac{CD + EF}{2} \times DF \\ &= \frac{4,79 + 4,04}{2} \times 1,73 = 7,64 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \text{Luas EFGH} &= \frac{EF + GH}{2} \times FH \\ &= \frac{4,04 + 3,29}{2} \times 1,73 = 6,34 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \text{Luas GHIJ} &= \frac{GH + IJ}{2} \times HJ \\ &= \frac{3,29 + 2,54}{2} \times 1,73 = 5,04 \text{ m}^2 \end{aligned}$$

$$\text{Luas IJKL} = \frac{IJ + KL}{2} \times JL = 3,64 \text{ m}^2$$



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Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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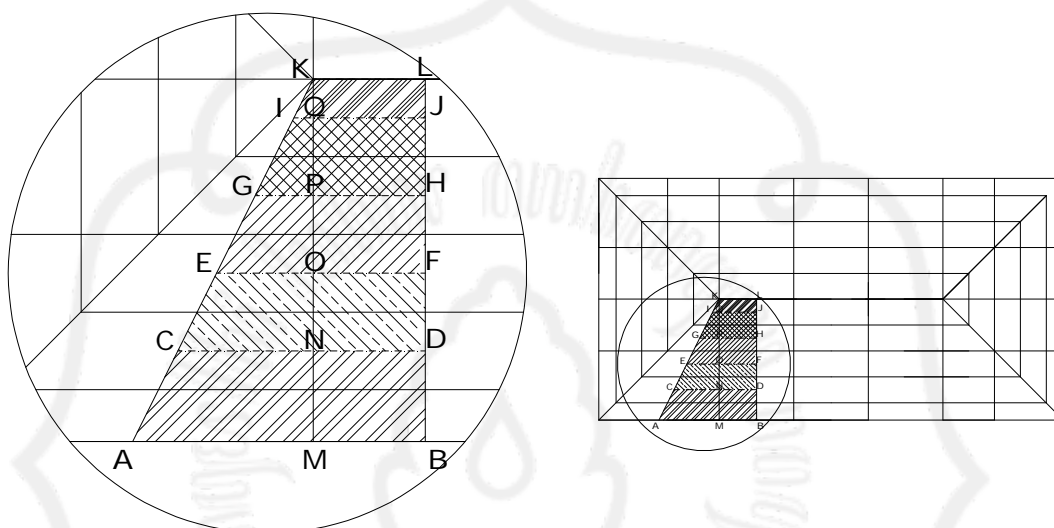
Panjang Gording rs = 5,17 m

Panjang Gording tu = 4,42 m

Panjang Gording vw = 3,67 m

Panjang Gording xy = 2,92 m

b. Plafon



Gambar 3.14. Luasan Plafon Kuda-Kuda Utama

$$\text{Panjang KL, MB, OF} = \frac{1}{2} \times 4,33 = 2,17 \text{ m}$$

$$\text{Panjang AB} = \text{AM} + \text{MB} = 5,67 \text{ m}$$

$$\text{Panjang KM, LB} = (4 \times 1,50) + 1 = 7,00 \text{ m}$$

$$\text{Panjang LJ} = 0,5 \times 1,50 = 0,75 \text{ m}$$

$$\text{Panjang BD} = (0,5 \times 1,50) + 1 = 1,75 \text{ m}$$

$$\text{Panjang DF, FH, HJ} = 1,50 \text{ m}$$

$$\text{Panjang CD} = 4,79 \text{ m}$$

$$\text{Panjang EF} = 4,04 \text{ m}$$

$$\text{Panjang GH} = 3,29 \text{ m}$$

$$\text{Panjang IJ} = 2,54 \text{ m}$$



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$$\begin{aligned} \text{Luas ABCD} &= \frac{AB + CD}{2} \times BD \\ &= \frac{5,67 + 4,79}{2} \times 1,75 = 9,15 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \text{Luas CDEF} &= \frac{CD + EF}{2} \times DF \\ &= \frac{4,79 + 4,04}{2} \times 1,50 = 6,62 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \text{Luas EFGH} &= \frac{EF + GH}{2} \times FH \\ &= \frac{4,04 + 3,29}{2} \times 1,50 = 5,50 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \text{Luas GHIJ} &= \frac{GH + IJ}{2} \times HJ \\ &= \frac{3,29 + 2,54}{2} \times 1,50 = 4,37 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \text{Luas IJKL} &= \frac{IJ + KL}{2} \times JL \\ &= \frac{3,29 + 2,54}{2} \times 0,75 = 2,19 \text{ m}^2 \end{aligned}$$

3.5.3. Perhitungan Pembebanan Kuda-kuda

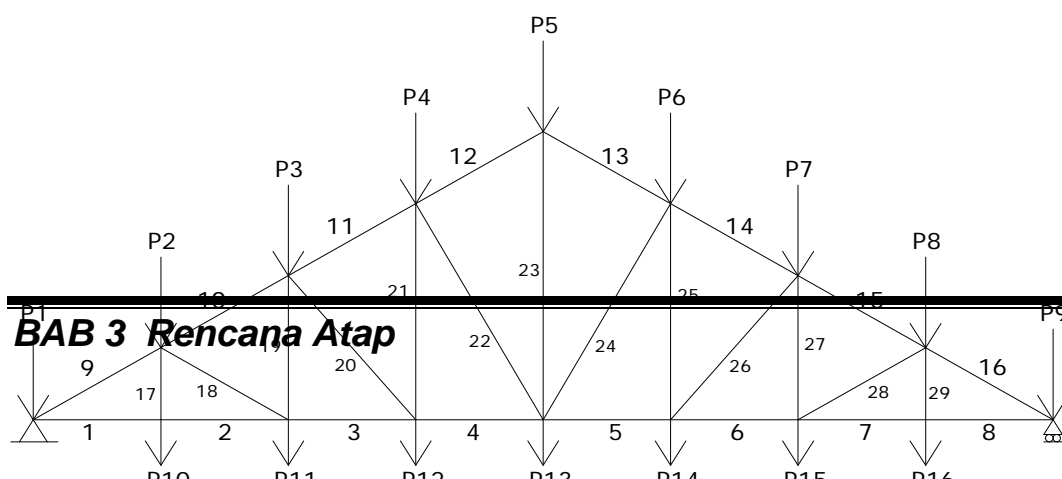
Data-data pembebanan :

Berat gording = 11 kg/m

Jarak antar kuda-kuda = 4,33 m

Berat penutup atap = 50 kg/m²

Berat profil = 25 kg/m (diasumsikan untuk profil secara umum)





Gambar 3.15. Pembebanan Kuda-kuda utama akibat beban mati

b. Perhitungan Beban➤ **Beban Mati**1) Beban $P_1 = P_9$

$$\begin{aligned} \text{a) Beban gording} &= \text{Berat profil gording} \times \text{Panjang Gording} \\ &= 11 \times 5,17 = 56,87 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{b) Beban atap} &= \text{Luasan} \times \text{Berat atap} \\ &= 10,56 \times 50 = 528 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{c) Beban kuda-kuda} &= \frac{1}{2} \times \text{Btg}(1 + 9) \times \text{berat profil kuda kuda} \\ &= \frac{1}{2} \times (1,5 + 1,73) \times 25 = 40,375 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{d) Beban plat sambung} &= 30 \% \times \text{beban kuda-kuda} \\ &= 30 \% \times 40,375 = 12,1125 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{e) Beban bracing} &= 10 \% \times \text{beban kuda-kuda} \\ &= 10 \% \times 40,375 = 4,0375 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{f) Beban plafon} &= \text{Luasan} \times \text{berat plafon} \\ &= 9,15 \times 18 = 164,7 \text{ kg} \end{aligned}$$

2) Beban $P_2 = P_8$

$$\begin{aligned} \text{a) Beban gording} &= \text{Berat profil gording} \times \text{Panjang Gording} \\ &= 11 \times 4,42 = 48,62 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{b) Beban atap} &= \text{Luasan} \times \text{berat atap} \\ &= 7,64 \times 50 = 382 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{c) Beban kuda-kuda} &= \frac{1}{2} \times \text{Btg}(9 + 10 + 17 + 18) \times \text{berat profil kuda kuda} \\ &= \frac{1}{2} \times (1,73 + 1,73 + 0,87 + 1,73) \times 25 = 75,75 \text{ kg} \end{aligned}$$

$$\text{d) Beban plat sambung} = 30 \% \times \text{beban kuda-kuda}$$



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Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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-
- $= 30 \% \times 75,75 = 22,725 \text{ kg}$
- e) Beban bracing $= 10 \% \times \text{beban kuda-kuda}$
 $= 10 \% \times 75,75 = 7,575 \text{ kg}$
- 3) Beban $P_3 = P_7$
- a) Beban gording $= \text{Berat profil gording} \times \text{Panjang Gording}$
 $= 11 \times 3,67 = 40,37 \text{ kg}$
- b) Beban atap $= \text{Luasan} \times \text{berat atap}$
 $= 6,34 \times 50 = 317 \text{ kg}$
- c) Beban kuda-kuda $= \frac{1}{2} \times \text{Btg}(10 + 11 + 19 + 20) \times \text{berat profil kuda kuda}$
 $= \frac{1}{2} \times (1,73 + 1,73 + 1,73 + 2,30) \times 25 = 93,625 \text{ kg}$
- d) Beban plat sambung $= 30 \% \times \text{beban kuda-kuda}$
 $= 30 \% \times 93,625 = 28,087 \text{ kg}$
- e) Beban bracing $= 10 \% \times \text{beban kuda-kuda}$
 $= 10 \% \times 93,625 = 9,3625 \text{ kg}$
- 4) Beban $P_4 = P_6$
- a) Beban gording $= \text{Berat profil gording} \times \text{Panjang Gording}$
 $= 11 \times 2,92 = 32,12 \text{ kg}$
- b) Beban atap $= \text{Luasan} \times \text{berat atap}$
 $= 5,04 \times 50 = 252 \text{ kg}$
- c) Beban kuda-kuda $= \frac{1}{2} \times \text{Btg}(11 + 12 + 21 + 22) \times \text{berat profil kuda -kuda}$
 $= \frac{1}{2} \times (1,73 + 1,73 + 2,60 + 3,00) \times 25 = 113,25 \text{ kg}$
- d) Beban plat sambung $= 30 \% \times \text{beban kuda-kuda}$
 $= 30 \% \times 113,25 = 33,975 \text{ kg}$
- e) Beban bracing $= 10 \% \times \text{beban kuda-kuda}$
 $= 10 \% \times 113,25 = 11,325 \text{ kg}$
- 5) Beban P_5
- a) Beban gording $= \text{Berat profil gording} \times \text{Panjang Gording}$
 $= 11 \times 2,17 = 23,87 \text{ kg}$
- b) Beban atap $= \text{Luasan} \times \text{berat atap}$
 $= 3,64 \times 2 \times 50 = 364 \text{ kg}$
- c) Beban kuda-kuda $= \frac{1}{2} \times \text{Btg}(12 + 13 + 23) \times \text{berat profil kuda kuda}$
-

BAB 3 Rencana Atap



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Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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-
- $= \frac{1}{2} \times (1,73 + 1,73 + 3,46) \times 25 = 86,5 \text{ kg}$
- d) Beban plat sambung $= 30 \% \times$ beban kuda-kuda
 $= 30 \% \times 86,5 = 25,95 \text{ kg}$
- e) Beban bracing $= 10 \% \times$ beban kuda-kuda
 $= 10 \% \times 86,5 = 8,65 \text{ kg}$
- f) Beban reaksi $=$ reaksi kuda-kuda trapesium $2 + 2$ reaksi jurai
 $= 463 \text{ kg} + (2 \times 728 \text{ kg}) = 1919 \text{ kg}$
- 6) Beban $P_{10} = P_{16}$
- a) Beban kuda-kuda $= \frac{1}{2} \times \text{Btg}(1+17+2) \times$ berat profil kuda kuda
 $= \frac{1}{2} \times (1,5 + 0,87 + 1,5) \times 25 = 48,375 \text{ kg}$
- b) Beban bracing $= 10 \% \times$ beban kuda-kuda
 $= 10 \% \times 48,375 = 4,8375 \text{ kg}$
- c) Beban plafon $=$ Luasan \times berat plafon
 $= 6,62 \times 18 = 119,16 \text{ kg}$
- d) Beban plat sambung $= 30 \% \times$ beban kuda-kuda
 $= 30 \% \times 48,375 = 14,5125 \text{ kg}$
- 7) Beban $P_{11} = P_{15}$
- a) Beban kuda-kuda $= \frac{1}{2} \times \text{Btg} (2 +18+19+3) \times$ berat profil kuda kuda
 $= \frac{1}{2} \times (1,5+1,5+1,73+1,73) \times 25 = 80,75 \text{ kg}$
- b) Beban bracing $= 10 \% \times$ beban kuda-kuda
 $= 10 \% \times 80,75 = 8,075 \text{ kg}$
- c) Beban plafon $=$ Luasan \times berat plafon
 $= 5,50 \times 18 = 99 \text{ kg}$
- d) Beban plat sambung $= 30 \% \times$ beban kuda-kuda
 $= 30 \% \times 80,75 = 24,225 \text{ kg}$
- 8) Beban $P_{12} = P_{14}$
- a) Beban kuda-kuda $= \frac{1}{2} \times \text{Btg} (3 +20+21+4) \times$ berat profil kuda kuda
 $= \frac{1}{2} \times (1,5+2,3+2,6+1,5) \times 25 = 98,75 \text{ kg}$
- b) Beban bracing $= 10 \% \times$ beban kuda-kuda
 $= 10 \% \times 98,75 = 9,875 \text{ kg}$
- c) Beban plafon $=$ Luasan \times berat plafon
-



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Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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$$= 4,37 \times 18 = 78,66 \text{ kg}$$

d) Beban plat sambung = 30 % × beban kuda-kuda
 $= 30 \% \times 98,75 = 29,625 \text{ kg}$

9) Beban P₁₃

a) Beban kuda-kuda = $\frac{1}{2} \times \text{Btg} (4+22+23+24+5) \times \text{berat profil kuda kuda}$
 $= \frac{1}{2} \times (1,5+3+3,46+3+1,5) \times 25 = 155,75 \text{ kg}$

b) Beban bracing = 10 % × beban kuda-kuda
 $= 10 \% \times 155,75 = 15,575 \text{ kg}$

c) Beban plafon = Luasan × berat plafon
 $= 2,19 \times 18 \times 2 = 78,84 \text{ kg}$

d) Beban plat sambung = 30 % × beban kuda-kuda
 $= 30 \% \times 155,75 = 46,725 \text{ kg}$

e) Beban reaksi = reaksi kuda-kuda trapesium 2
 $= 870 \text{ kg}$

Tabel 3.13. Rekapitulasi pembebanan kuda-kuda utama

Beban	Beban Atap (kg)	Beban gording (kg)	Beban Kuda-kuda (kg)	Beban Bracing (kg)	Beban Plat Sambung (kg)	Beban Plafon (kg)	Beban Reaksi (kg)	Jumlah Beban (kg)	Input SAP 2000 (kg)
P ₁ =P ₉	528	56,87	40,375	4,0375	12,1125	164,7	---	806,095	807
P ₂ =P ₈	382	48,62	75,75	7,575	22,725	---	---	536,67	537
P ₃ =P ₇	317	40,37	93,625	9,3625	28,087	---	---	468,44	469
P ₄ =P ₆	252	32,12	113,25	11,325	33,975	---	---	442,67	443
P ₅	364	23,87	86,5	8,65	25,95	---	1919	2427,97	2428

BAB 3 Rencana Atap



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Perencanaan Struktur Gedung Kantor Pajak 2 lantai

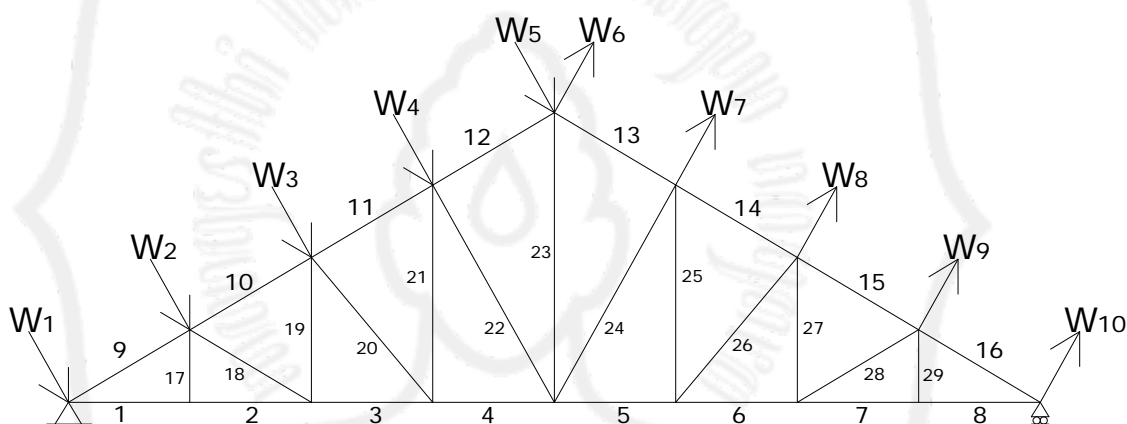
$P_{10}=P_{16}$	---	---	48,375	4,8375	14,5125	119,16	---	186,89	187
$P_{11}=P_1$ 5	---	---	80,75	8,075	24,225	99	---	212,05	213
$P_{12}=P_1$ 4	---	---	98,75	9,875	29,625	78,66	---	216,91	217
P_{13}	---	---	155,75	15,575	46,725	78,84	870	1166,89	1167

➤ Beban Hidup

Beban hidup yang bekerja pada $P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8,$ dan $P_9 = 100$ kg

➤ Beban Angin

Perhitungan beban angin :



Gambar 3.16. Pembebanan kuda-kuda utama akibat beban angin

Beban angin kondisi normal, minimum = 25 kg/m^2

1) Koefisien angin tekan = $0,02\alpha - 0,40$

$$= (0,02 \times 30^\circ) - 0,40 = 0,2$$

a) $W_1 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$

$$= 10,56 \times 0,2 \times 25 = 52,8 \text{ kg}$$

b) $W_2 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$

$$= 7,64 \times 0,2 \times 25 = 38,2 \text{ kg}$$

c) $W_3 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$

$$= 6,34 \times 0,2 \times 25 = 31,7 \text{ kg}$$



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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- d) $W_4 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 5,04 \times 0,2 \times 25 = 25,2 \text{ kg}$
- e) $W_5 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 3,64 \times 0,2 \times 25 = 18,2 \text{ kg}$
- 2) Koefisien angin hisap = - 0,40
- a) $W_6 = \text{luasan} \times \text{koef. angin hisap} \times \text{beban angin}$
 $= 3,64 \times (-0,4) \times 25 = - 36,4 \text{ kg}$
- b) $W_7 = \text{luasan} \times \text{koef. angin hisap} \times \text{beban angin}$
 $= 5,04 \times (-0,4) \times 25 = - 50,4 \text{ kg}$
- c) $W_8 = \text{luasan} \times \text{koef. angin hisap} \times \text{beban angin}$
 $= 6,34 \times (-0,4) \times 25 = - 63,4 \text{ kg}$
- d) $W_9 = \text{luasan} \times \text{koef. angin hisap} \times \text{beban angin}$
 $= 7,64 \times (-0,4) \times 25 = -76,4 \text{ kg}$
- e) $W_{10} = \text{luasan} \times \text{koef. angin hisap} \times \text{beban angin}$
 $= 10,56 \times (-0,4) \times 25 = -105,6 \text{ kg}$

Tabel 3.14. Perhitungan beban angin

Beban Angin	Beban (kg)	$W \times \text{Cos } \alpha$ (kg)	Input SAP2000	$W \times \text{Sin } \alpha$ (kg)	Input SAP2000
W_1	52,8	45,73	46	26,40	27
W_2	38,2	33,08	34	19,10	20
W_3	31,7	27,45	28	15,85	16
W_4	25,2	21,82	22	12,6	13
W_5	18,2	15,76	16	9,1	10
W_6	- 36,4	-31,52	32	-18,2	-19
W_7	- 50,4	-43,65	44	-25,2	-26



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

W ₈	- 63,4	-54,91	55	-31,7	-32
W ₉	-76,4	-66,16	67	-38,2	-39
W ₁₀	-105,6	-91,45	92	-52,50	-53

Dari perhitungan mekanika dengan menggunakan program **SAP 2000** diperoleh gaya batang yang bekerja pada batang kuda-kuda utama sebagai berikut :

Tabel 3.15. Rekapitulasi gaya batang

Nomor batang	Tarik (+) (kg)	Tekan (-) (kg)	Nomor batang	Tarik (+) (kg)	Tekan (-) (kg)
1	9975,36	-	16	-	11229,71
2	10026,42	-	17	119,18	-
3	9214,45	-	18	923,82	-
4	8195,58	-	19	860,41	-
5	8133,7	-	20	-	1527,74
6	9081,41	-	21	1497,25	-
7	9817,07	-	22	-	1906,42
8	9763,44	-	23	5898,84	-
9	-	11199,72	24	-	1783,85
10	-	10320,44	25	1417,69	-
11	-	9188,25	26	-	1420,65
12	-	8027,89	27	815,24	-
13	-	8072,27	28	-	837,11
14	-	9221,96	29	121,72	-
15	-	10347,78			

3.5.4. Perencanaan Profil Kuda- kuda

a. Perhitungan profil batang tarik

Untuk batang atas dan batang bawah:

$$P_{\text{maks.}} = 10026,42 \text{ kg}$$

$$\sigma_{\text{ijin}} = 1600 \text{ kg/cm}^2$$

$$F_{\text{netto}} = \frac{P_{\text{maks.}}}{\sigma_{\text{ijin}}}$$

$$= \frac{10906,15}{1600} = 6,816 \text{ cm}^2$$

$$F_{\text{bruto}} = 1,15 \times F_{\text{netto}}$$

BAB 3 Rencana Atap



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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$$= 1,15 \times 6,816 \text{ cm}^2 = 7,838 \text{ cm}^2$$

Dicoba, menggunakan baja profil $\perp 60 . 60 . 6$

$$F = 2 \times 6,91 \text{ cm}^2 = 13,82 \text{ cm}^2 \text{ (F = penampang profil)}$$

Kontrol tegangan yang terjadi :

$$\begin{aligned} \sigma &= \frac{P_{\text{maks.}}}{0,85 \cdot F} \\ &= \frac{10026,42}{0,85 \times 13,82} \\ &= 853,53 \text{ kg/cm}^2 \end{aligned}$$

$$\sigma \leq 0,75 \sigma_{\text{ijin}}$$

$$853,53 \leq 1200 \text{ kg/cm}^2 \dots\dots \text{ aman !!}$$

Untuk batang tengah:

$$P_{\text{maks.}} = 5818,31 \text{ kg}$$

$$\sigma_{\text{ijin}} = 1600 \text{ kg/cm}^2$$

$$\begin{aligned} F_{\text{netto}} &= \frac{P_{\text{maks.}}}{\sigma_{\text{ijin}}} \\ &= \frac{5818,31}{1600} = 3,636 \text{ cm}^2 \end{aligned}$$

$$\begin{aligned} F_{\text{bruto}} &= 1,15 \times F_{\text{netto}} \\ &= 1,15 \times 3,636 \text{ cm}^2 = 4,182 \text{ cm}^2 \end{aligned}$$

Dicoba, menggunakan baja profil $\perp 50 . 50 . 5$

$$F = 2 \times 4,80 \text{ cm}^2 = 9,60 \text{ cm}^2 \text{ (F = penampang profil)}$$

Kontrol tegangan yang terjadi :

$$\begin{aligned} \sigma &= \frac{P_{\text{maks.}}}{0,85 \cdot F} \\ &= \frac{5818,31}{0,85 \times 9,60} \\ &= 713,028 \text{ kg/cm}^2 \end{aligned}$$

$$\sigma \leq 0,75 \sigma_{\text{ijin}}$$

$$713,028 \leq 1200 \text{ kg/cm}^2 \dots\dots \text{ aman !!}$$



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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b. Perhitungan profil batang tekan

Untuk batang atas dan batang bawah:

$$P_{maks.} = 11229,71 \text{ kg}$$

$$lk = 1,73 \text{ m} = 173 \text{ cm}$$

Dicoba, menggunakan baja profil $\perp 60 \cdot 60 \cdot 6$

$$i_x = 1,82 \text{ cm}$$

$$F = 2 \times 6,91 = 13,82 \text{ cm}^2$$

$$\lambda = \frac{lk}{i_x}$$

$$= \frac{173}{1,82} = 95,05$$

$$\lambda_g = \pi \sqrt{\frac{E}{0,7 \times \sigma_{leleh}}} = \dots \text{dimana, } \sigma_{leleh} = 2400 \text{ kg/cm}^2$$

$$= 111,02 \text{ cm}$$

$$\lambda_s = \frac{\lambda}{\lambda_g} = \frac{95,05}{111,02}$$

$$= 0,856$$

Karena $\lambda_s \leq 1$, maka $\omega = 2,381 \times \lambda_s^2$

$$= 1,745$$

Kontrol tegangan yang terjadi:

$$\sigma = \frac{P_{maks} \times \omega}{F}$$

$$= \frac{11229,71 \times 1,745}{13,82}$$

$$= 1417,93 \text{ kg/cm}^2$$

$$\sigma \leq \sigma_{ijin}$$

$$1417,93 \text{ kg/cm}^2 \leq 1600 \text{ kg/cm}^2$$

Untuk batang tengah:

$$P_{maks.} = 1846,02 \text{ kg}$$

BAB 3 Rencana Atap



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Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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$$\sigma_{ijin} = 1600 \text{ kg/cm}^2$$

$$F_{netto} = \frac{P_{maks.}}{\sigma_{ijin}}$$

$$= \frac{1846,02}{1600} = 1,154 \text{ cm}^2$$

$$F_{bruto} = 1,15 \times F_{netto}$$

$$= 1,15 \times 1,154 \text{ cm}^2 = 1,327 \text{ cm}^2$$

Dicoba, menggunakan baja profil $\perp 50 . 50 . 5$

$$F = 2 \times 4,80 \text{ cm}^2 = 9,60 \text{ cm}^2 \text{ (F = penampang profil)}$$

Kontrol tegangan yang terjadi :

$$\sigma = \frac{P_{maks.}}{0,85 \cdot F}$$

$$= \frac{1846,02}{0,85 \times 9,60}$$

$$= 226,230 \text{ kg/cm}^2$$

$$\sigma \leq 0,75 \sigma_{ijin}$$

$$226,230 \leq 1200 \text{ kg/cm}^2 \dots\dots \text{ aman !!}$$

3.5.5. Perhitungan Alat Sambung

a. Batang Tarik

Untuk batang atas dan batang bawah:

Digunakan alat sambung baut-mur.

Diameter baut (\emptyset) = $\frac{5}{8}$ inch = 15,9 mm.

Diameter lubang = 17 mm.

$$\text{Tebal pelat sambung } (\delta) = 0,625 \times d$$

$$= 0,625 \times 15,9 = 9,9 \text{ mm.}$$

Menggunakan tebal plat 10 mm

➤ Tegangan geser yang diijinkan

BAB 3 Rencana Atap



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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$$\begin{aligned} \text{Teg. geser} &= 0,6 \times \sigma_{\text{ijin}} = 0,6 \times 1600 \\ &= 960 \text{ kg/cm}^2 \end{aligned}$$

➤ Tegangan tumpuan yang diijinkan

$$\begin{aligned} \text{Teg. tumpuan} &= 1,5 \times \sigma_{\text{ijin}} = 1,5 \times 1600 \\ &= 2400 \text{ kg/cm}^2 \end{aligned}$$

➤ Kekuatan baut :

$$\begin{aligned} \text{a) } P_{\text{geser}} &= 2 \times \frac{1}{4} \times \pi \times d^2 \times \tau_{\text{geser}} \\ &= 2 \times \frac{1}{4} \times \pi \times (1,59)^2 \times 960 = 3810,35 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{b) } P_{\text{desak}} &= \delta \times d \times \tau_{\text{tumpuan}} \\ &= 1 \times 1,59 \times 2400 = 3816 \text{ kg} \end{aligned}$$

P yang menentukan adalah $P_{\text{geser}} = 3810,35 \text{ kg}$

Perhitungan jumlah baut-mur,

$$n = \frac{P_{\text{maks.}}}{P_{\text{geser}}} = \frac{10026,42}{3810,35} = 2,63 \sim 3 \text{ baut}$$

Digunakan : 3 buah baut

Perhitungan jarak antar baut :

$$\text{a) } 1,5 d \leq S_1 \leq 3 d$$

$$\begin{aligned} \text{Diambil, } S_1 &= 2,5 d = 2,5 \times 1,59 \\ &= 3,975 \text{ cm} \\ &= 3,5 \text{ cm} \end{aligned}$$

$$\text{b) } 2,5 d \leq S_2 \leq 7 d$$

$$\begin{aligned} \text{Diambil, } S_2 &= 5 d = 5 \times 1,59 \\ &= 7,95 \text{ cm} \\ &= 7,5 \text{ cm} \end{aligned}$$

Untuk batang tengah:

Digunakan alat sambung baut-mur.

