

**PERENCANAAN
STRUKTUR GEDUNG SEKOLAH
2 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 :

NURUL CAHYA NINGRUM
1 8507057

**PROGRAM DIPLOMA III TEKNIK SIPIL
JURUSAN TEKNIK SIPIL FAKULTAS TEKNIK
UNIVERSITAS SEBELAS MARET
SURAKARTA
2011**

LEMBAR PENGESAHAN

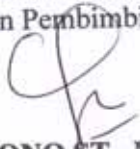
PERENCANAAN STRUKTUR DAN RENCANA ANGGARAN BIAYA GEDUNG KULIAH 2 LANTAI

TUGAS AKHIR

Dikerjakan Oleh:

NURUL CAHYA NINGRUM
NIM : I 8507057

Diperiksa dan disetujui :
Dosen Pembimbing


SETIONO ST., MSc
NIP. 1972022 4199702 1 001

Dipertahankan didepan tim penguji:


1. **SETIONO ST., MSc**
NIP. 1972022 4199702 1 001
2. **ACHMAD BASUKI, ST, MT**
NIP. 19710901 199702 1 001
3. **WIDI HARTONO, ST, MT**
NIP. 19730729 199903 1 001


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.....

.....


Mengetahui,

a.n. Ketua Jurusan Teknik Sipil
Fakultas Teknik UNS

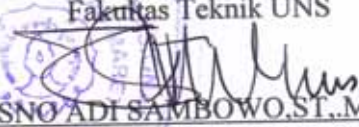

Ir. BAMBANG SANTOSA, MT
NIP. 19590823 198601 1 001

Disahkan,

Ketua Program Studi D III Teknik Sipil
Jurusan Teknik Sipil FT UNS


ACHMAD BASUKI, ST, MT
NIP. 19710901 199702 1 001

Mengetahui,
a.n. Dekan
Pembantu Dekan I
Fakultas Teknik UNS


KUSNO ADI SAMBOWO, ST, MT, PhD
NIP. 19691026199503 1 002



BAB 1

PENDAHULUAN

1.1 Latar Belakang

Semakin pesatnya perkembangan dunia teknik sipil di Indonesia saat ini menuntut terciptanya sumber daya manusia yang dapat mendukung kemajuannya dalam bidang ini. Dengan sumber daya manusia yang berkualitas tinggi, kita sebagai bangsa Indonesia akan dapat memenuhi tuntutan ini. Karena dengan hal ini kita akan semakin siap menghadapi tantangannya.

Bangsa Indonesia telah menyediakan berbagai sarana guna memenuhi sumber daya manusia yang berkualitas. Dalam merealisasikan hal ini Universitas Sebelas Maret Surakarta sebagai salah satu lembaga pendidikan yang dapat memenuhi kebutuhan tersebut memberikan Tugas Akhir sebuah perencanaan struktur 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 zaman yang semakin modern dan berteknologi, serta semakin derasnya arus globalisasi saat ini sangat diperlukan seorang teknisi yang berkualitas. Dalam hal ini khususnya 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 dan pengalaman dalam merencanakan struktur gedung.
3. Mahasiswa diharapkan dapat memecahkan suatu masalah yang dihadapi dalam perencanaan suatu struktur gedung.

1.3 Kriteria Perencanaan

1. Spesifikasi Bangunan

- a. Fungsi Bangunan : Gedung sekolah
- b. Luas Bangunan : 1200 m²
- c. Jumlah Lantai : 2 lantai
- d. Tinggi Tiap Lantai : 4 m
- e. Konstruksi Atap : Rangka kuda-kuda baja
- f. Penutup Atap : Genteng tanah liat
- g. Pondasi : Foot Plate

2. Spesifikasi Bahan

- a. Mutu Baja Profil : BJ 37
- b. Mutu Beton (f'c) : 25 MPa
- c. Mutu Baja Tulangan (fy) : Polos: 240 Mpa
Ulir : 320 Mpa.



1.4 Peraturan-Peraturan Yang Berlaku

- a. SNI 03-1729-2002_ Tata cara perencanaan struktur baja untuk bangunan gedung.
- b. SNI 03-2847-2002_ Tata cara perencanaan struktur beton untuk bangunan gedung.
- c. Peraturan Pembebanan Indonesia Untuk Gedung (PPIUG 1989).
- d. Peraturan Perencanaan Bangunan Baja Indonesia (PPBBI 1984).





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Perencanaan Struktur Gedung Sekolah 2 Lantai

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 1989**, beban-beban tersebut adalah :

1. Beban Mati (qd)

Beban mati adalah berat dari semua bagian suatu gedung yang bersifat tetap, termasuk segala unsur tambahan, penyelesaian-penyelesaian, mesin-mesin serta peralatan tetap yang merupakan bagian tak terpisahkan dari gedung. Untuk merencanakan gedung, 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 | 1800 kg/m ³ |
| 3. Beton biasa..... | 2200 kg/m ³ |

b) Komponen Gedung :

1. Langit – langit dan dinding (termasuk rusuk – rusuknya,
tanpa penggantung langit-langit atau pengaku), terdiri dari :
 - semen asbes (eternit) dengan tebal maximum 4mm..... 11 kg/m²
 - kaca dengan tebal 3 – 4 mm..... 10 kg/m²
2. Penggantung langit- langit (dari kayu), dengan bentang
maksimum 5 m dan jarak s.k.s. minimum 0,80 m..... 7 kg/m²



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3. Penutup lantai dari tegel, keramik dan beton (tanpa adukan)
per cm tebal 24 kg/m²
4. Adukan semen per cm tebal 21 kg/m²
5. Penutup atap genteng dengan reng dan usuk 50 kg/m²
6. Dinding pasangan batu merah setengah bata 1700 kg/m²

2. Beban Hidup (ql)

Beban hidup adalah semua bahan 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 1989**). Beban hidup yang bekerja pada bangunan ini disesuaikan dengan rencana fungsi bangunan tersebut. Beban hidup untuk bangunan ini terdiri dari :

- | | |
|-------------------------------|-----------------------|
| Beban atap | 100 kg/m ² |
| Beban tangga dan bordes | 300 kg/m ² |
| Beban lantai | 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 :

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Perencanaan Struktur Gedung Sekolah 2 Lantai

Tabel 2.1 Koefisien reduksi beban hidup

Penggunaan gedung	Koefisien reduksi beban hidup untuk perencanaan balok Induk dan portal
<ul style="list-style-type: none"> • PERUMAHAN / HUNIAN : Rumah tinggal, rumah sakit, dan hotel 	0,75
<ul style="list-style-type: none"> • PENDIDIKAN : Sekolah dan ruang kuliah 	0,90
<ul style="list-style-type: none"> • PENYIMPANAN : Gudang, perpustakaan dan ruang arsip 	0,90
<ul style="list-style-type: none"> • TANGGA : Pendidikan dan kantor 	0,75

Sumber : PPIUG 1989

3. Beban Angin (W)

Beban Angin adalah semua beban yang bekerja pada gedung atau bagian gedung yang disebabkan oleh selisih dalam tekanan udara (**PPIUG 1989**).

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 .

Sedangkan koefisien angin 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

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2.1.2. Sistem Kerjanya 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 kerjanya 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 Peraturan Pembebanan Indonesia Untuk Gedung 1989, 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.

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Perencanaan Struktur Gedung Sekolah 2 Lantai

Tabel 2.2 Faktor Pembebanan U

No.	KOMBINASI BEBAN	FAKTOR U
1.	D	1.4 D
2.	D, L	1,2 D + 1,6 L + 0,5 (A atau R)
3	D, L, W	1,2 D + 1,0 L ± 1,3 W + 0,5 (A atau R)

Keterangan :

- A = Beban Atap
- D = Beban mati
- L = Beban hidup
- Lr = Beban hidup tereduksi
- R = Beban air hujan
- W = Beban angin

Tabel 2.3 Faktor Reduksi Kekuatan ϕ

No	GAYA	ϕ
1.	Lentur tanpa beban aksial	0,80
2.	Aksial tarik dan aksial tarik dengan lentur	0,80
3.	Aksial tekan dan aksial tekan dengan lentur	0,65 – 0,80
4.	Geser dan torsi	0,60
5.	Tumpuan Beton	0,70

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 Peraturan Pembebanan Indonesia Untuk Gedung 1983 adalah sebagai berikut :

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Perencanaan Struktur Gedung Sekolah 2 Lantai

- 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

- Pada perencanaan atap ini, beban yang bekerja adalah :
 - Beban mati
 - Beban hidup
 - Beban angin
- Asumsi Perletakan
 - Tumpuan sebelah kiri adalah Sendi.
 - Tumpuan sebelah kanan adalah Rol.
- Analisa tampang menggunakan peraturan **SNI 03-1729-2002**.

Dan untuk perhitungan dimensi profil rangka kuda kuda:

- Batang tarik

$$A_g \text{ perlu} = \frac{P_{mak}}{F_y}$$

$$A_n \text{ perlu} = 0,85 \cdot A_g$$

$$\phi R_n = \phi(2,4 \cdot F_u \cdot d \cdot t)$$

$$n = \frac{P}{\phi R_n}$$

$$A_n = A_g - dt$$

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Perencanaan Struktur Gedung Sekolah 2 Lantai

L = Sambungan dengan Diameter

$$= 3.d$$

\bar{x} = jari-jari kelambatan

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

$$A_e = U.A_n$$

Check kekutan nominal

$$\phi P_n = 0,9.A_g.F_y$$

$$\phi P_n > P$$

b. Batang tekan

$$A_g \text{ perlu} = \frac{P_{mak}}{F_y}$$

$$A_n \text{ perlu} = 0,85.A_g$$

$$\frac{h}{t_w} = \frac{300}{\sqrt{F_y}}$$

$$\lambda_c = \frac{K.l}{r\pi} \sqrt{\frac{F_y}{E}}$$

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

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

$$\lambda_c \geq 1,2 \quad \longrightarrow \quad \omega = 1,25.\lambda_c^2$$

$$\phi R_n = \phi(1,2.F_u.d.t)$$

$$n = \frac{P}{\phi R_n}$$

$$F_{cr} = \frac{F_y}{\omega}$$

$$\phi P_n = \phi.A_g.F_y$$

$$\phi P_n > P$$

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Perencanaan Struktur Gedung Sekolah 2 Lantai

2.3. Perencanaan Tangga

Untuk perhitungan penulangan tangga dipakai kombinasi pembebanan akibat beban mati dan beban hidup yang disesuaikan dengan Peraturan Pembebanan Indonesia Untuk Gedung (**PPIUG 1989**) dan **SNI 03-2847-2002** dan analisa struktur menggunakan perhitungan **SAP 2000**.

sedangkan untuk tumpuan diasumsikan sebagai berikut :

- Tumpuan bawah adalah Jepit.
- Tumpuan tengah adalah Jepit.
- Tumpuan atas adalah Jepit.

Perhitungan untuk penulangan tangga

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

dimana, $\phi = 0,80$

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

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

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

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

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

$\rho_{\min} < \rho < \rho_{\max}$ —————> tulangan tunggal

$\rho < \rho_{\min}$ —————> dipakai $\rho_{\min} = 0,0025$

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

Luas tampang tulangan

$$A_s = \rho \cdot b \cdot d$$

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Perencanaan Struktur Gedung Sekolah 2 Lantai

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 1989**.
4. Analisa tampang menggunakan **SNI 03-2847-2002**.

Pemasangan tulangan lentur disyaratkan sebagai berikut :

1. Jarak minimum tulangan sengkang 25 mm
2. Jarak maksimum tulangan sengkang 240 atau 2h

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

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

dimana, $\phi = 0,80$

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

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

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

$$\rho_b = \frac{0,85 \cdot f_c}{f_y} \cdot \beta_1 \left(\frac{600}{600 + f_y} \right)$$

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

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

$\rho < \rho_{\min}$ → dipakai $\rho_{\min} = 0,0025$

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

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Perencanaan Struktur Gedung Sekolah 2 Lantai

Luas tampang tulangan

$$A_s = \rho b x d$$

2.5. Perencanaan Balok Anak

1. Pembebanan
2. Asumsi Perletakan : jepit jepit
3. Analisa struktur pada perencanaan atap ini menggunakan program **SAP 2000**.
4. Analisa tampang menggunakan peraturan **SNI 03-2847-2002**.

Perhitungan tulangan lentur :

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

dimana, $\phi = 0,80$

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

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

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

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

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

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

$\rho < \rho_{\min}$ \longrightarrow dipakai $\rho_{\min} = \frac{1,4}{f'_y}$

Perhitungan tulangan geser :

$$\phi = 0,60$$

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

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Perencanaan Struktur Gedung Sekolah 2 Lantai

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

$$\Phi \cdot V_c \leq V_u \leq 3 \Phi V_c$$

(perlu tulangan geser)

$$V_u < \emptyset V_c < 3 \emptyset V_c$$

(tidak 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)

2.6. Perencanaan Portal

1. Pembebanan
2. Asumsi Perletakan
 - Jepit pada kaki portal.
 - Bebas pada titik yang lain
3. Analisa struktur pada perencanaan atap ini menggunakan program **SAP 2000**.
4. Analisa tampang menggunakan peraturan **SNI 03-2847-2002**.

Perhitungan tulangan lentur :

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

dimana, $\phi = 0,80$

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

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

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

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Perencanaan Struktur Gedung Sekolah 2 Lantai

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

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

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

$\rho < \rho_{\min}$ \longrightarrow dipakai $\rho_{\min} = \frac{1,4}{f'_y}$

Perhitungan tulangan geser :

$$\phi = 0,60$$

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

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

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

(perlu tulangan geser)

$$V_u < \phi V_c < 3 \phi V_c$$

(tidak 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)

2.7. Perencanaan Pondasi

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

Perhitungan kapasitas dukung pondasi :

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Perencanaan Struktur Gedung Sekolah 2 Lantai

$$\sigma_{\text{yang terjadi}} = \frac{V_{\text{tot}}}{A} + \frac{M_{\text{tot}}}{\frac{1}{6} \cdot b \cdot L^2}$$

$$= \sigma_{\text{tanah terjadi}} < \sigma_{\text{ijin tanah}} \dots \dots \dots (\text{dianggap aman})$$

Sedangkan pada perhitungan tulangan lentur

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

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

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

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

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

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

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

$$\rho < \rho_{\text{min}} \longrightarrow \text{dipakai } \rho_{\text{min}} = 0,0036$$

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

Luas tampang tulangan

$$A_s = \rho \cdot b \cdot d$$

Perhitungan tulangan geser :

$$V_u = \sigma \cdot A_{\text{efektif}}$$

$$\phi = 0,60$$

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

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

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TUGAS AKHIR
Perencanaan Struktur Gedung Sekolah 2 Lantai

$$\Phi \cdot V_c \leq V_u \leq 3 \Phi V_c$$

(perlu tulangan geser)

$$V_u < \Phi V_c < 3 \Phi V_c$$

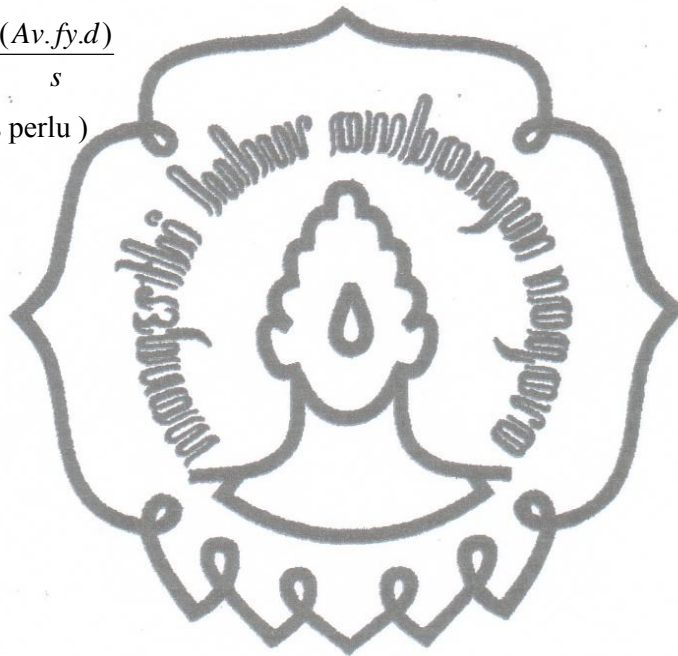
(tidak perlu tulangan geser)

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

(pilih tulangan terpasang)

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

(pakai V_s perlu)



commit to user

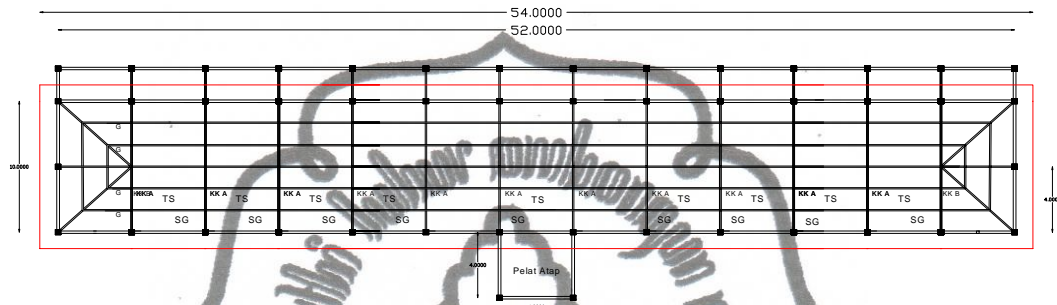


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Perencanaan Struktur Gedung Sekolah Dua lantai

BAB 3

PERENCANAAN ATAP

3.1 . Rencana Atap




Gambar 3.1 Rencana atap

Keterangan :

KK A = Kuda-kuda utama A	G = Gording
KK B = Kuda-kuda utama B	N = Nok
½ KK = Setengah kuda-kuda	JR = Jurai
SR = Sag Rod	TS = Track Stang

3.1.1. Dasar Perencanaan

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

- Bentuk rangka kuda-kuda : seperti tergambar(Gambar 3.2)
- Jarak antar kuda-kuda : 4,00 m
- Kemiringan atap (α) : 35°
- Bahan gording : baja profil *lip channels* ()



- e. Bahan rangka kuda-kuda : baja profil *double* siku sama kaki (\perp)
 f. Bahan penutup atap : genteng
 g. Alat sambung : baut-mur
 h. Jarak antar gording : 1,628 m
 i. Bentuk atap : Limasan
 j. Mutu baja profil : Bj-37 ($\sigma_{Leleh} = 2400 \text{ kg/cm}^2$)
 ($\sigma_{ultimate} = 3700 \text{ kg/cm}^2$)

3.2 . Perencanaan Gording

3.2.1. Perencanaan Pembebanan

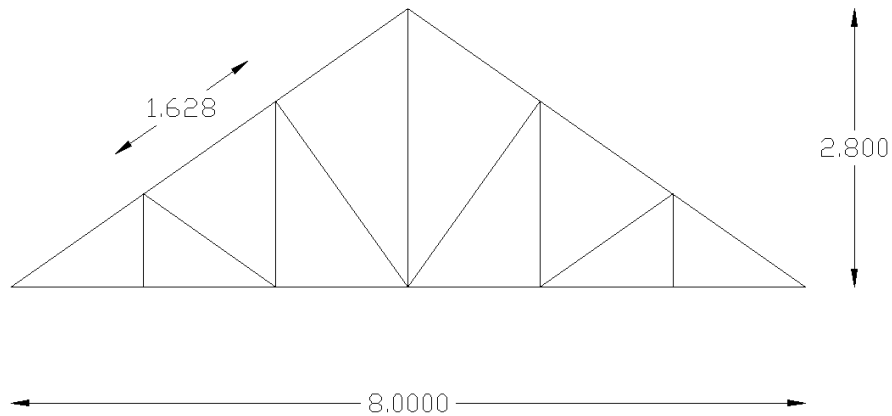
Dicoba menggunakan gording dengan dimensi baja profil tipe *lip channels*/ kanal kait (\square) $150 \times 75 \times 20 \times 4,5$ pada perencanaan kuda-kuda dengan data sebagai berikut :

- | | | | |
|------------------|----------------------|----------|----------------------|
| 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) = 35°

Jarak antar gording (s) = 1,628 m

Jarak antar kuda-kuda (L) = 4,00 m



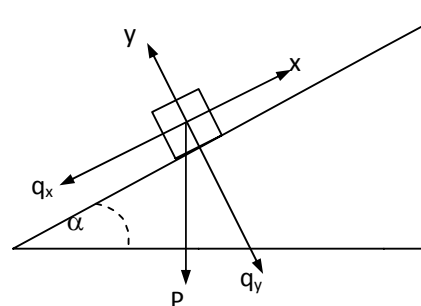
Gambar 3.2 Rangka Kuda-Kuda

Pembebanan berdasarkan Peraturan Pembebanan Indonesia Untuk Gedung (PPIUG) 1983, 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

3.2.2. Perhitungan Pembebanan

a. Beban Mati (titik)



(Gambar 3.3 Distribusi beban mati)

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$$\begin{aligned} \text{Berat gording} &= 11 \text{ kg/m} \\ \text{Berat penutup atap} &= 1,638 \times 50 = 81,4 \text{ kg/m} \\ \text{Berat plafond} &= (1,334 \times 18) = 24,012 \text{ kg/m} + \\ &= 116,412 \text{ kg/m} \end{aligned}$$

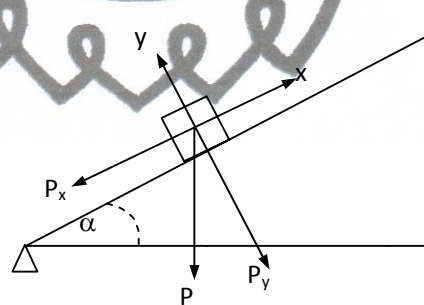
$$q_x = q \sin \alpha = 116,412 \times \sin 35^\circ = 66,7712 \text{ kg/m}$$

$$q_y = q \cos \alpha = 116,412 \times \cos 35^\circ = 95,36 \text{ kg/m}$$

$$M_{x1} = \frac{1}{8} \cdot q_y \cdot L^2 = \frac{1}{8} \times 95,36 \times (4)^2 = 190,72 \text{ kgm}$$

$$M_{y1} = \frac{1}{8} \cdot q_x \cdot L^2 = \frac{1}{8} \times 66,7712 \times (4)^2 = 133,5424 \text{ kgm}$$

b. Beban hidup



(Gambar 3.4 Distribusi beban hidup)

P diambil sebesar 100 kg.

$$P_x = P \sin \alpha = 100 \times \sin 35^\circ = 57,358 \text{ kg}$$

$$P_y = P \cos \alpha = 100 \times \cos 35^\circ = 81,916 \text{ kg}$$

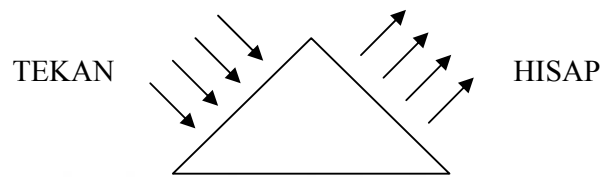
$$M_{x2} = \frac{1}{4} \cdot P_y \cdot L = \frac{1}{4} \times 81,915 \times 4 = 81,916 \text{ kgm}$$

$$M_{y2} = \frac{1}{4} \cdot P_x \cdot L = \frac{1}{4} \times 57,358 \times 4 = 57,358 \text{ kgm}$$

commit to user



c. **Beban angin**



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

Koefisien kemiringan atap (α) = 35° .

