



**PERENCANAAN STRUKTUR GEDUNG
FACTORY OUTLET DAN CAFE
DUA LANTAI**

TUGAS AKHIR



**Diajukan Sebagai Salah Satu Syarat Memperoleh Gelar Ahli Madya
Pada Program DIII Teknik Sipil Jurusan Teknik Sipil
Fakultas Teknik Universitas Sebelas Maret
Surakarta**

**Dikerjakan oleh :
BUDI SULISTIYONO
I.8507012**

**PROGRAM DIPLOMA III TEKNIK SIPIL
JURUSAN TEKNIK SIPIL FAKULTAS TEKNIK
UNIVERSITAS SEBELAS MARET
SURAKARTA**

2010



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 dapat menghasilkan tenaga yang bersumber daya dan mampu bersaing dalam dunia kerja.

1.2. Maksud Dan Tujuan

Dalam menghadapi pesatnya perkembangan jaman yang semakin modern dan berteknologi, serta semakin derasnya arus globalisasi saat ini, sangat diperlukan seorang teknisi yang berkualitas. Khususnya dalam ini adalah teknik sipil, sangat diperlukan 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 terangsang daya fikirnya dalam memecahkan suatu masalah yang dihadapi dalam perencanaan suatu struktur gedung.

1.3. Kriteria Perencanaan

1. Spesifikasi Bangunan

- a. Fungsi Bangunan : Swalayan
- b. Luas Bangunan : 950 m²
- c. Jumlah Lantai : 2 lantai
- d. Tinggi Lantai : 4,0 m
- e. Konstruksi Atap : Rangka kuda-kuda baja
- f. Penutup Atap : Genteng
- g. Pondasi : *Foot Plat*

2. Spesifikasi Bahan

- a. Mutu Baja Profil : BJ 37 ($\sigma_{leleh} = 2400 \text{ kg/cm}^2$)
($\sigma_{ijin} = 1600 \text{ kg/cm}^2$)
- b. Mutu Beton ($f'c$) : 25 MPa
- c. Mutu Baja Tulangan (f_y) : Polos : 240 MPa.
Ulir : 340 Mpa.



1.4. Peraturan-Peraturan Yang Berlaku

- a. Tata Cara Perhitungan Struktur Beton Untuk Bangunan Gedung **SNI 03-2847-2002**.
- b. Peraturan Beton Bertulang Indonesia (**PBBI 1971**).
- c. Peraturan Pembebanan Indonesia Untuk Gedung (**PPIUG 1983**).
- d. Tata Cara Perencanaan Struktur Baja Untuk Bangunan Gedung **SNI 03-1729-2002**



BAB 2

DASAR TEORI

2.1 Dasar Perencanaan



2.1.1 Jenis Pembebanan

Dalam merencanakan struktur suatu bangunan bertingkat, digunakan struktur yang mampu mendukung berat sendiri, gaya angin, beban hidup maupun beban khusus yang bekerja pada struktur bangunan tersebut.

Beban-beban yang bekerja pada struktur dihitung menurut **Peraturan Pembebanan Indonesia Untuk Gedung 1983**, beban - beban tersebut adalah :

1. Beban Mati (qd)

Beban mati adalah berat dari semua bagian dari suatu gedung yang bersifat tetap, termasuk segala unsur tambahan, penyelesaian–penyelesaian, mesin – mesin serta peralatan tetap yang merupakan bagian tak terpisahkan dari gedung itu. Untuk merencanakan gedung ini, beban mati yang terdiri dari berat sendiri bahan bangunan dan komponen gedung adalah :

a) Bahan Bangunan :

1. Beton Bertulang	2400 kg/m ³
2. Pasir basah	1800 kg/m ³
kering	1000 kg/m ³
3. Beton biasa	2200 kg/m ³

b) Komponen Gedung :

1. Dinding pasangan batu merah setengah bata	250 kg/m ³
2. Langit – langit dan dinding (termasuk rusuk – rusuknya, tanpa penggantung langit-langit atau pengaku), terdiri dari :	
- semen asbes (eternit) dengan tebal maximum 4 mm	11 kg/m ²
- kaca dengan tebal 3 – 4 mm	10 kg/m ²
3. Penutup atap genteng dengan reng dan usuk	50 kg/m ²
4. Penutup lantai dari tegel, keramik dan beton (tanpa adukan) per cm tebal	24 kg/m ²
5. Adukan semen per cm tebal	21 kg/m ²

2. Beban Hidup (ql)



Beban hidup adalah semua beban yang terjadi akibat penghuni atau pengguna suatu gedung, termasuk beban – beban pada lantai yang berasal dari barang – barang yang dapat berpindah, mesin – mesin serta peralatan yang merupakan bagian yang tidak terpisahkan dari gedung dan dapat diganti selama masa hidup dari gedung itu, sehingga mengakibatkan perubahan pembebanan lantai dan atap tersebut. Khususnya pada atap, beban hidup dapat termasuk beban yang berasal dari air hujan (**PPIUG 1983**).

Beban hidup yang bekerja pada bangunan ini disesuaikan dengan rencana fungsi bangunan tersebut. Beban hidup untuk bangunan gedung swalayan ini terdiri dari :

Beban atap.....	100 kg/m ²
Beban tangga dan bordes	300 kg/m ²
Beban lantai untuk swalayan	250 kg/m ²

Berhubung peluang untuk terjadi beban hidup penuh yang membebani semua bagian dan semua unsur struktur pemikul secara serempak selama unsur gedung tersebut adalah sangat kecil, maka pada perencanaan balok induk dan portal dari sistem pemikul beban dari suatu struktur gedung, beban hidupnya dikalikan dengan suatu koefisien reduksi yang nilainya tergantung pada penggunaan gedung yang ditinjau, seperti diperlihatkan pada tabel 2.1.

Tabel 2.1 Koefisien reduksi beban hidup

Penggunaan Gedung	Koefisien Beban Hidup untuk Perencanaan Balok Induk
• PERUMAHAN: Rumah sakit / Poliklinik	0,75
• PENDIDIKAN: Sekolah, Ruang kuliah	0,90
• PENYIMPANAN :	0,80



Gudang, Perpustakaan, swalayan • TANGGA : Perdagangan, penyimpanan	0,90
--	------

Sumber : PPIUG 1983

3. Beban Angin (W)

Beban Angin adalah semua beban yang bekerja pada gedung atau bagian gedung yang disebabkan oleh selisih dalam tekanan udara (kg/m^2).

Beban Angin ditentukan dengan menganggap adanya tekanan positif dan tekanan negatif (hisapan), yang bekerja tegak lurus pada bidang yang ditinjau. Besarnya tekanan positif dan negatif yang dinyatakan dalam kg/m^2 ini ditentukan dengan mengalikan tekanan tiup dengan koefisien – koefisien angin. Tekan tiup harus diambil minimum 25 kg/m^2 , kecuali untuk daerah di laut dan di tepi laut sampai sejauh 5 km dari tepi pantai. Pada daerah tersebut tekanan hisap diambil minimum 40 kg/m^2 .

$$P = \frac{V^2}{16} (\text{kg/m}^2)$$

Di mana V adalah kecepatan angin dalam m/det, yang harus ditentukan oleh instansi yang berwenang.

Sedangkan koefisien angin (+ berarti tekanan dan – berarti isapan), untuk gedung tertutup :

1. Dinding Vertikal

a) Di pihak angin + 0,9

b) Di belakang angin - 0,4

2. Atap segitiga dengan sudut kemiringan α

a) Di pihak angin : $\alpha < 65^\circ$ $0,02 \alpha - 0,4$

$65^\circ < \alpha < 90^\circ$ + 0,9

b) Di belakang angin, untuk semua α - 0,4

2.1.2 Sistem Bekerjanya Beban



Bekerjanya beban untuk bangunan bertingkat berlaku sistem gravitasi, yaitu elemen struktur yang berada di atas akan membebani elemen struktur di bawahnya, atau dengan kata lain elemen struktur yang mempunyai kekuatan lebih besar akan menahan atau memikul elemen struktur yang mempunyai kekuatan lebih kecil.

Dengan demikian sistem bekerjanya beban untuk elemen – elemen struktur gedung bertingkat secara umum dapat dinyatakan sebagai berikut : beban pelat lantai didistribusikan terhadap balok anak dan balok portal, beban balok portal didistribusikan ke kolom dan beban kolom kemudian diteruskan ke tanah dasar melalui pondasi.

2.1.3 Provisi Keamanan

Dalam pedoman beton **PPIUG 1983**, struktur harus direncanakan untuk memiliki cadangan kekuatan untuk memikul beban yang lebih tinggi dari beban normal. Kapasitas cadangan ini mencakup faktor pembebanan (U), yaitu untuk memperhitungkan pelampauan beban dan faktor reduksi (ϕ), yaitu untuk memperhitungkan kurangnya mutu bahan di lapangan. Pelampauan beban dapat terjadi akibat perubahan dari penggunaan untuk apa struktur direncanakan dan penafsiran yang kurang tepat dalam memperhitungkan pembebanan. Sedang kekurangan kekuatan dapat diakibatkan oleh variasi yang merugikan dari kekuatan bahan, pengerjaan, dimensi, pengendalian dan tingkat pengawasan.

Tabel 2.2 Faktor Pembebanan U

1	D	1,4 D
2	D, L, A,R	1,2 D + 1,6 L + 0,5 (A atau R)
3	D,L,W, A, R	1,2 D + 1,0 L ± 1,6 W + 0,5 (A atau R)
4	D, W	0,9 D ± 1,6 W
5	D,L,E	1,2 D + 1,0 L ± 1,0 E
6	D,E	0,9 D ± 1,0 E



7	D,F	$1,4 (D + F)$
8	D,T,L,A,R	$1,2 (D+ T) + 1,6 L + 0,5 (A \text{ atau } R)$

Sumber : SNI 03-2847-2002

Keterangan :

D = Beban mati

L = Beban hidup

W = Beban angin

A = Beban atap

R = Beban air hujan

E = Beban gempa

T = Pengaruh kombinasi suhu, rangkai, susut dan perbedaan penurunan

F = Beban akibat berat dan tekanan fluida yang diketahui dengan baik berat jenis dan tinggi maksimumnya yang terkontrol.

Tabel 2.3 Faktor Reduksi Kekuatan ϕ

No	Kondisi gaya	Faktor reduksi (ϕ)
----	--------------	---------------------------



1.	Lentur, tanpa beban aksial	0,80
2.	Beban aksial, dan beban aksial dengan lentur :	
	a. Aksial tarik dan aksial tarik dengan lentur	0,8
	b. Aksial tekan dan aksial tekan dengan lentur :	
	• Komponen struktur dengan tulangan spiral	0,7
	• Komponen struktur lainnya	0,65
3.	Geser dan torsi	0,75
4.	Tumpuan beton	0,65

Sumber : SNI 03-2847-2002

Karena kandungan agregat kasar untuk beton struktural seringkali berisi agregat kasar berukuran diameter lebih dari 2 cm, maka diperlukan adanya jarak tulangan minimum agar campuran beton basah dapat melewati tulangan baja tanpa terjadi pemisahan material sehingga timbul rongga-rongga pada beton. Sedang untuk melindungi dari karat dan kehilangan kekuatannya dalam kasus kebakaran, maka diperlukan adanya tebal selimut beton minimum.

Beberapa persyaratan utama pada **SNI 03-2847-2002** adalah sebagai berikut :

- Jarak bersih antara tulangan sejajar yang selapis tidak boleh kurang dari d_b atau 25 mm, dimana d_b adalah diameter tulangan.
- Jika tulangan sejajar tersebut diletakkan dalam dua lapis atau lebih, tulangan pada lapisan atas harus diletakkan tepat diatas tulangan di bawahnya dengan jarak bersih tidak boleh kurang dari 25 mm.

Tebal selimut beton minimum untuk beton yang dicor setempat adalah:

- Untuk pelat dan dinding = 20 mm
- Untuk balok dan kolom = 40 mm
- Beton yang berhubungan langsung dengan tanah atau cuaca = 50 mm

2.2 Perencanaan Atap

2.2.1. Perencanaan Kuda-Kuda

- Pembebanan



Pada perencanaan atap ini, beban yang bekerja adalah :

- a. Beban mati
 - b. Beban hidup
 - c. Beban angin
2. Asumsi Perletakan
 - a. Tumpuan sebelah kiri adalah Sendi.
 - b. Tumpuan sebelah kanan adalah Rol..
 3. Perencanaan struktur menggunakan program **SAP 2000**.
 4. Perhitungan profil kuda-kuda

a. Batang tarik

$$F_n = \frac{\rho_{mak}}{\sigma_{ijin}}$$

$$\sigma_{ijin} = \frac{2}{3} \times (\sigma_t = 2400 \text{ kg/cm}^2) = 1600 \text{ kg/cm}^2$$

$$F_{bruto} = 1,15 \times F_n \dots\dots (< F \text{ Profil})$$

Dengan syarat σ terjadi $\leq 0,75 \sigma$ ijin

$$\sigma \text{ terjadi} = \frac{\rho_{mak}}{0,85 \cdot F_{profil}}$$

b. Batang tekan

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

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

$$\lambda_s = \frac{\lambda}{\lambda_g}$$

$$\text{Apabila } \lambda_s \leq 0,25 \quad \longrightarrow \quad \omega = 1$$

$$0,25 < \lambda_s < 1,2 \quad \longrightarrow \quad \omega = \frac{1,43}{1,6 - 0,67 \cdot \lambda_s}$$

$$\lambda_s \geq 1,2 \quad \longrightarrow \quad \omega = 1,25 \cdot \lambda_s^2$$



kontrol tegangan :

$$\sigma = \frac{P_{\text{maks.}} \cdot \omega}{F_p} \leq \sigma_{\text{ijin}}$$

2.2.2. Perhitungan Alat Sambung

Alat sambung yang digunakan adalah baut.

a. Tegangan geser yang diijinkan

$$\text{Teg. Geser} = 0,6 \cdot \sigma_{\text{ijin}}$$

b. Tegangan tumpuan yang diijinkan

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

c. Tebal pelat sambung

$$\delta = 0,625 d$$

d. Kekuatan baut

- $P_{\text{geser}} = 2 \cdot \frac{1}{4} \cdot \pi \cdot d^2 \cdot \tau_{\text{geser}}$

- $P_{\text{desak}} = \delta \cdot d \cdot \tau_{\text{tumpuan}}$

Untuk menentukan jumlah baut tiap sambungan menggunakan kekuatan baut terhadap tegangan geser atau desak yang memiliki hasil lebih kecil dengan cara beban maksimal yang ditahan oleh batang dibagi dengan kekuatan baut yang terkecil.

Jarak antar baut ditentukan dengan rumus :

- $2,5 d \leq S \leq 7 d$
- $2,5 d \leq u \leq 7 d$
- $1,5 d \leq S_1 \leq 3 d$

Dimana :

d = diameter alat sambungan

s = jarak antar baut arah Horizontal

u = jarak antar baut arah Vertikal

s1 = jarak antar baut dengan tepi sambungan

2.3 Perencanaan Tangga



1. Pembebanan :
 - Beban mati
 - Beban hidup : 300 kg/m²
2. Asumsi Perletakan
 - Tumpuan bawah adalah Jepit.
 - Tumpuan tengah adalah Sendi.
 - Tumpuan atas adalah Jepit.
3. Perencanaan struktur menggunakan program **SAP 2000**.
4. Perencanaan tampang menggunakan peraturan **SNI 03-2847-2002**.

Perhitungan untuk penulangan tangga :

$$M_n = \frac{M_u}{\Phi}$$

Dimana $\Phi = 0.8$

$$M = \frac{f_y}{0.85 \cdot f'_c}$$

$$R_n = \frac{M_n}{b \cdot d^2}$$

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

$$\rho_b = \frac{0.85 \cdot f_c}{f_y} \cdot \beta \cdot \left(\frac{600}{600 + f_y} \right)$$

$$\rho_{\max} = 0.75 \cdot \rho_b$$

$\rho_{\min} < \rho < \rho_{\max}$ → tulangan tunggal

$\rho < \rho_{\min}$ → dipakai $\rho_{\min} = 0.0025$

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

$$M_n = \frac{M_u}{\phi}$$

dimana, $\phi = 0,80$

$$m = \frac{f_y}{0,85 \cdot f'_c}$$



$$R_n = \frac{M_n}{bxd^2}$$

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

$$\rho_b = \frac{0.85 \cdot f_c}{f_y} \cdot \beta \cdot \left(\frac{600}{600 + f_y} \right)$$

$$\rho_{\max} = 0.75 \cdot \rho_b$$

$$\rho_{\min} < \rho < \rho_{\max} \longrightarrow \text{tulangan tunggal}$$

$$\rho < \rho_{\min} \longrightarrow \text{dipakai } \rho_{\min} = 0.0025$$

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

Luas tampang tulangan

$$A_s = \rho bxd$$

2.4 Perencanaan Plat Lantai

1. Pembebanan :

- Beban mati
- Beban hidup : 250 kg/m²

2. Asumsi Perletakan : jepit penuh

3. Analisa struktur menggunakan tabel 13.3.2 **PPIUG 1983**.

4. Perencanaan tampang menggunakan peraturan **PBI 1971**.

Penulangan lentur dihitung analisa tulangan tunggal dengan langkah-langkah sebagai berikut :

$$M_n = \frac{M_u}{\Phi}$$

Dimana $\Phi = 0.8$

$$m = \frac{f_y}{0.85 \cdot f'_c}$$

$$R_n = \frac{M_n}{b \cdot d^2}$$



$$\rho = \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot Rn}{f_y}} \right)$$

$$\rho_b = \frac{0.85 \cdot f_c}{f_y} \cdot \beta \cdot \left(\frac{600}{600 + f_y} \right)$$

$$\rho_{\max} = 0.75 \cdot \rho_b$$

$$\rho_{\min} < \rho < \rho_{\max} \longrightarrow \text{tulangan tunggal}$$

$$\rho < \rho_{\min} \longrightarrow \text{dipakai } \rho_{\min} = 0.0025$$

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

Luas tampang tulangan

$$A_s = \rho b x d$$

2.5 Perencanaan Balok

1. Pembebanan :

- Beban mati
- Beban hidup : 250 kg/m²

2. Asumsi Perletakan : sendi sendi

3. Perencanaan struktur menggunakan program **SAP 2000**.

4. Perencanaan tampang menggunakan peraturan **SNI 03-2847-2002**.

5. Perhitungan tulangan lentur :

$$M_n = \frac{M_u}{\phi}$$

dimana, $\phi = 0,80$

$$m = \frac{f_y}{0,85 f'_c}$$

$$Rn = \frac{M_n}{b x d^2}$$

$$\rho = \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot Rn}{f_y}} \right)$$



$$\rho_b = \frac{0.85 \cdot f_c}{f_y} \cdot \beta \cdot \left(\frac{600}{600 + f_y} \right)$$

$$\rho_{\max} = 0.75 \cdot \rho_b$$

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

$$\rho_{\min} < \rho < \rho_{\max} \longrightarrow \text{tulangan tunggal}$$

$$\rho < \rho_{\min} \longrightarrow \text{dipakai } \rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{340} = 0,0041$$

b. Perhitungan tulangan geser :

$$\emptyset = 0,75$$

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

$$\emptyset V_c = 0,75 \times V_c$$

$$\emptyset \cdot V_c \leq V_u \leq 3 \emptyset V_c$$

(perlu tulangan geser)

$$V_s \text{ perlu} = V_u - V_c$$

(pilih tulangan terpasang)

$$V_s \text{ ada} = \frac{(A_v \cdot f_y \cdot d)}{S}$$

(pakai V_s perlu)

Tetapi jika terjadi $V_u < \emptyset V_c$, maka harus selalu dipasang tulangan geser minimum, kecuali untuk :

1. Pelat dan fondasi telapak.
2. Konstruksi pelat perusuk.
3. Balok dengan tinggi total yang tidak lebih dari nilai terbesar di antara 250 mm, 2,5 kali tebal sayap atau 0,5 kali lebar badan.

2.6 Perencanaan Portal

1. Pembebanan :

- Beban mati
- Beban hidup : 200 kg/m²



2. Asumsi Perletakan
 - Jepit pada kaki portal.
 - Bebas pada titik yang lain
3. Perencanaan struktur menggunakan program **SAP 2000**.
4. Perencanaan tampang menggunakan peraturan **SNI 03-2847-2002**.

a. Perhitungan tulangan lentur :

$$M_n = \frac{M_u}{\phi}$$

dimana, $\phi = 0,80$

$$m = \frac{f_y}{0,85x f'_c}$$

$$R_n = \frac{M_n}{bxd^2}$$

$$\rho = \frac{1}{m} \left(1 - \sqrt{1 - \frac{2.m.R_n}{f_y}} \right)$$

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

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

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

$$\rho_{\min} < \rho < \rho_{\max} \longrightarrow \text{tulangan tunggal}$$

$$\rho < \rho_{\min} \longrightarrow \text{dipakai } \rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{340} = 0,0041$$

b. Perhitungan tulangan geser :

$$\phi = 0,75$$

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

$$\phi V_c = 0,75 x V_c$$

$$\phi V_c \leq V_u \leq 3 \phi V_c$$

(perlu tulangan geser)



$$V_s \text{ perlu} = V_u - V_c$$

(pilih tulangan terpasang)

$$V_s \text{ ada} = \frac{(A_v \cdot f_y \cdot d)}{S}$$

(pakai V_s perlu)

Tetapi jika terjadi $V_u < \emptyset V_c$, maka harus selalu dipasang tulangan geser minimum, kecuali untuk :

1. Pelat dan fondasi telapak.
2. Konstruksi pelat perusuk.
3. Balok dengan tinggi total yang tidak lebih dari nilai terbesar di antara 250 mm, 2,5 kali tebal sayap atau 0,5 kali lebar badan.

2.7 Perencanaan Pondasi

1. Pembebanan : Beban aksial dan momen dari analisa struktur portal akibat beban mati dan beban hidup
2. Perencanaan tampang menggunakan peraturan **SNI 03-2847-2002**

$$q_{\text{ada}} = \frac{P}{A}$$

$$q_u = 1,3 cNc + qNq + 0,4 \gamma B N\gamma$$

$$q_{\text{ijin}} = q_u / SF$$

$$q_{\text{ada}} \leq q_{\text{ijin}} \dots\dots\dots (\text{aman})$$

- a. Perhitungan tulangan lentur :

$$M_u = \frac{1}{2} \cdot q_u \cdot t^2$$

$$m = \frac{f_y}{0,85x f'_c}$$

$$R_n = \frac{M_n}{bxd^2}$$



$$\rho = \frac{1}{m} \left(1 - \sqrt{1 - \frac{2.m.Rn}{f_y}} \right)$$

$$\rho_b = \frac{0.85.f_c}{f_y} \cdot \beta \left(\frac{600}{600 + f_y} \right)$$

$$\rho_{\max} = 0.75 \cdot \rho_b$$

$$\rho_{\min} < \rho < \rho_{\max} \longrightarrow \text{tulangan tunggal}$$

$$\rho < \rho_{\min} \longrightarrow \text{dipakai } \rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{340} = 0,0041$$

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

Luas tampang tulangan

$A_s = \text{Jumlah tulangan} \times \text{Luas}$

b. Perhitungan tulangan geser :

$$\phi = 0,75$$

$$V_c = \frac{1}{6} \cdot x \cdot \sqrt{f'c} \cdot b \cdot d$$

$$\phi V_c = 0,75 \times V_c$$

$$\phi \cdot V_c \leq V_u \leq 3 \phi V_c$$

(perlu tulangan geser)

$$V_s \text{ perlu} = V_u - V_c$$

(pilih tulangan terpasang)

$$V_s \text{ ada} = \frac{(A_v \cdot f_y \cdot d)}{S}$$

(pakai V_s perlu)

Tetapi jika terjadi $V_u < \phi V_c$, maka harus selalu dipasang tulangan geser minimum, kecuali untuk :

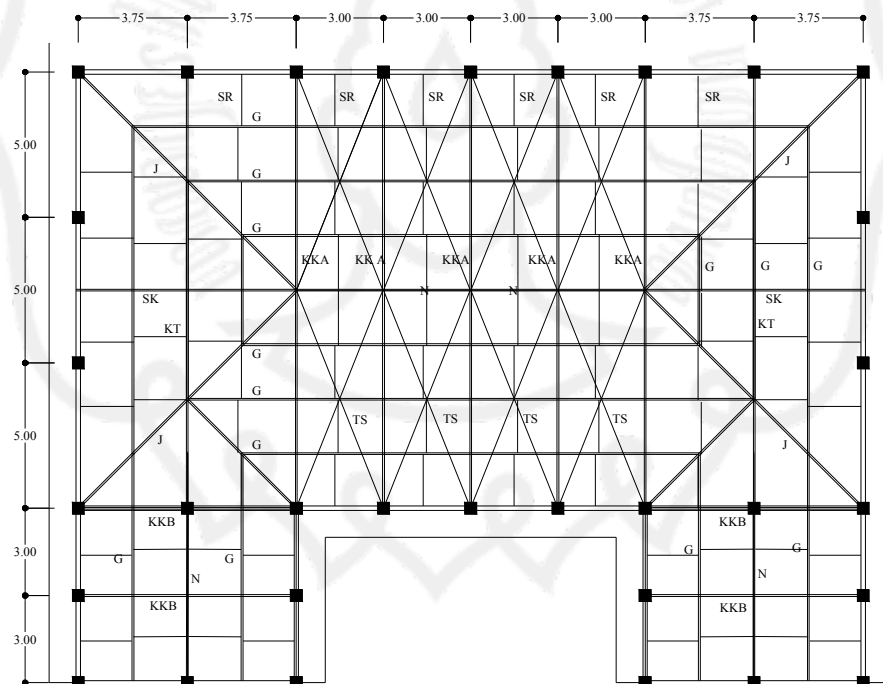
1. Pelat dan fondasi telapak.
2. Konstruksi pelat perusuk.



- Balok dengan tinggi total yang tidak lebih dari nilai terbesar di antara 250 mm, 2,5 kali tebal sayap atau 0,5 kali lebar badan.

BAB 3 PERENCANAAN ATAP

3.1. Rencana Atap



Gambar 3.1. Rencana Atap

Keterangan :



KK A = Kuda-kuda utama	G = Gording
KT = Kuda-kuda trapesium	N = Nok
SK = Setengah kuda-kuda utama	L = Lisplank
KK B = Kuda – kuda samping	SR = Sag Rod
J = Jurai	





3.2. Dasar Perencanaan

Secara umum data yang digunakan untuk perhitungan rencana atap adalah sebagai berikut :

- a. Bentuk rangka kuda-kuda : seperti tergambar.
- b. Jarak antar kuda-kuda : 3 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 : 1,875 m
- i. Bentuk atap : limasan.
- j. Mutu baja profil : Bj-37 ($\sigma_{ijin} = 1600 \text{ kg/cm}^2$)
($\sigma_{leleh} = 2400 \text{ kg/cm}^2$)

3.3. Perencanaan Gording

3.3.1. Perencanaan Pembebanan

Dicoba menggunakan gording dengan dimensi baja profil tipe *lip channels*/ kanal kait (□) 150 x 75 x 20 x 4,5 pada perencanaan kuda-kuda dengan data sebagai berikut :

- | | | | |
|------------------|--------------------------|----------|--------------------------|
| a. Berat gording | = 11 kg/m. | f. t_s | = 4,5 mm |
| b. I_x | = 489 cm ⁴ . | g. t_b | = 4,5 mm |
| c. I_y | = 99,2 cm ⁴ . | h. Z_x | = 65,2 cm ³ . |
| d. h | = 150 mm | i. Z_y | = 19,8 cm ³ . |
| e. b | = 75 mm | | |



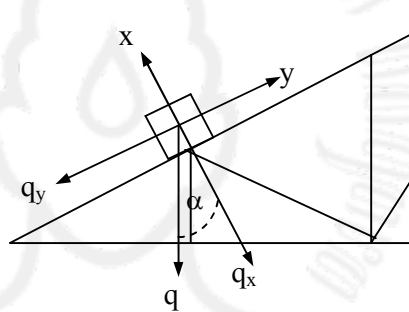
Kemiringan atap (α)	= 30° .
Jarak antar gording (s)	= 1,875 m.
Jarak antar kuda-kuda utama	= 3 m.
Jarak antara KU dengan KT	= 3,75 m.

Pembebanan berdasarkan SNI 03-1727-1989, sebagai berikut :

- Berat penutup atap = 50 kg/m^2 .
- Beban angin = 25 kg/m^2 .
- Berat hidup (pekerja) = 100 kg.
- Berat penggantung dan plafond = 18 kg/m^2

3.3.2. Perhitungan Pembebanan

a. Beban Mati (titik)



Berat gording	=	11	kg/m
Berat penutup atap	= (1,875 x 50)	=	93,75 kg/m
Berat plafon	= (1,5 x 18)	=	27 kg/m
		<hr/>	
	q =	131,75	kg/m

$$q_x = q \sin \alpha = 131,75 \times \sin 30^\circ = 65,875 \text{ kg/m.}$$

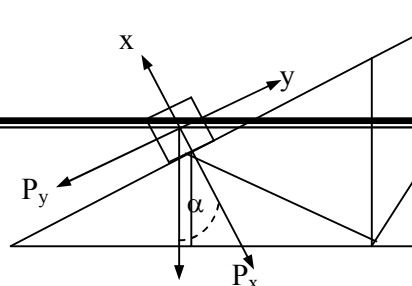
$$q_y = q \cos \alpha = 131,75 \times \cos 30^\circ = 114,099 \text{ kg/m.}$$

$$M_{x1} = \frac{1}{8} \cdot q_y \cdot L^2 = \frac{1}{8} \times 114,099 \times (3,75)^2 = 200,564 \text{ kgm.}$$

$$M_{y1} = \frac{1}{8} \cdot q_x \cdot L^2 = \frac{1}{8} \times 65,875 \times (3,75)^2 = 115,796 \text{ kgm.}$$

b. Beban hidup

Bab I Pendahuluan





P

P diambil sebesar 100 kg.

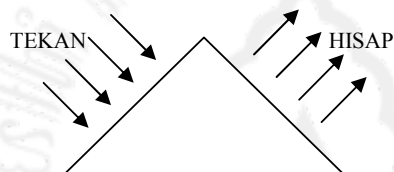
$$P_x = P \sin \alpha = 100 \times \sin 30^\circ = 50 \text{ kg.}$$

$$P_y = P \cos \alpha = 100 \times \cos 30^\circ = 86,603 \text{ kg.}$$

$$M_{x2} = \frac{1}{4} \cdot P_y \cdot L = \frac{1}{4} \times 86,603 \times 3,75 = 81,19 \text{ kgm.}$$

$$M_{y2} = \frac{1}{4} \cdot P_x \cdot L = \frac{1}{4} \times 50 \times 3,75 = 46,875 \text{ kgm.}$$

c. Beban angin



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

Koefisien kemiringan atap (α) = 30°.

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

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

Beban angin :

$$1) \text{ Angin tekan } (W_1) = \text{koef. Angin tekan} \times \text{beban angin} \times \frac{1}{2} \times (s_1 + s_2) \\ = 0,2 \times 25 \times \frac{1}{2} \times (1,875 + 1,875) = 9,375 \text{ kg/m.}$$

$$2) \text{ Angin hisap } (W_2) = \text{koef. Angin hisap} \times \text{beban angin} \times \frac{1}{2} \times (s_1 + s_2) \\ = -0,4 \times 25 \times \frac{1}{2} \times (1,875 + 1,875) = -18,75 \text{ kg/m.}$$

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

$$1) M_x (\text{tekan}) = \frac{1}{8} \cdot W_1 \cdot L^2 = \frac{1}{8} \times 9,375 \times (3,75)^2 = 16,48 \text{ kgm.}$$

$$2) M_x (\text{hisap}) = \frac{1}{8} \cdot W_2 \cdot L^2 = \frac{1}{8} \times -18,75 \times (3,75)^2 = -32,96 \text{ kgm.}$$

Tabel 3.1. Kombinasi Gaya Dalam pada Gording

Momen	Beban Mati	Beban Hidup	Beban Angin		Kombinasi	
			Tekan	Hisap	Minimum	Maksimum



M_x	200,564	81,19	16,48	- 32,96	281,754	298,234
M_y	115,796	46,875	-	-	162,671	162,671

3.3.3. Kontrol Terhadap Tegangan

➤ Kontrol terhadap momen Maximum

$$M_x = 298,234 \quad \text{kgm} = 29823,4 \quad \text{kgcm.}$$

$$M_y = 162,671 \quad \text{kgm} = 16267,1 \quad \text{kgcm.}$$

Asumsikan penampang kompak :

$$M_{nx} = Z_x \cdot f_y = 65,2 \cdot 2400 = 156480 \quad \text{kgcm}$$

$$M_{ny} = Z_y \cdot f_y = 19,8 \cdot 2400 = 47520 \quad \text{kgcm}$$

Check tahanan momen lentur yang terjadi :

$$\frac{M_x}{\phi_b \cdot M_{nx}} + \frac{M_y}{\phi_b \cdot M_{ny}} \leq 1$$

$$\frac{29823,4}{0,9 \cdot 156480} + \frac{162,671}{47520} = 0,59 \leq 1 \dots\dots\dots \text{ok}$$

➤ Kontrol terhadap momen Minimum

$$M_x = 281,754 \quad \text{kgm} = 28175,4 \quad \text{kgcm.}$$

$$M_y = 162,671 \quad \text{kgm} = 16267,1 \quad \text{kgcm.}$$

Asumsikan penampang kompak :

$$M_{nx} = Z_x \cdot f_y = 65,2 \cdot 2400 = 156480 \quad \text{kgcm}$$

$$M_{ny} = Z_y \cdot f_y = 19,8 \cdot 2400 = 47520 \quad \text{kgcm}$$



Check tahanan momen lentur yang terjadi :

$$\frac{M_x}{\phi_b \cdot M_{nx}} + \frac{M_y}{\phi_b \cdot M_{ny}} \leq 1$$

$$\frac{28175,4}{0,9 \cdot 156480} + \frac{162,671}{47520} = 0,52 \leq 1 \dots\dots\dots \text{ok}$$





3.3.4. Kontrol Terhadap Lendutan

Di coba profil : 150 x 75 x 20 x 4,5

$$E = 2,1 \times 10^6 \text{ kg/cm}^2 \quad q_y = 1,4073 \text{ kg/cm}$$

$$I_x = 489 \text{ cm}^4 \quad P_x = 50 \text{ kg}$$

$$I_y = 99,2 \text{ cm}^4 \quad P_y = 86,603 \text{ kg}$$

$$q_x = 0,8125 \text{ kg/cm}$$

$$Z_{ijin} = \frac{1}{180} \times 300 = 1,67 \text{ cm}$$

$$\begin{aligned} Z_x &= \frac{5 \cdot q_x \cdot L^4}{384 \cdot E \cdot I_y} + \frac{P_x \cdot L^3}{48 \cdot E \cdot I_y} \\ &= \frac{5 \times 0,8125 \times (375)^4}{384 \times 2,1 \cdot 10^6 \times 99,2} + \frac{50 \times 375^3}{48 \times 2,1 \cdot 10^6 \times 99,2} \\ &= 1,26 \text{ cm} \end{aligned}$$

$$\begin{aligned} Z_y &= \frac{5 \cdot q_y \cdot L^4}{384 \cdot E \cdot I_x} + \frac{P_y \cdot L^3}{48 \cdot E \cdot I_x} \\ &= \frac{5 \times 1,4073 \times (375)^4}{384 \times 2,1 \cdot 10^6 \times 489} + \frac{86,603 \times 375^3}{48 \times 2,1 \cdot 10^6 \times 489} \\ &= 0,44 \text{ cm} \end{aligned}$$

$$\begin{aligned} Z &= \sqrt{Z_x^2 + Z_y^2} \\ &= \sqrt{(1,26)^2 + (0,44)^2} = 1,33 \text{ cm} \end{aligned}$$

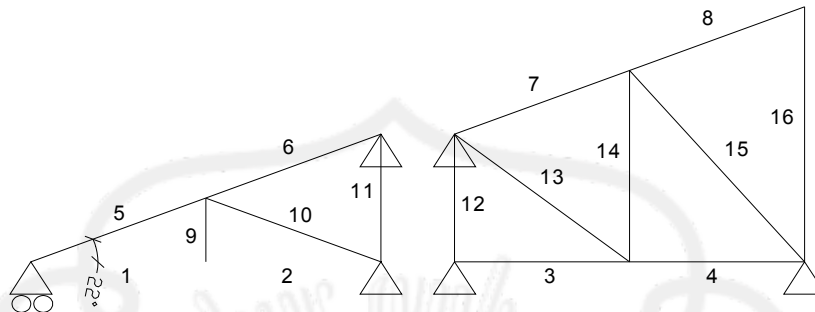
$$Z \leq Z_{ijin}$$

$$1,33 \text{ cm} \leq 1,67 \text{ cm} \quad \dots\dots\dots \text{ aman !}$$

Jadi, baja profil *lip channels* (□) dengan dimensi **150 × 75 × 20 × 4,5** aman dan mampu menerima beban apabila digunakan untuk gording.



3.4. Perencanaan Jurai



Gambar 3.2. Rangka Batang Jurai

3.4.1. Perhitungan Panjang Batang Jurai

Perhitungan panjang batang selanjutnya disajikan dalam tabel dibawah ini :

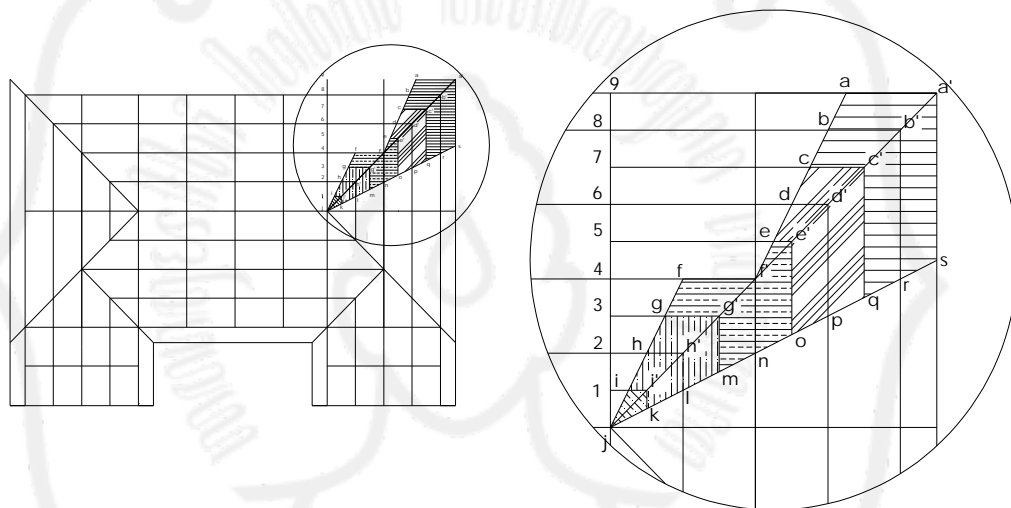
Tabel 3.2. Panjang Batang pada Jurai

Nomer Batang	Panjang Batang (m)
1	2,652
2	2,652
3	2,652
4	2,652
5	2,864
6	2,864
7	2,864
8	2,864
9	1,083
10	2,864



11	2,165
12	2,165
13	3,423
14	3,226
15	4,193
16	4,330

3.4.2. Perhitungan luasan jurai



Gambar 3.3. Luasan Atap Jurai

$$\text{Panjang } j'l = \frac{1}{2} \cdot 1,875 = 0,937 \text{ m}$$

$$\text{Panjang } j'l = 1-2 = 2-3 = 3-4 = 4-5 = 5-6 = 6-7 = 7-8 = 8-9 = 0,937 \text{ m}$$

$$\text{Panjang } aa' = 2,594 \text{ m}$$

$$\text{Panjang } a's = 4,292 \text{ m}$$

$$\text{Panjang } cc' = 1,537 \text{ m}$$

$$\text{Panjang } c'q = 3,314 \text{ m}$$

$$\text{Panjang } ee' = 0,515 \text{ m}$$

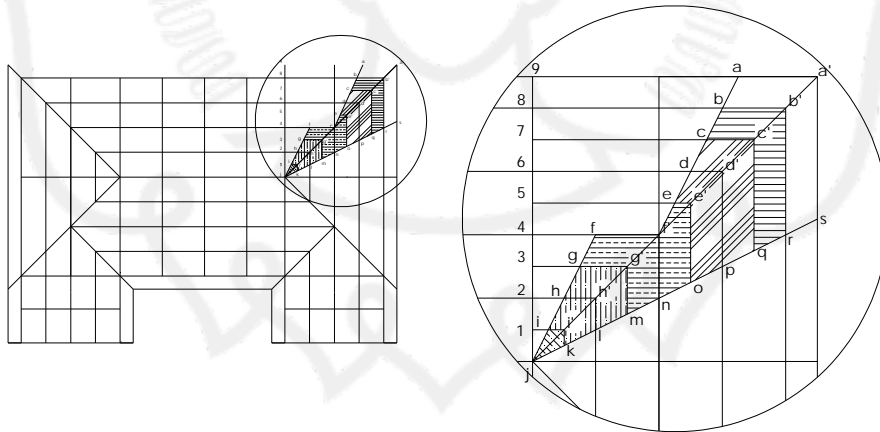
$$\text{Panjang } e'o = 2,367 \text{ m}$$

$$\text{Panjang } gg' = g'm = 1,410 \text{ m}$$

$$\text{Panjang } ii' = i'k = 0,471 \text{ m}$$



- **Luas aa'sqc'c** = $(\frac{1}{2} (aa' + cc') 7-9) + (\frac{1}{2} (a's + c'q) 7-9)$
 = $(\frac{1}{2} (2,594+1,537) 2 \cdot 0,937) + (\frac{1}{2} (4,292 + 3,314) 2 \cdot 0,937)$
 = $10,998 \text{ m}^2$
- **Luas cc'qoe'e** = $(\frac{1}{2} (cc' + ee') 5-7) + (\frac{1}{2} (c'q + e'o) 5-7)$
 = $(\frac{1}{2} (1,537+0,515) 2 \cdot 0,937) + (\frac{1}{2} (3,314+2,367) 2 \cdot 0,937)$
 = $7,246 \text{ m}^2$
- **Luas ee'omg'gff'** = $(\frac{1}{2} 4-5 \cdot ee') + (\frac{1}{2} (e'o + g'm) 3-5) + (\frac{1}{2} (ff' + gg') 3-5)$
 = $(\frac{1}{2} \times 0,937 \times 0,51) + (\frac{1}{2} (2,367+1,41) 1,8) + (\frac{1}{2} (1,894+1,515) 1,8)$
 = $6,862 \text{ m}^2$
- **Luas gg'mki'i** = $(\frac{1}{2} (gg' + ii') 1-3) \times 2$
 = $(\frac{1}{2} (1,41 + 0,471) 2 \cdot 0,937) \times 2$
 = $3,525 \text{ m}^2$
- **Luas jii'k** = $(\frac{1}{2} \times ii' \times j1) \times 2$
 = $(\frac{1}{2} \times 0,471 \times 0,937) \times 2$
 = $0,441 \text{ m}^2$



Gambar 3.4. Luasan Plafon Jurai

$$\text{Panjang } j1 = \frac{1}{2} \cdot 1,8 = 0,9 \text{ m}$$

$$\text{Panjang } j1 = 1-2 = 2-3 = 3-4 = 4-5 = 5-6 = 6-7 = 7-8 = 8-9 = 0,9 \text{ m}$$

$$\text{Panjang } bb' = 2,048 \text{ m}$$

$$\text{Panjang } b'r = 3,787 \text{ m}$$



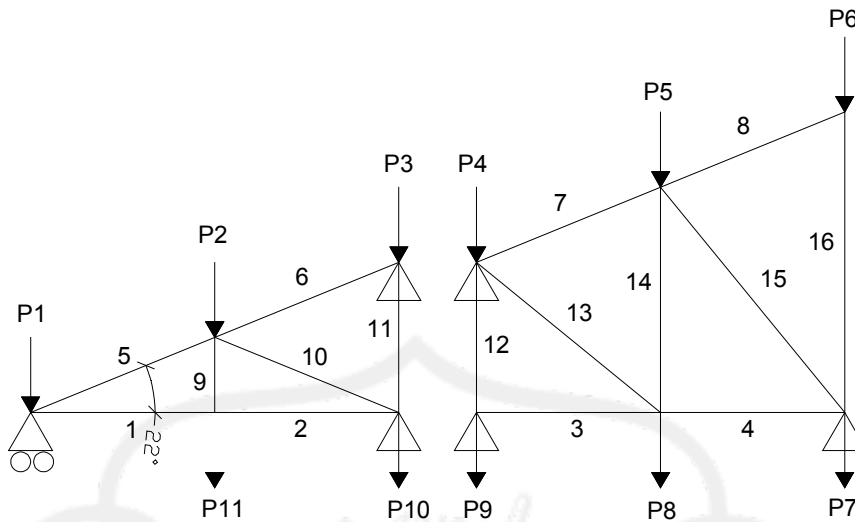
$$\begin{aligned} \text{Panjang } cc' &= 1,537 \text{ m} & \text{Panjang } c'q &= 3,314 \text{ m} \\ \text{Panjang } ee' &= 0,515 \text{ m} & \text{Panjang } e'o &= 2,367 \text{ m} \\ \text{Panjang } gg' &= g'm = 1,410 \text{ m} \\ \text{Panjang } ii' &= i'k = 0,471 \text{ m} \end{aligned}$$

- **Luas bb'rqc'** $= (\frac{1}{2} (bb' + cc') 7-8) + (\frac{1}{2} (b'r + c'q) 7-8)$
 $= (\frac{1}{2} (2,048 + 1,537) 0,9) + (\frac{1}{2} (3,787 + 3,314) 0,9)$
 $= 4,809 \text{ m}^2$
- **Luas cc'qoe'e** $= (\frac{1}{2} (cc' + ee') 5-7) + (\frac{1}{2} (c'q + e'o) 5-7)$
 $= (\frac{1}{2} (1,537+0,515) 2 \cdot 0,9) + (\frac{1}{2} (3,314 +2,367)2 \cdot 0,9)$
 $= 6,960 \text{ m}^2$
- **Luas ee'omg'gff'** $= (\frac{1}{2} 4-5 \cdot ee') + (\frac{1}{2} (e'o + g'm) 3-5) + (\frac{1}{2} (ff' + gg') 3-5)$
 $= (\frac{1}{2} \times 0,9 \times 0,515) + (\frac{1}{2} (2,367+1,41)1,8) + (\frac{1}{2}(1,89+1,51)1,8)$
 $= 6,520 \text{ m}^2$
- **Luas gg'mki'i** $= (\frac{1}{2} (gg' + ii') 1-3) \times 2$
 $= (\frac{1}{2} (1,41+0,471) 2 \cdot 0,9) \times 2$
 $= 3,386 \text{ m}^2$
- **Luas jii'k** $= (\frac{1}{2} \times ii' \times j1) \times 2$
 $= (\frac{1}{2} \times 0,471 \times 0,9) \times 2$
 $= 0,424 \text{ m}^2$

3.4.3. Perhitungan Pembebanan Jurai

Data-data pembebanan :

$$\begin{aligned} \text{Berat gording} &= 11 \text{ kg/m} \\ \text{Berat penutup atap} &= 50 \text{ kg/m}^2 \\ \text{Berat plafon dan penggantung} &= 18 \text{ kg/m}^2 \\ \text{Berat profil kuda-kuda} &= 15 \text{ kg/m} \end{aligned}$$