Diameter baut (\emptyset) = 15,9 mm.

Diameter lubang = 17 mm.

$$\begin{aligned} \text{Tebal pelat sambung } (\delta) &= 0,625 \times d \\ &= 0,625 \times 15,9 = 9,9 \text{ mm.} \end{aligned}$$



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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Menggunakan tebal plat 10 mm

➤ Tegangan geser yang diijinkan

$$\begin{aligned} \text{Teg. geser} &= 0,6 \times \sigma_{\text{ijin}} = 0,6 \times 1600 \\ &= 960 \text{ kg/cm}^2 \end{aligned}$$

➤ Tegangan tumpuan yang diijinkan

$$\begin{aligned} \text{Teg. tumpuan} &= 1,5 \times \sigma_{\text{ijin}} = 1,5 \times 1600 \\ &= 2400 \text{ kg/cm}^2 \end{aligned}$$

➤ Kekuatan baut :

$$\begin{aligned} \text{c) } P_{\text{geser}} &= 2 \times \frac{1}{4} \times \pi \times d^2 \times \tau_{\text{geser}} \\ &= 2 \times \frac{1}{4} \times \pi \times (1,59)^2 \times 960 = 3810,35 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{d) } P_{\text{desak}} &= \delta \times d \times \tau_{\text{tumpuan}} \\ &= 0,8 \times 1,59 \times 2400 = 3816 \text{ kg} \end{aligned}$$

P yang menentukan adalah $P_{\text{geser}} = 3810,35 \text{ kg}$

Perhitungan jumlah baut-mur,

$$n = \frac{P_{\text{maks.}}}{P_{\text{geser}}} = \frac{5818,31}{3810,35} = 1,5 \sim 2 \text{ baut}$$

Digunakan : 2 buah baut

Perhitungan jarak antar baut :

$$\text{a) } 1,5 d \leq S_1 \leq 3 d$$

$$\begin{aligned} \text{Diambil, } S_1 &= 2,5 d = 2,5 \times 1,59 \\ &= 3,975 \text{ cm} \\ &= 3,5 \text{ cm} \end{aligned}$$

$$\text{b) } 2,5 d \leq S_2 \leq 7 d$$

$$\begin{aligned} \text{Diambil, } S_2 &= 5 d = 5 \times 1,59 \\ &= 7,95 \text{ cm} \\ &= 7,5 \text{ cm} \end{aligned}$$

b. Batang Tekan

BAB 3 Rencana Atap



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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Untuk batang atas dan batang bawah:

Digunakan alat sambung baut-mur.

Diameter baut (\varnothing) = 15,9 mm.

Diameter lubang = 17 mm.

Tebal pelat sambung (δ) = $0,625 \times d$
 $= 0,625 \times 15,9 = 9,9$ mm.

Menggunakan tebal plat 10 mm

➤ Tegangan geser yang diijinkan

$$\begin{aligned} \text{Teg. geser} &= 0,6 \times \sigma_{\text{ijin}} \\ &= 0,6 \times 1600 = 960 \text{ kg/cm}^2 \end{aligned}$$

➤ Tegangan tumpuan yang diijinkan

$$\begin{aligned} \text{Teg. tumpuan} &= 1,5 \times \sigma_{\text{ijin}} \\ &= 1,5 \times 1600 = 2400 \text{ kg/cm}^2 \end{aligned}$$

➤ Kekuatan baut :

$$\begin{aligned} \text{a) } P_{\text{geser}} &= 2 \times \frac{1}{4} \times \pi \times d^2 \times \tau_{\text{geser}} \\ &= 2 \times \frac{1}{4} \times \pi \times (1,59)^2 \times 960 = 3810,35 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{b) } P_{\text{desak}} &= \delta \times d \times \tau_{\text{tumpuan}} \\ &= 1 \times 1,59 \times 2400 = 3816 \text{ kg} \end{aligned}$$

P yang menentukan adalah $P_{\text{geser}} = 3810,35$ kg

Perhitungan jumlah baut-mur,

$$n = \frac{P_{\text{maks.}}}{P_{\text{geser}}} = \frac{11229,71}{3810,35} = 2,95 \sim 3 \text{ baut}$$

Digunakan : 3 buah baut

Perhitungan jarak antar baut :

$$\text{a) } 1,5 d \leq S_1 \leq 3 d$$

$$\begin{aligned} \text{Diambil, } S_1 &= 2,5 d = 2,5 \times 1,59 \\ &= 3,975 \text{ cm} \\ &= 3,5 \text{ cm} \end{aligned}$$

$$\text{b) } 2,5 d \leq S_2 \leq 7 d$$

$$\text{Diambil, } S_2 = 5 d = 5 \times 1,59$$



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$$= 7,95 \text{ cm}$$

$$= 7,5 \text{ cm}$$

Untuk batang tengah:

Digunakan alat sambung baut-mur.

Diameter baut (\varnothing) = 15,9 mm.

Diameter lubang = 17 mm.

$$\begin{aligned} \text{Tebal pelat sambung } (\delta) &= 0,625 \times d \\ &= 0,625 \times 15,9 = 9,9 \text{ mm.} \end{aligned}$$

Menggunakan tebal plat 10 mm

➤ Tegangan geser yang diijinkan

$$\begin{aligned} \text{Teg. geser} &= 0,6 \times \sigma_{\text{ijin}} = 0,6 \times 1600 \\ &= 960 \text{ kg/cm}^2 \end{aligned}$$

➤ Tegangan tumpuan yang diijinkan

$$\begin{aligned} \text{Teg. tumpuan} &= 1,5 \times \sigma_{\text{ijin}} = 1,5 \times 1600 \\ &= 2400 \text{ kg/cm}^2 \end{aligned}$$

➤ Kekuatan baut :

$$\begin{aligned} \text{a) } P_{\text{geser}} &= 2 \times \frac{1}{4} \times \pi \times d^2 \times \tau_{\text{geser}} \\ &= 2 \times \frac{1}{4} \times \pi \times (1,59)^2 \times 960 = 3810,35 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{b) } P_{\text{desak}} &= \delta \times d \times \tau_{\text{tumpuan}} \\ &= 0,8 \times 1,59 \times 2400 = 3816 \text{ kg} \end{aligned}$$

P yang menentukan adalah $P_{\text{geser}} = 3810,35 \text{ kg}$

Perhitungan jumlah baut-mur,

$$n = \frac{P_{\text{maks.}}}{P_{\text{geser}}} = \frac{1846,02}{3810,35} = 0,5 \sim 2 \text{ baut}$$

Digunakan : 2 buah baut

Perhitungan jarak antar baut :

$$\text{a) } 1,5 d \leq S_1 \leq 3 d$$

$$\text{Diambil, } S_1 = 2,5 d = 2,5 \times 1,59$$

$$= 3,975 \text{ cm}$$

$$= 3,5 \text{ cm}$$

$$\text{b) } 2,5 d \leq S_2 \leq 7 d$$



Tugas Akhir

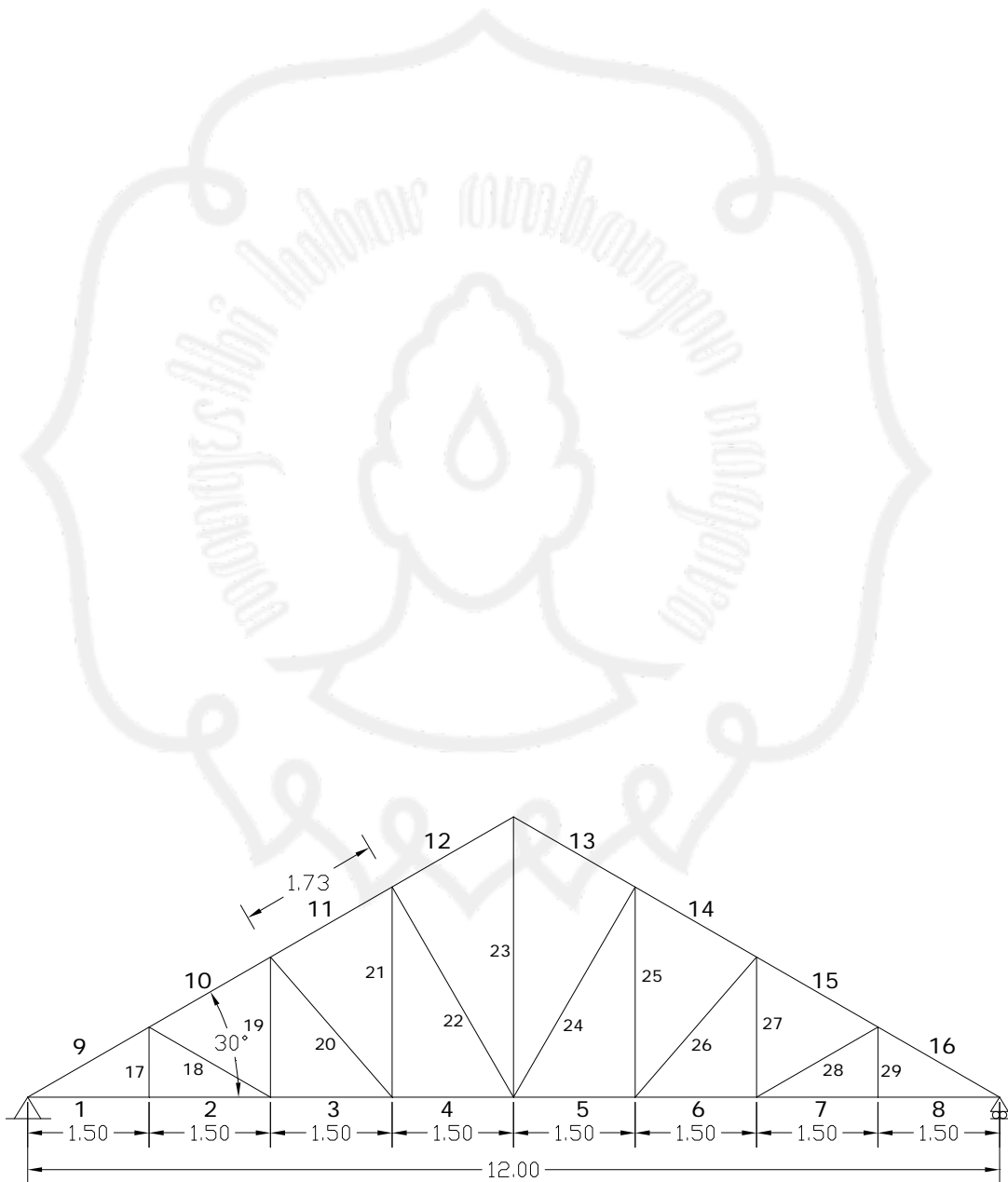
Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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$$\text{Diambil, } S_2 = 5 d = 5 \times 1,59$$

$$= 7,95 \text{ cm}$$

$$= 7,5 \text{ cm}$$



Tabel 3.16. Rekapitulasi perencanaan profil kuda-kuda

BAB 3 Rencana Atap



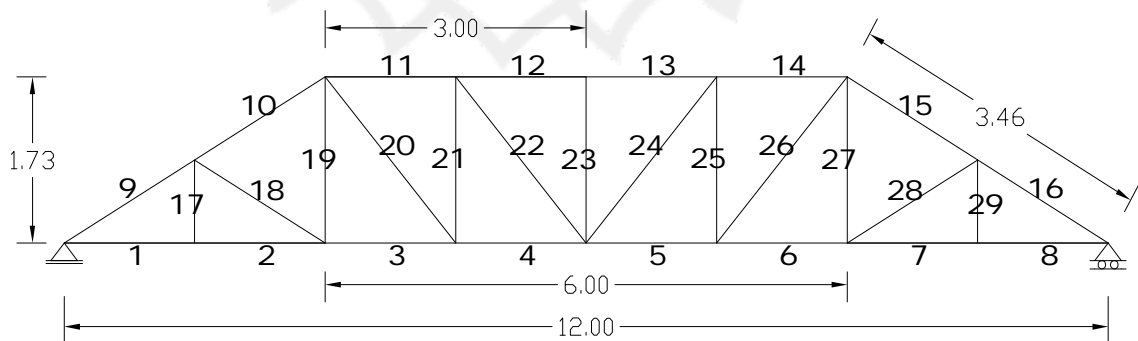
Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

Nomor Batang	Dimensi Profil	Baut (mm)	Nomor Batang	Dimensi Profil	Baut (mm)
1	⊥ 60 . 60 . 6	3 Ø 15,9	16	⊥ 60 . 60 . 6	3 Ø 15,9
2	⊥ 60 . 60 . 6	3 Ø 15,9	17	⊥ 50 . 50 . 5	2 Ø 15,9
3	⊥ 60 . 60 . 6	3 Ø 15,9	18	⊥ 50 . 50 . 5	2 Ø 15,9
4	⊥ 60 . 60 . 6	3 Ø 15,9	19	⊥ 50 . 50 . 5	2 Ø 15,9
5	⊥ 60 . 60 . 6	3 Ø 15,9	20	⊥ 50 . 50 . 5	2 Ø 15,9
6	⊥ 60 . 60 . 6	3 Ø 15,9	21	⊥ 50 . 50 . 5	2 Ø 15,9
7	⊥ 60 . 60 . 6	3 Ø 15,9	22	⊥ 50 . 50 . 5	2 Ø 15,9
8	⊥ 60 . 60 . 6	3 Ø 15,9	23	⊥ 50 . 50 . 5	2 Ø 15,9
9	⊥ 60 . 60 . 6	3 Ø 15,9	24	⊥ 50 . 50 . 5	2 Ø 15,9
10	⊥ 60 . 60 . 6	3 Ø 15,9	25	⊥ 50 . 50 . 5	2 Ø 15,9
11	⊥ 60 . 60 . 6	3 Ø 15,9	26	⊥ 50 . 50 . 5	2 Ø 15,9
12	⊥ 60 . 60 . 6	3 Ø 15,9	27	⊥ 50 . 50 . 5	2 Ø 15,9
13	⊥ 60 . 60 . 6	3 Ø 15,9	28	⊥ 50 . 50 . 5	2 Ø 15,9
14	⊥ 60 . 60 . 6	3 Ø 15,9	29	⊥ 50 . 50 . 5	2 Ø 15,9
15	⊥ 60 . 60 . 6	3 Ø 15,9	-	-	-

3.6. Perencanaan Kuda-kuda Trapesium (KT)

3.6.1. Perhitungan Panjang Batang Kuda-kuda



Gambar 3.17. Panjang Batang Kuda-Kuda Trapesium

BAB 3 Rencana Atap



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Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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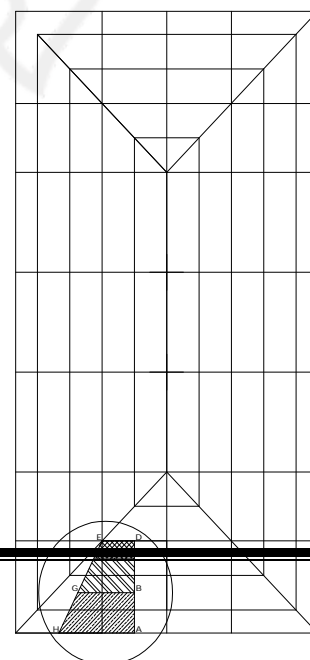
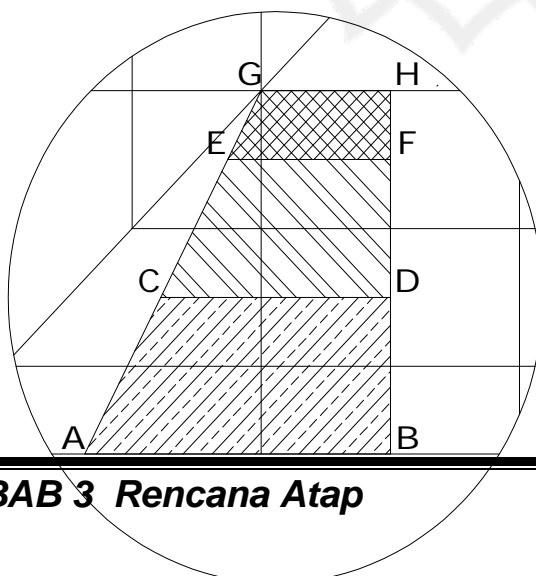
Perhitungan panjang batang selanjutnya disajikan dalam tabel dibawah ini :

Tabel 3.17. Perhitungan panjang batang pada kuda-kuda trapesium

Nomor Batang	Panjang Batang (m)	Nomor Batang	Panjang Batang (m)
1	1,5	16	1,73
2	1,5	17	0,87
3	1,5	18	1,73
4	1,5	19	1,73
5	1,5	20	2,30
6	1,5	21	1,73
7	1,5	22	2,30
8	1,5	23	1,73
9	1,73	24	2,30
10	1,73	25	1,73
11	1,5	26	2,30
12	1,5	27	1,73
13	1,5	28	1,73
14	1,5	29	0,87
15	1,73	-	-

3.6.2. Perhitungan Luasan

a. Kuda-kuda Trapesium





Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

Gambar 3.3. Luasan Atap Kuda-Kuda Trapesium

$$\text{Panjang AB} = 3,50 \text{ m}$$

$$\text{Panjang CD} = 2,63 \text{ m}$$

$$\text{Panjang EF} = 1,88 \text{ m}$$

$$\text{Panjang GH} = 1,50 \text{ m}$$

$$\text{Panjang BD} = (0,5 \times 1,73) + 1,15 \text{ m}$$

$$= 2,02 \text{ m}$$

$$\text{Panjang DF} = 1,73 \text{ m}$$

$$\text{Panjang FH} = 0,5 \times 1,73 \text{ m}$$

$$= 0,87 \text{ m}$$

$$\text{Luas ABCD} = \frac{AB + CD}{2} \times BD = \frac{3,5 + 2,63}{2} \times 2,02$$

$$= 6,19 \text{ m}^2$$

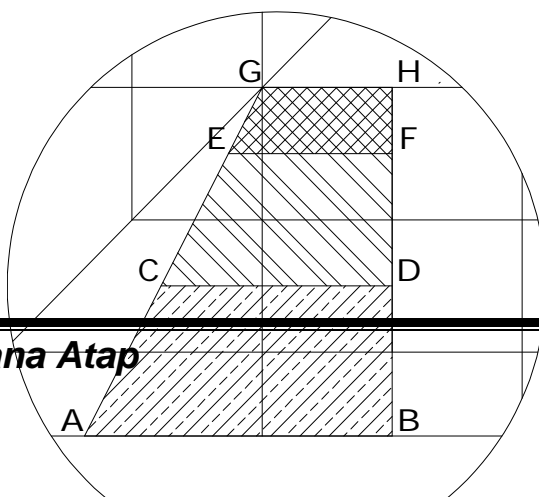
$$\text{Luas CDEF} = \frac{CD + EF}{2} \times DF = \frac{2,63 + 1,88}{2} \times 1,73$$

$$= 3,90 \text{ m}^2$$

$$\text{Luas EFGH} = \frac{EF + GH}{2} \times FH = \frac{1,88 + 1,50}{2} \times 1,73$$

$$= 2,92 \text{ m}^2$$

b. Plafon Trapesium





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Perencanaan Struktur Gedung Kantor Pajak 2 lantai

Gambar 3.4. Luasan Plafon Kuda-Kuda Trapesium

$$\text{Panjang AB} = 3,50 \text{ m}$$

$$\text{Panjang CD} = 2,63 \text{ m}$$

$$\text{Panjang EF} = 1,88 \text{ m}$$

$$\text{Panjang GH} = 1,50 \text{ m}$$

$$\begin{aligned} \text{Panjang BD} &= (0,5 \times 1,50) + 1,00 \text{ m} \\ &= 1,75 \text{ m} \end{aligned}$$

$$\text{Panjang DF} = 1,50 \text{ m}$$

$$\begin{aligned} \text{Panjang FH} &= 0,5 \times 1,50 \text{ m} \\ &= 0,75 \text{ m} \end{aligned}$$

$$\begin{aligned} \text{Luas ABCD} &= \frac{AB + CD}{2} \times BD = \frac{3,5 + 2,63}{2} \times 1,75 \\ &= 5,36 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \text{Luas CDEF} &= \frac{CD + EF}{2} \times DF = \frac{2,63 + 1,88}{2} \times 1,50 \\ &= 3,38 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \text{Luas EFGH} &= \frac{EF + GH}{2} \times FH = \frac{1,88 + 1,50}{2} \times 1,50 \\ &= 2,54 \text{ m}^2 \end{aligned}$$

3.6.3. Perhitungan Pembebanan Kuda-kuda

Data-data pembebanan :

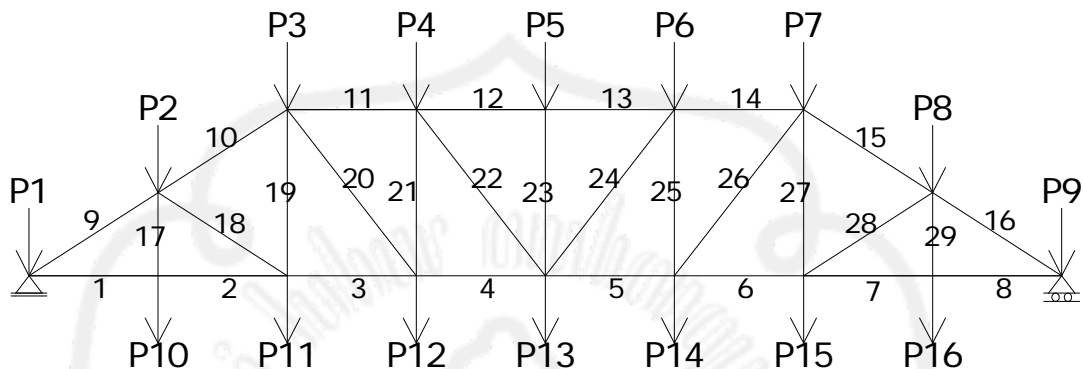


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Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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- Berat gording = 11 kg/m
 Jarak antar kuda-kuda = 4,33 m
 Berat penutup atap = 50 kg/m²
 Berat profil = 25 kg/m (diasumsikan untuk profil secara umum)
 Panjang bagian yang ditahan oleh kuda-kuda trapesium adalah 3 m.



Gambar 3.18. Pembebanan Kuda-kuda Trapesium Akibat Beban Mati

a. Perhitungan Beban

➤ Beban Mati

1) Beban $P_1 = P_9$

- a) Beban gording = Berat profil gording \times Panjang gording
 $= 11 \times 1,73 = 19,03 \text{ kg}$
- b) Beban atap = Luasan \times Berat atap
 $= 6,19 \times 50 = 309,50 \text{ kg}$
- c) Beban kuda-kuda = $\frac{1}{2} \times \text{Btg}(1 + 9) \times \text{berat profil kuda kuda}$
 $= \frac{1}{2} \times 3,23 \times 25 = 40,375 \text{ kg}$
- d) Beban plat sambung = 30 % \times beban kuda-kuda
 $= 30 \% \times 40,375 = 12,11 \text{ kg}$
- e) Beban bracing = 10 % \times beban kuda-kuda

BAB 6 Balok Anak



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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-
- $= 10 \% \times 40,375 = 4,04 \text{ kg}$
- f) Beban plafon $= \text{Luasan} \times \text{berat plafon}$
 $= 5,36 \times 18 = 96,48 \text{ kg}$
- 2) Beban $P_2 = P_8$
- a) Beban gording $= \text{Berat profil gording} \times \text{Panjang gording}$
 $= 11 \times 1,73 = 19,03 \text{ kg}$
- b) Beban atap $= \text{Luasan} \times \text{Berat atap}$
 $= 3,90 \times 50 = 195 \text{ kg}$
- c) Beban kuda-kuda $= \frac{1}{2} \times \text{Btg}(9 + 10 + 17) \times \text{berat kuda kuda}$
 $= \frac{1}{2} \times (1,73 + 1,73 + 0,87) \times 25$
 $= 54,125 \text{ kg}$
- d) Beban plat sambung $= 30 \% \times \text{beban kuda-kuda}$
 $= 30 \% \times 54,125 = 16,24 \text{ kg}$
- e) Beban bracing $= 10 \% \times \text{beban kuda-kuda}$
 $= 10 \% \times 54,125 = 5,412 \text{ kg}$
- 3) Beban $P_3 = P_7$
- a) Beban gording $= \text{Berat profil gording} \times \text{Panjang gording}$
 $= 11 \times 1,73 = 19,03 \text{ kg}$
- b) Beban atap $= \text{Luasan} \times \text{Berat atap}$
 $= 2,92 \times 50 = 146 \text{ kg}$
- c) Beban kuda-kuda $= \frac{1}{2} \times \text{Btg}(10 + 11 + 19 + 20) \times \text{berat profil kuda kuda}$
 $= \frac{1}{2} \times (1,73 + 1,50 + 1,73 + 2,30) \times 25$
 $= 90,75 \text{ kg}$
- d) Beban plat sambung $= 30 \% \times \text{beban kuda-kuda}$
 $= 30 \% \times 90,75 = 27,23 \text{ kg}$
- e) Beban bracing $= 10 \% \times \text{beban kuda-kuda}$
 $= 10 \% \times 90,75 = 9,075 \text{ kg}$
- f) Beban reaksi $= \text{Reaksi jurai}$
 $= 728 \text{ kg}$
- 4) Beban $P_4 = P_6$
- a) Beban kuda-kuda $= \frac{1}{2} \times \text{Btg}(11 + 12 + 21 + 22) \times \text{berat profil kuda kuda}$
 $= \frac{1}{2} \times (1,50 + 1,50 + 1,73 + 2,30) \times 25$
-



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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$$= 87,875 \text{ kg}$$

- b) Beban plat sambung = 30 % × beban kuda-kuda
 $= 30 \% \times 87,875 = 26,363 \text{ kg}$
- c) Beban bracing = 10 % × beban kuda-kuda
 $= 10 \% \times 87,875 = 8,7875 \text{ kg}$

5) Beban P_5

- a) Beban kuda-kuda = $\frac{1}{2} \times \text{Btg}(12 + 13 + 23) \times \text{berat profil kuda kuda}$
 $= \frac{1}{2} \times (1,50 + 1,50 + 1,73) \times 25$
 $= 59,125 \text{ kg}$
- d) Beban plat sambung = 30 % × beban kuda-kuda
 $= 30 \% \times 59,125 = 17,738 \text{ kg}$
- c) Beban bracing = 10 % × beban kuda-kuda
 $= 10 \% \times 59,125 = 5,9125 \text{ kg}$
- d) Beban reaksi = reaksi setengah kuda-kuda = 1145 kg

6) Beban $P_{10} = P_{16}$

- a) Beban kuda-kuda = $\frac{1}{2} \times \text{Btg}(1+17+2) \times \text{berat profil kuda kuda}$
 $= \frac{1}{2} \times (1,5 + 0,87 + 1,5) \times 25$
 $= 48,375 \text{ kg}$
- b) Beban bracing = 10 % × beban kuda-kuda
 $= 10 \% \times 48,375 = 4,838 \text{ kg}$
- c) Beban plafon = $\frac{1}{2} \times \text{Btg} (1 + 2) \times \text{berat plafon}$
 $= \frac{1}{2} \times 3,00 \times 50 = 75 \text{ kg}$
- d) Beban plat sambung = 30 % × beban kuda-kuda
 $= 30 \% \times 48,375 = 14,51 \text{ kg}$