1) Koefisien angin tekan = $(0,02\alpha - 0,4) = 0,3$

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

Beban angin :

1) Angin tekan (W_1) = koef. Angin tekan x beban angin x $1/2$ x (s_1+s_2)
 $= 0,3 \times 25 \times 1/2 \times (1,628+1,628) = 12,21 \text{ kg/m}$.

2) Angin hisap (W_2) = koef. Angin hisap x beban angin x $1/2$ x (s_1+s_2)
 $= -0,4 \times 25 \times 1/2 \times (1,628+1,628) = -16,28 \text{ kg/m}$.

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

1) $M_x(\text{tekan}) = 1/8 \cdot W_1 \cdot L^2 = 1/8 \times 12,21 \times (4)^2 = 24,42 \text{ kgm}$.

2) $M_x(\text{hisap}) = 1/8 \cdot W_2 \cdot L^2 = 1/8 \times -16,28 \times (4)^2 = -32,56 \text{ kgm}$.

Tabel 3.1 Kombinasi gaya dalam pada gording

Momen	Beban Mati (kgm)	Beban Hidup (kgm)	Beban Angin		Kombinasi	
			Tekan (kgm)	Hisap (kgm)	Minimum (kgm)	Maksimum (kgm)
M_x	190,72	81,916	24,42	-35,56	331,465	379,46
M_y	133,5424	57,358	-	-	252,023	252,023

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3.2.3. Kontrol Tahanan Momen

- Kontrol terhadap momen Maximum

$$M_x = 379,46 \quad \text{kgm} = 37946 \quad \text{kgcm.}$$

$$M_y = 252,023 \quad \text{kgm} = 25202,3 \quad \text{kgcm.}$$

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 :

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

$$\frac{37946}{0,9 \cdot 156480} + \frac{25202,3}{0,9 \cdot 47520} = 0,85 \leq 1 \dots \dots \text{OK } \odot$$

- Kontrol terhadap momen Minimum

$$M_x = 331,465 \quad \text{kgm} = 33146,5 \quad \text{kgcm.}$$

$$M_y = 252,023 \quad \text{kgm} = 25202,3 \quad \text{kgcm.}$$

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 :

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

$$\frac{33146,5}{0,9 \cdot 156480} + \frac{25202,3}{0,9 \cdot 47520} = 0,824 \leq 1 \dots \dots \text{OK } \odot$$

commit to user



3.2.4 Kontrol Terhadap Lentutan

Di coba profil : 150 x 75 x 20 x 4,5	q_x	= 0,6678 kg/cm
$E = 2,1 \times 10^6 \text{ kg/cm}^2$	q_y	= 0,954 kg/cm
$I_x = 489 \text{ cm}^4$	P_x	= 57,358 kg
$I_y = 99,2 \text{ cm}^4$	P_y	= 81,916 kg

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

$$= \frac{5 \cdot 0,6678 \cdot (400)^4}{384 \cdot 2,1 \cdot 10^6 \cdot 99,2} + \frac{57,358 \cdot 400^3}{48 \cdot 2,1 \cdot 10^6 \cdot 99,2} = 1,4357 \text{ cm}$$

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

$$= \frac{5 \cdot 0,954 \cdot (400)^4}{384 \cdot 2,1 \times 10^6 \cdot 489} + \frac{81,916 \cdot (400)^3}{48 \cdot 2,1 \cdot 10^6 \cdot 489} = 0,416 \text{ cm}$$

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

$$= \sqrt{(1,4357)^2 + (0,416)^2} = 1,495 \text{ cm}$$

$$Z \leq Z_{ijin}$$

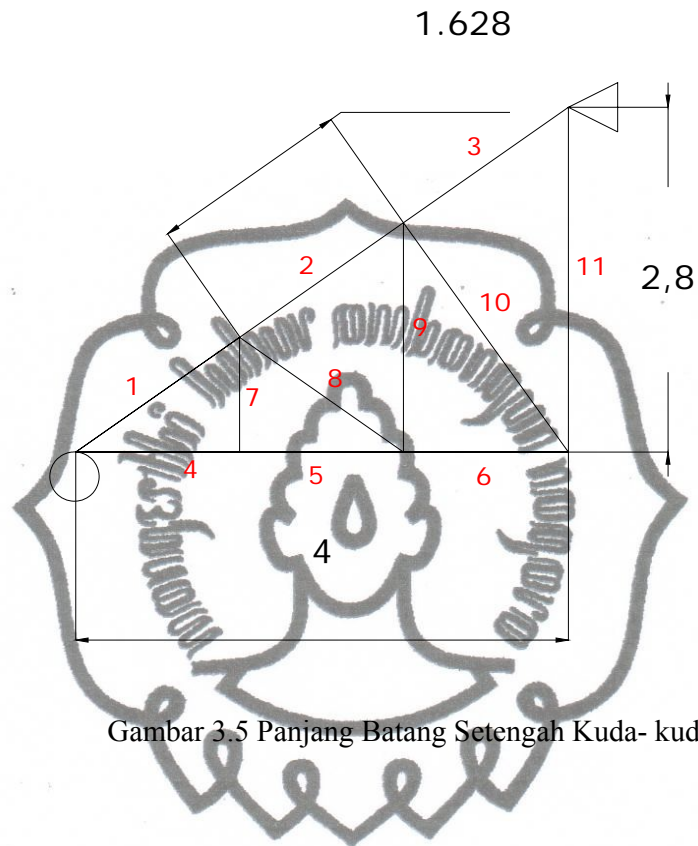
$$1,495 \text{ cm} \leq 1,66 \text{ cm} \quad \dots\dots\dots \text{aman !}$$

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

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3.3. Perencanaan Setengah Kuda-kuda



Gambar 3.5 Panjang Batang Setengah Kuda- kuda



3.3.1. Perhitungan Panjang Batang Setengah Kuda-kuda

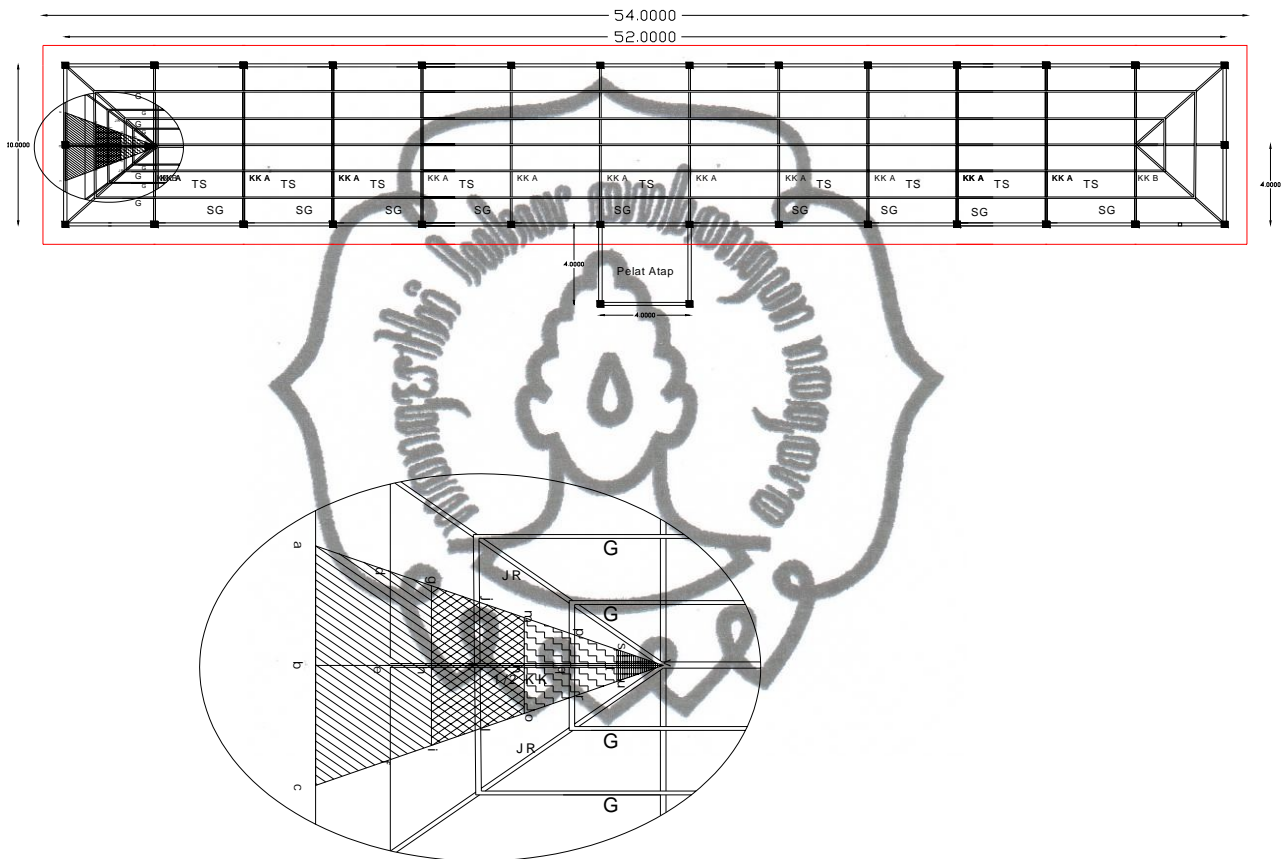
Perhitungan panjang batang selanjutnya disajikan dalam tabel dibawah ini :

Tabel 3.2 Perhitungan panjang batang pada setengah kuda-kuda

Nomer Batang	Panjang Batang
1	1,628 m
2	1,628 m
3	1,628 m
4	1,333 m
5	1,333 m
6	1,333 m
7	0,934 m
8	1,628 m
9	1,870 m
10	2,297 m
11	2,800 m



3.3.2. Perhitungan luasan Setengah Kuda-kuda



Gambar 3.6 Luasan Setengah Kuda-kuda

$$\text{Panjang atap } ve = 3 \times 1,628 = 4,884 \text{ m}$$

$$\text{Panjang atap } eb = 1,221 \text{ m}$$

$$\text{Panjang atap } vb = ve + eb = 6,105$$

$$\text{Panjang atap } vh = (2 \times 1,628) + 0,814 = 4,07$$

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$$\text{Panjang atap vk} = 2 \times 1,628 = 3,256$$

$$\text{Panjang atap vn} = 1,628 + 0,814 = 2,442$$

$$\text{Panjang atap vq} = 1,628$$

$$\text{Panjang atap vt} = \frac{1}{2} \times 1,628 = 0,814$$

$$\text{Panjang atap ac} = 5 \text{ m}$$

$$\text{Panjang atap df} = \frac{ve.ac}{vb} = 4 \text{ m}$$

$$\text{Panjang atap gi} = \frac{vh.ac}{vb} = 3,333 \text{ m}$$

$$\text{Panjang atap jl} = \frac{vk.ac}{vb} = 2,665 \text{ m}$$

$$\text{Panjang atap mo} = \frac{vn.ac}{vb} = 2 \text{ m}$$

$$\text{Panjang atap pr} = \frac{vq.ac}{vb} = 1,333 \text{ m}$$

$$\text{Panjang atap su} = \frac{vt.ac}{vb} = 0,666 \text{ m}$$

• **Luas atap giac**

$$= \left(\frac{gi + ac}{2} \right) x hb$$

$$= \left(\frac{3,333 + 5}{2} \right) x 2,035 = 8,478 \text{ m}^2$$

• **Luas atap mogi**

$$= \left(\frac{mo + gi}{2} \right) x nh$$

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$$= \left(\frac{2 + 3,333}{2} \right) \times 1,628 = 4,33 \text{ m}^2$$

• Luas atap sumo

$$= \left(\frac{su + mo}{2} \right) \times tn$$

$$= \left(\frac{0,666 + 2}{2} \right) \times 1,628 = 2,170 \text{ m}^2$$

• Luas atap vsu

$$= \frac{1}{2} \cdot Su \cdot tv$$

$$= \frac{1}{2} \cdot 0,666 \cdot 0,814 = 0,271 \text{ m}^2$$

Panjang plafond **ve** = $3 \times 1,334 = 4,002 \text{ m}$

Panjang plafond **eb** = 1 m

Panjang plafond **vb** = $ve + eb = 5,002 \text{ m}$

Panjang plafond **ac** = 5 m

Panjang plafond **vh** = $(2 \times 1,334) + 0,667 = 3,335$

Panjang plafond **vk** = $2 \times 1,334 = 2,668$

Panjang plafond **vn** = $1,334 + 0,667 = 2,001$

Panjang plafond **vq** = $1,334$

Panjang plafond **vt** = $\frac{1}{2} \times 1,1,334 = 0,667$

Panjang plafond **df** = $\frac{ve \cdot ac}{vb} = 4 \text{ m}$

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$$\text{Panjang plafond gi} = \frac{vh.ac}{vb} = 3,333 \text{ m}$$

$$\text{Panjang plafond jl} = \frac{vk.ac}{vb} = 2.665 \text{ m}$$

$$\text{Panjang plafond mo} = \frac{vn.ac}{vb} = 2 \text{ m}$$

$$\text{Panjang plafond pr} = \frac{vq.ac}{vb} = 1,333 \text{ m}$$

$$\text{Panjang plafond su} = \frac{vt.ac}{vb} = 0,666 \text{ m}$$

• Luas plafond giac

$$\begin{aligned} &= \left(\frac{gi + ac}{2} \right) x hb \\ &= \left(\frac{3,333 + 5,}{2} \right) x 1,667 = 6,93 \text{ m}^2 \end{aligned}$$

• Luas plafond mogi

$$\begin{aligned} &= \left(\frac{mo + gi}{2} \right) x nh \\ &= \left(\frac{2 + 3,333}{2} \right) x 1,334 = 3,538 \text{ m}^2 \end{aligned}$$

• Luas plafond sumo

$$\begin{aligned} &= \left(\frac{su + mo}{2} \right) x tn \\ &= \left(\frac{0,666 + 2}{2} \right) x 1,334 = 1,803 \text{ m}^2 \end{aligned}$$

• Luas plafond vsu

$$= \frac{1}{2} \cdot Su \cdot tv$$

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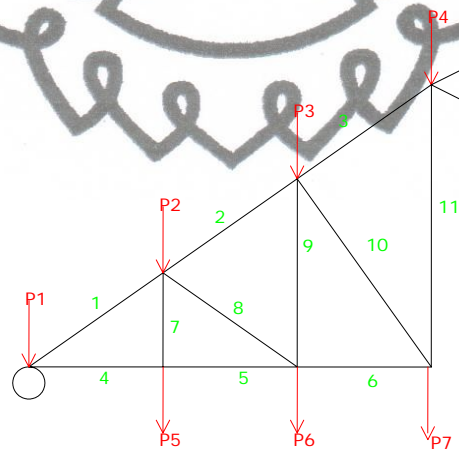


$$= \frac{1}{2} \cdot 0,666 \cdot 0,667 = 0,22 \text{ m}^2$$

3.3.3. Perhitungan Pembebanan Setengah Kuda-kuda

Data-data pembebanan :

- Berat gording = 11 kg/m (sumber tabel baja)
- Jarak antar kuda-kuda = 4,00 m (sumber : gambar perencanaan)
- Berat penutup atap = 50 kg/m² (sumber PPIUG 1989)
- Berat profil = 25 kg/m (sumber : tabel baja)
- Beban hujan = (40 - 0,8α) kg/m²
= 40 - 0,8 \cdot 35 = 12 kg/m²



Gambar 3.7 Pembebanan Setengah Kuda-kuda akibat beban mati

a) Perhitungan Beban

➤ Beban Mati

1) Beban P₁

- a) Beban gording = Berat profil gording x Panjang Gording

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$$= 11 \times 4 = 44 \text{ kg}$$

b) Beban atap = Luasan atap **giac** x Berat atap
 $= 8,478 \times 50 = 423,9 \text{ kg}$

c) Beban kuda-kuda = $\frac{1}{2} \times \text{Btg} (1 + 4) \times \text{berat profil kuda kuda}$
 $= \frac{1}{2} \times (1,628 + 1,334) \times 25 = 36,975 \text{ kg}$

d) Beban plat sambung = 30% x beban kuda-kuda
 $= 30\% \times 36,975 = 11,092 \text{ kg}$

e) Beban bracing = 10% x beban kuda-kuda
 $= 10\% \times 36,975 = 3,6975 \text{ kg}$

f) Beban plafon = Luasan plafond **giac** x berat plafon
 $= 6,93 \times 18 = 124,74 \text{ kg}$

2) Beban P₂

a) Beban gording = Berat profil gording x Panjang Gording
 $= 11 \times 2,665 = 29,315 \text{ kg}$

b) Beban atap = Luasan atap **mogi** x berat atap
 $= 4,33 \times 50 = 216,5 \text{ kg}$

c) Beban kuda-kuda = $\frac{1}{2} \times \text{Btg} (1 + 2 + 7 + 8) \times \text{berat profil kuda kuda}$
 $= \frac{1}{2} \times (1,628 + 1,628 + 0,934 + 1,628) \times 25$
 $= 72,725 \text{ kg}$

d) Beban plat sambung = 30% x beban kuda-kuda
 $= 30\% \times 72,725 = 21,82 \text{ kg}$

e) Beban bracing = 10% x beban kuda-kuda
 $= 10\% \times 72,725 = 7,2725 \text{ kg}$

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3) Beban P_3

- a) Beban gording = Berat profil gording x Panjang Gording
 $= 11 \times 1,332 = 16,984 \text{ kg}$
- b) Beban atap = Luasan atap **sumo** x berat atap
 $= 2,206 \times 50 = 110,3 \text{ kg}$
- c) Beban kuda-kuda = $\frac{1}{2} \times \text{Btg} (2 + 3 + 9 + 10) \times \text{berat profil kuda kuda}$
 $= \frac{1}{2} \times (1,628 + 1,628 + 1,870 + 2,297) \times 25$
 $= 92,7875 \text{ kg}$
- d) Beban plat sambung = 30% x beban kuda-kuda
 $= 30\% \times 92,7875 = 27,837 \text{ kg}$
- e) Beban bracing = 10% x beban kuda-kuda
 $= 10\% \times 92,7875 = 9,279 \text{ kg}$

4) Beban P_4

- a) Beban atap = Luasan atap **vsu** x berat atap
 $= 0,2934 \times 50 = 14,67 \text{ kg}$
- b) Beban kuda-kuda = $\frac{1}{2} \times \text{Btg}(3 + 11) \times \text{berat profil kuda kuda}$
 $= \frac{1}{2} \times (1,628 + 2,800) \times 25 = 55,35 \text{ kg}$
- c) Beban bracing = 10% x beban kuda-kuda
 $= 10\% \times 55,35 = 5,535 \text{ kg}$
- d) Beban plat sambung = 30% x beban kuda-kuda
 $= 30\% \times 55,35 = 16,605 \text{ kg}$



$$= 30\% \times 55,35 = 16,605 \text{ kg}$$

5) Beban P_5

a) Beban kuda-kuda = $\frac{1}{2} \times \text{Btg}(4 + 5 + 7) \times \text{berat profil kuda kuda}$

$$= \frac{1}{2} \times (1,333 + 1,333 + 0,934) \times 25$$

$$= 45 \text{ kg}$$

b) Beban bracing = $10\% \times \text{beban kuda-kuda}$

$$= 10\% \times 45 = 4,5 \text{ kg}$$

c) Beban plafon = Luasan plafond **mogi** x berat plafon

$$= 3,538 \times 18 = 74,16 \text{ kg}$$

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

$$= 30\% \times 45 = 13,5 \text{ kg}$$

6) Beban P_6

a) Beban kuda-kuda = $\frac{1}{2} \times \text{Btg}(5 + 6 + 8+9) \times \text{berat profil kuda kuda}$

$$= \frac{1}{2} \times (1,333 + 1,333 + 1,628 + 1,87) \times 25$$

$$= 77,05 \text{ kg}$$

b) Beban bracing = $10\% \times \text{beban kuda-kuda}$

$$= 10\% \times 77,05 = 7,705 \text{ kg}$$

c) Beban plafon = Luasan plafond **sumo** x berat plafon

$$= 1,803 \times 18 = 32,454 \text{ kg}$$

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$$\begin{aligned} \text{d) Beban plat sambung} &= 30\% \times \text{beban kuda-kuda} \\ &= 30\% \times 77,05 = 23,115 \text{ kg} \end{aligned}$$