Gambar 3.5. Pembebanan jurai akibat beban mati

a. Beban Mati

1) Beban P1

- a) Beban Gording = berat profil gording \times panjang gording bb'r
 $= 11 \times (2,048+3,787) = 64,185 \text{ kg}$
- b) Beban Atap = luasan aa'sqc'c \times berat atap
 $= 10,998 \times 50 = 549,9 \text{ kg}$
- c) Beban Plafon = luasan bb'rqc'c' \times berat plafon
 $= 4,809 \times 18 = 73,602 \text{ kg}$
- d) Beban Kuda-kuda = $\frac{1}{2} \times \text{btg} (1 + 5) \times$ berat profil kuda-kuda
 $= \frac{1}{2} \times (2,652 + 2,864) \times 25$
 $= 68,95 \text{ kg}$
- e) Beban Plat Sambung = 30 % \times beban kuda-kuda
 $= 30 \% \times 68,95 = 20,685 \text{ kg}$
- f) Beban Bracing = 10% \times beban kuda-kuda
 $= 10 \% \times 68,95 = 6,895 \text{ kg}$

2) Beban P2

- a) Beban Gording = berat profil gording \times panjang gording dd'p
 $= 11 \times (1,022+2,841) = 42,493 \text{ kg}$



- b) Beban Atap = luasan cc'qoe'e × berat atap
= $7,426 \times 50 = 371,3$ kg
- c) Beban Kuda-kuda = $\frac{1}{2} \times \text{btg} (5 + 9 + 10 + 6) \times \text{berat profil kuda-kuda}$
= $\frac{1}{2} \times (2,864 + 1,083 + 2,864 + 2,864) \times 25$
= 120,937 kg
- d) Beban Plat Sambung = 30 % × beban kuda-kuda
= 30 % × 120,937 = 36,281 kg
- e) Beban Bracing = 10% × beban kuda-kuda
= 10 % × 120,937 = 12,094 kg
- 3) Beban P3
- a) Beban Gording = berat profil gording × panjang gording ff'n
= $11 \times (1,894 + 1,894) = 41,668$ kg
- b) Beban Atap = luasan ee'omg'gff' × berat atap
= $6,862 \times 50 = 343,1$ kg
- c) Beban Kuda-kuda = $\frac{1}{2} \times \text{btg} (6 + 11) \times \text{berat profil kuda-kuda}$
= $\frac{1}{2} \times (2,864 + 2,165) \times 25$
= 77,507 kg
- d) Beban Plat Sambung = 30 % × beban kuda-kuda
= 30 % × 77,507 = 23,252 kg
- e) Beban Bracing = 10% × beban kuda-kuda
= 10 % × 77,507 = 7,751 kg
- 4) Beban P4
- a) Beban Gording = berat profil gording × panjang gording ff'n
= $911 \times (1,894 + 1,894) = 41,668$ kg
- b) Beban Atap = luasan ee'omg'g × berat atap
= $6,862 \times 50 = 343,1$ kg
- c) Beban Kuda-kuda = $\frac{1}{2} \times \text{btg} (12 + 13 + 7) \times \text{berat profil kuda-kuda}$
= $\frac{1}{2} \times (2,165 + 3,423 + 2,864) \times 25$
= 105,65 kg
- d) Beban Plat Sambung = 30 % × beban kuda-kuda
= 30 % × 105,65 = 36,281 kg



- e) Beban Bracing = $10\% \times \text{beban kuda-kuda}$
= $10\% \times 105,65 = 10,565 \text{ kg}$
- 5) Beban P5
- a) Beban Gording = berat profil gording \times panjang gording hh'l
= $11 \times (0,937+0,937) = 20,614 \text{ kg}$
- b) Beban Atap = luasan gg'mki'i \times berat atap
= $3,525 \times 50 = 176,25 \text{ kg}$
- c) Beban Kuda-kuda = $\frac{1}{2} \times \text{btg} (7 + 14 + 15 + 8) \times \text{berat profil kuda-kuda}$
= $\frac{1}{2} \times (2,864 + 3,226 + 4,193 + 2,864) \times 25$
= $164,338 \text{ kg}$
- d) Beban Plat Sambung = $30\% \times \text{beban kuda-kuda}$
= $30\% \times 164,338 = 49,301 \text{ kg}$
- e) Beban Bracing = $10\% \times \text{beban kuda-kuda}$
= $10\% \times 164,338 = 16,434 \text{ kg}$
- 6) Beban P6
- a) Beban Atap = luasan jii'k \times berat atap
= $0,441 \times 50 = 22,05 \text{ kg}$
- b) Beban Kuda-kuda = $\frac{1}{2} \times \text{btg} (8+16) \times \text{berat profil kuda-kuda}$
= $\frac{1}{2} \times (2,864 + 4,33) \times 25$
= $89,925 \text{ kg}$
- c) Beban Plat Sambung = $30\% \times \text{beban kuda-kuda}$
= $30\% \times 89,925 = 26,977 \text{ kg}$
- d) Beban Bracing = $10\% \times \text{beban kuda-kuda}$
= $10\% \times 89,925 = 8,992 \text{ kg}$
- 7) Beban P7
- a) Beban Plafon = luasan jii'k \times berat plafon
= $0,424 \times 18 = 7,632 \text{ kg}$



- b) Beban Kuda-kuda = $\frac{1}{2} \times \text{btg} (16 + 15 + 4) \times \text{berat profil kuda-kuda}$
= $\frac{1}{2} \times (4,33 + 4,193 + 2,652) \times 25$
= 139,687 kg
- c) Beban Plat Sambung = 30 % \times beban kuda-kuda
= 30 % \times 139,687 = 41,906 kg
- d) Beban Bracing = 10% \times beban kuda-kuda
= 10 % \times 139,687 = 13,969 kg
- 8) Beban P8
- a) Beban Plafon = luasan gg'mki'i \times berat plafon
= $3,386 \times 18 = 60,948$ kg
- b) Beban Kuda-kuda = $\frac{1}{2} \times \text{btg} (4 + 14 + 13 + 3) \times \text{berat profil kuda-kuda}$
= $\frac{1}{2} \times (2,652 + 3,226 + 3,423 + 2,652) \times 25$
= 149,412 kg
- c) Beban Plat Sambung = 30 % \times beban kuda-kuda
= 30 % \times 149,412 = 44,824 kg
- d) Beban Bracing = 10% \times beban kuda-kuda
= 10 % \times 149,412 = 14,941 kg
- 9) Beban P9
- a) Beban Plafon = luasan ee'omg'gff' \times berat plafon
= $6,52 \times 18 = 117,36$ kg
- b) Beban Kuda-kuda = $\frac{1}{2} \times \text{btg} (3 + 12) \times \text{berat profil kuda-kuda}$
= $\frac{1}{2} \times (2,652+2,165) \times 25$
= 60,212 kg
- c) Beban Plat Sambung = 30 % \times beban kuda-kuda
= 30 % \times 60,212 = 18,064 kg
- d) Beban Bracing = 10% \times beban kuda-kuda
= 10 % \times 60,212 = 6,021 kg
- 10) Beban P10
- a) Beban Plafon = luasan ee'omg'g' \times berat plafon
= $6,52 \times 18 = 117,36$ kg
- b) Beban Kuda-kuda = $\frac{1}{2} \times \text{btg} (11 + 10 + 2) \times \text{berat profil kuda-kuda}$



$$= \frac{1}{2} \times (2,165 + 2,864 + 2,652) \times 25$$

$$= 96,012 \text{ kg}$$

- c) Beban Plat Sambung = 30 % × beban kuda-kuda
 = 30 % × 96,012 = 28,804 kg
- d) Beban Bracing = 10% × beban kuda-kuda
 = 10 % × 96,012 = 9,601 kg

11) Beban P11

- a) Beban Plafon = luasan cc'qoe'e × berat plafon
 = 6,96 × 18 = 125,28 kg
- b) Beban Kuda-kuda = $\frac{1}{2} \times \text{btg} (2 + 9 + 1) \times \text{berat profil kuda-kuda}$
 = $\frac{1}{2} \times (2,652 + 1,083 + 2,652) \times 25$
 = 79,837 kg
- c) Beban Plat Sambung = 30 % × beban kuda-kuda
 = 30 % × 79,837 = 23,951 kg
- d) Beban Bracing = 10% × beban kuda-kuda
 = 10 % × 79,837 = 7,984 kg



Tabel 3.3. Rekapitulasi Pembebanan Jurai

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)
P1	549,9	64,185	68,950	6,895	20,685	73,602	784,217	785
P2	371,3	42,493	120,937	12,094	36,281	-	583,105	584
P3	343,1	41,668	77,507	7,751	23,252	-	493,278	494
P4	343,1	41,668	105,650	10,565	36,281	-	537,264	538
P5	176,25	20,614	164,338	16,434	49,301	-	426,937	427
P6	28,9	-	89,925	8,992	26,977	-	154,794	155
P7	-	-	139,687	13,969	41,906	7,632	203,194	204
P8	-	-	149,412	14,941	44,824	60,948	270,125	271
P9	-	-	60,212	6,021	18,064	117,36	201,657	202
P10	-	-	96,012	9,601	28,804	117,36	251,777	252
P11	-	-	79,837	7,984	23,951	125,28	237,052	238

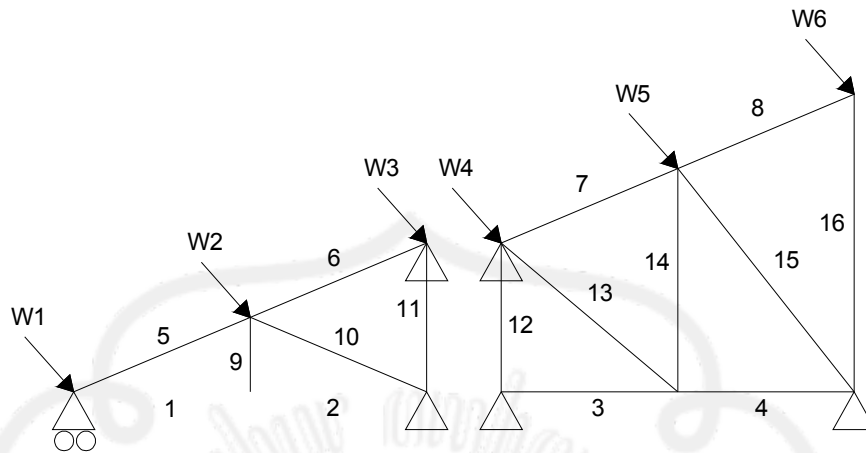
b. Beban Hidup

Beban hidup yang bekerja pada P1 = P2 = P5 = P6 = 100 kg ; P3 = P4 = 50 kg



c. Beban Angin

Perhitungan beban angin :



Gambar 3.6. Pembebanan Jurai akibat Beban Angin

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

- Koefisien angin tekan = $0,02\alpha - 0,40$
 $= (0,02 \times 30) - 0,40 = 0,2$
 - a) $W1 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 10,998 \times 0,2 \times 25 = 54,99 \text{ kg}$
 - b) $W2 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 7,426 \times 0,2 \times 25 = 37,13 \text{ kg}$
 - c) $W3 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 6,862 \times 0,2 \times 25 = 34,31 \text{ kg}$
 - d) $W4 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 6,862 \times 0,2 \times 25 = 34,31 \text{ kg}$
 - e) $W5 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 3,525 \times 0,2 \times 25 = 17,625 \text{ kg}$
 - f) $W6 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 0,441 \times 0,2 \times 25 = 2,205 \text{ kg}$



Tabel 3.4. Perhitungan Beban Angin Jurai

Beban Angin	Beban (kg)	W_x $W \cdot \cos \alpha$ (kg)	(Untuk Input SAP2000)	W_y $W \cdot \sin \alpha$ (kg)	(Untuk Input SAP2000)
W1	54,99	50,986	51	20,600	21
W2	37,13	34,426	35	13,909	14
W3	34,31	31,812	32	12,853	13
W4	34,31	31,812	32	12,853	13
W5	17,625	16,342	17	6,602	7
W6	2,205	2,044	3	0,826	1

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

Tabel 3.5. Rekapitulasi Gaya Batang Jurai

Batang	kombinasi	
	Tarik (+) (kg)	Tekan (-) (kg)
1	438,37	
2	421,97	
3		249,85
4	249,85	
5		527,94
6	1264,23	
7		295,40
8	314,06	
9	372,34	
10		1792,52
11	25,19	
12	25,19	
13	668,81	
14	98,89	
15		912,45
16	50,39	

3.4.4. Perencanaan Profil Jurai



a. Perhitungan profil batang tarik

$$P_{\text{maks.}} = 1264,23 \text{ kg}$$

$$F_y = 2400 \text{ kg/cm}^2 \text{ (240 MPa)}$$

$$F_u = 3700 \text{ kg/cm}^2 \text{ (370 MPa)}$$

$$A_g \text{ perlu} = \frac{P_{\text{mak}}}{F_y} = \frac{1264,23}{2400} = 0,53 \text{ cm}^2$$

Dicoba, menggunakan baja profil **┘ 45 . 45 . 5**

Dari tabel baja didapat data-data =

$$A_g = 4,30 \text{ cm}^2$$

$$\bar{x} = 1,35 \text{ cm}$$

$$A_n = 2 \cdot A_g - dt$$

$$= 860 - 14 \cdot 5 = 790 \text{ mm}^2$$

L = Sambungan dengan Diameter

$$= 3 \cdot 12,7 = 38,1 \text{ mm}$$

$$\bar{x} = 13,5 \text{ mm}$$

$$U = 1 - \frac{\bar{x}}{L}$$

$$= 1 - \frac{13,5}{38,1} = 0,645$$

$$A_e = U \cdot A_n$$

$$= 0,645 \cdot 790$$

$$= 509,55 \text{ mm}^2$$

Check kekuatan nominal



$$\begin{aligned}\phi P_n &= 0,75 \cdot A_e \cdot F_u \\ &= 0,75 \cdot 509,55 \cdot 370 \\ &= 141400,125 \text{ N} \\ &= 14140,0125 \text{ kg} > 1264,23 \text{ kg} \dots \text{OK}\end{aligned}$$

b. Perhitungan profil batang tekan

$$\begin{aligned}P_{\text{maks.}} &= 1792,52 \text{ kg} \\ l_k &= 2,864 \text{ m} = 286,4 \text{ cm} \\ A_g \text{ perlu} &= \frac{P_{\text{mak}}}{F_y} = \frac{1792,52}{2400} = 0,75 \text{ cm}^2\end{aligned}$$

Dicoba, menggunakan baja profil $\perp 45 \cdot 45 \cdot 5$ ($A_g = 4,30 \text{ cm}^2$)

Periksa kelangsingan penampang :

$$\begin{aligned}\frac{b}{2 \cdot t_w} < \frac{200}{\sqrt{F_y}} &= \frac{45}{6} < \frac{200}{\sqrt{240}} \\ &= 9,16 < 12,9\end{aligned}$$

$$\begin{aligned}\lambda &= \frac{K \cdot L}{r} = \frac{1 \cdot 286,4}{1,35} \\ &= 212,5\end{aligned}$$

$$\lambda_c = \frac{\lambda}{\pi} \sqrt{\frac{F_y}{E}}$$



$$= \frac{212,5}{3,14} \sqrt{\frac{240}{200000}}$$

$$= 2,34 \dots \dots \lambda_c \geq 1,2 \quad \longrightarrow \quad \omega = 1,25 \cdot \lambda_c^2$$

$$\omega = 1,25 \cdot \lambda_c^2 = 1,25 \cdot (2,34^2)$$

$$= 6,84$$

$$P_n = 2 \cdot A_g \cdot F_{cr}$$

$$= 2 \cdot 4,30 \cdot \frac{2400}{6,84}$$

$$= 3017,54$$

$$\frac{P}{\phi P_n} = \frac{1792,52}{0,85 \cdot 3017,54}$$

$$= 0,699 < 1 \dots \dots \dots \text{OK}$$

3.3.5. Perhitungan Alat Sambung

a. Batang Tekan

Digunakan alat sambung baut-mur.

Diameter baut (\varnothing) = 12,7 mm ($\frac{1}{2}$ inches)

Diameter lubang = 14 mm.

Tebal pelat sambung (δ) = 0,625 . d_b

$$= 0,625 \cdot 12,7 = 7,94 \text{ mm.}$$

Menggunakan tebal plat 8 mm

➤ Tahanan geser baut

$$P_n = m \cdot (0,4 \cdot f^{ub}) \cdot A_n$$

$$= 2 \cdot (0,4 \cdot 825) \cdot \frac{1}{4} \cdot \pi \cdot 12,7^2 = 8356,43 \text{ kg/baut}$$



- Tahanan tarik penyambung

$$P_n = 0,75 \cdot f^{ub} \cdot A_n$$

$$= 7833,9 \text{ kg/baut}$$

- Tahanan Tumpu baut :

$$P_n = 0,75 (2,4 \cdot f_u \cdot d_b \cdot t)$$

$$= 0,75 (2,4 \cdot 370 \cdot 12,7 \cdot 9)$$

$$= 7612,38 \text{ kg/baut}$$

P yang menentukan adalah $P_{tumpu} = 7612,38 \text{ kg}$.

Perhitungan jumlah baut-mur,

$$n = \frac{P_{maks.}}{P_{geser}} = \frac{1792,52}{7612,38} = 0,235 \sim 2 \text{ buah baut}$$

Digunakan : 2 buah baut

Perhitungan jarak antar baut :

a) $3d \leq S \leq 15t$ atau 200 mm

$$\text{Diambil, } S_1 = 3 d_b = 3 \cdot 12,7$$

$$= 38,1 \text{ mm} = 40 \text{ mm}$$

b) $1,5 d \leq S_2 \leq (4t + 100)$ atau 200 mm

$$\text{Diambil, } S_2 = 1,5 d_b = 1,5 \cdot 12,7$$

$$= 19,05 \text{ mm} = 20 \text{ mm}$$

b. Batang tarik

Digunakan alat sambung baut-mur.

Diameter baut (\emptyset) = 12,7 mm ($\frac{1}{2}$ inches)

Diameter lubang = 13,7 mm.

$$\text{Tebal pelat sambung } (\delta) = 0,625 \cdot d_b$$

$$= 0,625 \times 12,7 = 7,94 \text{ mm.}$$

Menggunakan tebal plat 8 mm

- Tahanan geser baut

$$P_n = n \cdot (0,4 \cdot f^{ub}) \cdot A_n$$

$$= 2 \cdot (0,4 \cdot 825) \cdot \frac{1}{4} \cdot \pi \cdot 12,7^2 = 8356,43 \text{ kg/baut}$$

- Tahanan tarik penyambung

$$P_n = 0,75 \cdot f^{ub} \cdot A_n$$



$$=7833,9 \text{ kg/baut}$$

➤ Tahanan Tumpu baut :

$$\begin{aligned} P_n &= 0,75 (2,4 \cdot f_u \cdot d_b \cdot t) \\ &= 0,75 (2,4 \cdot 370 \cdot 12,7 \cdot 9) \\ &= 7612,38 \text{ kg/baut} \end{aligned}$$

P yang menentukan adalah $P_{\text{tumpu}} = 7612,38 \text{ kg}$.

Perhitungan jumlah baut-mur,

$$n = \frac{P_{\text{maks.}}}{P_{\text{geser}}} = \frac{1264,23}{7612,38} = 0,166 \sim 2 \text{ buah baut}$$

Digunakan : 2 buah baut

Perhitungan jarak antar baut :

a) $3d \leq S \leq 15t$ atau 200 mm

$$\begin{aligned} \text{Diambil, } S_1 &= 3 d_b = 3 \cdot 12,7 \\ &= 38,1 \text{ mm} = 40 \text{ mm} \end{aligned}$$

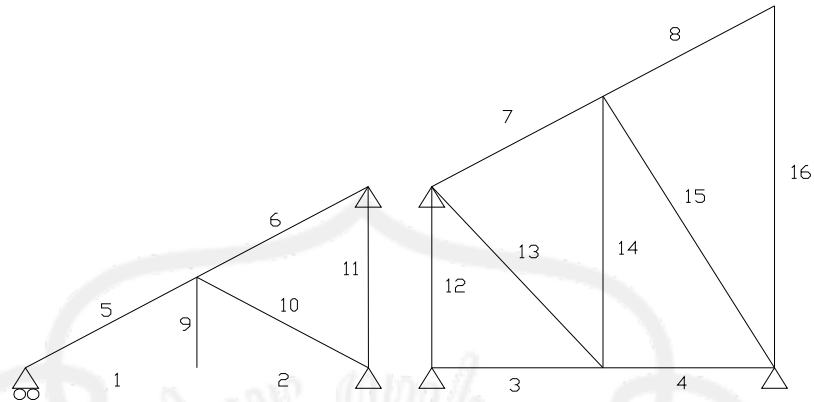
b) $1,5 d \leq S_2 \leq (4t + 100)$ atau 200 mm

$$\begin{aligned} \text{Diambil, } S_2 &= 1,5 d_b = 1,5 \cdot 12,7 \\ &= 19,05 \text{ mm} = 20 \text{ mm} \end{aligned}$$

**Tabel 3.6.** Rekapitulasi Perencanaan Profil Jurai

Nomer Batang	Dimensi Profil	Baut (mm)
1	┘ 45. 45. 5	2 Ø 12,7
2	┘ 45. 45. 5	2 Ø 12,7
3	┘ 45. 45. 5	2 Ø 12,7
4	┘ 45. 45. 5	2 Ø 12,7
5	┘ 45. 45. 5	2 Ø 12,7
6	┘ 45. 45. 5	2 Ø 12,7
7	┘ 45. 45. 5	2 Ø 12,7
8	┘ 45. 45. 5	2 Ø 12,7
9	┘ 45. 45. 5	2 Ø 12,7
10	┘ 45. 45. 5	2 Ø 12,7
11	┘ 45. 45. 5	2 Ø 12,7
12	┘ 45. 45. 5	2 Ø 12,7
13	┘ 45. 45. 5	2 Ø 12,7
14	┘ 45. 45. 5	2 Ø 12,7
15	┘ 45. 45. 5	2 Ø 12,7
16	┘ 45. 45. 5	2 Ø 12,7

3.5. Perencanaan Setengah Kuda-kuda



Gambar 3.7. Rangka Batang Setengah Kuda-kuda

3.5.1. Perhitungan Panjang Batang Setengah Kuda-kuda

Perhitungan panjang batang selanjutnya disajikan dalam tabel dibawah ini :

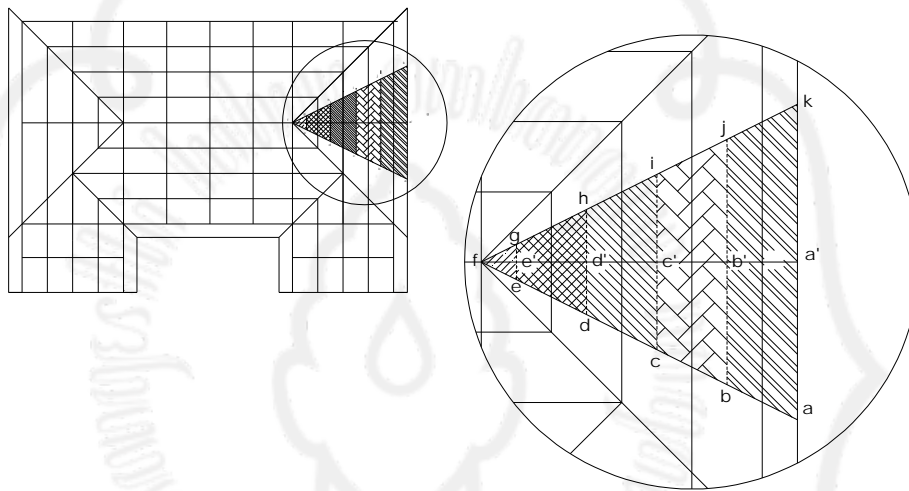
Tabel 3.7. Perhitungan Panjang Batang pada Setengah Kuda-kuda

Nomer Batang	Panjang Batang
1	1,875
2	1,875
3	1,875
4	1,875
5	2,165
6	2,165
7	2,165
8	2,165
9	1,083
10	2,165
11	2,165



12	2,165
13	2,864
14	3,248
15	3,750
16	4,330

3.5.2. Perhitungan luasan Setengah Kuda-kuda



Gambar 3.8. Luasan Atap Setengah Kuda-kuda

Panjang ak = 8,5 m

Panjang bj = 6,6 m

Panjang ci = 4,7 m

Panjang dh = 2,8 m

Panjang eg = 0,9 m

Panjang a'b' = b'c' = c'd' = d'e' = 1,875 m

Panjang e'f = $\frac{1}{2} \times 2,309 = 0,937$ m

- **Luas abjk** = $\frac{1}{2} \times (ak + bj) \times a'b'$
= $\frac{1}{2} \times (8,5 + 6,6) \times 1,875$



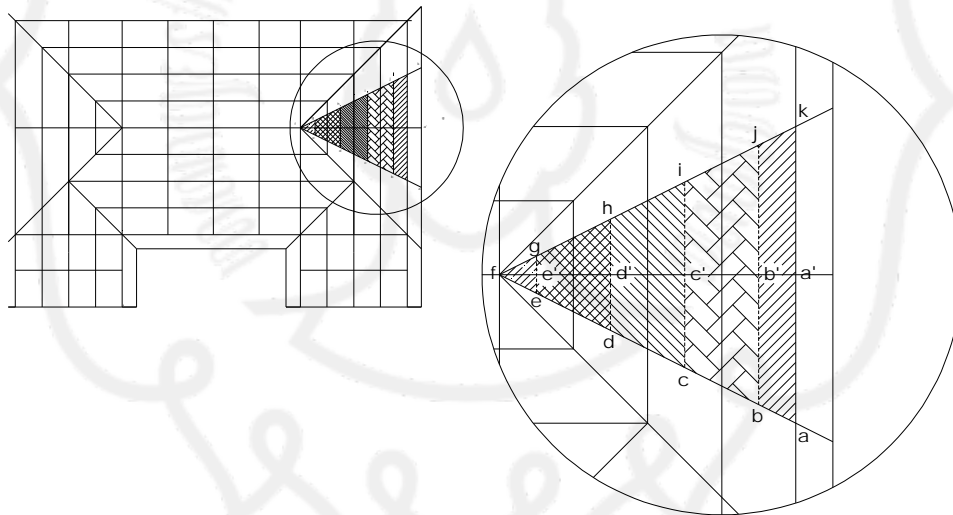
$$= 14,156 \text{ m}^2$$

- **Luas bcij** $= \frac{1}{2} \times (bj + ci) \times b'c'$
 $= \frac{1}{2} \times (6,6 + 4,7) \times 1,875$
 $= 10,594 \text{ m}^2$

- **Luas cdhi** $= \frac{1}{2} \times (ci + dh) \times c'd'$
 $= \frac{1}{2} \times (4,7 + 2,8) \times 1,875$
 $= 7,031 \text{ m}^2$

- **Luas degh** $= \frac{1}{2} \times (dh + eg) \times d'e'$
 $= \frac{1}{2} \times (2,8 + 0,9) \times 1,875$
 $= 3,469 \text{ m}^2$

- **Luas efg** $= \frac{1}{2} \times eg \times e'f$
 $= \frac{1}{2} \times 0,9 \times 0,937$
 $= 0,422 \text{ m}^2$



Gambar 3.9. Luasan Plafon

Panjang ak = 7,5 m

Panjang bj = 6,6 m

Panjang ci = 4,7 m



$$\text{Panjang dh} = 2,8 \text{ m}$$

$$\text{Panjang eg} = 0,9 \text{ m}$$

$$\text{Panjang a'b'} = e'f = 0,9 \text{ m}$$

$$\text{Panjang b'c'} = c'd' = d'e' = 1,8 \text{ m}$$

$$\begin{aligned} \bullet \text{ Luas abjk} &= \frac{1}{2} \times (ak + bj) \times a'b' \\ &= \frac{1}{2} \times (7,5 + 6,6) \times 0,9 \\ &= 6,345 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \bullet \text{ Luas bcij} &= \frac{1}{2} \times (bj + ci) \times b'c' \\ &= \frac{1}{2} \times (6,6 + 4,7) \times 1,8 \\ &= 10,17 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \bullet \text{ Luas cdhi} &= \frac{1}{2} \times (ci + dh) \times c'd' \\ &= \frac{1}{2} (4,7 + 2,8) \times 1,8 \\ &= 6,75 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \bullet \text{ Luas degf} &= \frac{1}{2} \times (dh + eg) \times d'e' \\ &= \frac{1}{2} \times (2,8 + 0,9) \times 1,8 \\ &= 3,33 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \bullet \text{ Luas efg} &= \frac{1}{2} \times eg \times e'f \\ &= \frac{1}{2} \times 0,9 \times 0,9 \\ &= 0,405 \text{ m}^2 \end{aligned}$$

3.5.3. Perhitungan Pembebanan Setengah Kuda-kuda

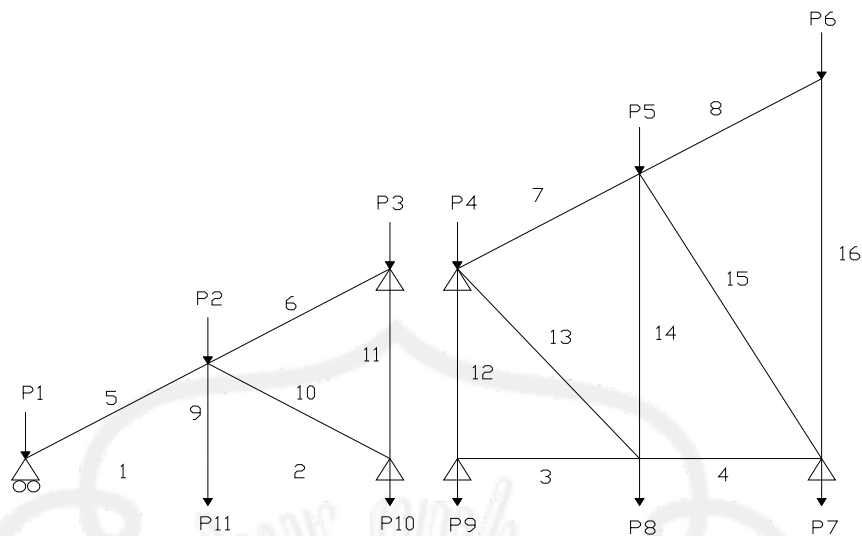
Data-data pembebanan :

$$\text{Berat gording} = 11 \text{ kg/m}$$

$$\text{Berat penutup atap} = 50 \text{ kg/m}^2$$

$$\text{Berat profil kuda - kuda} = 25 \text{ kg/m}$$

a. Beban Mati



Gambar 3.10. Pembebanan Setengah Kuda-kuda akibat Beban Mati

- 1) Beban P1
 - a) Beban Gording = berat profil gording \times panjang gording
 $= 11 \times 7,5 = 82,5 \text{ kg}$
 - b) Beban Atap = luasan abjk \times berat atap
 $= 14,156 \times 50 = 707,8 \text{ kg}$
 - c) Beban Plafon = luasan abjk \times berat plafon
 $= 14,156 \times 18 = 114,21 \text{ kg}$
 - d) Beban Kuda-kuda = $\frac{1}{2} \times \text{btg} (1 + 5) \times$ berat profil kuda-kuda
 $= \frac{1}{2} \times (1,875 + 2,165) \times 25$
 $= 50,5 \text{ kg}$
 - e) Beban Plat Sambung = $30 \% \times$ beban kuda-kuda
 $= 30 \% \times 50,5 = 15,15 \text{ kg}$
 - f) Beban Bracing = $10\% \times$ beban kuda-kuda
 $= 10 \% \times 50,5 = 5,05 \text{ kg}$

- 2) Beban P2



-
- a) Beban Gording = berat profil gording \times panjang gording
= $11 \times 5,625 = 61,875$ kg
- b) Beban Atap = luasan bcij \times berat atap
= $10,594 \times 50 = 529,7$ kg
- c) Beban Kuda-kuda = $\frac{1}{2} \times$ btg $(5 + 9 + 10 + 6) \times$ berat profil kuda-kuda
= $\frac{1}{2} \times (2,165 + 1,083 + 2,165 + 2,165) \times 25$
= $94,725$ kg
- d) Beban Plat Sambung = $30\% \times$ beban kuda-kuda
= $30\% \times 94,725 = 28,418$ kg
- e) Beban Bracing = $10\% \times$ beban kuda-kuda
= $10\% \times 94,725 = 9,472$ kg
- 3) Beban P3
- a) Beban Gording = berat profil gording \times panjang gording
= $11 \times 3,75 = 41,25$ kg
- b) Beban Atap = luasan cdhi \times berat atap
= $7,031 \times 50 = 351,55$ kg
- c) Beban Kuda-kuda = $\frac{1}{2} \times$ btg $(6 + 11) \times$ berat profil kuda-kuda
= $\frac{1}{2} \times (2,165 + 2,165) \times 25$
= $54,125$ kg
- d) Beban Plat Sambung = $30\% \times$ beban kuda-kuda
= $30\% \times 54,125 = 16,237$ kg
- e) Beban Bracing = $10\% \times$ beban kuda-kuda
= $10\% \times 54,125 = 5,412$ kg
- 4) Beban P4
- a) Beban Gording = berat profil gording \times panjang gording
= $11 \times 3,75 = 41,25$ kg
- b) Beban Atap = luasan cdhi \times berat atap
= $7,031 \times 50 = 351,55$ kg
- c) Beban Kuda-kuda = $\frac{1}{2} \times$ btg $(12 + 13 + 7) \times$ berat profil kuda-kuda
= $\frac{1}{2} \times (2,165 + 2,864 + 2,165) \times 25$
-



$$= 89,925 \text{ kg}$$

d) Beban Plat Sambung = 30 % × beban kuda-kuda
 $= 30 \% \times 89,925 = 26,977 \text{ kg}$

e) Beban Bracing = 10% × beban kuda-kuda
 $= 10 \% \times 89,925 = 8,992 \text{ kg}$

5) Beban P5

a) Beban Gording = berat profil gording × panjang gording
 $= 11 \times 1,875 = 20,625 \text{ kg}$

b) Beban Atap = luasan degg × berat atap
 $= 3,469 \times 50 = 173,45 \text{ kg}$

c) Beban Kuda-kuda = $\frac{1}{2} \times \text{btg} (7 + 14 + 15 + 7) \times \text{berat profil kuda-kuda}$
 $= \frac{1}{2} \times (2,165 + 3,248 + 3,750 + 2,165) \times 25$
 $= 141,6 \text{ kg}$

d) Beban Plat Sambung = 30 % × beban kuda-kuda
 $= 30 \% \times 141,6 = 42,48 \text{ kg}$

e) Beban Bracing = 10% × beban kuda-kuda
 $= 10 \% \times 141,6 = 14,16 \text{ kg}$

6) Beban P6

a) Beban Atap = luasan efg × berat atap
 $= 0,422 \times 50 = 21,1 \text{ kg}$

b) Beban Kuda-kuda = $\frac{1}{2} \times \text{btg} (8 + 16) \times \text{berat profil kuda-kuda}$
 $= \frac{1}{2} \times (2,165 + 4,33) \times 25$
 $= 81,187 \text{ kg}$

c) Beban Plat Sambung = 30 % × beban kuda-kuda
 $= 30 \% \times 81,187 = 24,356 \text{ kg}$

d) Beban Bracing = 10% × beban kuda-kuda
 $= 10 \% \times 81,187 = 8,119 \text{ kg}$

7) Beban P7

a) Beban Plafon = luasan efg × berat plafon
 $= 0,422 \times 18 = 7,596 \text{ kg}$



$$\begin{aligned} \text{b) Beban Kuda-kuda} &= \frac{1}{2} \times \text{btg} (16 + 15 + 4) \times \text{berat profil kuda-kuda} \\ &= \frac{1}{2} \times (4,33 + 3,75 + 1,875) \times 25 \\ &= 124,437 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{c) Beban Plat Sambung} &= 30 \% \times \text{beban kuda-kuda} \\ &= 30 \% \times 124,437 = 37,331 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{d) Beban Bracing} &= 10 \% \times \text{beban kuda-kuda} \\ &= 10 \% \times 124,437 = 12,444 \text{ kg} \end{aligned}$$

8) Beban P8

$$\begin{aligned} \text{a) Beban Plafon} &= \text{luasan degh} \times \text{berat plafon} \\ &= 3,469 \times 18 = 62,442 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{b) Beban Kuda-kuda} &= \frac{1}{2} \times \text{btg} (4 + 14 + 13 + 3) \times \text{berat profil kuda-kuda} \\ &= \frac{1}{2} \times (1,875 + 3,248 + 2,864 + 1,875) \times 25 \\ &= 123,275 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{c) Beban Plat Sambung} &= 30 \% \times \text{beban kuda-kuda} \\ &= 30 \% \times 123,275 = 36,982 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{d) Beban Bracing} &= 10 \% \times \text{beban kuda-kuda} \\ &= 10 \% \times 123,275 = 12,327 \text{ kg} \end{aligned}$$

9) Beban P9

$$\begin{aligned} \text{a) Beban Plafon} &= \text{luasan cdhi} \times \text{berat plafon} \\ &= 7,031 \times 18 = 126,558 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{b) Beban Kuda-kuda} &= \frac{1}{2} \times \text{btg} (3 + 12) \times \text{berat profil kuda-kuda} \\ &= \frac{1}{2} \times (1,875 + 2,165) \times 25 \\ &= 50,5 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{c) Beban Plat Sambung} &= 30 \% \times \text{beban kuda-kuda} \\ &= 30 \% \times 50,5 = 15,5 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{d) Beban Bracing} &= 10 \% \times \text{beban kuda-kuda} \\ &= 10 \% \times 50,5 = 5,05 \text{ kg} \end{aligned}$$

10) Beban P10

$$\begin{aligned} \text{a) Beban Plafon} &= \text{luasan cdhi} \times \text{berat plafon} \\ &= 7,031 \times 18 = 126,558 \text{ kg} \end{aligned}$$

$$\text{b) Beban Kuda-kuda} = \frac{1}{2} \times \text{btg} (11 + 10 + 2) \times \text{berat profil kuda-kuda}$$



$$= \frac{1}{2} \times (2,165 + 2,165 + 1,875) \times 25$$

$$= 77,562 \text{ kg}$$

- c) Beban Plat Sambung = 30 % × beban kuda-kuda
 $= 30 \% \times 77,562 = 23,269 \text{ kg}$
- d) Beban Bracing = 10% × beban kuda-kuda
 $= 10 \% \times 77,562 = 7,756 \text{ kg}$

11) Beban P11

- a) Beban Plafon = luasan bcij × berat plafon
 $= 10,594 \times 18 = 190,692 \text{ kg}$
- b) Beban Kuda-kuda = $\frac{1}{2} \times \text{btg} (2 + 9 + 1) \times \text{berat profil kuda-kuda}$
 $= \frac{1}{2} \times (1,875 + 1,083 + 1,875) \times 25$
 $= 60,412 \text{ kg}$
- c) Beban Plat Sambung = 30 % × beban kuda-kuda
 $= 30 \% \times 60,412 = 18,124 \text{ kg}$
- d) Beban Bracing = 10% × beban kuda-kuda
 $= 10 \% \times 60,412 = 6,041 \text{ kg}$



Tabel 3.8. Rekapitulasi Pembebanan 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)
P1	707,8	82,5	50,5	5,05	15,15	114,21	974,21	975
P2	529,7	61,875	94,725	9,472	28,418	-	723,19	724
P3	351,55	41,25	54,125	5,412	16,237	-	467,574	468
P4	351,55	41,25	89,925	8,992	26,977	-	518,694	519
P5	173,45	20,625	141,6	14,16	42,48	-	391,315	392
P6	21,1	-	81,187	8,119	24,356	-	134,762	135
P7	-	-	124,437	12,444	37,331	7,596	181,808	182
P8	-	-	123,275	12,327	36,982	62,442	234,026	235
P9	-	-	50,5	5,05	15,5	126,558	197,608	198
P10	-	-	77,562	7,756	23,269	126,558	234,145	235
P11	-	-	60,412	6,041	18,124	190,692	274,269	275

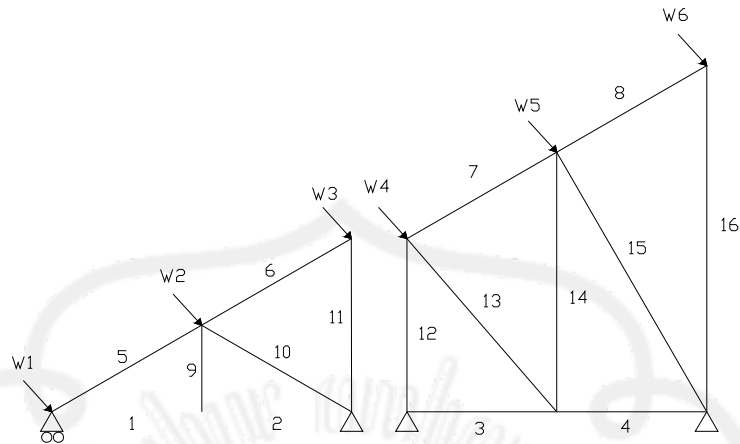
b. Beban Hidup

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



c. Beban Angin

Perhitungan beban angin :



Gambar 3.11. Pembebanan Setengah Kuda-kuda akibat Beban Angin

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

- Koefisien angin tekan = $0,02\alpha - 0,40$
 $= (0,02 \times 30) - 0,40 = 0,2$
 - a) $W1 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 14,156 \times 0,2 \times 25 = 70,78 \text{ kg}$
 - b) $W2 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 10,594 \times 0,2 \times 25 = 52,97 \text{ kg}$
 - c) $W3 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 7,031 \times 0,2 \times 25 = 35,155 \text{ kg}$
 - d) $W4 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 7,031 \times 0,2 \times 25 = 35,155 \text{ kg}$
 - e) $W5 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 3,469 \times 0,2 \times 25 = 17,345 \text{ kg}$
 - f) $W6 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 0,422 \times 0,2 \times 25 = 2,11 \text{ kg}$

Tabel 3.9. Perhitungan Beban Angin Setengah Kuda-kuda

Beban Angin	Beban (kg)	W_x	Untuk Input	W_y	Untuk Input
-------------	------------	-------	-------------	-------	-------------



		$W.Cos \alpha$ (kg)	SAP2000	$W.Sin \alpha$ (kg)	SAP2000
W1	70,780	61,297	62	35,390	36
W2	52,970	45,873	46	26,485	27
W3	35,155	30,445	31	17,577	18
W4	35,155	30,445	31	17,577	18
W5	17,345	15,021	16	8,672	9
W6	2,110	1,827	2	1,055	2

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

Tabel 3.10. Rekapitulasi Gaya Batang Setengah Kuda-kuda

Batang	Kombinasi	
	Tarik (+) (kg)	Tekan (-) (kg)
1	367,06	
2	354,46	
3		176,69
4	176,69	
5		491,06
6	1031,37	
7		197,92
8	197,49	
9	390,77	
10		1536,62
11		25,20
12		25,20
13	563,74	
14	27,89	
15		702,59
16	50,39	



3.5.4. Perencanaan Profil Setengah Kuda-kuda

a. Perhitungan profil batang tarik

$$P_{maks.} = 1031,37 \text{ kg}$$

$$F_y = 2400 \text{ kg/cm}^2 \text{ (240 MPa)}$$

$$F_u = 3700 \text{ kg/cm}^2 \text{ (370 MPa)}$$

$$A_g \text{ perlu} = \frac{P_{maks.}}{F_y} = \frac{1031,37}{2400} = 0,43 \text{ cm}^2$$

Dicoba, menggunakan baja profil **L 45 . 45 . 5**

Dari tabel baja didapat data-data =

$$A_g = 4,30 \text{ cm}^2$$

$$\bar{x} = 1,35 \text{ cm}$$

$$A_n = 2 \cdot A_g - dt$$

$$= 860 - 14 \cdot 5 = 790 \text{ mm}^2$$

L = Sambungan dengan Diameter

$$= 3 \cdot 12,7 = 38,1 \text{ mm}$$

$$\bar{x} = 13,5 \text{ mm}$$

$$U = 1 - \frac{\bar{x}}{L}$$

$$= 1 - \frac{13,5}{38,1} = 0,645$$

$$A_e = U \cdot A_n$$

$$= 0,645 \cdot 790$$

$$= 509,55 \text{ mm}^2$$

Check kekuatan nominal



$$\begin{aligned}\phi P_n &= 0,75 \cdot A_e \cdot F_u \\ &= 0,75 \cdot 509,55 \cdot 370 \\ &= 141400,125 \text{ N} \\ &= 14140,0125 \text{ kg} > 1031,37 \text{ kg} \dots \text{OK}\end{aligned}$$

c. Perhitungan profil batang tekan

$$\begin{aligned}P_{\text{maks.}} &= 1536,62 \text{ kg} \\ l_k &= 2,165 \text{ m} = 216,5 \text{ cm} \\ A_g \text{ perlu} &= \frac{P_{\text{mak}}}{F_y} = \frac{1536,62}{2400} = 0,64 \text{ cm}^2\end{aligned}$$

Dicoba, menggunakan baja profil $\perp 45 \cdot 45 \cdot 5$ ($A_g = 4,30 \text{ cm}^2$)

Periksa kelangsingan penampang :

$$\begin{aligned}\frac{b}{2 \cdot t_w} &< \frac{200}{\sqrt{F_y}} = \frac{45}{6} < \frac{200}{\sqrt{240}} \\ &= 9,16 < 12,9\end{aligned}$$

$$\begin{aligned}\lambda &= \frac{K \cdot L}{r} = \frac{1 \cdot 216,5}{1,35} \\ &= 160,37\end{aligned}$$

$$\lambda_c = \frac{\lambda}{\pi} \sqrt{\frac{F_y}{E}}$$



$$= \frac{160,37}{3,14} \sqrt{\frac{240}{200000}}$$

$$= 1,77 \dots \dots \lambda_c \geq 1,2 \quad \longrightarrow \quad \omega = 1,25 \cdot \lambda_c^2$$

$$\omega = 1,25 \cdot \lambda_c^2 = 1,25 \cdot (1,77^2)$$

$$= 3,92$$

$$P_n = 2 \cdot A_g \cdot F_{cr}$$

$$= 2 \cdot 4,30 \cdot \frac{2400}{3,92}$$

$$= 5265,31$$

$$\frac{P}{\phi P_n} = \frac{1536,62}{0,85 \cdot 5265,31}$$

$$= 0,343 < 1 \dots \dots \dots \text{OK}$$

3.3.5. Perhitungan Alat Sambung

a. Batang Tekan

Digunakan alat sambung baut-mur.

Diameter baut (\varnothing) = 12,7 mm (½ inches)

Diameter lubang = 14 mm.

Tebal pelat sambung (δ) = 0,625 . d_b

$$= 0,625 \cdot 12,7 = 7,94 \text{ mm.}$$

Menggunakan tebal plat 8 mm

➤ Tahanan geser baut

$$P_n = m \cdot (0,4 \cdot f^{ub}) \cdot A_n$$

$$= 2 \cdot (0,4 \cdot 825) \cdot \frac{1}{4} \cdot \pi \cdot 12,7^2 = 8356,43 \text{ kg/baut}$$



- Tahanan tarik penyambung

$$\begin{aligned} P_n &= 0,75 \cdot f^{ub} \cdot A_n \\ &= 7833,9 \text{ kg/baut} \end{aligned}$$

- Tahanan Tumpu baut :

$$\begin{aligned} P_n &= 0,75 (2,4 \cdot f_u \cdot d_b \cdot t) \\ &= 0,75 (2,4 \cdot 370 \cdot 12,7 \cdot 9) \\ &= 7612,38 \text{ kg/baut} \end{aligned}$$

P yang menentukan adalah $P_{tumpu} = 7612,38 \text{ kg}$.

Perhitungan jumlah baut-mur,

$$n = \frac{P_{maks.}}{P_{geser}} = \frac{1536,62}{7612,38} = 0,202 \sim 2 \text{ buah baut}$$

Digunakan : 2 buah baut

Perhitungan jarak antar baut :

a) $3d \leq S \leq 15t$ atau 200 mm

$$\begin{aligned} \text{Diambil, } S_1 &= 3 d_b = 3 \cdot 12,7 \\ &= 38,1 \text{ mm} = 40 \text{ mm} \end{aligned}$$

b) $1,5 d \leq S_2 \leq (4t + 100)$ atau 200 mm

$$\begin{aligned} \text{Diambil, } S_2 &= 1,5 d_b = 1,5 \cdot 12,7 \\ &= 19,05 \text{ mm} = 20 \text{ mm} \end{aligned}$$

b. Batang tarik

Digunakan alat sambung baut-mur.