7) Beban $P_{11} = P_{15}$

- a) Beban kuda-kuda = $\frac{1}{2} \times \text{Btg} (2 + 18 + 19 + 3) \times \text{berat profil kuda-kuda}$
 $= \frac{1}{2} \times (1,5 + 1,73 + 1,73 + 1,5) \times 25$
 $= 68,25 \text{ kg}$
- b) Beban bracing = 10 % × beban kuda-kuda
 $= 10 \% \times 68,25 = 6,825 \text{ kg}$
- c) Beban plafon = $\frac{1}{2} \times \text{Btg} (2 + 3) \times \text{berat plafon}$
 $= \frac{1}{2} \times 3,00 \times 50 = 75 \text{ kg}$



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- d) Beban plat sambung = $30\% \times \text{beban kuda-kuda}$
 $= 30\% \times 68,25 = 20,48 \text{ kg}$
- e) Beban reaksi = Reaksi setengah kuda-kuda
 $= 1145 \text{ kg}$
- 8) Beban $P_{12} = P_{14}$
- a) Beban kuda-kuda = $\frac{1}{2} \times \text{Btg} (3 + 20 + 21 + 4) \times \text{berat profil kuda-kuda}$
 $= \frac{1}{2} \times (1,5 + 2,3 + 1,73 + 1,5) \times 25$
 $= 87,875 \text{ kg}$
- b) Beban bracing = $10\% \times \text{beban kuda-kuda}$
 $= 10\% \times 87,875 = 8,788 \text{ kg}$
- c) Beban plafon = $\frac{1}{2} \times \text{Btg} (3 + 4) \times \text{berat plafon}$
 $= \frac{1}{2} \times 3,00 \times 50 = 75 \text{ kg}$
- e) Beban plat sambung = $30\% \times \text{beban kuda-kuda}$
 $= 30\% \times 87,875 = 26,36 \text{ kg}$
- 9) Beban P_{13}
- a) Beban kuda-kuda = $\frac{1}{2} \times \text{Btg} (4 + 22 + 23 + 24 + 5) \times \text{berat profil kuda-kuda}$
 $= \frac{1}{2} \times (1,5 + 2,3 + 1,73 + 2,3 + 1,5) \times 25$
 $= 116,625 \text{ kg}$
- b) Beban bracing = $10\% \times \text{beban kuda-kuda}$
 $= 10\% \times 116,652 = 11,665 \text{ kg}$
- c) Beban plafon = $\frac{1}{2} \times \text{Btg} (4 + 5) \times \text{berat plafon}$
 $= \frac{1}{2} \times 3,00 \times 50 = 75 \text{ kg}$
- d) Beban plat sambung = $30\% \times \text{beban kuda-kuda}$
 $= 30\% \times 116,652 = 34,988 \text{ kg}$
- e) Beban reaksi = R. setengah kuda-kuda + R. Kuda-kuda trapesium2
 $= 2042,69 \text{ kg}$

Tabel 3.18. Rekapitulasi pembebanan kuda-kuda trapesium

Beban	Beban Atap (kg)	Beban gordin g (kg)	Beban Kuda-kuda (kg)	Beban Bracin g (kg)	Beban Plat Sambun g (kg)	Beban Plafon (kg)	Beban Reaksi (kg)	Jumla h Beban (kg)	Input SAP200 0 (kg)
$P_1 = P_9$	309,5	19,03	40,375	4,038	12,11	96,48	---	481,533	482

BAB 6 Balok Anak



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Perencanaan Struktur Gedung Kantor Pajak 2 lantai

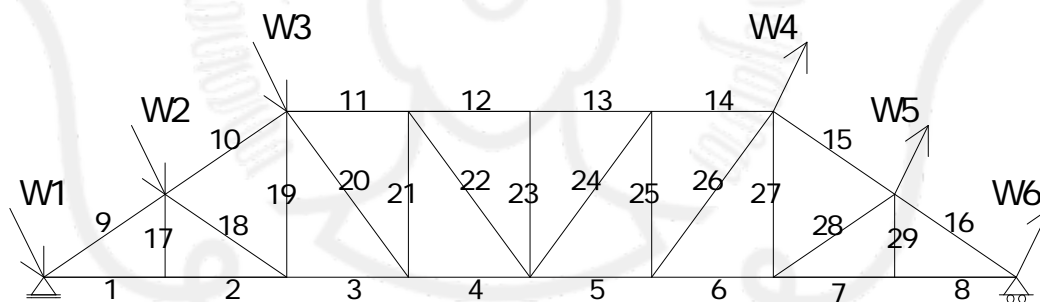
	0								
P ₂ =P ₈	195	19,03	54,125	5,413	16,24	---	---	289,808	290
P ₃ =P ₇	146	19,03	90,75	9,075	27,23	---	728	1020,09	1021
P ₄ =P ₆	---	---	87,875	8,788	26,363	---	---	123,026	124
P ₅	---	---	59,125	5,913	17,738	---	1145	1227,77 6	1228
P ₁₀ = P ₁₆	---	---	48,375	4,838	14,51	75	---	142,723	143
P ₁₁ =P ₁ 5	---	---	68,25	6,825	20,48	75	1145	1315,55 5	1316
P ₁₂ =P ₁ 4	---	---	87,875	8,788	26,36	75	---	198,023	199
P ₁₃	---	---	116,65 2	11,665	34,988	75	2042,69	2280,99	2281

➤ **Beban Hidup**

Beban hidup yang bekerja pada P₁, P₂, P₄, P₅, P₆, P₈, dan P₉ = 100 kg

➤ **Beban Angin**

Perhitungan beban angin :



Gambar 3.18. Pembebanan Kuda- Kuda Trapesium Akibat Beban Angin

Beban angin kondisi normal, minimum = 25 kg/m²

1) Koefisien angin tekan = $0,02\alpha - 0,40$

= $(0,02 \times 30^\circ) - 0,40 = 0,2$

a) $W_1 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$

= $5,36 \times 0,2 \times 25 = 26,8 \text{ kg}$

b) $W_2 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$

= $3,38 \times 0,2 \times 25 = 16,9 \text{ kg}$

BAB 6 Balok Anak



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$$\begin{aligned} \text{c) } W_3 &= \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin} \\ &= 2,54 \times 0,2 \times 25 = 12,7 \text{ kg} \end{aligned}$$

$$2) \text{ Koefisien angin hisap} = -0,40$$

$$\begin{aligned} \text{a) } W_4 &= \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin} \\ &= 2,54 \times -0,40 \times 25 = -25,4 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{b) } W_5 &= \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin} \\ &= 3,38 \times -0,40 \times 25 = -33,8 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{c) } W_6 &= \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin} \\ &= 5,36 \times -0,40 \times 25 = -53,6 \text{ kg} \end{aligned}$$

Tabel 3.19. Perhitungan beban angin

Beban Angin	Beban (kg)	$W \times \cos \alpha$ (kg)	Input SAP2000	$W \times \sin \alpha$ (kg)	Input SAP2000
W_1	26,8	23,21	24	13,4	7
W_2	16,9	14,64	15	8,45	13
W_3	12,7	10,99	11	6,35	7
W_4	-25,4	-21,99	22	-12,7	-13
W_5	-33,8	-29,27	30	-16,9	-17
W_6	-53,6	-46,42	47	-26,8	-27

Dari perhitungan mekanika dengan menggunakan program **SAP 2000** diperoleh gaya batang yang bekerja pada batang kuda-kuda trapesium sebagai berikut :

Tabel 3.20. Rekapitulasi gaya batang



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Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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Nomor batang	Tarik (+) (kg)	Tekan (-) (kg)	Nomor batang	Tarik (+) (kg)	Tekan (-) (kg)
1	10745,04	-	16	-	12312,15
2	10800,31	-	17	49,61	-
3	10373,27	-	18	-	516,34
4	12241,55	-	19	659,29	-
5	12218,59	-	20	2820,12	-
6	10327,1	-	21	-	1803,36
7	10717,65	-	22	1915,44	-
8	10661,58	-	23	-	132,44
9	-	12336,74	24	1950,07	-
10	-	11840,95	25	-	1829,35
11	-	12126,47	26	2854,76	-
12	-	13404,15	27	637,86	-
13	-	13403,94	28	-	474,73
14	-	12103,09	29	50,89	-
15	-	11817,85			

3.6.4. Perencanaan Profil Kuda-kuda Trapesium

a. Perhitungan profil batang tarik

Untuk batang atas dan batang bawah:

$$P_{\text{maks.}} = 12241,55 \text{ kg}$$

$$\sigma_{\text{ijin}} = 1600 \text{ kg/cm}^2$$

$$F_{\text{netto}} = \frac{P_{\text{maks.}}}{\sigma_{\text{ijin}}}$$

$$= \frac{12241,55}{1600} = 7,651 \text{ cm}^2$$

$$F_{\text{bruto}} = 1,15 \times F_{\text{netto}}$$

$$= 1,15 \times 7,651 \text{ cm}^2 = 8,799 \text{ cm}^2$$

Dicoba, menggunakan baja profil $\perp 60 . 60 . 6$

$$F = 2 \times 6,91 \text{ cm}^2 = 13,82 \text{ cm}^2 \text{ (F = penampang profil)}$$

Kontrol tegangan yang terjadi :



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Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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$$\begin{aligned}\sigma &= \frac{P_{\text{maks.}}}{0,85 \cdot F} \\ &= \frac{12241,55}{0,85 \times 13,82} \\ &= 1042,10 \text{ kg/cm}^2\end{aligned}$$

$$\sigma \leq 0,75 \sigma_{\text{ijin}}$$

$$1042,10 \leq 1200 \text{ kg/cm}^2 \dots\dots \text{aman !!}$$

Untuk batang tengah:

$$P_{\text{maks.}} = 2854,76 \text{ kg}$$

$$\sigma_{\text{ijin}} = 1600 \text{ kg/cm}^2$$

$$\begin{aligned}F_{\text{netto}} &= \frac{P_{\text{maks.}}}{\sigma_{\text{ijin}}} \\ &= \frac{2854,76}{1600} = 1,784 \text{ cm}^2\end{aligned}$$

$$\begin{aligned}F_{\text{bruto}} &= 1,15 \times F_{\text{netto}} \\ &= 1,15 \times 1,784 \text{ cm}^2 = 2,052 \text{ cm}^2\end{aligned}$$

Dicoba, menggunakan baja profil $\perp 50 \cdot 50 \cdot 5$

$$F = 2 \times 4,80 \text{ cm}^2 = 9,60 \text{ cm}^2 \text{ (F = penampang profil)}$$

Kontrol tegangan yang terjadi :

$$\begin{aligned}\sigma &= \frac{P_{\text{maks.}}}{0,85 \cdot F} \\ &= \frac{2854,76}{0,85 \times 9,60} \\ &= 349,848 \text{ kg/cm}^2\end{aligned}$$

$$\sigma \leq 0,75 \sigma_{\text{ijin}}$$

$$349,848 \leq 1200 \text{ kg/cm}^2 \dots\dots \text{aman !!}$$

b. Perhitungan profil batang tekan

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Untuk batang atas dan batang bawah:

$$P_{maks.} = 13404,15 \text{ kg}$$

$$lk = 1,50 \text{ m} = 150 \text{ cm}$$

Dicoba, menggunakan baja profil $\perp 60 . 60 . 6$

$$i_x = 1,82 \text{ cm}$$

$$F = 2 \times 6,91 = 13,82 \text{ cm}^2$$

$$\begin{aligned} \lambda &= \frac{lk}{i_x} \\ &= \frac{150}{1,82} = 82,42 \end{aligned}$$

$$\begin{aligned} \lambda_g &= \pi \sqrt{\frac{E}{0,7 \times \sigma_{leleh}}} = \dots \text{dimana, } \sigma_{leleh} = 2400 \text{ kg/cm}^2 \\ &= 111,02 \text{ cm} \end{aligned}$$

$$\begin{aligned} \lambda_s &= \frac{\lambda}{\lambda_g} = \frac{82,42}{111,02} \\ &= 0,742 \end{aligned}$$

$$\begin{aligned} \text{Karena } \lambda_s \leq 1, \text{ maka } \omega &= 2,381 \times \lambda_s^2 \\ &= 1,312 \end{aligned}$$

Kontrol tegangan yang terjadi:

$$\begin{aligned} \sigma &= \frac{P_{maks} \times \omega}{F} \\ &= \frac{13404,15 \times 1,312}{13,82} \\ &= 1272,78 \text{ kg/cm}^2 \end{aligned}$$

$$\sigma \leq \sigma_{ijin}$$

$$1272,78 \text{ kg/cm}^2 \leq 1600 \text{ kg/cm}^2$$

Untuk batang tengah:

$$P_{maks.} = 1789,08 \text{ kg}$$

$$\sigma_{ijin} = 1600 \text{ kg/cm}^2$$

$$F_{netto} = \frac{P_{maks.}}{\sigma_{ijin}}$$



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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$$= \frac{1789,08}{1600} = 1,118 \text{ cm}^2$$

$$\begin{aligned} F_{\text{bruto}} &= 1,15 \times F_{\text{netto}} \\ &= 1,15 \times 1,118 \text{ cm}^2 = 1,286 \text{ cm}^2 \end{aligned}$$

Dicoba, menggunakan baja profil $\perp 50.50.5$

$$F = 2 \times 4,80 \text{ cm}^2 = 9,60 \text{ cm}^2 \text{ (} F = \text{ penampang profil)}$$

Kontrol tegangan yang terjadi :

$$\begin{aligned} \sigma &= \frac{P_{\text{maks.}}}{0,85 \cdot F} \\ &= \frac{1789,08}{0,85 \times 9,60} \\ &= 219,25 \text{ kg/cm}^2 \end{aligned}$$

$$\sigma \leq 0,75 \sigma_{\text{ijin}}$$

$$219,25 \leq 1200 \text{ kg/cm}^2 \dots\dots \text{ aman !!}$$

3.5.5. Perhitungan Alat Sambung

a. Batang Tarik

Untuk batang atas dan batang bawah:

Digunakan alat sambung baut-mur.

Diameter baut (\varnothing) = 15,9 mm ($\frac{5}{8}$ inch).

Diameter lubang = 17 mm.

$$\begin{aligned} \text{Tebal pelat sambung } (\delta) &= 0,625 \times d \\ &= 0,625 \times 15,9 = 9,9 \text{ mm.} \end{aligned}$$

Menggunakan tebal plat 10 mm

➤ Tegangan geser yang diijinkan

$$\begin{aligned} \text{Teg. geser} &= 0,6 \times \sigma_{\text{ijin}} = 0,6 \times 1600 \\ &= 960 \text{ kg/cm}^2 \end{aligned}$$

➤ Tegangan tumpuan yang diijinkan

$$\text{Teg. tumpuan} = 1,5 \times \sigma_{\text{ijin}} = 1,5 \times 1600$$



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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$$= 2400 \text{ kg/cm}^2$$

➤ Kekuatan baut :

$$\begin{aligned} \text{c) } P_{\text{geser}} &= 2 \times \frac{1}{4} \times \pi \times d^2 \times \tau_{\text{geser}} \\ &= 2 \times \frac{1}{4} \times \pi \times (1,59)^2 \times 960 = 3810,35 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{d) } P_{\text{desak}} &= \delta \times d \times \tau_{\text{tumpuan}} \\ &= 1 \times 1,59 \times 2400 = 3816 \text{ kg} \end{aligned}$$

P yang menentukan adalah $P_{\text{geser}} = 3810,35 \text{ kg}$.

Perhitungan jumlah baut-mur,

$$n = \frac{P_{\text{maks.}}}{P_{\text{geser}}} = \frac{12241,55}{3810,35} = 3,21 \sim 4 \text{ baut}$$

Digunakan : 4 buah baut

Perhitungan jarak antar baut :

$$\text{a) } 1,5 d \leq S_1 \leq 3 d$$

$$\text{Diambil, } S_1 = 2,5 d = 2,5 \times 1,59$$

$$= 3,975 \text{ cm}$$

$$= 3,5 \text{ cm}$$

$$\text{b) } 2,5 d \leq S_2 \leq 7 d$$

$$\text{Diambil, } S_2 = 5 d = 5 \times 1,59$$

$$= 7,95 \text{ cm}$$

$$= 7,5 \text{ cm}$$

Untuk batang tengah:

Digunakan alat sambung baut-mur.

Diameter baut (\varnothing) = 15,9 mm.

Diameter lubang = 17 mm.

Tebal pelat sambung (δ) = $0,625 \times d$

$$= 0,625 \times 15,9 = 9,9 \text{ mm.}$$

Menggunakan tebal plat 10 mm

➤ Tegangan geser yang diijinkan

$$\text{Teg. geser} = 0,6 \times \sigma_{\text{ijin}} = 0,6 \times 1600$$



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$$= 960 \text{ kg/cm}^2$$

- Tegangan tumpuan yang diijinkan

$$\text{Teg. tumpuan} = 1,5 \times \sigma_{\text{ijin}} = 1,5 \times 1600$$

$$= 2400 \text{ kg/cm}^2$$

- Kekuatan baut :

$$\text{e) } P_{\text{geser}} = 2 \times \frac{1}{4} \times \pi \times d^2 \times \tau_{\text{geser}}$$

$$= 2 \times \frac{1}{4} \times \pi \times (1,59)^2 \times 960 = 3810,35 \text{ kg}$$

$$\text{f) } P_{\text{desak}} = \delta \times d \times \tau_{\text{tumpuan}}$$

$$= 0,8 \times 1,59 \times 2400 = 3816 \text{ kg}$$

P yang menentukan adalah $P_{\text{geser}} = 3810,35 \text{ kg}$

Perhitungan jumlah baut-mur,

$$n = \frac{P_{\text{maks.}}}{P_{\text{geser}}} = \frac{2854,76}{3810,35} = 0,8 \sim 2 \text{ baut}$$

Digunakan : 2 buah baut

Perhitungan jarak antar baut :

$$\text{a) } 1,5 d \leq S_1 \leq 3 d$$

$$\text{Diambil, } S_1 = 2,5 d = 2,5 \times 1,59$$

$$= 3,975 \text{ cm}$$

$$= 3,5 \text{ cm}$$

$$\text{b) } 2,5 d \leq S_2 \leq 7 d$$

$$\text{Diambil, } S_2 = 5 d = 5 \times 1,59$$

$$= 7,95 \text{ cm}$$

$$= 7,5 \text{ cm}$$

b. Batang Tekan

Untuk batang atas dan batang bawah:

Digunakan alat sambung baut-mur.

Diameter baut (\varnothing) = 15,9 mm.

Diameter lubang = 17 mm.

Tebal pelat sambung (δ) = $0,625 \times d$

$$= 0,625 \times 15,9 = 9,9 \text{ mm.}$$

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Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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Menggunakan tebal plat 10 mm

➤ Tegangan geser yang diijinkan

$$\begin{aligned}\text{Teg. geser} &= 0,6 \times \sigma_{\text{ijin}} \\ &= 0,6 \times 1600 = 960 \text{ kg/cm}^2\end{aligned}$$

➤ Tegangan tumpuan yang diijinkan

$$\begin{aligned}\text{Teg. tumpuan} &= 1,5 \times \sigma_{\text{ijin}} \\ &= 1,5 \times 1600 = 2400 \text{ kg/cm}^2\end{aligned}$$

➤ Kekuatan baut :

$$\begin{aligned}\text{a) } P_{\text{geser}} &= 2 \times \frac{1}{4} \times \pi \times d^2 \times \tau_{\text{geser}} \\ &= 2 \times \frac{1}{4} \times \pi \times (1,59)^2 \times 960 = 3810,35 \text{ kg}\end{aligned}$$

$$\begin{aligned}\text{b) } P_{\text{desak}} &= \delta \times d \times \tau_{\text{tumpuan}} \\ &= 1 \times 1,59 \times 2400 = 3816 \text{ kg}\end{aligned}$$

P yang menentukan adalah $P_{\text{geser}} = 3810,35 \text{ kg}$

Perhitungan jumlah baut-mur,

$$n = \frac{P_{\text{maks.}}}{P_{\text{geser}}} = \frac{13404,15}{3810,35} = 3,52 \sim 4 \text{ baut}$$

Digunakan : 4 buah baut

Perhitungan jarak antar baut :

$$\text{a) } 1,5 d \leq S_1 \leq 3 d$$

$$\text{Diambil, } S_1 = 2,5 d = 2,5 \times 1,59$$

$$= 3,975 \text{ cm}$$

$$= 3,5 \text{ cm}$$

$$\text{b) } 2,5 d \leq S_2 \leq 7 d$$

$$\text{Diambil, } S_2 = 5 d = 5 \times 1,59$$

$$= 7,95 \text{ cm}$$

$$= 7,5 \text{ cm}$$

Untuk batang tengah:



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Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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Digunakan alat sambung baut-mur.

Diameter baut (\varnothing) = 15,9 mm.

Diameter lubang = 17 mm.

$$\begin{aligned} \text{Tebal pelat sambung } (\delta) &= 0,625 \times d \\ &= 0,625 \times 15,9 = 9,9 \text{ mm.} \end{aligned}$$

Menggunakan tebal plat 10 mm.

➤ Tegangan geser yang diijinkan

$$\begin{aligned} \text{Teg. geser} &= 0,6 \times \sigma_{\text{ijin}} = 0,6 \times 1600 \\ &= 960 \text{ kg/cm}^2 \end{aligned}$$

➤ Tegangan tumpuan yang diijinkan

$$\begin{aligned} \text{Teg. tumpuan} &= 1,5 \times \sigma_{\text{ijin}} = 1,5 \times 1600 \\ &= 2400 \text{ kg/cm}^2 \end{aligned}$$

➤ Kekuatan baut :

$$\begin{aligned} \text{a) } P_{\text{geser}} &= 2 \times \frac{1}{4} \times \pi \times d^2 \times \tau_{\text{geser}} \\ &= 2 \times \frac{1}{4} \times \pi \times (1,59)^2 \times 960 = 3810,35 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{b) } P_{\text{desak}} &= \delta \times d \times \tau_{\text{tumpuan}} \\ &= 0,8 \times 1,59 \times 2400 = 3816 \text{ kg} \end{aligned}$$

P yang menentukan adalah $P_{\text{geser}} = 3810,35 \text{ kg}$

Perhitungan jumlah baut-mur,

$$n = \frac{P_{\text{maks.}}}{P_{\text{geser}}} = \frac{1789,08}{3810,35} = 0,5 \sim 2 \text{ baut}$$

Digunakan : 2 buah baut

Perhitungan jarak antar baut :

$$\text{a) } 1,5 d \leq S_1 \leq 3 d$$

$$\begin{aligned} \text{Diambil, } S_1 &= 2,5 d = 2,5 \times 1,59 \\ &= 3,975 \text{ cm} \\ &= 3,5 \text{ cm} \end{aligned}$$

$$\text{b) } 2,5 d \leq S_2 \leq 7 d$$



Tugas Akhir

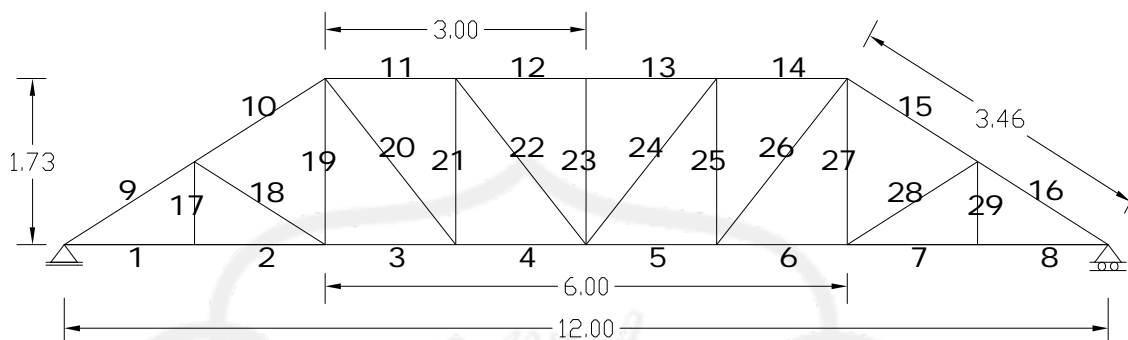
Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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Diambil, $S_2 = 5 d = 5 \times 1,59$

$= 7,95 \text{ cm}$

$= 7,5 \text{ cm}$



Tabel 3.21. Rekapitulasi perencanaan profil kuda-kuda trapesium

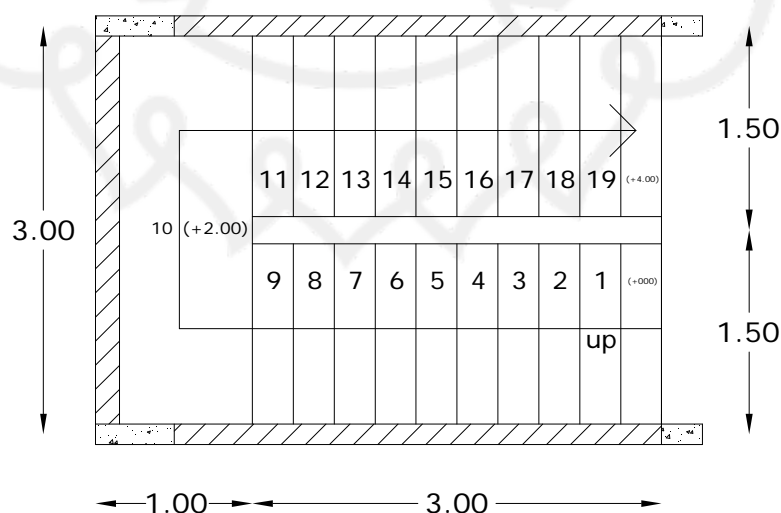
Nomor Batang	Dimensi Profil	Baut (mm)	Nomor Batang	Dimensi Profil	Baut (mm)
1	┴ 60 . 60 . 6	4 Ø 15,9	16	┴ 60 . 60 . 6	4 Ø 15,9
2	┴ 60 . 60 . 6	4 Ø 15,9	17	┴ 50 . 50 . 5	2 Ø 15,9
3	┴ 60 . 60 . 6	4 Ø 15,9	18	┴ 50 . 50 . 5	2 Ø 15,9
4	┴ 60 . 60 . 6	4 Ø 15,9	19	┴ 50 . 50 . 5	2 Ø 15,9
5	┴ 60 . 60 . 6	4 Ø 15,9	20	┴ 50 . 50 . 5	2 Ø 15,9
6	┴ 60 . 60 . 6	4 Ø 15,9	21	┴ 50 . 50 . 5	2 Ø 15,9
7	┴ 60 . 60 . 6	4 Ø 15,9	22	┴ 50 . 50 . 5	2 Ø 15,9
8	┴ 60 . 60 . 6	4 Ø 15,9	23	┴ 50 . 50 . 5	2 Ø 15,9
9	┴ 60 . 60 . 6	4 Ø 15,9	24	┴ 50 . 50 . 5	2 Ø 15,9
10	┴ 60 . 60 . 6	4 Ø 15,9	25	┴ 50 . 50 . 5	2 Ø 15,9
11	┴ 60 . 60 . 6	4 Ø 15,9	26	┴ 50 . 50 . 5	2 Ø 15,9
12	┴ 60 . 60 . 6	4 Ø 15,9	27	┴ 50 . 50 . 5	2 Ø 15,9
13	┴ 60 . 60 . 6	4 Ø 15,9	28	┴ 50 . 50 . 5	2 Ø 15,9
14	┴ 60 . 60 . 6	4 Ø 15,9	29	┴ 50 . 50 . 5	2 Ø 15,9
15	┴ 60 . 60 . 6	4 Ø 15,9	-	-	-

**BAB 4****PERENCANAAN TANGGA****4.1. Uraian Umum**

Tangga merupakan bagian dari struktur bangunan bertingkat yang sangat penting sebagai penunjang antara struktur bangunan lantai dasar dengan struktur bangunan tingkat di atasnya. Penempatan tangga pada struktur suatu bangunan sangat berhubungan dengan fungsi bangunan bertingkat yang akan dioperasikan. Pada bangunan umum, penempatan haruslah mudah diketahui dan terletak strategis untuk menjangkau ruang satu dengan yang lainnya, penempatan tangga harus disesuaikan dengan fungsi bangunan untuk mendukung kelancaran hubungan yang serasi antara pemakai bangunan tersebut.

4.2. Data Perencanaan Tangga

Untuk memahami detail tangga yang akan dihitung apat dilihat pada Gambar 4.1 berikut ini.