7) Beban P₇

$$\begin{aligned} \text{a) Beban kuda-kuda} &= \frac{1}{2} \times \text{Btg}(6 + 10 + 11) \times \text{berat profil kuda kuda} \\ &= \frac{1}{2} \times (1,333 + 2,297 + 2,8) \times 25 \\ &= 80,375 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{b) Beban bracing} &= 10\% \times \text{beban kuda-kuda} \\ &= 10\% \times 80,375 = 8,038 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{c) Beban plafon} &= \text{Luasan plafond vsu} \times \text{berat plafon} \\ &= 0,24 \times 18 = 4,32 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{d) Beban plat sambung} &= 30\% \times \text{beban kuda-kuda} \\ &= 30\% \times 80,375 = 24,113 \text{ kg} \end{aligned}$$

Tabel 3.3 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)
P ₁	423,9	44	36,975	3,6975	11,092	124,74	644,36	650
P ₂	216,5	29,315	72,725	7,2725	21,82	---	347,63	348
P ₃	110,3	14,652	92,7875	9,279	27,837	---	254,754	256
P ₄	14,67	---	55,35	5,535	16,605	---	92,16	93
P ₅	---	---	45	4,5	13,5	63,68	126,56	127

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P ₆	---	---	77,05	7,705	23,115	32,454	140,17	141
P ₇	---	---	80,375	8,038	24,113	4,32	116,84	120

➤ **Beban Hidup**

Beban hidup yang bekerja pada P₁, P₂, P₃, P₄ = 100 kg

➤ **Beban Hujan**

1) Beban P₁ = beban hujan x luas atap **giac**
 $= 12 \times 8,478 = 101,736 \text{ kg}$

2) Beban P₂ = beban hujan x luas atap **mogi**
 $= 12 \times 4,33 = 51,96 \text{ kg}$

3) Beban P₃ = beban hujan x luas atap **sumo**
 $= 12 \times 2,206 = 26,472 \text{ kg}$

4) Beban P₄ = beban hujan x luas atap **vsu**
 $= 12 \times 0,2934 = 3,5208 \text{ kg}$

Tabel3.4 Rekapitulasi Beban Hujan

Beban	Beban Hujan (kg)	Input SAP (kg)

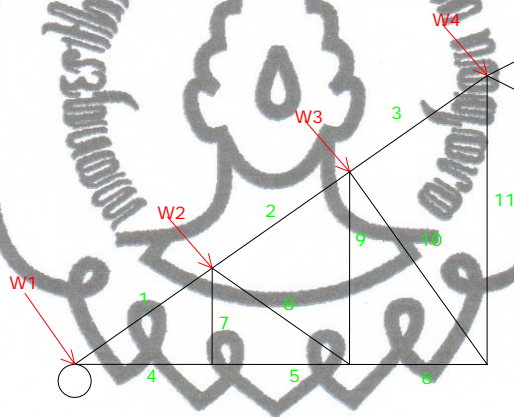
commit to user



P ₁	101,736	102
P ₂	51,96	52
P ₃	26,472	27
P ₄	3,521	5

➤ **Beban Angin**

Perhitungan beban angin :



Gambar 3.6. Pembebanan setengah kuda-kuda utama akibat beban angin

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

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

$$= (0,02 \times 35) - 0,40 = 0,3$$

$$\begin{aligned} \text{a) } W_1 &= \text{luasan atap } \mathbf{giac} \times \text{koef. angin tekan} \times \text{beban angin} \\ &= 8,478 \times 0,3 \times 25 = 63,585 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{b) } W_2 &= \text{luasan atap } \mathbf{mogi} \times \text{koef. angin tekan} \times \text{beban angin} \\ &= 4,33 \times 0,3 \times 25 = 32,475 \text{ kg} \end{aligned}$$

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- c) $W_3 = \text{luas atap } \mathbf{sumo} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 2,206 \times 0,3 \times 25 = 16,545 \text{ kg}$
- d) $W_4 = \text{luas atap } \mathbf{vsu} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 0,2934 \times 0,3 \times 25 = 2,2005 \text{ kg}$

Tabel 3.5. Perhitungan beban angin

Beban Angin	Beban (kg)	W_x		W_y	
		$W.Cos \alpha$ (kg)	(Untuk Input SAP2000)	$W.Sin \alpha$ (kg)	(Untuk Input SAP2000)
W_1	63,585	52,14	53 kg	36,24	37 kg
W_2	32,475	26,63	27 kg	18,51	19 kg
W_3	16,545	13,57	14 kg	9,431	10 kg
W_4	2,2005	1,804	3 kg	1,254	2 kg

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

Tabel 3.6. Rekapitulasi gaya batang setengah kuda-kuda

Batang	Kombinasi	
	Tarik (+) (kg)	Tekan (-) (kg)
1	-	1513,50
2	767,10	-
3	96,10	-
4	1194,45	-
5	1194,17	-

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6	-	561,06
7	211,70	-
8	-	768,08
9	684,37	-
10	-	955,57
11	-	990,17

3.3.4. Perencanaan Profil Kuda-kuda

a. Perhitungan profil batang tarik

$$P_{maks.} = 1194,45 \text{ kg}$$

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

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

$$A_g \text{ perlu} = \frac{P_{maks.}}{F_y} = \frac{1194,45}{2400} = 0,49 \text{ cm}^2$$

Dicoba, menggunakan baja profil $\perp 45 \cdot 45 \cdot 5$

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

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

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

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

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

$$A_e = U \cdot A_n$$

$$= 0,645 \cdot 790 = 509,55 \text{ mm}^2$$

Check kekuatan nominal

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

$$= 0,75 \cdot 537,56 \cdot 370$$

$$= 141400,125 \text{ N}$$

$$= 14140,0125 \text{ kg} > 950,31 \text{ kg} \dots \text{OK} \odot$$

a. Perhitungan profil batang 11 (batang tekan)

$$P_{\text{maks.}} = 990,17 \text{ kg}$$

$$l_k = 2,309 \text{ m} = 230,9 \text{ cm}$$

$$A_g \text{ perlu} = \frac{P_{\text{mak}}}{F_y} = \frac{990,17}{2400} = 0,41 \text{ cm}^2$$

Dicoba, menggunakan baja profil \bigcirc (Circular Hollow Sections) 76,3 . 2,8

Periksa kelangsingan penampang :

$$\frac{D}{t} < \frac{22000}{F_y} = \frac{76,3}{2,8} < \frac{22000}{240}$$

$$= 27,25 < 91,67$$

$$\lambda = \frac{K \cdot L}{r} = \frac{1.230,9}{2,6}$$

$$= 88,81$$

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

$$= \frac{88,81}{3,14} \sqrt{\frac{240}{200000}}$$

$$= 0,98 \dots 0,25 < \lambda_c < 1 \longrightarrow \omega = \frac{1,43}{1,6 - 0,67 \lambda_c}$$

$$\omega = \frac{1,43}{1,6 - 0,67 \cdot 0,98} = 1,516$$

commit to user



$$\begin{aligned}
 P_n &= A_g \cdot F_{cr} \\
 &= 6,465 \cdot \frac{2400}{1,516} \\
 &= 10234,83 \text{ kg} \\
 \frac{P}{\phi P_n} &= \frac{1338,44}{0,85 \cdot 10234,83} = 0,15 < 1 \dots \dots \dots \text{OK}
 \end{aligned}$$

b. Perhitungan profil batang tekan

$$P_{\text{maks.}} = 1513,50 \text{ kg}$$

$$l_k = 2,295 \text{ m} = 229,5 \text{ cm}$$

$$A_g \text{ perlu} = \frac{P_{\text{maks.}}}{F_y} = \frac{1513,50}{2400} = 0,63 \text{ cm}^2$$

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

Periksa kelangsingan penampang :

$$\begin{aligned}
 \frac{b}{2 \cdot t_w} &< \frac{200}{\sqrt{F_y}} = \frac{55}{6} < \frac{200}{\sqrt{240}} \\
 &= 9,16 < 12,9
 \end{aligned}$$

$$\begin{aligned}
 \lambda &= \frac{K \cdot L}{r} = \frac{1 \cdot 229,5}{1,35} \\
 &= 170
 \end{aligned}$$

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

$$= \frac{170}{3,14} \sqrt{\frac{240}{200000}}$$

$$= 1,875 \dots \dots \lambda_c \geq 1,2 \longrightarrow \omega = 1,25 \cdot \lambda_c^2$$

$$\omega = 1,25 \cdot \lambda_c^2 = 1,25 \cdot (1,689^2)$$

$$= 4,394$$

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

$$= 2 \cdot 4,30 \cdot \frac{2400}{4,394}$$

$$= 4697,31$$

$$\frac{P}{\phi P_n} = \frac{1057,69}{0,85 \cdot 4697,31}$$

$$= 0,265 < 1 \dots \dots \dots \text{OK } \odot$$

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

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

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

➤ Tahanan Tumpu baut :

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

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

Perhitungan jumlah baut-mur,

$$n = \frac{P_{maks.}}{P_{geser}} = \frac{1057,69}{7612,38} = 0,1389 \sim 2 \text{ buah baut}$$

Digunakan : 2 buah baut

Perhitungan jarak antar baut :

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

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

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. *commit to user*



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

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,

$$n = \frac{P_{\text{maks.}}}{P_{\text{geser}}} = \frac{950,31}{7612,38} = 0,1248 \sim 2 \text{ buah baut}$$

Digunakan : 2 buah baut

Perhitungan jarak antar baut :

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

Diambil, $S_1 = 3 d_b = 4 \cdot 12,7$

$$= 50,8 \text{ mm}$$

commit to user



$$= 60 \text{ mm}$$

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

$$\text{Diambil, } S_2 = 1,5 d_b = 2 \cdot 12,7$$

$$= 25,4 \text{ mm}$$

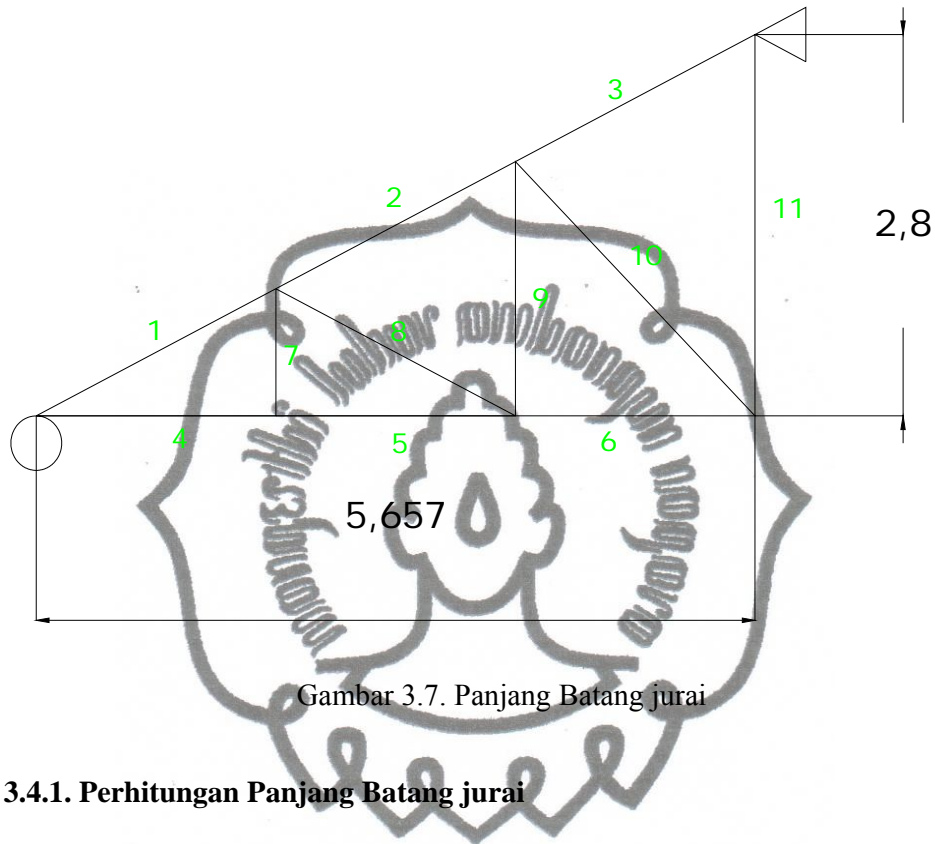
$$= 30 \text{ mm}$$

Tabel 3.7. 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	○ 76,3 . 2,8	2 Ø 12,7



3.4. Perencanaan Jurai



Gambar 3.7. Panjang Batang jurai

3.4.1. Perhitungan Panjang Batang jurai

Perhitungan panjang batang selanjutnya disajikan dalam tabel dibawah ini :

Tabel 3.8. Perhitungan panjang batang pada jurai

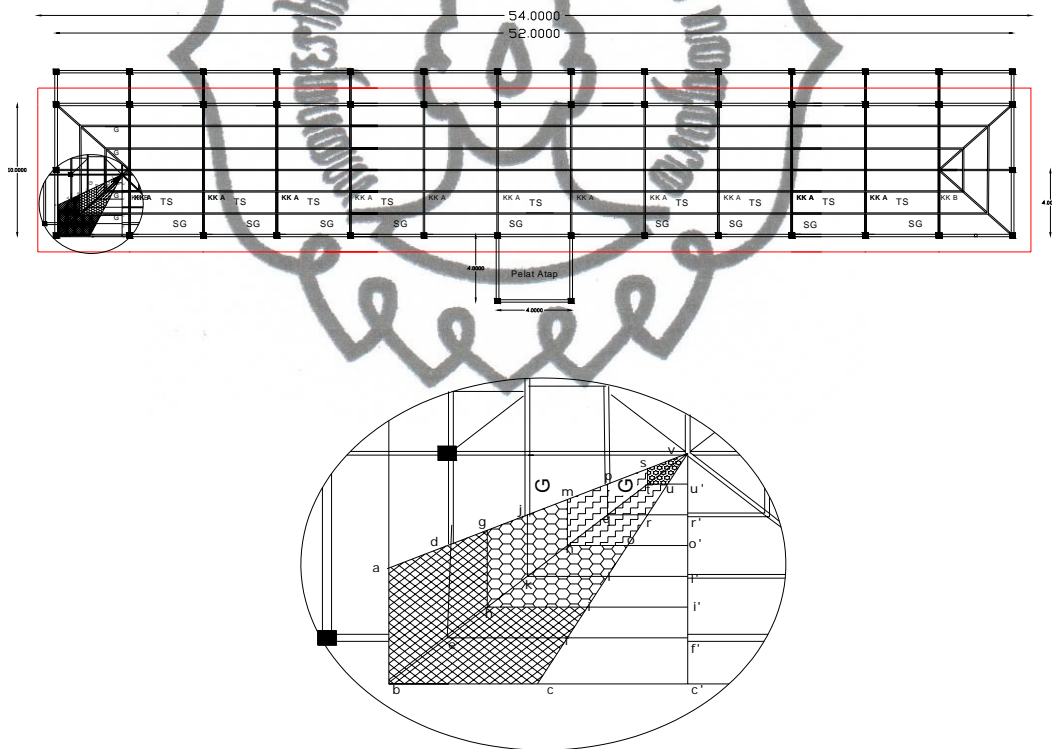
Nomer Batang	Panjang Batang (m)
1	2,104
2	2,104
3	2,104
4	1,886
5	1,886

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6	1,886
7	0,933
8	2,104
9	1,867
10	2,653
11	2,8

3.4.2. Perhitungan luasan jurai



Gambar 3.8. Luasan Jurai

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$$\begin{aligned} \text{Panjang atap } \mathbf{vu'} &= 0.5 \times 1,628 = 0,814 \text{ m} \\ \text{Panjang atap } \mathbf{vu'} &= \mathbf{ur'} = \mathbf{r'o'} = \mathbf{o'l'} = \mathbf{l'i'} = \mathbf{i'f'} \\ \text{Panjang atap } \mathbf{f'c'} &= 1,221 \text{ m} \\ \text{Panjang atap } \mathbf{i'c'} &= i'f' + f'c' = 0,814 + 1,221 = 2,035 \\ \text{Panjang atap } \mathbf{bc} &= 2,5 \text{ m} \\ \text{Panjang atap } \mathbf{hi} &= 1,666 \text{ m} \\ \text{Panjang atap } \mathbf{no} &= 1 \text{ m} \\ \text{Panjang atap } \mathbf{tu} &= 0,3605 \text{ m} \\ \text{Panjang atap } \mathbf{ef} &= 2 \text{ m} \\ \text{Panjang atap } \mathbf{kl} &= 1,333 \text{ m} \\ \text{Panjang atap } \mathbf{qr} &= 0,667 \text{ m} \end{aligned}$$

• Luas atap abcihg

$$\begin{aligned} &= (2 \times \left(\frac{hi + bc}{2} \right) \times i'c') \\ &= (2 \times \left(\frac{1,666 + 2,5}{2} \right) \times 2,035) \\ &= 8,475 \text{ m}^2 \end{aligned}$$

• Luas atap ghionm

$$\begin{aligned} &= (2 \times \left(\frac{hi + no}{2} \right) \times o'i') \\ &= (2 \times \left(\frac{1,666 + 1}{2} \right) \times 1,628) \\ &= 4,341 \text{ m}^2 \end{aligned}$$

commit to user



• **Luas atap mnouts**

$$= (2 \times \left(\frac{no + tu}{2} \right) \times u'o')$$

$$= (2 \times \left(\frac{1 + 0,3605}{2} \right) \times 1,628) = 2,206 \text{ m}^2$$

• **Luas atap stuv**

$$= 2 \times \left(\frac{1}{2} \times tu \times vu' \right)$$

$$= 2 \times \left(\frac{1}{2} \times 0,3605 \times 0,814 \right)$$

$$= 0,293 \text{ m}^2$$

• **Panjang Gording def**

$$= de + ef$$

$$= 2 + 2 = 4 \text{ m}$$

• **Panjang Gording jkl**

$$= jk + kl$$

$$= 1,333 + 1,333 = 2,666 \text{ m}$$

• **Panjang Gording pqr**

$$= pq + qr$$

$$= 0,667 + 0,667 = 1,334 \text{ m}$$

Panjang plafond **vu'** = $0,5 \times 1,333 = 0,666 \text{ m}$

Panjang plafond **vu'** = $ur' = r'o' = o'l' = l'i' = i'f'$

Panjang plafond **f'c'** = 1 m

Panjang plafond **i'c'** = $i'f' + f'c' = 0,666 + 1 = 1,666$

Panjang plafond **bc** = $2,5 \text{ m}$

commit to user



Panjang plafond **hi** = 1,666 m

Panjang plafond **no** = 1 m

Panjang plafond **tu** = 0,3605

• **Luas plafond abcihg**

$$= (2 \times \left(\frac{hi + bc}{2} \right) \times i'c')$$

$$= (2 \times \left(\frac{1,666 + 2,5}{2} \right) \times 1,666) = 6,934 \text{ m}^2$$

• **Luas plafond ghionm**

$$= (2 \times \left(\frac{hi + no}{2} \right) \times o'i')$$

$$= (2 \times \left(\frac{1,666 + 1}{2} \right) \times 1,333) = 3,554 \text{ m}^2$$

• **Luas plafond mnouts**

$$= (2 \times \left(\frac{no + tu}{2} \right) \times u'o')$$

$$= (2 \times \left(\frac{1 + 0,3605}{2} \right) \times 1,333) = 1,803 \text{ m}^2$$

• **Luas plafond stuv**

$$= 2 \times \left(\frac{1}{2} \times tu \times vu' \right)$$

$$= 2 \times \left(\frac{1}{2} \times 0,3605 \times 0,666 \right) = 0,2404 \text{ m}^2$$



3.4.3. Perhitungan Pembebanan Jurai

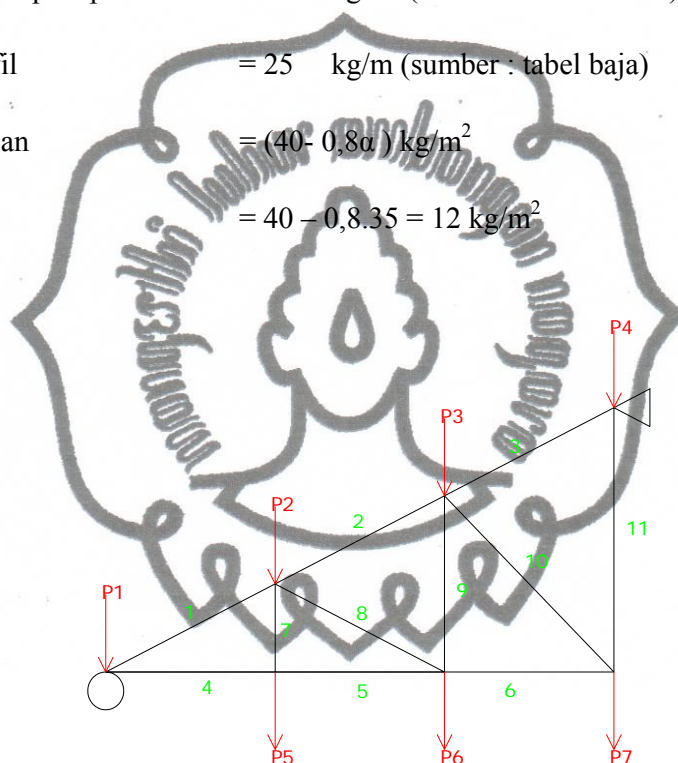
Data-data pembebanan :