Diameter baut (\emptyset) = 12,7 mm ($\frac{1}{2}$ inches)

Diameter lubang = 13,7 mm.

$$\begin{aligned} \text{Tebal pelat sambung } (\delta) &= 0,625 \cdot d_b \\ &= 0,625 \times 12,7 = 7,94 \text{ mm.} \end{aligned}$$

Menggunakan tebal plat 8 mm

- Tahanan geser baut

$$\begin{aligned} P_n &= n \cdot (0,4 \cdot f^{ub}) \cdot A_n \\ &= 2 \cdot (0,4 \cdot 825) \cdot \frac{1}{4} \cdot \pi \cdot 12,7^2 = 8356,43 \text{ kg/baut} \end{aligned}$$

- Tahanan tarik penyambung

$$P_n = 0,75 \cdot f^{ub} \cdot A_n$$



$$=7833,9 \text{ kg/baut}$$

➤ Tahanan Tumpu baut :

$$\begin{aligned} P_n &= 0,75 (2,4 \cdot f_u \cdot d_b \cdot t) \\ &= 0,75 (2,4 \cdot 370 \cdot 12,7 \cdot 9) \\ &= 7612,38 \text{ kg/baut} \end{aligned}$$

P yang menentukan adalah $P_{\text{tumpu}} = 7612,38 \text{ kg}$.

Perhitungan jumlah baut-mur,

$$n = \frac{P_{\text{maks.}}}{P_{\text{geser}}} = \frac{1031,37}{7612,38} = 0,135 \sim 2 \text{ buah baut}$$

Digunakan : 2 buah baut

Perhitungan jarak antar baut :

a) $3d \leq S \leq 15t$ atau 200 mm

$$\begin{aligned} \text{Diambil, } S_1 &= 3 d_b = 3 \cdot 12,7 \\ &= 38,1 \text{ mm} \\ &= 40 \text{ mm} \end{aligned}$$

b) $1,5 d \leq S_2 \leq (4t + 100)$ atau 200 mm

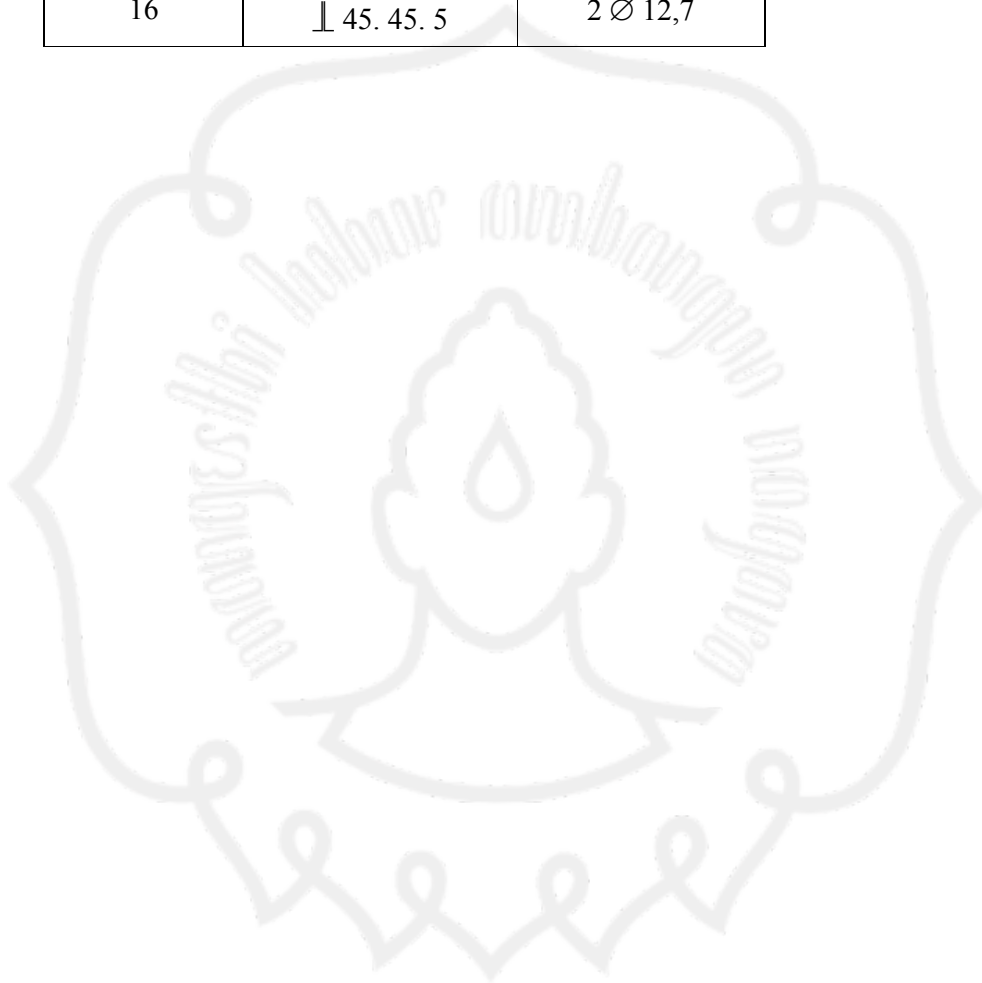
$$\begin{aligned} \text{Diambil, } S_2 &= 1,5 d_b = 1,5 \cdot 12,7 \\ &= 19,05 \text{ mm} \\ &= 20 \text{ mm} \end{aligned}$$

Tabel 3.11. Rekapitulasi Perencanaan Profil Setengah Kuda-kuda

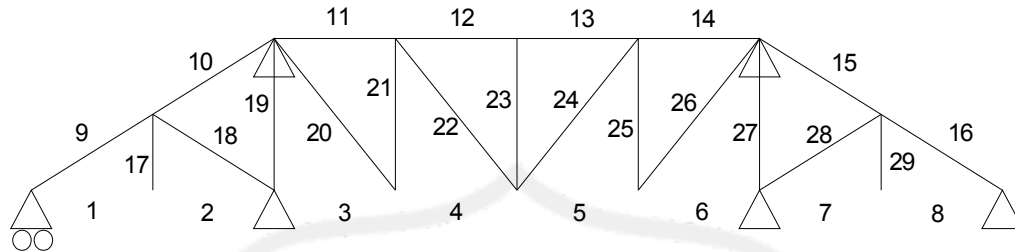
Nomer Batang	Dimensi Profil	Baut (mm)
1	┘ 45. 45. 5	2 Ø 12,7
2	┘ 45. 45. 5	2 Ø 12,7
3	┘ 45. 45. 5	2 Ø 12,7
4	┘ 45. 45. 5	2 Ø 12,7
5	┘ 45. 45. 5	2 Ø 12,7
6	┘ 45. 45. 5	2 Ø 12,7
7	┘ 45. 45. 5	2 Ø 12,7
8	┘ 45. 45. 5	2 Ø 12,7
9	┘ 45. 45. 5	2 Ø 12,7



10	⊥ 45. 45. 5	2 Ø 12,7
11	⊥ 45. 45. 5	2 Ø 12,7
12	⊥ 45. 45. 5	2 Ø 12,7
13	⊥ 45. 45. 5	2 Ø 12,7
14	⊥ 45. 45. 5	2 Ø 12,7
15	⊥ 45. 45. 5	2 Ø 12,7
16	⊥ 45. 45. 5	2 Ø 12,7



3.6. Perencanaan Kuda-kuda Trapesium



Gambar 3.12. Rangka Batang Kuda-kuda Trapesium

3.6.1. Perhitungan Panjang Batang Kuda-kuda Trapesium

Perhitungan panjang batang selanjutnya disajikan dalam tabel dibawah ini :

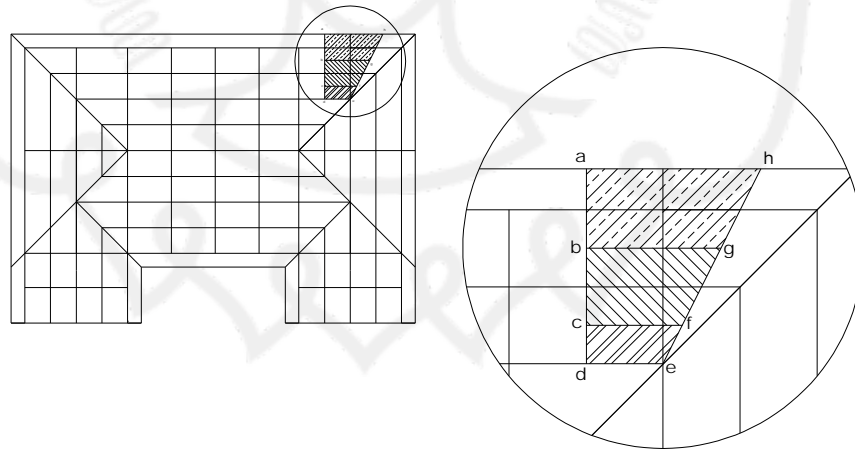
Tabel 3.12. Perhitungan Panjang Batang pada Kuda-kuda Trapesium

Nomer Batang	Panjang Batang (m)
1	1,875
2	1,875
3	1,875
4	1,875
5	1,875
6	1,875
7	1,875
8	1,875
9	2,165
10	2,165
11	1,875
12	1,875
13	1,875
14	1,875



15	2,165
16	2,165
17	1,083
18	2,165
19	2,165
20	2,864
21	2,165
22	2,864
23	2,165
24	2,864
25	2,165
26	2,864
27	2,165
28	2,165
29	1,083

3.6.2. Perhitungan luasan kuda-kuda trapesium



Gambar 3.13. Luasan Atap Kuda-kuda Trapesium

Panjang ah = 4,245 m

Panjang bg = 3,276 m



$$\text{Panjang cf} = 2,336 \text{ m}$$

$$\text{Panjang de} = 1,875 \text{ m}$$

$$\text{Panjang ab} = 1,930 \text{ m}$$

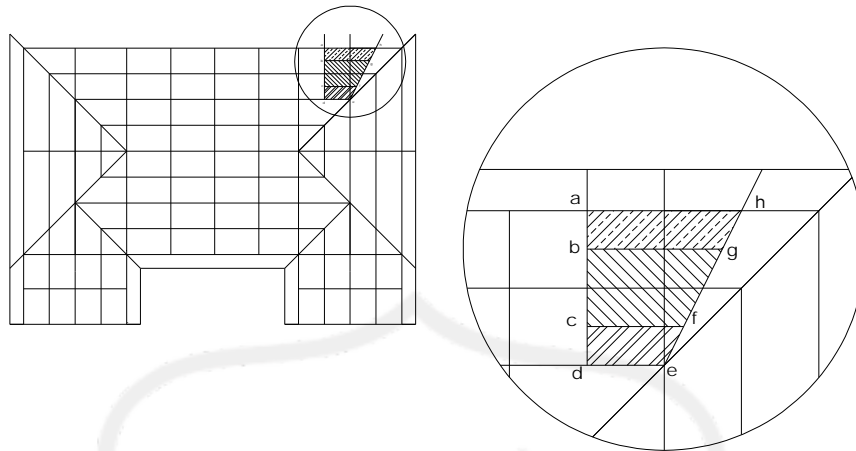
$$\text{Panjang bc} = 1,875 \text{ m}$$

$$\text{Panjang cd} = 0,937 \text{ m}$$

$$\begin{aligned} \bullet \text{ Luas abgh} &= \left(\frac{ah + bg}{2} \right) \times ab \\ &= \left(\frac{4,245 + 3,276}{2} \right) \times 1,930 \\ &= 7,258 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \bullet \text{ Luas bcfg} &= \left(\frac{bg + cf}{2} \right) \times bc \\ &= \left(\frac{3,276 + 2,336}{2} \right) \times 1,875 \\ &= 5,261 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \bullet \text{ Luas cdef} &= \left(\frac{cf + de}{2} \right) \times cd \\ &= \left(\frac{2,336 + 1,875}{2} \right) \times 0,937 \\ &= 1,973 \text{ m}^2 \end{aligned}$$



Gambar 3.14. Luasan Plafon Kuda-kuda Trapesium

$$\text{Panjang ah} = 3,750 \text{ m}$$

$$\text{Panjang bg} = 3,276 \text{ m}$$

$$\text{Panjang cf} = 2,336 \text{ m}$$

$$\text{Panjang de} = 1,875 \text{ m}$$

$$\text{Panjang ab} = 0,9 \text{ m}$$

$$\text{Panjang bc} = 1,8 \text{ m}$$

$$\text{Panjang cd} = 0,9 \text{ m}$$

$$\begin{aligned} \bullet \text{ Luas abgh} &= \left(\frac{\text{ah} + \text{bg}}{2} \right) \times \text{ab} \\ &= \left(\frac{3,750 + 3,276}{2} \right) \times 0,9 \\ &= 3,162 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \bullet \text{ Luas bcfg} &= \left(\frac{\text{bg} + \text{cf}}{2} \right) \times \text{bc} \\ &= \left(\frac{3,276 + 2,336}{2} \right) \times 1,8 \\ &= 5,050 \text{ m}^2 \end{aligned}$$



$$\begin{aligned}
 \bullet \text{ Luas cdef} &= \left(\frac{cf + de}{2} \right) \times cd \\
 &= \left(\frac{2,336 + 1,875}{2} \right) \times 0,9 \\
 &= 1,895 \text{ m}^2
 \end{aligned}$$

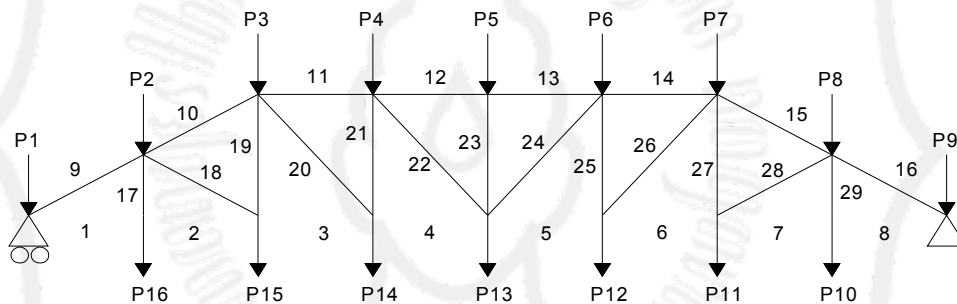
3.6.3. Perhitungan Pembebanan Kuda-kuda Trapesium

Data-data pembebanan :

Berat gording = 11 kg/m

Berat penutup atap = 50 kg/m²

Berat profil = 25 kg/m



Gambar 3.15. Pembebanan Kuda-kuda Trapesium akibat Beban Mati

a. Beban Mati

1) Beban P1 = P9

- a) Beban gording = Berat profil gording × Panjang Gording
= 11 × 3,75 = 41,25 kg
- b) Beban atap = Luasan × Berat atap
= 7,258 × 50 = 362,9 kg
- c) Beban plafon = Luasan × berat plafon



-
- $= 3,291 \times 18 = 67,5 \text{ kg}$
- d) Beban kuda-kuda $= \frac{1}{2} \times \text{Btg} (1 + 9) \times \text{berat profil kuda kuda}$
 $= \frac{1}{2} \times (1,875 + 2,165) \times 25$
 $= 50,5 \text{ kg}$
- e) Beban plat sambung $= 30 \% \times \text{beban kuda-kuda}$
 $= 30 \% \times 50,5 = 15,15 \text{ kg}$
- f) Beban bracing $= 10 \% \times \text{beban kuda-kuda}$
 $= 10 \% \times 50,5 = 5,05 \text{ kg}$
- 2) Beban P2 = P8
- a) Beban gording $= \text{Berat profil gording} \times \text{Panjang Gording}$
 $= 11 \times 2,820 = 31,02 \text{ kg}$
- b) Beban atap $= \text{Luasan} \times \text{Berat atap}$
 $= 5,261 \times 50 = 263,05 \text{ kg}$
- c) Beban kuda-kuda $= \frac{1}{2} \times \text{Btg} (9+17+18+10) \times \text{berat profil kuda kuda}$
 $= \frac{1}{2} \times (2,165 + 1,083 + 2,165 + 2,165) \times 25$
 $= 94,725 \text{ kg}$
- d) Beban plat sambung $= 30 \% \times \text{beban kuda-kuda}$
 $= 30 \% \times 94,725 = 28,417 \text{ kg}$
- e) Beban bracing $= 10 \% \times \text{beban kuda-kuda}$
 $= 10 \% \times 94,725 = 9,472 \text{ kg}$
- 3) Beban P3 = P7
- a) Beban gording $= \text{Berat profil gording} \times \text{Panjang Gording}$
 $= 11 \times 1,875 = 20,625 \text{ kg}$
- b) Beban atap $= \text{Luasan} \times \text{Berat atap}$
 $= 1,973 \times 50 = 98,65 \text{ kg}$
- c) Beban kuda-kuda $= \frac{1}{2} \times \text{Btg} (10+19+20+11) \times \text{berat profil kuda kuda}$
 $= \frac{1}{2} \times (2,165 + 2,165 + 2,864 + 1,875) \times 25$
 $= 113,362 \text{ kg}$
- d) Beban plat sambung $= 30 \% \times \text{beban kuda-kuda}$
 $= 30 \% \times 113,362 = 34,009 \text{ kg}$
-



$$\begin{aligned} \text{e) Beban bracing} &= 10 \% \times \text{beban kuda-kuda} \\ &= 10 \% \times 113,362 = 11,336 \text{ kg} \\ \text{f) Beban reaksi} &= \text{reaksi jurai 1} + \text{reaksi jurai 2} \\ &= 1221,27 \text{ kg} + 1340,28 \text{ kg} = 2561,55 \text{ kg} \end{aligned}$$

4) Beban P4 = P6

$$\begin{aligned} \text{a) Beban kuda-kuda} &= \frac{1}{2} \times \text{Btg} (11+21+22+12) \times \text{berat profil kuda kuda} \\ &= \frac{1}{2} \times (1,875 + 2,165 + 2,864 + 1,875) \times 25 \\ &= 109,737 \text{ kg} \\ \text{b) Beban plat sambung} &= 30 \% \times \text{beban kuda-kuda} \\ &= 30 \% \times 109,737 = 32,921 \text{ kg} \\ \text{c) Beban bracing} &= 10 \% \times \text{beban kuda-kuda} \\ &= 10 \% \times 109,737 = 10,974 \text{ kg} \end{aligned}$$

5) Beban P5

$$\begin{aligned} \text{a) Beban kuda-kuda} &= \frac{1}{2} \times \text{Btg} (12 + 23 + 13) \times \text{berat profil kuda kuda} \\ &= \frac{1}{2} \times (1,875 + 2,165 + 1,875) \times 25 \\ &= 73,937 \text{ kg} \\ \text{b) Beban plat sambung} &= 30 \% \times \text{beban kuda-kuda} \\ &= 30 \% \times 73,937 = 22,181 \text{ kg} \\ \text{c) Beban bracing} &= 10 \% \times \text{beban kuda-kuda} \\ &= 10 \% \times 73,937 = 7,394 \text{ kg} \\ \text{d) Beban reaksi} &= \text{reaksi } \frac{1}{2} \text{ kuda-kuda 1} + \text{reaksi } \frac{1}{2} \text{ kuda-kuda 2} \\ &= 1221,83 \text{ kg} + 1296,77 \text{ kg} = 2518,6 \text{ kg} \end{aligned}$$

6) Beban P10 = P16

$$\begin{aligned} \text{a) Beban plafon} &= \text{Luasan} \times \text{berat plafon} \\ &= 5,050 \times 18 = 90,900 \text{ kg} \\ \text{b) Beban kuda-kuda} &= \frac{1}{2} \times \text{Btg} (8 + 29 + 7) \times \text{berat profil kuda kuda} \\ &= \frac{1}{2} \times (1,875 + 1,083 + 1,875) \times 25 \\ &= 60,412 \text{ kg} \end{aligned}$$



$$\begin{aligned} \text{c) Beban plat sambung} &= 30 \% \times \text{beban kuda-kuda} \\ &= 30 \% \times 60,412 = 18,124 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{d) Beban bracing} &= 10 \% \times \text{beban kuda-kuda} \\ &= 10 \% \times 60,412 = 6,041 \text{ kg} \end{aligned}$$

7) Beban P11 = P15

$$\begin{aligned} \text{a) Beban plafon} &= \text{Luasan} \times \text{berat plafon} \\ &= 1,895 \times 18 = 34,11 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{b) Beban kuda-kuda} &= \frac{1}{2} \times \text{Btg} (7+28+27+6) \times \text{berat profil kuda kuda} \\ &= \frac{1}{2} \times (1,875 + 2,165 + 2,165 + 1,875) \times 25 \\ &= 101 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{c) Beban plat sambung} &= 30 \% \times \text{beban kuda-kuda} \\ &= 30 \% \times 101 = 30,3 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{d) Beban bracing} &= 10 \% \times \text{beban kuda-kuda} \\ &= 10 \% \times 101 = 10,1 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{e) Beban reaksi} &= \text{reaksi jurai 1} + \text{reaksi jurai 2} \\ &= 1071,58 \text{ kg} + 302,04 \text{ kg} = 1373,62 \text{ kg} \end{aligned}$$

8) Beban P12 = P14

$$\begin{aligned} \text{a) Beban kuda-kuda} &= \frac{1}{2} \times \text{Btg} (6+26+25+5) \times \text{berat profil kuda kuda} \\ &= \frac{1}{2} \times (1,875 + 2,864 + 2,165 + 1,875) \times 25 \\ &= 109,737 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{b) Beban plat sambung} &= 30\% \times \text{beban kuda-kuda} \\ &= 30\% \times 109,737 = 32,921 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{c) Beban bracing} &= 10\% \times \text{beban kuda-kuda} \\ &= 10\% \times 109,737 = 10,974 \text{ kg} \end{aligned}$$

9) Beban P13

$$\begin{aligned} \text{a) Beban kuda-kuda} &= \frac{1}{2} \times \text{Btg} (4+22+23+24+5) \times \text{berat profil kuda kuda} \\ &= \frac{1}{2} \times (1,875 + 2,864 + 2,165 + 2,864 + 1,875) \times 25 \\ &= 145,537 \text{ kg} \end{aligned}$$

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



- $= 30 \% \times 145,537 = 43,661 \text{ kg}$
- c) Beban bracing $= 10 \% \times \text{beban kuda-kuda}$
 $= 10 \% \times 145,537 = 14,554 \text{ kg}$
- d) Beban reaksi $= \text{reaksi } \frac{1}{2} \text{ kuda-kuda 1} + \text{reaksi } \frac{1}{2} \text{ kuda-kuda 2}$
 $= 978,25 \text{ kg} + 289,46 \text{ kg} = 1267,71 \text{ kg}$

Tabel 3.13. Rekapitulasi Pembebanan Kuda-kuda Trapesium

Beban	Beban Atap (kg)	Beban gording (kg)	Beban Kuda - kuda (kg)	Beban Bracing (kg)	Beban Plat Penyambung (kg)	Beban Plafon (kg)	Beban Reaksi (kg)	Jumlah Beban (kg)	Input SAP (kg)
P1=P9	362,9	41,25	50,5	5,05	15,15	67,5	-	542,35	543
P2=P8	263,05	31,02	94,725	9,472	28,417	-	-	426,684	427
P3=P7	98,65	20,625	113,362	11,336	34,009	-	2561,55	2839,532	2840
P4=P6	-	-	109,737	10,974	39,921	-	-	160,632	161
P5	-	-	73,937	7,394	22,181	-	2518,6	2622,112	2623
P10=P16	-	-	60,412	6,041	18,124	90,9	-	175,477	176
P11=P15	-	-	101	10,1	30,3	34,11	1373,62	1549,13	1550
P12=P14	-	-	109,737	10,974	32,921	-	-	153,632	154
P13	-	-	145,537	14,554	43,661	-	1267,71	1471,462	1472

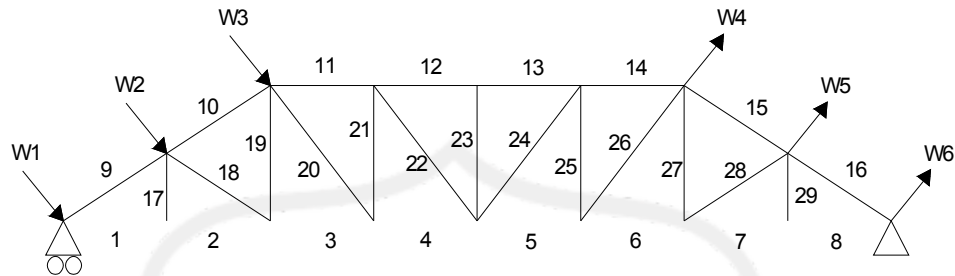
➤ **Beban Hidup**

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



➤ **Beban Angin**

Perhitungan beban angin :



Gambar 3.16. Pembebanan Kuda-kuda Trapesium akibat Beban Angin

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

- 1) Koefisien angin tekan = $0,02\alpha - 0,40$
 $= (0,02 \times 35) - 0,40 = 0,2$
 - a) $W1 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 7,258 \times 0,2 \times 25 = 36,290 \text{ kg}$
 - b) $W2 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 5,261 \times 0,2 \times 25 = 26,305 \text{ kg}$
 - c) $W3 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 1,973 \times 0,2 \times 25 = 9,865 \text{ kg}$
- 2) Koefisien angin hisap = $-0,40$
 - a) $W4 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 1,973 \times -0,4 \times 25 = -19,730 \text{ kg}$
 - b) $W5 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 5,261 \times -0,4 \times 25 = -52,610 \text{ kg}$
 - c) $W6 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 7,258 \times -0,4 \times 25 = -72,580 \text{ kg}$



Tabel 3.14. Perhitungan Beban Angin Kuda-kuda Trapesium

Beban Angin	Beban (kg)	W_x $W \cdot \cos \alpha$ (kg)	(Untuk Input SAP2000)	W_y $W \cdot \sin \alpha$ (kg)	(Untuk Input SAP2000)
W_1	36,290	31,428	32	18,145	19
W_2	26,305	22,781	23	13,152	14
W_3	9,865	8,543	9	4,932	5
W_4	-19,730	-17,087	-18	-9,865	-10
W_5	-52,610	-45,561	-46	-26,305	-27
W_6	-72,580	-62,856	-63	-36,290	-37

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

Tabel 3.15. Rekapitulasi Gaya Batang Kuda-kuda Trapesium

Batang	kombinasi	
	Tarik (+) (kg)	Tekan (-) (kg)
1	17033,13	
2	17092,08	
3	16468,12	
4	19359,85	
5	19335,45	
6	16419,10	
7	16989,20	
8	16929,44	
9		19751,47
10		19032,90
11		19369,73
12		21612,86
13		21612,72
14		19345,03
15		19001,06
16		19720,19
17		102,22



18		742,97
19	2438,60	
20	4383,63	
21		3004,61
22	3385,89	
23		3316,98
24	3422,88	
25		3032,47
26	4420,66	
27	2407,07	
28		681,18
29	103,33	

3.6.4. Perencanaan Profil Kuda-kuda Trapesium

a. Perhitungan Profil Batang Tarik

$$P_{maks.} = 19359,85 \text{ kg}$$

$$F_y = 2400 \text{ kg/cm}^2 \text{ (240 MPa)}$$

$$F_u = 3700 \text{ kg/cm}^2 \text{ (370 MPa)}$$

$$A_g \text{ perlu} = \frac{P_{mak}}{F_y} = \frac{19359,85}{2400} = 8,07 \text{ cm}^2$$

Dicoba, menggunakan baja profil **L 80 . 80 . 8**

Dari tabel baja didapat data-data =

$$A_g = 12,3 \text{ cm}^2$$

$$\bar{x} = 2,42 \text{ cm}$$

$$A_n = 2.A_g - dt$$

$$= 2460 - 23.8 = 2276 \text{ mm}^2$$

L = Sambungan dengan Diameter

$$= 3.12,7 = 38,1 \text{ mm}$$



$$\bar{x} = 24,2 \text{ mm}$$

$$U = 1 - \frac{\bar{x}}{L}$$

$$= 1 - \frac{24,2}{38,1} = 0,365$$

$$A_e = U \cdot A_n$$

$$= 0,365 \cdot 2276$$

$$= 830,74 \text{ mm}^2$$

Check kekuatan nominal

$$\phi P_n = 0,75 \cdot A_e \cdot F_u$$

$$= 0,75 \cdot 830,74 \cdot 370$$

$$= 230530,35 \text{ N}$$

$$= 23053,035 \text{ kg} > 19359,85 \text{ kg} \dots \text{OK}$$

d. Perhitungan profil batang tekan

$$P_{\text{maks.}} = 21612,86 \text{ kg}$$

$$l_k = 1,875 \text{ m} = 187,5 \text{ cm}$$

$$A_g \text{ perlu} = \frac{P_{\text{mak}}}{F_y} = \frac{21612,86}{2400} = 9,01 \text{ cm}^2$$

Dicoba, menggunakan baja profil $\perp 80 \cdot 80 \cdot 8$ ($A_g = 12,3 \text{ cm}^2$)

Periksa kelangsingan penampang :

$$\frac{b}{2 \cdot t_w} < \frac{200}{\sqrt{F_y}} = \frac{80}{10} < \frac{200}{\sqrt{240}}$$



$$= 8 < 12,9$$

$$\lambda = \frac{K.L}{r} = \frac{1.187,5}{2,42}$$

$$= 77,48$$

$$\lambda_c = \frac{\lambda}{\pi} \sqrt{\frac{F_y}{E}}$$

$$= \frac{77,48}{3,14} \sqrt{\frac{240}{200000}}$$

$$= 0,855 \dots 0,25 < \lambda_c < 1,2 \longrightarrow \omega = \frac{1,43}{1,6 - 0,67\lambda_c}$$

$$\omega = \frac{1,43}{1,6 - 0,67\lambda_c} = \frac{1,43}{1,6 - 0,67 \cdot 0,855}$$

$$= 1,392$$

$$P_n = 2 \cdot A_g \cdot F_{cr}$$

$$= 2 \cdot 12,3 \cdot \frac{2400}{1,392}$$

$$= 42413,79$$

$$\frac{P}{\phi P_n} = \frac{21612,86}{0,85 \cdot 42413,79}$$

$$= 0,599 < 1 \dots \dots \dots \text{OK}$$

3.3.5. Perhitungan Alat Sambung

a. Batang Tekan

Digunakan alat sambung baut-mur.

Diameter baut (\varnothing) = 12,7 mm (½ inches)



Diameter lubang = 14 mm.

$$\begin{aligned} \text{Tebal pelat sambung } (\delta) &= 0,625 \cdot d_b \\ &= 0,625 \cdot 12,7 = 7,94 \text{ mm.} \end{aligned}$$

Menggunakan tebal plat 8 mm

➤ Tahanan geser baut

$$\begin{aligned} P_n &= m \cdot (0,4 \cdot f^{ub}) \cdot A_n \\ &= 2 \cdot (0,4 \cdot 825) \cdot \frac{1}{4} \cdot \pi \cdot 12,7^2 = 8356,43 \text{ kg/baut} \end{aligned}$$

➤ Tahanan tarik penyambung

$$\begin{aligned} P_n &= 0,75 \cdot f^{ub} \cdot A_n \\ &= 7833,9 \text{ kg/baut} \end{aligned}$$

➤ Tahanan Tumpu baut :

$$\begin{aligned} P_n &= 0,75 (2,4 \cdot f_u \cdot d_b \cdot t) \\ &= 0,75 (2,4 \cdot 370 \cdot 12,7 \cdot 9) \\ &= 7612,38 \text{ kg/baut} \end{aligned}$$

P yang menentukan adalah $P_{\text{tumpu}} = 7612,38 \text{ kg}$.

Perhitungan jumlah baut-mur,

$$n = \frac{P_{\text{maks.}}}{P_{\text{geser}}} = \frac{21612,86}{7612,38} = 2,83 \sim 3 \text{ buah baut}$$

Digunakan : 3 buah baut

Perhitungan jarak antar baut :

a) $3d \leq S \leq 15t$ atau 200 mm

$$\begin{aligned} \text{Diambil, } S_1 &= 3 d_b = 3 \cdot 12,7 \\ &= 38,1 \text{ mm} \\ &= 40 \text{ mm} \end{aligned}$$

b) $1,5 d \leq S_2 \leq (4t + 100)$ atau 200 mm

$$\begin{aligned} \text{Diambil, } S_2 &= 1,5 d_b = 1,5 \cdot 12,7 \\ &= 19,05 \text{ mm} \\ &= 20 \text{ mm} \end{aligned}$$

b. Batang tarik

Digunakan alat sambung baut-mur.

Diameter baut (\varnothing) = 12,7 mm ($\frac{1}{2}$ inches)



Diameter lubang = 13,7 mm.

$$\begin{aligned} \text{Tebal pelat sambung } (\delta) &= 0,625 \cdot d_b \\ &= 0,625 \times 12,7 = 7,94 \text{ mm.} \end{aligned}$$

Menggunakan tebal plat 8 mm

➤ Tahanan geser baut

$$\begin{aligned} P_n &= n \cdot (0,4 \cdot f^{ub}) \cdot A_n \\ &= 2 \cdot (0,4 \cdot 825) \cdot \frac{1}{4} \cdot \pi \cdot 12,7^2 = 8356,43 \text{ kg/baut} \end{aligned}$$

➤ Tahanan tarik penyambung

$$\begin{aligned} P_n &= 0,75 \cdot f^{ub} \cdot A_n \\ &= 7833,9 \text{ kg/baut} \end{aligned}$$

➤ Tahanan Tumpu baut :

$$\begin{aligned} P_n &= 0,75 (2,4 \cdot f_u \cdot d_b \cdot t) \\ &= 0,75 (2,4 \cdot 370 \cdot 12,7 \cdot 9) \\ &= 7612,38 \text{ kg/baut} \end{aligned}$$

P yang menentukan adalah $P_{\text{tumpu}} = 7612,38 \text{ kg}$.

Perhitungan jumlah baut-mur,

$$n = \frac{P_{\text{maks.}}}{P_{\text{geser}}} = \frac{19359,85}{7612,38} = 2,54 \sim 3 \text{ buah baut}$$

Digunakan : 3 buah baut

Perhitungan jarak antar baut :

a) $3d \leq S \leq 15t$ atau 200 mm

$$\begin{aligned} \text{Diambil, } S_1 &= 3 d_b = 3 \cdot 12,7 \\ &= 38,1 \text{ mm} \\ &= 40 \text{ mm} \end{aligned}$$

b) $1,5 d \leq S_2 \leq (4t + 100)$ atau 200 mm

$$\begin{aligned} \text{Diambil, } S_2 &= 1,5 d_b = 1,5 \cdot 12,7 \\ &= 19,05 \text{ mm} \\ &= 20 \text{ mm} \end{aligned}$$

Tabel 3.16. Rekapitulasi Perencanaan Profil Kuda-kuda Trapesium

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



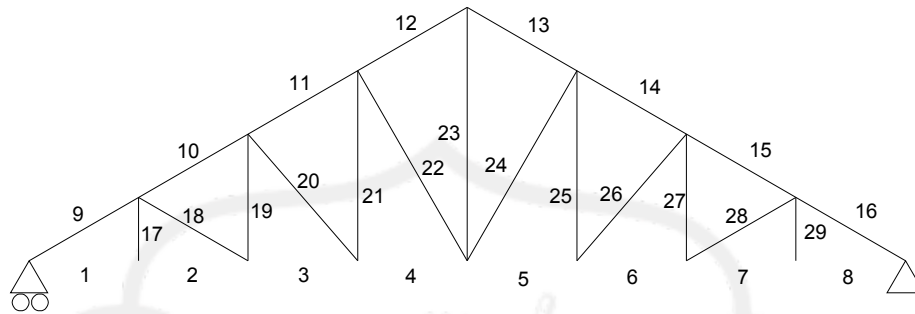
1	┆ 80. 80. 8	3 Ø 12,7
2	┆ 80. 80. 8	3 Ø 12,7
3	┆ 80. 80. 8	3 Ø 12,7
4	┆ 80. 80. 8	3 Ø 12,7
5	┆ 80. 80. 8	3 Ø 12,7
6	┆ 80. 80. 8	3 Ø 12,7
7	┆ 80. 80. 8	3 Ø 12,7
8	┆ 80. 80. 8	3 Ø 12,7
9	┆ 80. 80. 8	3 Ø 12,7
10	┆ 80. 80. 8	3 Ø 12,7
11	┆ 80. 80. 8	3 Ø 12,7
12	┆ 80. 80. 8	3 Ø 12,7
13	┆ 80. 80. 8	3 Ø 12,7
14	┆ 80. 80. 8	3 Ø 12,7
15	┆ 80. 80. 8	3 Ø 12,7
16	┆ 80. 80. 8	3 Ø 12,7
17	┆ 80. 80. 8	3 Ø 12,7
18	┆ 80. 80. 8	3 Ø 12,7
19	┆ 80. 80. 8	3 Ø 12,7
20	┆ 80. 80. 8	3 Ø 12,7
21	┆ 80. 80. 8	3 Ø 12,7
22	┆ 80. 80. 8	3 Ø 12,7
23	┆ 80. 80. 8	3 Ø 12,7
24	┆ 80. 80. 8	3 Ø 12,7
25	┆ 80. 80. 8	3 Ø 12,7
26	┆ 80. 80. 8	3 Ø 12,7
27	┆ 80. 80. 8	3 Ø 12,7
28	┆ 80. 80. 8	3 Ø 12,7
29	┆ 80. 80. 8	3 Ø 12,7





3.7. Perencanaan Kuda-kuda Utama

3.7.1. Perhitungan Panjang Batang Kuda-kuda



Gambar 3.17. Rangka Batang Kuda-kuda Utama

Perhitungan panjang batang selanjutnya disajikan dalam tabel dibawah ini :

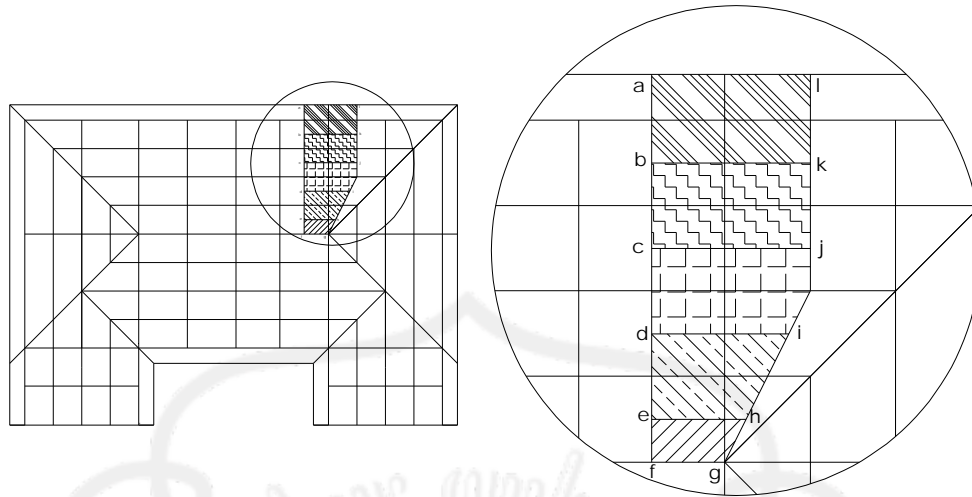
Tabel 3.17. Perhitungan Panjang Batang pada Kuda-kuda Utama

No batang	Panjang batang
1	1,875
2	1,875
3	1,875
4	1,875
5	1,875
6	1,875
7	1,875
8	1,875
9	2,165
10	2,165
11	2,165
12	2,165



13	2,165
14	2,165
15	2,165
16	2,165
17	1,083
18	2,165
19	2,165
20	2,864
21	3,248
22	3,750
23	4,330
24	3,750
25	3,248
26	2,864
27	2,165
28	2,165
29	1,083

3.7.2. Perhitungan Luasan Kuda-Kuda Utama



Gambar 3.18. Luasan Atap Kuda-kuda Utama

$$\text{Panjang al} = \text{Panjang bk} = \text{Panjang cj} = 3,483 \text{ m}$$

$$\text{Panjang di} = 3,010 \text{ m}$$

$$\text{Panjang eh} = 2,070 \text{ m}$$

$$\text{Panjang fg} = 1,600 \text{ m}$$

$$\text{Panjang ab} = 1,937 \text{ m}, bc = cd = de = 1,875 \text{ m}$$

$$\text{Panjang ef} = \frac{1}{2} \cdot 1,875 = 0,937 \text{ m}$$

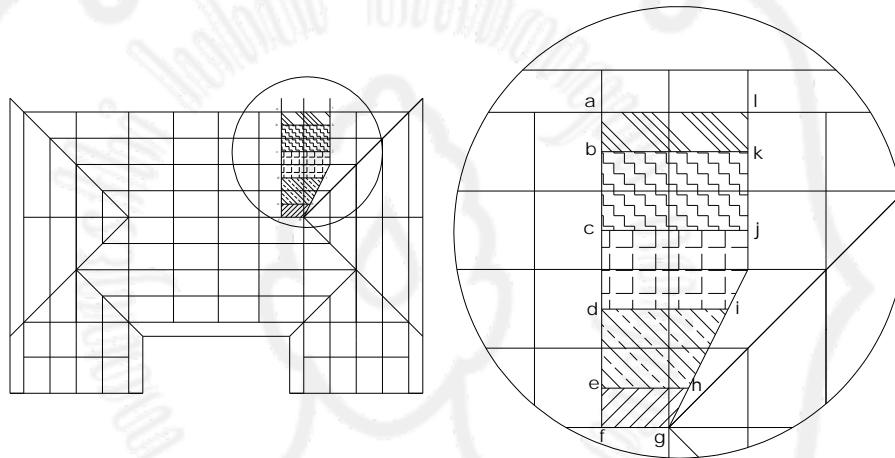
$$\begin{aligned} \bullet \text{ Luas abkl} &= al \times ab \\ &= 3,483 \times 1,937 = 6,872 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \bullet \text{ Luas bcjk} &= bk \times bc \\ &= 3,483 \times 1,875 = 5,531 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \bullet \text{ Luas cdij} &= (cj \times \frac{1}{2} cd) + \left(\frac{cj + di}{2} \times \frac{1}{2} \cdot cd \right) \\ &= (3,483 \times \frac{1}{2} \cdot 1,875) + \left(\frac{3,483 + 3,010}{2} \times \frac{1}{2} \cdot 1,875 \right) \\ &= 6,305 \text{ m}^2 \end{aligned}$$



$$\begin{aligned}
 \bullet \text{ Luas dehi} &= \left(\frac{di + eh}{2} \right) \times de \\
 &= \left(\frac{3,010 + 2,070}{2} \right) \times 1,875 \\
 &= 4,762 \text{ m}^2 \\
 \bullet \text{ Luas efgh} &= \left(\frac{eh + fg}{2} \right) \times ef \\
 &= \left(\frac{2,070 + 1,600}{2} \right) \times 0,937 \\
 &= 1,719 \text{ m}^2
 \end{aligned}$$



Gambar 3.19. Luasan Plafon Kuda-kuda Utama

$$\begin{aligned}
 \text{Panjang al} &= \text{Panjang bk} = \text{Panjang cj} = 3,483 \text{ m} \\
 \text{Panjang di} &= 3,010 \text{ m} \\
 \text{Panjang eh} &= 2,070 \text{ m} \\
 \text{Panjang fg} &= 1,600 \text{ m} \\
 \text{Panjang ab} &= 0,937 \text{ m} \\
 \text{Panjang bc} &= \text{cd} = \text{de} = 1,8 \text{ m} \\
 \text{Panjang ef} &= 0,9 \text{ m}
 \end{aligned}$$

$$\bullet \text{ Luas abkl} = al \times ab$$



$$= 3,483 \times 0,937 = 3,263 \text{ m}^2$$

• **Luas bcjk** = $bk \times bc$

$$= 3,483 \times 1,8 = 6,269 \text{ m}^2$$

• **Luas cdij** = $(cj \times \frac{1}{2} cd) + \left(\frac{cj+di}{2} \times \frac{1}{2} \cdot cd \right)$

$$= (3,483 \times \frac{1}{2} 1,8) + \left(\frac{3,483 + 3,010}{2} \times \frac{1}{2} \cdot 1,8 \right)$$

$$= 6,056 \text{ m}^2$$

• **Luas dehi** = $\left(\frac{di + eh}{2} \right) \times de$

$$= \left(\frac{3,010 + 2,070}{2} \right) \times 1,8$$

$$= 4,572 \text{ m}^2$$

• **Luas efgh** = $\left(\frac{eh + fg}{2} \right) \times ef$

$$= \left(\frac{2,010 + 1,600}{2} \right) \times 0,9$$

$$= 1,651 \text{ m}^2$$

3.7.3. Perhitungan Pembebanan Kuda-kuda Utama

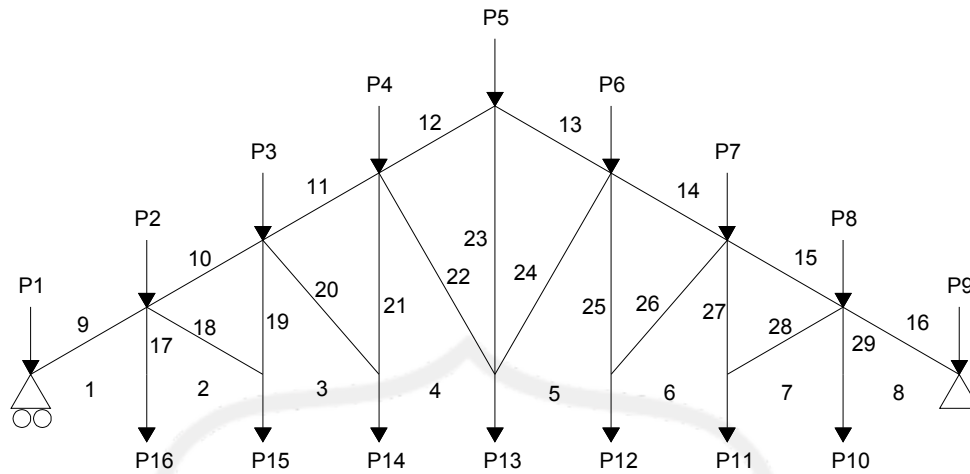
Data-data pembebanan :

Berat gording = 11 kg/m

Jarak antar kuda-kuda utama = 3 m

Berat penutup atap = 50 kg/m²

Berat profil = 15 kg/m



Gambar 3.20. Pembebanan Kuda-kuda Utama akibat Beban Mati

a. Beban Mati

1) Beban P1 = P9

- a) Beban gording = Berat profil gording \times Panjang Gording
 $= 11 \times 3,483 = 38,313 \text{ kg}$
- b) Beban atap = Luasan \times Berat atap
 $= 6,872 \times 50 = 343,6 \text{ kg}$
- c) Beban plafon = Luasan \times berat plafon
 $= 3,263 \times 18 = 58,734 \text{ kg}$
- d) Beban kuda-kuda = $\frac{1}{2} \times \text{Btg} (1 + 9) \times \text{berat profil kuda kuda}$
 $= \frac{1}{2} \times (1,875 + 2,165) \times 25$
 $= 50,5 \text{ kg}$
- e) Beban plat sambung = 30 % \times beban kuda-kuda
 $= 30 \% \times 50,5 = 15,15 \text{ kg}$
- f) Beban bracing = 10 % \times beban kuda-kuda
 $= 10 \% \times 50,5 = 5,05 \text{ kg}$