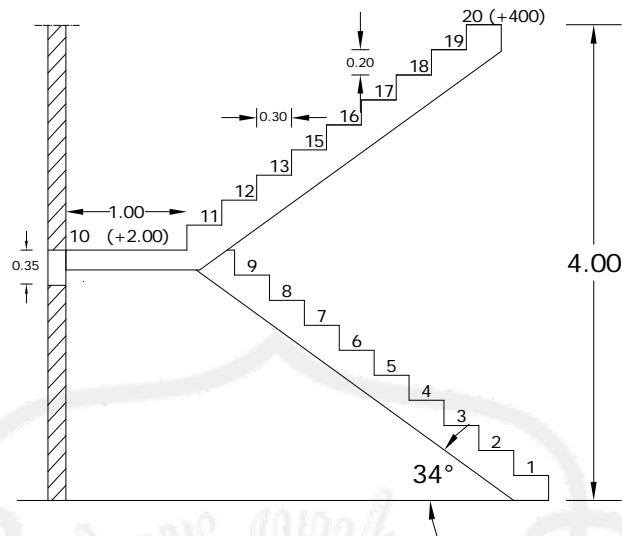




Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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Gambar 4.1. Detail tangga

Data – data tangga :

- Tebal plat tangga = 12 cm
- Tebal bordes tangga = 12 cm
- Lebar datar = 400 cm
- Lebar tangga rencana = 150 cm
- Dimensi bordes = 100 x 300 cm
- Lebar antrede = 30 cm
- Jumlah antrede = $300 / 30 = 10$ buah
- Tinggi optrede = 20 cm
- Jumlah optrade = $200 / 20 = 10$ buah
- Sudut Tangga = $\text{Arc tg} (200/300)$
 $= 33,69^\circ \sim 34^\circ < 35^\circ$ (OK)

4.3. Perhitungan Tebal Plat Equivalen dan Pembebanan

BAB 6 Balok Anak

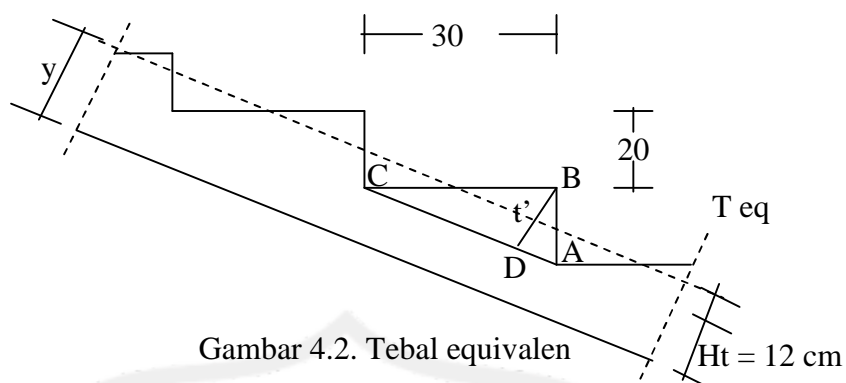


Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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4.3.1. Perhitungan Tebal Plat Equivalen



Gambar 4.2. Tebal equivalen

$$\begin{aligned}\frac{BD}{AB} &= \frac{BC}{AC} \\ BD &= \frac{AB \times BC}{AC} \\ &= \frac{20 \times 30}{\sqrt{(20)^2 + (30)^2}} \\ &= 16,64 \text{ cm} \sim 17 \text{ cm}\end{aligned}$$

$$\begin{aligned}t_{eq} &= \frac{2}{3} \times BD \\ &= \frac{2}{3} \times 17 \\ &= 11,33 \text{ cm} \sim 12 \text{ cm}\end{aligned}$$

Jadi total equivalent plat tangga

$$\begin{aligned}Y &= t_{eq} + h_t \\ &= 12 + 12 \\ &= 24 \text{ cm} \\ &= 0,24 \text{ m}\end{aligned}$$

4.3.2. Perhitungan Beban

a. Pembebanan tangga (SNI 03-1727-1989)

1. Akibat beban mati (qD)

$$\text{Berat tegel keramik (1 cm)} = 0,01 \times 1 \times 2,45 = 0,0245 \text{ ton/m}$$

$$\text{Berat spesi (2 cm)} = 0,02 \times 1 \times 2,1 = 0,0420 \text{ ton/m}$$

BAB 6 Balok Anak



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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$$\begin{aligned}
 \text{Berat plat tangga} &= 0,24 \times 1 \times 2,4 &= 0,5760 \text{ ton/m} \\
 \text{Berat sandaran tangga} &= 0,7 \times 0,1 \times 1,0 \times 2 &= 0,1400 \text{ ton/m} \\
 & & \underline{qD = 0,7825 \text{ ton/m}^+}
 \end{aligned}$$

2. Akibat beban hidup (qL)

$$\begin{aligned}
 qL &= 1 \times 0,300 \text{ ton/m} \\
 &= 0,300 \text{ ton/m}
 \end{aligned}$$

3. Beban ultimate (qU)

$$\begin{aligned}
 qU &= 1,2 \times qD + 1,6 \times qL \\
 &= 1,2 \times 0,7825 + 1,6 \times 0,300 \\
 &= 1,419 \text{ ton/m}
 \end{aligned}$$

b. Pembebanan pada bordes (SNI 03-1727-1989)

1. Akibat beban mati (qD)

$$\begin{aligned}
 \text{Berat tegel keramik (1 cm)} &= 0,01 \times 1 \times 2,4 &= 0,024 \text{ ton/m} \\
 \text{Berat spesi (2 cm)} &= 0,02 \times 1 \times 2,1 &= 0,042 \text{ ton/m} \\
 \text{Berat plat bordes} &= 0,20 \times 1 \times 2,4 &= 0,480 \text{ ton/m} \\
 \text{Berat sandaran tangga} &= 0,7 \times 0,1 \times 1,0 \times 2 &= 0,140 \text{ ton/m} \\
 & & \underline{qD = 0,686 \text{ ton/m}^+}
 \end{aligned}$$

2. Akibat beban hidup (qL)

$$\begin{aligned}
 qL &= 2 \times 0,300 \text{ ton/m} \\
 &= 0,600 \text{ ton/m}
 \end{aligned}$$

3. Beban ultimate (qU)

$$\begin{aligned}
 qU &= 1,2 \times qD + 1,6 \times qL \\
 &= 1,2 \times 0,686 + 1,6 \times 0,600 \\
 &= 1,783 \text{ ton/m.}
 \end{aligned}$$

Perhitungan analisa struktur tangga menggunakan Program SAP 2000 tumpuan di asumsikan jepit, sendi, sendi seperti pada Gambar 4.3 dibawah ini.

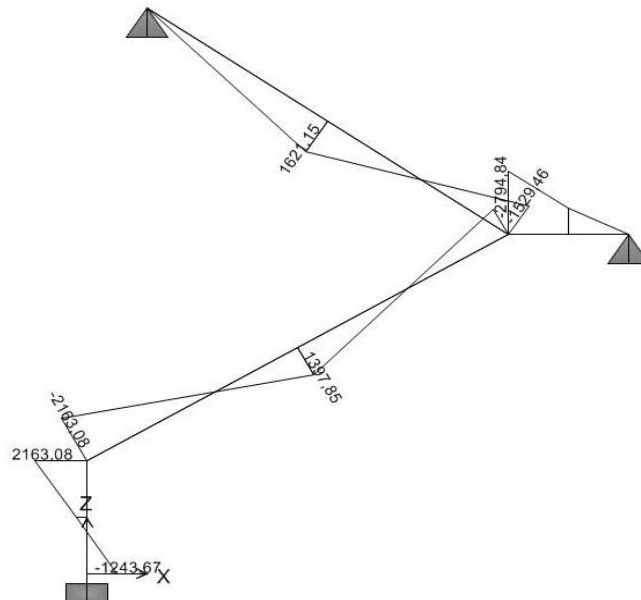


Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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Gambar 4.3 Rencana tumpuan tangga



Gambar 4.4 Bidang momen tangga

4.4. Perhitungan Tulangan Tangga dan Bordes

Data :

$$\begin{aligned}
 b &= 1000 \\
 d &= h - p - \frac{1}{2} D \text{ tul} - \frac{1}{2} \emptyset \text{ sengkang} \\
 &= 120 - 20 - \frac{1}{2} \cdot 13 - 4 \\
 &= 89,5 \text{ mm} \\
 f_y &= 320 \text{ MPa} \\
 f'_c &= 17,5 \text{ MPa}
 \end{aligned}$$



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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Untuk plat digunakan :

$$\rho_b = \frac{0,85 \cdot f_c}{f_y} \beta \left(\frac{600}{600 + f_y} \right)$$

$$= \frac{0,85 \times 17,5}{320} 0,85 \left(\frac{600}{600 + 320} \right)$$

$$= 0,026$$

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

$$= 0,75 \times 0,026$$

$$= 0,0198$$

$$\rho_{\min} = 0,0025$$

4.4.1. Perhitungan Tulangan Tumpuan Tangga

Dari perhitungan **SAP 2000** diperoleh momen terbesar pada batang nomor **1**:

$$M_u = \mathbf{2164} \text{ kgm} = 2,164 \times 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{2,164 \times 10^7}{0,8} = 2,705 \times 10^7 \text{ Nmm}$$

$$m = \frac{f_y}{0,85 \times f_c} = \frac{320}{0,85 \times 17,5} = 21,513$$

$$R_n = \frac{M_n}{b \times d^2} = \frac{2,705 \times 10^7}{1000 \times (89,5)^2} = 3,377 \text{ N/mm}$$

$$\rho_{\text{perlu}} = \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \times m \times R_n}{f_y}} \right)$$

$$= \frac{1}{320} \left(1 - \sqrt{1 - \frac{2 \times 21,513 \times 3,377}{320}} \right)$$

$$= 0,0121$$

$$\rho_{\text{perlu}} < \rho_{\max}$$

$$> \rho_{\min}$$

di pakai $\rho_{\text{perlu}} = 0,0121$

$$A_s = \rho_{\text{perlu}} \cdot b \cdot d$$

$$= 0,0121 \times 1000 \times 89,5$$

BAB 6 Balok Anak



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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$$= 1082,95 \text{ mm}^2$$

$$\text{Dipakai tulangan } D \text{ } 13 \text{ mm} = \frac{1}{4} \times \pi \times 13^2 = 132,665 \text{ mm}^2$$

$$\text{Jumlah tulangan dalam } 1 \text{ m}^2 = \frac{1082,95}{132,665} = 8,2 \approx 9 \text{ buah}$$

$$\text{Jarak tulangan } 1 \text{ m} = \frac{1000}{9} = 111,11 \text{ mm}$$

Dipakai tulangan 9 D 13 mm – 110 mm

$$\begin{aligned} \text{As yang timbul} &= 9 \times \frac{1}{4} \times \pi \times 13^2 \\ &= 1193,99 \text{ mm}^2 > \text{As} \dots\dots\dots \text{Aman !} \end{aligned}$$

4.4.2. Perhitungan Tulangan Lapangan

Dari perhitungan **SAP 2000** diperoleh momen terbesar pada batang nomor **3**:

$$M_u = 1622 \text{ kgm} = 1,622 \times 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{1,622 \times 10^7}{0,8} = 2,028 \times 10^7 \text{ Nmm}$$

$$m = \frac{f_y}{0,85 \times f_c} = \frac{320}{0,85 \times 17,5} = 21,513$$

$$R_n = \frac{M_n}{b \times d^2} = \frac{2,028 \times 10^7}{1000 \times (89,5)^2} = 2,532 \text{ N/mm}$$

$$\begin{aligned} \rho_{\text{perlu}} &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \times m \times R_n}{f_y}} \right) \\ &= \frac{1}{21,513} \left(1 - \sqrt{1 - \frac{2 \times 21,513 \times 2,503}{320}} \right) \\ &= 0,00862 \end{aligned}$$

$$\rho_{\text{perlu}} < \rho_{\text{max}}$$

$$> \rho_{\text{min}}$$

di pakai $\rho_{\text{perlu}} = 0,00862$

$$\begin{aligned} \text{As} &= \rho_{\text{perlu}} \cdot b \cdot d \\ &= 0,00862 \times 1000 \times 89,5 \\ &= 771,49 \text{ mm}^2 \end{aligned}$$

BAB 6 Balok Anak



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Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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$$\text{Dipakai tulangan } D 13 \text{ mm} = \frac{1}{4} \times \pi \times 13^2 = 132,665 \text{ mm}^2$$

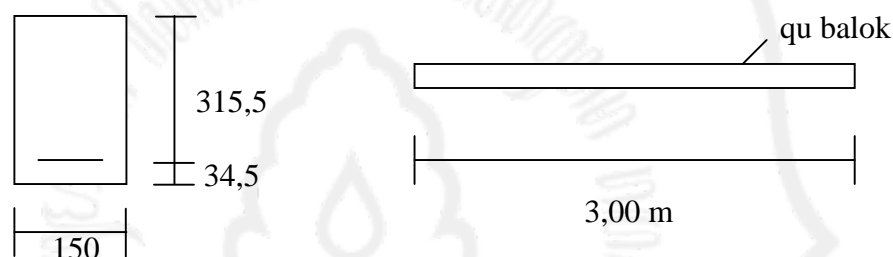
$$\text{Jumlah tulangan dalam } 1 \text{ m}^2 = \frac{771,49}{132,665} = 5,8 \approx 6 \text{ buah}$$

$$\text{Jarak tulangan } 1 \text{ m} = \frac{1000}{6} = 166,67 \text{ mm}$$

Dipakai tulangan 6 D 13 mm – 160 mm

$$\begin{aligned} \text{As yang timbul} &= 6 \times \frac{1}{4} \times \pi \times 13^2 \\ &= 795,99 \text{ mm}^2 > \text{As Aman !} \end{aligned}$$

4.5. Perencanaan Balok Bordes



Data perencanaan:

$$h = 350 \text{ mm direncanakan memakai tulangan } D 13 \text{ mm}$$

$$b = 150 \text{ mm}$$

$$p = 20 \text{ mm}$$

$$d = h - p - \text{Ø sengkang} - \frac{1}{2}\text{Ø tul}$$

$$= 350 - 20 - 8 - 6,5 = 315,5 \text{ mm}$$

Pembebanan:

➤ Beban mati (qD)

$$\text{Berat sendiri} = 0,15 \times 0,35 \times 2,4 = 0,126 \text{ ton/m}$$

$$\text{Berat dinding} = 0,15 \times 2 \times 1,7 = 0,510 \text{ ton/m}$$

$$\text{Berat plat bordes} = 0,12 \times 3 \times 2,4 = 0,864 \text{ ton/m}$$

$$\underline{\quad\quad\quad} +$$

$$qD = 0,864 \text{ ton/m}$$

➤ Akibat beban hidup dari bordes (qL)

BAB 6 Balok Anak



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Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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$$qL = 0,300 \text{ ton/m}$$

- Beban ultimate (qU)

$$\begin{aligned} qU &= 1,2 \times qD + 1,6 \times qL \\ &= 1,2 \times 0,864 + 1,6 \times 0,300 \\ &= 1,517 \text{ ton/m} \end{aligned}$$

- Beban reaksi bordes

$$\begin{aligned} q_u &= \frac{\text{Reaksi bordes}}{\text{lebar bordes}} \\ &= \frac{\frac{1}{2} \times 1,730}{1} \\ &= 0,865 \text{ ton/m} = 865 \text{ kg/m} \end{aligned}$$

4.5.1. Perhitungan tulangan lentur

Dari perhitungan **SAP 2000** diperoleh momen terbesar pada batang nomor 2:

$$M_u = 2794,84 \text{ kgm} = 2,795 \times 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{2,795 \times 10^7}{0,8} = 3,493 \times 10^7 \text{ Nmm}$$

$$m = \frac{f_y}{0,85 \cdot f_c} = \frac{320}{0,85 \times 17,5} = 21,513$$

$$\begin{aligned} \rho_b &= \frac{0,85 \times f_c}{f_y} \times \beta \times \left(\frac{600}{600 + f_y} \right) \\ &= \frac{0,85 \times 17,5}{320} \times 0,85 \times \left(\frac{600}{600 + 320} \right) \\ &= 0,0258 \end{aligned}$$

$$\begin{aligned} \rho_{\max} &= 0,75 \times \rho_b \\ &= 0,0193 \end{aligned}$$

$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{320} = 0,004375$$

$$R_n = \frac{M_n}{b \times d^2} = \frac{3,493 \times 10^7}{150 \times (315,5)^2} = 2,339 \text{ N/mm}$$



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$$\rho_{\text{perlu}} = \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \times m \times R_n}{f_y}} \right)$$

$$= \frac{1}{21,513} \left(1 - \sqrt{1 - \frac{2 \times 21,513 \times 2,339}{320}} \right) = 0,008$$

$$\rho_{\text{perlu}} > \rho_{\text{min}}$$

$$< \rho_{\text{max}}$$

di pakai $\rho_{\text{perlu}} = 0,008$

$$A_s = \rho_{\text{perlu}} \cdot b \cdot d$$

$$= 0,008 \times 150 \times 315,5$$

$$= 378,6 \text{ mm}^2$$

$$\text{Dipakai tulangan D 13 mm} = \frac{1}{4} \times \pi \times 13^2 = 132,67 \text{ mm}^2$$

$$\text{Jumlah tulangan} = \frac{378,6}{132,67} = 2,8 \approx 3 \text{ buah}$$

$$\text{As yang timbul} = 3 \times \frac{1}{4} \times \pi \times 13^2$$

$$= 398,04 \text{ mm}^2 > A_s \dots\dots\dots \text{Aman !}$$

Dipakai tulangan **3 D 13 mm**

4.5.2. Perhitungan Tulangan Geser

Dari perhitungan **SAP 2000** diperoleh gaya geser terbesar pada batang nomor 2:

$$V_u = 3859,24 \text{ kg} = 3,859 \times 10^4 \text{ N}$$

$$V_c = \frac{1}{6} \times b \times d \times \sqrt{f'_c}$$

$$= \frac{1}{6} \times 150 \times 315,5 \times \sqrt{17,5}$$

$$= 3,2996 \times 10^4 \text{ N}$$

$$\phi V_c = 0,6 \times V_c$$

$$= 0,6 \times 3,2996 \times 10^4 \text{ N} = 1,980 \times 10^4 \text{ N}$$

$$\phi V_s = V_u - \phi V_c$$

$$= (3,859 \times 10^4 \text{ N}) - (1,980 \times 10^4 \text{ N}) = 1,879 \times 10^4 \text{ N}$$

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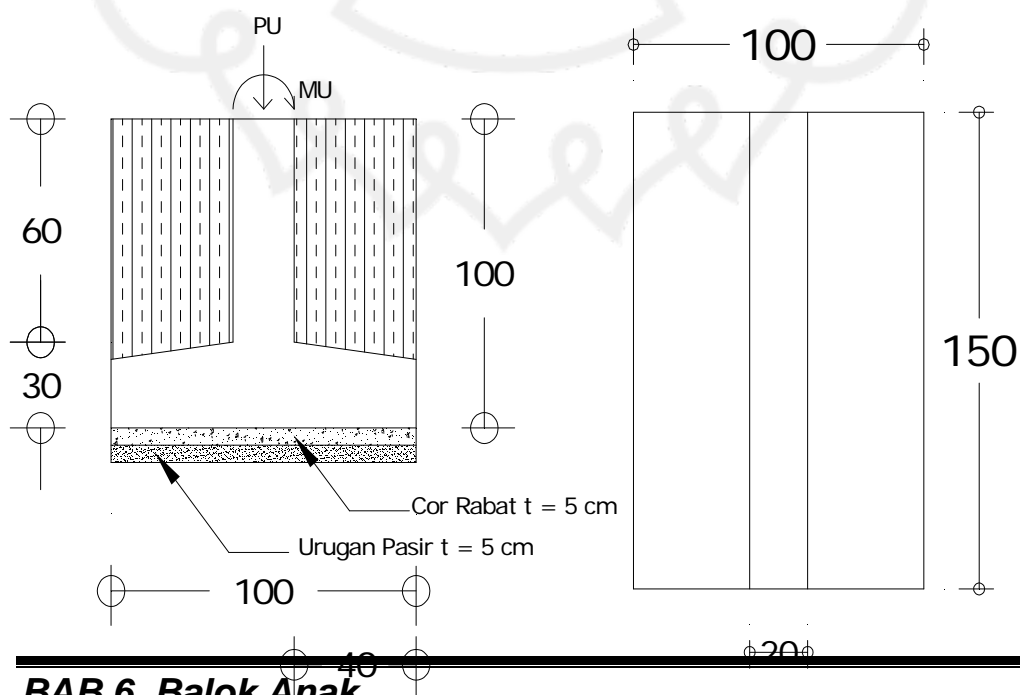
$$V_{S_{perlu}} = \frac{1,879 \times 10^4 \text{ N}}{0,8} = 2,349 \times 10^4 \text{ N}$$

$$S_{ada} = \frac{A_v \times f_y \times d}{V_{S_{perlu}}} = \frac{2 \times 50,24 \times 240 \times 315,5}{2,349 \times 10^4} = 323,89 \text{ mm}$$

$$S_{max} = \frac{d}{2} = \frac{315,5}{2} = 157,75 \text{ mm} \approx 150 \text{ mm}$$

Jadi dipakai sengkang $\varnothing 8 - 150 \text{ mm}$

4.6. Perhitungan Pondasi Tangga



**Gambar 4.4. Pondasi Tangga**

Dari perhitungan **SAP 2000** pada Frame diperoleh :

- **Pu = 6105,5 kg**
- **Mu = 2163,1 kgm**

Dimensi Pondasi :

$$\sigma_{\text{tanah}} = \frac{Pu}{A}$$

$$A = \frac{Pu}{\sigma_{\text{tanah}}} = \frac{6105,5}{35000}$$

$$= 0,17 \text{ m}^2$$

$$B = L = \sqrt{A} = \sqrt{0,17}$$

$$= 0,42 \text{ m} \sim 1,00 \text{ m}$$

Direncanakan pondasi telapak dengan kedalaman 1 m dan lebar telapak (B) 1,0 m

- Tebal = 300 mm
- d = 300 - (50 + 6,5 + 8) = 235,5 mm
- Ukuran alas = 1000 × 1500 mm
- γ tanah = 1,7 t/m³ = 1700 kg/m³
- σ tanah = 3,5 kg/cm² = 35.000 kg/m²

4.6.1. Perencanaan kapasitas dukung pondasi

a. Perhitungan kapasitas dukung pondasi

➤ Pembebanan pondasi

$$\text{Berat telapak pondasi} = 1 \times 1,5 \times 0,20 \times 2,4 = 0,72 \text{ ton}$$

$$\text{Berat tanah} = 2 (0,4 \times 0,6 \times 1,5) \times 1,7 = 1,224 \text{ ton}$$

$$\text{Berat Kolom} = 0,2 \times 1,5 \times 0,6 \times 2,4 = 0,432 \text{ ton}$$



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$$\begin{aligned}
 P_u &= 6,106 \text{ ton} + \\
 \Sigma P &= 8,482 \text{ ton} \\
 &= 8482 \text{ kg}
 \end{aligned}$$

$$e = \frac{\sum M_u}{\sum P} = \frac{2163}{8482}$$

$$= 0,26 < 1/6. B = 0,29$$

$$\sigma_{\text{yang terjadi}} = \frac{\sum P}{A} \pm \frac{M_u}{\frac{1}{6} \cdot b \cdot L^2}$$

$$\begin{aligned}
 \sigma_{\text{yang terjadi}} &= \frac{\sum P}{A} + \frac{M_u}{\frac{1}{6} \cdot b \cdot L^2} \\
 &= \frac{8482}{1 \times 1,50} + \frac{2163}{\frac{1}{6} \times 1 \times (1,50)^2}
 \end{aligned}$$

$$= 11422,67 \text{ kg/m}^2$$

$$= \sigma_{\text{tanah yang terjadi}} < \sigma_{\text{ijin tanah}} \dots \dots \dots \text{Ok!}$$

4.6.2. Perhitungan Tulangan Lentur

$$\begin{aligned}
 M_u &= \frac{1}{2} \times \sigma \times t^2 \\
 &= \frac{1}{2} \times 11422,67 \times (0,4)^2 = 913,81 \text{ kgm} = 0,914 \times 10^7 \text{ Nmm}
 \end{aligned}$$

$$M_n = \frac{0,914 \times 10^7}{0,8} = 1,143 \times 10^7 \text{ Nmm}$$

$$m = \frac{f_y}{0,85 \times 17,5} = \frac{320}{0,85 \times 17,5} = 21,513$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{1,143 \times 10^7}{1000 \times (235,5)^2} = 0,206$$

$$\begin{aligned}
 \rho_b &= \frac{0,85 \cdot f_c}{f_y} \beta \left(\frac{600}{600 + f_y} \right) \\
 &= \frac{0,85 \times 17,5}{320} \times 0,85 \times \left(\frac{600}{600 + 320} \right) = 0,0258
 \end{aligned}$$

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

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$$= 0,0193$$

$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{320} = 0,004375$$

$$\rho_{\text{perlu}} = \frac{1}{m} \left(1 - \sqrt{1 - \frac{2m \cdot R_n}{f_y}} \right)$$

$$= \frac{1}{21,513} \cdot \left(1 - \sqrt{1 - \frac{2 \times 21,513 \times 0,206}{320}} \right)$$

$$= 0,00065$$

$$\rho_{\text{perlu}} < \rho_{\max}$$

$$< \rho_{\min}$$

dipakai $\rho_{\min} = 0,004375$

$$\begin{aligned} \text{As perlu} &= \rho_{\min} \cdot b \cdot d \\ &= 0,004375 \times 1000 \times 235,5 \\ &= 1030,31 \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} \text{Digunakan tulangan D 13} &= \frac{1}{4} \cdot \pi \cdot \emptyset^2 \\ &= \frac{1}{4} \times 3,14 \times (13)^2 = 132,665 \text{ mm}^2 \end{aligned}$$

$$\text{Jumlah tulangan (n)} = \frac{1030,31}{132,665} = 7,8 \approx 8 \text{ buah}$$

$$\text{Jarak tulangan} = \frac{1000}{8} = 125 \text{ mm}$$

Sehingga dipakai tulangan **D 13– 125 mm**

$$\begin{aligned} \text{As yang timbul} &= 8 \times \frac{1}{4} \times \pi \times 13^2 \\ &= 1061,32 \text{ mm}^2 > \text{As Aman !} \end{aligned}$$

4.6.3. Perhitungan Tulangan Geser

$$\begin{aligned} V_u &= \sigma \times A_{\text{efektif}} \\ &= 11422,67 \times (0,4 \times 1) \\ &= 4,569 \times 10^4 \text{ N} \end{aligned}$$

$$\begin{aligned} V_c &= 1/6 \cdot \sqrt{f_c} \cdot b \cdot d \\ &= 1/6 \times \sqrt{17,5} \times 1000 \times 235,5 \\ &= 16,419 \times 10^4 \text{ N} \end{aligned}$$

BAB 6 Balok Anak



$$\phi V_c = 0,6 \cdot V_c$$

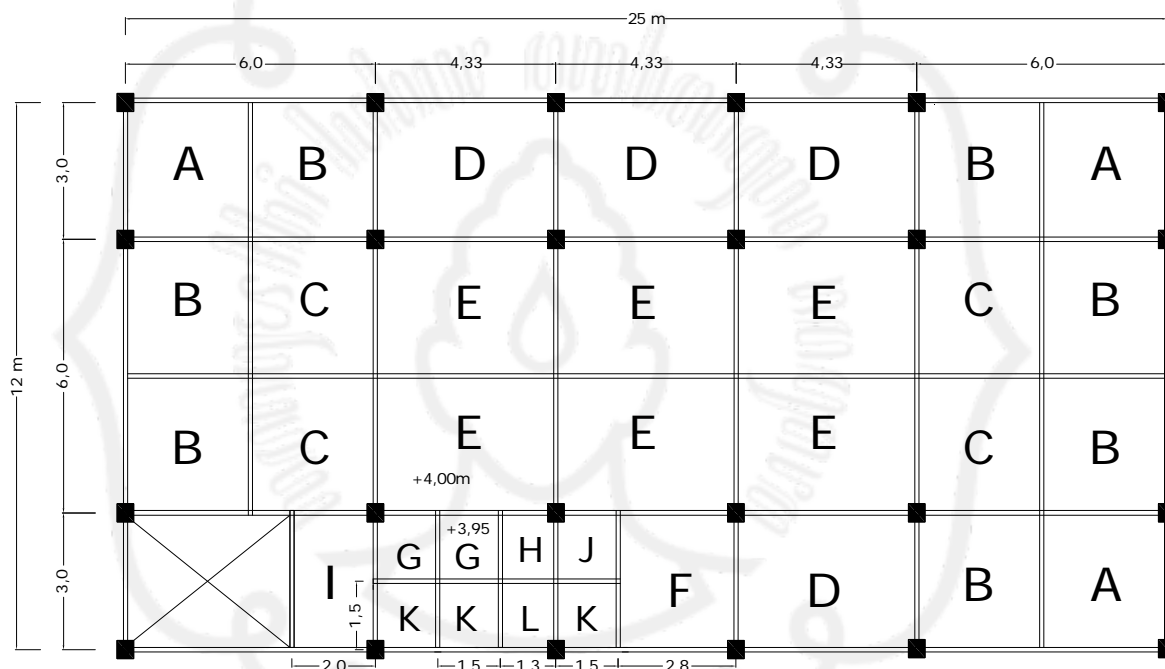
$$= 0,6 \times 16,419 \times 10^4 = 9,851 \times 10^4 \text{ N}$$

$V_u < \phi V_c$ tidak perlu tulangan geser.