Berat gording = 11 kg/m (sumber tabel baja)

Berat penutup atap = 50 kg/m² (sumber PPIUG 1989)

Berat profil = 25 kg/m (sumber : tabel baja)

Beban hujan = $(40 - 0,8\alpha)$ kg/m²
 $= 40 - 0,8 \cdot 35 = 12$ kg/m²



Gambar 3.10. Pembebanan jurai akibat beban mati

a. Perhitungan Beban

➤ Beban Mati

1) Beban P_1

a) Beban gording = Berat profil gording x Panjang Gording def
 $= 11 \times 4 = 44$ kg

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- b) Beban atap = Luasan atap **abcihg** x Berat atap
= $8,475 \times 50 = 423,75$ kg
- c) Beban plafon = Luasan plafond **abcihg** x berat plafon
= $6,934 \times 18 = 124,81$ kg
- d) Beban kuda-kuda = $\frac{1}{2} \times \text{Btg} (1 + 4) \times \text{berat profil kuda kuda}$
= $\frac{1}{2} \times (2,104 + 1,886) \times 25 = 49,875$ kg
- e) Beban plat sambung = 30% x beban kuda-kuda
= $30\% \times 49,875 = 14,963$ kg
- f) Beban bracing = 10% x beban kuda-kuda
= $10\% \times 49,875 = 4,988$ kg
- 2) Beban P_2
- a) Beban gording = Berat profil gording x Panjang Gording jkl
= $11 \times 2,666 = 29,326$ kg
- b) Beban atap = Luasan atap **ghionm** x berat atap
= $4,331 \times 50 = 216,55$ kg
- c) Beban kuda-kuda = $\frac{1}{2} \times \text{Btg} (1 + 2 + 7 + 8) \times \text{berat profil kuda kuda}$
= $\frac{1}{2} \times (2,104 + 2,104 + 0,933 + 2,104) \times 25$
= $90,563$ kg
- d) Beban plat sambung = 30% x beban kuda-kuda
= $30\% \times 90,563 = 27,17$ kg
- e) Beban bracing = 10% x beban kuda-kuda
= $10\% \times 90,563 = 9,057$ kg

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- 3) Beban P_3
- Beban gording = Berat profil gording x Panjang Gording pqr
= $11 \times 1,334 = 14,674 \text{ kg}$
 - Beban atap = Luasan atap **mnouts** x berat atap
= $2,206 \times 50 = 110,3 \text{ kg}$
 - Beban kuda-kuda = $\frac{1}{2} \times \text{Btg} (2 + 3 + 9 + 10) \times \text{berat profil kuda kuda}$
= $\frac{1}{2} \times (2,104 + 2,104 + 1,867 + 2,653) \times 25$
= $109,1 \text{ kg}$
 - Beban plat sambung = $30\% \times \text{beban kuda-kuda}$
= $30\% \times 109,1 = 32,73 \text{ kg}$
 - Beban bracing = $10\% \times \text{beban kuda-kuda}$
= $10\% \times 109,1 = 10,91 \text{ kg}$
- 4) Beban P_4
- Beban atap = Luasan atap **stuv** x berat atap
= $0,293 \times 50 = 14,65 \text{ kg}$
 - Beban kuda-kuda = $\frac{1}{2} \times \text{Btg} (3 + 11) \times \text{berat profil kuda kuda}$
= $\frac{1}{2} \times (2,104 + 2,8) \times 25 = 61,3 \text{ kg}$
 - Beban bracing = $10\% \times \text{beban kuda-kuda}$
= $10\% \times 61,3 = 6,13 \text{ kg}$
 - Beban plat sambung = $30\% \times \text{beban kuda-kuda}$
= $30\% \times 61,3 = 18,39 \text{ kg}$
- 5) Beban P_5
- Beban kuda-kuda = $\frac{1}{2} \times \text{Btg}(4 + 5 + 7) \times \text{berat profil kuda kuda}$
= $\frac{1}{2} \times (1,886 + 1,886 + 0,933) \times 25 = 58,813 \text{ kg}$

commit to user



- b) Beban bracing = 10% x beban kuda-kuda
= 10% x 58,813 = 5,882 kg
- c) Beban plafon = Luasan plafond **ghionm** x berat plafon
= 3,537 x 18 = 63,66 kg
- d) Beban plat sambung = 30% x beban kuda-kuda
= 30% x 73,513 = 17,644 kg
- 6) Beban P₆
- a) Beban kuda-kuda = $\frac{1}{2}$ x Btg(5+6+8+9) x berat profil kuda kuda
= $\frac{1}{2}$ x (1,886+1,886+2,104+1,867) x 25
= 96,788 kg
- b) Beban bracing = 10% x beban kuda-kuda
= 10% x 96,788 = 9,679 kg
- c) Beban plafon = Luasan plafond **mnouts** x berat plafon
= 1,803 x 18 = 31,986 kg
- d) Beban plat sambung = 30% x beban kuda-kuda
= 30% x 96,788 = 32,454 kg
- 7) Beban P₇
- a) Beban kuda-kuda = $\frac{1}{2}$ x Btg (6 + 10 + 11) x berat profil kuda kuda
= $\frac{1}{2}$ x (1,886 + 2,653 + 2,8) x 25
= 91,738 kg

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- b) Beban bracing = 10% x beban kuda-kuda
= 10% x 91,738 = 9,174 kg
- c) Beban plafon = Luasan plafond **stuv** x berat plafon
= 0,2404 x 18 = 3,996 kg
- d) Beban plat sambung = 30% x beban kuda-kuda
= 30% x 91,738 = 27,522 kg

Tabel 3.9. 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 (kg)
P ₁	423,75	44	49,88	4,99	14,97	124,81	662,38	663
P ₂	216,55	29,33	90,57	9,06	27,17	-	372,61	373
P ₃	110,3	14,68	109,1	10,91	32,73	-	277,74	278
P ₄	14,65	-	61,3	6,13	18,39	-	100,47	101
P ₅	-	-	58,82	5,89	17,65	63,66	145,98	146
P ₆	-	-	96,77	9,67	29,04	32,454	168,23	170
P ₇	-	-	91,74	9,18	27,53	4,327	132,77	134

➤ **Beban Hidup**

Beban hidup yang bekerja pada P₁, P₂, P₃, P₄ = 100 kg

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➤ **Beban Hujan**

- 1) **Beban P1** = beban hujan x luas atap **abcihg**
= $12 \times 8,475 = 101,7 \text{ kg}$
- 2) **Beban P2** = beban hujan x luas atap **ghinm**
= $12 \times 4,331 = 51,972 \text{ kg}$
- 3) **Beban P3** = beban hujan x luas atap **mnouts**
= $12 \times 2,206 = 26,472 \text{ kg}$
- 4) **Beban P4** = beban hujan x luas atap **stuv**
= $12 \times 0,293 = 3,516 \text{ kg}$

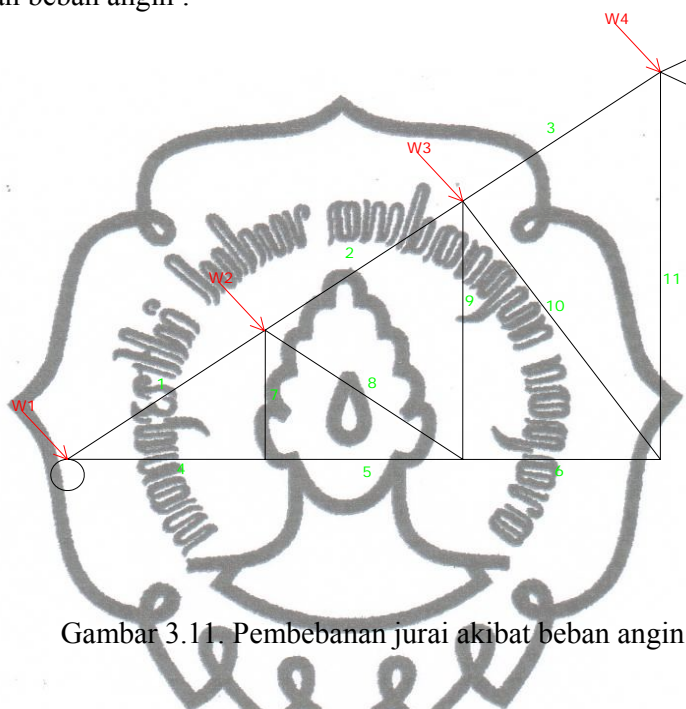
Tabel 3.10. Rekapitulasi Beban Hujan

Beban	Beban Hujan (kg)	Input SAP (kg)
P ₁	101,7	102
P ₂	51,972	52
P ₃	26,472	27
P ₄	3,516	5



➤ **Beban Angin**

Perhitungan beban angin :



Gambar 3.11. Pembebanan jurai akibat beban angin

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

$$2) \text{ Koefisien angin tekan} = 0,02\alpha - 0,40 \\ = (0,02 \times 35) - 0,40 = 0,3$$

$$a) W_1 = \text{luasan atap } \mathbf{abcihg} \times \text{koef. angin tekan} \times \text{beban angin} \\ = 8,475 \times 0,3 \times 25 = 63,5625 \text{ kg}$$

$$b) W_2 = \text{luasan atap } \mathbf{ghionm} \times \text{koef. angin tekan} \times \text{beban angin} \\ = 4,331 \times 0,3 \times 25 \\ = 32,478 \text{ kg}$$

$$c) W_3 = \text{luasan atap } \mathbf{mnouts} \times \text{koef. angin tekan} \times \text{beban angin} \\ = 2,206 \times 0,3 \times 25 \\ = 16,545 \text{ kg}$$

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$$\begin{aligned}
 \text{d) } W_4 &= \text{luasan atap } \mathbf{stuv} \times \text{koef. angin tekan} \times \text{beban angin} \\
 &= 0,293 \times 0,3 \times 25 \\
 &= 2,1975 \text{ kg}
 \end{aligned}$$

Tabel 3.11. Perhitungan beban angin

Beban Angin	Beban (kg)	W _x		W _y	
		W.Cos α (kg)	(Untuk Input SAP2000)	W.Sin α (kg)	(Untuk Input SAP2000)
W ₁	63,5625	52,121	53 kg	36,231	37 kg
W ₂	32,478	26,632	27 kg	18,512	19 kg
W ₃	16,545	13,567	14 kg	9,431	10 kg
W ₄	2,197	1,802	3 kg	1,252	2 kg



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

Tabel 3.12. Rekapitulasi gaya batang jurai

Batang	kombinasi	
	Tarik (+) (kg)	Tekan (-) (kg)
1	-	1669,68
2	831,88	-
3	74,7	-
4	1464,79	-
5	1464,23	-
6	-	691,68
7	190,42	-
8	-	863,54
9	603,47	-
10	-	964,82
11	-	855,84

3.4.4. Perencanaan Profil jurai

a. Perhitungan profil batang tarik

$$P_{maks.} = 1464,79\text{kg}$$

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

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

$$A_g \text{ perlu} = \frac{P_{\text{mak}}}{F_y} = \frac{1464,79}{2400} = 0,610 \text{ cm}^2$$

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

Dari tabel baja didapat data-data =

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

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

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

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

$$L = \text{Sambungan dengan Diameter}$$

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

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

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

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

$$A_e = U \cdot A_n$$

$$= 0,645 \cdot 790 = 509,55 \text{ mm}^2$$

Check kekuatan nominal

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

$$= 0,75 \cdot 537,56 \cdot 370$$

$$= 141400,125 \text{ N}$$

$$= 14140,0125 \text{ kg} > 1969,50 \text{ kg} \dots \text{ OK } \textcircled{\smile}$$

commit to user



b. Perhitungan profil batang tekan

$$P_{maks.} = 1669,68 \text{ kg}$$

$$lk = 2,295 \text{ m} = 229,5 \text{ cm}$$

$$A_g \text{ perlu} = \frac{P_{mak}}{F_y} = \frac{1669,68}{2400} = 0,695 \text{ cm}^2$$

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

Periksa kelangsingan penampang :

$$\frac{b}{2.t_w} < \frac{200}{\sqrt{F_y}} = \frac{55}{6} < \frac{200}{\sqrt{240}}$$

$$= 9,16 < 12,9$$

$$\lambda = \frac{K.L}{r} = \frac{1.229,5}{1,35}$$

$$= 170$$

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

$$= \frac{170}{3,14} \sqrt{\frac{240}{200000}}$$

$$= 1,875 \dots \dots \lambda_c \geq 1,2 \longrightarrow \omega = 1,25 \cdot \lambda_c^2$$

$$\omega = 1,25 \cdot \lambda_c^2 = 1,25 \cdot (1,689^2)$$

$$= 4,394$$

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

$$= 2 \cdot 4,30 \cdot \frac{2400}{4,394}$$

$$= 4697,31$$

$$\frac{P}{\phi P_n} = \frac{2033,74}{0,85 \cdot 4697,31}$$

$$= 0,509 < 1 \dots \dots \dots \text{OK } \odot$$

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b. Perhitungan profil batang 11 (batang tekan)

$$P_{maks.} = 866,84 \text{ kg}$$

$$lk = 2,309 \text{ m} = 230,9 \text{ cm}$$

$$A_g \text{ perlu} = \frac{P_{mak}}{F_y} = \frac{855,84}{2400} = 0,356 \text{ cm}^2$$

Dicoba, menggunakan baja profil  (Circular Hollow Sections) 76,3 . 2,8

Periksa kelangsingan penampang :

$$\frac{D}{t} < \frac{22000}{F_y} = \frac{76,3}{2,8} < \frac{22000}{240}$$

$$= 27,25 < 91,67$$

$$\lambda = \frac{K.L}{r} = \frac{1.230,9}{2,6}$$

$$= 88,81$$

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

$$= \frac{88,81}{3,14} \sqrt{\frac{240}{200000}}$$

$$= 0,98 \dots 0,25 < \lambda_c < 1 \longrightarrow \omega = \frac{1,43}{1,6 - 0,67\lambda_c}$$

$$\omega = \frac{1,43}{1,6 - 0,67 \cdot 0,98} = 1,516$$

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

$$= 6,465 \cdot \frac{2400}{1,516}$$

$$= 10234,83 \text{ kg}$$

$$\frac{P}{\phi P_n} = \frac{1338,44}{0,85 \cdot 10234,83}$$

$$= 0,15 < 1 \dots \dots \dots \text{OK}$$

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3.3.5. Perhitungan Alat Sambung

a. Batang Tekan

Digunakan alat sambung baut-mur.

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

Diameter lubang = 14,7 mm.

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

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

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

➤ 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 $P_{tumpu} = 7612,38$ kg.

Perhitungan jumlah baut-mur,

$$n = \frac{P_{maks.}}{P_{geser}} = \frac{1669,68}{7612,38} = 0,219 \sim 2 \text{ buah baut}$$

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Digunakan : 2 buah baut

Perhitungan jarak antar baut :

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

$$\text{Diambil, } S_1 = 3 d_b = 4. 12,7$$

$$= 50,8 \text{ mm}$$

$$= 60 \text{ mm}$$

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

$$\text{Diambil, } S_2 = 1,5 d_b = 2. 12,7$$

$$= 25,4 \text{ mm}$$

$$= 30 \text{ mm}$$

b. Batang tarik

Digunakan alat sambung baut-mur.

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

Diameter lubang = 13,7 mm.

Tebal pelat sambung (δ) = $0,625 \cdot d_b$

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

Menggunakan tebal plat 8 mm

➤ Tahanan geser baut

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

$$= 2.(0,4.825) \cdot \frac{1}{4} \cdot \pi \cdot 12,7^2 = 8356,43 \text{ kg/baut}$$

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- Tahanan tarik penyambung

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

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

- 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 $P_{tumpu} = 7612,38 \text{ kg}$.

Perhitungan jumlah baut-mur,

$$n = \frac{P_{maks.}}{P_{geser}} = \frac{1464,79}{7612,38} = 0,192 \sim 2 \text{ buah baut}$$

Digunakan : 2 buah baut

Perhitungan jarak antar baut :

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

Diambil, $S_1 = 3 d_b = 4 \cdot 12,7$

$$= 50,8 \text{ mm}$$

$$= 60 \text{ mm}$$

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

Diambil, $S_2 = 1,5 d_b = 2 \cdot 12,7$

$$= 25,4 \text{ mm}$$

$$= 30 \text{ mm}$$

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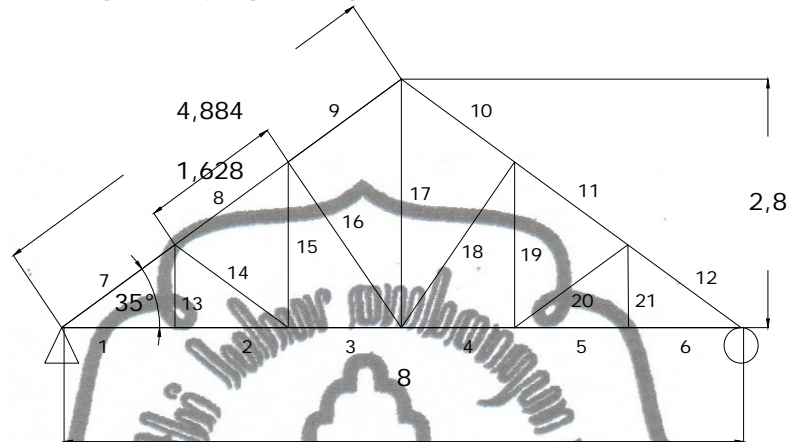
Tabel 3.13 Rekapitulasi perencanaan profil jurai

Nomor 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	○ 76,3 . 2,8	2 Ø 12,7



3.5. Perencanaan Kuda-kuda Utama A

3.5.1. Perhitungan Panjang Batang Kuda-kuda



Gambar 3.12 Panjang batang kuda-kuda

Perhitungan panjang batang selanjutnya disajikan dalam tabel dibawah ini :

Tabel 3.14 Perhitungan panjang batang pada kuda-kuda utama A (KK)

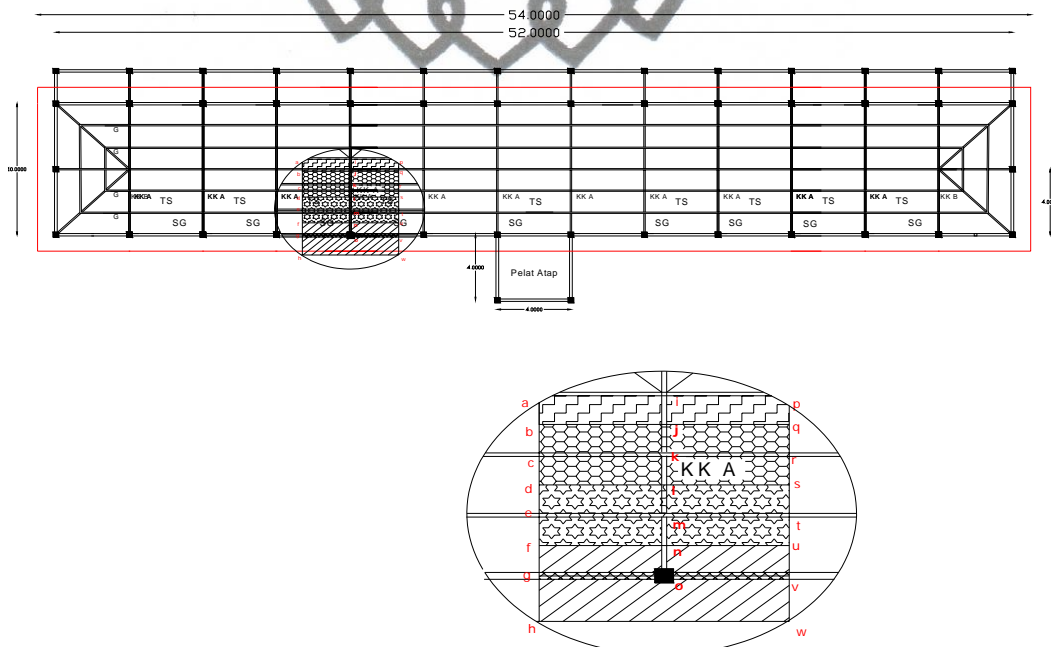
No batang	Panjang batang
1	1,333 m
2	1,333 m
3	1,333 m
4	1,333 m
5	1,333 m
6	1,333 m
7	1,628 m
8	1,628 m
9	1,628 m
10	1,628 m

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11	1,628 m
12	1,628 m
13	0,934 m
14	1,628 m
15	1,870 m
16	2,297 m
17	2,8 m
18	2,297 m
19	1,870 m
20	1,628 m
21	0,934 m