2) Beban P2 = P8



-
- a) Beban gording = Berat profil gording \times Panjang Gording
= $11 \times 3,483 = 38,313$ kg
- b) Beban atap = Luasan \times Berat atap
= $5,531 \times 50 = 276,55$ kg
- c) Beban kuda-kuda = $\frac{1}{2} \times$ Btg (9+17+18+10) \times berat profil kuda kuda
= $\frac{1}{2} \times (2,165 + 1,083 + 2,165 + 2,165) \times 25$
= $94,725$ kg
- d) Beban plat sambung = 30 % \times beban kuda-kuda
= 30 % \times $94,725 = 28,417$ kg
- e) Beban bracing = 10 % \times beban kuda-kuda
= 10 % \times $94,725 = 9,472$ kg
- 3) Beban P3 = P7
- a) Beban gording = Berat profil gording \times Panjang Gording
= $11 \times 3,483 = 38,313$ kg
- b) Beban atap = Luasan \times Berat atap
= $6,305 \times 50 = 447,350$ kg
- c) Beban kuda-kuda = $\frac{1}{2} \times$ Btg (10+19+20+11) \times berat profil kuda kuda
= $\frac{1}{2} \times (2,165 + 2,165 + 2,864 + 2,165) \times 25$
= $116,987$ kg
- d) Beban plat sambung = 30 % \times beban kuda-kuda
= 30 % \times $116,987 = 35,096$ kg
- e) Beban bracing = 10 % \times beban kuda-kuda
= 10 % \times $116,987 = 11,699$ kg
- 4) Beban P4 = P6
- a) Beban gording = Berat profil gording \times Panjang Gording
= $11 \times 2,5 = 27,5$ kg
- b) Beban atap = Luasan \times Berat atap
= $4,762 \times 50 = 238,1$ kg
- c) Beban kuda-kuda = $\frac{1}{2} \times$ Btg (11+21+22+12) \times berat profil kuda kuda
= $\frac{1}{2} \times (2,165 + 3,248 + 3,75 + 2,165) \times 25$
-



$$= 141,6 \text{ kg}$$

d) Beban plat sambung = 30 % × beban kuda-kuda

$$= 30 \% \times 141,6 = 42,48 \text{ kg}$$

e) Beban bracing = 10 % × beban kuda-kuda

$$= 10 \% \times 141,6 = 14,16 \text{ kg}$$

5) Beban P5

a) Beban gording = Berat profil gording × Panjang Gording

$$= 11 \times 1,5 = 16,5 \text{ kg}$$

b) Beban atap = Luasan × Berat atap

$$= 1,719 \times 50 = 85,95 \text{ kg}$$

c) Beban kuda-kuda = $\frac{1}{2} \times \text{Btg} (12 + 23 + 13) \times \text{berat profil kuda kuda}$

$$= \frac{1}{2} \times (2,165 + 4,330 + 2,165) \times 25$$

$$= 108,25 \text{ kg}$$

d) Beban plat sambung = 30 % × beban kuda-kuda

$$= 30 \% \times 108,25 = 32,475 \text{ kg}$$

e) Beban bracing = 10 % × beban kuda-kuda

$$= 10 \% \times 108,25 = 10,825 \text{ kg}$$

f) Beban reaksi = (2 . reaksi jurai) + reaksi $\frac{1}{2}$ kuda-kuda

$$= (2 \cdot 548,33 \text{ kg}) + 493,63 \text{ kg} = 1590,29 \text{ kg}$$

6) Beban P10 = P16

a) Beban plafon = Luasan × berat plafon

$$= 6,269 \times 18 = 112,842 \text{ kg}$$

b) Beban kuda-kuda = $\frac{1}{2} \times \text{Btg} (8 + 29 + 7) \times \text{berat profil kuda kuda}$

$$= \frac{1}{2} \times (1,875 + 1,083 + 1,875) \times 25$$

$$= 60,412 \text{ kg}$$

c) Beban plat sambung = 30 % × beban kuda-kuda

$$= 30 \% \times 60,412 = 18,124 \text{ kg}$$

d) Beban bracing = 10 % × beban kuda-kuda

$$= 10 \% \times 60,412 = 6,041 \text{ kg}$$



7) Beban P11 = P15

- a) Beban plafon = Luasan \times berat plafon
= $6,056 \times 18 = 109,008$ kg
- b) Beban kuda-kuda = $\frac{1}{2} \times$ Btg $(7+28+27+6) \times$ berat profil kuda kuda
= $\frac{1}{2} \times (1,875 + 2,165 + 2,165 + 1,875) \times 25$
= 101 kg
- c) Beban plat sambung = 30 % \times beban kuda-kuda
= 30 % \times 101 = 30,3 kg
- d) Beban bracing = 10 % \times beban kuda-kuda
= 10 % \times 101 = 10,1 kg

8) Beban P12 = P14

- a) Beban plafon = Luasan \times berat plafon
= $4,572 \times 18 = 82,296$ kg
- b) Beban kuda-kuda = $\frac{1}{2} \times$ Btg $(6+26+25+5) \times$ berat profil kuda kuda
= $\frac{1}{2} \times (1,875 + 2,864 + 3,248 + 1,875) \times 25$
= 123,275 kg
- c) Beban plat sambung = 30% \times beban kuda-kuda
= 30% \times 123,275 = 36,982 kg
- d) Beban bracing = 10% \times beban kuda-kuda
= 10% \times 123,275 = 12,327 kg

9) Beban P13

- a) Beban plafon = $(2 \times$ Luasan) \times berat plafon
= $2 \times 1,651 \times 18 = 59,436$ kg
- b) Beban kuda-kuda = $\frac{1}{2} \times$ Btg $(4+22+23+24+5) \times$ berat profil kuda-kuda
= $\frac{1}{2} \times (1,875 + 3,750 + 4,330 + 3,750 + 1,875) \times 25$
= 194,75 kg
- c) Beban plat sambung = 30 % \times beban kuda-kuda
= 30 % \times 194,75 = 58,425 kg
- d) Beban bracing = 10 % \times beban kuda-kuda
= 10 % \times 194,75 = 19,475 kg



$$\begin{aligned} \text{e) Beban reaksi} &= (2 \times \text{reaksi jurai}) + \text{reaksi } \frac{1}{2} \text{ kuda-kuda} \\ &= (2 \times 1042,34 \text{ kg}) + 904,56 \text{ kg} = 2989,24 \text{ kg} \end{aligned}$$

Tabel 3.18. Rekapitulasi Beban Mati Kuda-kuda Utama

Beban	Beban Atap (kg)	Beban gording (kg)	Beban Kuda - kuda (kg)	Beban Bracing (kg)	Beban Plat Penyambung (kg)	Beban Plafon (kg)	Beban Reaksi (kg)	Jumlah Beban (kg)	Input SAP (kg)
P1=P9	343,60	38,313	50,5	5,05	15,5	58,734	-	511,697	512
P2=P8	276,55	38,313	94,725	9,472	28,417	-	-	447,477	448
P3=P7	447,35	38,313	116,987	11,699	35,096	-	-	649,445	650
P4=P6	238,10	27,5	141,60	14,16	42,48	-	-	463,84	464
P5	85,95	16,5	108,25	10,825	32,475	-	1590,29	1844,29	1845
P10=P16	-	-	60,412	6,041	18,124	112,842	-	197,419	198
P11=P15	-	-	101	10,1	30,3	109,008	-	250,408	251
P12=P14	-	-	123,275	12,327	36,982	82,296	-	254,88	255
P13	-	-	194,75	19,475	58,425	59,436	2989,24	3321,326	3322

b. Beban Hidup

Beban hidup yang bekerja pada P1, P2, P3, P4, P6, P7, P8, P9 = 100 kg



- 2) Koefisien angin hisap = - 0,40
- $W_6 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 1,719 \times -0,4 \times 25 = -17,19 \text{ kg}$
 - $W_7 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 4,762 \times -0,4 \times 25 = -47,62 \text{ kg}$
 - $W_8 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 6,305 \times -0,4 \times 25 = -63,05 \text{ kg}$
 - $W_9 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 5,531 \times -0,4 \times 25 = -55,31 \text{ kg}$
 - $W_{10} = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 6,872 \times -0,4 \times 25 = -68,72 \text{ kg}$

Tabel 3.19. Perhitungan Beban Angin Kuda-kuda Utama

Beban Angin	Beban (kg)	W_x $W.Cos \alpha$ (kg)	(Untuk Input SAP2000)	W_y $W.Sin \alpha$ (kg)	(Untuk Input SAP2000)
W_1	34,36	29,757	30	17,18	18
W_2	27,655	23,950	24	13,827	14
W_3	31,525	27,301	28	15,762	16
W_4	23,81	20,620	21	11,905	12
W_5	8,595	7,443	8	4,297	5
W_6	-17,19	-14,887	-15	-8,595	-9
W_7	-47,62	-41,240	-42	-23,81	-24
W_8	-63,05	-54,603	-55	-31,525	-32
W_9	-55,31	-47,900	-48	-27,655	-28
W_{10}	-68,72	-59,513	-60	-34,36	-35



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

Tabel 3.20. Rekapitulasi Gaya Batang Kuda-kuda Utama

Batang	kombinasi	
	Tarik (+) kg	Tekan(+) kg
1	12034,52	
2	12080,78	
3	11285,92	
4	10111,86	
5	10055,34	
6	11165,97	
7	11905,47	
8	11857,98	
9		13963,85
10		13093,07
11		11782,01
12		10471,57
13		10485,46
14		11788,74
15		13102,70
16		13974,92
17	183,74	
18		912,81
19	909,93	
20		1781,07
21	1768,79	
22		2196,27
23	7895,51	
24		2083,87
25	1697,08	
26		1685,08



27	877,40	
28		849,64
29	185,12	

3.7.4. Perencanaan Profil Kuda-kuda

a. Perhitungan Profil Batang Tarik

$$P_{maks.} = 12080,78 \text{ kg}$$

$$F_y = 2400 \text{ kg/cm}^2 \text{ (240 MPa)}$$

$$F_u = 3700 \text{ kg/cm}^2 \text{ (370 MPa)}$$

$$A_g \text{ perlu} = \frac{P_{mak}}{F_y} = \frac{12080,78}{2400} = 5,03 \text{ cm}^2$$

Dicoba, menggunakan baja profil $\perp 70 \cdot 70 \cdot 7$

Dari tabel baja didapat data-data =

$$A_g = 9,40 \text{ cm}^2$$

$$\bar{x} = 2,12 \text{ cm}$$

$$A_n = 2 \cdot A_g - dt$$

$$= 1880 - 20 \cdot 7 = 1740 \text{ mm}^2$$

L = Sambungan dengan Diameter

$$= 3 \cdot 12,7 = 38,1 \text{ mm}$$

$$\bar{x} = 21,2 \text{ mm}$$

$$U = 1 - \frac{\bar{x}}{L}$$

$$= 1 - \frac{21,2}{38,1} = 0,444$$

$$A_e = U \cdot A_n$$



$$= 0,444.1740$$

$$= 772,56 \text{ mm}^2$$

Check kekuatan nominal

$$\phi P_n = 0,75 \cdot A_e \cdot F_u$$

$$= 0,75 \cdot 772,56 \cdot 370$$

$$= 214385,4 \text{ N}$$

$$= 21438,54 \text{ kg} > 12080,78 \text{ kg} \dots \text{OK}$$

e. Perhitungan profil batang tekan

$$P_{\text{maks.}} = 13974,92 \text{ kg}$$

$$l_k = 2,165 \text{ m} = 216,5 \text{ cm}$$

$$A_g \text{ perlu} = \frac{P_{\text{mak}}}{F_y} = \frac{13974,92}{2400} = 5,82 \text{ cm}^2$$

Dicoba, menggunakan baja profil $\perp 70 \cdot 70 \cdot 7$ ($A_g = 9,40 \text{ cm}^2$)

Periksa kelangsingan penampang :

$$\frac{b}{2 \cdot t_w} < \frac{200}{\sqrt{F_y}} = \frac{70}{9} < \frac{200}{\sqrt{240}}$$

$$= 7,78 < 12,9$$

$$\lambda = \frac{K \cdot L}{r} = \frac{1.216,5}{2,12}$$

$$= 102,12$$



$$\lambda_c = \frac{\lambda}{\pi} \sqrt{\frac{F_y}{E}}$$

$$= \frac{102,12}{3,14} \sqrt{\frac{240}{200000}}$$

$$= 1,13 \dots 0,25 < \lambda_c < 1,2 \longrightarrow \omega = \frac{1,43}{1,6 - 0,67\lambda_c}$$

$$\omega = \frac{1,43}{1,6 - 0,67\lambda_c} = \frac{1,43}{1,6 - 0,67 \cdot 1,13}$$

$$= 1,697$$

$$P_n = 2 \cdot A_g \cdot F_{cr}$$

$$= 2 \cdot 9,40 \cdot \frac{2400}{1,697}$$

$$= 26588,097$$

$$\frac{P}{\phi P_n} = \frac{13974,92}{0,85 \cdot 26588,097}$$

$$= 0,618 < 1 \dots \dots \dots \text{OK}$$

3.3.5. Perhitungan Alat Sambung

a. Batang Tekan

Digunakan alat sambung baut-mur.

Diameter baut (\varnothing) = 12,7 mm (1/2 inches)

Diameter lubang = 14 mm.

$$\begin{aligned} \text{Tebal pelat sambung } (\delta) &= 0,625 \cdot d_b \\ &= 0,625 \cdot 12,7 = 7,94 \text{ mm.} \end{aligned}$$

Menggunakan tebal plat 8 mm

➤ Tahanan geser baut

$$P_n = m \cdot (0,4 \cdot f^{ub}) \cdot A_n$$



$$= 2 \cdot (0,4 \cdot 825) \cdot \frac{1}{4} \cdot \pi \cdot 12,7^2 = 8356,43 \text{ kg/baut}$$

- Tahanan tarik penyambung

$$P_n = 0,75 \cdot f^{ub} \cdot A_n$$

$$= 7833,9 \text{ kg/baut}$$

- Tahanan Tumpu baut :

$$P_n = 0,75 (2,4 \cdot f_u \cdot d_b \cdot t)$$

$$= 0,75 (2,4 \cdot 370 \cdot 12,7 \cdot 9)$$

$$= 7612,38 \text{ kg/baut}$$

P yang menentukan adalah $P_{tumpu} = 7612,38 \text{ kg}$.

Perhitungan jumlah baut-mur,

$$n = \frac{P_{maks.}}{P_{geser}} = \frac{13974,92}{7612,38} = 1,83 \sim 2 \text{ buah baut}$$

Digunakan : 2 buah baut

Perhitungan jarak antar baut :

- a) $3d \leq S \leq 15t$ atau 200 mm

$$\text{Diambil, } S_1 = 3 d_b = 3 \cdot 12,7$$

$$= 38,1 \text{ mm} = 40 \text{ mm}$$

- b) $1,5 d \leq S_2 \leq (4t + 100)$ atau 200 mm

$$\text{Diambil, } S_2 = 1,5 d_b = 1,5 \cdot 12,7$$

$$= 19,05 \text{ mm}$$

$$= 20 \text{ mm}$$

b. Batang tarik

Digunakan alat sambung baut-mur.

Diameter baut (\varnothing) = 12,7 mm ($\frac{1}{2}$ inches)

Diameter lubang = 13,7 mm.

$$\text{Tebal pelat sambung } (\delta) = 0,625 \cdot d_b$$

$$= 0,625 \times 12,7 = 7,94 \text{ mm.}$$

Menggunakan tebal plat 8 mm

- Tahanan geser baut

$$P_n = n \cdot (0,4 \cdot f^{ub}) \cdot A_n$$

$$= 2 \cdot (0,4 \cdot 825) \cdot \frac{1}{4} \cdot \pi \cdot 12,7^2 = 8356,43 \text{ kg/baut}$$

- Tahanan tarik penyambung



$$P_n = 0,75 \cdot f^{ub} \cdot A_n$$

$$= 7833,9 \text{ kg/baut}$$

➤ Tahanan Tumpu baut :

$$P_n = 0,75 (2,4 \cdot f_u \cdot d_b \cdot t)$$

$$= 0,75 (2,4 \cdot 370 \cdot 12,7 \cdot 9)$$

$$= 7612,38 \text{ kg/baut}$$

P yang menentukan adalah $P_{tumpu} = 7612,38 \text{ kg}$.

Perhitungan jumlah baut-mur,

$$n = \frac{P_{maks.}}{P_{geser}} = \frac{12080,78}{7612,38} = 1,58 \sim 2 \text{ buah baut}$$

Digunakan : 2 buah baut

Perhitungan jarak antar baut :

a) $3d \leq S \leq 15t$ atau 200 mm

$$\text{Diambil, } S_1 = 3 d_b = 3 \cdot 12,7$$

$$= 38,1 \text{ mm}$$

$$= 40 \text{ mm}$$

b) $1,5 d \leq S_2 \leq (4t + 100)$ atau 200 mm

$$\text{Diambil, } S_2 = 1,5 d_b = 1,5 \cdot 12,7$$

$$= 19,05 \text{ mm}$$

$$= 20 \text{ mm}$$

Tabel 3.21. Rekapitulasi Perencanaan Profil Kuda-kuda Utama

Nomer Batang	Dimensi Profil	Baut (mm)
1	┴ 70. 70. 7	2 Ø 12,7
2	┴ 70. 70. 7	2 Ø 12,7
3	┴ 70. 70. 7	2 Ø 12,7
4	┴ 70. 70. 7	2 Ø 12,7
5	┴ 70. 70. 7	2 Ø 12,7
6	┴ 70. 70. 7	2 Ø 12,7
7	┴ 70. 70. 7	2 Ø 12,7

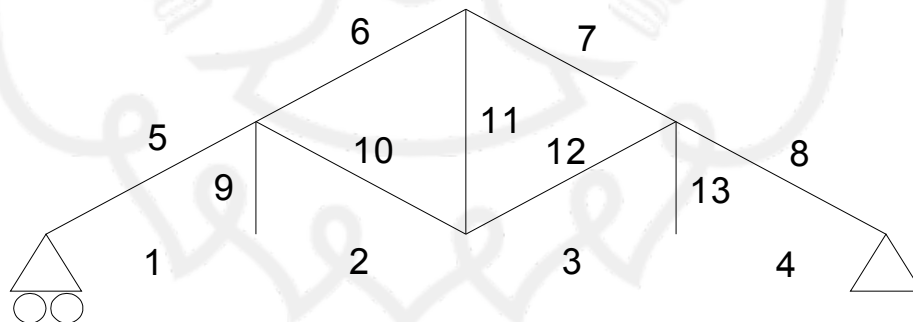


8	⊥ 70. 70. 7	2 Ø 12,7
9	⊥ 70. 70. 7	2 Ø 12,7
10	⊥ 70. 70. 7	2 Ø 12,7
11	⊥ 70. 70. 7	2 Ø 12,7
12	⊥ 70. 70. 7	2 Ø 12,7
13	⊥ 70. 70. 7	2 Ø 12,7
14	⊥ 70. 70. 7	2 Ø 12,7
15	⊥ 70. 70. 7	2 Ø 12,7
16	⊥ 70. 70. 7	2 Ø 12,7
17	⊥ 70. 70. 7	2 Ø 12,7
18	⊥ 70. 70. 7	2 Ø 12,7
19	⊥ 70. 70. 7	2 Ø 12,7
20	⊥ 70. 70. 7	2 Ø 12,7
21	⊥ 70. 70. 7	2 Ø 12,7
22	⊥ 70. 70. 7	2 Ø 12,7
23	⊥ 70. 70. 7	2 Ø 12,7
24	⊥ 70. 70. 7	2 Ø 12,7
25	⊥ 70. 70. 7	2 Ø 12,7
26	⊥ 70. 70. 7	2 Ø 12,7
27	⊥ 70. 70. 7	2 Ø 12,7
28	⊥ 70. 70. 7	2 Ø 12,7
29	⊥ 70. 70. 7	2 Ø 12,7



3.6. Perencanaan Kuda-kuda Utama B (KK B)

3.7.5. Perhitungan Panjang Batang Kuda-kuda B



Gambar 3.17. Panjang batang kuda-kuda B

Perhitungan panjang batang selanjutnya disajikan dalam tabel dibawah ini :

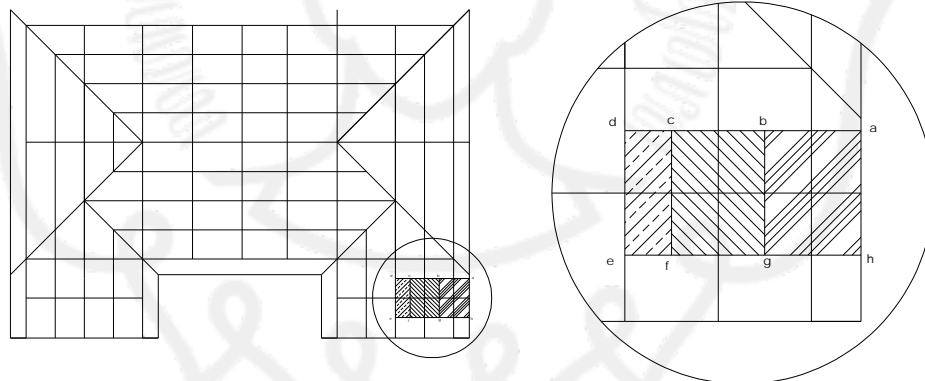
Tabel 3.17. Perhitungan Panjang Batang Pada Kuda-kuda Utama (KKB)

No batang	Panjang batang (m)
-----------	--------------------



1	1,875
2	1,875
3	1,875
4	1,875
5	2,165
6	2,165
7	2,165
8	2,165
9	1,083
10	2,165
11	2,165
12	2,165
13	1,083

3.6.2 Perhitungan Luasan Setengah Kuda-Kuda Utama B



Gambar 3.18. Luasan Atap Kuda-kuda B

Panjang de, cf, bg, ah = 2,5 m

Panjang ef = 0,937 m

Panjang fg = 1,875 m

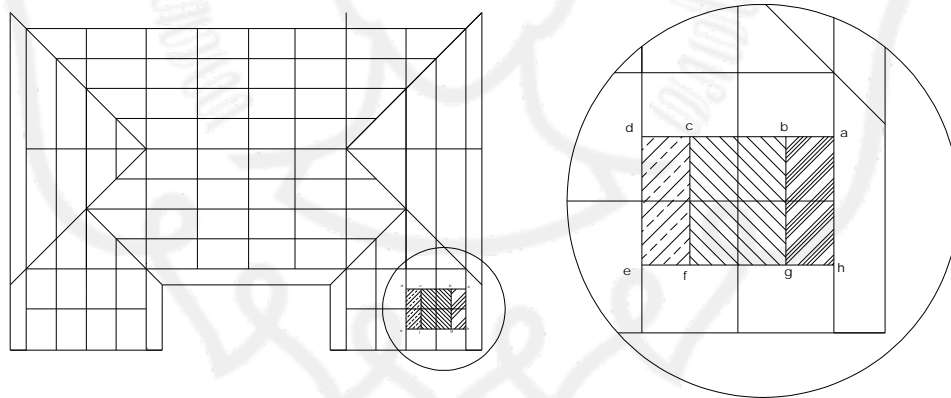
Panjang gh = 1,937 m



$$\text{Luas decf} = de \times ef = 2,5 \times 0,937 = 2,34 \text{ m}^2$$

$$\begin{aligned} \text{Luas cfgb} &= cf \times fg \\ &= 2,5 \times 1,875 = 4,69 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \text{Luas bggh} &= bg \times gh \\ &= 2,5 \times 1,937 = 4,84 \text{ m}^2 \end{aligned}$$



Gambar 3.19. Luasan Plafon Kuda-kuda B

Panjang de, cf, bg, ah = 2,5 m

Panjang ef = 0,9 m



$$\text{Panjang fg} = 1,8 \text{ m}$$

$$\text{Panjang gh} = 0,9 \text{ m}$$

$$\text{Luas decf} = de \times ef = 2,5 \times 0,9 = 2,25 \text{ m}^2$$

$$\begin{aligned} \text{Luas cfgb} &= cf \times fg \\ &= 2,5 \times 1,8 = 4,5 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \text{Luas bgha} &= bg \times gh \\ &= 2,5 \times 0,9 = 2,25 \text{ m}^2 \end{aligned}$$

3.6.3. Perhitungan Pembebanan Kuda-kuda Utama B

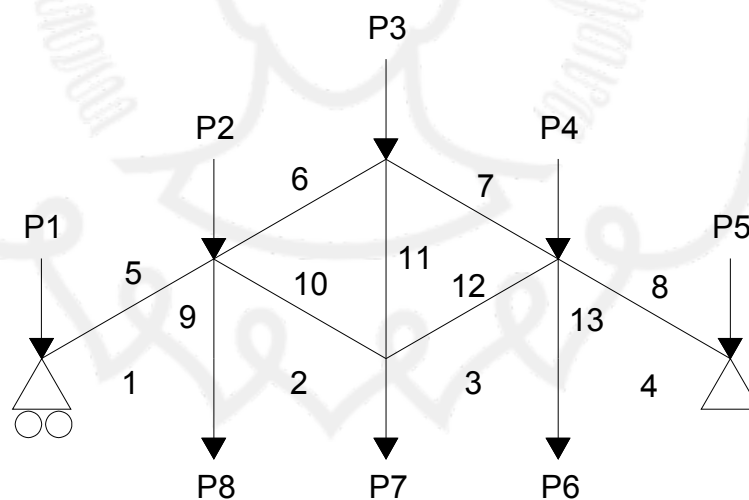
Data-data pembebanan :

$$\text{Berat gording} = 11 \text{ kg/m}$$

$$\text{Jarak antar kuda-kuda utama} = 3,00 \text{ m}$$

$$\text{Berat penutup atap} = 50 \text{ kg/m}^2$$

$$\text{Berat profil} = 25 \text{ kg/m}$$



Gambar 3.20.. Pembebanan Kuda- kuda utama akibat beban mati

Perhitungan Beban

➤ Beban Mati



-
- 1) Beban $P_1 = P_5$
- a) Beban gording = Berat profil gording x panjang gording
= $11 \times 2,5 = 27,5$ kg
 - b) Beban atap = Luasan atap **bg_{ha}** x Berat atap
= $2,34 \times 50 = 117$ kg
 - c) Beban kuda-kuda = $\frac{1}{2} \times Btg (5 + 1) \times$ berat profil kuda kuda
= $\frac{1}{2} \times (2,165 + 1,875) \times 25 = 50,5$ kg
 - d) Beban plat sambung = 30% x beban kuda-kuda
= $0,3 \times 50,5 = 15,15$ kg
 - e) Beban bracing = 10% x beban kuda-kuda
= $0,1 \times 50,5 = 5,05$ kg
 - f) Beban plafon = Luasan x berat plafon
= $2,25 \times 18 = 40,5$ kg
- 2) Beban $P_2 = P_4$
- a) Beban gording = Berat profil gording x panjang gording
= $11 \times 2,5 = 27,5$ kg
 - b) Beban atap = Luasan atap **cf_{gb}** x berat atap
= $4,69 \times 50 = 234,5$ kg
 - c) Beban kuda-kuda = $\frac{1}{2} \times Btg(5 + 9 + 6 + 10) \times$ berat profil kuda kuda
= $\frac{1}{2} \times (2,165 + 1,083 + 2,165 + 2,165) \times 25$
= $94,72$ kg
 - d) Beban plat sambung = 30% x beban kuda-kuda
= $0,3 \times 94,72 = 28,42$ kg
 - e) Beban bracing = 10% x beban kuda-kuda
= $0,1 \times 94,72 = 9,47$ kg
- 3) Beban P_3
- a) Beban gording = Berat profil gording x panjang gording
= $11 \times 2,5 = 27,5$ kg
-



- b) Beban atap = Luasan atap **bg_{ha}** x berat atap
= 4,84 x 50 = 242 kg
- c) Beban kuda-kuda = $\frac{1}{2}$ x Btg (6 + 11 + 7) x berat profil kuda kuda
= $\frac{1}{2}$ x (2,165+2,165+2,165) x 25 = 81,19 kg
- d) Beban plat sambung = 30% x beban kuda-kuda
= 0,3 x 81,19 = 24,36 kg
- e) Beban bracing = 10% x beban kuda-kuda
= 0,1 x 81,19 = 8,12 kg
- 4) Beban P₆ = P₈
- a) Beban kuda-kuda = $\frac{1}{2}$ x Btg(3 +13 + 4) x berat profil kuda kuda
= $\frac{1}{2}$ x (1,875 + 1,083 + 1,875) x 25
= 60,41 kg
- b) Beban plat sambung = 30% x beban kuda-kuda
= 0,3 x 60,41 = 18,12 kg
- c) Beban bracing = 10% x beban kuda-kuda
= 0,1 x 60,41 = 6,04 kg
- d) Beban Plafon = Luasan plafon x berat plafon
= 2,25 x 18 = 40,5 kg
- 5) Beban P₇
- a) Beban kuda-kuda = $\frac{1}{2}$ x Btg (2+10+11+12+3) x berat profil kuda kuda
= $\frac{1}{2}$ x (1,875+2,165+2,165 +2,165+1,875) x 25
= 128,06 kg
- b) Beban plat sambung = 30% x beban kuda-kuda
= 0,3 x 128,06 = 38,42 kg
- c) Beban bracing = 10% x beban kuda-kuda
= 0,1 x 128,06 = 12,81 kg
- d) Beban Plafon = Luasan plafon x berat plafon
= 2,25 x 18 = 40,5 kg

Tabel 3.18. Rekapitulasi Beban Mati

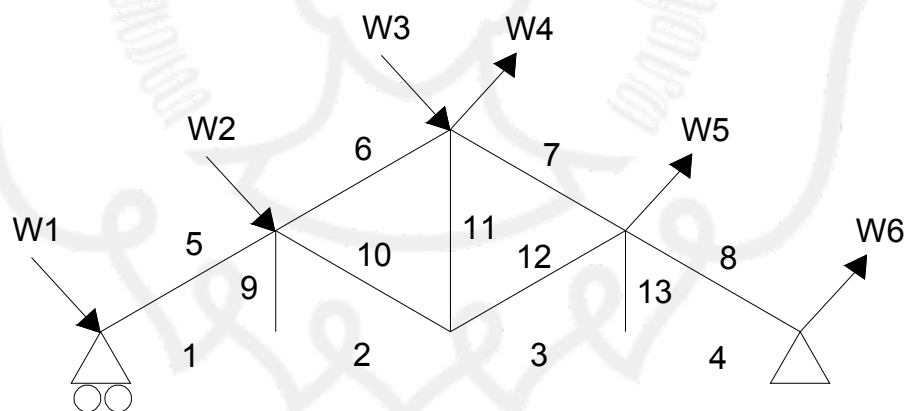
Beban	Beban Atap (kg)	Beban gording (kg)	Beban Kuda - kuda (kg)	Beban Bracing (kg)	Beban Plat Penyambung (kg)	Beban Plafon (kg)	Jumlah Beban (kg)	Input SAP (kg)
$P_1=P_5$	117	27,5	50,5	5,05	15,15	40,5	255,7	256
$P_2=P_4$	234,5	27,5	94,72	9,47	28,42	-	394,61	395
P_3	242	27,5	81,19	8,12	24,36	-	383,17	384
$P_6=P_8$	-	-	60,41	6,04	18,12	40,5	125,07	126
P_7	-	-	128,06	12,81	38,42	40,5	219,79	220

➤ **Beban Hidup**

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

➤ **Beban Angin**

Perhitungan beban angin :



Gambar 3.21. Pembebanan kuda-kuda utama B akibat beban angin

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



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

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

$$= 4,84 \times 0,2 \times 25$$

$$= 24,2 \text{ kg}$$

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

$$= 4,69 \times 0,2 \times 25$$

$$= 23,45 \text{ kg}$$

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

$$= 2,34 \times 0,2 \times 25$$

$$= 11,7 \text{ kg}$$

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

$$a) W_4 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$$

$$= 2,34 \times -0,4 \times 25$$

$$= -23,4 \text{ kg}$$

$$b) W_5 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$$

$$= 4,69 \times -0,4 \times 25$$

$$= -46,9 \text{ kg}$$

$$c) W_6 = \text{luasan} \times \text{koef. angin tekan} \times \text{beban angin}$$

$$= 4,84 \times -0,4 \times 25$$

$$= -48,4 \text{ kg}$$

Tabel 3.19. Perhitungan Beban Angin

Beban Angin	Beban (kg)	W _x W.Cos α (kg)	(Untuk Input SAP2000)	W _y W.Sin α (kg)	(Untuk Input SAP2000)
W ₁	24,2	20,988	21	12,100	13
W ₂	23,45	20,308	21	11,725	12
W ₃	11,7	10,132	11	5,85	6
W ₄	-23,4	20,265	21	11,7	12
W ₅	-46,9	40,616	41	23,45	24
W ₆	-48,4	41,916	42	24,2	25



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

Tabel 3.20. Rekapitulasi Gaya Batang Kuda-kuda Utama

Batang	kombinasi	
	Tarik (+) kg	Tekan(-) Kg
1	2510,04	-
2	2506,69	-
3	2506,69	-
4	2510,04	-
5	-	2915,04
6	-	2032,93
7	-	2032,93
8	-	2915,04
9	191,09	-
10	-	878,06
11	1315,39	-
12	-	879,06



13	191,09	-
----	--------	---

3.6.4. Perencanaan Profil Kuda-kuda

a. Perhitungan profil batang tarik

$$P_{maks.} = 2510,04 \text{ kg}$$

$$F_y = 2400 \text{ kg/cm}^2 \text{ (240 MPa)}$$

$$F_u = 3700 \text{ kg/cm}^2 \text{ (370 MPa)}$$

$$A_g \text{ perlu} = \frac{P_{mak}}{F_y} = \frac{2510,04}{2400} = 1,05 \text{ cm}^2$$

Dicoba, menggunakan baja profil **┘ 55 . 55 . 8**

Dari tabel baja didapat data-data =

$$A_g = 8,23 \text{ cm}^2$$

$$\bar{x} = 1,64 \text{ cm}$$

$$A_n = 2.A_g - dt$$

$$= 1646 - 17.8 = 1510 \text{ mm}^2$$

L = Sambungan dengan Diameter

$$= 3.12,7 = 38,1 \text{ mm}$$

$$\bar{x} = 16,4 \text{ mm}$$



$$U = 1 - \frac{\bar{x}}{L}$$

$$= 1 - \frac{16,4}{38,1} = 0,569$$

$$A_e = U \cdot A_n$$

$$= 0,569 \cdot 1510$$

$$= 859,19 \text{ mm}^2$$

Check kekuatan nominal

$$\phi P_n = 0,75 \cdot A_e \cdot F_u$$

$$= 0,75 \cdot 859,19 \cdot 370$$

$$= 238425,2 \text{ N}$$

$$= 23842,52 \text{ kg} > 5173,44 \text{ kg} \dots \text{OK}$$

f. Perhitungan profil batang tekan

$$P_{\text{maks.}} = 2915,04 \text{ kg}$$

$$l_k = 2,31 \text{ m} = 231 \text{ cm}$$

$$A_g \text{ perlu} = \frac{P_{\text{mak}}}{F_y} = \frac{2915,04}{2400} = 1,21 \text{ cm}^2$$

Dicoba, menggunakan baja profil $\perp 55 \cdot 55 \cdot 8$ ($A_g = 8,23 \text{ cm}^2$)

Periksa kelangsingan penampang :



$$\frac{b}{2.t_w} < \frac{200}{\sqrt{F_y}} = \frac{55}{8} < \frac{200}{\sqrt{240}}$$

$$= 6,87 < 12,9$$

$$\lambda = \frac{K.L}{r} = \frac{1.231}{1,64}$$

$$= 140,85$$

$$\lambda_c = \frac{\lambda}{\pi} \sqrt{\frac{F_y}{E}}$$

$$= \frac{140,85}{3,14} \sqrt{\frac{240}{200000}}$$

$$= 1,55 \dots \dots \lambda_c \geq 1,2 \quad \longrightarrow \quad \omega = 1,25 \cdot \lambda_c^2$$

$$\omega = 1,25 \cdot \lambda_c^2 = 1,25 \cdot (1,55^2)$$

$$= 3$$

$$P_n = 2 \cdot A_g \cdot F_{cr}$$

$$= 2 \cdot 8,23 \cdot \frac{2400}{3}$$

$$= 13168$$

$$\frac{P}{\phi P_n} = \frac{6117,22}{0,85 \cdot 13168}$$

$$= 0,546 < 1 \dots \dots \dots \text{OK}$$



3.3.5. Perhitungan Alat Sambung

a. Batang Tekan

Digunakan alat sambung baut-mur.

Diameter baut (\varnothing) = 12,7 mm ($\frac{1}{2}$ inches)

Diameter lubang = 14 mm.

$$\begin{aligned} \text{Tebal pelat sambung } (\delta) &= 0,625 \cdot d_b \\ &= 0,625 \cdot 12,7 = 7,94 \text{ mm.} \end{aligned}$$

Menggunakan tebal plat 8 mm

➤ Tahanan geser baut

$$\begin{aligned} P_n &= m \cdot (0,4 \cdot f^{ub}) \cdot A_n \\ &= 2 \cdot (0,4 \cdot 825) \cdot \frac{1}{4} \cdot \pi \cdot 12,7^2 = 8356,43 \text{ kg/baut} \end{aligned}$$

➤ Tahanan tarik penyambung

$$\begin{aligned} P_n &= 0,75 \cdot f^{ub} \cdot A_n \\ &= 7833,9 \text{ kg/baut} \end{aligned}$$

➤ Tahanan Tumpu baut :

$$\begin{aligned} P_n &= 0,75 (2,4 \cdot f_u \cdot d_b \cdot t) \\ &= 0,75 (2,4 \cdot 370 \cdot 12,7 \cdot 9) \\ &= 7612,38 \text{ kg/baut} \end{aligned}$$

P yang menentukan adalah $P_{\text{tumpu}} = 7612,38 \text{ kg}$.

Perhitungan jumlah baut-mur,

$$n = \frac{P_{\text{maks.}}}{P_{\text{geser}}} = \frac{6117,22}{7612,38} = 0,803 \sim 2 \text{ buah baut}$$

Digunakan : 2 buah baut

Perhitungan jarak antar baut :

a) $3d \leq S \leq 15t$ atau 200 mm

$$\begin{aligned} \text{Diambil, } S_1 &= 3 d_b = 3 \cdot 12,7 \\ &= 38,1 \text{ mm} = 40 \text{ mm} \end{aligned}$$

b) $1,5 d \leq S_2 \leq (4t + 100)$ atau 200 mm

$$\begin{aligned} \text{Diambil, } S_2 &= 1,5 d_b = 1,5 \cdot 12,7 \\ &= 19,05 \text{ mm} = 20 \text{ mm} \end{aligned}$$



b. Batang tarik

Digunakan alat sambung baut-mur.

Diameter baut (\varnothing) = 12,7 mm ($\frac{1}{2}$ inches)

Diameter lubang = 13,7 mm.

Tebal pelat sambung (δ) = $0,625 \cdot d_b$
 $= 0,625 \times 12,7 = 7,94$ mm.

Menggunakan tebal plat 8 mm

➤ Tahanan geser baut

$$P_n = n \cdot (0,4 \cdot f^{ub}) \cdot A_n$$

$$= 2 \cdot (0,4 \cdot 825) \cdot \frac{1}{4} \cdot \pi \cdot 12,7^2 = 8356,43 \text{ kg/baut}$$

➤ Tahanan tarik penyambung

$$P_n = 0,75 \cdot f^{ub} \cdot A_n$$

$$= 7833,9 \text{ kg/baut}$$

➤ Tahanan Tumpu baut :

$$P_n = 0,75 (2,4 \cdot f_u \cdot d_b t)$$

$$= 0,75 (2,4 \cdot 370 \cdot 12,7 \cdot 9)$$

$$= 7612,38 \text{ kg/baut}$$

P yang menentukan adalah $P_{tumpu} = 7612,38$ kg.

Perhitungan jumlah baut-mur,

$$n = \frac{P_{maks.}}{P_{geser}} = \frac{5173,44}{7612,38} = 0,679 \sim 2 \text{ buah baut}$$

Digunakan : 2 buah baut

Perhitungan jarak antar baut :

a) $3d \leq S \leq 15t$ atau 200 mm

$$\text{Diambil, } S_1 = 3 d_b = 3 \cdot 12,7$$

$$= 38,1 \text{ mm}$$

$$= 40 \text{ mm}$$

b) $1,5 d \leq S_2 \leq (4t + 100)$ atau 200 mm

$$\text{Diambil, } S_2 = 1,5 d_b = 1,5 \cdot 12,7$$

$$= 19,05 \text{ mm}$$

$$= 20 \text{ mm}$$

Tabel 3.21. Rekapitulasi Perencanaan Profil Kuda-kuda



Nomer Batang	Dimensi Profil	Baut (mm)
1	┴ 55 . 55 . 8	2 Ø 12,7
2	┴ 55 . 55 . 8	2 Ø 12,7
3	┴ 55 . 55 . 8	2 Ø 12,7
4	┴ 55 . 55 . 8	2 Ø 12,7
5	┴ 55 . 55 . 8	2 Ø 12,7
6	┴ 55 . 55 . 8	2 Ø 12,7
7	┴ 55 . 55 . 8	2 Ø 12,7
8	┴ 55 . 55 . 8	2 Ø 12,7
9	┴ 55 . 55 . 8	2 Ø 12,7
10	┴ 55 . 55 . 8	2 Ø 12,7
11	┴ 55 . 55 . 8	2 Ø 12,7
12	┴ 55 . 55 . 8	2 Ø 12,7
13	┴ 55 . 55 . 8	2 Ø 12,7

BAB 4 PERENCANAAN TANGGA

4.1 Uraian Umum

Tangga merupakan bagian dari struktur bangunan bertingkat yang sangat penting untuk penunjang antara struktur bangunan dasar dengan struktur bangunan tingkat atasnya. Penempatan tangga pada struktur suatu bangunan sangat berhubungan dengan fungsi bangunan bertingkat yang akan dioperasikan .

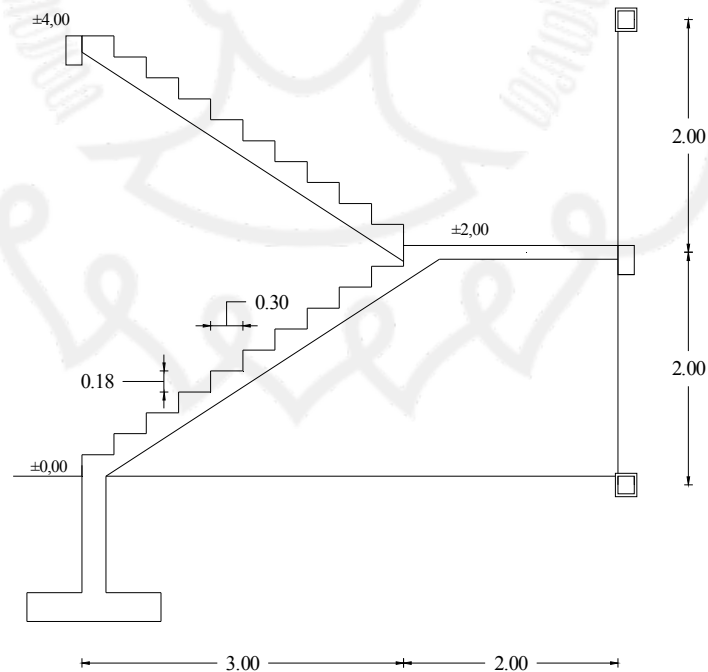
Pada bangunan umum, penempatan haruslah mudah diketahui dan terletak strategis untuk menjangkau ruang satu dengan yang lainnya, penempatan tangga harus



disesuaikan dengan fungsi bangunan untuk mendukung kelancaran hubungan yang serasi antara pemakai bangunan tersebut.