Jadi dipakai sengkang untuk penghubung $\phi 8 - 200 \text{ mm}$

BAB 5 PLAT LANTAI

5.1. Perencanaan Plat Lantai



Gambar 5.1 Denah Plat lantai

I. Plat Lantai

a. Beban Hidup (q_L)

Berdasarkan PPIUG untuk gedung 1989 yaitu :

$$\text{Beban hidup fungsi gedung untuk kantor tiap } 1 \text{ m} = 250 \text{ kg/m}^2$$

b. Beban Mati (q_D) tiap 1 m

$$\text{Berat plat sendiri} = 0,12 \times 2400 \times 1 = 288 \text{ kg/m}$$

$$\text{Berat pasir} = 0,02 \times 1600 = 32 \text{ kg/m}$$

BAB 6 Balok Anak



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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Berat penutup lantai	= 0,01 x 2400	= 24	kg/m
Berat spesi	= 0,02 X 2100	= 42	kg/m
Berat plafond dan penggantung		= 18	kg/m
		<hr/>	
		qD = 404	kg/m

c. Beban Ultimate (qU)

Untuk tinjauan lebar 1 m pelat mak⁹⁵

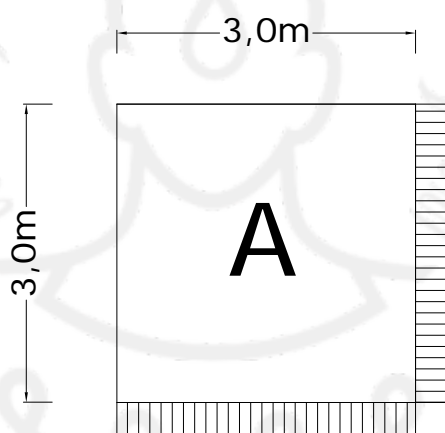
$$\begin{aligned}
 qU &= 1,2 qD + 1,6 qL \\
 &= 1,2 \times 404 + 1,6 \times 250 \\
 &= 884,8 \text{ kg/m}^2
 \end{aligned}$$

5.2. Perhitungan Momen

Perhitungan momen menggunakan tabel PPIUG 1989.

Perhitungan momen diambil kesimpulan dengan empat tipe plat momen yaitu :

a. Plat tipe A



Gambar 5.2 Pelat tipe A

$$\frac{L_y}{L_x} = \frac{3}{3} = 1$$

$$M_lx = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \times 884,8 \times (3)^2 \times 28 = 222,970 \text{ kgm}$$

$$M_ly = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \times 884,8 \times (3)^2 \times 28 = 222,970 \text{ kgm}$$

$$M_{tx} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \times 884,8 \times (3)^2 \times 68 = 541,498 \text{ kgm}$$

BAB 6 Balok Anak



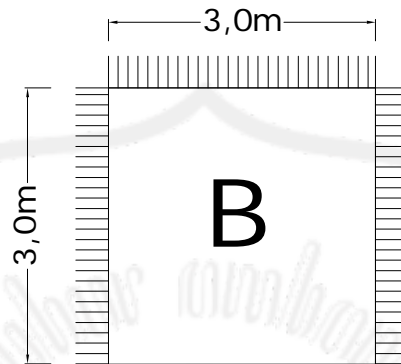
Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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$$M_{ty} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \times 884,8 \times (3)^2 \times 68 = 541,498 \text{ kgm}$$

b. Plat tipe B



Gambar 5.3 Pelat tipe B

$$\frac{L_y}{L_x} = \frac{3}{3} = 1$$

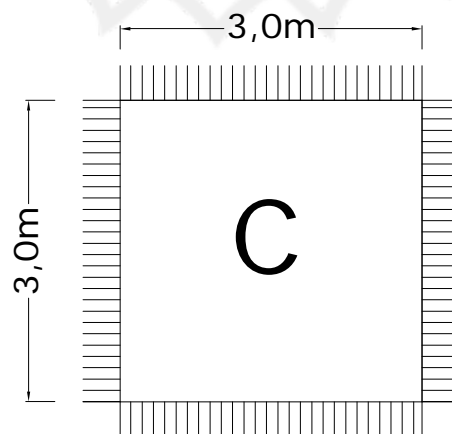
$$M_{lx} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \times 884,8 \times (3)^2 \times 21 = 167,227 \text{ kgm}$$

$$M_{ly} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \times 884,8 \times (3)^2 \times 26 = 207,043 \text{ kgm}$$

$$M_{tx} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \times 884,8 \times (3)^2 \times 55 = 437,976 \text{ kgm}$$

$$M_{ty} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \times 884,8 \times (3)^2 \times 60 = 477,792 \text{ kgm}$$

c. Plat tipe C





Gambar 5.4 Plat tipe C

$$\frac{L_y}{L_x} = \frac{3}{3} = 1$$

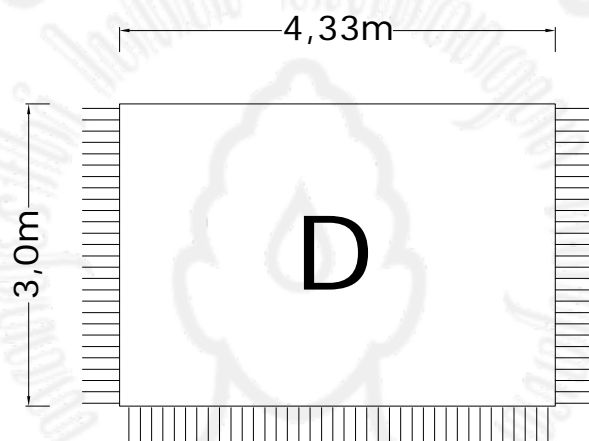
$$M_{lx} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \times 884,8 \times (3)^2 \times 21 = 167,227 \text{ kgm}$$

$$M_{ly} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \times 884,8 \times (3)^2 \times 21 = 167,227 \text{ kgm}$$

$$M_{tx} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \times 884,8 \times (3)^2 \times 52 = 414,086 \text{ kgm}$$

$$M_{ty} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \times 884,8 \times (3)^2 \times 52 = 414,086 \text{ kgm}$$

d. Plat tipe D



Gambar 5.5 Plat tipe D

$$\frac{L_y}{L_x} = \frac{4,33}{3} = 1,44 \sim 1,5$$

$$M_{lx} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \times 884,8 \times (3)^2 \times 36 = 342,418 \text{ kgm}$$

$$M_{ly} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \times 884,8 \times (3)^2 \times 17 = 207,043 \text{ kgm}$$

$$M_{tx} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \times 884,8 \times (3)^2 \times 76 = 748,541 \text{ kgm}$$

$$M_{ty} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \times 884,8 \times (3)^2 \times 57 = 605,203 \text{ kgm}$$



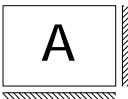
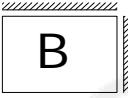


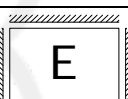
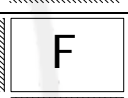

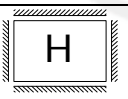


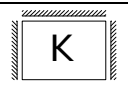
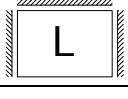
Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

Perhitungan selanjutnya disajikan dalam tabel dibawah ini.

5.3. Penulangan Plat Lantai

Tabel 5.1. Perhitungan Plat Lantai

TIPE PLAT	L_y/L_x (m)	M_{lx} (kgm)	M_{ly} (kgm)	M_{tx} (kgm)	M_{ty} (kgm)
	$3/3 = 1$	222,970	222,970	541,498	541,498
	$3/3 = 1$	167,227	207,043	437,976	477,792
	$3/3 = 1$	167,227	167,227	414,086	414,086
	<u>$4,33/3 = 1,5$</u>	<u>342,418</u>	<u>207,043</u>	<u>748,541</u>	<u>605,203</u>
	$4,33/3 = 1,5$	286,675	135,374	605,203	453,902
	$3/2,8 = 1,1$	180,358	187,294	450,894	450,894
	$1,5/1,5 = 1$	81,623	23,890	165,236	113,476
	$1,5/1,3 = 1,2$	41,869	29,906	95,700	83,737
	$3/2 = 1,5$	169,882	88,480	364,538	272,518
	$2,5/1,5 = 1,7$	75,650	27,871	161,255	113,476
	$1,5/1,5 = 1$	41,807	51,761	109,494	119,448
	$2,5/1,5 = 1,7$	97,549	45,788	205,052	155,282

**Tugas Akhir****Perencanaan Struktur Gedung Kantor Pajak 2 lantai**

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Untuk perencanaan ini dipakai tipe plat yang mempunyai momen terbesar yaitu :

Tipe plat D

$M_{lx} = 342,418 \text{ kgm}$

$M_{ly} = 207,043 \text{ kgm}$

$M_{tx} = 748,541 \text{ kgm}$

$M_{ty} = 605,203 \text{ kgm}$





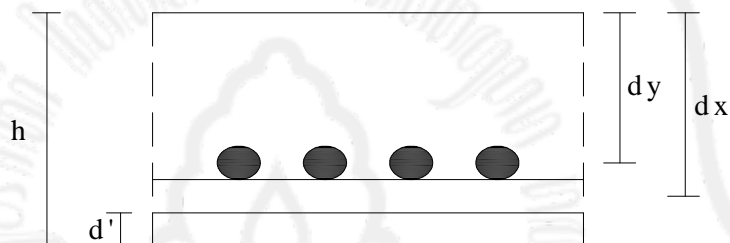
Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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Data : Tebal plat (h)	= 12 cm = 120 mm
Tebal penutup (d')	= 20 mm
Diameter tulangan (Ø)	= 10 mm
b	= 1000
f _y	= 240 MPa
f'c	= 17,5 MPa
Tinggi Efektif (d)	= h - d' = 120 - 20 = 100 mm

Tinggi efektif



Gambar 5.3 Perencanaan Tinggi Efektif

$$\begin{aligned}
 dx &= h - d' - \frac{1}{2} \text{Ø} \\
 &= 120 - 20 - 5 = 95 \text{ mm} \\
 dy &= h - d' - \text{Ø} - \frac{1}{2} \text{Ø} \\
 &= 120 - 20 - 10 - \frac{1}{2} \cdot 10 = 85 \text{ mm}
 \end{aligned}$$

untuk plat digunakan

$$\begin{aligned}
 \rho_b &= \frac{0,85 \cdot f_c}{f_y} \cdot \beta \cdot \left(\frac{600}{600 + f_y} \right) \\
 &= \frac{0,85 \cdot 17,5}{240} \cdot 0,85 \cdot \left(\frac{600}{600 + 240} \right) \\
 &= 0,0376 \\
 \rho_{\max} &= 0,75 \times \rho_b \\
 &= 0,0282
 \end{aligned}$$



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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$$\rho_{\min} = 0,0025 \text{ (untuk plat)}$$

5.4. Penulangan lapangan arah x

$$M_u = 342,418 \text{ kgm} = 0,342 \times 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{0,342 \times 10^7}{0,8} = 0,4275 \times 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{0,4275 \cdot 10^7}{1000 \cdot (95)^2} = 0,4737 \text{ N/mm}^2$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{240}{0,85 \cdot 17,5} = 16,134$$

$$\rho_{\text{perlu}} = \frac{1}{m} \times \left(1 - \sqrt{1 - \frac{2m \cdot R_n}{f_y}} \right)$$

$$= \frac{1}{16,134} \times \left(1 - \sqrt{1 - \frac{2 \cdot 16,134 \cdot 0,4737}{240}} \right)$$

$$= 0,00201$$

$$\rho < \rho_{\max}$$

$$\rho < \rho_{\min}, \text{ di pakai } \rho_{\min} = 0,0025$$

$$A_s = \rho_{\min} \cdot b \cdot d$$

$$= 0,0025 \times 1000 \times 95$$

$$= 237,5 \text{ mm}^2$$

$$\text{Digunakan tulangan } \varnothing 8 = \frac{1}{4} \cdot \pi \cdot (8)^2 = 50,24 \text{ mm}^2$$

$$\text{Jumlah tulangan} = \frac{237,5}{50,24} = 4,7 \sim 5 \text{ buah.}$$

$$\text{Jarak tulangan dalam } 1 \text{ m}^1 = \frac{1000}{5} = 200 \text{ mm}$$

$$\text{Jarak maksimum} = 2 \times h = 2 \times 120 = 240 \text{ mm}$$

$$\text{As terpasang} = 5 \cdot \frac{1}{4} \cdot \pi \cdot (8)^2 = 251,2 > A_s \text{ok!}$$

Dipakai tulangan $\varnothing 8 - 200 \text{ mm}$

BAB 6 Balok Anak



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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5.5. Penulangan lapangan arah y

$$M_u = 207,043 \text{ kgm} = 0,207 \times 10^6 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{0,207 \times 10^7}{0,8} = 0,2588 \times 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{0,2588 \times 10^7}{1000 \cdot (85)^2} = 0,358 \text{ N/mm}^2$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{240}{0,85 \cdot 17,5} = 16,134$$

$$\begin{aligned} \rho_{\text{perlu}} &= \frac{1}{m} \times \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot R_n}{f_y}} \right) \\ &= \frac{1}{16,134} \times \left(1 - \sqrt{1 - \frac{2 \cdot 16,134 \cdot 0,358}{240}} \right) \\ &= 0,00151 \end{aligned}$$

$$\rho < \rho_{\text{max}}$$

$$\rho < \rho_{\text{min}}, \text{ di pakai } \rho_{\text{min}} = 0,0025$$

$$\begin{aligned} A_s &= \rho_{\text{perlu}} \cdot b \cdot d \\ &= 0,0025 \times 1000 \times 85 \\ &= 212,5 \text{ mm}^2 \end{aligned}$$

$$\text{Digunakan tulangan } \varnothing 8 = \frac{1}{4} \cdot \pi \cdot (8)^2 = 50,24 \text{ mm}^2$$

$$\text{Jumlah tulangan} = \frac{212,5}{50,24} = 4,3 \sim 5 \text{ buah.}$$

$$\text{Jarak tulangan dalam } 1 \text{ m}^1 = \frac{1000}{5} = 200 \text{ mm}$$

$$\text{Jarak maksimum} = 2 \times h = 2 \times 120 = 240 \text{ mm}$$

$$\text{As terpasang} = 5 \cdot \frac{1}{4} \cdot \pi \cdot (8)^2 = 251,2 > A_s \dots \dots \text{ok!}$$

Dipakai tulangan $\varnothing 8 - 200 \text{ mm}$

BAB 6 Balok Anak



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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5.6. Penulangan tumpuan arah x

$$M_u = 748,541 \text{ kgm} = 0,749 \times 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{0,748 \times 10^7}{0,8} = 0,936 \times 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{0,936 \times 10^7}{1000 \cdot (95)^2} = 1,0371 \text{ N/mm}^2$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{240}{0,85 \cdot 17,5} = 16,134$$

$$\begin{aligned} \rho_{\text{perlu}} &= \frac{1}{m} \times \left(1 - \sqrt{1 - \frac{2m \cdot R_n}{f_y}} \right) \\ &= \frac{1}{16,134} \times \left(1 - \sqrt{1 - \frac{2 \cdot 16,134 \cdot 1,036}{240}} \right) \\ &= 0,00448 \end{aligned}$$

$$\rho < \rho_{\text{max}}$$

$$\rho > \rho_{\text{min}}, \text{ di pakai } \rho_{\text{perlu}} = 0,00448$$

$$\begin{aligned} A_s &= \rho_{\text{perlu}} \cdot b \cdot d \\ &= 0,00448 \times 1000 \times 95 \\ &= 456 \text{ mm}^2 \end{aligned}$$

$$\text{Digunakan tulangan } \emptyset 8 = \frac{1}{4} \cdot \pi \cdot (8)^2 = 50,24 \text{ mm}^2$$

$$\text{Jumlah tulangan} = \frac{456}{50,24} = 10 \text{ buah.}$$

$$\text{Jarak tulangan dalam } 1 \text{ m}^1 = \frac{1000}{10} = 100$$

$$\text{Jarak maksimum} = 2 \times h = 2 \times 120 = 240 \text{ mm}$$

$$\text{As terpasang} = 10 \cdot \frac{1}{4} \cdot \pi \cdot (8)^2 = 502,4 > A_s \dots \dots \text{ok!}$$

Dipakai tulangan $\emptyset 8 - 100 \text{ mm}$



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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5.7. Penulangan tumpuan arah y

$$M_u = 605,203 \text{ kgm} = 0,605 \times 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{0,604 \times 10^7}{0,8} = 0,756 \times 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{0,756 \times 10^7}{1000 \cdot (85)^2} = 1,046 \text{ N/mm}^2$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{240}{0,85 \cdot 17,5} = 16,134$$

$$\begin{aligned} \rho_{\text{perlu}} &= \frac{1}{m} \times \left(1 - \sqrt{1 - \frac{2m \cdot R_n}{f_y}} \right) \\ &= \frac{1}{16,134} \times \left(1 - \sqrt{1 - \frac{2 \cdot 16,134 \cdot 1,045}{240}} \right) \\ &= 0,00452 \end{aligned}$$

$$\rho < \rho_{\text{max}}$$

$$\rho > \rho_{\text{min}}, \text{ di pakai } \rho_{\text{perlu}} = 0,00452$$

$$\begin{aligned} A_s &= \rho_{\text{perlu}} \cdot b \cdot d \\ &= 0,00452 \times 1000 \times 85 \\ &= 384,2 \text{ mm}^2 \end{aligned}$$

$$\text{Digunakan tulangan } \varnothing 8 = \frac{1}{4} \cdot \pi \cdot (8)^2 = 50,24 \text{ mm}^2$$

$$\text{Jumlah tulangan} = \frac{384,2}{50,24} = 7,64 \sim 8 \text{ buah.}$$

$$\text{Jarak tulangan dalam } 1 \text{ m}^1 = \frac{1000}{8} = 125 \text{ mm} \sim 100 \text{ mm}$$

$$\text{Jarak maksimum} = 2 \times h = 2 \times 120 = 240 \text{ mm}$$

$$\text{As terpasang} = 8 \cdot \frac{1}{4} \cdot \pi \cdot (8)^2 = 401,92 > A_s \dots \text{OK!}$$

Dipakai tulangan $\varnothing 8 - 100 \text{ mm}$

5.8. Rekapitulasi Tulangan

BAB 6 Balok Anak



Dari perhitungan diatas diperoleh :

Tulangan lapangan arah x $\varnothing 8 - 200 \text{ mm}$

Tulangan lapangan arah y $\varnothing 8 - 200 \text{ mm}$

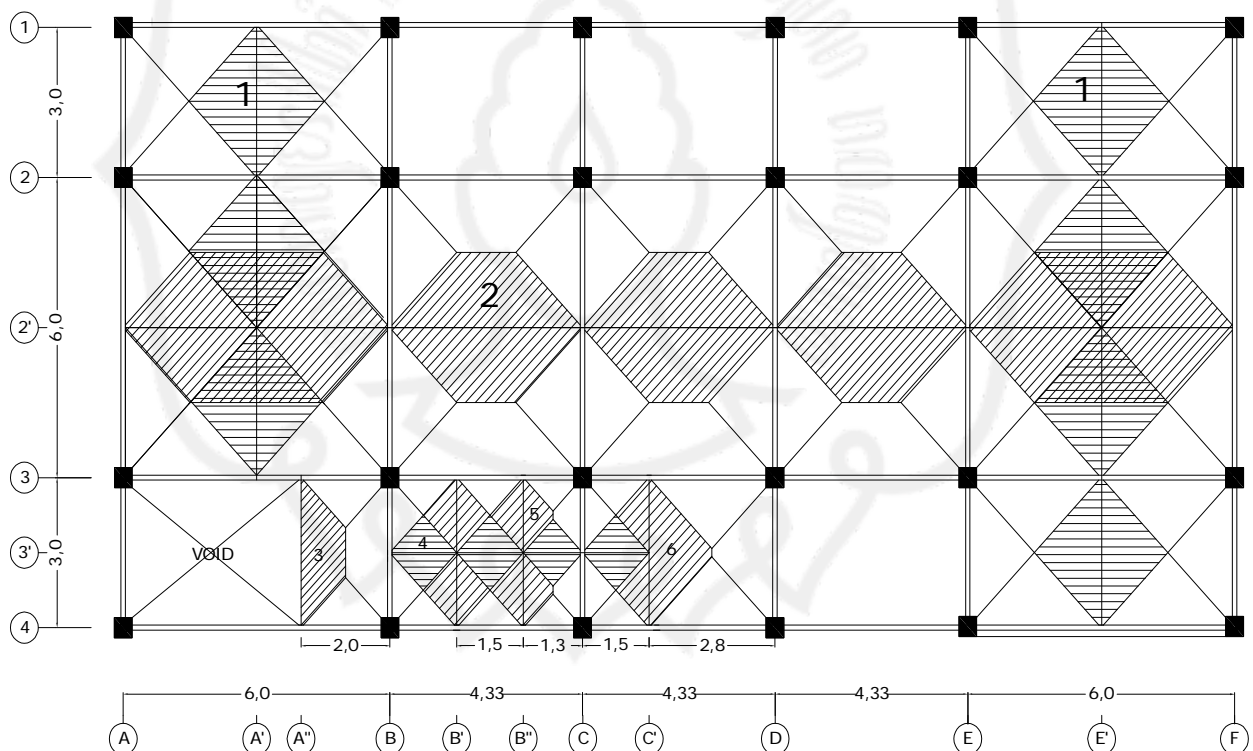
Tulangan tumpuan arah x $\varnothing 8 - 100 \text{ mm}$

Tulangan tumpuan arah y $\varnothing 8 - 100 \text{ mm}$

BAB 6

BALOK ANAK

6.1. Perencanaan Balok Anak



Gambar 6.1 Area Pembebanan Balok Anak

Keterangan :

Balok Anak : As A'(1-3)

Balok Anak : As E'(1-4)

**Tugas Akhir****Perencanaan Struktur Gedung Kantor Pajak 2 lantai**

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Balok Anak : As 2'(A-F)

Balok Anak : As A''(3-4)

Balok Anak : As 3'(B-B')

Balok Anak : As B''(3-4)

Balok Anak : As C'(3-4)





Tugas Akhir

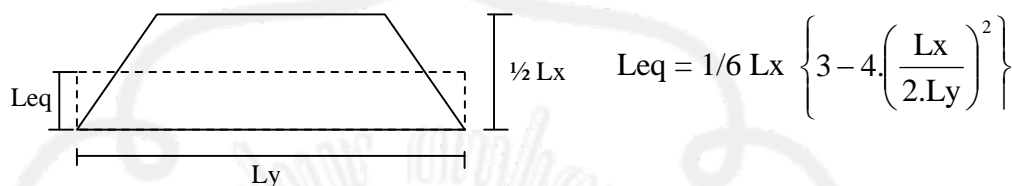
Perencanaan Struktur Gedung Kantor Pajak 2 lantai

1

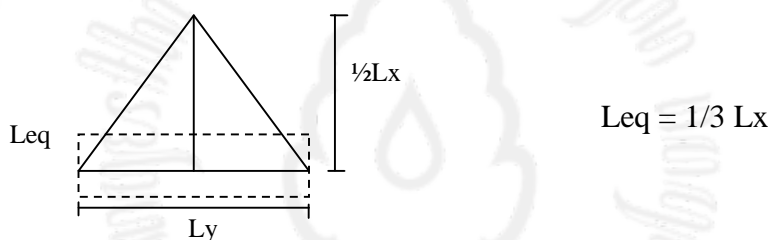
6.1.1. Perhitungan Lebar Equivalen

Untuk mengubah beban segitiga dan beban trapesium dari plat menjadi beban merata pada bagian balok, maka beban plat harus diubah menjadi beban equivalent yang besarnya dapat ditentukan sebagai berikut :

a Lebar Equivalen Tipe I



b Lebar Equivalen Tipe II



6.1.2. Lebar Equivalen Balok Anak

Tabel 6.1. Hitungan Lebar equivalen

No.	Ukuran Plat (m ²)	Lx (m)	Ly (m)	Leq (segitiga)	Leq (trapesium)
1.	3 × 3	3	3	1	-
2.	3 × 4,33	3	4,33	-	1,26
3.	2 × 3	2	3	0,667	0,852
4.	1,5 × 1,5	1,5	1,5	0,5	-
5.	1,5 × 1,3	1,3	1,5	0,433	0,487
6.	2,8 × 3	2,8	3	-	0,993



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

2

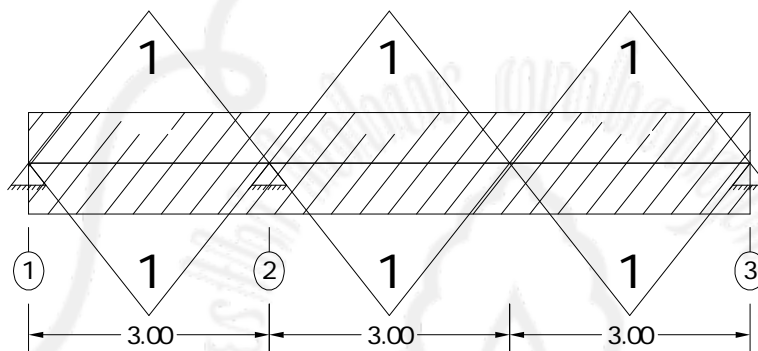
a. Dimensi Balok

$$h = \frac{1}{10} \cdot L = 50 \text{ cm}$$

$$b = \frac{1}{15} \cdot L = 25 \text{ cm}$$

6.2. Perhitungan Balok Anak as A'(1-3)

6.2.1. Pembebanan



a. Beban Mati (q_D)

Pembebanan balok elemen A'(1-3)

- Berat sendiri = $0,25 \times (0,50 - 0,12) \times 2400 \text{ kg/m}^3 = 228 \text{ kg/m}$
- Beban Plat = $(1 \times 2) \times 404 \text{ kg/m}^2 = 808 \text{ kg/m}$

$$q_D = 1036 \text{ kg/m}$$

b. Beban hidup (q_L)

Beban hidup digunakan 200 kg/m^2

$$q_L = 2 \times 200 \text{ kg/m}^2$$

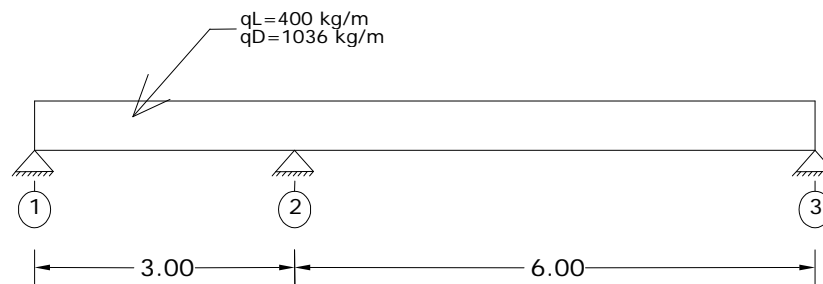
$$= 400 \text{ kg/m}$$



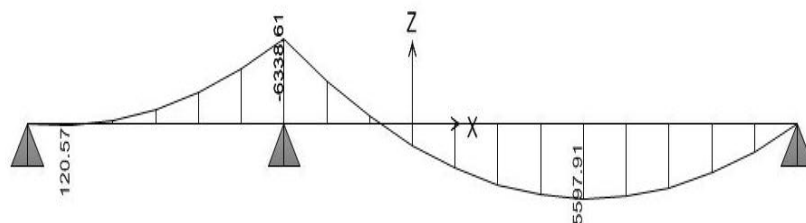
Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