3.5.2. Perhitungan Luasan Setengah Kuda-Kuda Utama A



Gambar 3.13 Luasan Kuda-k

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$$\text{Panjang atap } io = pv = 3 \times 1,628 = 4,884 \text{ m}$$

$$\text{Panjang atap } uv = 0,814 \text{ m}$$

$$\text{Panjang atap } vw = 1,221 \text{ m}$$

$$\text{Panjang atap } pw = pv + vw$$

$$= 6,105 \text{ m}$$

$$\text{Panjang atap } ov = 2,00 \text{ m}$$

$$\text{Panjang atap } gv = 4,00 \text{ m}$$

$$\text{Panjang atap } uw = uv + vw$$

$$= 2,035 \text{ m}$$

$$\text{Luas atap } aipqjb$$

$$= ab \times ap$$

$$= 0,814 \times 4,00$$

$$= 3,256 \text{ m}^2$$

$$\text{Luas atap } bjqsld$$

$$= bq \times bd$$

$$= 4,00 \times 1,628$$

$$= 6,512 \text{ m}^2$$

$$\text{Luas atap } dlsunf$$

$$= ds \times df$$

$$= 4,00 \times 1,628$$

$$= 6,512 \text{ m}^2$$

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Luas atap **f_{nuwh}**

$$= f_u \times f_h$$

$$= 4,00 \times 2,035$$

$$= 8,140 \text{ m}^2$$

Panjang Gording **ap**

$$= 4,00 \text{ m}$$

Panjang Gording **cr**

$$= 4,00 \text{ m}$$

Panjang Gording **et**

$$= 4,00 \text{ m}$$

Panjang Gording **gv**

$$= 4,00 \text{ m}$$

Panjang plafon **pv** = 3 x 1,333

$$= 3,999 \text{ m}$$

Panjang plafon **uv** = 0,666 m

Panjang plafon **vw** = 1,00 m

Panjang plafon **pw** = pv + vw

$$= 4,999 \text{ m}$$

Panjang plafon **ov** = 2,00 m

Panjang plafon **hw** = 4,00 m

Luas plafon **aipqjb**

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$$= a_p \times a_b$$

$$= 4,00 \times 0,666 = 2,664 \text{ m}^2$$

Luas plafon **bjqsld**

$$= b_q \times b_d$$

$$= 4,00 \times 1,333 = 5,332 \text{ m}^2$$

Luas plafon **dlsunf**

$$= d_s \times d_f$$

$$= 4,00 \times 1,333 = 5,332 \text{ m}^2$$

Luas plafon **fnuwh**

$$= f_u \times f_h$$

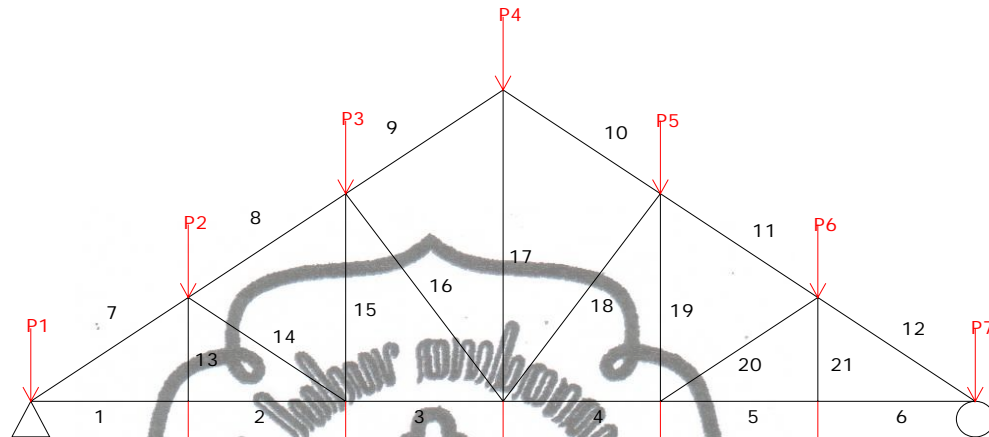
$$= 4,00 \times 1,666 = 6,664 \text{ m}^2$$

3.5.3. Perhitungan Pembebanan Kuda-kuda Utama A

Data-data pembebanan :

Berat gording	= 11 kg/m (sumber tabel baja)
Jarak antar kuda-kuda	= 4,00 m (sumber : gambar perencanaan)
Berat penutup atap	= 50 kg/m ² (sumber PPIUG 1989)
Berat profil	= 25 kg/m (sumber : tabel baja)
Beban hujan	= (40- 0,8α) kg/m ²
	= 40 – 0,8.35 = 12 kg/m ²

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Gambar 3.15 Pembebanan Kuda-kuda utama A akibat beban mati

a. Perhitungan Beban

➤ Beban Mati

1) Beban $P_1 = P_7$

- a) Beban gording = Berat profil gording x jarak kuda-kuda
= $11 \times 4,00 = 44,00 \text{ kg}$
- b) Beban atap = Luasan atap **f_{nuwh}** x Berat atap
= $8,140 \times 50 = 407 \text{ kg}$
- c) Beban kuda-kuda = $\frac{1}{2} \times \text{Btg} (1 + 7) \times \text{berat profil kuda kuda}$
= $\frac{1}{2} \times (1,333 + 1,628) \times 25 = 37,013 \text{ kg}$
- d) Beban plat sambung = $30\% \times \text{beban kuda-kuda}$
= $30\% \times 37,013 = 11,104 \text{ kg}$
- e) Beban bracing = $10\% \times \text{beban kuda-kuda}$
= $10\% \times 37,013 = 3,702 \text{ kg}$

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- f) Beban plafon = Luasan plafond **fnuwh** x berat plafon
= $6,664 \times 18 = 119,96$ kg
- 2) Beban $P_2 = P_6$
- a) Beban gording = Berat profil gording x panjang gording **et**
= $11 \times 4,00 = 44$ kg
- b) Beban atap = Luasan atap **dlsunf** x berat atap
= $6,512 \times 50 = 325,6$ kg
- c) Beban kuda-kuda = $\frac{1}{2} \times \text{Btg}(7+8+13+14) \times \text{berat profil kuda kuda}$
= $\frac{1}{2} \times (1,628 + 1,628 + 0,934 + 1,628) \times 25$
= $61,05$ kg
- d) Beban plat sambung = $30\% \times \text{beban kuda-kuda}$
= $30\% \times 61,05 = 18,32$ kg
- e) Beban bracing = $10\% \times \text{beban kuda-kuda}$
= $10\% \times 61,05 = 6,11$ kg
- 3) Beban $P_3 = P_5$
- a) Beban gording = Berat profil gording x panjang gording **cr**
= $11 \times 4,00 = 44$ kg
- b) Beban atap = Luasan atap **bjqsld** x berat atap
= $6,512 \times 50 = 325,6$ kg
- c) Beban kuda-kuda = $\frac{1}{2} \times \text{Btg}(8+9+15+16) \times \text{berat profil kuda kuda}$
= $\frac{1}{2} \times (1,628 + 1,628 + 1,870 + 2,297) \times 25 = 92,79$ kg
- d) Beban plat sambung = $30\% \times \text{beban kuda-kuda}$
= $30\% \times 92,79 = 27,84$ kg
- e) Beban bracing = $10\% \times \text{beban kuda-kuda}$
= $10\% \times 92,79 = 9,279$ kg
- 4) Beban P_4
- a) Beban gording = Berat profil gording x panjang gording **ap**

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$$= 11 \times 4 = 44 \text{ kg}$$

b) Beban atap = (2 x Luasan atap **aipqjb**) x berat atap

$$= (2 \times 3,256) \times 50 = 325,6 \text{ kg}$$

c) Beban kuda-kuda = $\frac{1}{2}$ x Btg(9+10 +17) x berat profil kuda kuda

$$= \frac{1}{2} \times (1,628 + 1,628 + 2,8) \times 25$$

$$= 75,7 \text{ kg}$$

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

$$= 30\% \times 75,7 = 22,71 \text{ kg}$$

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

$$= 10\% \times 75,7 = 7,57 \text{ kg}$$

5) Beban $P_8 = P_{12}$

a) Beban kuda-kuda = $\frac{1}{2}$ x Btg (1+2+13) x berat profil kuda kuda

$$= \frac{1}{2} \times (1,333+1,333+1,628) \times 25 = 53,675 \text{ kg}$$

b) Beban plafon = Luasan plafond **dlsunf** x berat plafon

$$= 5,332 \times 18 = 95,976 \text{ kg}$$

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

$$= 30\% \times 53,675 = 16,103 \text{ kg}$$

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

$$= 10\% \times 53,675 = 5,368 \text{ kg}$$

6) Beban P_{10}

a) Beban kuda-kuda = $\frac{1}{2}$ x Btg (3+4+16+17+18) x berat profil kuda kuda

$$= \frac{1}{2} \times (1,333+1,333+2,297+2,8+2,297) \times 25$$

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$$= 125,75 \text{ kg}$$

b) Beban plafon = (2 x luasan plafond **aipqjb**) x berat plafon
 = (2 x 2,664) x 18 = 95,904 kg

c) Beban plat sambung = 30% x beban kuda-kuda
 = 30% x 125,75 = 37,725 kg

d) Beban bracing = 10% x beban kuda-kuda
 = 10% x 125,75 = 12,575 kg

7) Beban $P_9 = P_{11}$

a) Beban kuda-kuda = $\frac{1}{2}$ x Btg (2+3+14+15) x berat profil kuda kuda
 = $\frac{1}{2}$ x (1,333+1,333+1,628+1,870)x25 = 77,05 kg

b) Beban plafon = Luasan plafond **bjqsl** x berat plafon
 = 5,332 x 18 = 95,976 kg

c) Beban plat sambung = 30% x beban kuda-kuda
 = 30% x 77,05 = 23,115 kg

d) Beban bracing = 10% x beban kuda-kuda
 = 10% x 77,05 = 7,705 kg

Tabel 3.15 Rekapitulasi beban mati

Beban	Beban Atap (kg)	Beban gording (kg)	Beban Kuda - kuda (kg)	Beban Bracing (kg)	Beban Plat sambung (kg)	Beban Plafon (kg)	Jumlah Beban (kg)	Input SAP (kg)
$P_1=P_7$	407,45	44	37,013	3,702	11,104	119,96	622,779	625
$P_2=P_6$	325,6	44	61,05	6,11	18,32	-	411,08	412

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P ₄	325,6	44	75,7	7,57	22,71	-	475,8	376
P ₈ =P ₁₂	-	-	53,675	5,367	16,103	95,976	171,121	172
P ₁₀	-	-	125,75	12,575	37,725	95,904	274,954	275
P ₉ =P ₁₁	-	-	77,05	7,705	23,115	95,976	203,846	205
P ₃ =P ₅	325,6	44	92,79	9,279	27,84	-	455,09	406

➤ **Beban Hidup**

Beban hidup yang bekerja pada P₁, P₂, P₃, P₄, P₅, P₆, P₇ = 100 kg

➤ **Beban Hujan**

1) Beban P₁ = beban hujan x luas atap **fnuwh**

$$= 12 \times 8,14 = 97,68 \text{ kg}$$

2) Beban P₂ = beban hujan x luas atap **diusnf**

$$= 12 \times 6,512 = 78,144 \text{ kg}$$

3) Beban P₃ = beban hujan x luas atap **bjqslid**

$$= 12 \times 6,512 = 78,144 \text{ kg}$$

4) Beban P₄ = beban hujan x (2 x luas atap **aipqjb**)

$$= 12 \times (2 \times 3,256) = 78,144 \text{ kg}$$

Tabel 3.16 Rekapitulasi Beban Hujan

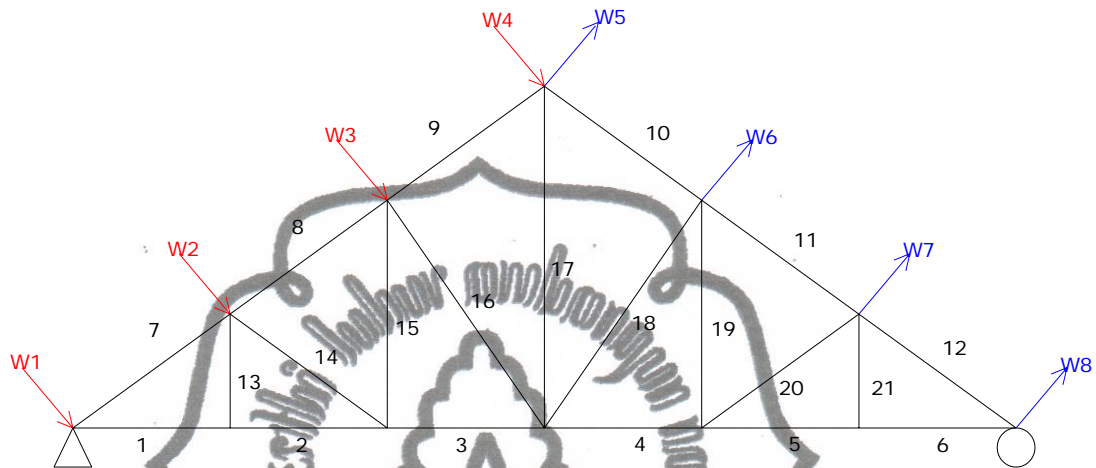
Beban	Beban Hujan (kg)	Input SAP (kg)
P ₁	97,68	98
P ₂	78,144	80
P ₃	78,144	80
P ₄	78,144	80

commit to user



➤ Beban Angin

Perhitungan beban angin :



Gambar 3.16 Pembebanan kuda-kuda utama A akibat beban angin

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

$$1). \text{ Koefisien angin tekan} = 0,02\alpha - 0,40 \\ = (0,02 \times 35) - 0,40 = 0,3$$

$$a). W_1 = \text{luasan atap } \mathbf{fuhw} \times \text{koef. angin tekan} \times \text{beban angin} \\ = 8,140 \times 0,3 \times 25 = 61,05 \text{ kg}$$

$$b). W_2 = \text{luasan atap } \mathbf{dsfu} \times \text{koef. angin tekan} \times \text{beban angin} \\ = 6,512 \times 0,3 \times 25 \\ = 48,64 \text{ kg}$$

$$c). W_3 = \text{luasan atap } \mathbf{bqds} \times \text{koef. angin tekan} \times \text{beban angin} \\ = 6,512 \times 0,3 \times 25 \\ = 48,64 \text{ kg}$$

$$d). W_4 = \text{luasan atap } \mathbf{apqb} \times \text{koef. angin tekan} \times \text{beban angin} \\ = 3,256 \times 0,3 \times 25$$

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$$= 24,42 \text{ kg}$$

2). Koefisien angin hisap = - 0,40

a). $W_5 = \text{luasan atap } \mathbf{apqb} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 3,256 \times -0,4 \times 25$

$$= -32,56 \text{ kg}$$

b). $W_6 = \text{luasan atap } \mathbf{bqds} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 6,512 \times -0,4 \times 25$

$$= -65,12 \text{ kg}$$

c). $W_7 = \text{luasan atap } \mathbf{dsfu} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 6,512 \times -0,4 \times 25$

$$= -65,12 \text{ kg}$$

d). $W_8 = \text{luasan atap } \mathbf{fuhw} \times \text{koef. angin tekan} \times \text{beban angin}$
 $= 8,140 \times -0,4 \times 25$

$$= -81,40 \text{ kg}$$

Tabel 3.17 Perhitungan beban angin

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	61,05	50,01	51 kg	35,02	36 kg
W_2	48,64	39,85	40 kg	27,90	28 kg
W_3	48,64	39,85	40 kg	27,90	28 kg
W_4	24,42	20,04	21 kg	14,01	15 kg
W_5	-32,56	-26,68	-27 kg	-18,68	-19 kg

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W_6	-65,12	-53,35	-54 kg	-37,36	-38 kg
W_7	-65,12	-53,35	-54 kg	-37,36	-38 kg
W_8	-81,40	-66,68	-67 kg	-46,69	-47 kg

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

Tabel 3.18. Rekapitulasi gaya batang kuda-kuda utama A

Batang	kombinasi	
	Tarik (+) (kg)	Tekan (-) (kg)
1	3422,31	-
2	3422,31	-
3	2721,36	-
4	2721,36	-
5	3422,31	-
6	3422,31	-
7	-	4179,07
8	-	3322,89
9	-	2501,41
10	-	2501,41

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11	-	3323,17
12	-	4179,07
13	281,56	-
14	-	867,36
15	739,93	-
16	-	1159,16
17	2250,01	-
18	-	1159,16
19	739,39	-
20	-	821,48
21	281,56	-

3.5.4. Perencanaan Profil Kuda-kuda utama A

a. Perhitungan profil batang tarik

$$P_{maks.} = 3422,31 \text{ kg}$$

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

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

$$A_g \text{ perlu} = \frac{P_{mak}}{F_y} = \frac{3422,31}{2400} = 1,426 \text{ cm}^2$$

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

Dari tabel baja didapat data-data =

commit to user



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

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

$$\begin{aligned} A_n &= 2 \cdot A_g - d \cdot t \\ &= 860 - 14 \cdot 5 = 790 \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} L &= \text{Sambungan dengan Diameter} \\ &= 3 \cdot 12,7 = 38,1 \text{ mm} \end{aligned}$$

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

$$\begin{aligned} U &= 1 - \frac{\bar{x}}{L} \\ &= 1 - \frac{13,5}{38,1} = 0,645 \end{aligned}$$

$$\begin{aligned} A_e &= U \cdot A_n \\ &= 0,645 \cdot 790 \\ &= 509,55 \text{ mm}^2 \end{aligned}$$

Check kekuatan nominal

$$\begin{aligned} \phi P_n &= 0,75 \cdot A_e \cdot F_u \\ &= 0,75 \cdot 537,56 \cdot 370 \\ &= 141400,125 \text{ N} \\ &= 14140,0125 \text{ kg} > 3422,31 \text{ kg} \dots \text{ OK} \text{ ☺} \end{aligned}$$

b. Perhitungan profil batang tekan

$$P_{\text{maks.}} = 4179,07 \text{ kg}$$

$$l_k = 2,067 \text{ m} = 206,7 \text{ cm}$$

$$A_g \text{ perlu} = \frac{P_{\text{mak}}}{F_y} = \frac{1057,69}{2400} = 0,44 \text{ cm}^2$$

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

Periksa kelangsingan penampang : *commit to user*



$$\frac{b}{2.t_w} < \frac{200}{\sqrt{F_y}} = \frac{55}{6} < \frac{200}{\sqrt{240}}$$

$$= 9,16 < 12,9$$

$$\lambda = \frac{K.L}{r} = \frac{1.206,7}{1,35} = 153,11$$

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

$$= \frac{153,11}{3,14} \sqrt{\frac{240}{200000}}$$

$$= 1,689 \dots \dots \lambda_c \geq 1,2$$

$$\omega = 1,25 \cdot \lambda_c^2$$

$$\omega = 1,25 \cdot \lambda_c^2 = 1,25 \cdot (1,689^2)$$

$$= 3,566$$

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

$$= 2 \cdot 4,30 \cdot \frac{2400}{3,566}$$

$$= 5788,16$$

$$\frac{P}{\phi P_n} = \frac{4179,07}{0,85 \cdot 5788,16}$$

$$= 0,849 < 1 \dots \dots \dots \text{OK } \textcircled{\smiley}$$

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

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

commit to user



Menggunakan tebal plat 8 mm

➤ Tahanan geser baut

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

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

➤ Tahanan tarik penyambung

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

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

➤ Tahanan Tumpu baut :

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

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

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

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

Perhitungan jumlah baut-mur,

$$n = \frac{P_{maks.}}{P_{tumpu}} = \frac{4179,07}{7612,38} = 0,548 \sim 2 \text{ buah baut}$$

Digunakan : 2 buah baut

Perhitungan jarak antar baut :

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

Diambil, $S_1 = 3 d_b = 4 \cdot 12,7$

$$= 50,8 \text{ mm}$$

$$= 60 \text{ mm}$$

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

$$\text{Diambil, } S_2 = 1,5 d_b = 2 \cdot 12,7$$

$$= 25,4 \text{ mm}$$

$$= 30 \text{ mm}$$

b. Batang tarik

Digunakan alat sambung baut-mur.