4.2. Data Perencanaan Tangga

Gambar 4.1 Perencanaan Tangga



Gambar 4.2 Potongan Tangga

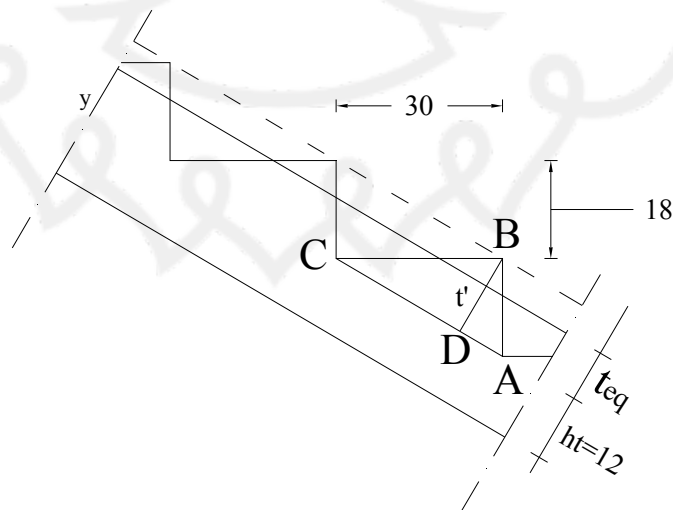


Data-data perencanaan tangga:

Tebal plat tangga	= 12 cm
Tebal bordes tangga	= 15 cm
Lebar datar	= 500 cm
Lebar tangga rencana	= 140 cm
Dimensi bordes	= 200 x 300 cm
Lebar antrede	= 30 cm
Tinggi optrede	= 18 cm
Antrede	= $300 / 30 = 10$ buah
Optrede	= $10 + 1 = 11$ buah
$\alpha = \text{Arc.tg} (200/300)$	= $33,69^\circ < 35^\circ \dots\dots(\text{ok})$

4.3. Perhitungan Tebal Plat Equivalen dan Pembebanan

4.3.1. Perhitungan Tebal Plat Equivalen



Gambar 4.3 Tebal Equivalen



$$\frac{BD}{AB} = \frac{BC}{AC}$$

$$\begin{aligned} BD &= \frac{AB \times BC}{AC} \\ &= \frac{18 \times 30}{\sqrt{(18)^2 + (30)^2}} \\ &= 15,43 \text{ cm} \end{aligned}$$

$$\begin{aligned} t_{eq} &= 2/3 \times BD \\ &= 2/3 \times 15,43 \\ &= 10,29 \text{ cm} \end{aligned}$$

Jadi total equivalent plat tangga :

$$\begin{aligned} Y &= t_{eq} + ht \\ &= 10,29 + 12 \\ &= 22,29 \text{ cm} \\ &= 0,23 \text{ m} \end{aligned}$$

4.3.2. Perhitungan Beban

a. Pembebanan tangga (tabel 2 . 1 PPIUG 1983)

1. Akibat beban mati (q_D)

Berat tegel keramik(1 cm)	= 0,01 x 1,4 x 2400	= 33,6 kg/m
Berat spesi (2 cm)	= 0,02 x 1,4 x 2100	= 58,8 kg/m
Berat plat tangga	= 0,23 x 1,4 x 2400	= 772,8 kg/m
Berat sandaran tangga	= 0,7 x 0,1 x 1000 x 1	= 70 kg/m
		$q_D = 935,2 \text{ kg/m} +$

2. Akibat beban hidup (q_L)

$$\begin{aligned} q_L &= 1,40 \times 300 \text{ kg/m}^2 \\ &= 420 \text{ kg/m} \end{aligned}$$

3. Beban ultimate (q_U)

$$\begin{aligned} q_U &= 1,2 \cdot q_D + 1,6 \cdot q_L \\ &= 1,2 \cdot 935,2 + 1,6 \cdot 420 \end{aligned}$$



$$= 1794,24 \text{ kg/m}$$

b. Pembebanan pada bordes (tabel 2 . 1 PPIUG 1983)

1. Akibat beban mati (q_D)

Berat tegel keramik (1 cm)	$= 0,01 \times 3 \times 2400$	$= 72$	kg/m
Berat spesi (2 cm)	$= 0,02 \times 3 \times 2100$	$= 126$	kg/m
Berat plat bordes	$= 0,15 \times 3 \times 2400$	$= 1080$	kg/m
Berat sandaran tangga	$= 0,7 \times 0,1 \times 1000 \times 2$	$= 140$	$\text{kg/m} +$
		$q_D = 1418$	kg/m

2. Akibat beban hidup (q_L)

$$q_L = 3 \times 300 \text{ kg/m}^2$$

$$= 900 \text{ kg/m}$$

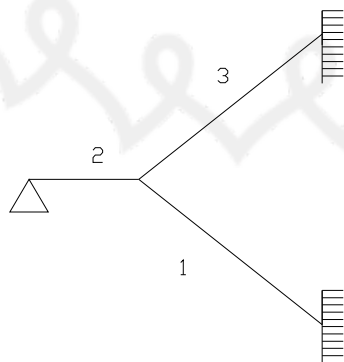
3. Beban ultimate (q_U)

$$q_U = 1,2 \cdot q_D + 1,6 \cdot q_L$$

$$= 1,2 \cdot 1418 + 1,6 \cdot 900$$

$$= 3141,6 \text{ kg/m}$$

Perhitungan analisa struktur tangga menggunakan Program SAP 2000 tumpuan di asumsikan jepit, sendi, jepit seperti pada gambar berikut :



Gambar 4.3 Rencana Tumpuan Tangga



4.4. Perhitungan Tulangan Tangga dan Bordes

4.4.1. Perhitungan Tulangan Tumpuan

$$b = 1400 \text{ mm}$$

$$h = 200 \text{ mm (tebal bordes)}$$

$$p \text{ (selimut beton)} = 30 \text{ mm}$$

Tulangan \emptyset 12 mm

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

$$= 200 - 30 - 6$$

$$= 164 \text{ mm}$$

Dari perhitungan **SAP 2000** diperoleh M_u :

$$M_u = 2053,45 \text{ kgm} = 2,0535 \cdot 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{2,0535 \cdot 10^7}{0,8} = 2,57 \cdot 10^7 \text{ Nmm}$$

$$m = \frac{f_y}{0,85 \cdot f_c} = \frac{240}{0,85 \cdot 25} = 11,29$$

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

$$= \frac{0,85 \cdot 25}{240} \cdot \beta \cdot \left(\frac{600}{600 + 240} \right)$$

$$= 0,053$$

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

$$= 0,75 \cdot 0,053$$

$$= 0,04$$

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

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{2,57 \cdot 10^7}{1400 \cdot (164)^2} = 0,68 \text{ N/mm}$$



$$\begin{aligned}\rho_{ada} &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot R_n}{f_y}} \right) \\ &= \frac{1}{11,29} \left(1 - \sqrt{1 - \frac{2 \cdot 11,29 \cdot 0,68}{240}} \right) \\ &= 0,003\end{aligned}$$

$$\rho_{ada} < \rho_{max}$$

$$\rho_{ada} > \rho_{min}$$

di pakai $\rho_{ada} = 0,003$

$$\begin{aligned}A_s &= \rho_{ada} \cdot b \cdot d \\ &= 0,003 \times 1400 \times 164 \\ &= 688,8 \text{ mm}^2\end{aligned}$$

$$\text{Dipakai tulangan } \varnothing 12 \text{ mm} = \frac{1}{4} \cdot \pi \times 12^2 = 113,04 \text{ mm}^2$$

$$\text{Jumlah tulangan} = \frac{688,8}{113,04} = 6,09 \approx 8 \text{ buah}$$

$$\text{Jarak tulangan 1 m} = \frac{1000}{8} = 125 \text{ mm}$$

Dipakai tulangan $\varnothing 12 \text{ mm} - 120 \text{ mm}$

$$\begin{aligned}\text{As yang timbul} &= 8,33 \cdot \frac{1}{4} \cdot \pi \cdot d^2 \\ &= 941,62 \text{ mm}^2 > A_s \dots\dots\dots \text{Aman !}\end{aligned}$$

4.4.2. Perhitungan Tulangan Lapangan

$$M_u = 981,27 \text{ kgm} = 0,9813 \cdot 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{0,9813 \cdot 10^7}{0,8} = 1,23 \cdot 10^7 \text{ Nmm}$$

$$m = \frac{f_y}{0,85 \cdot f_c} = \frac{240}{0,85 \cdot 25} = 11,29$$

$$\begin{aligned}\rho_b &= \frac{0,85 \cdot f_c}{f_y} \cdot \beta \cdot \left(\frac{600}{600 + f_y} \right) \\ &= \frac{0,85 \cdot 25}{240} \cdot \beta \cdot \left(\frac{600}{600 + 240} \right) \\ &= 0,053\end{aligned}$$

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



$$= 0,75 \cdot 0,053$$

$$= 0,04$$

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

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{1,23 \cdot 10^7}{1400 \cdot (164)^2} = 0,33 \text{ N/mm}^2$$

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

$$= \frac{1}{11,29} \left(1 - \sqrt{1 - \frac{2 \cdot 11,29 \cdot 0,33}{240}} \right)$$

$$= 0,0014$$

$$\rho_{\text{ada}} < \rho_{\min}$$

$$\rho_{\min} < \rho_{\max}$$

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

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

$$= 0,0025 \times 1400 \times 164$$

$$= 574 \text{ mm}^2$$

$$\text{Dipakai tulangan } \varnothing 12 \text{ mm} = \frac{1}{4} \cdot \pi \times 12^2 = 113,04 \text{ mm}^2$$

$$\text{Jumlah tulangan dalam 1 m} = \frac{574}{113,04} = 5,07 \approx 6 \text{ tulangan}$$

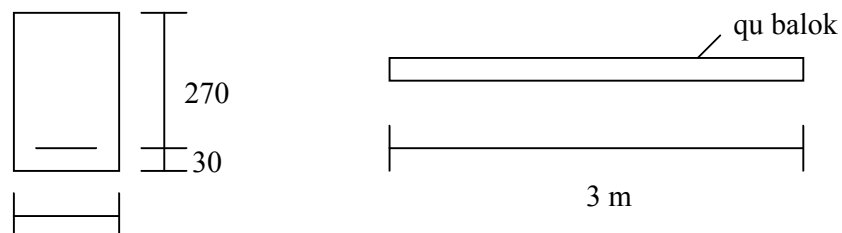
$$\text{Jarak tulangan 1 m} = \frac{1000}{6} = 166,67 \text{ mm}$$

Dipakai tulangan $\varnothing 12 \text{ mm} - 150 \text{ mm}$

$$\text{As yang timbul} = 6,67 \cdot \frac{1}{4} \times \pi \times d^2$$

$$= 753,98 \text{ mm}^2 > A_s \dots\dots\dots \text{aman!}$$

4.5. Perencanaan Balok Bordes





150

Data perencanaan:

$$h = 300 \text{ mm}$$

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

$$d' = 30 \text{ mm}$$

$$d = h - d' = 300 - 30 = 270 \text{ mm}$$

4.5.1. Pembebanan Balok Bordes

- Beban mati (q_D)

$$\text{Berat sendiri} = 0,15 \times 0,30 \times 2400 = 108 \text{ kg/m}$$

$$\text{Berat dinding} = 0,15 \times 2 \times 1700 = 510 \text{ kg/m}$$

$$\text{Berat plat bordes} = 0,2 \times 2400 = 480 \text{ kg/m}$$

$$\underline{q_D = 1098 \text{ kg/m}}$$

- Akibat beban hidup (q_L)

$$q_L = 200 \text{ kg/m}$$

- Beban ultimate (q_U)

$$q_U = 1,2 \cdot q_D + 1,6 \cdot q_L$$

$$= 1,2 \cdot 1098 + 1,6 \cdot 300$$

$$= 1797,6 \text{ kg/m}$$

- Beban reaksi bordes

$$q_u = \frac{\text{Reaksi bordes}}{\text{lebar bordes}}$$

$$= \frac{1/2 \cdot 1797,6}{1,5}$$

$$= 599,2 \text{ Kg/m}$$

4.5.2. Perhitungan tulangan lentur

Tulangan tumpuan



$$M_u = 1842,3 \text{ kgm} = 1,8423 \cdot 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{1,8423 \cdot 10^7}{0,8} = 2,3 \cdot 10^7 \text{ Nmm}$$

$$m = \frac{f_y}{0,85 \cdot f_c} = \frac{240}{0,85 \cdot 25} = 11,29$$

$$\begin{aligned} \rho_b &= \frac{0,85 \cdot f_c}{f_y} \cdot \beta \cdot \left(\frac{600}{600 + f_y} \right) \\ &= \frac{0,85 \cdot 25}{240} \cdot 0,85 \cdot \left(\frac{600}{600 + 240} \right) \\ &= 0,053 \end{aligned}$$

$$\begin{aligned} \rho_{\max} &= 0,75 \cdot \rho_b \\ &= 0,04 \end{aligned}$$

$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{240} = 0,0058$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{2,3 \cdot 10^7}{150 \cdot (270)^2} = 2,1 \text{ N/mm}$$

$$\begin{aligned} \rho_{\text{ada}} &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot R_n}{f_y}} \right) \\ &= \frac{1}{11,29} \cdot \left(1 - \sqrt{1 - \frac{2 \cdot 11,29 \cdot 2,1}{240}} \right) \\ &= 0,009 \end{aligned}$$

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

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

di pakai $\rho_{\text{ada}} = 0,009$

$$\begin{aligned} A_s &= \rho_{\text{ada}} \cdot b \cdot d \\ &= 0,009 \cdot 150 \cdot 270 \\ &= 364,5 \text{ mm}^2 \end{aligned}$$

$$\text{Dipakai tulangan } \varnothing 12 \text{ mm} = \frac{1}{4} \cdot \pi \cdot 12^2 = 113,04 \text{ mm}^2$$

$$\text{Jumlah tulangan} = \frac{364,5}{113,04} = 3,22 \approx 4 \text{ buah}$$

$$\text{As yang timbul} = 4 \cdot \frac{1}{4} \cdot \pi \cdot d^2$$

$$= 452,16 \text{ mm}^2 > A_s \text{ Aman !}$$



Dipakai tulangan $\varnothing 12$ mm

4.5.3. Perhitungan Tulangan Geser Balok Bordes

$$V_u = 2456,4 \text{ kg} = 24564 \text{ N}$$

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

$$= 1/6 \cdot 150 \cdot 270 \cdot \sqrt{25}$$

$$= 33750 \text{ N}$$

$$\varnothing V_c = 0,75 \cdot V_c$$

$$= 25312,5 \text{ N}$$

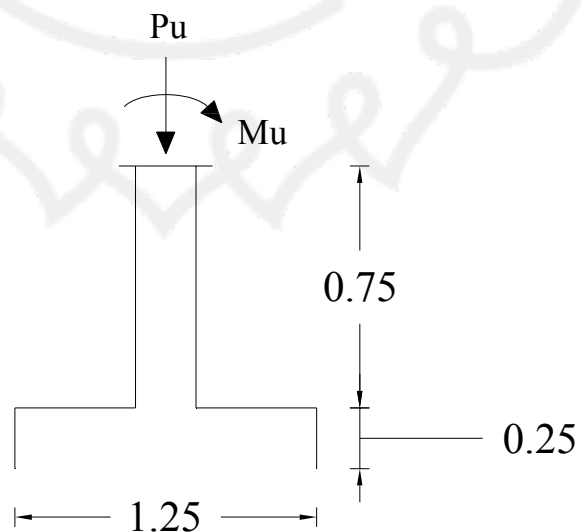
$$3 \varnothing V_c = 75937,5 \text{ N}$$

$V_u < \varnothing V_c$ tidak perlu tulangan geser

$$S_{\max} = \frac{270}{2} = 135 \text{ mm}$$

Jadi dipakai sengkang dengan tulangan $\varnothing 8 - 100$ mm

4.6. Perhitungan Pondasi Tangga





Gambar 4.3 Pondasi Tangga

Direncanakan pondasi telapak dengan kedalaman 1,25 m dan panjang 1,40m

- Tebal = 250 mm
- Ukuran alas = 1400 x 1250 mm
- γ tanah = 1,7 t/m³ = 1700 kg/m³
- σ tanah = 2,5 kg/cm² = 25000 kg/m²
- Pu = 10704.30 kg
- h = 250 mm
- d = h - p - 1/2 ϕ_t - ϕ_s
= 250 - 30 - 1/2 . 12 - 8 = 206 mm

4.7. Perencanaan kapasitas dukung pondasi

4.7.1. Perhitungan kapasitas dukung pondasi

➤ Pembebanan pondasi

Berat telapak pondasi	= 1,4 x 1,25 x 0,25 x 2400	= 1050	kg
Berat tanah	= 2 (0,5 x 0,75) x 1 x 1700	= 1275	kg
Berat kolom	= (0,25 x 1,4 x 0,75) x 2400	= 630	kg
Pu		= 10704.3	kg
V tot		= 13659,3	kg

$$\sigma_{\text{yang terjadi}} = \frac{V_{\text{tot}}}{A} + \frac{M_{\text{tot}}}{\frac{1}{6} \cdot b \cdot L^2}$$

$$\begin{aligned} \sigma_{\text{tanah}} &= \frac{13659,3}{1,4 \cdot 1,25} \pm \frac{2053,45}{1/6 \cdot 1,4 \cdot (1,25)^2} = 13437,63 \text{ kg/m}^2 \\ &= 13437,63 \text{ kg/m}^2 < 25000 \text{ kg/m}^2 \\ &= \sigma_{\text{yang terjadi}} < \sigma_{\text{ijin tanah}} \dots \dots \dots \text{Ok!} \end{aligned}$$

4.7.2. Perhitungan Tulangan Lentur

$$\begin{aligned} M_u &= \frac{1}{2} \cdot q_u \cdot t^2 = \frac{1}{2} \cdot 13437,63 \cdot (0,5)^2 \\ &= 1679,7 \text{ kg/m} = 1,6797 \cdot 10^7 \text{ Nmm} \end{aligned}$$

$$M_n = \frac{1,679 \cdot 10^7}{0,8} = 2,098 \times 10^7 \text{ Nmm}$$



$$m = \frac{f_y}{0,85 \cdot 25} = \frac{240}{0,85 \cdot 25} = 11,29$$

$$\begin{aligned} \rho_b &= \frac{0,85 \cdot f_c}{f_y} \beta \left(\frac{600}{600 + f_y} \right) \\ &= \frac{0,85 \cdot 25}{240} \cdot 0,85 \cdot \left(\frac{600}{600 + 240} \right) \\ &= 0,053 \end{aligned}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{2,098 \cdot 10^7}{1400 \cdot (206)^2} = 0,353$$

$$\begin{aligned} \rho_{\max} &= 0,75 \cdot \rho_b \\ &= 0,04 \end{aligned}$$

$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{240} = 0,0058$$

$$\begin{aligned} \rho_{\text{ada}} &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2m \cdot R_n}{f_y}} \right) \\ &= \frac{1}{11,29} \cdot \left(1 - \sqrt{1 - \frac{2 \cdot 11,29 \cdot 0,353}{240}} \right) \\ &= 0,0014 \end{aligned}$$

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

$$\rho_{\text{ada}} < \rho_{\min} \longrightarrow \text{dipakai } \rho_{\min} = 0,0058$$

▪ Untuk Arah Sumbu Panjang

$$\begin{aligned} A_{s \text{ ada}} &= \rho_{\min} \cdot b \cdot d \\ &= 0,0058 \cdot 1400 \cdot 206 \\ &= 1672,72 \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} \text{digunakan tul } \varnothing 12 &= \frac{1}{4} \cdot \pi \cdot d^2 \\ &= \frac{1}{4} \cdot 3,14 \cdot (12)^2 \\ &= 113,04 \text{ mm}^2 \end{aligned}$$

$$\text{Jumlah tulangan (n)} = \frac{1672,72}{113,04} = 14,79 \sim 15 \text{ buah}$$



$$\text{Jarak tulangan} = \frac{1400}{15} = 93,33 \text{ mm} = 90 \text{ mm}$$

Sehingga dipakai tulangan **Ø 12 - 90 mm**

$$\begin{aligned} \text{As yang timbul} &= 15 \times 113,04 \\ &= 1695,6 > \text{As} \dots\dots\dots\text{ok!} \end{aligned}$$

▪ Untuk Arah Sumbu Pendek

$$\begin{aligned} \text{As perlu} &= \rho_{\min} b \cdot d \\ &= 0,0058 \cdot 1250 \cdot 206 \\ &= 1493,5 \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} \text{Digunakan tulangan } \text{Ø} 12 &= \frac{1}{4} \cdot \pi \cdot d^2 \\ &= \frac{1}{4} \cdot 3,14 \cdot (12)^2 \\ &= 113,04 \text{ mm}^2 \end{aligned}$$

$$\text{Jumlah tulangan (n)} = \frac{1493,5}{113,04} = 13,2 \sim 14 \text{ buah}$$

$$\text{Jarak tulangan} = \frac{1250}{14} = 89,28 \text{ mm} = 80 \text{ mm}$$

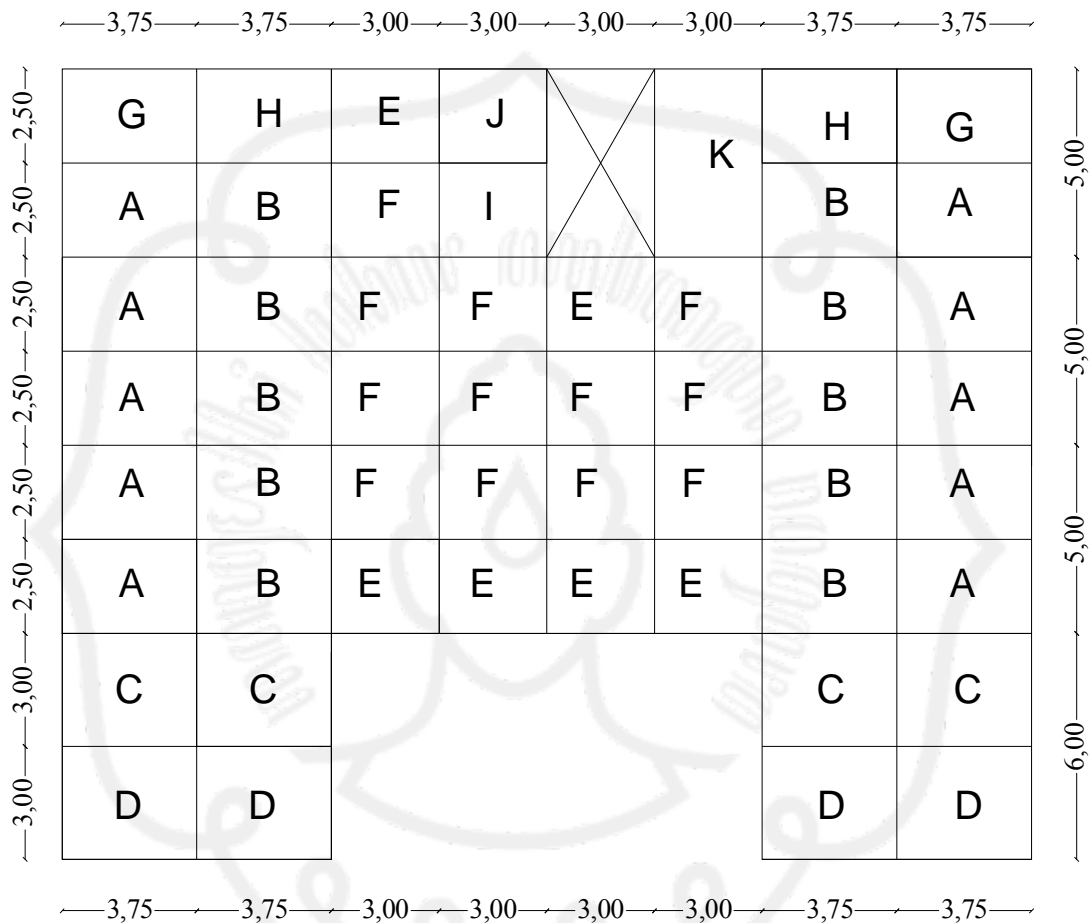
Sehingga dipakai tulangan **Ø12 - 80 mm**

$$\begin{aligned} \text{As yang timbul} &= 14 \times 113,04 \\ &= 1582,6 > \text{As} \dots\dots\dots\text{ok!} \end{aligned}$$



BAB 5 PLAT LANTAI

5.1. Perencanaan Pelat Lantai



Gambar 5.1 Denah Plat lantai

5.2. Perhitungan Pembebanan Plat Lantai

I. Plat Lantai

a. Beban Hidup (qL)

Berdasarkan PPIUG untuk gedung 1983 yaitu :

Beban hidup fungsi gedung untuk swalayan tiap 1 m = 250 kg/m²



b. Beban Mati (q_D) tiap 1 m

Berat plat sendiri	$= 0,12 \times 2400 \times 1$	$= 288$ kg/m
Berat keramik (1 cm)	$= 0,01 \times 2400 \times 1$	$= 24$ kg/m`
Berat Spesi (2 cm)	$= 0,02 \times 2100 \times 1$	$= 42$ kg/m
Berat plafond + instalasi listrik		$= 18$ kg/m
Berat Pasir (2 cm)	$= 0,02 \times 1,6 \times 1$	$= 32$ kg/m
		<hr/> $q_D = 404$ kg/m

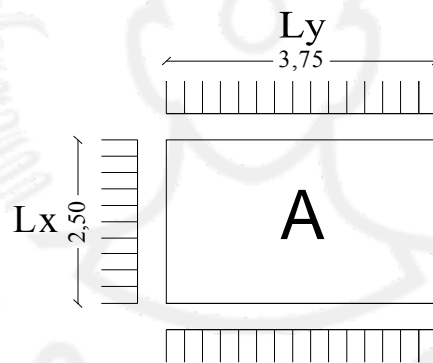
c. Beban Ultimate (q_U)

Untuk tinjauan lebar 1 m pelat maka :

$$\begin{aligned} q_U &= 1,2 q_D + 1,6 q_L \\ &= 1,2 \cdot 404 + 1,6 \cdot 250 \\ &= 884,8 \text{ kg/m}^2 \end{aligned}$$

5.3. Perhitungan Momen

a. Tipe pelat A



Gambar 5.2 Plat tipe A

$$\frac{L_y}{L_x} = \frac{3,75}{2,5} = 1,5$$

$$M_{lx} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 38 = 210,14 \text{ kgm}$$

$$M_{ly} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 15 = 82,95 \text{ kgm}$$

$$M_{tx} = - 0,001 \cdot q_u \cdot L_x^2 \cdot x = -0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 79 = - 436,87 \text{ kgm}$$

$$M_{ty} = - 0,001 \cdot q_u \cdot L_x^2 \cdot x = - 0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 57 = - 315,21 \text{ kgm}$$

b. Tipe pelat B

Bab I Pendahuluan





Gambar 5.3 Plat tipe B

$$\frac{L_y}{L_x} = \frac{3,75}{2,5} = 1,5$$

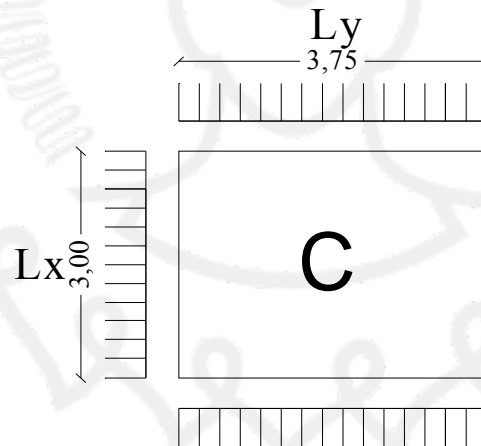
$$M_{lx} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 36 = 199,08 \text{ kgm}$$

$$M_{ly} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 17 = 94,01 \text{ kgm}$$

$$M_{tx} = -0,001 \cdot q_u \cdot L_x^2 \cdot x = -0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 76 = -420,28 \text{ kgm}$$

$$M_{ty} = -0,001 \cdot q_u \cdot L_x^2 \cdot x = -0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 57 = -315,21 \text{ kgm}$$

c. Tipe pelat C



Gambar 5.4 Plat tipe C

$$\frac{L_y}{L_x} = \frac{3,75}{3} = 1,2$$

$$M_{lx} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \cdot 884,8 \cdot (3)^2 \cdot 32 = 254,82 \text{ kgm}$$

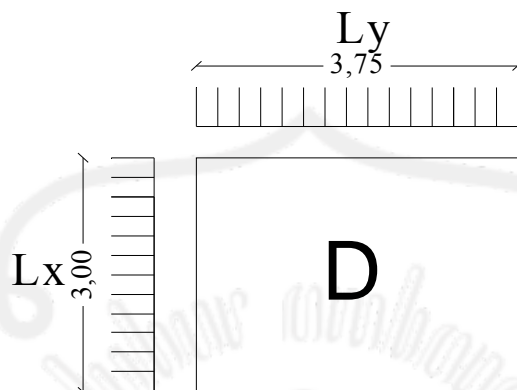


$$Mly = 0,001 \cdot qu \cdot Lx^2 \cdot x = 0.001 \cdot 884,8 \cdot (3)^2 \cdot 19 = 151,30 \text{ kgm}$$

$$Mtx = -0,001 \cdot qu \cdot Lx^2 \cdot x = -0.001 \cdot 884,8 \cdot (3)^2 \cdot 71 = -565,39 \text{ kgm}$$

$$Mty = -0,001 \cdot qu \cdot Lx^2 \cdot x = -0.001 \cdot 884,8 \cdot (3)^2 \cdot 57 = -453,90 \text{ kgm}$$

d. Tipe plat D



Gambar 5.5 Plat tipe D

$$\frac{Ly}{Lx} = \frac{3,75}{3} = 1,2$$

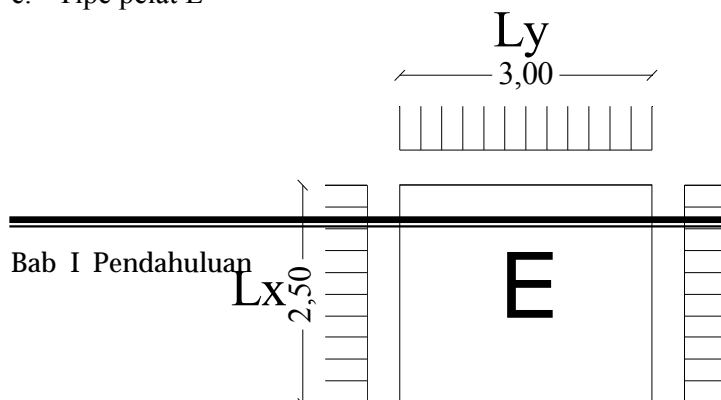
$$Mlx = 0,001 \cdot qu \cdot Lx^2 \cdot x = 0.001 \cdot 884,8 \cdot (3)^2 \cdot 38 = 302,60 \text{ kgm}$$

$$Mly = 0,001 \cdot qu \cdot Lx^2 \cdot x = 0.001 \cdot 884,8 \cdot (3)^2 \cdot 28 = 222,97 \text{ kgm}$$

$$Mtx = -0,001 \cdot qu \cdot Lx^2 \cdot x = -0.001 \cdot 884,8 \cdot (3)^2 \cdot 85 = -676,87 \text{ kgm}$$

$$Mty = -0,001 \cdot qu \cdot Lx^2 \cdot x = -0.001 \cdot 884,8 \cdot (3)^2 \cdot 74 = -589,28 \text{ kgm}$$

e. Tipe pelat E





Gambar 5.6 Plat tipe E

$$\frac{L_y}{L_x} = \frac{3,0}{2,5} = 1,2$$

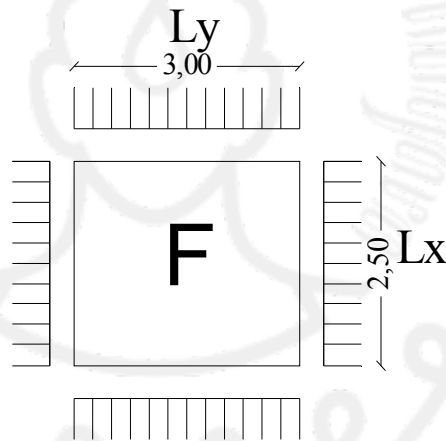
$$M_{lx} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 31 = 171,43 \text{ kgm}$$

$$M_{ly} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 28 = 154,84 \text{ kgm}$$

$$M_{tx} = -0,001 \cdot q_u \cdot L_x^2 \cdot x = -0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 74 = -409,22 \text{ kgm}$$

$$M_{ty} = -0,001 \cdot q_u \cdot L_x^2 \cdot x = -0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 69 = -381,57 \text{ kgm}$$

f. Tipe pelat F



Gambar 5.6 Plat tipe F

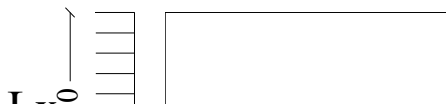
$$\frac{L_y}{L_x} = \frac{3,0}{2,5} = 1,2$$

$$M_{lx} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 28 = 154,84 \text{ kgm}$$

$$M_{ly} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 20 = 110,60 \text{ kgm}$$

$$M_{tx} = -0,001 \cdot q_u \cdot L_x^2 \cdot x = -0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 64 = -353,92 \text{ kgm}$$

$$M_{ty} = -0,001 \cdot q_u \cdot L_x^2 \cdot x = -0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 56 = -309,68 \text{ kgm}$$





g. Tipe pelat G

Gambar 5.6 Plat tipe G

$$\frac{L_y}{L_x} = \frac{3,75}{2,5} = 1,5$$

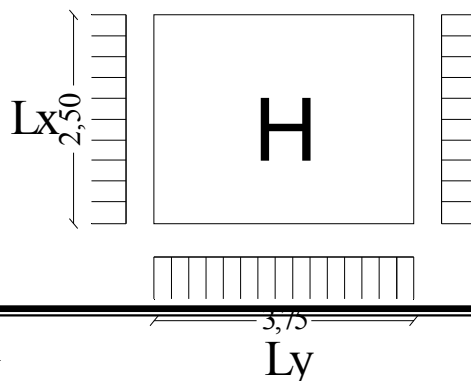
$$M_{lx} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 48 = 265,44 \text{ kgm}$$

$$M_{ly} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 25 = 138,25 \text{ kgm}$$

$$M_{tx} = -0,001 \cdot q_u \cdot L_x^2 \cdot x = -0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 103 = -569,59 \text{ kgm}$$

$$M_{ty} = -0,001 \cdot q_u \cdot L_x^2 \cdot x = -0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 77 = -425,81 \text{ kgm}$$

h. Tipe pelat H





Gambar 5.6 Plat tipe H

$$\frac{L_y}{L_x} = \frac{3,75}{2,5} = 1,5$$

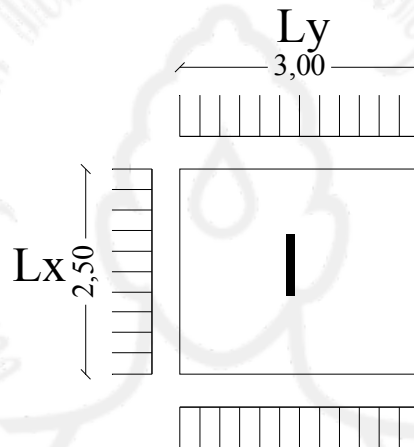
$$M_{lx} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 43 = 237,79 \text{ kgm}$$

$$M_{ly} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 26 = 143,78 \text{ kgm}$$

$$M_{tx} = -0,001 \cdot q_u \cdot L_x^2 \cdot x = -0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 96 = -530,88 \text{ kgm}$$

$$M_{ty} = -0,001 \cdot q_u \cdot L_x^2 \cdot x = -0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 76 = -420,28 \text{ kgm}$$

i. Tipe pelat I



Gambar 5.6 Plat tipe J

$$\frac{L_y}{L_x} = \frac{3,0}{2,5} = 1,2$$

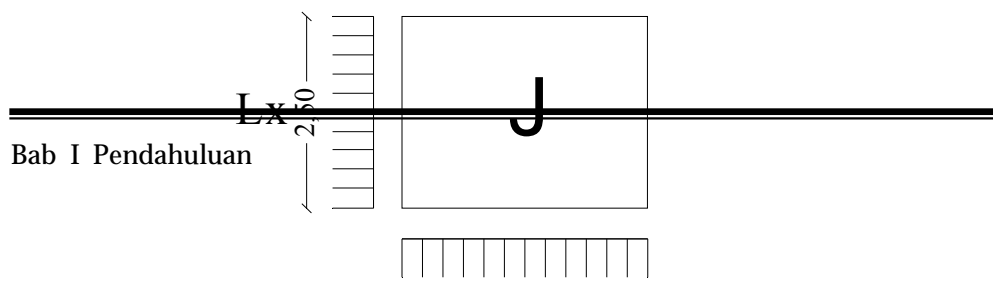
$$M_{lx} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 32 = 176,96 \text{ kgm}$$

$$M_{ly} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 19 = 105,07 \text{ kgm}$$

$$M_{tx} = -0,001 \cdot q_u \cdot L_x^2 \cdot x = -0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 71 = -392,63 \text{ kgm}$$

$$M_{ty} = -0,001 \cdot q_u \cdot L_x^2 \cdot x = -0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 57 = -315,21 \text{ kgm}$$

j. Tipe pelat J





Gambar 5.6 Plat tipe I

$$\frac{L_y}{L_x} = \frac{3,0}{2,5} = 1,2$$

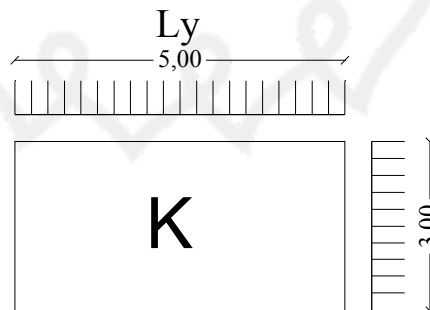
$$M_{lx} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 38 = 210,14 \text{ kgm}$$

$$M_{ly} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 28 = 154,84 \text{ kgm}$$

$$M_{tx} = -0,001 \cdot q_u \cdot L_x^2 \cdot x = -0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 85 = -470,05 \text{ kgm}$$

$$M_{ty} = -0,001 \cdot q_u \cdot L_x^2 \cdot x = -0,001 \cdot 884,8 \cdot (2,5)^2 \cdot 74 = -409,22 \text{ kgm}$$

k. Tipe pelat K



Gambar 5.6 Plat tipe G



$$\frac{L_y}{L_x} = \frac{5,0}{3,0} = 1,8$$

$$M_{lx} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \cdot 884,8 \cdot (3,0)^2 \cdot 0,55 = 437,98 \text{ kgm}$$

$$M_{ly} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \cdot 884,8 \cdot (3,0)^2 \cdot 0,22 = 175,19 \text{ kgm}$$

$$M_{tx} = -0,001 \cdot q_u \cdot L_x^2 \cdot x = -0,001 \cdot 884,8 \cdot (3,0)^2 \cdot 0,113 = -889,84 \text{ kgm}$$

$$M_{ty} = -0,001 \cdot q_u \cdot L_x^2 \cdot x = -0,001 \cdot 884,8 \cdot (3,0)^2 \cdot 0,078 = -621,13 \text{ kgm}$$

5.4. 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)
A	$3,75/2,5=1,5$	210,14	82,95	436,87	315,21
B	$3,75/2,5=1,5$	199,08	94,01	420,28	315,21
C	$3,75/3,0=1,2$	254,82	151,30	565,39	453,90
D	$3,75/3,0=1,2$	302,60	<u>222,97</u>	676,87	589,28
E	$3,0/2,5=1,2$	171,43	154,84	409,22	381,57
F	$3,0/2,5=1,2$	154,84	110,60	353,92	309,68
G	$5,0/2,5=2,0$	265,44	60,83	458,99	315,21



H	5,0/2,5=2,0	237,79	143,78	530,88	420,28
I	3,0/2,5=1,2	176,96	105,07	392,63	315,21
J	3,0/2,5=1,2	210,14	154,84	470,05	409,22
k	3,75/3,0=1,5	<u>437,98</u>	175,19	<u>889,84</u>	<u>621,13</u>

Dari perhitungan momen diambil momen terbesar yaitu:

$$M_{lx} = 437,98 \text{ kgm}$$

$$M_{ly} = 222,97 \text{ kgm}$$

$$M_{tx} = - 889,97 \text{ kgm}$$

$$M_{ty} = - 621,13 \text{ kgm}$$

$$\text{Data : Tebal plat (h)} = 12 \text{ cm} = 120 \text{ mm}$$

$$\text{Tebal penutup (d')} = 20 \text{ mm}$$

$$\text{Diameter tulangan (} \emptyset \text{)} = 10 \text{ mm}$$

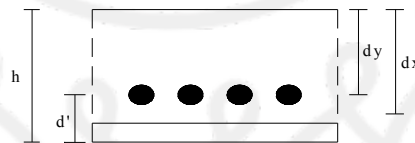
$$b = 1000$$

$$f_y = 340 \text{ Mpa}$$

$$f'_c = 25 \text{ Mpa}$$

$$\text{Tinggi Efektif (d)} = h - d' = 120 - 20 = 100 \text{ mm}$$

Tinggi efektif



Gambar 5.15. Perencanaan Tinggi Efektif

$$\begin{aligned} dx &= h - d' - \frac{1}{2} \emptyset \\ &= 120 - 20 - 5 = 95 \text{ mm} \end{aligned}$$

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



untuk plat digunakan

$$\begin{aligned}\rho_b &= \frac{0,85 \cdot f_c}{f_y} \cdot \beta \cdot \left(\frac{600}{600 + f_y} \right) \\ &= \frac{0,85 \cdot 25}{240} \cdot 0,85 \cdot \left(\frac{600}{600 + 240} \right) \\ &= 0,0538\end{aligned}$$

$$\begin{aligned}\rho_{\max} &= 0,75 \cdot \rho_b \\ &= 0,0403\end{aligned}$$

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

5.5. Penulangan lapangan arah x

$$M_u = 437,98 \text{ kgm} = 4,38 \cdot 10^6 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{4,38 \cdot 10^6}{0,8} = 5,48 \cdot 10^6 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{5,48 \cdot 10^6}{1000 \cdot (95)^2} = 0,61 \text{ N/mm}^2$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{240}{0,85 \cdot 25} = 11,294$$

$$\begin{aligned}\rho_{\text{perlu}} &= \frac{1}{m} \cdot \left(1 - \sqrt{1 - \frac{2m \cdot R_n}{f_y}} \right) \\ &= \frac{1}{11,294} \cdot \left(1 - \sqrt{1 - \frac{2 \cdot 11,294 \cdot 0,61}{240}} \right) \\ &= 0,0018\end{aligned}$$

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

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

$$\begin{aligned}A_s &= \rho_{\min} \cdot b \cdot d \\ &= 0,0025 \cdot 1000 \cdot 95 \\ &= 237,5 \text{ mm}^2\end{aligned}$$

$$\text{Digunakan tulangan } \varnothing 10 = \frac{1}{4} \cdot \pi \cdot (10)^2 = 78,5 \text{ mm}^2$$



$$\begin{aligned} \text{Jumlah tulangan} &= \frac{237,5}{78,5} = 3,02 \sim 3 \text{ buah.} \\ \text{Jarak tulangan dalam } 1 \text{ m}^1 &= \frac{1000}{3} = 333,333 \text{ mm} \sim 240 \text{ mm} \\ \text{Jarak maksimum} &= 2 \times h = 2 \times 120 = 240 \text{ mm} \\ \text{As yang timbul} &= 3 \cdot \frac{1}{4} \cdot \pi \cdot (10)^2 = 235,5 > 175,75 \text{ (As) ...ok!} \end{aligned}$$

Dipakai tulangan $\varnothing 10 - 200 \text{ mm}$

5.6. Penulangan lapangan arah y

$$M_u = 222,97 \text{ kgm} = 2,2297 \cdot 10^6 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{2,2297 \cdot 10^6}{0,8} = 2,787 \cdot 10^6 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{2,787 \cdot 10^6}{1000 \cdot (85)^2} = 0,386 \text{ N/mm}^2$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{240}{0,85 \cdot 25} = 11,29$$

$$\begin{aligned} \rho_{\text{perlu}} &= \frac{1}{m} \times \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot R_n}{f_y}} \right) \\ &= \frac{1}{11,294} \cdot \left(1 - \sqrt{1 - \frac{2 \cdot 11,294 \cdot 0,386}{240}} \right) \\ &= 0,0017 \end{aligned}$$

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

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

$$\begin{aligned} A_s &= \rho_{\text{min}} \cdot b \cdot d \\ &= 0,0025 \cdot 1000 \cdot 85 \\ &= 212,51 \text{ mm}^2 \end{aligned}$$

$$\text{Digunakan tulangan } \varnothing 10 = \frac{1}{4} \cdot \pi \cdot (10)^2 = 78,5 \text{ mm}^2$$

$$\text{Jumlah tulangan} = \frac{212,5}{78,5} = 2,71 \sim 3 \text{ buah.}$$

$$\text{Jarak tulangan dalam } 1 \text{ m}^1 = \frac{1000}{3} = 333,333 \text{ mm}$$



$$\begin{aligned}\text{Jarak maksimum} &= 2 \times h = 2 \times 120 = 240 \text{ mm} \\ \text{As yang timbul} &= 3 \cdot \frac{1}{4} \cdot \pi \cdot (10)^2 = 235,5 > 178,5 \text{ (As) } \dots \text{ok!}\end{aligned}$$

Dipakai tulangan $\varnothing 10 - 200 \text{ mm}$

5.7. Penulangan tumpuan arah x

$$M_u = 889,84 \text{ kgm} = 8,898 \cdot 10^6 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{8,898 \cdot 10^6}{0,8} = 11,12 \cdot 10^6 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{11,12 \cdot 10^6}{1000 \cdot (85)^2} = 1,54 \text{ N/mm}^2$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{240}{0,85 \cdot 25} = 11,29$$

$$\begin{aligned}\rho_{\text{perlu}} &= \frac{1}{m} \cdot \left(1 - \sqrt{1 - \frac{2m \cdot R_n}{f_y}} \right) \\ &= \frac{1}{11,294} \cdot \left(1 - \sqrt{1 - \frac{2 \cdot 11,294 \cdot 1,54}{240}} \right) \\ &= 0,006\end{aligned}$$

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

$$\rho > \rho_{\text{min}}, \text{ di pakai } \rho_{\text{perlu}} = 0,006$$

$$\begin{aligned}\text{As} &= \rho_{\text{perlu}} \cdot b \cdot d \\ &= 0,006 \cdot 1000 \cdot 85 \\ &= 510 \text{ mm}^2\end{aligned}$$

$$\text{Digunakan tulangan } \varnothing 10 = \frac{1}{4} \cdot \pi \cdot (10)^2 = 78,5 \text{ mm}^2$$

$$\text{Jumlah tulangan} = \frac{510}{78,5} = 6,5 \sim 7 \text{ buah.}$$

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

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

$$\text{As yang timbul} = 7 \cdot \frac{1}{4} \cdot \pi \cdot (10)^2 = 549,5 > 178,5 \text{ (As) } \dots \text{ok!}$$



Dipakai tulangan $\varnothing 10 - 100 \text{ mm}$

5.8. Penulangan tumpuan arah y

$$M_u = 621,13 \text{ kgm} = 6,211.10^6 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{6,211.10^6}{0,8} = 7,76.10^6 \text{ Nmm}$$

$$R_n = \frac{M_n}{b.d^2} = \frac{7,6.10^6}{1000.(95)^2} = 0,86 \text{ N/mm}^2$$

$$m = \frac{f_y}{0,85.f'c} = \frac{240}{0,85.25} = 11,29$$

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

$$= \frac{1}{11,294} \cdot \left(1 - \sqrt{1 - \frac{2.11,294.0,86}{240}} \right)$$

$$= 0,0036$$

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

$$\rho > \rho_{\text{min}}, \text{ di pakai } \rho_{\text{perlu}} = 0,0036$$

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

$$= 0,0036 \cdot 1000 \cdot 95$$

$$= 342 \text{ mm}^2$$

$$\text{Digunakan tulangan } \varnothing 10 = \frac{1}{4} \cdot \pi \cdot (10)^2 = 78,5 \text{ mm}^2$$

$$\text{Jumlah tulangan} = \frac{342}{78,5} = 4,3 \sim 5 \text{ buah.}$$

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

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

$$\text{As yang timbul} = 5 \cdot \frac{1}{4} \cdot \pi \cdot (10)^2 = 392,5 > 178,5 \text{ (As)ok!}$$

Dipakai tulangan $\varnothing 10 - 100 \text{ mm}$



5.9. Rekapitulasi Tulangan

Dari perhitungan diatas diperoleh :

Tulangan lapangan arah x $\varnothing 10 - 200 \text{ mm}$

Tulangan lapangan arah y $\varnothing 10 - 200 \text{ mm}$

Tulangan tumpuan arah x $\varnothing 10 - 100 \text{ mm}$

Tulangan tumpuan arah y $\varnothing 10 - 100 \text{ mm}$

Tabel 5.2. Penulangan Plat Lantai

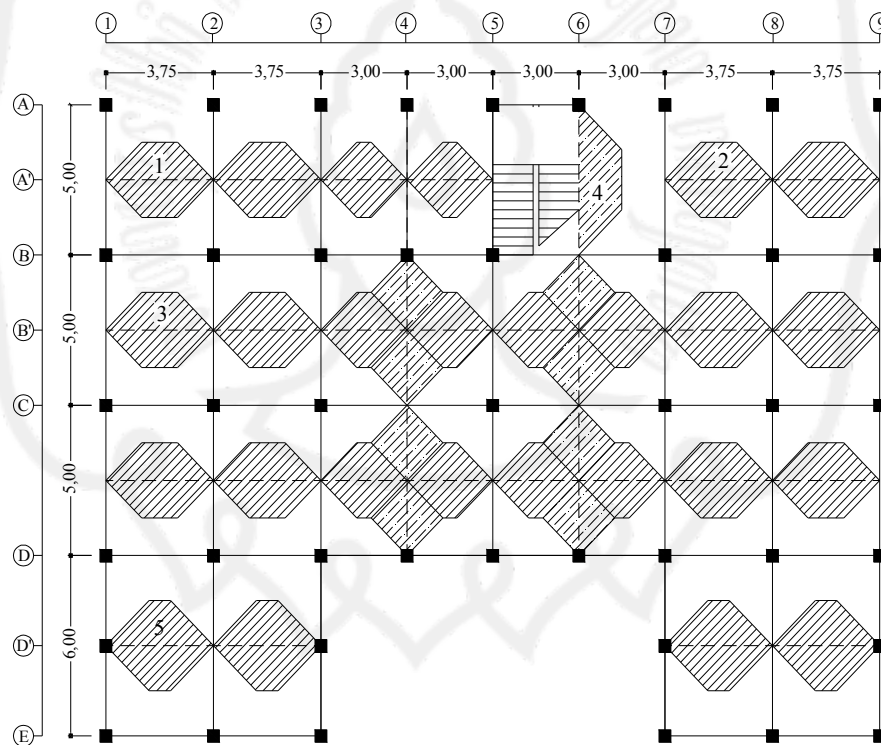
TIPE PLAT	Momen				Tulangan Lapangan		Tulangan Tumpuan	
	Mlx (kgm)	Mly (kgm)	Mtx (kgm)	Mty (kgm)	Arah x (mm)	Arah y (mm)	Arah x (mm)	Arah y (mm)
A	210,14	82,95	436,87	315,21	$\varnothing 10-200$	$\varnothing 10-200$	$\varnothing 10-100$	$\varnothing 10-100$
B	199,08	94,01	420,28	315,21	$\varnothing 10-200$	$\varnothing 10-200$	$\varnothing 10-100$	$\varnothing 10-100$
C	254,82	151,30	565,39	453,90	$\varnothing 10-200$	$\varnothing 10-200$	$\varnothing 10-100$	$\varnothing 10-100$
D	302,60	<u>222,97</u>	676,87	589,28	$\varnothing 10-200$	<u>$\varnothing 10-200$</u>	$\varnothing 10-100$	$\varnothing 10-100$
E	171,43	154,84	409,22	381,57	$\varnothing 10-200$	$\varnothing 10-200$	$\varnothing 10-100$	$\varnothing 10-100$
F	154,84	110,60	353,92	309,68	$\varnothing 10-200$	$\varnothing 10-200$	$\varnothing 10-100$	$\varnothing 10-100$
G	265,44	60,83	458,99	315,21	$\varnothing 10-200$	$\varnothing 10-200$	$\varnothing 10-100$	$\varnothing 10-100$
H	237,79	143,78	530,88	420,28	$\varnothing 10-200$	$\varnothing 10-200$	$\varnothing 10-100$	$\varnothing 10-100$
I	176,96	105,07	392,63	315,21	$\varnothing 10-200$	$\varnothing 10-200$	$\varnothing 10-100$	$\varnothing 10-100$