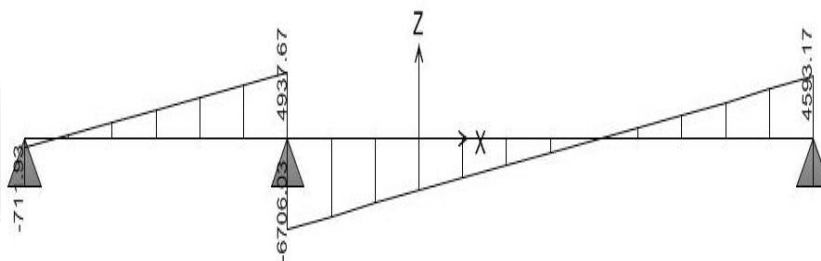
3



Bidang momen:



Bidang geser:



6.2.2. Perhitungan Tulangan

a) Tulangan Lentur Balok Anak

Data Perencanaan :

$$h = 500 \text{ mm}$$

$$\emptyset_t = 16 \text{ mm}$$

$$b = 250 \text{ mm}$$

$$\emptyset_s = 8 \text{ mm}$$

$$p = 40 \text{ mm}$$

$$f_y = 320 \text{ Mpa}$$



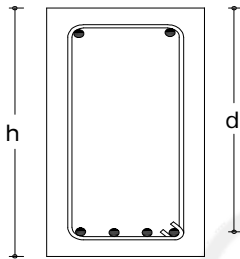
Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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$$f'c = 17,5 \text{ MPa}$$

$$\begin{aligned} d &= h - p - 1/2 \text{ } \varnothing_t - \varnothing_s \\ &= 500 - 40 - 1/2 \cdot 16 - 8 \\ &= 444 \text{ mm} \end{aligned}$$



$$\begin{aligned} \rho_b &= \frac{0,85 \cdot f'c \cdot \beta}{f_y} \left(\frac{600}{600 + f_y} \right) \\ &= \frac{0,85 \cdot 17,5}{320} \cdot 0,85 \left(\frac{600}{600 + 320} \right) \\ &= 0,0258 \\ \rho_{\max} &= 0,75 \cdot \rho_b \\ &= 0,75 \cdot 0,0258 \\ &= 0,01935 \\ \rho_{\min} &= \frac{1,4}{f_y} = \frac{1,4}{320} = 0,00438 \end{aligned}$$

Daerah Tumpuan :

Dari Perhitungan **SAP 2000** diperoleh :

$$M_u = 6339 \text{ kgm} = 6,339 \times 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{6,339 \times 10^7}{0,8} = 7,924 \times 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{7,924 \times 10^7}{250 \times 444^2} = 1,608$$

$$m = \frac{f_y}{0,85 \cdot f'c} = \frac{320}{0,85 \cdot 17,5} = 21,5126$$

$$\rho = \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot R_n}{f_y}} \right)$$



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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$$= \frac{1}{21,5126} \left(1 - \sqrt{1 - \frac{2 \times 21,5126 \times 1,608}{320}} \right) = 0,0053$$

$$\rho > \rho_{\min}$$

$$\rho < \rho_{\max} \rightarrow \text{Pakai tulangan tunggal}$$

Digunakan $\rho = 0,0053$

$$\text{As perlu} = \rho \cdot b \cdot d$$

$$= 0,0053 \times 250 \times 444$$

$$= 588,3 \text{ mm}^2$$

$$n = \frac{\text{As perlu}}{\frac{1}{4} \cdot \pi \cdot 16^2}$$

$$= \frac{588,3}{200,96} = 2,9 \approx 3 \text{ tulangan}$$

$$\text{As ada} = n \cdot \frac{1}{4} \cdot \pi \cdot d^2$$

$$= 3 \cdot \frac{1}{4} \cdot \pi \cdot 16^2$$

$$= 602,88 > \text{As perlu} \rightarrow \text{Aman..!!}$$

$$a = \frac{\text{As ada} \cdot f_y}{0,85 \cdot f'c \cdot b} = \frac{602,88 \times 320}{0,85 \times 17,5 \times 250} = 51,878$$

$$\text{Mn ada} = \text{As ada} \cdot f_y (d - a/2)$$

$$= 602,88 \cdot 320 (444 - 51,878/2)$$

$$= 8,065 \times 10^7 \text{ Nmm}$$

$$\text{Mn ada} > \text{Mn} \rightarrow \text{Aman..!!}$$

Kontrol Spasi :

$$S = \frac{b - 2p - n\phi \text{ tulangan} - 2\phi \text{ sengkang}}{n - 1}$$

$$= \frac{250 - 2 \cdot 40 - 3 \cdot 16 - 2 \cdot 8}{3 - 1} = 53 > 25 \text{ mm.....oke!!}$$

Jadi dipakai tulangan 3 D 16 mm

Daerah Lapangan :

Dari Perhitungan **SAP 2000** diperoleh :

$$\text{Mu} = 5598 \text{ kgm} = 5,598 \times 10^7 \text{ Nmm}$$

BAB 1 Pendahuluan



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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$$M_n = \frac{M_u}{\phi} = \frac{5,598 \times 10^7}{0,8} = 6,998 \times 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{6,998 \times 10^7}{250 \times 444^2} = 1,420$$

$$m = \frac{f_y}{0,85 \cdot f'c} = \frac{320}{0,85 \cdot 17,5} = 21,5126$$

$$\rho = \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot R_n}{f_y}} \right)$$

$$= \frac{1}{21,5126} \left(1 - \sqrt{1 - \frac{2 \times 21,5126 \times 1,420}{320}} \right) = 0,0047$$

$$\rho > \rho_{\min}$$

$$\rho < \rho_{\max} \rightarrow \text{Pakai tulangan tunggal}$$

$$\text{Digunakan } \rho = 0,0047$$

$$\text{As perlu} = \rho \cdot b \cdot d$$

$$= 0,0047 \times 250 \times 444$$

$$= 521,7 \text{ mm}^2$$

$$n = \frac{\text{As perlu}}{\frac{1}{4} \cdot \pi \cdot 16^2}$$

$$= \frac{521,7}{200,96} = 2,6 \approx 3 \text{ tulangan}$$

$$\text{As ada} = n \cdot \frac{1}{4} \cdot \pi \cdot d^2$$

$$= 3 \cdot \frac{1}{4} \cdot \pi \cdot 16^2$$

$$= 602,88 > \text{As perlu} \rightarrow \text{Aman..!!}$$

$$a = \frac{\text{As ada} \cdot f_y}{0,85 \cdot f'c \cdot b} = \frac{602,88 \times 320}{0,85 \times 17,5 \times 250} = 51,887$$

$$M_n \text{ ada} = \text{As ada} \cdot f_y (d - a/2)$$

$$= 602,88 \cdot 320 (444 - 51,887/2)$$

$$= 8,065 \times 10^7 \text{ Nmm}$$

$$M_n \text{ ada} > M_n \rightarrow \text{Aman..!!}$$

Jadi dipakai tulangan 3 D 16 mm



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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b) Tulangan Geser Balok anak

Dari perhitungan **SAP 2000** Diperoleh :

$$V_u = 6707 \text{ kgm} = 67070 \text{ N}$$

$$f'_c = 17,5 \text{ Mpa}$$

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

$$d = 444 \text{ mm}$$

$$V_c = 1/6 \cdot \sqrt{f'_c} \cdot b \cdot d = 1/6 \cdot \sqrt{17,5} \cdot 250 \cdot 444$$

$$= 77391,05 \text{ N}$$

$$\emptyset V_c = 0,6 \cdot 77391,05 \text{ N} = 46434,63 \text{ N}$$

$$3 \emptyset V_c = 3 \cdot 46434,63 = 139303,89 \text{ N}$$

Syarat tulangan geser : $\emptyset V_c < V_u < 3 \emptyset V_c$

$$: 46434,63 < 67070 < 139303,89 \text{ N}$$

Jadi diperlukan tulangan geser:

$$S_{\max} \leq d/2 \leq 600 \text{ mm}$$

$$\emptyset V_{\text{perlu}} = V_u - \emptyset V_c$$

$$= 67070 - 46434,63 = 20635,37 \text{ N}$$

$$V_s \text{ perlu} = \frac{\phi V_{sp}}{0,6} = \frac{20635,37}{0,6} = 34392,28 \text{ N}$$

$$A_v = 2 \cdot \frac{1}{4} \pi (8)^2$$

$$= 2 \cdot \frac{1}{4} \cdot 3,14 \cdot 64 = 100,48 \text{ mm}^2$$

$$S = \frac{A_v \cdot f_y \cdot d}{V_s \text{ perlu}} = \frac{100,48 \times 240 \times 444}{34393} = 311,32 \text{ mm}$$

$$S_{\max} = d/2 = \frac{444}{2} = 222 \text{ mm}$$

Jadi dipakai sengkang dengan tulangan $\emptyset 8 - 200 \text{ mm}$

Dipakai $\emptyset 8 - 200 \text{ mm}$:



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

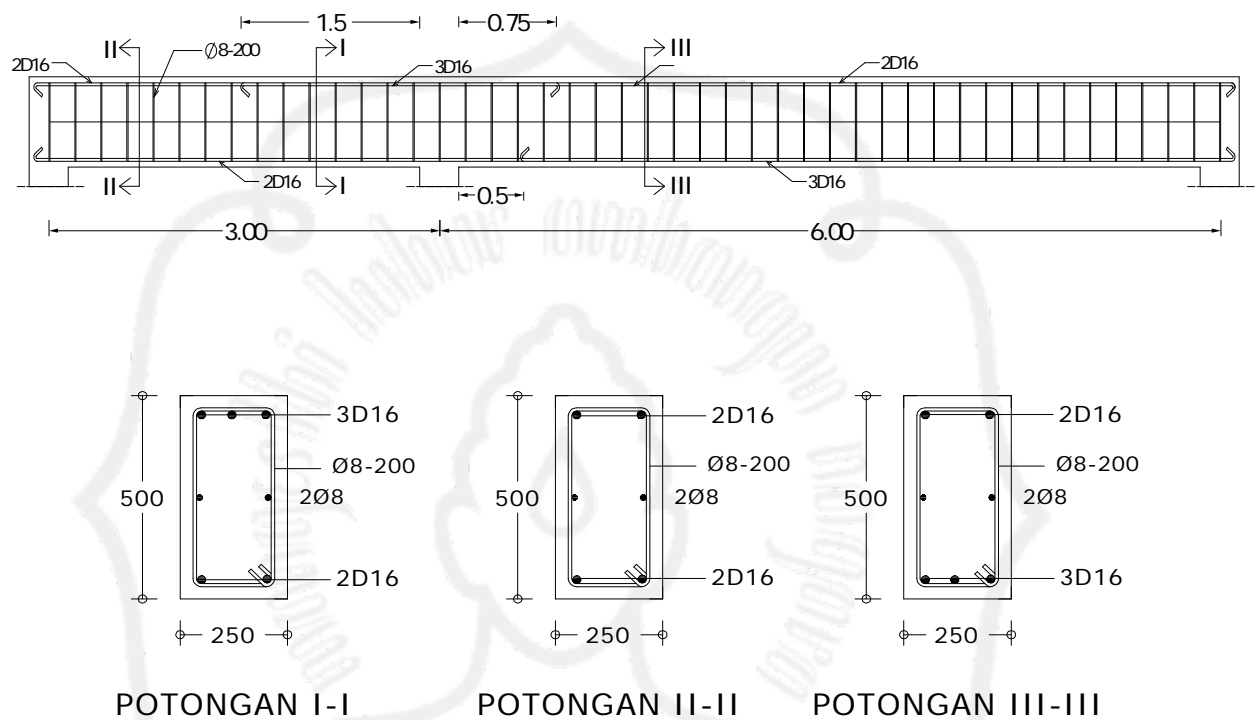
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$$V_s \text{ ada} = \frac{A_v \cdot f_y \cdot d}{S} = \frac{100,48 \times 240 \times 444}{200} = 53535,74 \text{ N}$$

$V_s \text{ ada} > V_s \text{ perlu}$

$53535,74 > 34393 \dots\dots$ (aman)

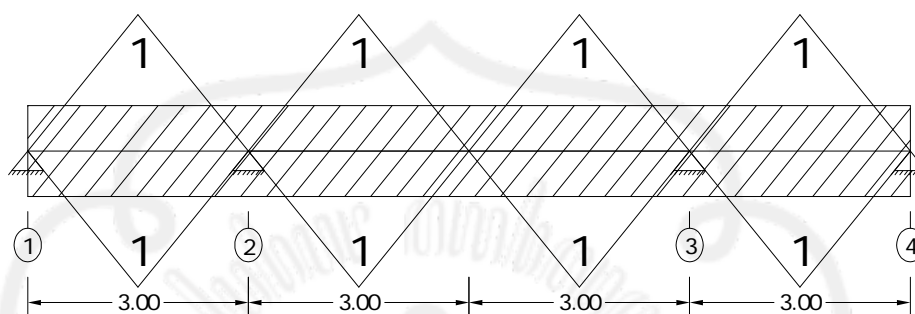
6.2.3. Gambar Tulangan





6.3. Perhitungan Balok Anak as E'(1-4)

6.3.1. Pembebanan



a. Beban Mati (q_D)

Pembebanan balok elemen E'(1-4)

- Berat sendiri = $0,25 \times (0,50 - 0,12) \times 2400 \text{ kg/m}^3 = 228 \text{ kg/m}$
- Beban Plat = $(1 \times 2) \times 404 \text{ kg/m}^2 = 808 \text{ kg/m}$

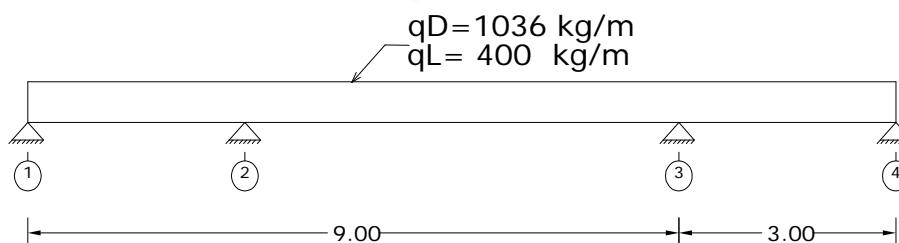
$$\underline{q_D = 1036 \text{ kg/m}}$$

b. Beban hidup (q_L)

Beban hidup digunakan 200 kg/m^2

$$q_L = (1 \times 2) \times 200 \text{ kg/m}$$

$$= 400 \text{ kg/m}$$



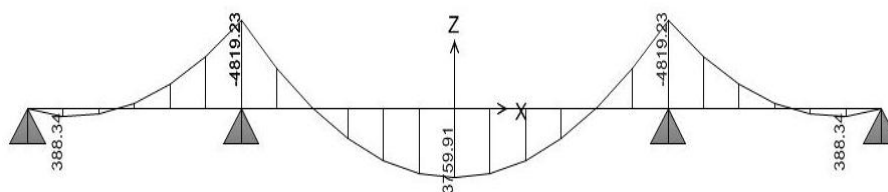
Bidang momen:



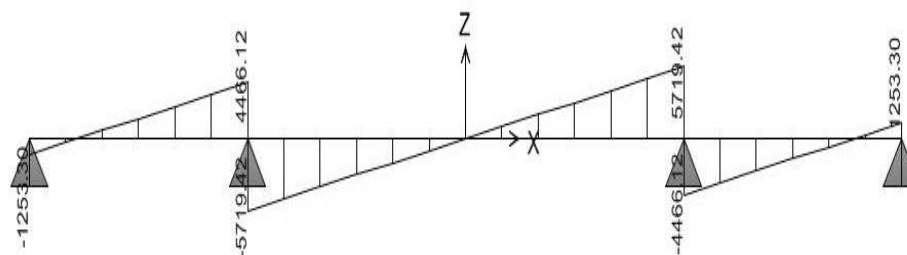
Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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Bidang geser:



6.3.2. Perhitungan Tulangan

a) Tulangan Lentur Balok Anak

Data Perencanaan :

$$h = 500 \text{ mm}$$

$$\varnothing_t = 16 \text{ mm}$$

$$b = 250 \text{ mm}$$

$$\varnothing_s = 8 \text{ mm}$$

$$p = 40 \text{ mm}$$

$$d = h - p - 1/2 \varnothing_t - \varnothing_s$$

$$f_y = 320 \text{ Mpa}$$

$$= 500 - 40 - 1/2 \cdot 16 - 8$$

$$f'_c = 17,5 \text{ MPa}$$

$$= 444 \text{ mm}$$

$$\begin{aligned} \rho_b &= \frac{0,85 \cdot f'_c \cdot \beta \left(\frac{600}{600 + f_y} \right)}{f_y} \\ &= \frac{0,85 \cdot 17,5}{320} \cdot 0,85 \left(\frac{600}{600 + 320} \right) \\ &= 0,0258 \end{aligned}$$

$$\begin{aligned} \rho_{\max} &= 0,75 \cdot \rho_b \\ &= 0,75 \cdot 0,0258 \\ &= 0,01935 \end{aligned}$$

$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{320} = 0,00438$$



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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Daerah Tumpuan :

Dari Perhitungan **SAP 2000** diperoleh :

$$M_u = 4820 \text{ kgm} = 4,820 \times 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{4,820 \times 10^7}{0,8} = 6,025 \times 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{6,025 \times 10^7}{250 \times 444^2} = 1,223$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{320}{0,85 \cdot 17,5} = 21,5126$$

$$\rho = \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot R_n}{f_y}} \right)$$

$$= \frac{1}{21,5126} \left(1 - \sqrt{1 - \frac{2 \times 21,5126 \times 1,223}{320}} \right) = 0,004$$

$$\rho < \rho_{\min}$$

$$\rho < \rho_{\max} \rightarrow \text{Pakai tulangan tunggal}$$

$$\text{Digunakan } \rho_{\min} = 0,00438$$

$$\begin{aligned} \text{As perlu} &= \rho_{\min} \cdot b \cdot d \\ &= 0,00438 \times 250 \times 444 \\ &= 486,18 \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} n &= \frac{\text{As perlu}}{\frac{1}{4} \cdot \pi \cdot 16^2} \\ &= \frac{486,18}{200,96} = 2,42 \approx 3 \text{ tulangan} \end{aligned}$$

$$\begin{aligned} \text{As ada} &= n \cdot \frac{1}{4} \cdot \pi \cdot d^2 \\ &= 3 \cdot \frac{1}{4} \cdot \pi \cdot 16^2 \\ &= 602,88 > \text{As perlu} \rightarrow \text{Aman..!!} \end{aligned}$$

Jadi dipakai tulangan 3 D 16 mm

Daerah Lapangan :

Dari Perhitungan **SAP 2000** diperoleh :

$$M_u = 3760 \text{ kgm} = 3,760 \times 10^7 \text{ Nmm}$$

BAB 1 Pendahuluan



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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$$M_n = \frac{M_u}{\phi} = \frac{3,760 \times 10^7}{0,8} = 4,7 \times 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{4,7 \times 10^7}{250 \times 444^2} = 0,954$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{320}{0,85 \cdot 17,5} = 21,5126$$

$$\rho = \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot R_n}{f_y}} \right)$$

$$= \frac{1}{21,5126} \left(1 - \sqrt{1 - \frac{2 \times 21,5126 \times 0,954}{320}} \right) = 0,0031$$

$$\rho < \rho_{\min}$$

$$\rho < \rho_{\max} \rightarrow \text{Pakai tulangan tunggal}$$

$$\text{Digunakan } \rho_{\min} = 0,00438$$

$$\begin{aligned} \text{As perlu} &= \rho_{\min} \cdot b \cdot d \\ &= 0,00438 \times 250 \times 444 \\ &= 486,18 \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} n &= \frac{\text{As perlu}}{\frac{1}{4} \cdot \pi \cdot 16^2} \\ &= \frac{486,18}{200,96} = 2,42 \approx 3 \text{ tulangan} \end{aligned}$$

$$\begin{aligned} \text{As ada} &= n \cdot \frac{1}{4} \cdot \pi \cdot d^2 \\ &= 3 \cdot \frac{1}{4} \cdot \pi \cdot 16^2 \\ &= 602,88 > \text{As perlu} \rightarrow \text{Aman..!!} \end{aligned}$$

Jadi dipakai tulangan 3 D 16 mm

b) Tulangan Geser Balok anak

Dari perhitungan SAP 2000 Diperoleh :

$$V_u = 5720 \text{ kgm} = 5720 \text{ N}$$

$$f'_c = 17,5 \text{ Mpa}$$

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

BAB 1 Pendahuluan



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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$$d = 444 \text{ mm}$$

$$V_c = 1/6 \cdot \sqrt{f'_c} \cdot b \cdot d = 1/6 \cdot \sqrt{17,5} \cdot 250 \cdot 444$$

$$= 77391,05 \text{ N}$$

$$\phi V_c = 0,6 \cdot 77391,05 \text{ N} = 46434,63 \text{ N}$$

$$3 \phi V_c = 3 \cdot 46434,63 = 139303,89 \text{ N}$$

Syarat tulangan geser : $\phi V_c < V_u < 3 \phi V_c$

$$: 46434,63 \text{ N} < 57200 \text{ N} < 139303,89 \text{ N}$$

Jadi diperlukan tulangan geser:

$$S_{\max} \leq d/2 \leq 600 \text{ mm}$$

$$\phi V_s \text{ perlu} = V_u - \phi V_c$$

$$= 57200 \text{ N} - 46434,63 \text{ N} = 10765,37 \text{ N}$$

$$V_s \text{ perlu} = \frac{\phi V_s \text{ perlu}}{0,6} = \frac{10765,37}{0,6} = 17942,28 \text{ N}$$

$$A_v = 2 \cdot \frac{1}{4} \pi (8)^2$$

$$= 2 \cdot \frac{1}{4} \cdot 3,14 \cdot 64 = 100,48 \text{ mm}^2$$

$$S = \frac{A_v \cdot f_y \cdot d}{V_s \text{ perlu}} = \frac{100,48 \times 240 \times 444}{17943} = 596,76 \text{ mm}$$

$$S_{\max} = d/2 = \frac{444}{2} = 222 \text{ mm}$$

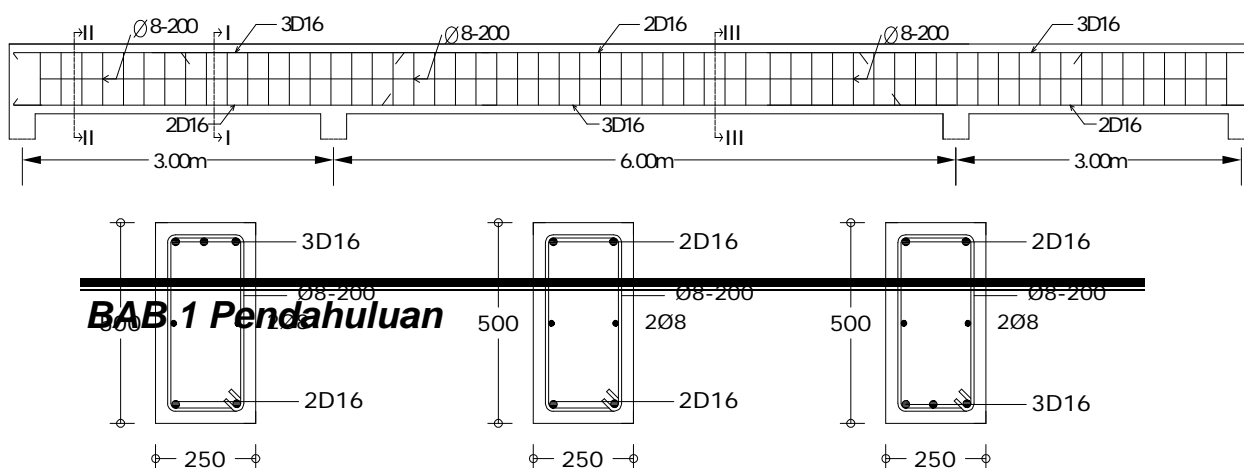
Jadi dipakai sengkang dengan tulangan $\phi 8 - 200 \text{ mm}$

Dipakai $\phi 8 - 200 \text{ mm}$:

$$V_s \text{ ada} = \frac{A_v \cdot f_y \cdot d}{S} = \frac{100,48 \times 240 \times 444}{200} = 53535,74 \text{ N}$$

$V_s \text{ ada} > V_s \text{ perlu} \dots$ (aman)

6.3.3. Gambar Tulangan

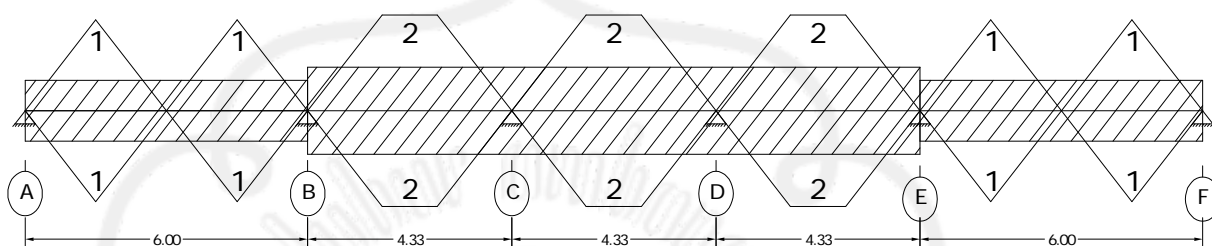


BAB.1 Pendahuluan



6.4. Perhitungan Balok Anak as 2'(A-F)

6.4.1. Pembebanan



a. Beban Mati (q_D)

Pembebanan balok elemen A-B= E-F

- Berat sendiri = $0,25 \times (0,50 - 0,12) \times 2400 \text{ kg/m}^3 = 228 \text{ kg/m}$

- Beban Plat = $(1 \times 2) \times 404 \text{ kg/m}^2 = 808 \text{ kg/m}$

$$q_{D1} = 1036 \text{ kg/m}$$

Pembebanan balok elemen B-E

- Berat sendiri = $0,25 \times (0,50 - 0,12) \times 2400 \text{ kg/m}^3 = 228 \text{ kg/m}$

- Beban Plat = $(2 \times 1,26) \times 404 \text{ kg/m}^2 = 1018,08 \text{ kg/m}$

$$q_{D2} = 1246,08 \text{ kg/m}$$

b. Beban hidup (q_L)

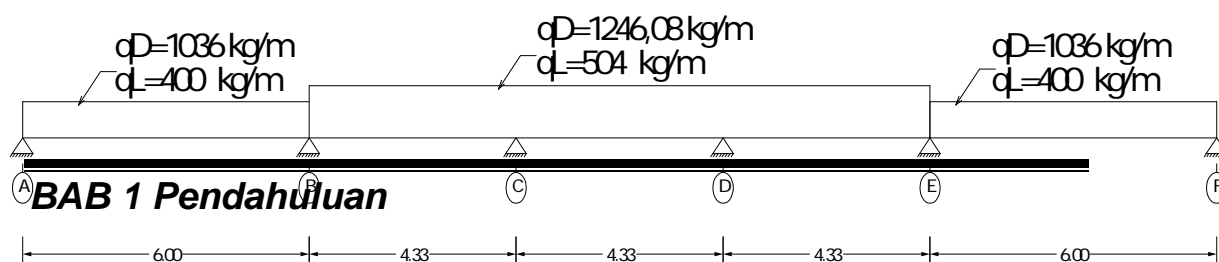
Beban hidup digunakan 200 kg/m^2

$$q_{L1} = 2 \times 200 \text{ kg/m}^2$$

$$= 400 \text{ kg/m}$$

$$q_{L2} = (2 \times 1,26) \times 200 \text{ kg/m}^2$$

$$= 504 \text{ kg/m}$$

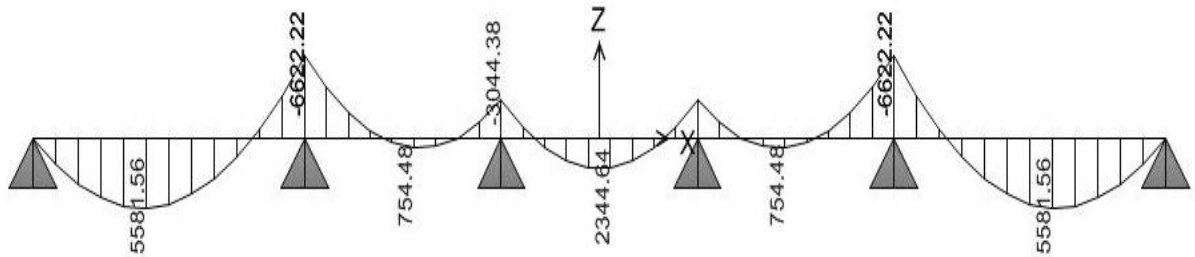




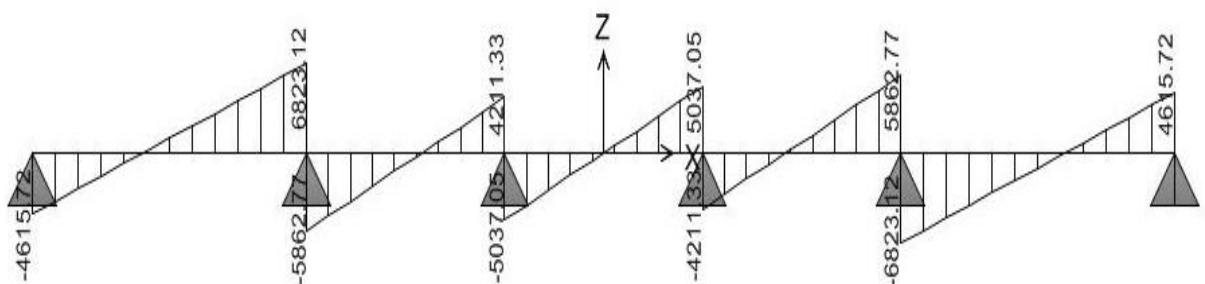
Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