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

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

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

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

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 :

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

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

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

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

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Perhitungan jumlah baut-mur,

$$n = \frac{P_{\text{maks.}}}{P_{\text{tumpu}}} = \frac{3422,31}{7612,38} = 0,449 \sim 2 \text{ buah baut}$$

Digunakan : 2 buah baut

Perhitungan jarak antar baut :

$$\text{Diambil, } S_1 = 3 d_b = 4 \cdot 12,7$$

$$= 50,8 \text{ mm}$$

$$= 60 \text{ mm}$$

$$\text{a) } 1,5 d \leq S_2 \leq (4t + 100) \text{ atau } 200 \text{ mm}$$

$$\text{Diambil, } S_2 = 1,5 d_b = 2 \cdot 12,7$$

$$= 25,4 \text{ mm}$$

$$= 30 \text{ mm}$$

Tabel 3.19 Rekapitulasi perencanaan profil kuda-kuda utama A

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

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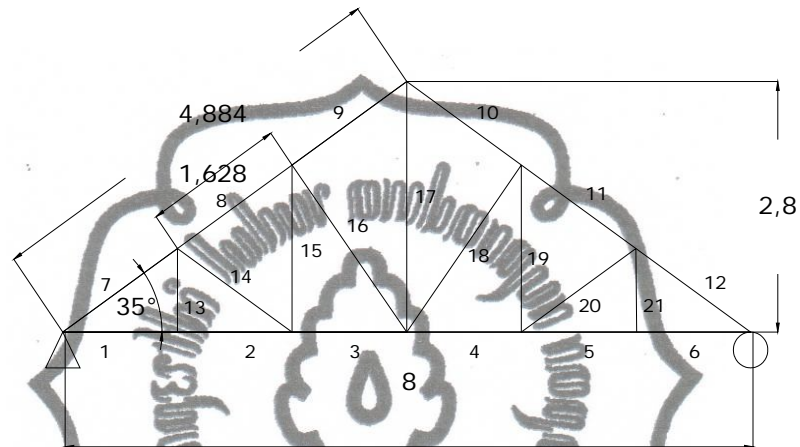
8	┆ 45 . 45 . 5	2 Ø 12,7
9	┆ 45 . 45 . 5	3 Ø 12,7
10	┆ 45 . 45 . 5	3 Ø 12,7
11	┆ 45 . 45 . 5	2 Ø 12,7
12	┆ 45 . 45 . 5	3 Ø 12,7
13	┆ 45 . 45 . 5	2 Ø 12,7
14	┆ 45 . 45 . 5	2 Ø 12,7
15	┆ 45 . 45 . 5	2 Ø 12,7
16	┆ 45 . 45 . 5	2 Ø 12,7
17	┆ 45 . 45 . 5	3 Ø 12,7
18	┆ 45 . 45 . 5	2 Ø 12,7
19	┆ 45 . 45 . 5	2 Ø 12,7
20	┆ 45 . 45 . 5	2 Ø 12,7
21	┆ 45 . 45 . 5	2 Ø 12,7

commit to user



3.6. Perencanaan Kuda-kuda Utama (KK B)

3.6.1. Perhitungan Panjang Batang Kuda-kuda B



Gambar 3.17 Panjang batang kuda-kuda B

Perhitungan panjang batang selanjutnya disajikan dalam tabel dibawah ini :

Tabel 3.20 Perhitungan panjang batang pada kuda-kuda utama B (KK)

No batang	Panjang batang
1	1,333 m
2	1,333 m
3	1,333 m
4	1,333 m
5	1,333 m
6	1,333 m
7	1,628 m
8	1,628 m

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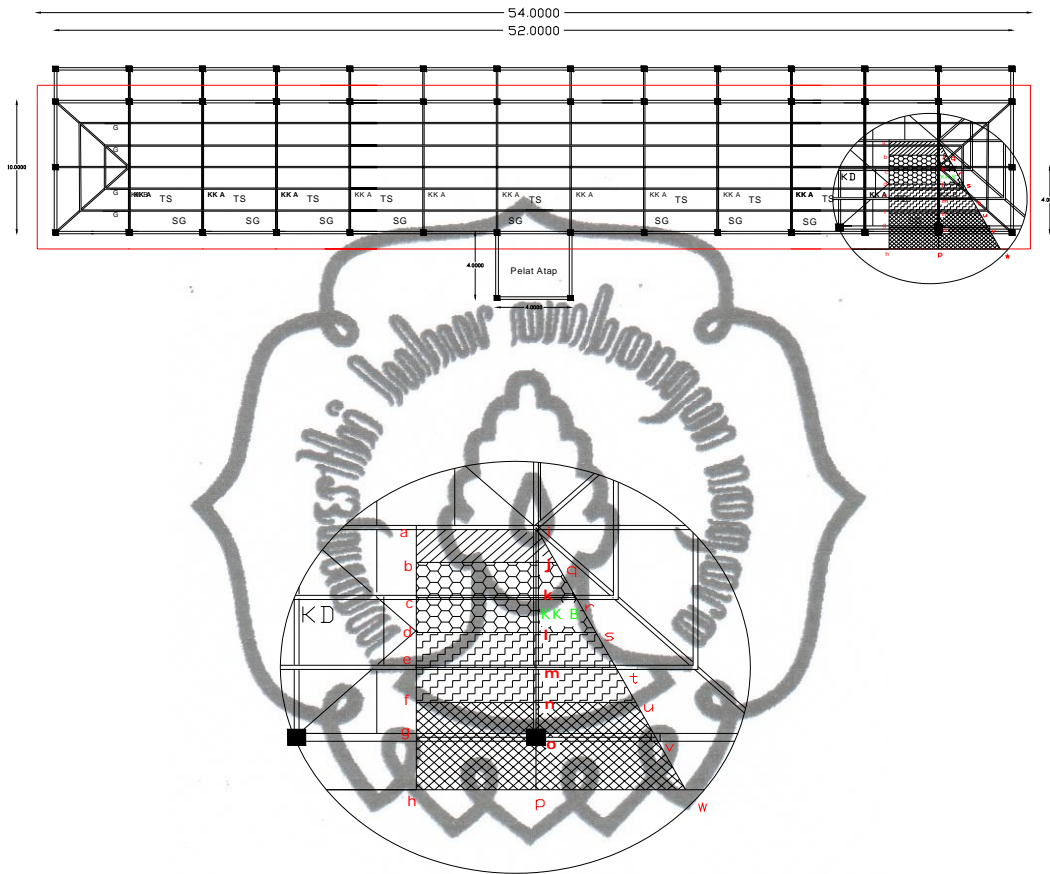
88

9	1,628 m
10	1,628 m
11	1,628 m
12	1,628 m
13	0,934 m
14	1,628 m
15	1,870 m
16	2,297 m
17	2,8 m
18	2,297 m
19	1,870 m
20	1,628 m
21	0,934 m

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3.6.2. Perhitungan Luasan Setengah Kuda-Kuda Utama B



Gambar 3.18 Luasan Kuda-kuda B

Panjang atap **io** = 3 x 1,628 = 4,884 m

Panjang atap **op** = 1,221 m

Panjang atap **ip** = io + op
= 6,105 m

Panjang atap **ov** = 2,00 m

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$$\text{Panjang atap } \mathbf{go} = 2,00 \text{ m}$$

$$\text{Panjang atap } \mathbf{pw} = \frac{ip.v0}{io}$$

$$= 2,5 \text{ m}$$

$$\text{Panjang atap } \mathbf{nu} = \frac{in.v0}{io}$$

$$= 1,67 \text{ m}$$

$$\text{Panjang atap } \mathbf{ls} = \frac{il.ov}{io}$$

$$= 1,00 \text{ m}$$

$$\text{Panjang atap } \mathbf{jq} = \frac{ij.ov}{io}$$

$$= 0,34 \text{ m}$$

$$\text{Panjang atap } \mathbf{np} = \frac{1}{2} mo + op$$

$$= (0,5 \times 1,628) + 1,221$$

$$= 2,035 \text{ m}$$

Luas atap **fuhw**

$$= (fh \times hp) + \left(\frac{nu + pw}{2} \right) \times np$$

$$= (2,035 \times 2) + \left(\frac{1,67 + 2,5}{2} \right) \times 2,035$$

$$= 8,313 \text{ m}^2$$

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Luas atap **dsfu**

$$\begin{aligned}
 &= (df \times fn) + \left(\frac{ls + nu}{2} \right) \times ln \\
 &= (1,628 \times 2) + \left(\frac{1,00 + 1,67}{2} \right) \times 1,628 \\
 &= 5,43 \text{ m}^2
 \end{aligned}$$

Luas atap **bqds**

$$\begin{aligned}
 &= (bd \times dl) + \left(\frac{jq + ls}{2} \right) \times jl \\
 &= (1,628 \times 2) + \left(\frac{0,34 + 1,00}{2} \right) \times 1,628 \\
 &= 4,35 \text{ m}^2
 \end{aligned}$$

Luas atap **aibq**

$$\begin{aligned}
 &= (ab \times bj) + (0,5 \times ij \times jq) \\
 &= (0,814 \times 2) + (0,5 \times 0,814 \times 0,34) \\
 &= 1,77 \text{ m}^2
 \end{aligned}$$

Panjang Gording **gv**

$$\begin{aligned}
 &= go + ov \\
 &= 2 + 2 \\
 &= 4,00 \text{ m}
 \end{aligned}$$

Panjang Gording **et = em + mt**

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$$\text{atap } \mathbf{mt} = \frac{im.ov}{io} = 1,34 \text{ m}$$

$$= \mathbf{em + mt}$$

$$= 2 + 1,34$$

$$= 3,34 \text{ m}$$

Panjang Gording $\mathbf{cr} = \mathbf{ck + kr}$

$$\text{atap } \mathbf{kr} = \frac{ik.ov}{io} = 0,67 \text{ m}$$

$$= \mathbf{ck + kr}$$

$$= 2 + 0,67$$

$$= 2,67 \text{ m}$$

Panjang plafon $\mathbf{io} = 3 \times 1,333$

$$= 3,999 \text{ m}$$

Panjang plafon $\mathbf{op} = 1,00 \text{ m}$

Panjang plafon $\mathbf{ip} = io + op$

$$= 4,999 \text{ m}$$

Panjang plafon $\mathbf{ov} = 2,00 \text{ m}$

Panjang plafon $\mathbf{hp} = 2,00 \text{ m}$

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$$\begin{aligned} \text{Panjang plafon } \mathbf{pw} &= \frac{ip.v0}{io} \\ &= 2,51 \text{ m} \end{aligned}$$

$$\begin{aligned} \text{Panjang plafon } \mathbf{nu} &= \frac{in.v0}{io} \\ &= 2,04 \text{ m} \end{aligned}$$

$$\begin{aligned} \text{Panjang plafon } \mathbf{ls} &= \frac{il.ov}{io} \\ &= 1,222 \text{ m} \end{aligned}$$

$$\begin{aligned} \text{Panjang plafon } \mathbf{jq} &= \frac{ij.ov}{io} \\ &= 0,408 \text{ m} \end{aligned}$$

$$\begin{aligned} \text{Panjang plafon } \mathbf{np} &= \frac{1}{2} mo + op \\ &= (0,5 \times 1,333) + 1 \\ &= 1,67 \text{ m} \end{aligned}$$

Luas plafon **fuhw**

$$\begin{aligned} &= (fn \times fh) + \left(\frac{nu + pw}{2} \right) \times np \\ &= (2 \times 1,67) + \left(\frac{2,04 + 2,51}{2} \right) \times 1,67 \\ &= 7,14 \text{ m}^2 \end{aligned}$$

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Luas plafon **dsfu**

$$\begin{aligned}
 &= (df \times fn) + \left(\frac{ls + nu}{2} \right) \times ln \\
 &= (1,333 \times 2) + \left(\frac{1,222 + 2,04}{2} \right) \times 1,333 \\
 &= 4,841 \text{ m}^2
 \end{aligned}$$

Luas plafon **bqds**

$$\begin{aligned}
 &= (bd \times dl) + \left(\frac{jq + ls}{2} \right) \times jl \\
 &= (1,333 \times 2) + \left(\frac{0,408 + 1,222}{2} \right) \times 1,333 \\
 &= 3,753 \text{ m}^2
 \end{aligned}$$

Luas plafon **aibq**

$$\begin{aligned}
 &= (ab \times bj) + (0,5 \times ij \times jq) \\
 &= (0,666 \times 2) + (0,5 \times 0,666 \times 0,408) \\
 &= 1,468 \text{ m}^2
 \end{aligned}$$

3.6.3. Perhitungan Pembebanan Kuda-kuda Utama B

Data-data pembebanan :

Berat gording = 11 kg/m (sumber tabel baja)

Jarak antar kuda-kuda = 4,00 m (sumber : gambar perencanaan)

Berat penutup atap = 50 kg/m² (sumber PPIUG 1989)

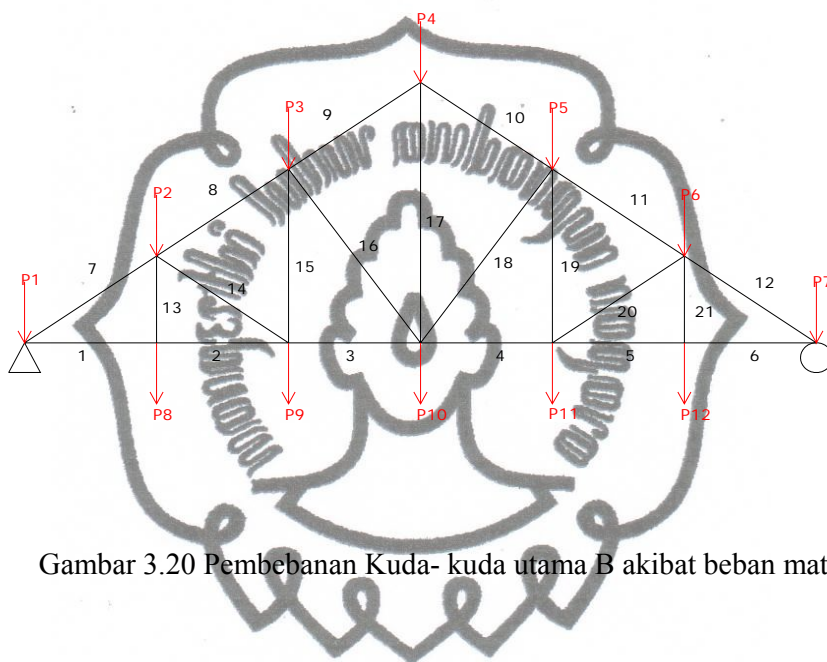
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Berat profil = 25 kg/m (sumber : tabel baja)

Beban hujan = $(40 - 0,8\alpha)$ kg/m²

$$= 40 - 0,8 \cdot 35 = 12 \text{ kg/m}^2$$



Gambar 3.20 Pembebanan Kuda-kuda utama B akibat beban mati

b. Perhitungan Beban

➤ Beban Mati

1) Beban $P_1 = P_7$

g) Beban gording = Berat profil gording x jarak kuda-kuda
 $= 11 \times 4,00$
 $= 44 \text{ kg}$

h) Beban atap = Luas atap **fu**hw x Berat atap
 $= 8,313 \times 50$
 $= 415,65 \text{ kg}$

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$$\begin{aligned}
 \text{i) Beban kuda-kuda} &= \frac{1}{2} \times \text{Btg} (1 + 7) \times \text{berat profil kuda kuda} \\
 &= \frac{1}{2} \times (1,333 + 1,628) \times 25 \\
 &= 37,0125 \text{ kg}
 \end{aligned}$$

$$\begin{aligned}
 \text{j) Beban plat sambung} &= 30\% \times \text{beban kuda-kuda} \\
 &= 0,3 \times 37,0125 \\
 &= 11,104 \text{ kg}
 \end{aligned}$$

$$\begin{aligned}
 \text{k) Beban bracing} &= 10\% \times \text{beban kuda-kuda} \\
 &= 0,1 \times 37,0125 \\
 &= 3,702 \text{ kg}
 \end{aligned}$$

$$\begin{aligned}
 \text{l) Beban plafon} &= \text{Luas plafon} \times \text{berat plafon} \\
 &= 7,14 \times 18 \\
 &= 128,52 \text{ kg}
 \end{aligned}$$

2) Beban $P_2 = P_6$

$$\begin{aligned}
 \text{f) Beban gording} &= \text{Berat profil gording} \times \text{panjang gording} \\
 &= 11 \times 3,34 \\
 &= 36,74 \text{ kg}
 \end{aligned}$$

$$\begin{aligned}
 \text{g) Beban atap} &= \text{Luas atap} \times \text{berat atap} \\
 &= 5,43 \times 50 \\
 &= 271,5 \text{ kg}
 \end{aligned}$$

$$\begin{aligned}
 \text{h) Beban kuda-kuda} &= \frac{1}{2} \times \text{Btg} (7+8 +13 +14) \times \text{berat profil kuda kuda} \\
 &= \frac{1}{2} \times (1,628 + 1,628 + 0,934 + 1,628) \times 25 \\
 &= 72,73 \text{ kg}
 \end{aligned}$$

$$\begin{aligned}
 \text{i) Beban plat sambung} &= 30\% \times \text{beban kuda-kuda} \\
 &= 0,3 \times 72,73 \\
 &= 21,82 \text{ kg}
 \end{aligned}$$

$$\begin{aligned}
 \text{j) Beban bracing} &= 10\% \times \text{beban kuda-kuda}
 \end{aligned}$$

commit to user



$$= 0,1 \times 72,73$$

$$= 7,273 \text{ kg}$$

3) Beban $P_3 = P_5$

f) Beban gording = Berat profil gording x panjang gording **cr**
 $= 11 \times 2,67$

$$= 29,37 \text{ kg}$$

g) Beban atap = Luas atap **bdgs** x berat atap
 $= 4,35 \times 50$

$$= 217,5 \text{ kg}$$

h) Beban kuda-kuda = $\frac{1}{2} \times \text{Big} (8 + 9 + 15 + 16) \times \text{berat profil kuda kuda}$
 $= \frac{1}{2} \times (1,628 + 1,628 + 1,870 + 2,297) \times 25$

$$= 92,8 \text{ kg}$$

i) Beban plat sambung = 30% x beban kuda-kuda
 $= 0,3 \times 92,8$

$$= 27,84 \text{ kg}$$

j) Beban bracing = 10% x beban kuda-kuda
 $= 0,1 \times 92,8$

$$= 9,28 \text{ kg}$$

4) Beban P_4

a) Beban gording = Berat profil gording x panjang gording **ai**
 $= 11 \times 2$

$$= 22 \text{ kg}$$

commit to user



Tugas Akhir
Perencanaan Struktur Gedung Sekolah Dua lantai

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$$\begin{aligned}
 \text{b) Beban atap} &= (2 \times \text{Luas atap aibq}) \times \text{berat atap} \\
 &= (2 \times 1,77) \times 50 = 177 \text{ kg} \\
 \text{c) Beban kuda-kuda} &= \frac{1}{2} \times \text{Btg} (9+10+17) \times \text{berat profil kuda kuda} \\
 &= \frac{1}{2} \times (1,628 + 1,628 + 2,8) \times 25 \\
 &= 75,7 \text{ kg} \\
 \text{f) Beban plat sambung} &= 30\% \times \text{beban kuda-kuda} \\
 &= 0,3 \times 75,7 \\
 &= 22,71 \text{ kg} \\
 \text{g) Beban bracing} &= 10\% \times \text{beban kuda-kuda} \\
 &= 0,1 \times 75,7 \\
 &= 7,57 \text{ kg} \\
 \text{h) Beban reaksi} &= (2 \times \text{reaksi jurai}) + \text{reaksi setengah kuda-kuda} \\
 &= (2 \times 1768,28) + 772,14 \\
 &= 4308,7 \text{ kg}
 \end{aligned}$$

5) Beban $P_8 = P_{12}$

$$\begin{aligned}
 \text{e) Beban kuda-kuda} &= \frac{1}{2} \times \text{Btg} (1+2+13) \times \text{berat profil kuda kuda} \\
 &= \frac{1}{2} \times (1,333+1,333+0,934) \times 25 \\
 &= 45 \text{ kg} \\
 \text{f) Beban plafon} &= \text{Luas plafon dsfu} \times \text{berat plafon} \\
 &= 4,841 \times 18 \\
 &= 87,14 \text{ kg}
 \end{aligned}$$

commit to user



- g) Beban plat sambung = 30% x beban kuda-kuda
= 0,3 x 45
= 13,5 kg
- h) Beban bracing = 10% x beban kuda-kuda
= 0,1 x 45
= 4,5 kg
- 6) Beban P_{10}
- e) Beban kuda-kuda = $\frac{1}{2}$ x Btg (3+4+16+17+18) x berat profil kuda kuda
= $\frac{1}{2}$ x (1,333+1,333+2,297+2,8+2,297) x 25
= 125,75 kg
- f) Beban plafon = (2 x luas plafon aibq) x berat plafon
= (2 x 1,468) x 18
= 52,848 kg
- g) Beban plat sambung = 30% x beban kuda-kuda
= 0,3 x 125,75
= 37,725 kg
- h) Beban bracing = 10% x beban kuda-kuda
= 0,1 x 125,75
= 12,575 kg
- i) Beban reaksi = (2 x reaksi jurai) + reaksi setengah kuda-kuda
= (2 x 1929,92) + 1184,13
= 5043,97 kg

commit to user



7) Beban $P_9 = P_{11}$

$$\begin{aligned} \text{e) Beban kuda-kuda} &= \frac{1}{2} \times \text{Btg} (2+3+14+15) \times \text{berat profil kuda kuda} \\ &= \frac{1}{2} \times (1,333+1,333+1,628+1,870) \times 25 \\ &= 77,05 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{f) Beban plafon} &= \text{Luas plafon} \times \text{berat plafon} \\ &= 3,753 \times 18 \\ &= 67,554 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{g) Beban plat sambung} &= 30\% \times \text{beban kuda-kuda} \\ &= 0,3 \times 77,05 = 23,115 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{h) Beban bracing} &= 10\% \times \text{beban kuda-kuda} \\ &= 0,1 \times 77,05 = 7,705 \text{ kg} \end{aligned}$$

Tabel 3.21 Rekapitulasi beban mati kuda – kuda B

Beban	Beban Atap (kg)	Beban gording (kg)	Beban Kuda - kuda (kg)	Beban Bracing (kg)	Beban Plat sambung (kg)	Beban Plafon (kg)	Beban reaksi (kg)	Jumlah Beban (kg)	Input SAP (kg)
$P_1=P_7$	415,65	44	37,0125	3,702	11,104	128,52		639,989	640
$P_2=P_6$	271,5	36,74	72,73	7,273	21,82	-		410,063	411
P_4	177	22	75,7	7,57	22,71	-	4308,7	4591,9	4592
$P_8=P_{12}$	-	-	45	4,5	13,5	87,14		150,14	151
P_{10}	-	-	125,75	12,575	37,725	52,848	5043,97	5272,68	5273
$P_9=P_{11}$	-	-	77,05	7,705	23,115	67,554		175,424	176
$P_3=P_5$	217,5	29,37	92,8	9,28	27,84	-		376,79	378

commit to user



➤ **Beban Hidup**

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

➤ **Beban Hujan**

1) Beban $P_1 =$ beban hujan x luas atap **fuwh**

$$= 12 \times 8,313 = 99,756 \text{ kg}$$

2) Beban $P_2 =$ beban hujan x luas atap **dsfu**

$$= 12 \times 5,43 = 65,16 \text{ kg}$$

3) Beban $P_3 =$ beban hujan x luas atap **bqds**

$$= 12 \times 4,35 = 52,2 \text{ kg}$$

4) Beban $P_4 =$ beban hujan x (2 x luas atap **aibq**)

$$= 12 \times (2 \times 1,77) = 42,48 \text{ kg}$$

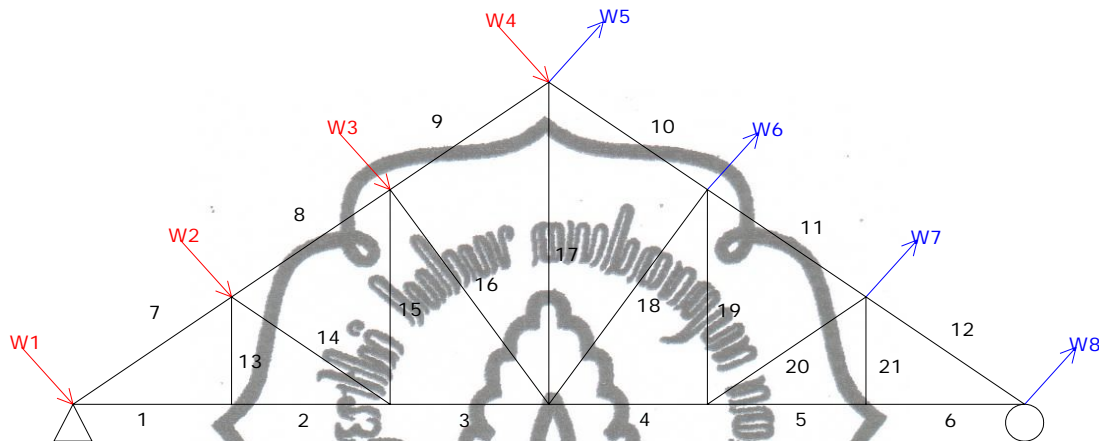
Tabel 3.16 Rekapitulasi Beban Hujan

Beban	Beban Hujan (kg)	Input SAP (kg)
P_1	99,756	100
P_2	65,16	66
P_3	52,2	53
P_4	42,48	43