J	210,14	154,84	470,05	409,22	Ø10-200	Ø10-200	Ø10-100	Ø10-100
K	<u>437,98</u>	175,19	<u>889,84</u>	<u>621,13</u>	<u>Ø10-200</u>	Ø10-200	<u>Ø10-100</u>	<u>Ø10-100</u>

BAB 6 BALOK ANAK

6.1. Perencanaan Balok Anak



Gambar 6.1 Area Pembebanan Balok Anak



Keterangan:

Balok anak : as A' (1 - 5)

Balok anak : as B' (1 - 9)

Balok anak : as D' (1 - 3)

Balok anak : as C' (1 - 4)

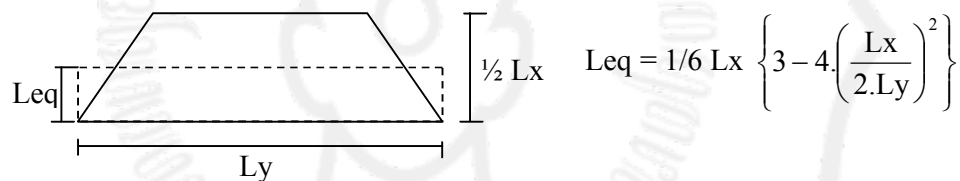
Balok anak : as 4 (B - D)

Balok anak : as 6 (A - D)

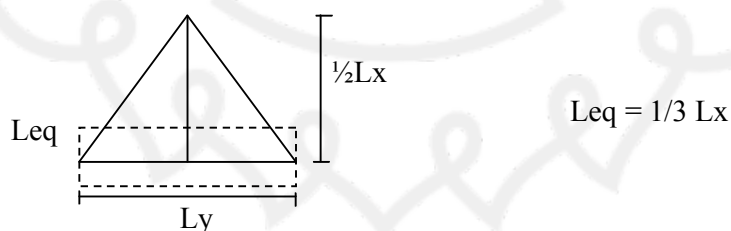
6.1.1. Perhitungan Lebar Equivalen

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

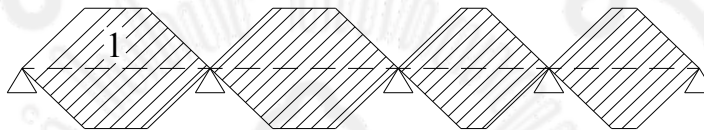
No.	Ukuran Plat (m ²)	Lx (m)	Ly (m)	Leq (segitiga)	Leq (trapesium)
1.	3,0 × 5,0	2,5	5,0	-	1,32



2.	2,5 x 3,0	2,5	3,0	0,83	-
3.	2,5 x 3,75	2,5	3,75	-	1,06
4.	3,0 x 3,75	3,0	3,75	-	1,18
5.	2,5 x 3,0	2,5	3,0	-	0,96

6.2. Pembebanan Balok Anak as A'

6.2.1. Pembebanan



Gambar 6.2 Lebar Equivalen Balok Anak as 1'

Perencanaan Dimensi Balok

$$\begin{aligned}
 h &= 1/12 \cdot L_y \\
 &= 1/12 \cdot 3750 \\
 &= 312,5 \text{ mm} = 350 \text{ mm} \\
 b &= 2/3 \cdot h \\
 &= 2/3 \cdot 312,5 \\
 &= 250 \text{ mm (h dipakai} = 350 \text{ mm, } b = 250 \text{ mm)}
 \end{aligned}$$

1. Beban Mati (q_D)

Pembebanan balok (A – B)

$$\begin{aligned}
 \text{Berat sendiri} &= 0,25 \times (0,35 - 0,12) \times 2400 \text{ kg/m}^3 = 138 \text{ kg/m} \\
 \text{Beban plat} &= (2 \times 1,06) \times 404 \text{ kg/m}^2 = \underline{956,25 \text{ kg/m}} \\
 q_{D1} &= 1094,25 \text{ kg/m}
 \end{aligned}$$

Pembebanan balok as (B – C)

$$\begin{aligned}
 \text{Berat sendiri} &= 0,25 \times (0,35 - 0,12) \times 2400 \text{ kg/m}^3 = 138 \text{ kg/m} \\
 \text{Beban plat} &= (2 \times 0,96) \times 404 \text{ kg/m}^2 = \underline{775,68 \text{ kg/m}}
 \end{aligned}$$



$$= 0,0254$$

$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{340} = 0,0041$$

Daerah Tumpuan

Dari perhitungan **SAP 2000** diperoleh :

$$M_u = 3345.57 \text{ kgm} = 3,3456 \cdot 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{3,3456 \cdot 10^7}{0,8} = 4,182 \cdot 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{4,182 \cdot 10^7}{250 \times (294)^2} = 1,93 \text{ N/mm}^2$$

$$m = \frac{f_y}{0,85 \cdot f_c} = \frac{340}{0,85 \cdot 25} = 16$$

$$\begin{aligned} \rho_{\text{perlu}} &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2m \cdot R_n}{f_y}} \right) \\ &= \frac{1}{16} \left(1 - \sqrt{1 - \frac{2 \times 16 \times 1,93}{340}} \right) \\ &= 0,006 \end{aligned}$$

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

$$\rho > \rho_{\min}, \text{ di pakai } \rho_{\text{perlu}} = 0,006$$

$$\begin{aligned} A_s &= \rho \cdot b \cdot d \\ &= 0,006 \cdot 250 \cdot 294 \\ &= 441 \text{ mm}^2 \end{aligned}$$

$$\text{Digunakan tulangan D 16} = \frac{1}{4} \cdot \pi \cdot (16)^2 = 200,96 \text{ mm}^2$$

$$\text{Jumlah tulangan} = \frac{441}{200,96} = 2,2 \sim 3 \text{ buah.}$$

Dipakai **3 D 16 mm**



$$\begin{aligned} \text{As ada} &= 3 \cdot \frac{1}{4} \cdot \pi \cdot 16^2 \\ &= 602,88 \text{ mm}^2 > \text{As} \dots\dots\dots \text{aman !} \end{aligned}$$

$$a = \frac{\text{As ada} \times f_y}{0,85 \times f'_c \times b} = \frac{602,88 \times 340}{0,85 \times 25 \times 250} = 38,58$$

$$\begin{aligned} \text{Mn ada} &= \text{As ada} \times f_y \left(d - \frac{a}{2} \right) \\ &= 602,88 \times 340 \left(294 - \frac{38,58}{2} \right) \\ &= 5,6617 \cdot 10^7 \text{ Nmm} \end{aligned}$$

Mn ada > Mn aman !

Jadi dipakai tulangan D 16 mm

Daerah Lapangan

Dari perhitungan **SAP 2000** diperoleh :

$$\text{Mu} = 2306.89 \text{ kgm} = 2,3069 \cdot 10^7 \text{ Nmm}$$

$$\text{Mn} = \frac{\text{Mu}}{\phi} = \frac{2,3069 \cdot 10^7}{0,8} = 2,88 \cdot 10^7 \text{ Nmm}$$

$$\text{Rn} = \frac{\text{Mn}}{b \cdot d^2} = \frac{2,88 \cdot 10^7}{250 \times (294)^2} = 1,33 \text{ N/mm}^2$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{340}{0,85 \cdot 25} = 16$$

$$\begin{aligned} \rho_{\text{perlu}} &= \frac{1}{m} \cdot \left(1 - \sqrt{1 - \frac{2m \cdot \text{Rn}}{f_y}} \right) \\ &= \frac{1}{16} \cdot \left(1 - \sqrt{1 - \frac{2 \times 16 \times 1,33}{340}} \right) \\ &= 0,004 \end{aligned}$$

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

$$\rho < \rho_{\text{min}}, \text{ di pakai } \rho_{\text{min}} = 0,0041$$

$$\begin{aligned} \text{As} &= \rho_{\text{min}} \cdot b \cdot d \\ &= 0,0041 \cdot 250 \cdot 294 \\ &= 301,35 \text{ mm}^2 \end{aligned}$$



$$\text{Digunakan tulangan D 16} = \frac{1}{4} \cdot \pi \cdot (16)^2 = 200,96 \text{ mm}^2$$

$$\text{Jumlah tulangan} = \frac{301,35}{200,96} = 1,49 \sim 2 \text{ buah.}$$

Dipakai **2 D 16 mm**

$$\begin{aligned} \text{As ada} &= 2 \cdot \frac{1}{4} \cdot \pi \cdot 16^2 \\ &= 401,91 \text{ mm}^2 > \text{As} \dots\dots\dots \text{aman !} \end{aligned}$$

$$a = \frac{\text{As ada} \times f_y}{0,85 \times f'_c \times b} = \frac{401,91 \times 340}{0,85 \times 25 \times 250} = 25,72$$

$$\begin{aligned} \text{Mn ada} &= \text{As ada} \times f_y \left(d - \frac{a}{2}\right) \\ &= 401,91 \times 340 \left(294 - \frac{25,72}{2}\right) \\ &= 3,84176 \cdot 10^7 \text{ Nmm} \end{aligned}$$

Mn ada > Mn aman !

Jadi dipakai tulangan D 16 mm

Tulangan Geser

Dari perhitungan SAP 2000 diperoleh :

$$V_u = 4944,33 \text{ kg} = 49443,3 \text{ N}$$

$$f'_c = 25 \text{ Mpa}$$

$$f_y = 340 \text{ Mpa}$$

$$d = h - p - \frac{1}{2} \emptyset = 350 - 40 - \frac{1}{2} (12) = 304 \text{ mm}$$

$$\begin{aligned} V_c &= \frac{1}{6} \cdot \sqrt{f'_c} \cdot b \cdot d \\ &= \frac{1}{6} \cdot \sqrt{25} \cdot 250 \cdot 304 \\ &= 63333,33 \text{ N} \end{aligned}$$

$$\begin{aligned} \emptyset V_c &= 0,75 \cdot 63333,33 \text{ N} \\ &= 47500 \text{ N} \end{aligned}$$

$$\begin{aligned} 3 \emptyset V_c &= 3 \cdot 47500 \\ &= 142500 \text{ N} \end{aligned}$$

$$\emptyset V_c < V_u < 3 \emptyset V_c$$

$$47500 \text{ N} < 49443,3 \text{ N} < 142500 \text{ N}$$

Jadi diperlukan tulangan geser

$$\begin{aligned} \emptyset V_s &= V_u - \emptyset V_c \\ &= 49443,3 - 47500 = 1943,3 \text{ N} \end{aligned}$$



$$V_s \text{ perlu} = \frac{\phi V_s}{0,75} = \frac{1943,3}{0,75} = 2591,07 \text{ N}$$

$$A_v = 2 \cdot \frac{1}{4} \pi (8)^2$$

$$= 2 \cdot \frac{1}{4} \cdot 3,14 \cdot 64 = 100,48 \text{ mm}^2$$

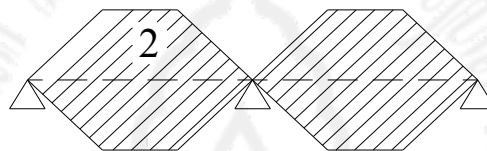
$$s = \frac{A_v \cdot f_y \cdot d}{V_s \text{ perlu}} = \frac{100,48 \times 240 \times 304}{2591,07} = 2829,3 \text{ mm}$$

$$S \text{ max} = d/2 = \frac{304}{2} = 152 \text{ mm}$$

Jadi dipakai sengkang dengan tulangan $\emptyset 8 - 150 \text{ mm}$

6.3. Pembebanan Balok Anak as A'

6.3.1. Pembebanan



Gambar 6. 3 Lebar Equivalen Balok Anak as A'

Perencanaan Dimensi Balok :

$$h = 1/12 \cdot L_y$$

$$= 1/12 \cdot 3750$$

$$= 312,5 \text{ mm} = 350 \text{ mm}$$

$$b = 2/3 \cdot h$$

$$= 2/3 \cdot 312,5$$

$$= 233,33 \text{ mm (h dipakai} = 350 \text{ mm, } b = 250 \text{ mm)}$$

1. Beban Mati (q_D)

Pembebanan balok as 4' (A – B)

Berat sendiri	= $0,25 \times (0,35 - 0,12) \times 2400 \text{ kg/m}^3$	=138	kg/m
Beban Plat	= $(2 \times 1,06) \times 404 \text{ kg/m}^2$	=856,48	kg/m
		=994,48	kg/m
		qD	

2. Beban hidup (q_L)



Beban hidup digunakan 250 kg/m^2

$$q_L = (2 \times 1,06) \times 250 \text{ kg/m}^2 = 530 \text{ kg/m}$$

3. Beban berfaktor (q_U)

$$\begin{aligned} q_U &= 1,2 \cdot q_D + 1,6 \cdot q_L \\ &= (1,2 \times 994,48) + (1,6 \times 530) \\ &= 2041,38 \text{ kg/m} \end{aligned}$$

6.3.2. Perhitungan Tulangan

Tulangan Lentur Balok Anak

Data Perencanaan :

$$\begin{aligned} h &= 350 \text{ mm} & \emptyset_t &= 16 \text{ mm} \\ b &= 250 \text{ mm} & \emptyset_s &= 8 \text{ mm} \\ p &= 40 \text{ mm} & d &= h - p - 1/2 \emptyset_t - \emptyset_s \\ f_y &= 340 \text{ Mpa} & &= 350 - 40 - 1/2 \cdot 16 - 8 \\ f'_c &= 25 \text{ MPa} & &= 294 \end{aligned}$$

Tulangan Lentur Daerah Lapangan

$$\begin{aligned} \rho_b &= \frac{0,85 \cdot f'_c \cdot \beta \left(\frac{600}{600 + f_y} \right)}{f_y} \\ &= \frac{0,85 \cdot 25}{340} \cdot 0,85 \left(\frac{600}{600 + 340} \right) \\ &= 0,0339 \end{aligned}$$

$$\begin{aligned} \rho_{\max} &= 0,75 \cdot \rho_b \\ &= 0,75 \cdot 0,0339 \\ &= 0,0254 \end{aligned}$$

$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{340} = 0,0041$$

Daerah Tumpuan

Dari perhitungan **SAP 2000** diperoleh :

$$M_u = 3566,03 \text{ kgm} = 3,566 \cdot 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{3,566 \cdot 10^7}{0,8} = 4,458 \cdot 10^7 \text{ Nmm}$$



$$R_n = \frac{M_n}{b \cdot d^2} = \frac{4,458 \cdot 10^7}{250 \times (294)^2} = 2,1 \text{ N/mm}^2$$

$$m = \frac{f_y}{0,85 \cdot f_c} = \frac{340}{0,85 \cdot 25} = 16$$

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

$$= \frac{1}{16} \left(1 - \sqrt{1 - \frac{2 \times 16 \times 2,1}{340}} \right)$$

$$= 0,007$$

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

$$\rho > \rho_{\text{min}}, \text{ di pakai } \rho_{\text{perlu}} = 0,007$$

$$A_s = \rho \cdot b \cdot d$$

$$= 0,007 \cdot 250 \cdot 294$$

$$= 514,5 \text{ mm}^2$$

$$\text{Digunakan tulangan D 16} = \frac{1}{4} \cdot \pi \cdot (16)^2 = 200,96 \text{ mm}^2$$

$$\text{Jumlah tulangan} = \frac{514,5}{200,96} = 2,7 \sim 3 \text{ buah.}$$

Dipakai tulangan 3 D 16 mm

$$A_s \text{ ada} = 3 \cdot \frac{1}{4} \cdot \pi \cdot 16^2$$

$$= 602,88 \text{ mm}^2 > A_s \dots\dots\dots \text{aman !}$$

$$a = \frac{A_s \text{ ada} \times f_y}{0,85 \times f_c \times b} = \frac{602,88 \times 340}{0,85 \times 25 \times 250} = 38,58$$

$$M_n \text{ ada} = A_s \text{ ada} \times f_y \left(d - \frac{a}{2} \right)$$

$$= 602,88 \times 340 \left(294 - \frac{38,58}{2} \right)$$

$$= 5,6309836 \cdot 10^7 \text{ Nmm}$$

$$M_n \text{ ada} > M_n \dots\dots\dots \text{aman !}$$

Jadi dipakai tulangan D 16 mm

Daerah Lapangan



Dari perhitungan **SAP 2000** diperoleh :

$$M_u = 2026.86 \text{ kgm} = 2,0268 \cdot 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{2,0268 \cdot 10^7}{0,8} = 2,533 \cdot 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{2,533 \cdot 10^7}{250 \times (294)^2} = 1,17 \text{ N/mm}^2$$

$$m = \frac{f_y}{0,85 \cdot f_c} = \frac{340}{0,85 \cdot 25} = 16$$

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

$$= \frac{1}{16} \cdot \left(1 - \sqrt{1 - \frac{2 \times 16 \times 1,17}{340}} \right)$$

$$= 0,0035$$

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

$$\rho > \rho_{\text{min}}, \text{ di pakai } \rho_{\text{min}} = 0,0041$$

$$\begin{aligned} A_s &= \rho \cdot b \cdot d \\ &= 0,0041 \cdot 250 \cdot 294 \\ &= 301,35 \text{ mm}^2 \end{aligned}$$

$$\text{Digunakan tulangan D 16} = \frac{1}{4} \cdot \pi \cdot (16)^2 = 200,96 \text{ mm}^2$$

$$\text{Jumlah tulangan} = \frac{301,35}{200,96} = 1,49 \sim 2 \text{ buah.}$$

Dipakai tulangan 2 D 16 mm

$$\begin{aligned} A_s \text{ ada} &= 2 \cdot \frac{1}{4} \cdot \pi \cdot 16^2 \\ &= 401,92 \text{ mm}^2 > A_s \dots\dots\dots \text{ aman !} \end{aligned}$$

$$a = \frac{A_s \text{ ada} \times f_y}{0,85 \times f_c \times b} = \frac{401,92 \times 340}{0,85 \times 25 \times 250} = 25,72$$

$$\begin{aligned} M_n \text{ ada} &= A_s \text{ ada} \times f_y \left(d - \frac{a}{2} \right) \\ &= 401,92 \times 340 \left(294 - \frac{25,72}{2} \right) \end{aligned}$$



$$= 3,8418568 \cdot 10^7 \text{ Nmm}$$

Mn ada > Mn aman !

Jadi dipakai tulangan D 16 mm

Tulangan Geser

Dari perhitungan SAP 2000 diperoleh :

$$V_u = 4778.57 \text{ kg} = 47785,1 \text{ N}$$

$$f'_c = 25 \text{ Mpa}$$

$$f_y = 340 \text{ Mpa}$$

$$d = h - p - \frac{1}{2} \emptyset = 350 - 40 - \frac{1}{2} (12) = 304 \text{ mm}$$

$$\begin{aligned} V_c &= 1/6 \cdot \sqrt{f'_c} \cdot b \cdot d \\ &= 1/6 \cdot \sqrt{25} \cdot 250 \cdot 304 \\ &= 63333,33 \text{ N} \end{aligned}$$

$$\begin{aligned} \emptyset V_c &= 0,75 \cdot 63333,33 \text{ N} \\ &= 47500 \text{ N} \end{aligned}$$

$$\begin{aligned} 3 \emptyset V_c &= 3 \cdot 47500 \\ &= 142500 \text{ N} \end{aligned}$$

$$\emptyset V_c < V_u < 3 \emptyset V_c$$

$$47500 \text{ N} < 47785,1 \text{ N} < 142500 \text{ N}$$

Jadi di perlukan tulangan geser

$$\begin{aligned} \emptyset V_s &= V_u - \emptyset V_c \\ &= 47785,1 - 47500 = 285,1 \text{ N} \end{aligned}$$

$$V_s \text{ perlu} = \frac{\emptyset V_s}{0,75} = \frac{285,1}{0,75} = 380,133 \text{ N}$$

$$\begin{aligned} A_v &= 2 \cdot \frac{1}{4} \pi (8)^2 \\ &= 2 \cdot \frac{1}{4} \cdot 3,14 \cdot 64 = 100,48 \text{ mm}^2 \end{aligned}$$

$$s = \frac{A_v \cdot f_y \cdot d}{V_s \text{ perlu}} = \frac{100,48 \times 240 \times 304}{380,133} = 19285,6 \text{ mm}$$

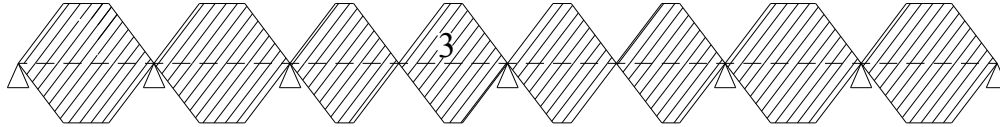
$$S \text{ max} = d/2 = \frac{304}{2} = 152 \text{ mm}$$

Jadi dipakai sengkang dengan tulangan $\emptyset 8 - 150 \text{ mm}$



6.4. Pembebanan Balok Anak as B'

6.2.1. Pembebanan



Gambar 6.2 Lebar Equivalen Balok Anak as C'

Perencanaan Dimensi Balok

$$\begin{aligned}
 h &= 1/12 \cdot L_y \\
 &= 1/12 \cdot 3750 \\
 &= 312,5 \text{ mm} = 350 \text{ mm} \\
 b &= 2/3 \cdot h \\
 &= 2/3 \cdot 312,5 \\
 &= 250 \text{ mm (h dipakai = 350 mm, b = 250 mm)}
 \end{aligned}$$

1. Beban Mati (q_D)

Pembebanan balok (A – B)

$$\begin{aligned}
 \text{Berat sendiri} &= 0,25 \times (0,35 - 0,12) \times 2400 \text{ kg/m}^3 = 138 \text{ kg/m} \\
 \text{Beban plat} &= (2 \times 1,06) \times 404 \text{ kg/m}^2 = \underline{956,25 \text{ kg/m}} \\
 q_{D1} &= 1094,25 \text{ kg/m}
 \end{aligned}$$

Pembebanan balok as (B – C)

$$\begin{aligned}
 \text{Berat sendiri} &= 0,25 \times (0,35 - 0,12) \times 2400 \text{ kg/m}^3 = 138 \text{ kg/m} \\
 \text{Beban plat} &= (2 \times 0,96) \times 404 \text{ kg/m}^2 = \underline{775,68 \text{ kg/m}} \\
 q_{D2} &= 913,68 \text{ kg/m}
 \end{aligned}$$

2. Beban hidup (q_L)

Beban hidup digunakan 250 kg/m²

$$\begin{aligned}
 q_{L1} &= (2 \times 1,06) \times 250 \text{ kg/m}^2 \\
 &= 530 \text{ kg/m}
 \end{aligned}$$



$$\begin{aligned} qL_2 &= (2 \times 0,96) \times 250 \text{ kg/m}^2 \\ &= 480 \text{ kg/m} \end{aligned}$$

4. Beban berfaktor (q_U)

$$\begin{aligned} qU_1 &= 1,2 \cdot qD + 1,6 \cdot qL \\ &= 1,2 \cdot 1094,25 + 1,6 \cdot 530 \\ &= 2161,1 \text{ kg/m} \end{aligned}$$

$$\begin{aligned} qU_2 &= 1,2 \cdot qD + 1,6 \cdot qL \\ &= 1,2 \cdot 913,68 + 1,6 \cdot 480 \\ &= 1802,50 \text{ kg/m} \end{aligned}$$

6.2.2. Perhitungan Tulangan

b. Tulangan Lentur Balok Anak

Data Perencanaan :

$$\begin{aligned} h &= 350 \text{ mm} & \emptyset_t &= 16 \text{ mm} \\ b &= 250 \text{ mm} & \emptyset_s &= 8 \text{ mm} \\ p &= 40 \text{ mm} & d &= h - p - 1/2 \emptyset_t - \emptyset_s \\ f_y &= 340 \text{ Mpa} & &= 350 - 40 - 1/2 \cdot 16 - 8 \\ f_c &= 25 \text{ Mpa} & &= 294 \end{aligned}$$

Tulangan Lentur Daerah Lapangan

$$\begin{aligned} \rho_b &= \frac{0,85 \cdot f_c \cdot \beta}{f_y} \left(\frac{600}{600 + f_y} \right) \\ &= \frac{0,85 \cdot 25}{340} \cdot 0,85 \left(\frac{600}{600 + 340} \right) \\ &= 0,0339 \end{aligned}$$

$$\begin{aligned} \rho_{\max} &= 0,75 \cdot \rho_b \\ &= 0,75 \cdot 0,0339 \\ &= 0,0254 \end{aligned}$$

$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{340} = 0,0041$$



Daerah Tumpuan

Dari perhitungan **SAP 2000** diperoleh :

$$M_u = 3324.28 \text{ kgm} = 3,3243 \cdot 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{3,3243 \cdot 10^7}{0,8} = 4,15 \cdot 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{4,15 \cdot 10^7}{250 \times (294)^2} = 1,92 \text{ N/mm}^2$$

$$m = \frac{f_y}{0,85 \cdot f_c} = \frac{340}{0,85 \cdot 25} = 16$$

$$\begin{aligned} \rho_{\text{perlu}} &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2m \cdot R_n}{f_y}} \right) \\ &= \frac{1}{16} \left(1 - \sqrt{1 - \frac{2 \times 16 \times 1,92}{340}} \right) \\ &= 0,006 \end{aligned}$$

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

$$\rho > \rho_{\text{min}}, \text{ di pakai } \rho_{\text{perlu}} = 0,006$$

$$\begin{aligned} A_s &= \rho \cdot b \cdot d \\ &= 0,006 \cdot 250 \cdot 294 \\ &= 441 \text{ mm}^2 \end{aligned}$$

$$\text{Digunakan tulangan D 16} = \frac{1}{4} \cdot \pi \cdot (16)^2 = 200,96 \text{ mm}^2$$

$$\text{Jumlah tulangan} = \frac{441}{200,96} = 2,2 \sim 3 \text{ buah.}$$

Dipakai **3 D 16 mm**

$$\begin{aligned} A_s \text{ ada} &= 3 \cdot \frac{1}{4} \cdot \pi \cdot 16^2 \\ &= 602,88 \text{ mm}^2 > A_s \dots\dots\dots \text{aman !} \end{aligned}$$

$$a = \frac{A_s \text{ ada} \times f_y}{0,85 \times f_c \times b} = \frac{602,88 \times 340}{0,85 \times 25 \times 250} = 38,58$$

$$\begin{aligned} M_n \text{ ada} &= A_s \text{ ada} \times f_y \left(d - \frac{a}{2} \right) \\ &= 602,88 \times 340 \left(294 - \frac{38,58}{2} \right) \end{aligned}$$



$$= 5,6617 \cdot 10^7 \text{ Nmm}$$

Mn ada > Mn aman !

Jadi dipakai tulangan D 16 mm

Daerah Lapangan

Dari perhitungan **SAP 2000** diperoleh :

$$M_u = 2314,88 \text{ kgm} = 2,315 \cdot 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{2,315 \cdot 10^7}{0,8} = 2,89 \cdot 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{2,89 \cdot 10^7}{250 \times (294)^2} = 1,34 \text{ N/mm}^2$$

$$m = \frac{f_y}{0,85 \cdot f_c} = \frac{340}{0,85 \cdot 25} = 16$$

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

$$= \frac{1}{16} \left(1 - \sqrt{1 - \frac{2 \times 16 \times 1,34}{340}} \right)$$

$$= 0,004$$

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

$$\rho > \rho_{\text{min}}, \text{ di pakai } \rho_{\text{min}} = 0,004$$

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

$$= 0,0041 \cdot 250 \cdot 294$$

$$= 301,35 \text{ mm}^2$$

$$\text{Digunakan tulangan D 16} = \frac{1}{4} \cdot \pi \cdot (16)^2 = 200,96 \text{ mm}^2$$

$$\text{Jumlah tulangan} = \frac{301,35}{200,96} = 1,49 \sim 2 \text{ buah.}$$

Dipakai 2 D 16 mm

$$A_s \text{ ada} = 2 \cdot \frac{1}{4} \cdot \pi \cdot 16^2$$

$$= 401,91 \text{ mm}^2 > A_s \text{ aman !}$$



$$a = \frac{As_{ada} \times f_y}{0,85 \times f_c \times b} = \frac{401,91 \times 340}{0,85 \times 25 \times 250} = 25,72$$

$$\begin{aligned} M_{n\ ada} &= As_{ada} \times f_y \left(d - \frac{a}{2} \right) \\ &= 401,91 \times 340 \left(294 - \frac{25,72}{2} \right) \\ &= 3,84176 \cdot 10^7 \text{ Nmm} \end{aligned}$$

$M_{n\ ada} > M_n$ aman !

Jadi dipakai tulangan D 16 mm

Tulangan Geser

Dari perhitungan SAP 2000 diperoleh :

$$V_u = 4938,65 \text{ kg} = 49386,5 \text{ N}$$

$$f_c = 25 \text{ Mpa}$$

$$f_y = 340 \text{ Mpa}$$

$$d = h - p - \frac{1}{2} \emptyset = 350 - 40 - \frac{1}{2} (12) = 304 \text{ mm}$$

$$\begin{aligned} V_c &= \frac{1}{6} \cdot \sqrt{f_c} \cdot b \cdot d \\ &= \frac{1}{6} \cdot \sqrt{25} \cdot 250 \cdot 304 \\ &= 63333,33 \text{ N} \end{aligned}$$

$$\begin{aligned} \emptyset V_c &= 0,75 \cdot 63333,33 \text{ N} \\ &= 47500 \text{ N} \end{aligned}$$

$$\begin{aligned} 3 \emptyset V_c &= 3 \cdot 47500 \\ &= 142500 \text{ N} \end{aligned}$$

$$\emptyset V_c < V_u < 3 \emptyset V_c$$

$$47500 \text{ N} < 49386,5 \text{ N} < 142500 \text{ N}$$

Jadi di perlukan tulangan geser

$$\begin{aligned} \emptyset V_s &= V_u - \emptyset V_c \\ &= 49386,5 - 47500 = 1886,5 \text{ N} \end{aligned}$$

$$V_s \text{ perlu} = \frac{\phi V_s}{0,75} = \frac{1886,5}{0,75} = 2515,33 \text{ N}$$

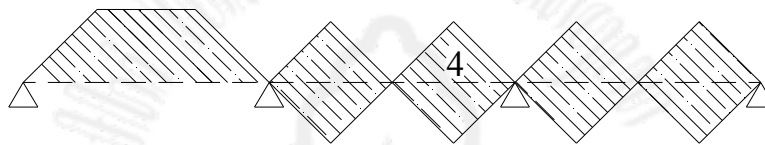


$$\begin{aligned}
 A_v &= 2 \cdot \frac{1}{4} \pi (8)^2 \\
 &= 2 \cdot \frac{1}{4} \cdot 3,14 \cdot 64 = 100,48 \text{ mm}^2 \\
 s &= \frac{A_v \cdot f_y \cdot d}{V_s \text{ perlu}} = \frac{100,48 \times 240 \times 304}{2515,33} = 2914,6 \text{ mm} \\
 S_{\text{max}} &= d/2 = \frac{304}{2} = 152 \text{ mm}
 \end{aligned}$$

Jadi dipakai sengkang dengan tulangan $\emptyset 8 - 150 \text{ mm}$

6.5. Pembebanan Balok Anak as 6

6.5.1. Pembebanan



Gambar 6.5. Lebar Equivalen Balok Anak as 4'

Perencanaan Dimensi Balok

$$\begin{aligned}
 h &= 1/15 \cdot L_y \\
 &= 1/15 \cdot 5000 \\
 &= 333,33 \text{ mm} = 350 \text{ mm} \\
 b &= 2/3 \cdot h \\
 &= 2/3 \cdot 333,33 \\
 &= 222 \text{ mm (h dipakai} = 350 \text{ mm, } b = 250 \text{ mm)}
 \end{aligned}$$

1. Beban Mati (q_D)

Pembebanan balok as 4' (A – B)

Berat sendiri	= $0,25 \times (0,350 - 0,12) \times 2400 \text{ kg/m}^3$	= 138	kg/m	
Beban Plat	= $(1,32) \times 404 \text{ kg/m}^2$	= 533,28	kg/m	
		<hr style="width: 100%;"/>		
		q_{D1}	= 671,28	kg/m

Pembebanan balok as 4' (A – B)

Berat sendiri	= $0,25 \times (0,35 - 0,12) \times 2400 \text{ kg/m}^3$	= 138	kg/m	
---------------	--	-------	------	--



$$\begin{aligned} \text{Beban Plat} &= (2 \times 0,83) \times 404 \text{ kg/m}^2 && = 670,64 \text{ kg/m} \\ &&& \text{qD2} && = 808,64 \text{ kg/m} \end{aligned}$$

2. Beban hidup (q_L)

Beban hidup digunakan 250 kg/m^2

$$q_{L1} = 1,32 \times 250 \text{ kg/m}^2 = 330 \text{ kg/m}$$

$$q_{L2} = (2 \times 0,83) \times 250 \text{ kg/m}^2 = 415 \text{ kg/m}$$

3. Beban berfaktor (q_U)

$$\begin{aligned} q_{U1} &= 1,2 \cdot q_D + 1,6 \cdot q_L \\ &= (1,2 \times 671,28) + (1,6 \times 330) \\ &= 1333,54 \text{ kg/m} \end{aligned}$$

$$\begin{aligned} q_{U2} &= 1,2 \cdot q_D + 1,6 \cdot q_L \\ &= (1,2 \times 808,64) + (1,6 \times 415) \\ &= 1634,37 \text{ kg/m} \end{aligned}$$

6.5.2. Perhitungan Tulangan

a. Tulangan lentur balok anak

Data Perencanaan :

$$\begin{aligned} h &= 350 \text{ mm} && \emptyset_t &= 16 \text{ mm} \\ b &= 250 \text{ mm} && \emptyset_s &= 8 \text{ mm} \\ p &= 40 \text{ mm} && d &= h - p - 1/2 \emptyset_t - \emptyset_s \\ f_y &= 340 \text{ Mpa} && &= 350 - 40 - 1/2 \cdot 16 - 8 \\ f'_c &= 25 \text{ MPa} && &= 294 \end{aligned}$$

$$\begin{aligned} \rho_b &= \frac{0,85 \cdot f'_c \cdot \beta}{f_y} \left(\frac{600}{600 + f_y} \right) \\ &= \frac{0,85 \cdot 25}{340} \cdot 0,85 \left(\frac{600}{600 + 340} \right) \\ &= 0,0339 \\ \rho_{\max} &= 0,75 \cdot \rho_b \\ &= 0,75 \cdot 0,0339 \end{aligned}$$



$$= 0,0254$$

$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{340} = 0,0041$$

Daerah Tumpuan :

Dari perhitungan **SAP 2000** diperoleh :

$$M_u = 3136.12 \text{ kgm} = 3,1361 \cdot 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{3,1361 \cdot 10^7}{0,8} = 3,92 \cdot 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{3,92 \cdot 10^7}{250 \times (294)^2} = 1,81 \text{ N/mm}^2$$

$$m = \frac{f_y}{0,85 \cdot f_c} = \frac{340}{0,85 \cdot 25} = 16$$

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

$$= \frac{1}{16} \left(1 - \sqrt{1 - \frac{2 \times 16 \times 1,81}{340}} \right)$$

$$= 0,006$$

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

$$\rho > \rho_{\min}, \text{ di pakai } \rho_{\text{perlu}} = 0,006$$

$$\begin{aligned} A_s &= \rho \cdot b \cdot d \\ &= 0,006 \cdot 250 \cdot 294 \\ &= 441 \text{ mm}^2 \end{aligned}$$

$$\text{Digunakan tulangan D 16} = \frac{1}{4} \cdot \pi \cdot (16)^2 = 200,96 \text{ mm}^2$$

$$\text{Jumlah tulangan} = \frac{441}{200,96} = 2,2 \sim 3 \text{ buah.}$$

Dipakai **3 D 16 mm**

$$\begin{aligned} A_s \text{ ada} &= 3 \cdot \frac{1}{4} \cdot \pi \cdot 16^2 \\ &= 602,88 \text{ mm}^2 > A_s \dots\dots\dots \text{ aman !} \end{aligned}$$

$$a = \frac{A_s \text{ ada} \times f_y}{0,85 \times f_c \times b} = \frac{602,88 \times 340}{0,85 \times 25 \times 250} = 38,58$$



$$\begin{aligned} M_n \text{ ada} &= A_s \text{ ada} \times f_y (d - \frac{a}{2}) \\ &= 602,88 \times 340 (294 - \frac{35,58}{2}) \\ &= 5,6617 \cdot 10^7 \text{ Nmm} \end{aligned}$$

$M_n \text{ ada} > M_n \dots\dots\dots$ aman !

Jadi dipakai tulangan D 16 mm

Daerah Lapangan :

Dari perhitungan **SAP 2000** diperoleh :

$$M_u = 2746.23 \text{ kgm} = 2,7462 \cdot 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{2,7462 \cdot 10^7}{0,8} = 3,43 \cdot 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{3,43 \cdot 10^7}{250 \times (294)^2} = 1,59 \text{ N/mm}^2$$

$$m = \frac{f_y}{0,85 \cdot f_c} = \frac{340}{0,85 \cdot 25} = 16$$

$$\begin{aligned} \rho_{\text{perlu}} &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2m \cdot R_n}{f_y}} \right) \\ &= \frac{1}{16} \left(1 - \sqrt{1 - \frac{2 \times 16 \times 1,59}{340}} \right) \\ &= 0,005 \end{aligned}$$

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

$$\rho > \rho_{\text{min}}, \text{ di pakai } \rho_{\text{perlu}} = 0,005$$

$$\begin{aligned} A_s &= \rho \cdot b \cdot d \\ &= 0,005 \cdot 250 \cdot 294 \\ &= 367,5 \text{ mm}^2 \end{aligned}$$

$$\text{Digunakan tulangan D 16} = \frac{1}{4} \cdot \pi \cdot (16)^2 = 200,96 \text{ mm}^2$$

$$\text{Jumlah tulangan} = \frac{367,5}{200,96} = 1,82 \sim 2 \text{ buah.}$$

Dipakai 2 D 16 mm

$$A_s \text{ ada} = 2 \cdot \frac{1}{4} \cdot \pi \cdot 16^2$$



$$= 401,91 \text{ mm}^2 > A_s \dots\dots\dots \text{aman !}$$

$$a = \frac{A_s \text{ ada} \times f_y}{0,85 \times f'_c \times b} = \frac{401,91 \times 340}{0,85 \times 25 \times 250} = 25,72$$

$$\begin{aligned} M_n \text{ ada} &= A_s \text{ ada} \times f_y \left(d - \frac{a}{2} \right) \\ &= 401,91 \times 340 \left(294 - \frac{25,72}{2} \right) \\ &= 3,84176 \cdot 10^7 \text{ Nmm} \end{aligned}$$

$$M_n \text{ ada} > M_n \dots\dots\dots \text{aman !}$$

Jadi dipakai tulangan D 16 mm

Tulangan Geser

Dari perhitungan SAP 2000 diperoleh :

$$V_u = 3961,12 \text{ kg} = 39611,2 \text{ N}$$

$$f'_c = 25 \text{ Mpa}$$

$$f_y = 340 \text{ Mpa}$$

$$d = h - p - \frac{1}{2} \emptyset = 350 - 40 - \frac{1}{2} (12) = 304 \text{ mm}$$

$$\begin{aligned} V_c &= \frac{1}{6} \cdot \sqrt{f'_c} \cdot b \cdot d \\ &= \frac{1}{6} \cdot \sqrt{25} \cdot 250 \cdot 304 \\ &= 63333,33 \text{ N} \end{aligned}$$

$$\begin{aligned} \emptyset V_c &= 0,75 \cdot 63333,33 \text{ N} \\ &= 47500 \text{ N} \end{aligned}$$

$$\begin{aligned} 3 \emptyset V_c &= 3 \cdot 47500 \\ &= 142500 \text{ N} \end{aligned}$$

$$V_u < \emptyset V_c < 3 \emptyset V_c$$

$$39611,2 \text{ N} < 47500 \text{ N} < 142500 \text{ N}$$

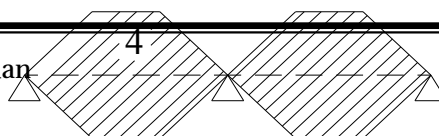
Jadi tidak diperlukan tulangan geser

$$S_{\text{max}} = d/2 = \frac{304}{2} = 152 \text{ mm}$$

Jadi dipakai sengkang dengan tulangan $\emptyset 8 - 150 \text{ mm}$

6.6. Pembebanan Balok Anak as D'

6.4.1. Pembebanan





Gambar 6.4. Lebar Equivalen Balok Anak as 4'

Perencanaan Dimensi Balok :

$$\begin{aligned} h &= 1/12 \cdot L_y \\ &= 1/10 \cdot 3750 \\ &= 375 \text{ mm} = 350 \text{ mm} \end{aligned}$$

$$\begin{aligned} b &= 2/3 \cdot h \\ &= 2/3 \cdot 350 \\ &= 233,33 \text{ mm (h dipakai = 350 mm, b = 250 mm)} \end{aligned}$$

1. Beban Mati (q_D)

Pembebanan balok as 4' (A – B)

$$\text{Berat sendiri} = 0,25 \times (0,35 - 0,12) \times 2400 \text{ kg/m}^3 = 138 \text{ kg/m}$$

$$\text{Beban Plat} = (2 \times 1,18) \times 404 \text{ kg/m}^2 = 953,44 \text{ kg/m}$$

$$q_D = 1091,44 \text{ kg/m}$$

2. Beban hidup (q_L)

Beban hidup digunakan 250 kg/m²

$$q_L = (2 \times 1,18) \times 250 \text{ kg/m}^2 = 590 \text{ kg/m}$$

3. Beban berfaktor (q_U)

$$\begin{aligned} q_U &= 1,2 \cdot q_D + 1,6 \cdot q_L \\ &= (1,2 \times 1091,44) + (1,6 \times 590) \\ &= 2253,73 \text{ kg/m} \end{aligned}$$

6.5.2. Perhitungan Tulangan

a. Tulangan lentur balok anak

Data Perencanaan :

$$h = 350 \text{ mm} \qquad \qquad \qquad \varnothing_t = 16 \text{ mm}$$

$$b = 250 \text{ mm} \qquad \qquad \qquad \varnothing_s = 8 \text{ mm}$$



$$\begin{aligned}
 p &= 40 \text{ mm} & d &= h - p - 1/2 \text{ } \varnothing_t - \varnothing_s \\
 f_y &= 340 \text{ Mpa} & &= 350 - 40 - 1/2 \cdot 16 - 8 \\
 f'_c &= 25 \text{ MPa} & &= 294
 \end{aligned}$$

$$\begin{aligned}
 \rho_b &= \frac{0,85 \cdot f'_c \cdot \beta}{f_y} \left(\frac{600}{600 + f_y} \right) \\
 &= \frac{0,85 \cdot 25}{340} \cdot 0,85 \left(\frac{600}{600 + 340} \right) \\
 &= 0,0339
 \end{aligned}$$

$$\begin{aligned}
 \rho_{\max} &= 0,75 \cdot \rho_b \\
 &= 0,75 \cdot 0,0339 \\
 &= 0,0254
 \end{aligned}$$

$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{340} = 0,004$$

Daerah Tumpuan :

Dari perhitungan **SAP 2000** diperoleh :

$$M_u = 3936.85 \text{ kgm} = 3,937 \cdot 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{3,937 \cdot 10^7}{0,8} = 4,92 \cdot 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{4,92 \cdot 10^7}{250 \times (294)^2} = 2,28 \text{ N/mm}^2$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{340}{0,85 \cdot 25} = 16$$

$$\begin{aligned}
 \rho_{\text{perlu}} &= \frac{1}{m} \cdot \left(1 - \sqrt{1 - \frac{2m \cdot R_n}{f_y}} \right) \\
 &= \frac{1}{16} \cdot \left(1 - \sqrt{1 - \frac{2 \times 16 \times 2,28}{340}} \right) \\
 &= 0,0071
 \end{aligned}$$

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

$$\rho > \rho_{\min}, \text{ di pakai } \rho_{\text{perlu}} = 0,0071$$



$$\begin{aligned} A_s &= \rho_{\min} \cdot b \cdot d \\ &= 0,0071 \cdot 250 \cdot 294 \\ &= 521,85 \text{ mm}^2 \end{aligned}$$

$$\text{Digunakan tulangan D 16} = \frac{1}{4} \cdot \pi \cdot (16)^2 = 200,96 \text{ mm}^2$$

$$\text{Jumlah tulangan} = \frac{521,85}{200,96} = 2,6 \sim 3 \text{ buah.}$$

Dipakai tulangan 3 D 16 mm

$$\begin{aligned} A_s \text{ ada} &= 3 \cdot \frac{1}{4} \cdot \pi \cdot 16^2 \\ &= 602,88 \text{ mm}^2 > A_s \dots\dots\dots \text{aman !} \end{aligned}$$

$$a = \frac{A_s \text{ ada} \times f_y}{0,85 \times f'_c \times b} = \frac{602,88 \times 340}{0,85 \times 25 \times 250} = 38,58$$

$$\begin{aligned} M_n \text{ ada} &= A_s \text{ ada} \times f_y \left(d - \frac{a}{2} \right) \\ &= 602,88 \times 340 \left(294 - \frac{38,58}{2} \right) \\ &= 5,6309836 \cdot 10^7 \text{ Nmm} \end{aligned}$$

$$M_n \text{ ada} > M_n \dots\dots\dots \text{aman !}$$

Jadi dipakai tulangan D 16 mm

Daerah Lapangan :

Dari perhitungan **SAP 2000** diperoleh :

$$M_u = 2237.63 \text{ kgm} = 2,238 \cdot 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{2,238 \cdot 10^7}{0,8} = 2,8 \cdot 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{2,8 \cdot 10^7}{250 \times 294^2} = 1,31 \text{ N/mm}^2$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{340}{0,85 \cdot 25} = 16$$