Bidang momen:



Bidang geser:



6.4.2. Perhitungan Tulangan

a) Tulangan Lentur Balok Anak

Data Perencanaan :

$$h = 500 \text{ mm}$$

$$\varnothing_t = 16 \text{ mm}$$

$$b = 250 \text{ mm}$$

$$\varnothing_s = 8 \text{ mm}$$

$$p = 40 \text{ mm}$$

$$d = h - p - 1/2 \varnothing_t - \varnothing_s$$

$$f_y = 320 \text{ Mpa}$$

$$= 500 - 40 - 1/2 \cdot 16 - 8$$

$$f'_c = 17,5 \text{ MPa}$$

$$= 444 \text{ mm}$$

$$\rho_b = \frac{0,85 \cdot f'_c \cdot \beta}{f_y} \left(\frac{600}{600 + f_y} \right)$$



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

$$= \frac{0,85 \cdot 17,5}{320} \cdot 0,85 \left(\frac{600}{600 + 320} \right)$$

$$= 0,0258$$

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

$$= 0,75 \cdot 0,0258$$

$$\rho_{\max} = 0,01935$$

$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{320} = 0,00438$$

Daerah Tumpuan 1 :

Dari Perhitungan **SAP 2000** diperoleh :

$$M_u = 6623 \text{ kgm} = 6,623 \times 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{6,623 \times 10^7}{0,8} = 8,278 \times 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{8,278 \times 10^7}{250 \times 444^2} = 1,680$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{320}{0,85 \cdot 17,5} = 21,5126$$

$$\rho = \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot R_n}{f_y}} \right)$$

$$= \frac{1}{21,5126} \left(1 - \sqrt{1 - \frac{2 \times 21,5126 \times 1,680}{320}} \right) = 0,0056$$

$$\rho > \rho_{\min}$$

$$\rho < \rho_{\max} \rightarrow \text{Pakai tulangan tunggal}$$

Digunakan $\rho = 0,0056$

$$A_s \text{ perlu} = \rho \cdot b \cdot d$$

$$= 0,0056 \times 250 \times 444$$

$$= 621,6 \text{ mm}^2$$

$$n = \frac{A_s \text{ perlu}}{\frac{1}{4} \cdot \pi \cdot 16^2}$$



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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$$= \frac{621,6}{200,96} = 3,1 \approx 4 \text{ tulangan}$$

$$\begin{aligned} \text{As ada} &= n \cdot \frac{1}{4} \cdot \pi \cdot d^2 \\ &= 4 \cdot \frac{1}{4} \cdot \pi \cdot 16^2 \\ &= 803,84 > \text{As perlu} \rightarrow \text{Aman..!!} \end{aligned}$$

$$a = \frac{\text{Asada} \cdot f_y}{0,85 \cdot f'_c \cdot b} = \frac{803,84 \times 320}{0,85 \times 17,5 \times 250} = 69,171$$

$$\begin{aligned} \text{Mn ada} &= \text{As ada} \cdot f_y (d - a/2) \\ &= 803,84 \cdot 320 (444 - 69,171/2) \\ &= 10,531 \times 10^7 \text{ Nmm} \end{aligned}$$

$$\text{Mn ada} > \text{Mn} \rightarrow \text{Aman..!!}$$

Kontrol Spasi :

$$\begin{aligned} S &= \frac{b - 2p - n\phi \text{ tulangan} - 2\phi \text{ sengkang}}{n - 1} \\ &= \frac{250 - 2 \cdot 40 - 4 \cdot 16 - 2 \cdot 8}{4 - 1} = 30 > 25 \text{ mm.....oke!!} \end{aligned}$$

Jadi dipakai tulangan 4 D 16 mm

Daerah Tumpuan 2 :

Dari Perhitungan **SAP 2000** diperoleh :

$$\text{Mu} = 3045 \text{ kgm} = 3,045 \times 10^7 \text{ Nmm}$$

$$\text{Mn} = \frac{\text{Mu}}{\phi} = \frac{3,045 \times 10^7}{0,8} = 3,806 \times 10^7 \text{ Nmm}$$

$$\text{Rn} = \frac{\text{Mn}}{b \cdot d^2} = \frac{3,806 \times 10^7}{250 \times 444^2} = 0,772$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{320}{0,85 \cdot 17,5} = 21,5126$$

$$\rho = \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot \text{Rn}}{f_y}} \right)$$

$$= \frac{1}{21,5126} \left(1 - \sqrt{1 - \frac{2 \times 21,5126 \times 0,772}{320}} \right) = 0,0025$$

$$\rho < \rho_{\min}$$



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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$\rho < \rho_{\max}$ → Pakai tulangan tunggal

Digunakan $\rho_{\min} = 0,00438$

As perlu = $\rho_{\min} \cdot b \cdot d$

$$= 0,00438 \times 250 \times 444$$

$$= 486,18 \text{ mm}^2$$

$$n = \frac{\text{As perlu}}{\frac{1}{4} \cdot \pi \cdot 16^2}$$

$$= \frac{486,18}{200,96} = 2,42 \approx 3 \text{ tulangan}$$

As ada = $n \cdot \frac{1}{4} \cdot \pi \cdot d^2$

$$= 3 \cdot \frac{1}{4} \cdot \pi \cdot 16^2$$

$$= 602,88 > \text{As perlu} \rightarrow \text{Aman..!!}$$

Jadi dipakai tulangan 3 D 16 mm

Daerah Lapangan :

Dari Perhitungan SAP 2000 diperoleh :

$$M_u = 5582 \text{ kgm} = 5,582 \times 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{5,582 \times 10^7}{0,8} = 6,978 \times 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{6,978 \times 10^7}{250 \times 444^2} = 1,133$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{320}{0,85 \cdot 17,5} = 21,5126$$

$$\rho = \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot R_n}{f_y}} \right)$$

$$= \frac{1}{21,5126} \left(1 - \sqrt{1 - \frac{2 \times 21,5126 \times 1,134}{320}} \right) = 0,0043$$

$\rho > \rho_{\min}$

$\rho < \rho_{\max}$ → Pakai tulangan tunggal

Digunakan $\rho_{\min} = 0,00438$



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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$$\begin{aligned} \text{As perlu} &= \rho_{\min} \cdot b \cdot d \\ &= 0,00438 \times 250 \times 444 \\ &= 486,18 \text{ mm}^2 \end{aligned}$$

$$n = \frac{\text{As perlu}}{\frac{1}{4} \cdot \pi \cdot 16^2}$$

$$n = \frac{486,18}{200,96} = 2,4 \approx 3 \text{ tulangan}$$

$$\begin{aligned} \text{As ada} &= n \cdot \frac{1}{4} \cdot \pi \cdot d^2 \\ &= 3 \cdot \frac{1}{4} \cdot \pi \cdot 16^2 \\ &= 602,88 > \text{As perlu} \rightarrow \text{Aman..!!} \end{aligned}$$

$$a = \frac{\text{As ada} \cdot f_y}{0,85 \cdot f'_c \cdot b} = \frac{602,88 \times 320}{0,85 \times 17,5 \times 250} = 51,88$$

$$\begin{aligned} \text{Mn ada} &= \text{As ada} \cdot f_y (d - a/2) \\ &= 602,88 \cdot 320 (444 - 51,88/2) \\ &= 8,065 \times 10^7 \text{ Nmm} \end{aligned}$$

$$\text{Mn ada} > \text{Mn} \rightarrow \text{Aman..!!}$$

Jadi dipakai tulangan 3 D 16 mm

b) Tulangan Geser Balok anak

Dari perhitungan **SAP 2000** Diperoleh :

$$V_u = 6824 \text{ kgm} = 68240 \text{ N}$$

$$f'_c = 17,5 \text{ Mpa}$$

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

$$d = 444 \text{ mm}$$

$$\begin{aligned} V_c &= 1/6 \cdot \sqrt{f'_c} \cdot b \cdot d = 1/6 \cdot \sqrt{17,5} \cdot 250 \cdot 444 \\ &= 77391,05 \text{ N} \end{aligned}$$

$$\emptyset V_c = 0,6 \cdot 77391,05 \text{ N} = 46434,63 \text{ N}$$

$$3 \emptyset V_c = 3 \cdot 46434,63 = 139303,89 \text{ N}$$

$$\text{Syarat tulangan geser : } \emptyset V_c < V_u < 3 \emptyset V_c$$

$$: 46434,63 \text{ N} < 68240 \text{ N} < 139303,89 \text{ N}$$

Jadi diperlukan tulangan geser:

BAB 1 Pendahuluan



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

$$S_{max} \leq d/2 \leq 600 \text{ mm}$$

$$\phi V_s \text{ perlu} = V_u - \phi V_c$$

$$= 68240 \text{ N} - 46434,63 = 21805,37 \text{ N}$$

$$V_s \text{ perlu} = \frac{\phi V_{sperlu}}{0,6} = \frac{21805,37}{0,6} = 36342,28 \text{ N}$$

$$A_v = 2 \cdot \frac{1}{4} \pi (8)^2$$

$$= 2 \cdot \frac{1}{4} \cdot 3,14 \cdot 64 = 100,48 \text{ mm}^2$$

$$S = \frac{A_v \cdot f_y \cdot d}{V_s \text{ perlu}} = \frac{100,48 \times 240 \times 444}{36343} = 294,62 \text{ mm}$$

$$S_{max} = d/2 = \frac{444}{2} = 222 \text{ mm}$$

Jadi dipakai sengkang dengan tulangan $\phi 8 - 200 \text{ mm}$

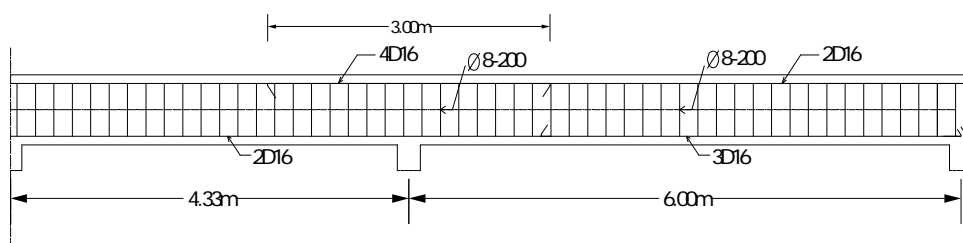
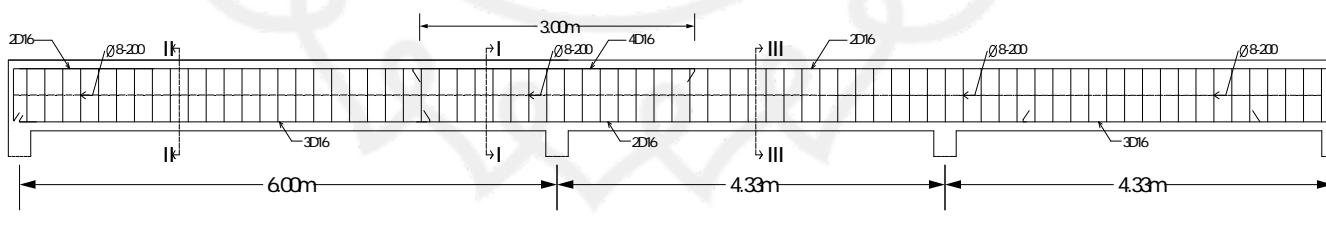
Dipakai $\phi 8 - 200 \text{ mm}$:

$$V_s \text{ ada} = \frac{A_v \cdot f_y \cdot d}{S} = \frac{100,48 \times 240 \times 444}{200} = 53535,74 \text{ N}$$

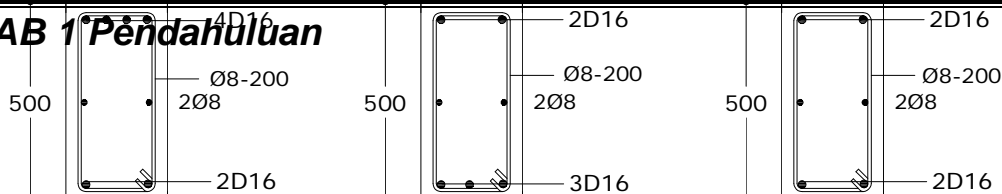
$V_s \text{ ada} > V_s \text{ perlu}$

$53535,74 > 36343 \dots\dots$ (aman)

6.4.3. Gambar Tulangan



BAB 1 Pendahuluan



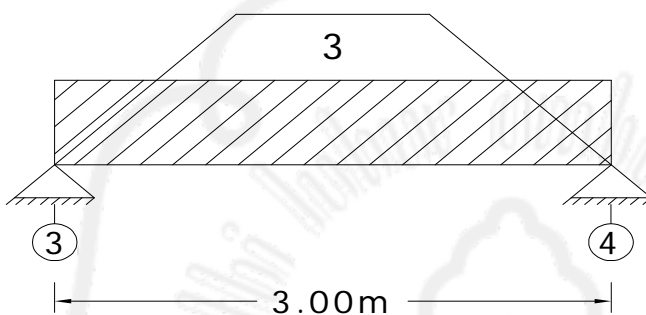


Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

6.5. Perhitungan Balok Anak as A''(3-4)

6.5.1. Pembebanan Balok



Dimensi Balok:

$$\begin{aligned} h &= 1/10 \cdot L \\ &= 1/10 \cdot 3000 \text{ mm} \\ &= 300 \text{ mm} \end{aligned}$$

$$\begin{aligned} b &= 1/15 \cdot L \\ &= 1/15 \cdot 3000 \text{ mm} \\ &= 200 \text{ mm} \end{aligned}$$

jadi dipakai ;

$$h = 300 \text{ mm}$$

$$b = 200 \text{ mm}$$

a. Beban Mati (qD)

Pembebanan balok as A''(3-4):

- Berat sendiri = $0,2 \times (0,3 - 0,12) \times 2400 \text{ kg/m}^3 = 86,4 \text{ kg/m}$
- Beban Plat = $(0,852) \times 404 \text{ kg/m}^2 = 344,21 \text{ kg/m}$

$$qD = 430,61 \text{ kg/m}$$

b. Beban hidup (qL)

Beban hidup digunakan 200 kg/m^2

$$qL = 0,852 \times 200 \text{ kg/m}$$

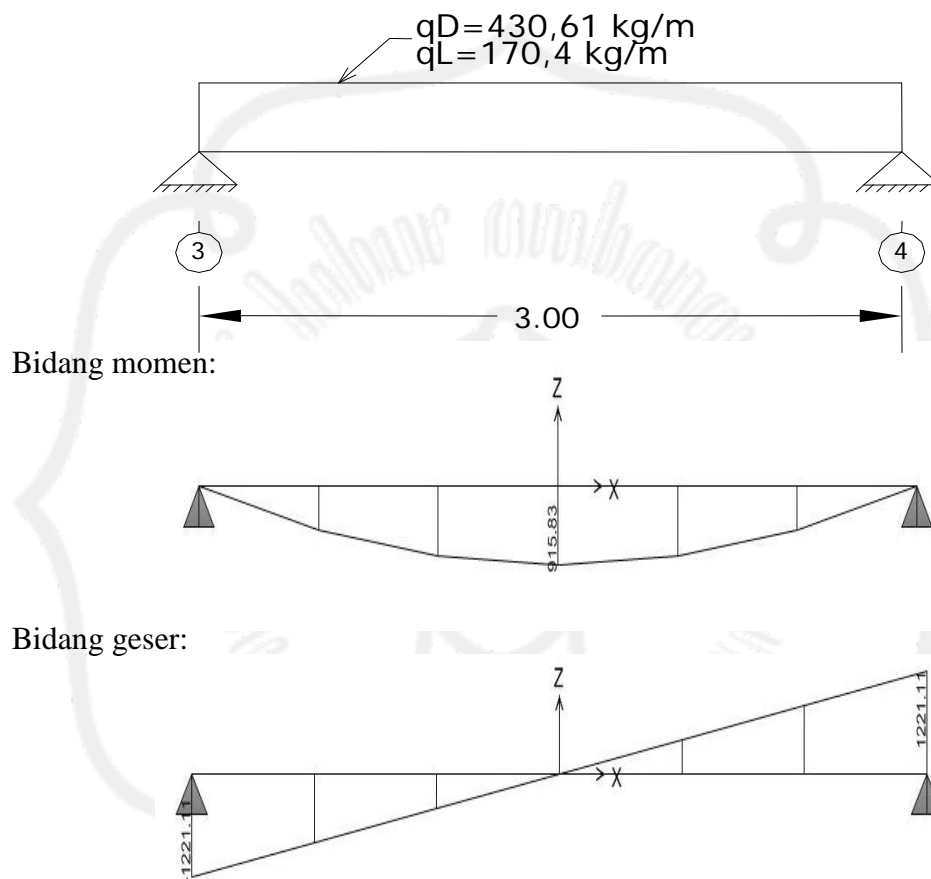


Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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$$= 170,4 \text{ kg/m}$$



6.5.2. Perhitungan Tulangan

a) Tulangan Lentur Balok Anak

Data Perencanaan :

$$h = 300 \text{ mm}$$

$$\emptyset_t = 12 \text{ mm}$$

$$b = 200 \text{ mm}$$

$$\emptyset_s = 8 \text{ mm}$$

$$p = 40 \text{ mm}$$

$$d = h - p - 1/2 \emptyset_t - \emptyset_s$$

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

$$= 300 - 40 - 1/2 \cdot 12 - 8$$

BAB 1 Pendahuluan



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

$$f'c = 17,5 \text{ MPa}$$

$$= 246 \text{ mm}$$

$$\begin{aligned} \rho_b &= \frac{0,85 \cdot f'c \cdot \beta}{f_y} \left(\frac{600}{600 + f_y} \right) \\ &= \frac{0,85 \cdot 17,5}{240} \cdot 0,85 \left(\frac{600}{600 + 240} \right) \\ &= 0,0376 \end{aligned}$$

$$\begin{aligned} \rho_{\max} &= 0,75 \cdot \rho_b \\ &= 0,75 \cdot 0,0376 \\ &= 0,0282 \end{aligned}$$

$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{240} = 0,00583$$

Daerah Lapangan :

Dari Perhitungan **SAP 2000** diperoleh :

$$M_u = 916 \text{ kgm} = 0,916 \times 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{0,916 \times 10^7}{0,8} = 1,145 \times 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{1,145 \times 10^7}{200 \times 246^2} = 0,946$$

$$m = \frac{f_y}{0,85 \cdot f'c} = \frac{240}{0,85 \cdot 17,5} = 16,134$$

$$\begin{aligned} \rho &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot R_n}{f_y}} \right) \\ &= \frac{1}{16,134} \left(1 - \sqrt{1 - \frac{2 \times 16,134 \times 0,946}{240}} \right) = 0,0041 \end{aligned}$$

$$\rho < \rho_{\min}$$

$\rho < \rho_{\max} \rightarrow$ Pakai tulangan tunggal

Digunakan $\rho_{\min} = 0,00583$

$$\text{As perlu} = \rho \cdot b \cdot d$$

$$= 0,00583 \times 200 \times 246$$

$$= 286,836 \text{ mm}^2$$

BAB 1 Pendahuluan



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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$$\begin{aligned}
 n &= \frac{A_s \text{ perlu}}{\frac{1}{4} \cdot \pi \cdot 12^2} \\
 &= \frac{286,836}{113,04} = 2,54 \approx 3 \text{ tulangan}
 \end{aligned}$$

$$\begin{aligned}
 A_s \text{ ada} &= n \cdot \frac{1}{4} \cdot \pi \cdot d^2 \\
 &= 3 \cdot \frac{1}{4} \cdot \pi \cdot 12^2 \\
 &= 339,12 > A_s \text{ perlu} \rightarrow \text{Aman..!!}
 \end{aligned}$$

$$a = \frac{A_s \text{ ada} \cdot f_y}{0,85 \cdot f'c \cdot b} = \frac{339,12 \times 240}{0,85 \times 17,5 \times 200} = 27,36$$

$$\begin{aligned}
 M_n \text{ ada} &= A_s \text{ ada} \cdot f_y (d - a/2) \\
 &= 339,12 \cdot 240 (246 - 27,36/2) \\
 &= 1,891 \times 10^7 \text{ Nmm}
 \end{aligned}$$

$$M_n \text{ ada} > M_n \rightarrow \text{Aman..!!}$$

Jadi dipakai tulangan 3 D 12 mm

b) Tulangan Geser Balok anak

Dari perhitungan SAP 2000 Diperoleh :

$$V_u = 1222 \text{ kgm} = 12220 \text{ N}$$

$$f'c = 17,5 \text{ Mpa}$$

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

$$d = 246 \text{ mm}$$

$$\begin{aligned}
 V_c &= 1/6 \cdot \sqrt{f'c} \cdot b \cdot d = 1/6 \cdot \sqrt{17,5} \cdot 200 \cdot 246 \\
 &= 34303,06 \text{ N}
 \end{aligned}$$

$$\emptyset V_c = 0,6 \cdot 34303,06 \text{ N} = 20581,84 \text{ N}$$

$$0,5 \emptyset V_c = 0,5 \cdot 20581,84 \text{ N} = 10290,92 \text{ N}$$

$$\text{Syarat tulangan geser : } 0,5 \emptyset V_c < V_u < \emptyset V_c$$

$$: 10290,92 \text{ N} < 12220 \text{ N} < 20581,84 \text{ N}$$

Jadi diperlukan tulangan geser minimum:

BAB 1 Pendahuluan



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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$$S_{\max} \leq d/2 \leq 600 \text{ mm}$$

$$\phi V_s \text{ perlu} = \phi \frac{1}{3} \times b \times d$$

$$= 9840 \text{ N}$$

$$V_s \text{ perlu} = \frac{\phi V_s \text{ perlu}}{0,6} = \frac{9840}{0,6} = 16400 \text{ N}$$

$$A_v = 2 \cdot \frac{1}{4} \pi (8)^2$$

$$= 2 \cdot \frac{1}{4} \cdot 3,14 \cdot 64 = 100,48 \text{ mm}^2$$

$$S = \frac{A_v \cdot f_y \cdot d}{V_s \text{ perlu}} = \frac{100,48 \times 240 \times 246}{16400} = 361,728 \text{ mm}$$

$$S_{\max} = d/2 = \frac{246}{2} = 123 \text{ mm}$$

Jadi dipakai sengkang dengan tulangan $\phi 8 - 100 \text{ mm}$

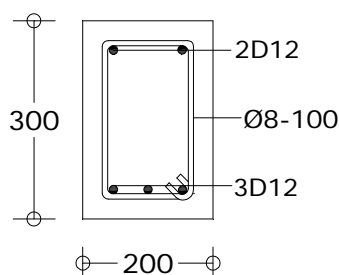
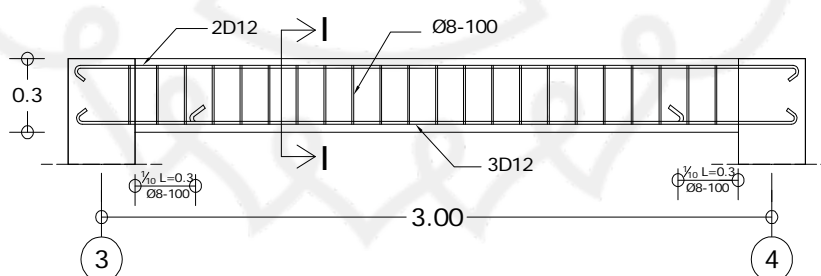
Dipakai $\phi 8 - 100 \text{ mm}$:

$$V_s \text{ ada} = \frac{A_v \cdot f_y \cdot d}{S} = \frac{100,48 \times 240 \times 246}{100} = 59323,39 \text{ N}$$

$V_s \text{ ada} > V_s \text{ perlu}$

$59323,39 > 16400 \text{ N}$ (aman)

6.5.3. Gambar Tulangan



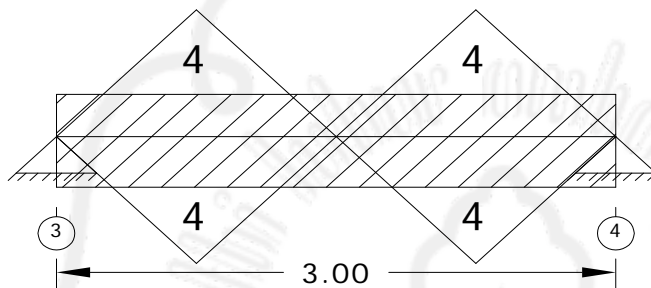


Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

6.6. Perhitungan Balok Anak as B'(3-4) = B''(3-4)

6.7.1. Pembebanan



a. Beban Mati (q_D) Pembebanan balok elemen B''(3-4)

- Berat sendiri = $0,2 \times (0,3 - 0,12) \times 2400 \text{ kg/m}^3 = 86,4 \text{ kg/m}$
- Beban Plat = $(0,5+0,5) \times 404 \text{ kg/m}^2 = 404 \text{ kg/m}$
- Berat dinding = $0,15 \times (4-0,3) \times 1700 \text{ kg/m}^2 = 943,5 \text{ kg/m}$

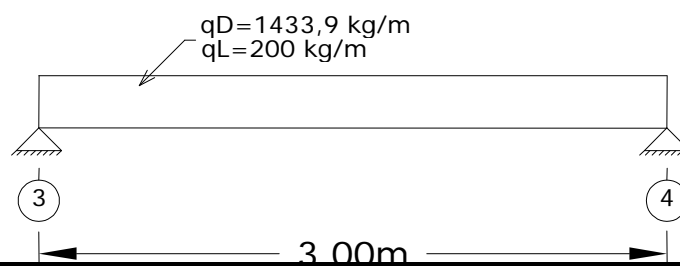
$$q_D = 1433,9 \text{ kg/m}$$

b. Beban hidup (q_L)

Beban hidup digunakan 200 kg/m^2

$$q_L = (0,5+0,5) \times 200 \text{ kg/m}^2$$

$$= 200 \text{ kg/m}$$



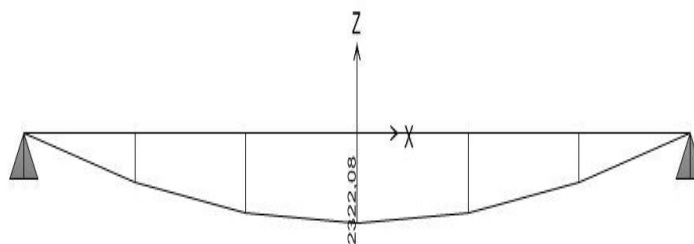


Tugas Akhir

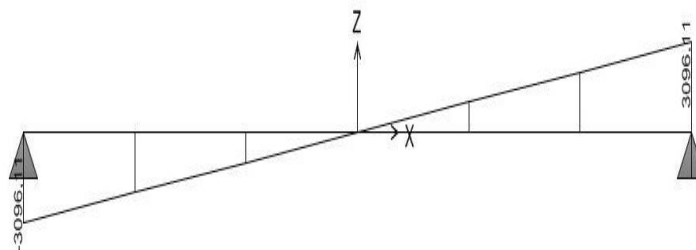
Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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Bidang momen