➤ **Beban Angin**

Perhitungan beban angin :



Gambar 3.21 Pembebanan kuda-kuda utama B akibat beban angin
Beban angin kondisi normal, minimum = 25 kg/m².

$$3) \text{ Koefisien angin tekan} = 0,02\alpha - 0,40 \\ = (0,02 \times 35) - 0,40 = 0,3$$

$$a) W_1 = \text{luasan atap } \mathbf{fuhw} \times \text{koef. angin tekan} \times \text{beban angin} \\ = 8,313 \times 0,3 \times 25 = 62,35 \text{ kg}$$

$$b) W_2 = \text{luasan atap } \mathbf{dsfu} \times \text{koef. angin tekan} \times \text{beban angin} \\ = 5,43 \times 0,3 \times 25 \\ = 40,73 \text{ kg}$$

$$c) W_3 = \text{luasan atap } \mathbf{bqds} \times \text{koef. angin tekan} \times \text{beban angin} \\ = 4,35 \times 0,3 \times 25 \\ = 32,63 \text{ kg}$$

$$d) W_4 = \text{luasan atap } \mathbf{aibq} \times \text{koef. angin tekan} \times \text{beban angin} \\ = 1,77 \times 0,3 \times 25 = 13,275 \text{ kg}$$

commit to user



4) Koefisien angin hisap = - 0,40

$$\begin{aligned} \text{a) } W_5 &= \text{luasan atap aibq} \times \text{koef. angin tekan} \times \text{beban angin} \\ &= 1,77 \times -0,4 \times 25 \\ &= -17,7 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{b) } W_6 &= \text{luasan atap bqds} \times \text{koef. angin tekan} \times \text{beban angin} \\ &= 4,35 \times -0,4 \times 25 \\ &= -43,5 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{c) } W_7 &= \text{luasan atap dsfu} \times \text{koef. angin tekan} \times \text{beban angin} \\ &= 5,43 \times -0,4 \times 25 \\ &= -54,3 \text{ kg} \end{aligned}$$

$$\begin{aligned} \text{d) } W_8 &= \text{luasan atap fuhw} \times \text{koef. angin tekan} \times \text{beban angin} \\ &= 8,313 \times -0,4 \times 25 \\ &= -83,13 \text{ kg} \end{aligned}$$

Tabel 3.22 Perhitungan beban angin kuda - kuda B

Beban Angin	Beban (kg)	Wx		Wy	
		$W.Cos \alpha$ (kg)	(Untuk Input SAP2000)	$W.Sin \alpha$ (kg)	(Untuk Input SAP2000)
W_1	62,35	51,08	52 kg	35,77	36 kg
W_2	40,73	33,36	34 kg	23,37	24 kg
W_3	32,63	26,73	27 kg	18,72	19 kg
W_4	13,275	10,88	11 kg	7,614	8 kg
W_5	-17,7	-14,5	-15 kg	-10,16	-11 kg
W_6	-43,5	-35,64	-36 kg	-24,96	-25 kg

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W ₇	-54,3	-44,48	-45 kg	-31,15	-32 kg
W ₈	-83,13	-68,1	-69 kg	-47,69	-48 kg

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

Tabel 3.23. Rekapitulasi gaya batang kuda-kuda utama B

Batang	kombinasi	
	Tarik (+) (kg)	Tekan (-) (kg)
1	12378,56	-
2	12453,29	-
3	11979,33	-
4	11979,33	-
5	12453,29	-
6	12378,56	-
7	-	15172,18
8	-	14665,69
9	-	13783,20
10	-	13795,88
11	-	14665,69

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12	-	15172,18
13	39,42	-
14	-	623,31
15	758,68	-
16	-	1075,77
17	9096,00	-
18	-	1092,14
19	758,68	-
20	-	646,53
21	39,42	-

3.6.4. Perencanaan Profil Kuda-kuda utama B

a. Perhitungan profil batang tarik

$$P_{\text{maks.}} = 12378,56 \text{ kg}$$

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

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

$$A_g \text{ perlu} = \frac{P_{\text{maks.}}}{F_y} = \frac{12378,56}{2400} = 5,15 \text{ cm}^2$$

Dicoba, menggunakan baja profil **┘ 55. 55. 5**

Dari tabel baja didapat data-data =

$$A_g = 6,31 \text{ cm}^2$$

commit to user



$$\bar{x} = 1,66 \text{ cm}$$

$$\begin{aligned} A_n &= 2 \cdot A_g \cdot d_t \\ &= 1262 \cdot 14,76 = 1173,8 \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} L &= \text{Sambungan dengan Diameter} \\ &= 3 \cdot 12,7 = 38,1 \text{ mm} \end{aligned}$$

$$\bar{x} = 16,6 \text{ mm}$$

$$\begin{aligned} U &= 1 - \frac{\bar{x}}{L} \\ &= 1 - \frac{16,6}{38,1} = 0,435 \end{aligned}$$

$$\begin{aligned} A_e &= U \cdot A_n \\ &= 0,435 \cdot 1173,8 \\ &= 510,603 \text{ mm}^2 \end{aligned}$$

Check kekuatan nominal

$$\begin{aligned} \phi P_n &= 0,75 \cdot A_e \cdot F_u \\ &= 0,75 \cdot 510,603 \cdot 370 \\ &= 141692,3 \text{ N} = 14169,23 \text{ kg} > 12378,56 \text{ kg} \dots \text{OK} \text{ ☺} \end{aligned}$$

c. Perhitungan profil batang 17 (batang tarik)

$$P = 9096,00 \text{ kg}$$

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

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

$$A_g \text{ perlu} = \frac{P}{F_y} = \frac{9096}{2400} = 3,79 \text{ cm}^2$$

Dicoba, menggunakan baja profil  (Circular Hollow Sections) 76,3 . 2,8

Dari tabel baja didapat data-data =

$$A_g = 6,465 \text{ cm}^2$$

$$\bar{x} = 3,815 \text{ cm}$$

commit to user



$$A_n = A_g - d t$$

$$= 646,5 - 38,15 \cdot 2,8 = 539,68 \text{ mm}^2$$

L = Sambungan dengan Diameter

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

$$\bar{x} = 38,15 \text{ mm}$$

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

$$= 1 - \frac{38,15}{38,1} = 1,001$$

$$A_e = U \cdot A_n$$

$$= 1,001 \cdot 539,68 = 540,22 \text{ mm}^2$$

Check kekuatan nominal

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

$$= 0,75 \cdot 540,22 \cdot 370$$

$$= 149911,05 \text{ N}$$

$$= 14991,105 \text{ kg} > 2197,15 \text{ kg} \dots \text{OK}$$

b. Perhitungan profil batang tekan

$$P_{\text{maks.}} = 15172,18 \text{ kg}$$

$$l_k = 1,628 \text{ m} = 162,8 \text{ cm}$$

$$A_g \text{ perlu} = \frac{P_{\text{maks.}}}{F_y} = \frac{15172,18}{2400} = 6,32 \text{ cm}^2$$

Dicoba, menggunakan baja profil $\perp 55. 55. 5$ ($A_g = 4,80 \text{ cm}^2$)

Periksa kelangsingan penampang :

$$\frac{b}{t} < \frac{200}{\sqrt{F_y}} = \frac{70}{7} < \frac{200}{\sqrt{240}}$$

$$= 10 < 12,9$$

commit to user



$$\lambda = \frac{K.L}{r} = \frac{1.162,8}{1,66}$$

$$= 98,072$$

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

$$= \frac{98,072}{3,14} \sqrt{\frac{240}{200000}}$$

$$= 1,081 \dots 0,25 < \lambda_c < 1,2 \rightarrow \omega = \frac{1,43}{1,6 - 0,67\lambda_c}$$

$$\omega = \frac{1,43}{1,6 - 0,67 \cdot 1,081}$$

$$= 1,632$$

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

$$= 2.6,31 \cdot \frac{2400}{1,780}$$

$$= 18558,82 \text{ kg}$$

$$\frac{P}{\phi P_n} = \frac{15172,18}{0,85 \cdot 18558,82}$$

$$= 0,962 < 1 \dots \dots \dots \text{OK } \odot$$

3.3.5. Perhitungan Alat Sambung

a. Batang Tekan

Digunakan alat sambung baut-mur.

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

Diameter lubang = 14,7 mm.

Tebal pelat sambung (δ) = 0,625 . d

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

commit to user



Menggunakan tebal plat 8 mm

➤ Tahanan geser baut

$$R_n = n \cdot (0,4 \cdot f^{tb}) \cdot A_n$$

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

➤ Tahanan tarik penyambung

$$R_n = 0,75 \cdot f^{tb} \cdot A_n$$

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

➤ Tahanan Tumpu baut :

$$R_n = 0,75 (2,4 \cdot f_u \cdot d_t)$$

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

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

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

Perhitungan jumlah baut-mur,

$$n = \frac{P_{maks.}}{P_{tumpu}} = \frac{15172,18}{7612,38} = 1,993 \sim 3 \text{ buah baut}$$

Digunakan : 3 buah baut

Perhitungan jarak antar baut :

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

Diambil, $S_1 = 3 d_b = 4 \cdot 12,7$

$$= 50,8 \text{ mm}$$

$$= 60 \text{ mm}$$

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

commit to user



Diambil, $S_2 = 1,5 d_b = 2 \cdot 12,7$

$$= 25,4 \text{ mm}$$

$$= 30 \text{ mm}$$

b. Batang tarik

Digunakan alat sambung baut-mur.

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

Diameter lubang = 13,7 mm.

Tebal pelat sambung (δ) = $0,625 \cdot d$
 $= 0,625 \times 12,7 = 7,94 \text{ mm}$

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 :

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

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

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

commit to user



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

Perhitungan jumlah baut-mur,

$$n = \frac{P_{maks.}}{P_{tumpu}} = \frac{12378,56}{7612,38} = 1,626 \sim 3 \text{ buah baut}$$

Digunakan : 4 buah baut

Perhitungan jarak antar baut :

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

Diambil, $S_1 = 3 d_b = 4 \cdot 12,7$

$$= 50,8 \text{ mm}$$

$$= 60 \text{ mm}$$

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

Diambil, $S_2 = 1,5 d_b = 2 \cdot 12,7$

$$= 25,4 \text{ mm}$$

$$= 30 \text{ mm}$$

Tabel 3.24 Rekapitulasi perencanaan profil kuda-kuda utama B

Nomer Batang	Dimensi Profil	Baut (mm)
1	┘ 55. 55. 5	3 Ø 12,7
2	┘ 55. 55. 5	3 Ø 12,7
3	┘ 55. 55. 5	3 Ø 12,7
4	┘ 55. 55. 5	3 Ø 12,7
5	┘ 55. 55. 5	3 Ø 12,7
6	┘ 55. 55. 5	3 Ø 12,7
7	┘ 55. 55. 5	3 Ø 12,7
8	┘ 55. 55. 5	3 Ø 12,7

commit to user



Tugas Akhir
Perencanaan Struktur Gedung Sekolah Dua lantai

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9	┆ 55. 55. 5	3 Ø 12,7
10	┆ 55. 55. 5	3 Ø 12,7
11	┆ 55. 55. 5	3 Ø 12,7
12	┆ 55. 55. 5	3 Ø 12,7
13	┆ 55. 55. 5	3 Ø 12,7
14	┆ 55. 55. 5	3 Ø 12,7
15	┆ 55. 55. 5	3 Ø 12,7
16	┆ 55. 55. 5	3 Ø 12,7
17	○ 76,3. 2,8	3 Ø 12,7
18	┆ 55. 55. 5	3 Ø 12,7
19	┆ 55. 55. 5	3 Ø 12,7
20	┆ 55. 55. 5	3 Ø 12,7
21	┆ 55. 55. 5	3 Ø 12,7

commit to user



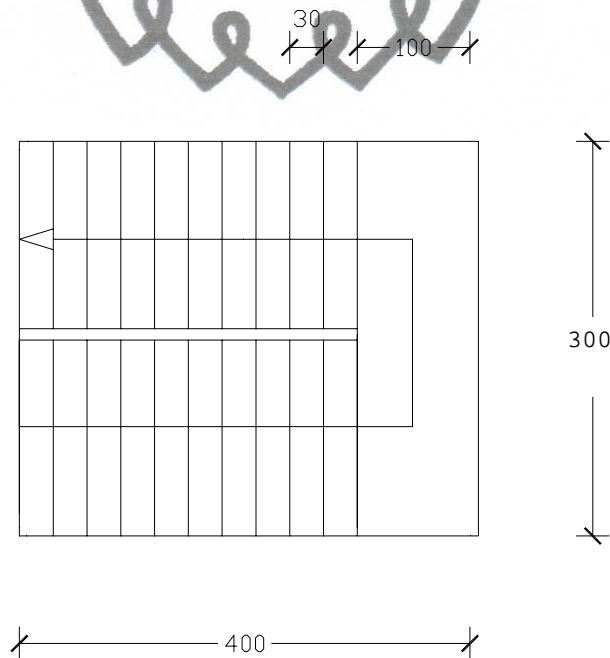
BAB 4 PERENCANAAN TANGGA

4.1. Uraian Umum

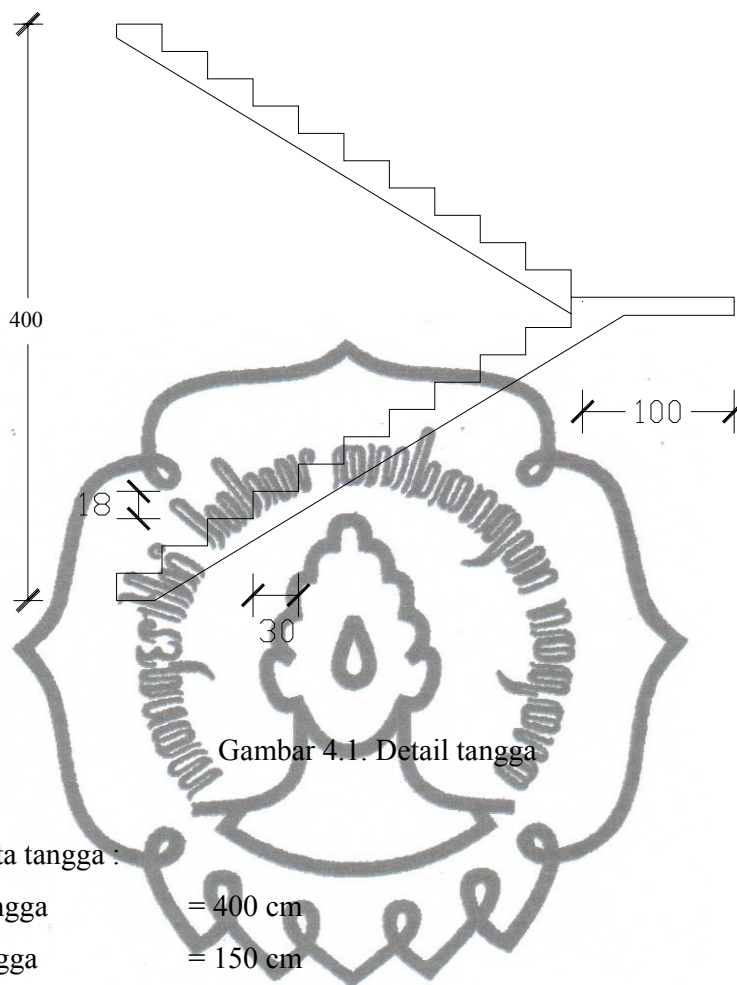
Tangga merupakan bagian dari struktur bangunan bertingkat yang penting sebagai penunjang antara struktur bangunan lantai dasar dengan struktur bangunan tingkat atasnya. Penempatan tangga pada struktur suatu bangunan berhubungan dengan fungsi bangunan bertingkat yang akan dioperasikan.

Pada bangunan umum, penempatan tangga harus mudah diketahui dan 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



commit to user



Gambar 4.1. Detail tangga

Data – data tangga :

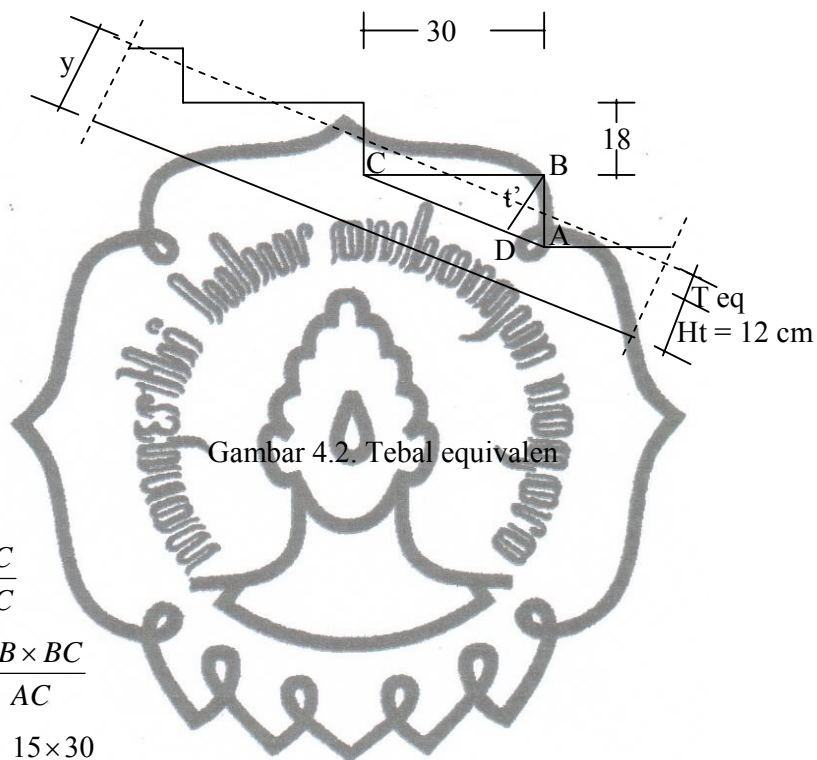
Tinggi tangga	= 400 cm
Lebar tangga	= 150 cm
Lebar datar	= 400 cm
Tebal plat tangga	= 12 cm
Tebal plat bordes tangga	= 15 cm
Dimensi bordes	= 100 x 300 cm
lebar antrade	= 30 cm
Tinggi oprade	= 18 cm (Termasuk spesi + tegel keramik)
Jumlah antrede	= $300 / 30$
	= 10 buah
Jumlah oprade	= 10 + 1
	= 11 buah
$\alpha = \text{Arc.tg} (200/300)$	= $33,69^{\circ}$
	= $34^{\circ} < 35^{\circ}$ OK

commit to user



4.3. Perhitungan Tebal Plat Equivalen dan Pembebanan

4.3.1. Perhitungan Tebal Plat Equivalen



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

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

$$= \frac{15 \times 30}{\sqrt{(15)^2 + (30)^2}}$$

$$= 13,43 \text{ cm}$$

$$T_{eq} = 2/3 \times BD$$

$$= 2/3 \times 13,438$$

$$= 8,98 \text{ cm}$$

Jadi total equivalent plat tangga

$$Y = t_{eq} + h_t$$

$$= 8,98 + 12$$

$$= 20,98 \text{ cm}$$

$$= 0,2098 \text{ m}$$

commit to user



4.3.2. Perhitungan Beban

a. Pembebanan Tangga (SNI 03-2847-2002)

1. Akibat beban mati (qD)

Berat tegel keramik (1 cm)	$= 0,01 \times 1,5 \times 2,4$	$= 0,036$	ton/m
Berat spesi (2 cm)	$= 0,02 \times 1,5 \times 2,1$	$= 0,063$	ton/m
Berat plat tangga	$= 0,2229 \times 1,5 \times 2,4$	$= 0,825$	ton/m
		$= 0,924$	ton/m

2. Akibat beban hidup (qL)

Faktor reduksi untuk tangga (PPIUG '89) : 0,75

$$qL = 0,75 \cdot (1,5 \times 0,300)$$

$$= 0,3375 \text{ ton/m}$$

b. Pembebanan pada Bordes (SNI 03-2847-2002)