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



$$= \frac{1}{16} \left(1 - \sqrt{1 - \frac{2 \times 16 \times 1,31}{340}} \right)$$

$$= 0,004$$

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

$$\rho > \rho_{\min}, \text{ di pakai } \rho_{\min} = 0,0041$$

$$\begin{aligned} A_s &= \rho_{\min} \cdot b \cdot d \\ &= 0,0041 \cdot 250 \cdot 294 \\ &= 301,35 \text{ mm}^2 \end{aligned}$$

$$\text{Digunakan tulangan D 16} = \frac{1}{4} \cdot \pi \cdot (16)^2 = 200,96 \text{ mm}^2$$

$$\text{Jumlah tulangan} = \frac{301,35}{200,96} = 1,49 \sim 2 \text{ buah.}$$

Dipakai tulangan 2 D 16 mm

$$\begin{aligned} A_s \text{ ada} &= 2 \cdot \frac{1}{4} \cdot \pi \cdot 16^2 \\ &= 401,92 \text{ mm}^2 > A_s \dots\dots\dots \text{aman !} \end{aligned}$$

$$a = \frac{A_s \text{ ada} \times f_y}{0,85 \times f_c \times b} = \frac{401,92 \times 340}{0,85 \times 25 \times 250} = 25,72$$

$$\begin{aligned} M_n \text{ ada} &= A_s \text{ ada} \times f_y \left(d - \frac{a}{2} \right) \\ &= 401,92 \times 340 \left(294 - \frac{25,72}{2} \right) \\ &= 3,841857 \cdot 10^7 \text{ Nmm} \end{aligned}$$

$$M_n \text{ ada} > M_n \dots\dots\dots \text{aman !}$$

Jadi dipakai tulangan D 16 mm

Tulangan Geser

Dari perhitungan SAP 2000 diperoleh :

$$V_u = 5275,48 \text{ kg} = 52755,9 \text{ N}$$

$$f_c = 25 \text{ Mpa}$$

$$f_y = 340 \text{ Mpa}$$

$$d = h - p - \frac{1}{2} \varnothing = 350 - 40 - \frac{1}{2} (12) = 304 \text{ mm}$$

$$\begin{aligned} V_c &= \frac{1}{6} \cdot \sqrt{f_c} \cdot b \cdot d \\ &= \frac{1}{6} \cdot \sqrt{25} \cdot 250 \cdot 304 \\ &= 63333,33 \text{ N} \end{aligned}$$



$$\begin{aligned}\emptyset V_c &= 0,75 \cdot 63333,33 \text{ N} \\ &= 47500 \text{ N}\end{aligned}$$

$$\begin{aligned}3 \emptyset V_c &= 3 \cdot 47500 \\ &= 142500 \text{ N}\end{aligned}$$

$$\emptyset V_c < V_u < 3 \emptyset V_c$$

$$47500 \text{ N} < 52755,9 \text{ N} < 142500 \text{ N}$$

Jadi diperlukan tulangan geser

$$\begin{aligned}\emptyset V_{\text{perlu}} &= V_u - \emptyset V_c \\ &= 52755,9 - 47500 = 5255,9 \text{ N}\end{aligned}$$

$$V_s \text{ perlu} = \frac{\phi V_{sp}}{0,75} = \frac{5255,9}{0,75} = 7007,87 \text{ N}$$

$$\begin{aligned}A_v &= 2 \cdot \frac{1}{4} \pi (8)^2 \\ &= 2 \cdot \frac{1}{4} \cdot 3,14 \cdot 64 = 100,48 \text{ mm}^2\end{aligned}$$

$$S = \frac{A_v \cdot f_y \cdot d}{V_s \text{ perlu}} = \frac{100,48 \times 340 \times 304}{7007,87} = 1046,11 \text{ mm}$$

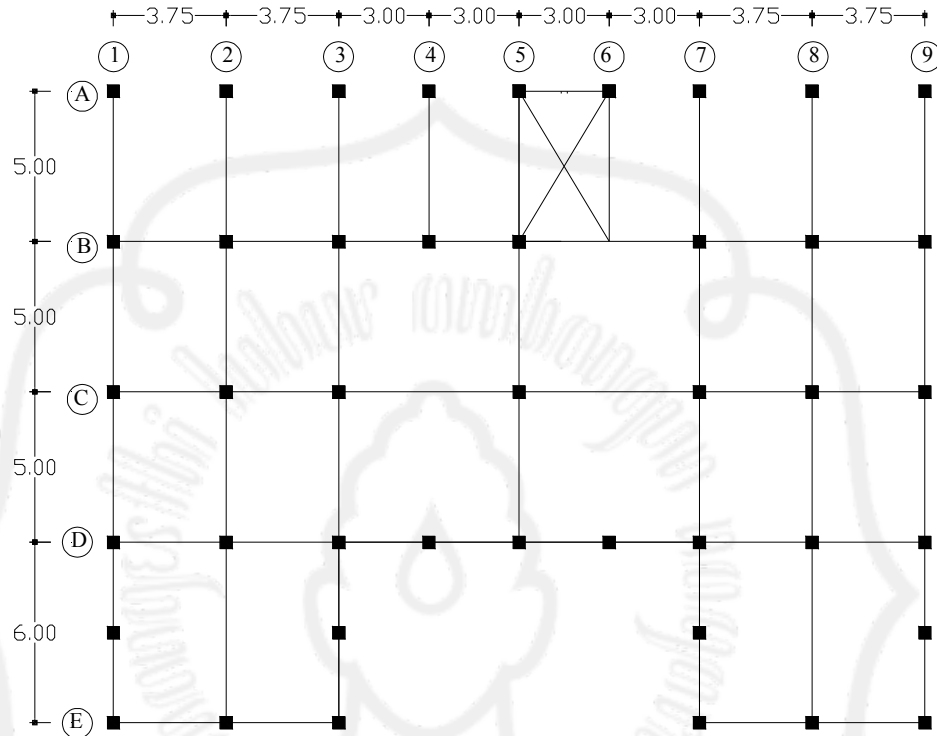
$$S_{\text{max}} = d/2 = \frac{304}{2} = 152 \text{ mm}$$

Jadi dipakai sengkang dengan tulangan **Ø 8 – 150 mm**



BAB 7 PORTAL

7.1. Perencanaan Portal



Gambar 7. 1 Gambar Denah Portal

Keterangan:

Balok Portal : As A	Balok Portal : As 2
Balok Portal : As B	Balok Portal : As 3
Balok Portal : As C	Balok Portal : As 5
Balok Portal : As D	Balok Portal : As 7
Balok Portal : As E	Balok Portal : As 8
Balok Portal : As 1	Balok Portal : As 9



7.1.1. Dasar Perencanaan

Secara umum data yang digunakan untuk perhitungan rencana portal adalah sebagai berikut :

- a. Bentuk denah portal : Seperti pada gambar
- b. Model perhitungan : SAP 2000 (3 D)
- c. Perencanaan dimensi rangka : b (mm) x h (mm)
 - Dimensi kolom : 500 mm x 500 mm
 - Dimensi sloof : 200 mm x 300 mm
 - Dimensi balok : 300 mm x 500 mm
 - Dimensi ring balk : 200 mm x 250 mm
- d. Kedalaman pondasi : 2 m
- e. Mutu baja tulangan : U34 (fy = 340 MPa)
- f. Mutu baja sengkang : U24 (fy = 240 MPa)

7.1.2 Perencanaan Pembebanan

Secara umum data pembebanan portal adalah sebagai berikut:

a. Beban Mati (q_D)

➤ Berat sendiri = $0,3 \times (0,5 - 0,12) \times 2400 = 274 \text{ kg/m}$

➤ Plat Lantai

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

Berat keramik (1 cm) = $0,01 \times 2400 \times 1 = 24 \text{ kg/m}$

Berat Spesi (2 cm) = $0,02 \times 2100 \times 1 = 42 \text{ kg/m}$

Berat plafond + instalasi listrik = 18 kg/m

Berat Pasir (2 cm) = $0,02 \times 1600 \times 1 = 32 \text{ kg/m}$

$q_D = 404 \text{ kg/m}$

➤ Dinding

Berat sendiri dinding = $0,15 (4 - 0,4) \times 1700 = 918 \text{ kg/m}$

➤ Atap

Kuda kuda Utama = $7927,50 \text{ kg (SAP 2000)}$

Jurai = $1368,18 \text{ kg (SAP 2000)}$

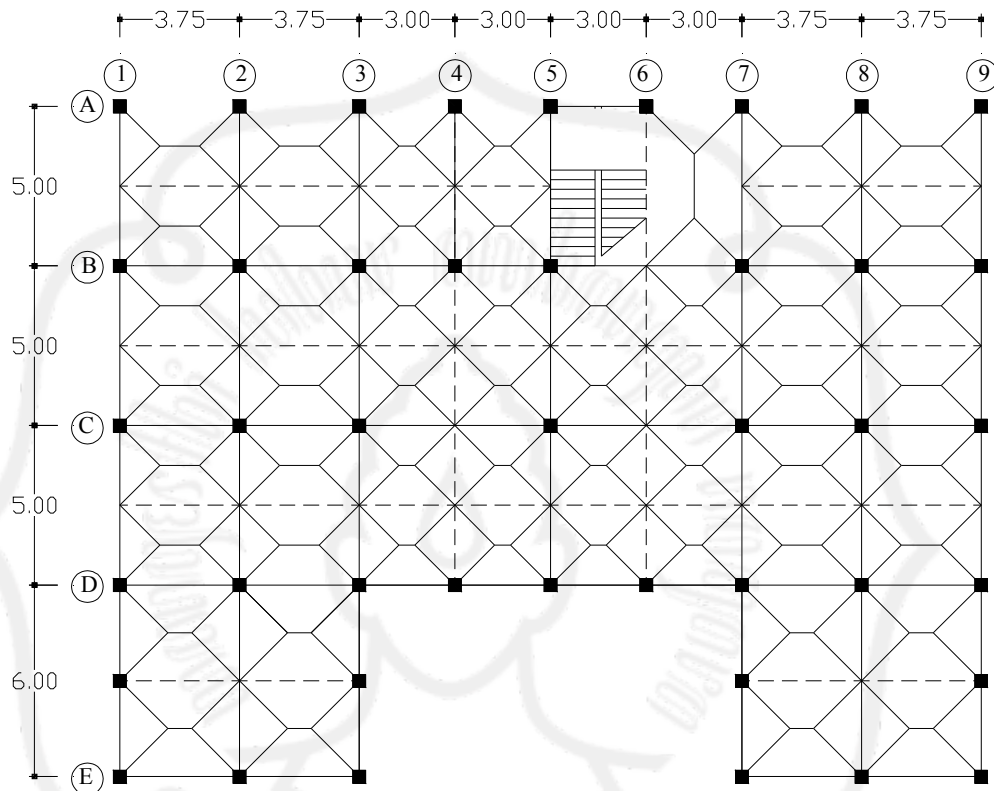
Setengah Kuda-kuda = $1641,06 \text{ kg (SAP 2000)}$



b. Beban hidup untuk toko (q_L)

$$\text{Beban hidup} = 250 \times 0,8 = 200 \text{ kg/m}^2$$

7.2. Perhitungan Luas Equivalen untuk Plat Lantai



$$\text{Luas equivalent segitiga} : \frac{1}{3} \cdot lx$$

$$\text{Luas equivalent trapezium} : \frac{1}{6} \cdot lx \left(3 - 4 \left(\frac{lx}{2 \cdot ly} \right)^2 \right)$$



Tabel 7.1. Hitungan Lebar Equivalen

No	Ukuran Pelat (m ²)	Ly (m)	Lx (m)	Leq (trapezium)	Leq (segitiga)
1	5,0 x 3,0	5,0	2,5	1,32	1,00
2	3,75 x 2,5	3,75	2,5	1,06	0,83
3	3,0 x 2,5	3,0	2,5	0,96	0,83
4	3,75 x 3,0	3,75	3,0	1,18	1,00

7.3. Perhitungan Pembebanan Balok

7.3.1. Perhitungan Pembebanan Balok Memanjang

Pada perhitungan pembebanan balok, diambil satu perencanaan sebagai acuan penulangan Balok memanjang, perencanaan tersebut pada balok **As A** **bentang 1 - 9**

- Pembebanan balok induk A 1-2 dan 2 - 3

Beban Mati (qd):

$$\text{Berat sendiri} = 0,3 \times (0,5 - 0,12) \times 2400 = 274 \quad \text{kg/m}$$

$$\text{Berat plat lantai} = 404 \cdot (1,06) = 428,2 \quad \text{kg/m}$$

$$\text{Berat dinding} = 0,15 (4 - 0,5) \times 1700 = 892,5 \quad \text{kg/m}$$

$$\text{Jumlah} = 1594,7 \quad \text{kg/m}$$

$$\text{Beban hidup (ql)} : 200 \cdot (1,06) = 212 \quad \text{kg/m}$$

Beban berfaktor (qU1)

$$qU1 = 1,2 \cdot qD + 1,6 \cdot qL$$

$$= (1,2 \cdot 1594,7) + (1,6 \cdot 212)$$

$$= 2252,84 \quad \text{kg/m}$$



- Pembebanan balok induk A 3-4 dan 4 – 5

Beban mati (qd):

$$\begin{aligned} \text{Berat sendiri} &= 0,3 \times (0,5-0,12) \times 2400 = 274 && \text{kg/m} \\ \text{Berat plat lantai} &= 404 \cdot (0,96) = 387,8 && \text{kg/m} \\ \text{Berat dinding} &= 0,15 (4 - 0,5) \times 1700 = 892,5 && \text{kg/m} \\ \text{Jumlah} & & \underline{\hspace{1cm}} & = 1554,3 && \text{kg/m} \end{aligned}$$

$$\text{Beban hidup (ql)} : 200 \cdot (0,96) = 192 \text{ kg/m}$$

Beban berfaktor (qU1)

$$\begin{aligned} qU &= 1,2 \cdot qD + 1,6 \cdot qL \\ &= (1,2 \cdot 1554,3) + (1,6 \cdot 192) \\ &= 2172,4 \text{ kg/m} \end{aligned}$$

- Pembebanan balok induk A 5-7

Beban mati (qd):

$$\begin{aligned} \text{Berat sendiri} &= 0,3 \times (0,5-0,12) \times 2400 = 274 && \text{kg/m} \\ \text{Berat plat lantai} &= 404 \cdot (1,00) = 404 && \text{kg/m} \\ \text{Berat dinding} &= 0,15 (4 - 0,5) \times 1700 = 892,5 && \text{kg/m} \\ \text{Jumlah} & & \underline{\hspace{1cm}} & = 1570,5 && \text{kg/m} \end{aligned}$$

$$\text{Beban hidup (ql)} : 200 \cdot (1,00) = 200 \text{ kg/m}$$

Beban berfaktor (qU2)

$$\begin{aligned} qU &= 1,2 \cdot qD + 1,6 \cdot qL \\ &= (1,2 \cdot 1570,5) + (1,6 \cdot 200) \\ &= 2204,6 \text{ kg/m} \end{aligned}$$

- Pembebanan balok induk A 7-8 dan 8-9

Beban Mati (qd):

$$\begin{aligned} \text{Berat sendiri} &= 0,3 \times (0,5 - 0,12) \times 2400 = 274 && \text{kg/m} \\ \text{Berat plat lantai} &= 404 \cdot (1,06) = 428,2 && \text{kg/m} \\ \text{Berat dinding} &= 0,15 (4 - 0,5) \times 1700 = 892,5 && \text{kg/m} \end{aligned}$$



$$\begin{aligned}
 & \text{Jumlah} & = & 1594,7 & \text{ kg/m} \\
 \text{Beban hidup (qI)} & : 200 \cdot (1,06) & = & 212 & \text{ kg/m} \\
 \text{Beban berfaktor (qU)} \\
 qU & = 1,2 \cdot qD + 1,6 \cdot qL \\
 & = (1,2 \cdot 1594,7) + (1,6 \cdot 212) \\
 & = 2220,8 & \text{ kg/m}
 \end{aligned}$$

➤ Pembebanan ringbalk

Beban mati (qd)

$$\text{Berat sendiri} = 0,200 \times 0,250 \times 2400 = 120 \text{ kg/m}$$

➤ Pembebanan sloof

Beban mati (qd)

$$\text{Berat sendiri} = 0,2 \times 0,3 \times 2400 = 144 \text{ kg/m}$$

$$\text{Berat dinding} = 0,15 \times (4-0,30) \times 1700 = 944 \text{ kg/m}$$

$$\text{Jumlah} = 1088 \text{ kg/m}$$

➤ Beban titik :

$$\text{Beban titik pada kuda-kuda utama} = 7927,50 \text{ kg}$$

$$\text{Beban titik pada Jurai} = 1368,18 \text{ kg}$$



Table 7.2. Rekapitulasi Hitungan Pembebanan Portal Memanjang

BALOK INDUK		PEMBEBANAN							
		BEBAN MATI (kg/m ²)				Jumlah (berat sendiri+berat plat lantai+berat dinding)	BEBAN HIDUP (kg/m ²)		
		plat lantai			berat dinding		beban	No. Leq	jumlah
Balok As	bentang	beban	No. Leq	jumlah					
A	1-3	404	2	428	892.5	1595	200	2	212
	3-5	404	3	388	892.5	1554	200	3	192
	5-7	404	1	404	892.5	1571	200	1	200
	7-9	404	2	428	892.5	1595	200	2	212
B	1-3	404	2+2	856	892.5	2023	200	2+2	424
	3-5	404	3+3	776	892.5	1942	200	3+3	384
	5-7	404	3	388	892.5	1554	200	3	192
	7-9	404	2+2	856	-	1130	200	2+2	424
C	1-3	404	2+2	856	-	1130	200	2+2	424
	3-5	404	3+3	776	-	1050	200	3+3	384
	5-7	404	3+3	776	-	1050	200	3+3	384
	7-9	404	2+2	856	-	1130	200	2+2	424
D	1-3	404	2+2	905	-	1179	200	2+2	448
	3-5	404	3	388	892.5	1554	200	3	192
	5-7	404	3	388	892.5	1554	200	3	192
	7-9	404	2+2	905	-	1179	200	2+2	448
E	1-3	404	4	477	892.5	1643	200	4	236
	7-9	404	4	477	892.5	1643	200	4	236

No	1	2	3	4
L _{eq} segitiga	0,83	0,83	0,83	1,00
L _{eq} trapesium	1,32	1,06	0,96	1,18

$$\text{Berat sendiri balok} = 0,3 \times (0,5 - 0,12) \times 2400 = 274 \text{ kg/m}$$

7.3.2. Perhitungan Pembebanan Balok Melintang



Pada perhitungan pembebanan balok, diambil satu perencanaan sebagai acuan penulangan Balok melintang. Perencanaan tersebut pada balok

As 1 Bentang A-E

- Pembebanan balok induk 1 (A-B)

Beban Mati (qd):

$$\text{Berat sendiri} = 0,3 \times (0,5 - 0,12) \times 2400 = 274 \quad \text{kg/m}$$

$$\text{Berat plat lantai} = 404 \times 0,83 = 335 \quad \text{kg/m}$$

$$\text{Berat dinding} = 0,15 (4 - 0,5) \times 1700 = 892,5 \quad \text{kg/m}$$

$$\text{Jumlah} = 1501,5 \quad \text{kg/m}$$

$$\text{Beban hidup (ql)} = 200 \cdot 0,83 = 166 \quad \text{kg/m}$$

- Pembebanan balok induk 1 (B-C)

Beban Mati (qd):

$$\text{Berat sendiri} = 0,3 \times (0,5 - 0,12) \times 2400 = 274 \quad \text{kg/m}$$

$$\text{Berat plat lantai} = 404 \times 0,83 = 335 \quad \text{kg/m}$$

$$\text{Berat dinding} = 0,15 (4 - 0,5) \times 1700 = 892,5 \quad \text{kg/m}$$

$$\text{Jumlah} = 1501,5 \quad \text{kg/m}$$

$$\text{Beban hidup (ql)} = 200 \cdot 0,83 = 166 \quad \text{kg/m}$$

- Pembebanan balok induk 1 (C-D)

Beban Mati (qd):

$$\text{Berat sendiri} = 0,3 \times (0,5 - 0,12) \times 2400 = 274 \quad \text{kg/m}$$

$$\text{Berat plat lantai} = 404 \times 0,83 = 335 \quad \text{kg/m}$$

$$\text{Berat dinding} = 0,15 (4 - 0,5) \times 1700 = 892,5 \quad \text{kg/m}$$

$$\text{Jumlah} = 1501,5 \quad \text{kg/m}$$

$$\text{Beban hidup (ql)} = 200 \cdot 0,83 = 166 \quad \text{kg/m}$$

- Pembebanan balok induk 1 (D-E)



Beban mati (qd):

Berat sendiri	= $0,3 \times (0,5-0,12) \times 2400$	= 274	kg/m
Berat plat lantai	= $404 \times 1,00$	= 404	kg/m
Berat dinding	= $0,15 (4 - 0,5) \times 1700$	= 892,5	kg/m
	Jumlah	= 1570,5	kg/m
Beban hidup (ql)	: $200 \times 1,00$	= 200	kg/m

➤ Pembebanan ringbalk

Beban mati (qd)

$$\text{Berat sendiri} = 0,20 \times 0,25 \times 2400 = 120 \text{ kg/m}$$

➤ Pembebanan sloof

Beban mati (qd)

$$\text{Berat sendiri} = 0,2 \times 0,3 \times 2400 = 144 \text{ kg/m}$$

$$\text{Berat dinding} = 0,15 (4 - 0,3) \times 1700 = 944 \text{ kg/m}$$

$$\text{Jumlah} = 1088 \text{ kg/m}$$

➤ Beban titik :

$$\text{Beban titik pada setengah kuda-kuda} = 1126.69 \text{ kg}$$

$$\text{Beban titik pada Jurai} = 1368.18 \text{ kg}$$

Table 7.3. Rekapitulasi Hitungan Pembebanan Portal Melintang

BALOK INDUK	PEMBEBANAN
----------------	------------



Balok As	bentang	BEBAN MATI (kg/m)				Jumlah (berat sendiri+berat plat lantai+berat dinding)	BEBAN HIDUP (kg/m)		
		plat lantai			berat dinding		beban	No. Leq	jumlah
		beban	No. Leq	jumlah					
1	A-B	404	2	335	892.5	1553	200	2	166
	B-C	404	2	335	892.5	1553	200	2	166
	C-D	404	2	335	892.5	1553	200	2	166
	D-E	404	4	404	892.5	1622	200	4	200
2	A-B	404	2+2	671	-	945	200	2+2	332
	B-C	404	2+2	671	-	945	200	2+2	332
	C-D	404	2+2	671	-	945	200	2+2	332
	D-E	404	4+4	808	-	1082	200	4+4	400
3	A-B	404	2+3	671	892.5	1889	200	2+3	332
	B-C	404	2+3	671	-	945	200	2+3	332
	C-D	404	2+3	671	-	945	200	2+3	332
	D-E	404	4	404	892.5	1622	200	4	200
5	A-B	404	3	335	892.5	1553	200	3	166
	B-C	404	3+3	671	-	945	200	3+3	332
	C-D	404	3+3	671	-	945	200	3+3	332
7	A-B	404	1+2	869	892.5	2087	200	1+2	430
	B-C	404	2+3	671	-	945	200	2+3	332
	C-D	404	2+3	671	-	945	200	2+3	332
	D-E	404	4	335	892.5	1553	200	4	166
8	A-B	404	2+2	671	-	945	200	2+2	332
	B-C	404	2+2	671	-	945	200	2+2	332
	C-D	404	2+2	671	-	945	200	2+2	332
	D-E	404	4+4	808	-	1082	200	4+4	400
9	A-B	404	2	335	892.5	1553	200	2	166
	B-C	404	2	335	892.5	1553	200	2	166
	C-D	404	2	335	892.5	1553	200	2	166
	D-E	404	4	404	892.5	1622	200	4	200
No		1	2	3	4				
L _{eq} segitiga		1,00	0,83	0,83	1,00				
L _{eq} trapesium		1,32	1,06	0,96	1,18				



$$\text{Berat sendiri balok} = 0,3 \times (0,5 - 0,12) \times 2400 = 274 \text{ kg/m}$$

7.4. Penulangan Ring Balk

7.4.1. Perhitungan Tulangan Lentur Ring Balk

Data perencanaan :

$$h = 250 \text{ mm}$$

$$b = 200 \text{ mm}$$

$$p = 40 \text{ mm}$$

$$f_y = 340 \text{ Mpa}$$

$$f'_c = 25 \text{ Mpa}$$

$$\varnothing_t = 16 \text{ mm}$$

$$\varnothing_s = 8 \text{ mm}$$

$$d = h - p - \varnothing_s - \frac{1}{2} \cdot \varnothing_t$$

$$= 250 - 40 - 8 - \frac{1}{2} \cdot 16$$

$$= 194 \text{ mm}$$

$$\begin{aligned} \rho_b &= \frac{0,85 \cdot f'_c \cdot \beta}{f_y} \left(\frac{600}{600 + f_y} \right) \\ &= \frac{0,85 \cdot 25}{340} \cdot 0,85 \left(\frac{600}{600 + 340} \right) \\ &= 0,0339 \end{aligned}$$

$$\begin{aligned} \rho_{\max} &= 0,75 \cdot \rho_b \\ &= 0,75 \cdot 0,0339 \\ &= 0,0254 \end{aligned}$$

$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{340} = 0,0041$$

Daerah Tumpuan

Dari Perhitungan **SAP 2000** diperoleh momen terbesar pada **batang nomor 400**.

$$M_u = 1122,10 \text{ kgm} = 1,1221 \times 10^7 \text{ Nmm}$$



$$M_n = \frac{M_u}{\phi} = \frac{1,1221 \times 10^7}{0,8} = 1,40 \times 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{1,40 \times 10^7}{200 \times 194^2} = 1,86$$

$$m = \frac{f_y}{0,85 \cdot f_c} = \frac{340}{0,85 \times 25} = 16$$

$$\begin{aligned} \rho &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot R_n}{f_y}} \right) \\ &= \frac{1}{16} \left(1 - \sqrt{1 - \frac{2 \times 16 \times 1,86}{340}} \right) \\ &= 0,0057 \end{aligned}$$

$$\rho < \rho_{\min}$$

$\rho < \rho_{\max} \rightarrow$ dipakai tulangan tunggal

Digunakan $\rho_{\text{perlu}} = 0,0057$

$$\begin{aligned} A_s \text{ perlu} &= \rho \cdot b \cdot d \\ &= 0,0057 \times 200 \times 194 \\ &= 221,16 \text{ mm}^2 \end{aligned}$$

Digunakan tulangan D 16

$$\begin{aligned} n &= \frac{A_s \text{ perlu}}{\frac{1}{4} \pi \cdot 16^2} = \frac{221,16}{200,96} \\ &= 1,12 \approx 2 \text{ tulangan} \end{aligned}$$

$$A_s' = \frac{1}{4} \pi \cdot 16^2 = \frac{1}{4} \cdot 3,14 \cdot 16^2 = 200,96$$

$$A_s \text{ ada} = 2 \times 200,96 = 401,92 \text{ mm}^2$$

$A_s' > A_s$aman Ok !

Dipakai tulangan **2 D 16 mm**

Jadi dipakai tulangan D 16 mm

b. Daerah Lapangan

Dari Perhitungan **SAP 2000** diperoleh momen terbesar pada **batang nomor 400**.

$$M_u = 1042,07 \text{ kgm} = 1,042 \times 10^7 \text{ Nmm}$$



$$M_n = \frac{M_u}{\phi} = \frac{1,042 \times 10^7}{0,8} = 1,35 \times 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{1,35 \times 10^7}{200 \times 194^2} = 1,79$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{340}{0,85 \times 25} = 16$$

$$\begin{aligned} \rho &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot R_n}{f_y}} \right) \\ &= \frac{1}{16} \left(1 - \sqrt{1 - \frac{2 \times 16 \times 1,79}{340}} \right) \\ &= 0,0055 \end{aligned}$$

$$\rho < \rho_{\min}$$

$\rho < \rho_{\max} \rightarrow$ dipakai tulangan tunggal

Digunakan $\rho_{\min} = 0,0055$

$$\begin{aligned} A_s \text{ perlu} &= \rho_{\min} \cdot b \cdot d \\ &= 0,0055 \times 200 \times 194 \\ &= 213,4 \text{ mm}^2 \end{aligned}$$

Digunakan tulangan D 16

$$\begin{aligned} n &= \frac{A_s \text{ perlu}}{\frac{1}{4} \pi \cdot 16^2} = \frac{213,4}{200,96} \\ &= 1,1 \approx 2 \text{ tulangan} \end{aligned}$$

$$A_s' = \frac{1}{4} \pi \cdot 16^2 = \frac{1}{4} \cdot 3,14 \cdot 16^2 = 200,96$$

$$A_s \text{ ada} = 2 \times 200,96 = 401,92 \text{ mm}^2$$

$A_s' > A_s$aman Ok !

Dipakai tulangan **2 D 16 mm**

Jadi dipakai tulangan D 16 mm

7.4.2. Perhitungan Tulangan Geser Ring Balk

Dari Perhitungan SAP 2000 diperoleh momen terbesar pada **batang nomor 400**:

$$V_u = 1026,36 \text{ kg} = 10264 \text{ N}$$

$$f'_c = 25 \text{ Mpa}$$



$$f_y = 340 \text{ Mpa}$$

$$d = h - p - \frac{1}{2} \varnothing = 350 - 40 - \frac{1}{2} (12) = 304 \text{ mm}$$

$$\begin{aligned} V_c &= 1/6 \cdot \sqrt{f_c} \cdot b \cdot d \\ &= 1/6 \cdot \sqrt{25} \cdot 250 \cdot 304 \\ &= 63333,33 \text{ N} \end{aligned}$$

$$\begin{aligned} \phi V_c &= 0,75 \cdot 63333,33 \\ &= 47500 \text{ N} \end{aligned}$$

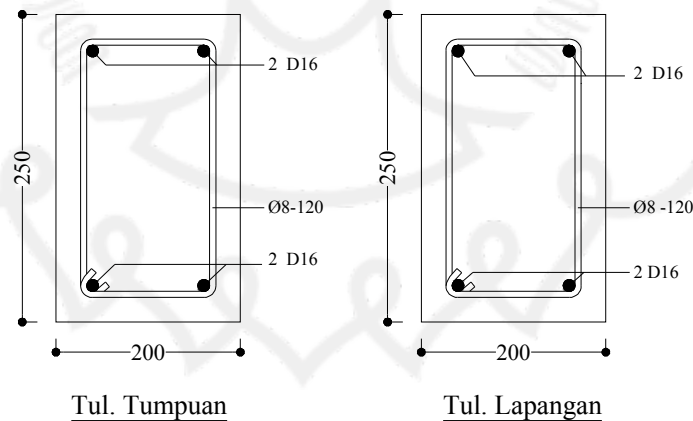
$$\begin{aligned} 3 \phi V_c &= 3 \cdot 47500 \\ &= 142500 \text{ N} \end{aligned}$$

$$\begin{aligned} \text{Syarat tulangan geser : } V_u &< \phi V_c < 3\phi V_c \\ &: 10264 \text{ N} < 47500 \text{ N} < 142500 \text{ N} \end{aligned}$$

Jadi tidak diperlukan tulangan geser

$$S_{\max} = d/2 = \frac{294}{2} = 147 \text{ mm}$$

Jadi dipakai sengkang dengan tulangan $\varnothing 8 - 120 \text{ mm}$



7.6. Penulangan Balok Portal

7.6.1. Perhitungan Tulangan Lentur Balok Portal Memanjang

Data perencanaan :

$$h = 500 \text{ mm}$$

$$b = 300 \text{ mm}$$



$$p = 40 \text{ mm}$$

$$f_y = 340 \text{ Mpa}$$

$$f'_c = 25 \text{ MPa}$$

$$\varnothing_t = 19 \text{ mm}$$

$$\varnothing_s = 10 \text{ mm}$$

$$\begin{aligned} d &= h - p - \varnothing_s - \frac{1}{2} \cdot \varnothing_t \\ &= 500 - 40 - 10 - \frac{1}{2} \cdot 19 \\ &= 441 \text{ mm} \end{aligned}$$

$$\begin{aligned} \rho_b &= \frac{0,85 \cdot f'_c \cdot \beta}{f_y} \left(\frac{600}{600 + f_y} \right) \\ &= \frac{0,85 \cdot 25}{340} \cdot 0,85 \left(\frac{600}{600 + 340} \right) \\ &= 0,0339 \end{aligned}$$

$$\begin{aligned} \rho_{\max} &= 0,75 \cdot \rho_b \\ &= 0,75 \cdot 0,0339 \\ &= 0,0254 \end{aligned}$$

$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{340} = 0,0041$$

Daerah Tumpuan

Dari Perhitungan **SAP 2000** diperoleh momen terbesar pada **batang nomor 292**.

$$M_u = 11314,50 \text{ kgm} = 11,3145 \times 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\varphi} = \frac{11,3145 \times 10^7}{0,8} = 14,14 \times 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{14,14 \times 10^7}{300 \times 441^2} = 2,42$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{340}{0,85 \times 25} = 16$$

$$\begin{aligned} \rho &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot R_n}{f_y}} \right) \\ &= \frac{1}{16} \left(1 - \sqrt{1 - \frac{2 \times 16 \times 2,42}{340}} \right) \end{aligned}$$



$$= 0,008$$

$$\rho > \rho_{\min}$$

$$\rho < \rho_{\max} \rightarrow \text{dipakai tulangan tunggal}$$

$$\text{Digunakan } \rho = 0,008$$

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

$$= 0,008 \times 300 \times 441$$

$$= 1058,4 \text{ mm}^2$$

Digunakan tulangan D 19

$$n = \frac{A_s \text{ perlu}}{\frac{1}{4} \pi \cdot 19^2} = \frac{1058,4}{283,385}$$

$$= 3,73 \approx 4 \text{ tulangan}$$

$$A_s' = 4 \times 283,385 = 1133,54 \text{ mm}^2$$

$$A_s' > A_s \dots \dots \dots \text{aman Ok !}$$

Dipakai tulangan **4 D 19 mm**

Jadi dipakai tulangan D 19 mm

Daerah Lapangan

Dari Perhitungan **SAP 2000** diperoleh momen terbesar pada **batang nomor 292**.

$$M_u = 11431.69 \text{ kgm} = 11,4317 \times 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{11,4317 \times 10^7}{0,8} = 15,04 \times 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{15,04 \times 10^7}{300 \times 441^2} = 2,58$$

$$m = \frac{f_y}{0,85 \cdot f_c} = \frac{340}{0,85 \times 25} = 16$$

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

$$= \frac{1}{16} \left(1 - \sqrt{1 - \frac{2 \times 16 \times 2,58}{340}} \right)$$

$$= 0,0082$$



$$\rho > \rho_{\min}$$

$\rho < \rho_{\max} \rightarrow$ dipakai tulangan tunggal

Digunakan $\rho = 0,0082$

$$As \text{ perlu} = \rho \cdot b \cdot d$$

$$= 0,0082 \times 300 \times 441$$

$$= 1084,86 \text{ mm}^2$$

Digunakan tulangan D 19

$$n = \frac{As \text{ perlu}}{\frac{1}{4} \pi \cdot 19^2} = \frac{1084,86}{283,385}$$

$$= 3,84 \approx 4 \text{ tulangan}$$

$$As' = 4 \times 283,385 = 1133,54 \text{ mm}^2$$

$As' > As$aman Ok !

Dipakai tulangan **4 D 19 mm**

Jadi dipakai tulangan D 19 mm

7.6.2. Perhitungan Tulangan Geser Portal Memanjang

Dari Perhitungan SAP 2000 diperoleh momen terbesar pada **batang nomor 292**:

$$Vu = 10840,06 \text{ kg} = 108400,6 \text{ N}$$

$$f'c = 25 \text{ Mpa}$$

$$fy = 340 \text{ Mpa}$$

$$d = h - p - \frac{1}{2} \emptyset$$

$$= 500 - 40 - \frac{1}{2} (12)$$

$$= 454 \text{ mm}$$

$$Vc = \frac{1}{6} \cdot \sqrt{f'c} \cdot b \cdot d$$

$$= \frac{1}{6} \cdot \sqrt{25} \cdot 300 \cdot 454$$

$$= 113500 \text{ N}$$

$$\phi Vc = 0,75 \cdot 113500 = 85125 \text{ N}$$

$$3 \phi Vc = 3 \cdot 85125 = 255375 \text{ N}$$

Syarat tulangan geser : $\emptyset Vc < Vu < 3\emptyset Vc$

$$: 85125 \text{ N} < 108400,6 \text{ N} < 255375 \text{ N}$$

Jadi diperlukan tulangan geser



$$\begin{aligned}\phi V_s &= V_u - \phi V_c \\ &= 108400,6 - 85125 = 23275,6 \text{ N}\end{aligned}$$

$$V_s \text{ perlu} = \frac{\phi V_s}{0,75} = \frac{23275,6}{0,75} = 41378,84 \text{ N}$$

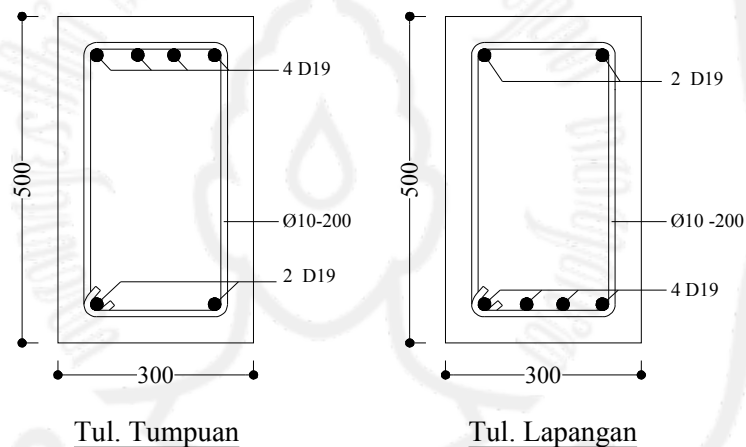
$$\begin{aligned}A_v &= 2 \cdot \frac{1}{4} \pi (10)^2 \\ &= 2 \cdot \frac{1}{4} \cdot 3,14 \cdot 100 = 157 \text{ mm}^2\end{aligned}$$

$$S = \frac{A_v \cdot f_y \cdot d}{V_s \text{ perlu}} = \frac{157 \cdot 240 \cdot 454}{41378,84} = 365,4 \text{ mm}$$

$$S_{\text{max}} = d/2 = \frac{454}{2} = 227 \text{ mm}$$

Jadi dipakai sengkang dengan tulangan $\phi 10 - 200 \text{ mm}$

Potongan balok portal memanjang



7.6.3. Perhitungan Tulangan Lentur Balok Portal Melintang

Data perencanaan :

$$h = 500 \text{ mm}$$

$$b = 300 \text{ mm}$$

$$p = 40 \text{ mm}$$

$$f_y = 340 \text{ Mpa}$$

$$f'_c = 25 \text{ MPa}$$

$$\phi_t = 19 \text{ mm}$$

$$\phi_s = 10 \text{ mm}$$



$$\begin{aligned} d &= h - p - \emptyset_s - \frac{1}{2} \cdot \emptyset_t \\ &= 500 - 40 - 10 - \frac{1}{2} \cdot 19 \\ &= 441 \text{ mm} \end{aligned}$$

$$\begin{aligned} \rho_b &= \frac{0,85 \cdot f_c \cdot \beta}{f_y} \left(\frac{600}{600 + f_y} \right) \\ &= \frac{0,85 \cdot 25}{340} \cdot 0,85 \left(\frac{600}{600 + 340} \right) \\ &= 0,0339 \end{aligned}$$

$$\begin{aligned} \rho_{\max} &= 0,75 \cdot \rho_b \\ &= 0,75 \cdot 0,0339 \\ &= 0,0254 \end{aligned}$$

$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{340} = 0,0041$$

Daerah Tumpuan

Dari Perhitungan **SAP 2000** diperoleh momen terbesar pada **batang nomor 309**.

$$M_u = 16128,99 \text{ kgm} = 16,12899 \times 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{16,12899 \times 10^7}{0,8} = 20,16 \times 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{20,17 \times 10^7}{300 \times 440,5^2} = 3,45$$

$$m = \frac{f_y}{0,85 \cdot f_c} = \frac{340}{0,85 \times 25} = 16$$

$$\begin{aligned} \rho &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot R_n}{f_y}} \right) \\ &= \frac{1}{16} \left(1 - \sqrt{1 - \frac{2 \times 16 \times 3,45}{340}} \right) \\ &= 0,01 \end{aligned}$$

$$\rho > \rho_{\min}$$

$$\rho < \rho_{\max} \rightarrow \text{dipakai tulangan tunggal}$$

Digunakan $\rho = 0,010$



$$\begin{aligned} \text{As perlu} &= \rho \cdot b \cdot d \\ &= 0,01 \times 300 \times 441 \\ &= 1323 \text{ mm}^2 \end{aligned}$$

Digunakan tulangan D 19

$$\begin{aligned} n &= \frac{\text{As perlu}}{\frac{1}{4} \pi \cdot 19^2} = \frac{1323}{283,385} \\ &= 4,67 \approx 5 \text{ tulangan} \end{aligned}$$

$$\text{As} = 5 \times 283,385 = 1416,92 \text{ mm}^2$$

As' > As.....aman Ok !

Dipakai tulangan **5 D 19 mm**

Jadi dipakai tulangan D 19 mm

Daerah Lapangan

Dari Perhitungan **SAP 2000** diperoleh momen terbesar pada **batang nomor 309**.

$$\text{Mu} = 14384.87 \text{ kgm} = 14,385 \times 10^7 \text{ Nmm}$$

$$\text{Mn} = \frac{\text{Mu}}{\phi} = \frac{14,385 \times 10^7}{0,8} = 17,98 \times 10^7 \text{ Nmm}$$

$$\text{Rn} = \frac{\text{Mn}}{b \cdot d^2} = \frac{17,98 \times 10^7}{300 \times 441^2} = 3,08$$

$$m = \frac{f_y}{0,85 \cdot f_c} = \frac{340}{0,85 \times 25} = 16$$

$$\begin{aligned} \rho &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot \text{Rn}}{f_y}} \right) \\ &= \frac{1}{16} \left(1 - \sqrt{1 - \frac{2 \times 16 \times 3,08}{340}} \right) \\ &= 0,0098 \end{aligned}$$

$$\rho > \rho_{\min}$$

$\rho < \rho_{\max} \rightarrow$ dipakai tulangan tunggal

Digunakan $\rho = 0,0098$



$$\begin{aligned} \text{As perlu} &= \rho \cdot b \cdot d \\ &= 0,0098 \times 300 \times 441 \\ &= 1296,54 \text{ mm}^2 \end{aligned}$$

Digunakan tulangan D 19

$$\begin{aligned} n &= \frac{\text{As perlu}}{\frac{1}{4} \pi \cdot 19^2} = \frac{1296,54}{283,385} \\ &= 4,57 \approx 5 \text{ tulangan} \end{aligned}$$

$$\text{As}' = 5 \times 283,385 = 1416,92 \text{ mm}^2$$

As' > As.....aman Ok !

Dipakai tulangan **5 D 19 mm**

Jadi dipakai tulangan D 19 mm

7.6.4. Perhitungan Tulangan Geser Balok Portal Melintang

Dari Perhitungan **SAP 2000** diperoleh momen terbesar pada **batang nomor 309**:

$$V_u = 13145,56 \text{ kg} = 131455,6 \text{ N}$$

$$\begin{aligned} V_c &= 1/6 \cdot \sqrt{f_c} \cdot b \cdot d \\ &= 1/6 \cdot \sqrt{25} \cdot 300 \cdot 438 \\ &= 109500 \text{ N} \end{aligned}$$

$$\phi V_c = 0,75 \cdot 109500 = 82125 \text{ N}$$

$$3 \phi V_c = 3 \cdot 82125 = 246375 \text{ N}$$

$$\phi V_c < V_u < 3\phi V_c$$

$$82125 < 131477,4 \text{ N} < 246375 \text{ N}$$

Jadi diperlukan tulangan geser

$$\begin{aligned} \phi V_s &= V_u - \phi V_c \\ &= 131455,6 - 82125 = 49330,6 \text{ N} \end{aligned}$$

$$V_s \text{ perlu} = \frac{\phi V_s}{0,75} = \frac{49330,6}{0,75} = 65774,1 \text{ N}$$

$$\begin{aligned} A_v &= 2 \cdot \frac{1}{4} \pi (10)^2 \\ &= 2 \cdot \frac{1}{4} \cdot 3,14 \cdot 100 = 157 \text{ mm}^2 \end{aligned}$$

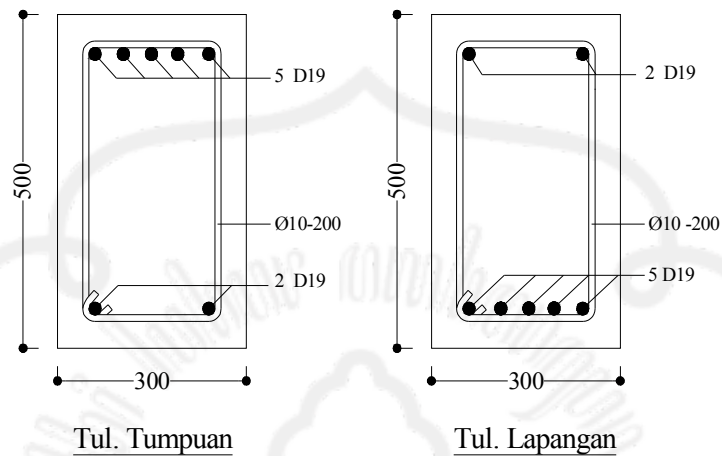
$$S = \frac{A_v \cdot f_y \cdot d}{V_s \text{ perlu}} = \frac{157 \cdot 240 \cdot 454}{65774,1} = 245,67 \text{ mm}$$



$$S_{\max} = d/2 = \frac{454}{2} = 227 \text{ mm}$$

Jadi dipakai sengkang dengan tulangan $\text{Ø} 10 - 200 \text{ mm}$

Potongan portal melintang



7.7. Penulangan Kolom

7.7.1. Perhitungan Tulangan Lentur Kolom

Data perencanaan :

$b = 400 \text{ mm}$	$\text{Ø tulangan} = 16 \text{ mm}$
$h = 400 \text{ mm}$	$\text{Ø sengkang} = 8 \text{ mm}$
$f'_c = 25 \text{ MPa}$	$s \text{ (tebal selimut)} = 40 \text{ mm}$
$f_y = 340 \text{ MPa}$	

Dari Perhitungan **SAP 2000** diperoleh gaya terbesar pada **batang nomor 134**

$$P_u = 44625.37 \text{ kg} = 446253,7 \text{ N}$$

$$M_u = 2138.80 \text{ kgm} = 2,139 \times 10^7 \text{ Nmm}$$

$$\begin{aligned} d &= h - s - \text{Ø sengkang} - \frac{1}{2} \text{Ø tulangan} \\ &= 400 - 40 - 8 - \frac{1}{2} \cdot 16 \\ &= 344 \text{ mm} \end{aligned}$$



$$d' = h - d$$

$$= 400 - 344$$

$$= 56 \text{ mm}$$

$$e = \frac{Mu}{Pu} = \frac{2,139 \cdot 10^7}{446353,7} = 47,92 \text{ mm}$$

$$e_{\min} = 0,1 \cdot h = 0,1 \cdot 500 = 50 \text{ mm}$$

$$c_b = \frac{600}{600 + f_y} \cdot d = \frac{600}{600 + 340} \cdot 344 = 219,57$$

$$a_b = \beta_1 \times c_b$$

$$= 0,85 \times 219,57$$

$$= 186,63$$

$$P_{n_b} = 0,85 \cdot f'_c \cdot a_b \cdot b$$

$$= 0,85 \cdot 25 \cdot 186,63 \cdot 400$$

$$= 1586355 \text{ N}$$

$$P_{n_{\text{perlu}}} = \frac{Pu}{\phi} ; 0,1 \cdot f'_c \cdot A_g = 0,1 \cdot 25 \cdot 400 \cdot 400 = 4 \cdot 10^5 \text{ N}$$

→ karena $P_u = 446353,7 \text{ N} > 0,1 \cdot f'_c \cdot A_g$, maka $\phi : 0,75$

$$P_{n_{\text{perlu}}} = \frac{Pu}{\phi} = \frac{446353,7}{0,75} = 595138,3 \text{ N}$$

$P_{n_{\text{perlu}}} < P_{n_b}$ → analisis keruntuhan tarik

$$a = \frac{P_n}{0,85 \cdot f'_c \cdot b} = \frac{595138,3}{0,85 \cdot 25 \cdot 400} = 70,01$$

$$A_s = \frac{P_{n_{\text{perlu}}} \left(\frac{h}{2} - e - \frac{a}{2} \right)}{f_y (d - d')} = \frac{595138,3 \cdot \left(\frac{400}{2} - 47,92 - \frac{70,01}{2} \right)}{340(344 - 56)} = 711,56 \text{ mm}^2$$

luas memanjang minimum :

$$A_{s_t} = 1 \% A_g = 0,01 \cdot 400 \cdot 400 = 1600 \text{ mm}^2$$

Sehingga, $A_s = A_{s_t}$

$$A_s = \frac{A_{s_t}}{2} = \frac{1600}{2} = 800 \text{ mm}^2$$

Menghitung jumlah tulangan

$$n = \frac{711,56}{\frac{1}{4} \cdot \pi \cdot (16)^2} = 3,54 \approx 4 \text{ tulangan}$$



$$\begin{aligned} \text{As ada} &= 4 \cdot \frac{1}{4} \cdot \pi \cdot 16^2 \\ &= 803,84 \text{ mm}^2 > 711,56 \text{ mm}^2 \end{aligned}$$

As ada > As perlu..... Ok!