Bidang geser:



6.7.2. Perhitungan Tulangan

a) Tulangan Lentur Balok Anak

Data Perencanaan :

$$h = 300 \text{ mm}$$

$$\varnothing_t = 16 \text{ mm}$$

$$b = 200 \text{ mm}$$

$$\varnothing_s = 8 \text{ mm}$$

$$p = 40 \text{ mm}$$

$$d = h - p - 1/2 \varnothing_t - \varnothing_s$$

$$f_y = 320 \text{ Mpa}$$

$$= 300 - 40 - 1/2 \cdot 16 - 8$$

$$f'_c = 17,5 \text{ MPa}$$

$$= 244 \text{ mm}$$

$$\rho_b = \frac{0,85 \cdot f'_c \cdot \beta \left(\frac{600}{600 + f_y} \right)}{f_y}$$

$$= \frac{0,85 \cdot 17,5}{320} \cdot 0,85 \left(\frac{600}{600 + 320} \right)$$

$$= 0,0258$$

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

$$= 0,75 \cdot 0,0258$$

$$= 0,0193$$

$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{320} = 0,00438$$



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

Daerah Lapangan :

Dari Perhitungan SAP 2000 diperoleh :

$$M_u = 2322 \text{ kgm} = 2,322 \times 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{2,322 \times 10^7}{0,8} = 2,903 \times 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{2,903 \times 10^7}{200 \times 244^2} = 2,438$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{320}{0,85 \cdot 17,5} = 21,513$$

$$\rho = \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot R_n}{f_y}} \right)$$

$$= \frac{1}{21,513} \left(1 - \sqrt{1 - \frac{2 \times 21,513 \times 2,438}{320}} \right) = 0,0084$$

$$\rho > \rho_{\min}$$

$$\rho < \rho_{\max} \rightarrow \text{Pakai tulangan tunggal}$$

Digunakan $\rho = 0,0084$

$$\begin{aligned} A_s \text{ perlu} &= \rho \cdot b \cdot d \\ &= 0,0084 \times 200 \times 244 \\ &= 408,59 \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} n &= \frac{A_s \text{ perlu}}{\frac{1}{4} \cdot \pi \cdot 16^2} \\ &= \frac{408,59}{200,96} = 2,1 \approx 3 \text{ tulangan} \end{aligned}$$

$$\begin{aligned} A_s \text{ ada} &= n \cdot \frac{1}{4} \cdot \pi \cdot d^2 \\ &= 3 \cdot \frac{1}{4} \cdot \pi \cdot 16^2 \\ &= 602,88 > A_s \text{ perlu} \rightarrow \text{Aman..!!} \end{aligned}$$

$$a = \frac{A_s \text{ ada} \cdot f_y}{0,85 \cdot f'_c \cdot b} = \frac{602,88 \times 320}{0,85 \times 17,5 \times 200} = 64,85$$

$$\begin{aligned} M_n \text{ ada} &= A_s \text{ ada} \cdot f_y (d - a/2) \\ &= 602,88 \cdot 320 (244 - 68,85/2) \end{aligned}$$



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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$$= 4,043 \times 10^7 \text{ Nmm}$$

$M_n \text{ ada} > M_n \rightarrow \text{Aman..!!}$

Kontrol Spasi :

$$S = \frac{b - 2p - n\phi \text{ tulangan} - 2\phi \text{ sengkang}}{n - 1}$$

$$= \frac{200 - 2 \cdot 40 - 3 \cdot 16 - 2 \cdot 8}{3 - 1} = 28 > 25 \text{ mm.....oke!!}$$

Jadi dipakai tulangan 3 D 16 mm

b) Tulangan Geser Balok anak

Dari perhitungan **SAP 2000** Diperoleh :

$$V_u = 3097 \text{ kgm} = 30970 \text{ N}$$

$$f'_c = 17,5 \text{ Mpa}$$

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

$$d = 244 \text{ mm}$$

$$V_c = 1/6 \cdot \sqrt{f'_c} \cdot b \cdot d = 1/6 \cdot \sqrt{17,5} \cdot 200 \cdot 244$$

$$= 34024,17 \text{ N}$$

$$\phi V_c = 0,6 \cdot 34024,17 \text{ N} = 20414,50 \text{ N}$$

$$3 \phi V_c = 3 \cdot 20414,50 = 61243,5 \text{ N}$$

Syarat tulangan geser : $\phi V_c < V_u < 3 \phi V_c$

$$: 20414,50 \text{ N} < 30970 \text{ N} < 61243,5 \text{ N}$$

Jadi diperlukan tulangan geser:

$$S_{\max} \leq d/2 \leq 600 \text{ mm}$$

$$\phi V_s \text{ perlu} = V_u - \phi V_c$$

$$= 30970 \text{ N} - 20414,50 \text{ N} = 10555,5 \text{ N}$$

$$V_s \text{ perlu} = \frac{\phi V_s \text{ perlu}}{0,6} = \frac{10555,5}{0,6} = 17592,5 \text{ N}$$

$$A_v = 2 \cdot \frac{1}{4} \pi (8)^2$$

$$= 2 \cdot \frac{1}{4} \cdot 3,14 \cdot 64 = 100,48 \text{ mm}^2$$

$$S = \frac{A_v \cdot f_y \cdot d}{V_s \text{ perlu}} = \frac{100,48 \times 240 \times 244}{17593} = 334,47 \text{ mm}$$

$$S_{\max} = d/2 = \frac{244}{2} = 122 \text{ mm}$$

BAB 1 Pendahuluan



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

Jadi dipakai sengkang dengan tulangan $\text{Ø} 8 - 100 \text{ mm}$

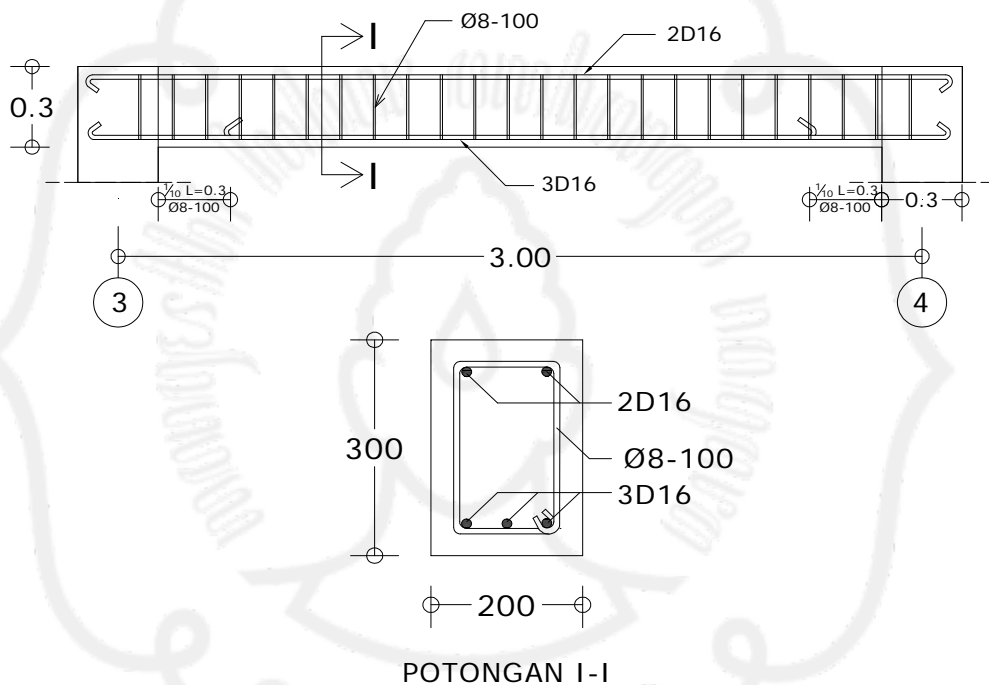
Dipakai $\text{Ø} 8 - 100 \text{ mm}$:

$$V_s \text{ ada} = \frac{A_v \cdot f_y \cdot d}{S} = \frac{100,48 \times 240 \times 244}{100} = 58841,1 \text{ N}$$

$V_s \text{ ada} > V_s \text{ perlu}$

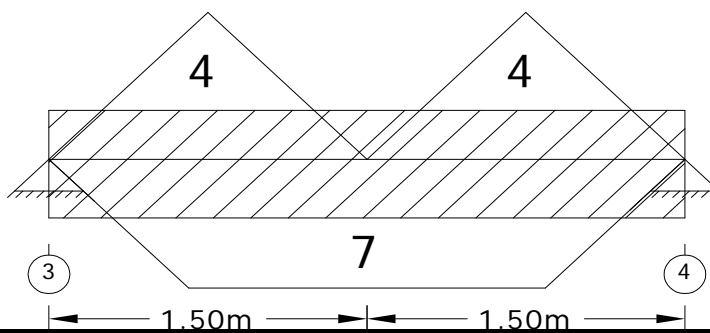
$58841 > 17360 \text{ N} \dots\dots (\text{aman})$

6.6.3. Gambar Tulangan



6.7. Perhitungan Balok Anak as C'(3-4)

6.8.1. Pembebanan





Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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a. Beban Mati (qD)

Pembebanan balok elemen G-G'

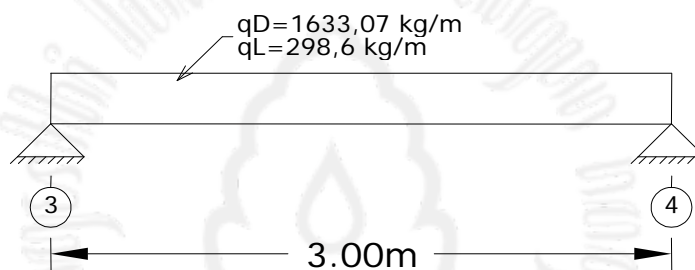
- Berat sendiri = $0,2 \times (0,3 - 0,12) \times 2400 \text{ kg/m}^3 = 86,4 \text{ kg/m}$
 - Beban Plat = $(0,5 + 0,993) \times 404 \text{ kg/m}^2 = 603,17 \text{ kg/m}$
 - Berat dinding = $0,15 \times (4 - 0,3) \times 1700 \text{ kg/m}^2 = 943,5 \text{ kg/m}$
-
- $qD = 1633,07 \text{ kg/m}$

b. Beban hidup (qL)

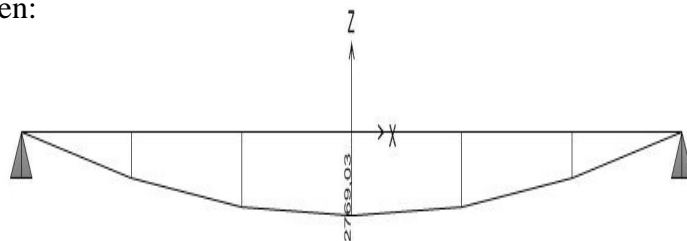
Beban hidup digunakan 200 kg/m^2

$$qL = (0,5 + 0,993) \times 200 \text{ kg/m}^2$$

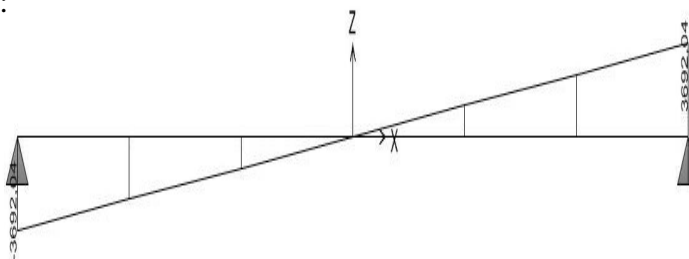
$$= 298,6 \text{ kg/m}$$



Bidang momen:



Bidang geser:



6.8.2. Perhitungan Tulangan



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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a) Tulangan Lentur Balok Anak

Data Perencanaan :

$$\begin{aligned}
 h &= 300 \text{ mm} & \emptyset_t &= 16 \text{ mm} \\
 b &= 200 \text{ mm} & \emptyset_s &= 8 \text{ mm} \\
 p &= 40 \text{ mm} & d &= h - p - 1/2 \emptyset_t - \emptyset_s \\
 f_y &= 320 \text{ Mpa} & &= 300 - 40 - 1/2 \cdot 16 - 8 \\
 f'_c &= 17,5 \text{ MPa} & &= 244 \text{ mm}
 \end{aligned}$$

$$\rho_b = \frac{0,85 \cdot f'_c \cdot \beta}{f_y} \left(\frac{600}{600 + f_y} \right)$$

$$\begin{aligned}
 &= \frac{0,85 \cdot 17,5}{320} \cdot 0,85 \left(\frac{600}{600 + 320} \right) \\
 &= 0,0258
 \end{aligned}$$

$$\begin{aligned}
 \rho_{\max} &= 0,75 \cdot \rho_b \\
 &= 0,75 \cdot 0,0258 \\
 &= 0,0193
 \end{aligned}$$

$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{320} = 0,00438$$

Daerah Lapangan :

Dari Perhitungan **SAP 2000** diperoleh :

$$M_u = 2770 \text{ kgm} = 2,770 \times 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{2,770 \times 10^7}{0,8} = 3,463 \times 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{3,463 \times 10^7}{200 \times 244^2} = 2,908$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{320}{0,85 \cdot 17,5} = 21,5126$$

$$\rho = \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot R_n}{f_y}} \right)$$

$$= \frac{1}{21,5126} \left(1 - \sqrt{1 - \frac{2 \times 21,5126 \times 2,908}{320}} \right) = 0,010$$

$$\rho > \rho_{\min}$$



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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$\rho < \rho_{\max}$ → Pakai tulangan tunggal

Digunakan $\rho = 0,010$

$$\begin{aligned} \text{As perlu} &= \rho \cdot b \cdot d \\ &= 0,010 \times 200 \times 244 \\ &= 498,15 \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} n &= \frac{\text{As perlu}}{\frac{1}{4} \cdot \pi \cdot 16^2} \\ &= \frac{498,15}{200,96} = 2,5 \approx 3 \text{ tulangan} \end{aligned}$$

$$\begin{aligned} \text{As ada} &= n \cdot \frac{1}{4} \cdot \pi \cdot d^2 \\ &= 3 \cdot \frac{1}{4} \cdot \pi \cdot 16^2 \\ &= 602,88 > \text{As perlu} \rightarrow \text{Aman..!!} \end{aligned}$$

$$a = \frac{\text{As ada} \cdot f_y}{0,85 \cdot f'c \cdot b} = \frac{602,88 \times 320}{0,85 \times 17,5 \times 200} = 64,85$$

$$\begin{aligned} \text{Mn ada} &= \text{As ada} \cdot f_y (d - a/2) \\ &= 602,88 \cdot 320 (244 - 64,85/2) \\ &= 4,043 \times 10^7 \text{ Nmm} \end{aligned}$$

$\text{Mn ada} > \text{Mn} \rightarrow \text{Aman..!!}$

Jadi dipakai tulangan 3 D 16 mm

b) Tulangan Geser Balok anak

Dari perhitungan **SAP 2000** Diperoleh :

$$V_u = 3693 \text{ kgm} = 36930 \text{ N}$$

$$f'c = 17,5 \text{ Mpa}$$

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

$$d = 244 \text{ mm}$$

$$\begin{aligned} V_c &= 1/6 \cdot \sqrt{f'c} \cdot b \cdot d = 1/6 \cdot \sqrt{17,5} \cdot 200 \cdot 244 \\ &= 34024,17 \text{ N} \end{aligned}$$

$$\emptyset V_c = 0,6 \cdot 34024,17 \text{ N} = 20414,50 \text{ N}$$

$$3 \emptyset V_c = 3 \cdot 20414,50 = 61243,5 \text{ N}$$

Syarat tulangan geser : $\emptyset V_c < V_u < 3 \emptyset V_c$

BAB 1 Pendahuluan



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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$$: 20414,50 \text{ N} < 36930 \text{ N} < 61243,5 \text{ N}$$

Jadi diperlukan tulangan geser:

$$S_{\max} \leq d/2 \leq 600 \text{ mm}$$

$$\emptyset V_s \text{ perlu} = V_u - \emptyset V_c$$

$$= 36930 \text{ N} - 20414,50 \text{ N} = 16515,5 \text{ N}$$

$$V_s \text{ perlu} = \frac{\phi V_{s \text{ perlu}}}{0,6} = \frac{16515,5}{0,6} = 27525,83 \text{ N}$$

$$A_v = 2 \cdot \frac{1}{4} \pi (8)^2$$

$$= 2 \cdot \frac{1}{4} \cdot 3,14 \cdot 64 = 100,48 \text{ mm}^2$$

$$S = \frac{A_v \cdot f_y \cdot d}{V_s \text{ perlu}} = \frac{100,48 \times 240 \times 244}{27526} = 213,77 \text{ mm}$$

$$S_{\max} = d/2 = \frac{244}{2} = 122 \text{ mm}$$

Jadi dipakai sengkang dengan tulangan $\emptyset 8 - 100 \text{ mm}$

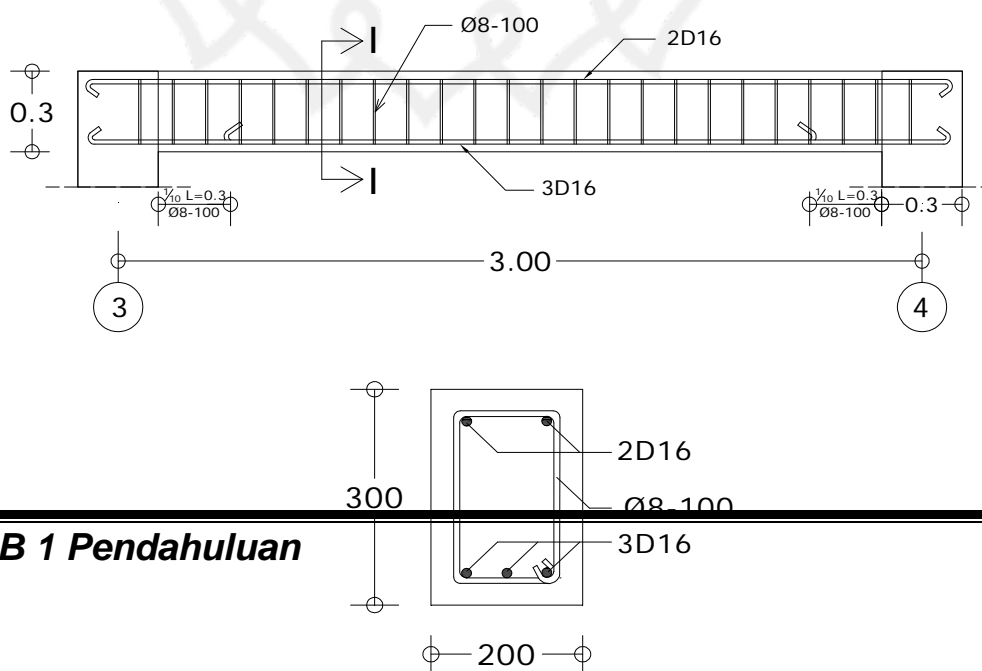
Dipakai $\emptyset 8 - 100 \text{ mm}$:

$$V_s \text{ ada} = \frac{A_v \cdot f_y \cdot d}{S} = \frac{100,48 \times 240 \times 244}{100} = 58841,1 \text{ N}$$

$V_s \text{ ada} > V_s \text{ perlu}$

$58841 > 27525,83 \text{ N}$ (aman)

6.8.3. Gambar Tulangan





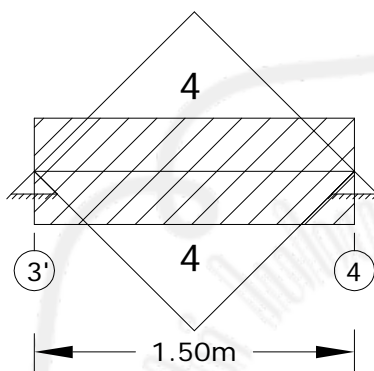
Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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6.9. Perhitungan Balok Anak as 3'(B-B')

6.9.1. Pembebanan



a. Beban Mati (q_D)

Pembebanan balok elemen 3'(B-B')

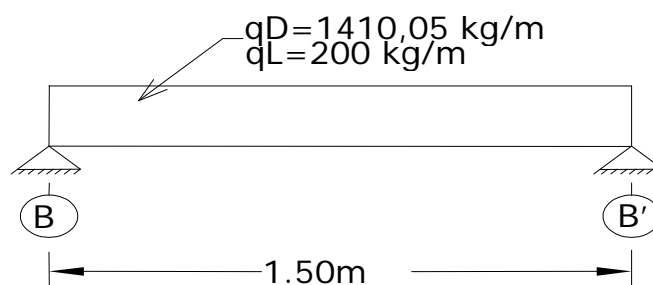
- Berat sendiri = $0,15 \times (0,25 - 0,12) \times 2400 \text{ kg/m}^3 = 46,8 \text{ kg/m}$
- Beban Plat = $(0,5 \times 2) \times 404 \text{ kg/m}^2 = 404 \text{ kg/m}$
- Berat dinding = $0,15 \times (4 - 0,25) \times 1700 \text{ kg/m}^2 = 956,25 \text{ kg/m}$

$$q_D = 1410,05 \text{ kg/m}$$

b. Beban hidup (q_L)

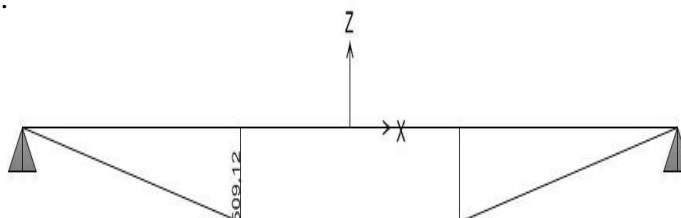
Beban hidup digunakan 200 kg/m^2

$$q_L = (0,5 \times 2) \times 200 \text{ kg/m}^2 = 200 \text{ kg/m}$$



Bidang momen:

BAB 1 Pen

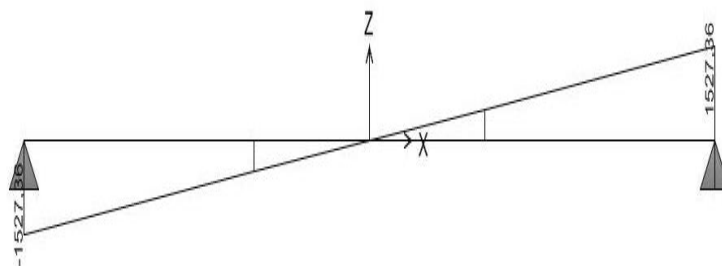




Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

Bidang geser:



6.9.2. Perhitungan Tulangan

a) Tulangan Lentur Balok Anak

Data Perencanaan :

h	$= 250 \text{ mm}$	\varnothing_t	$= 12 \text{ mm}$
b	$= 150 \text{ mm}$	\varnothing_s	$= 8 \text{ mm}$
p	$= 40 \text{ mm}$	d	$= h - p - 1/2 \varnothing_t - \varnothing_s$
f_y	$= 240 \text{ Mpa}$		$= 250 - 40 - 1/2 \cdot 12 - 8$
f'_c	$= 17,5 \text{ MPa}$		$= 196 \text{ mm}$

$$\rho_b = \frac{0,85 \cdot f'_c \cdot \beta}{f_y} \left(\frac{600}{600 + f_y} \right)$$

$$= \frac{0,85 \cdot 17,5}{240} \cdot 0,85 \left(\frac{600}{600 + 240} \right)$$

$$= 0,0376$$

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

$$= 0,75 \cdot 0,0376$$

$$= 0,0282$$

$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{240} = 0,00583$$

Daerah Lapangan :



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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Dari Perhitungan **SAP 2000** diperoleh :

$$M_u = 510 \text{ kgm} = 0,510 \times 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{0,510 \times 10^7}{0,8} = 0,638 \times 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{0,638 \times 10^7}{150 \times 196^2} = 1,107$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{240}{0,85 \cdot 17,5} = 16,134$$

$$\rho = \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot R_n}{f_y}} \right)$$

$$= \frac{1}{16,134} \left(1 - \sqrt{1 - \frac{2 \times 16,134 \times 1,107}{240}} \right) = 0,00480$$

$$\rho < \rho_{\min}$$

$$\rho < \rho_{\max} \rightarrow \text{Pakai tulangan tunggal}$$

$$\text{Digunakan } \rho_{\min} = 0,00583$$

$$\begin{aligned} \text{As perlu} &= \rho_{\min} \cdot b \cdot d \\ &= 0,00583 \times 150 \times 196 \\ &= 171,402 \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} n &= \frac{\text{As perlu}}{\frac{1}{4} \cdot \pi \cdot 12^2} \\ &= \frac{171,402}{113,04} = 1,5 \approx 2 \text{ tulangan} \end{aligned}$$

$$\begin{aligned} \text{As ada} &= n \cdot \frac{1}{4} \cdot \pi \cdot d^2 \\ &= 2 \cdot \frac{1}{4} \cdot \pi \cdot 12^2 \\ &= 226,08 > \text{As perlu} \rightarrow \text{Aman..!!} \end{aligned}$$

$$a = \frac{\text{As ada} \cdot f_y}{0,85 \cdot f'_c \cdot b} = \frac{226,08 \times 240}{0,85 \times 17,5 \times 150} = 24,32$$

$$\begin{aligned} M_n \text{ ada} &= \text{As ada} \cdot f_y (d - a/2) \\ &= 226,08 \cdot 240 (196 - 24,32/2) \\ &= 0,998 \times 10^7 \text{ Nmm} \end{aligned}$$



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

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Mn ada > Mn → Aman..!!

Jadi dipakai tulangan 2 D 12 mm

b) Tulangan Geser Balok anak

Dari perhitungan SAP 2000 Diperoleh :

$$V_u = 1528 \text{ kgm} = 15280 \text{ N}$$

$$f'_c = 17,5 \text{ Mpa}$$

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

$$d = 196 \text{ mm}$$

$$V_c = 1/6 \cdot \sqrt{f'_c} \cdot b \cdot d = 1/6 \cdot \sqrt{17,5} \cdot 150 \cdot 196$$

$$= 20498,17 \text{ N}$$

$$\phi V_c = 0,6 \times 20498,17 \text{ N} = 12298,9 \text{ N}$$

$$3 \phi V_c = 3 \times 12298,90 \text{ N} = 36896,7 \text{ N}$$

Syarat tulangan geser : $\phi V_c < V_u < 3 \phi V_c$

$$: 12298,9 \text{ N} < 15280 \text{ N} < 36896,7 \text{ N}$$

Jadi diperlukan tulangan geser:

$$S_{\max} \leq d/2 \leq 600 \text{ mm}$$

$$\phi V_s \text{ perlu} = V_u - \phi V_c$$

$$= 15280 \text{ N} - 12298,9 \text{ N} = 2981,1 \text{ N}$$

$$V_s \text{ perlu} = \frac{\phi V_s \text{ perlu}}{0,6} = \frac{2981,1}{0,6} = 4968,5 \text{ N}$$

$$A_v = 2 \cdot \frac{1}{4} \pi (8)^2$$

$$= 2 \cdot \frac{1}{4} \cdot 3,14 \cdot 64 = 100,48 \text{ mm}^2$$

$$S = \frac{A_v \cdot f_y \cdot d}{V_s \text{ perlu}} = \frac{100,48 \times 240 \times 196}{4968,5} = 951,30 \text{ mm}$$

$$S_{\max} = d/2 = \frac{196}{2} = 98 \text{ mm}$$

Jadi dipakai sengkang dengan tulangan $\phi 8 - 100 \text{ mm}$

Dipakai $\phi 8 - 100 \text{ mm}$:



Tugas Akhir

Perencanaan Struktur Gedung Kantor Pajak 2 lantai

$$V_s \text{ ada} = \frac{A_v \cdot f_y \cdot d}{S} = \frac{100,48 \times 240 \times 196}{100} = 47265,79 \text{ N}$$

$V_s \text{ ada} > V_s \text{ perlu}$

$47265,79 > 5301,83 \text{ N} \dots\dots (\text{aman})$

6.9.3. Gambar Tulangan