Dipakai tulangan **4 D 16 mm**

Jadi dipakai tulangan D 16 mm

7.7.2. Perhitungan Tulangan Geser Kolom

Dari Perhitungan **SAP 2000** diperoleh gaya terbesar pada **batang nomor 134**

$$V_u = 827.99 \text{ kgm} = 8280 \text{ N}$$

$$\begin{aligned} V_c &= \left(1 + \frac{P_u}{14 \cdot A_g}\right) \sqrt{\frac{f'_c}{6}} \cdot b \cdot d \\ &= \left(1 + \frac{44,62537 \times 10^4}{14 \times 400 \times 400}\right) \sqrt{\frac{25}{6}} \times 400 \times 344 = 33,68 \times 10^4 \text{ N} \end{aligned}$$

$$\phi V_c = 0,75 \times V_c = 25,26 \times 10^4 \text{ N}$$

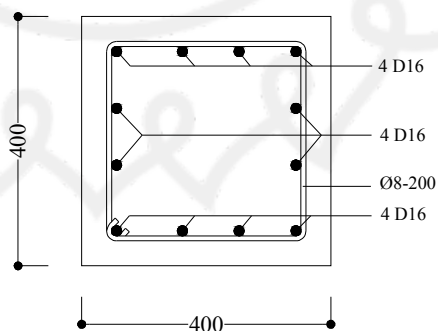
$$0,5 \phi V_c = 12,63 \times 10^4 \text{ N}$$

$V_u < 0,5 \phi V_c \Rightarrow$ tanpa diperlukan tulangan geser.

$$0,8217 \times 10^4 \text{ N} < 12,63 \times 10^4$$

Dipakai sengkang praktis untuk penghubung tulangan memanjang : $\phi 8 - 200 \text{ mm}$

Penulangan Kolom



7.8. Penulangan Sloof



7.8.1. Hitungan Tulangan Lentur Sloof

Data perencanaan :

$$h = 300 \text{ mm}$$

$$b = 200 \text{ mm}$$

$$p = 40 \text{ mm}$$

$$f_y = 340 \text{ Mpa}$$

$$f'_c = 25 \text{ MPa}$$

$$\varnothing_t = 16 \text{ mm}$$

$$\varnothing_s = 8 \text{ mm}$$

$$\begin{aligned} d &= h - p - \varnothing_s - \frac{1}{2} \cdot \varnothing_t \\ &= 300 - 40 - 8 - \frac{1}{2} \cdot 16 \\ &= 244 \text{ mm} \end{aligned}$$

$$\begin{aligned} \rho_b &= \frac{0,85 \cdot f'_c \cdot \beta}{f_y} \left(\frac{600}{600 + f_y} \right) \\ &= \frac{0,85 \cdot 25}{340} \cdot 0,85 \left(\frac{600}{600 + 340} \right) = 0,0339 \end{aligned}$$

$$\begin{aligned} \rho_{\max} &= 0,75 \cdot \rho_b \\ &= 0,75 \cdot 0,0339 = 0,0254 \end{aligned}$$

$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{340} = 0,0041$$

Daerah Tumpuan

Dari Perhitungan **SAP 2000** diperoleh momen terbesar pada **batang nomor 199**.

$$M_u = 3911.95 \text{ kgm} = 3,9119 \times 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\varphi} = \frac{3,9119 \times 10^7}{0,8} = 4,89 \times 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{4,89 \times 10^7}{200 \times 244^2} = 4,09$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{340}{0,85 \times 25} = 16$$



$$\rho = \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot Rn}{f_y}} \right)$$

$$= \frac{1}{16} \left(1 - \sqrt{1 - \frac{2 \times 16 \times 4,09}{340}} \right) = 0,013$$

$$\rho > \rho_{\min}$$

$\rho < \rho_{\max} \rightarrow$ dipakai tulangan tunggal

Digunakan $\rho = 0,013$

$$\begin{aligned} A_s \text{ perlu} &= \rho \cdot b \cdot d \\ &= 0,013 \times 200 \times 244 \\ &= 634 \text{ mm}^2 \end{aligned}$$

Digunakan tulangan D 16

$$n = \frac{A_s \text{ perlu}}{\frac{1}{4} \pi \cdot 16^2} = \frac{634}{200,96}$$

$$= 3,16 \approx 4 \text{ tulangan}$$

$$A_s' = 4 \times 200,96 = 803,84 \text{ mm}^2$$

$A_s' > A_s$aman Ok !

Dipakai tulangan **4 D 16 mm**

Jadi dipakai tulangan **D 16 mm**

Daerah Lapangan

Dari Perhitungan **SAP 2000** diperoleh momen terbesar pada **batang nomor 199**.

$$M_u = 1979.61 \text{ kgm} = 1,9796 \times 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{1,9796 \times 10^7}{0,8} = 2,47 \times 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{2,47 \times 10^7}{200 \times 244^2} = 2,07$$

$$m = \frac{f_y}{0,85 \cdot f_c} = \frac{340}{0,85 \times 25} = 16$$

$$\rho = \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot Rn}{f_y}} \right)$$



$$= \frac{1}{16} \left(1 - \sqrt{1 - \frac{2 \times 16 \times 2,07}{340}} \right)$$

$$= 0,006$$

$$\rho > \rho_{\min}$$

$$\rho < \rho_{\max} \rightarrow \text{dipakai tulangan tunggal}$$

$$\text{Digunakan } \rho = 0,006$$

$$\text{As perlu} = \rho \cdot b \cdot d$$

$$= 0,006 \times 200 \times 244$$

$$= 292,8 \text{ mm}^2$$

Digunakan tulangan D 16

$$n = \frac{\text{As perlu}}{\frac{1}{4} \pi \cdot 16^2} = \frac{292,8}{200,96}$$

$$= 1,45 \approx 2 \text{ tulangan}$$

$$\text{As}' = 2 \times 200,96 = 401,92 \text{ mm}^2$$

$$\text{As}' > \text{As} \dots \dots \dots \text{aman Ok !}$$

Dipakai tulangan **2 D 16 mm**

Jadi dipakai tulangan **D 16 mm**

7.8.2. Perhitungan Tulangan Geser Sloof

Dari Perhitungan **SAP 2000** diperoleh momen terbesar pada **batang nomor 199**:

$$V_u = 3922.25 \text{ kg} = 39222,5 \text{ N}$$

$$V_c = 1/6 \cdot \sqrt{f_c} \cdot b \cdot d$$

$$= 1/6 \cdot \sqrt{25} \cdot 200 \cdot 244$$

$$= 40666,67 \text{ N}$$

$$\phi V_c = 0,75 \cdot 40666,67$$

$$= 30500 \text{ N}$$

$$3 \phi V_c = 3 \cdot 30500$$

$$= 91500 \text{ N}$$



Syarat tulangan geser : $\emptyset V_c < V_u < 3\emptyset V_c$

$$: 30500 \text{ N} < 39222,5 \text{ N} < 91500 \text{ N}$$

Jadi diperlukan tulangan geser

$$\emptyset V_s = V_u - \emptyset V_c$$

$$= 39222,5 - 30500 = 8722,5 \text{ N}$$

$$V_s \text{ perlu} = \frac{\emptyset V_s}{0,75} = \frac{8722,5}{0,75} = 11630 \text{ N}$$

$$A_v = 2 \cdot \frac{1}{4} \pi (8)^2$$

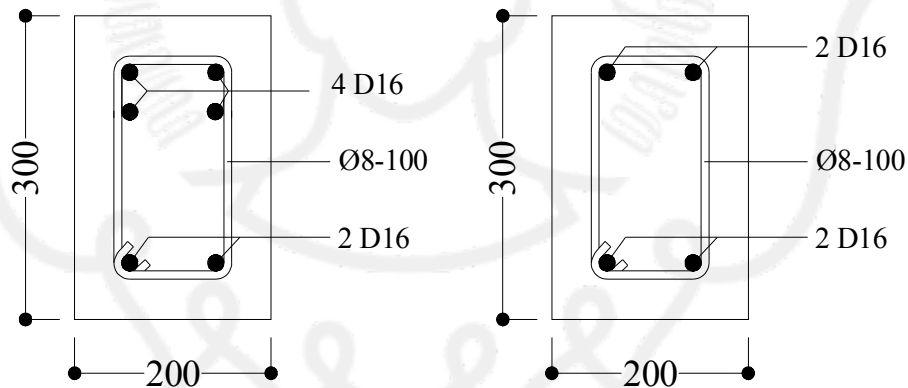
$$= 2 \cdot \frac{1}{4} \cdot 3,14 \cdot 64 = 100,48 \text{ mm}^2$$

$$S = \frac{A_v \cdot f_y \cdot d}{V_s \text{ perlu}} = \frac{100,48 \cdot 240 \cdot 244}{11630} = 502,18 \text{ mm}$$

$$S \text{ max} = d/2 = \frac{244}{2} = 122 \text{ mm}$$

Jadi dipakai sengkang dengan tulangan $\emptyset 8 - 100 \text{ mm}$

Potongan tulangan Sloof



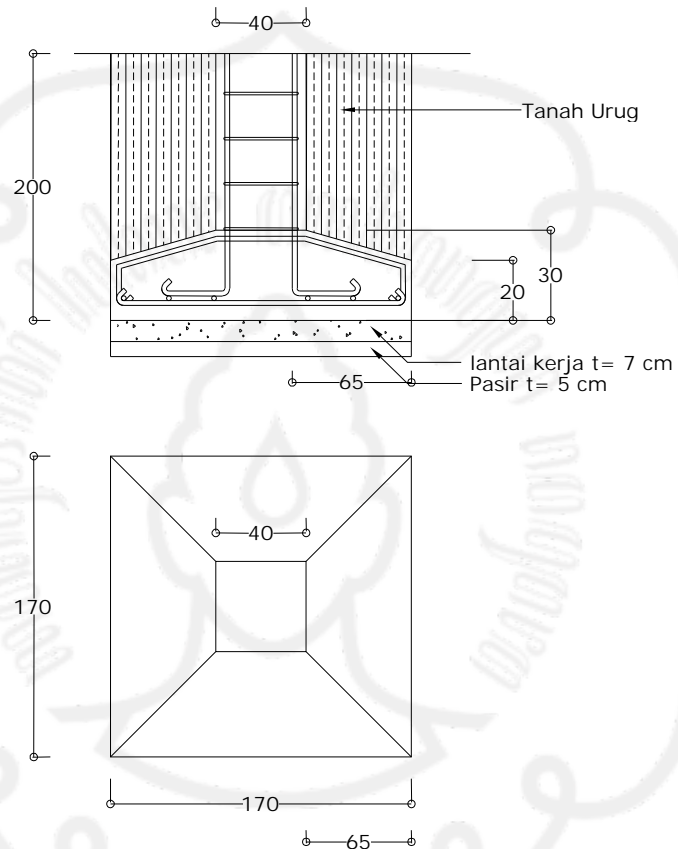
Tul. Tumpuan

Tul. Lapangan

BAB 8

PONDASI

8.1. Data Perencanaan



Gambar 8.1. Perencanaan Pondasi

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

- **Pu** = 56669.83 kg
- **Mu** = 134.28 kgm



Dimensi Pondasi :

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

$$A = \frac{Pu}{\sigma_{\text{tanah}}} = \frac{56669.83}{25000}$$

$$= 2,27 \text{ m}^2$$

$$B = L = \sqrt{A} = \sqrt{2,27}$$

$$= 1,51 \text{ m} \sim 1,7 \text{ m}$$

Chek Ketebalan

$$Vu = 23451,2 \times 1,7 (0,85 - 0,2 - d)$$

$$d \geq \frac{10Vu}{\sqrt{f'c}L} = \frac{39867,1(0,65 - d)}{\sqrt{25} \times 1,7}$$

$$d \geq \frac{25913,6 - 39867,1d}{9,5}$$

$$9,5 d \geq 25913,6 - 39867,1 d$$

$$d \geq 0,65 \text{ m} = 650 \text{ mm}$$

Direncanakan pondasi telapak dengan kedalaman 2,0 m ukuran 1,7 m × 1,7 m

- $f'c$ = 25 Mpa
 - f_y = 340 Mpa
 - σ_{tanah} = 2,5 kg/cm² = 25000 kg/m²
 - γ_{tanah} = 1,7 t/m³ = 1700 kg/m³
 - γ_{beton} = 2,4 t/m³
- $$d = h - p - \frac{1}{2} \text{Øtul. utama}$$
- $$= 300 - 50 - 8$$
- $$= 242 \text{ mm}$$

8.2. Perencanaan Kapasitas Dukung Pondasi

8.2.1. Perhitungan kapasitas dukung pondasi



➤ Pembebanan pondasi

$$\text{Berat telapak pondasi} = 1,7 \times 1,7 \times 0,30 \times 2400 = 2080,8 \text{ kg}$$

$$\text{Berat kolom pondasi} = 0,4 \times 0,4 \times 1,7 \times 2400 = 652,8 \text{ kg}$$

$$\text{Berat tanah} = (1,7^2 \times 1,7) - (0,4^2 \times 1,7) \times 1700 = 7889,7 \text{ kg}$$

$$P_u = 56676,8 \text{ kg}$$

$$\Sigma P = 67300,1 \text{ kg}$$

$$e = \frac{\Sigma Mu}{\Sigma P} = \frac{134,28}{67300,1}$$

$$= 0,002 \text{ kg} < 1/6 \cdot B = 0,28$$

$$\sigma \text{ yang terjadi} = \frac{\Sigma P}{A} + \frac{Mu}{\frac{1}{6} \cdot b \cdot L^2}$$

$$= \frac{67300,1}{1,7 \times 1,7} + \frac{134,28}{\frac{1}{6} \times 1,7 \times (1,7)^2}$$

$$= 23451,2 \text{ kg/m}^2 < 25000 \text{ kg/m}^2$$

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

8.2.2. Perhitungan Tulangan Lentur

$$M_u = \frac{1}{2} \cdot \sigma \cdot t^2 = \frac{1}{2} \times (23451,2) \times (0,65)^2$$

$$= 4954,07 \text{ kgm} = 4,954 \times 10^7 \text{ Nmm}$$

$$M_n = \frac{4,954 \times 10^7}{0,8} = 6,19 \times 10^7 \text{ Nmm}$$

$$m = \frac{f_y}{0,85 \cdot f_c} = \frac{340}{0,85 \times 25} = 16$$

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

$$= \frac{0,85 \cdot 25}{340} \cdot 0,85 \left(\frac{600}{600 + 340} \right) = 0,0339$$

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

$$= 0,75 \cdot 0,0339$$

$$= 0,0254$$



$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{340} = 0,0041$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{6,19 \times 10^7}{1700 \times (242)^2} = 0,62$$

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

$$= \frac{1}{16} \left(1 - \sqrt{1 - \frac{2 \times 16 \times 0,62}{340}} \right)$$

$$\rho = 0,0018$$

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

$\rho < \rho_{\min} \rightarrow$ dipakai tulangan tunggal

Digunakan $\rho_{\min} = 0,0041$

$$\begin{aligned} \text{As perlu} &= \rho_{\min} \cdot b \cdot d \\ &= 0,0041 \times 1900 \times 242 \\ &= 1885,18 \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} \text{Digunakan tul D 16} &= \frac{1}{4} \cdot \pi \cdot d^2 \\ &= \frac{1}{4} \times 3,14 \times (16)^2 \\ &= 200,96 \text{ mm}^2 \end{aligned}$$

$$\text{Jumlah tulangan (n)} = \frac{1885,18}{200,96} = 9,38 \approx 10 \text{ buah}$$

$$\text{Jarak tulangan} = \frac{1000}{10} = 100 \text{ mm}$$

Dipakai tulangan D 16 - 100 mm

As yang timbul = $10 \times 200,96 = 2009,6 > \text{As} \dots \dots \dots \text{ok!}$

Maka, digunakan tulangan **D 16 - 100 mm**



BAB 9

RENCANA ANGGARAN BIAYA

9.1. Rencana Anggaran Biaya (RAB)

Rencana anggaran biaya (RAB) adalah tolok ukur dalam perencanaan pembangunan, baik rumah tinggal, ruko, rukan, maupun gedung lainnya. Dengan RAB kita dapat mengukur kemampuan materi dan mengetahui jenis-jenis material dalam pembangunan, sehingga biaya yang kita keluarkan lebih terarah dan sesuai dengan yang telah direncanakan.

9.2. Data Perencanaan

Secara umum data yang digunakan untuk perhitungan rencana anggaran biaya (RAB) adalah sebagai berikut :

- a. Analisa pekerjaan : Daftar analisa pekerjaan proyek Kota Surakarta
- b. Harga upah & bahan : Dinas Pekerjaan Umum Kota Surakarta
- c. Harga satuan : terlampir

9.3. Perhitungan Volume

9.3.1 Pekerjaan Pendahuluan

A. Pekerjaan pembersihan lokasi

$$\begin{aligned} \text{Volume} &= \text{panjang} \times \text{lebar} \\ &= 27 \times 21 = 567 \text{ m}^2 \end{aligned}$$

B. Pekerjaan pembuatan pagar setinggi 2m

$$\text{Volume} = \sum \text{panjang} = 100 \text{ m}$$

C. Pekerjaan *bouwplank*

$$\begin{aligned} \text{Volume} &= (\text{panjang} \times 2) \times (\text{lebar} \times 2) \\ &= (27 \times 2) + (21 \times 2) = 96 \text{ m}^2 \end{aligned}$$



9.3.2 Pekerjaan Tanah

A. Galian pondasi

➤ Footplat

$$\begin{aligned} \text{Volume} &= (\text{panjang} \times \text{lebar} \times \text{tinggi}) \times \sum n \\ &= (1,7 \times 1,7 \times 2) \times 43 = 248,54 \text{ m}^3 \end{aligned}$$

➤ Pondasi batu kali

$$\begin{aligned} \text{Volume} &= (\text{lebar} \times \text{tinggi}) \times \sum \text{panjang} \\ &= (0,8 \times 0,8) \times 131,5 = 84,16 \text{ m}^3 \end{aligned}$$

➤ Pondasi tangga

$$\begin{aligned} \text{Volume} &= (\text{lebar} \times \text{tinggi}) \times \sum \text{panjang} \\ &= (1,25 \times 1,25) \times 1 = 1,56 \text{ m}^3 \end{aligned}$$

B. Urugan Pasir bawah Pondasi dan bawah lantai ($t=5\text{cm}$)

➤ Footplat

$$\begin{aligned} \text{Volume} &= (\text{panjang} \times \text{lebar} \times \text{tinggi}) \times \sum n \\ &= (1,7 \times 1,7 \times 0,05) \times 43 = 6,21 \text{ m}^3 \end{aligned}$$

➤ Pondasi batu kali

$$\begin{aligned} \text{Volume} &= (\text{lebar} \times \text{tinggi}) \times \sum \text{panjang} \\ &= (0,8 \times 0,05) \times 131,5 = 5,26 \text{ m}^3 \end{aligned}$$

➤ Pondasi tangga

$$\begin{aligned} \text{Volume} &= (\text{lebar} \times \text{tinggi}) \times \sum \text{panjang} \\ &= (1,25 \times 0,05) \times 1 = 0,0625 \text{ m}^3 \end{aligned}$$

➤ Lantai

$$\begin{aligned} \text{Volume} &= \text{tinggi} \times \text{luas lantai} \\ &= 0,05 \times 495 = 24,75 \text{ m}^2 \end{aligned}$$



C. Urugan Tanah Galian

$$\begin{aligned} \text{Volume} &= V. \text{tanah galian- batukali-lantai kerja- pasir urug} \\ &= (248,54+84,16+1,56)-63,12-(3,73+3,16)-(6,21+5,26+0,0625) \\ &= 252,72 \text{ m}^3 \end{aligned}$$

9.3.3 Pekerjaan Pondasi

A. Pondasi Batu Kali

$$\begin{aligned} \text{Volume} &= (0,3+0,7) \times 0,5 \times 0,5 \times 160 \\ &= 40 \text{ m}^3 \end{aligned}$$

B. Pondasi batu kosong

$$\begin{aligned} \text{Volume} &= 0,15 \times 0,8 \times 160 \\ &= 19,2 \text{ m}^3 \end{aligned}$$

9.3.4 Pekerjaan Beton

A. Beton Sloof

sloof

$$\begin{aligned} \text{Volume} &= (\text{panjang x lebar}) \times \sum \text{panjang} \\ &= (0,2 \times 0,3) \times 254 = 15,24 \text{ m}^3 \end{aligned}$$

B. Balok induk 30/50

$$\begin{aligned} \text{Volume} &= (\text{tinggi x lebar x panjang}) \\ &= (0,38 \times 0,3 \times 261) = 29,75 \text{ m}^3 \end{aligned}$$

C. Balok anak 25/35

$$\begin{aligned} \text{Volume} &= (\text{tinggi x lebar x panjang}) \\ &= (0,23 \times 0,25 \times 120) = 6,9 \text{ m}^3 \end{aligned}$$

D. Kolom utama

Kolom 40/40

$$\begin{aligned} \text{Volume} &= (\text{panjang x lebar x tinggi}) \\ &= (0,4 \times 0,4 \times 8) \times 43 = 55,1 \text{ m}^3 \end{aligned}$$

E. Ringbalk

$$\begin{aligned} \text{Volume} &= (\text{tinggi x lebar}) \times \sum \text{panjang} \\ &= (0,2 \times 0,3) \times 177 = 8,85 \text{ m}^3 \end{aligned}$$

F. Plat lantai (t=12cm)



$$\begin{aligned}\text{Volume} &= \text{luas lantai } 2 \times \text{tebal} \\ &= 495 \times 0,12 = 59,4 \text{ m}^3\end{aligned}$$

G. Balok praktis 15/15

$$\begin{aligned}\text{Volume} &= (\text{tinggi} \times \text{lebar}) \times \sum \text{panjang} \\ &= (0,15 \times 0,15) \times 231 = 5,198 \text{ m}^3\end{aligned}$$

H. Tangga

$$\begin{aligned}\text{Volume} &= ((\text{luas plat tangga} \times \text{tebal}) \times 2) + \text{plat bordes} \\ &= (6 \times 0,12) \times 2 + (3 \times 0,15) \\ &= 1,89 \text{ m}^3\end{aligned}$$

I. Pondasi telapak (*footplat*)

Footplat

$$\begin{aligned}\text{Volume} &= (\text{panjang} \times \text{lebar} \times \text{tinggi}) \times \sum n \\ &= \{ (1,7 \cdot 1,7 \cdot 0,3) + (0,4 \cdot 0,4 \cdot 1,7) + (2 \cdot \frac{1}{2} \cdot 1 \cdot 0,2) \} \times 43 \\ &= 57,58 \text{ m}^3\end{aligned}$$

Footplat tangga

$$\begin{aligned}\text{Volume} &= \text{panjang} \times \text{lebar} \times \text{tinggi} \\ &= \{ (1,25 \cdot 1 \cdot 0,2) + (0,4 \cdot 1,25 \cdot 0,8) + (2 \cdot \frac{1}{2} \cdot 1 \cdot 0,1) \} \\ &= 0,75 \text{ m}^3\end{aligned}$$

9.3.5 Pekerjaan pemasangan Bata merah dan Pemlesteran

A. Pasangan dinding bata merah

$$\begin{aligned}\text{Luas dinding} &= (108 \times 4 \times 2) + (52 \times 4) + (33,5 \times 4) \\ &= 1206 \text{ m}^2\end{aligned}$$

$$\begin{aligned}\text{Volume} &= \text{Luas dinding} - \text{luas pintu jendela} \\ &= 1206 - 168,4 = 1037,6 \text{ m}^2\end{aligned}$$

B. Pemlesteran dan pengacian

$$\begin{aligned}\text{Volume} &= \text{volume dinding bata merah} \times 2 \text{ sisi} \\ &= 1037,6 \times 2 = 2075,2 \text{ m}^2\end{aligned}$$

C. Lantai kerja ($t=5 \text{ cm}$)



➤ Footplat

$$\begin{aligned} \text{Volume} &= (\text{panjang} \times \text{lebar} \times \text{tinggi}) \times \sum n \\ &= (1,7 \times 1,7 \times 0,05) \times 43 = 6,21 \text{ m}^3 \end{aligned}$$

➤ Pondasi batu kali

$$\begin{aligned} \text{Volume} &= (\text{lebar} \times \text{tinggi}) \times \sum \text{panjang} \\ &= (0,8 \times 0,05) \times 160 = 6,4 \text{ m}^3 \end{aligned}$$

9.3.6. Pekerjaan Pemasangan Kusen dan Pintu

A. Pemasangan kusen dan Pintu aluminium

$$\begin{aligned} \text{Volume} &= P1 + P2 + PJ + J1 + J2 + J3 + J4 \\ &= 345 \text{ m} \end{aligned}$$

B. Pemasangan daun pintu dan jendela

$$\begin{aligned} \text{Volume} &= (10,9 + 12,4 + 7,68) \\ &= 30,98 \text{ m}^2 \end{aligned}$$

C. Pasang kaca polos (t=5mm)

$$\text{Luas tipe P1} = (2,3 \times 2,35) \times 2 = 9,3 \text{ m}^2$$

$$P2 = (0,6 \times 1,9) \times 4 = 3,42 \text{ m}^2$$

$$PJ = 3,42 + (0,7 \times 1,4) = 8,96 \text{ m}^2$$

$$J1 = (3,3 \times 2,45) \times 8 = 64,68 \text{ m}^2$$

$$J2 = (1,95 \times 2,55) \times 2 = 9,95 \text{ m}^2$$

$$J3 = (1,95 \times 1,15) \times 16 = 35,88 \text{ m}^2$$

$$J4 = (0,75 \times 1,95) \times 16 = 23,4 \text{ m}^2$$

$$\begin{aligned} \text{Volume} &= \text{luas P1} + P2 + PJ + J1 + J2 + J3 + J4 \\ &= 151,03 \text{ m}^2 \end{aligned}$$

D. Pasang kaca buram (t = 5 mm)

$$\begin{aligned} \text{Volume} &= (0,6 \times 1,95) \times 4 \\ &= 4,56 \text{ m}^2 \end{aligned}$$

9.3.7. Pekerjaan Atap

A. Pekerjaan kuda kuda



- Setengah kuda-kuda (doble siku 45.45.5)
 - Σ panjang profil under = 7,5 m
 - Σ panjang profil tarik = 8,66 m
 - Σ panjang profil kaki kuda-kuda = 10,83 m
 - Σ panjang profil sokong = 8,78 m
 - Volume = $35,76 \times 2 = 71,52$ m
- Jurai kuda-kuda (doble siku 45.45.5)
 - Σ panjang profil under = 10,61 m
 - Σ panjang profil tarik = 11,46 m
 - Σ panjang profil kaki kuda-kuda = 10,804 m
 - Σ panjang profil sokong = 10,48 m
 - Volume = Σ panjang x Σ n
 - = $43,35 \times 4 = 173,4$ m
- Kuda – kuda Trapesium (doble siku 80.80.8)
 - Σ panjang profil under = 15 m
 - Σ panjang profil tarik = 16,6 m
 - Σ panjang profil kaki kuda-kuda = 13 m
 - Σ panjang profil sokong = 15,79 m
 - Volume = Σ panjang x Σ n
 - = $60,39 \times 2 = 120,78$ m
- Kuda-kuda utama A (doble siku 70.70.7)
 - Σ panjang profil under = 15 m
 - Σ panjang profil tarik = 17,32 m
 - Σ panjang profil kaki kuda-kuda = 17,32 m
 - Σ panjang profil sokong = 17,56 m
 - Volume = Σ panjang x Σ n
 - = $67,2 \times 5 = 336$ m
- Kuda-kuda utama B (doble siku 55.55.8)
 - Σ panjang profil under = 7,5 m
 - Σ panjang profil tarik = 8,66 m



$$\Sigma \text{panjang profil kaki kuda-kuda} = 4,33 \text{ m}$$

$$\Sigma \text{panjang profil sokong} = 4,33 \text{ m}$$

$$\begin{aligned} \text{Volume} &= \Sigma \text{panjang} \times \Sigma n \\ &= 24,82 \times 4 = 99,28 \text{ m} \end{aligned}$$

- Gording (150.70.20.4,5)

$$\Sigma \text{panjang profil gording} = 185 \text{ m}$$

- B. Pekerjaan pasang kaso $\frac{5}{7}$ dan reng $\frac{3}{4}$

$$\begin{aligned} \text{Volume} &= \text{luas atap} + \text{luas emperan} \\ &= 685,29 + 97 \\ &= 782,29 \text{ m}^2 \end{aligned}$$

- C. Pekerjaan pasang Listplank

$$\begin{aligned} \text{Volume} &= \Sigma \text{keliling atap} \\ &= 97 \text{ m} \end{aligned}$$

- D. Pekerjaan pasang genting

$$\begin{aligned} \text{Volume} &= \text{luas atap} \\ &= 685,29 \text{ m}^2 \end{aligned}$$

- E. Pasang kerpus

$$\begin{aligned} \text{Volume} &= \Sigma \text{panjang} \\ &= 84,5 \text{ m} \end{aligned}$$

9.3.8. Pekerjaan Plafon

- A. Pembuatan dan pemasangan rangka plafon

$$\begin{aligned} \text{Volume} &= (\text{panjang} \times \text{lebar}) \times 2 \\ &= (27 \times 15 \times 2) + (7,5 \times 6 \times 2) = 900 \text{ m}^2 \end{aligned}$$

- B. Pasang plafon

$$\begin{aligned} \text{Volume} &= \text{luas rangka plafon} \\ &= 900 \text{ m}^2 \end{aligned}$$

9.3.9. Pekerjaan keramik

- A. Pasang keramik 40/40

$$\text{Volume} = \text{luas lantai}$$



$$\begin{aligned} &= 900 - (30 \times 2) - (15 \times 2) \\ &= 810 \text{ m}^2 \end{aligned}$$

B. Pasang keramik 20/20

$$\begin{aligned} \text{Volume} &= \text{luas lantai} \\ &= (6 \times 5) \times 2 \\ &= 60 \text{ m}^2 \end{aligned}$$

9.3.10. Pekerjaan instalasi air

A. Pekerjaan pengeboran titik air

$$\begin{aligned} \text{Volume} &= \sum n \\ &= 1 \text{ unit} \end{aligned}$$

B. Pekerjaan saluran pembuangan

$$\text{Volume} = \sum \text{panjang pipa} = 158 \text{ m}$$

C. Pekerjaan saluran air bersih

$$\text{Volume} = \sum \text{panjang pipa} = 140 \text{ m}$$

9.3.11. Pekerjaan instalasi Listrik

A. Instalasi stop kontak

$$\text{Volume} = \sum n = 10 \text{ unit}$$



B. Titik lampu

- TL 36 watt

$$\text{Volume} = \sum n = 54 \text{ unit}$$

- pijar 25 watt

$$\text{Volume} = \sum n = 32 \text{ unit}$$

C. Instalasi saklar

- Saklar single

$$\text{Volume} = \sum n = 9 \text{ unit}$$

- Saklar double

$$\text{Volume} = \sum n = 14 \text{ unit}$$

9.3.12. Pekerjaan pengecatan

A. Pengecatan dinding

$$\begin{aligned} \text{Volume} &= \text{plesteran dinding} \times 2 \\ &= 4150,4 \text{ m}^2 \end{aligned}$$

B. Pengecatan menggunakan Cat minyak (pada listplank)

$$\text{Volume} = 97 \times 0,2 = 19,4 \text{ m}^2$$

BAB 10

REKAPITULASI

10.1 Perencanaan Atap

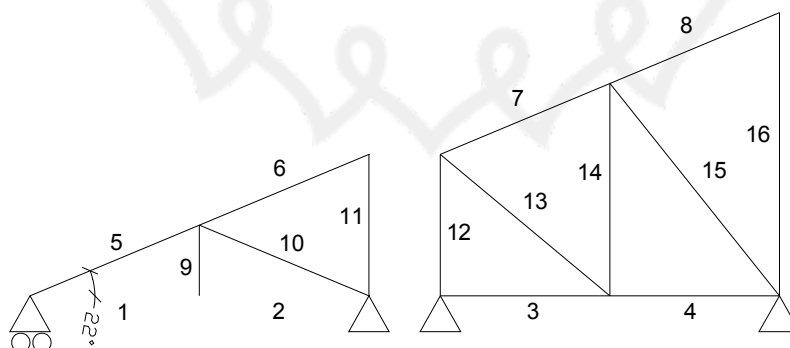
Secara umum data yang digunakan untuk perhitungan rencana atap adalah sebagai berikut :



- j. Bentuk rangka kuda-kuda : seperti tergambar.
 k. Jarak antar kuda-kuda : 3 m
 l. Kemiringan atap (α) : 30°
 m. Bahan gording : *lip channels* (\square) $150 \times 75 \times 20 \times 4,5$.
 n. Bahan rangka kuda-kuda : baja profil *double* siku sama kaki (\perp).
 o. Bahan penutup atap : genteng.
 p. Alat sambung : baut-mur.
 q. Jarak antar gording : 1,875 m
 r. Bentuk atap : limasan.
 j. Mutu baja profil : Bj-37 ($\sigma_{ijin} = 1600 \text{ kg/cm}^2$)
 ($\sigma_{leleh} = 2400 \text{ kg/cm}^2$)

Berikut adalah hasil rekapitulasi profil baja yang direncanakan

1. Jurai



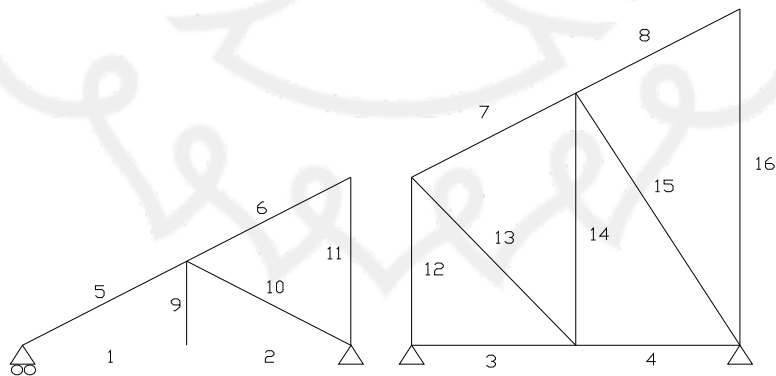
Rekapitulasi Perencanaan Profil Jurai

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



1	⊥ 45. 45. 5	2 Ø 12,7
2	⊥ 45. 45. 5	2 Ø 12,7
3	⊥ 45. 45. 5	2 Ø 12,7
4	⊥ 45. 45. 5	2 Ø 12,7
5	⊥ 45. 45. 5	2 Ø 12,7
6	⊥ 45. 45. 5	2 Ø 12,7
7	⊥ 45. 45. 5	2 Ø 12,7
8	⊥ 45. 45. 5	2 Ø 12,7
9	⊥ 45. 45. 5	2 Ø 12,7
10	⊥ 45. 45. 5	2 Ø 12,7
11	⊥ 45. 45. 5	2 Ø 12,7
12	⊥ 45. 45. 5	2 Ø 12,7
13	⊥ 45. 45. 5	2 Ø 12,7
14	⊥ 45. 45. 5	2 Ø 12,7
15	⊥ 45. 45. 5	2 Ø 12,7
16	⊥ 45. 45. 5	2 Ø 12,7

2. Setengah Kuda – Kuda



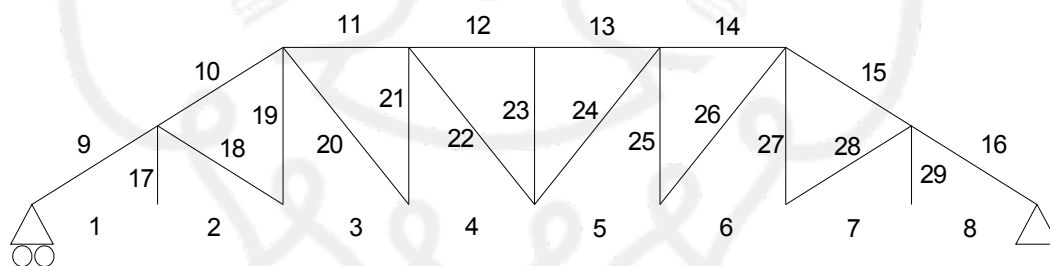
Rekapitulasi Perencanaan Profil Setengah Kuda-kuda

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



1	┘ 45. 45. 5	2 Ø 12,7
2	┘ 45. 45. 5	2 Ø 12,7
3	┘ 45. 45. 5	2 Ø 12,7
4	┘ 45. 45. 5	2 Ø 12,7
5	┘ 45. 45. 5	2 Ø 12,7
6	┘ 45. 45. 5	2 Ø 12,7
7	┘ 45. 45. 5	2 Ø 12,7
8	┘ 45. 45. 5	2 Ø 12,7
9	┘ 45. 45. 5	2 Ø 12,7
10	┘ 45. 45. 5	2 Ø 12,7
11	┘ 45. 45. 5	2 Ø 12,7
12	┘ 45. 45. 5	2 Ø 12,7
13	┘ 45. 45. 5	2 Ø 12,7
14	┘ 45. 45. 5	2 Ø 12,7
15	┘ 45. 45. 5	2 Ø 12,7
16	┘ 45. 45. 5	2 Ø 12,7

3. Kuda – Kuda Trapesium



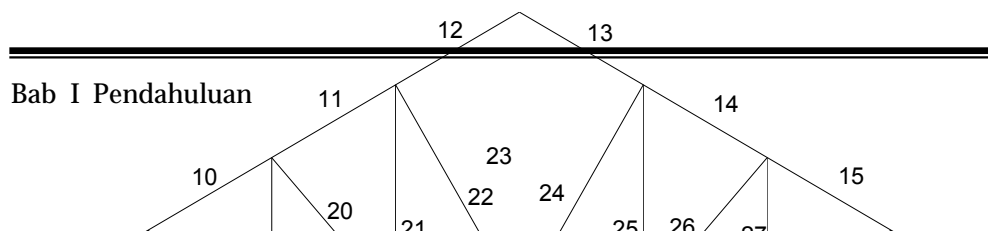
Rekapitulasi Perencanaan Profil Kuda-kuda Trapesium

Nomer Batang	Dimensi Profil	Baut (mm)
1	┘ 80. 80. 8	3 Ø 12,7
2	┘ 80. 80. 8	3 Ø 12,7
3	┘ 80. 80. 8	3 Ø 12,7
4	┘ 80. 80. 8	3 Ø 12,7



5	⊥ 80. 80. 8	3 Ø 12,7
6	⊥ 80. 80. 8	3 Ø 12,7
7	⊥ 80. 80. 8	3 Ø 12,7
8	⊥ 80. 80. 8	3 Ø 12,7
9	⊥ 80. 80. 8	3 Ø 12,7
10	⊥ 80. 80. 8	3 Ø 12,7
11	⊥ 80. 80. 8	3 Ø 12,7
12	⊥ 80. 80. 8	3 Ø 12,7
13	⊥ 80. 80. 8	3 Ø 12,7
14	⊥ 80. 80. 8	3 Ø 12,7
15	⊥ 80. 80. 8	3 Ø 12,7
16	⊥ 80. 80. 8	3 Ø 12,7
17	⊥ 80. 80. 8	3 Ø 12,7
18	⊥ 80. 80. 8	3 Ø 12,7
19	⊥ 80. 80. 8	3 Ø 12,7
20	⊥ 80. 80. 8	3 Ø 12,7
21	⊥ 80. 80. 8	3 Ø 12,7
22	⊥ 80. 80. 8	3 Ø 12,7
23	⊥ 80. 80. 8	3 Ø 12,7
24	⊥ 80. 80. 8	3 Ø 12,7
25	⊥ 80. 80. 8	3 Ø 12,7
26	⊥ 80. 80. 8	3 Ø 12,7
27	⊥ 80. 80. 8	3 Ø 12,7
28	⊥ 80. 80. 8	3 Ø 12,7
29	⊥ 80. 80. 8	3 Ø 12,7

4. Kuda – Kuda Utama A





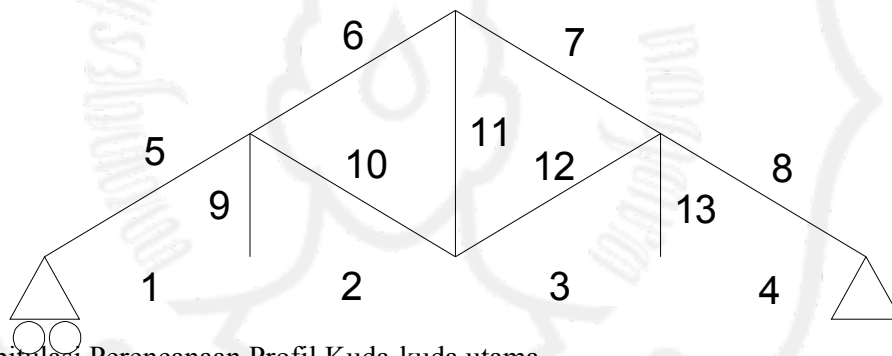
Rekapitulasi Perencanaan Profil Kuda-kuda Utama

Nomer Batang	Dimensi Profil	Baut (mm)
1	┴ 70. 70. 7	2 Ø 12,7
2	┴ 70. 70. 7	2 Ø 12,7
3	┴ 70. 70. 7	2 Ø 12,7
4	┴ 70. 70. 7	2 Ø 12,7
5	┴ 70. 70. 7	2 Ø 12,7
6	┴ 70. 70. 7	2 Ø 12,7
7	┴ 70. 70. 7	2 Ø 12,7
8	┴ 70. 70. 7	2 Ø 12,7
9	┴ 70. 70. 7	2 Ø 12,7
10	┴ 70. 70. 7	2 Ø 12,7
11	┴ 70. 70. 7	2 Ø 12,7
12	┴ 70. 70. 7	2 Ø 12,7
13	┴ 70. 70. 7	2 Ø 12,7
14	┴ 70. 70. 7	2 Ø 12,7
15	┴ 70. 70. 7	2 Ø 12,7
16	┴ 70. 70. 7	2 Ø 12,7
17	┴ 70. 70. 7	2 Ø 12,7
18	┴ 70. 70. 7	2 Ø 12,7
19	┴ 70. 70. 7	2 Ø 12,7
20	┴ 70. 70. 7	2 Ø 12,7
21	┴ 70. 70. 7	2 Ø 12,7



22	⊥ 70. 70. 7	2 Ø 12,7
23	⊥ 70. 70. 7	2 Ø 12,7
24	⊥ 70. 70. 7	2 Ø 12,7
25	⊥ 70. 70. 7	2 Ø 12,7
26	⊥ 70. 70. 7	2 Ø 12,7
27	⊥ 70. 70. 7	2 Ø 12,7
28	⊥ 70. 70. 7	2 Ø 12,7
29	⊥ 70. 70. 7	2 Ø 12,7

5. Kuda – Kuda Utama B



Rekapitulasi Perencanaan Profil Kuda-kuda utama

Nomer Batang	Dimensi Profil	Baut (mm)
1	⊥ 55 . 55 . 8	2 Ø 12,7
2	⊥ 55 . 55 . 8	2 Ø 12,7
3	⊥ 55 . 55 . 8	2 Ø 12,7
4	⊥ 55 . 55 . 8	2 Ø 12,7
5	⊥ 55 . 55 . 8	2 Ø 12,7
6	⊥ 55 . 55 . 8	2 Ø 12,7
7	⊥ 55 . 55 . 8	2 Ø 12,7
8	⊥ 55 . 55 . 8	2 Ø 12,7



9	⊥ 55 . 55 . 8	2 Ø 12,7
10	⊥ 55 . 55 . 8	2 Ø 12,7
11	⊥ 55 . 55 . 8	2 Ø 12,7
12	⊥ 55 . 55 . 8	2 Ø 12,7
13	⊥ 55 . 55 . 8	2 Ø 12,7

10.2 Perencanaan Tangga

Data perencanaan tangga

- Tebal plat tangga = 12 cm
- Tebal bordes tangga = 15 cm
- Lebar datar = 400 cm
- Lebar tangga rencana = 140 cm
- Dimensi bordes = 200 x 300 cm
- Lebar antrade = 30 cm
- Antrede = 300 / 30 = 10 buah
- Optrede = 10 + 1 = 11 buah
- $\alpha = \text{Arc.tg} (200/300) = 33,69^\circ < 35^\circ \dots\dots(\text{ok})$

10.2.1 Penulangan Tangga

a. Penulangan tangga dan bordes

Tumpuan = Ø 12 mm – 120 mm

Lapangan = Ø 12 mm – 150 mm

b. Penulangan balok bordes

Dimensi balok 15/30

Lentur = Ø 12 mm

Geser = Ø 8 – 100 mm



10.3 Perencanaan Plat Lantai

Rekapitulasi penulangan plat lantai :

- Tulangan lapangan arah x \varnothing 10 mm – 200 mm
- Tulangan lapangan arah y \varnothing 10 mm – 200 mm
- Tulangan tumpuan arah x \varnothing 10 mm – 100 mm
- Tulangan tumpuan arah y \varnothing 10 mm – 100 mm

10.5 Perencanaan Balok Anak

Penulangan Balok Anak

a. Tulangan balok anak as A'

Tumpuan : 3 D 16 mm
 Lapangan : 2 D 16 mm
 Geser : \varnothing 8 – 150 mm

b. Tulangan balok anak as A''

Tumpuan : 3 D 16 mm
 Lapangan : 2 D 16 mm
 Geser : \varnothing 8 – 150 mm

c. Tulangan balok anak as B'

Tumpuan : 3 D 16 mm
 Lapangan : 2 D 16 mm
 Geser : \varnothing 8 – 150 mm

d. Tulangan balok anak as 6'

Tumpuan : 3 D 16 mm
 Lapangan : 2 D 16 mm
 Geser : \varnothing 8 – 150 mm

e. Tulangan balok anak as D'

Tumpuan : 3 D 16 mm
 Lapangan : 2 D 16 mm
 Geser : \varnothing 8 – 150 mm

10.6 Perencanaan Portal



- a. Dimensi Ring Balk 200 mm x 250 mm
- Tumpuan : 2 D 16 mm
Lapangan : 2 D 16 mm
Geser : Ø 8 – 120 mm
- b. Dimensi Balok Portal 300 mm x 500 mm
(Balok portal memanjang)
- Tumpuan : 4 D 19 mm
Lapangan : 4 D 19 mm
Geser : Ø 10 – 200 mm
- (Balok portal melintang)
- Tumpuan : 5 D 19 mm
Lapangan : 5 D 19 mm
Geser : Ø 10 – 200 mm
- c. Dimensi Kolom 400 mm x 400 mm
- Tulangan : 4 D 16 mm
Geser : Ø 8 – 200 mm
- e. Dimensi Sloof
- Tumpuan : 4 D 16 mm
Lapangan : 2 D 16 mm
Geser : Ø 8 – 100 mm

10.7 Perencanaan Pondasi

- Kedalaman = 2,0 m
- Ukuran alas = 1700 mm x 1700 mm
- γ tanah = $1,7 \text{ t/m}^3 = 1700 \text{ kg/m}^3$
- σ tanah = $2,5 \text{ kg/cm}^2 = 2500 \text{ kg/m}^3$
- Tebal = 30 cm
- Penulangan pondasi
- Tul. Lentur = D 16 – 100 mm