1. Akibat beban mati (qD)

Berat tegel keramik (1 cm)	$= 0,01 \times 3 \times 2,4$	$= 0,072$	ton/m
Berat spesi (2 cm)	$= 0,02 \times 3 \times 2,1$	$= 0,126$	ton/m
Berat plat bordes	$= 0,15 \times 3 \times 2,4$	$= 1,08$	ton/m
		$= 1,278$	ton/m

2. Akibat beban hidup (qL)

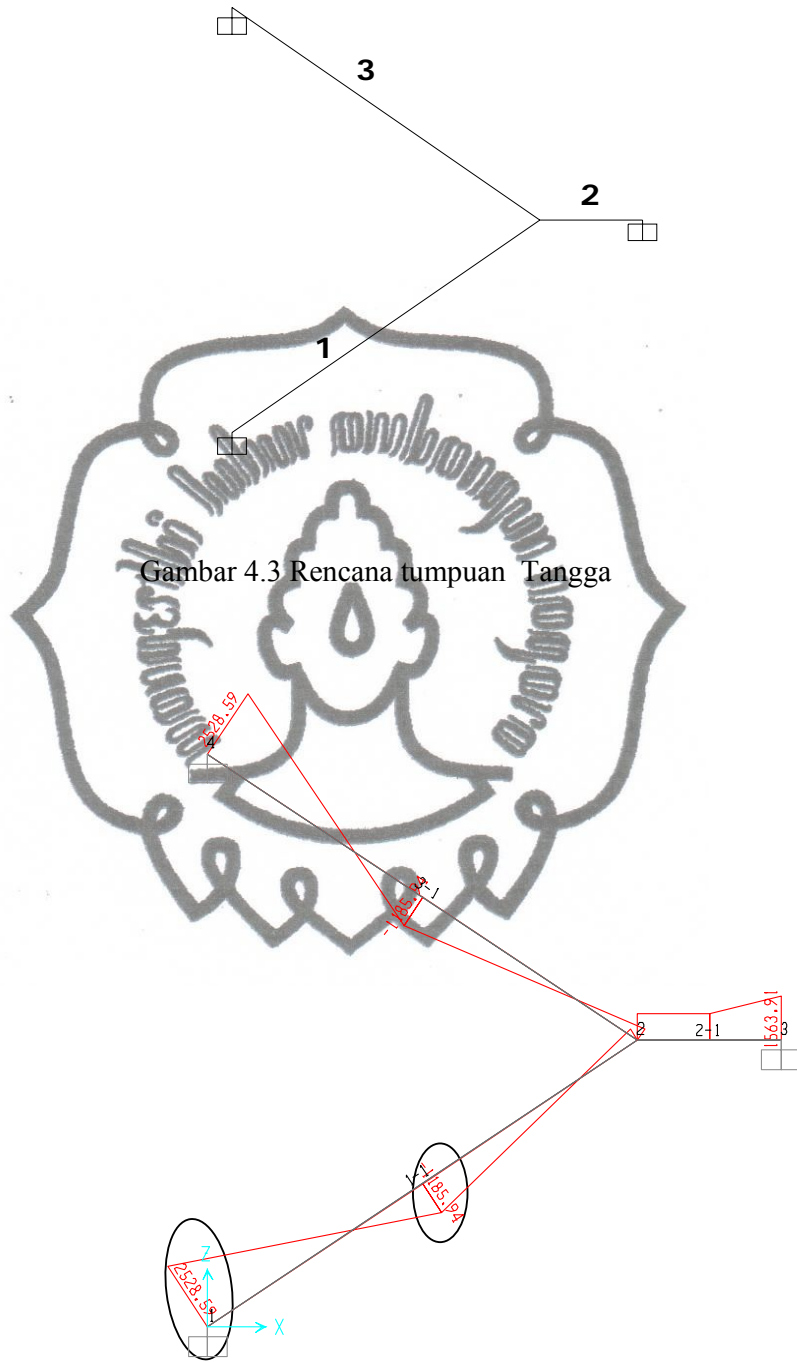
Faktor reduksi untuk tangga (PPIUG '89) : 0,75

$$qL = 0,75 \cdot (3 \times 0,300) \text{ ton/m}$$

$$= 0,675 \text{ ton/m}$$

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

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Gambar 4.4 Bidang momen Tangga

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4.4. Perhitungan Tulangan Tangga dan Bordes

4.4.1. Perhitungan Tulangan Tumpuan

Dicoba menggunakan tulangan \varnothing 12 mm

$$h = 120 \text{ mm}$$

$$d' = p + 1/2 \varnothing \text{ tul}$$

$$= 20 + 6$$

$$= 26 \text{ mm}$$

$$d = h - d'$$

$$= 120 - 26$$

$$= 94 \text{ mm}$$

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

$$M_u = 2528,59 \text{ kgm} = 2,5286 \cdot 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{2,5286 \cdot 10^7}{0,8} = 3,22825 \cdot 10^7 \text{ Nmm}$$

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

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

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

$$= 0,0537$$

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

$$= 0,040275$$

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

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{3,22825 \cdot 10^7}{1500 \cdot (94)^2} = 2,436 \text{ N/mm}$$

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$$\begin{aligned}\rho_{\text{ada}} &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot R_n}{f_y}} \right) \\ &= \frac{1}{11,29} \left(1 - \sqrt{1 - \frac{2 \cdot 11,29 \cdot 2,436}{240}} \right) \\ &= 0,0108\end{aligned}$$

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

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

di pakai $\rho_{\text{ada}} = 0,0108$

$$\begin{aligned}A_s &= \rho_{\text{min}} \cdot b \cdot d \\ &= 0,0108 \times 1500 \times 94 \\ &= 1522,8 \text{ mm}^2\end{aligned}$$

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

$$\text{Jumlah tulangan} = \frac{1522,8}{113,04} = 13,47 \approx 15 \text{ buah}$$

$$\text{Jarak tulangan} = \frac{1500}{14} = 100 \text{ mm}$$

$$\begin{aligned}\text{Jarak maksimum tulangan} &= 2 \times h \\ &= 2 \times 120 = 240 \text{ mm}\end{aligned}$$

Dipakai tulangan $\varnothing 12 \text{ mm} - 100 \text{ mm}$

$$\begin{aligned}\text{As yang timbul} &= 15 \cdot \frac{1}{4} \cdot \pi \cdot d^2 \\ &= 15 \times 0,25 \times 3,14 \times (12)^2 \\ &= 1695,6 \text{ mm}^2 > A_s \dots\dots\dots \text{OK } \odot\end{aligned}$$

4.4.2. Perhitungan Tulangan Lapangan

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

$$M_u = 1185,94 \text{ kgm} = 1,186 \cdot 10^7 \text{ Nmm}$$

$$M_n = \frac{1,186 \cdot 10^7}{0,8} = 1,4825 \cdot 10^7 \text{ Nmm}$$

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

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$$\begin{aligned}\rho_b &= \frac{0,85 \cdot f_c}{f_y} \cdot \beta \cdot \left(\frac{600}{600 + f_y} \right) \\ &= \frac{0,85 \cdot 25}{240} \cdot \beta \cdot \left(\frac{600}{600 + 240} \right) \\ &= 0,0537\end{aligned}$$

$$\begin{aligned}\rho_{\max} &= 0,75 \cdot \rho_b \\ &= 0,040275\end{aligned}$$

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

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{1,4825 \cdot 10^7}{1500 \cdot (94)^2} = 1,118 \text{ N/mm}^2$$

$$\begin{aligned}\rho_{\text{ada}} &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot R_n}{f_y}} \right) \\ &= \frac{1}{11,29} \left(1 - \sqrt{1 - \frac{2 \cdot 11,29 \cdot 1,118}{240}} \right) \\ &= 0,00479\end{aligned}$$

$$\begin{aligned}\rho_{\text{ada}} &< \rho_{\max} \\ &> \rho_{\min}\end{aligned}$$

di pakai $\rho_{\text{ada}} = 0,00479$

$$\begin{aligned}A_s &= \rho_{\min} \cdot b \cdot d \\ &= 0,00479 \times 1500 \times 94 \\ &= 675,39 \text{ mm}^2\end{aligned}$$

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

$$\text{Jumlah tulangan dalam 1 m} = \frac{675,39}{113,04} = 5,97 \approx 10 \text{ tulangan}$$

$$\text{Jarak tulangan} = \frac{1500}{10} = 150 \text{ mm}$$

$$\begin{aligned}\text{Jarak maksimum tulangan} &= 2 \times h \\ &= 2 \times 120 = 240\end{aligned}$$

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Dipakai tulangan $\varnothing 12 \text{ mm} - 150 \text{ mm}$

$$\text{As yang timbul} = 10 \cdot \frac{1}{4} \times \pi \times d^2 = 1130,4 \text{ mm}^2 > \text{As OK}$$

4.5 Perencanaan Balok Bordes



Data – data perencanaan balok bordes:

$$h = 300 \text{ mm}$$

$$b = 200 \text{ mm}$$

$$\phi_{\text{tul}} = 12 \text{ mm}$$

$$\phi_{\text{sk}} = 8 \text{ mm}$$

$$\begin{aligned} d' &= p - \phi_{\text{sk}} - \frac{1}{2} \phi_{\text{tul}} \\ &= 40 + 8 + 6 \\ &= 54 \text{ mm} \end{aligned}$$

$$\begin{aligned} d &= h - d' \\ &= 300 - 54 \\ &= 246 \text{ mm} \end{aligned}$$

4.5.1. Pembebanan Balok Bordes

1. Beban mati (q_D)

$$\text{Berat sendiri} = 0,20 \times (0,3 - 0,15) \times 2400 = 72 \text{ kg/m}$$

$$\text{Berat dinding} = 0,15 \times 2 \times 1700 = 510 \text{ kg/m}$$

$$\text{Berat plat bordes} = 0,15 \times 2400 = 360 \text{ kg/m}$$

$$q_D = 942 \text{ kg/m}$$

2. Beban Hidup (q_L) = 300 kg/m

3. Beban reaksi bordes

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$$\begin{aligned}
 q_U &= \frac{\text{reaksibordes}}{\text{lebarbordes}} \\
 &= \frac{1912.53}{1} \\
 &= 1912.53 \text{ kg/m}
 \end{aligned}$$

4.5.2. Perhitungan Tulangan

a. Penulangan daerah tumpuan

$$M_u = 1207,80 \text{ kgm} = 1,2078 \cdot 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{1,2078 \cdot 10^7}{0,8} = 1,50975 \cdot 10^7 \text{ Nmm}$$

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

$$\begin{aligned}
 \rho_b &= \frac{0,85 \cdot f_c}{f_y} \cdot \beta \cdot \left(\frac{600}{600 + f_y} \right) \\
 &= \frac{0,85 \cdot 25}{240} \cdot \beta \cdot \left(\frac{600}{600 + 240} \right) \\
 &= 0,0512
 \end{aligned}$$

$$\begin{aligned}
 \rho_{\max} &= 0,75 \cdot \rho_b \\
 &= 0,0384
 \end{aligned}$$

$$\rho_{\min} = \frac{1,4}{f_y} = 0,005834$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{1,50975 \cdot 10^7}{200 \cdot (246)^2} = 1,2474 \text{ N/mm}$$

$$\begin{aligned}
 \rho_{\text{ada}} &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot R_n}{f_y}} \right) \\
 &= \frac{1}{11,29} \left(1 - \sqrt{1 - \frac{2 \cdot 11,29 \cdot 1,2474}{240}} \right) \\
 &= 0,00536
 \end{aligned}$$

$$\rho_{\text{ada}} < \rho_{\min}$$

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

$$\begin{aligned} A_s &= \rho_{ada} \cdot b \cdot d \\ &= 0,005834 \times 200 \times 246 \\ &= 287 \text{ mm}^2 \end{aligned}$$

Dipakai tulangan $\varnothing 12$ mm

$$\begin{aligned} A_s &= \frac{1}{4} \cdot \pi \cdot (12)^2 \\ &= 113,04 \text{ mm}^2 \end{aligned}$$

$$\text{Jumlah tulangan} = \frac{287}{113,04} = 2,53 \approx 3 \text{ buah}$$

$$\begin{aligned} \text{As yang timbul} &= 3 \cdot \frac{1}{4} \cdot \pi \cdot d^2 \\ &= 3 \cdot \frac{1}{4} \cdot 3,14 \cdot (12)^2 \\ &= 339,12 \text{ mm}^2 > A_s (263,712 \text{ mm}^2) \dots \dots \text{OK. } \odot \end{aligned}$$

Kontrol Spasi :

$$\begin{aligned} S &= \frac{b - 2s - n\phi \text{ tulangan} - 2\phi \text{ sengkang}}{n - 1} \\ &= \frac{200 - 2 \cdot 40 - 3 \cdot 12 - 2 \cdot 8}{3 - 1} = 34 > 25 \text{ mm.} \dots \dots \text{OK. } \odot \end{aligned}$$

Dipakai tulangan **3 $\varnothing 12$ mm**

b. Penulangan daerah Lapangan

$$M_u = 603,90 \text{ kgm} = 6,039 \cdot 10^6 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{6,039 \cdot 10^6}{0,8} = 7,54875 \cdot 10^6 \text{ Nmm}$$

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

$$\begin{aligned} \rho_b &= \frac{0,85 \cdot f_c}{f_y} \cdot \beta \cdot \left(\frac{600}{600 + f_y} \right) \\ &= \frac{0,85 \cdot 25}{240} \cdot \beta \cdot \left(\frac{600}{600 + 240} \right) \\ &= 0,0512 \end{aligned}$$

commit to user



$$\begin{aligned}\rho_{\max} &= 0,75 \cdot \rho_b \\ &= 0,0384\end{aligned}$$

$$\rho_{\min} = \frac{1,4}{f_y} = 0,005834$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{7,54875 \cdot 10^6}{200 \cdot (246)^2} = 0,6237 \text{ N/mm}$$

$$\begin{aligned}\rho_{\text{ada}} &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot R_n}{f_y}} \right) \\ &= \frac{1}{11,29} \left(1 - \sqrt{1 - \frac{2 \cdot 11,29 \cdot 0,6237}{240}} \right) \\ &= 0,00264\end{aligned}$$

$$\rho_{\text{ada}} < \rho_{\min}$$

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

$$\begin{aligned}A_s &= \rho_{\min} \cdot b \cdot d \\ &= 0,005834 \times 200 \times 246 \\ &= 287 \text{ mm}^2\end{aligned}$$

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

$$\begin{aligned}A_s &= \frac{1}{4} \cdot \pi \cdot (12)^2 \\ &= 113,04 \text{ mm}^2\end{aligned}$$

$$\text{Jumlah tulangan} = \frac{287}{113,04} = 2,53 \approx 3 \text{ buah}$$

$$\begin{aligned}\text{As yang timbul} &= 3 \cdot \frac{1}{4} \cdot \pi \cdot d^2 \\ &= 3 \cdot \frac{1}{4} \cdot 3,14 \cdot (12)^2 \\ &= 339,12 \text{ mm}^2 > A_s (287 \text{ mm}^2) \dots \dots \dots \text{OK.}\end{aligned}$$

Kontrol Spasi :

$$\begin{aligned}S &= \frac{b - 2s - n\varnothing \text{ tulangan} - 2\varnothing \text{ sengkang}}{n - 1} \\ &= \frac{200 - 2 \cdot 40 - 3 \cdot 12 - 2 \cdot 8}{3 - 1} = 34 > 25 \text{ mm} \dots \text{OK.}\end{aligned}$$

Dipakai tulangan **3 $\varnothing 12 \text{ mm}$**

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4.5.3. Perhitungan Tulangan Geser

$$V_u = 2415,60 \text{ kg} = 24156 \text{ N}$$

$$\begin{aligned} V_c &= 1/6 \cdot b \cdot d \cdot \sqrt{f_c} \\ &= 1/6 \cdot 150 \cdot 246 \cdot \sqrt{25} \\ &= 30750 \text{ N} \end{aligned}$$

$$\begin{aligned} \emptyset V_c &= 0,6 \cdot V_c \\ &= 0,6 \cdot 30750 \text{ N} \\ &= 18450 \end{aligned}$$

$$\begin{aligned} \emptyset V_s &= V_u - \emptyset V_c \\ &= 24156 - 18450 = 5706 \text{ N} \end{aligned}$$

$$V_{S_{perlu}} = \frac{5706}{0,8} = 7132,5 \text{ N}$$

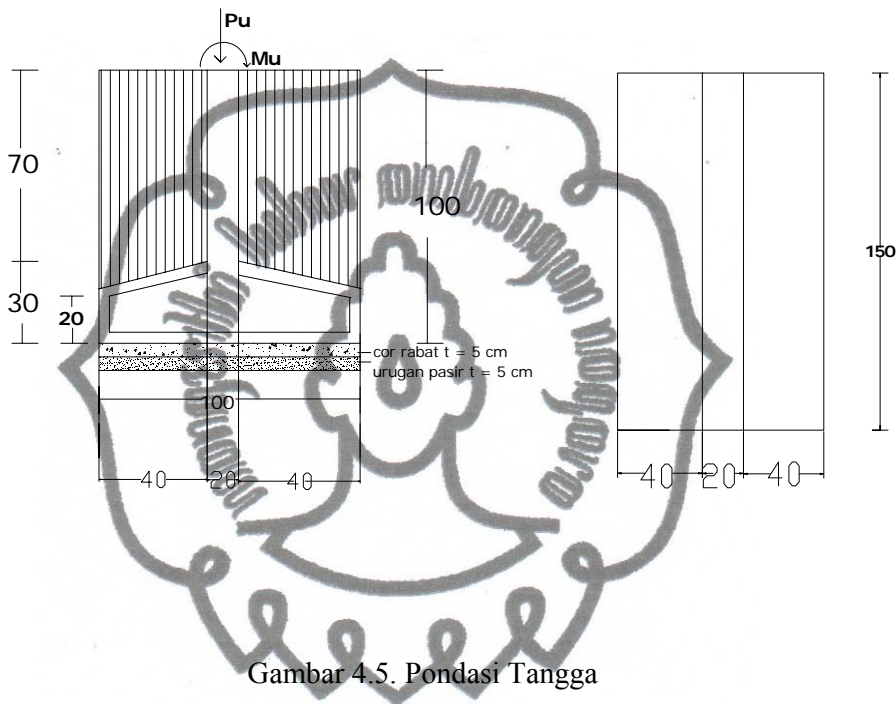
$$S_{ada} = \frac{A_v \times f_y \times d}{V_{S_{perlu}}} = \frac{2 \times 50,24 \times 240 \times 246}{7132,5} = 831,73 \text{ mm}$$

$$S_{max} = \frac{d}{2} = \frac{246}{2} = 123 \text{ mm} \approx 120 \text{ mm}$$

Jadi dipakai sengkang $\emptyset 8 - 120 \text{ mm}$



4.6. Perhitungan Pondasi Tangga



Gambar 4.5. Pondasi Tangga

Dari perhitungan SAP 2000 pada diperoleh gaya terbesar :

- **Pu = 8234,07 kg**
- **Mu = 2528,59 kgm**

Dimensi Pondasi :

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

$$A = \frac{P_u}{\sigma_{\text{tanah}}} = \frac{8234,07}{25000}$$

$$= 0,329 \text{ m}^2$$

$$B = L = \sqrt{A} = \sqrt{0,329}$$

$$= 0,573 \text{ m} \sim 1,00 \text{ m}$$

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

Tebal footplate = 300 mm

$$d = 300 - (50 + 6,5 + 8) = 235,5 \text{ mm}$$

$$\text{Ukuran alas} = 1000 \times 1500 \text{ mm}$$

$$\gamma \text{ tanah} = 3 \text{ t/m}^3 = 3000 \text{ kg/m}^3$$

$$\sigma \text{ tanah} = 25000 \text{ kg/m}^2$$

4.7 Perencanaan kapasitas dukung pondasi

a. Perhitungan kapasitas dukung pondasi

Pembebanan pondasi

$$\text{Berat telapak pondasi} = 1 \times 1,5 \times 0,2 \times 2400 = 720 \text{ kg}$$

$$\text{Berat tanah} = 2(0,7 \times 0,4) \times 1 \times 1700 = 952 \text{ kg}$$

$$\text{Berat kolom} = 0,2 \times 0,7 \times 1,5 \times 2400 = 504 \text{ kg}$$

$$P_u = 8234,07 \text{ kg}$$

$$\Sigma V = 10410,07 \text{ kg}$$

$$e = \frac{\Sigma M}{\Sigma V} = \frac{2528,59}{10410,07}$$

$$= 0,24 \text{ kg} < 1/6.B$$

$$= 0,24 \text{ kg} < 1/6.1,5$$

$$= 0,24 < 0,25 \text{ OK :-)}$$

$$\sigma_{\text{yang terjadi}} = \frac{\Sigma V}{A} + \frac{Mu}{\frac{1}{6}.b.L^2}$$

$$\sigma_{\text{tanah}} = \frac{10410,07}{1.1,5} + \frac{2528,59}{1/6.1.(1,5)^2} = 13682,94 \text{ kg/m}^2$$

$$= 13682,94 \text{ kg/m}^2 < 25000 \text{ kg/m}^2$$

$$= \sigma_{\text{yang terjadi}} < \sigma_{\text{ijin tanah}} \text{ OK.}$$

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4.7.1 Perhitungan Tulangan Lentur

$$\begin{aligned} M_u &= \frac{1}{2} \cdot \sigma \cdot t^2 \\ &= \frac{1}{2} \cdot 13682,94 \cdot (0,3)^2 = 615,73 \text{ kg/m} = 6,157 \cdot 10^6 \text{ N/mm} \end{aligned}$$

$$M_n = \frac{6,157 \cdot 10^6}{0,8} = 7696250 \text{ Nmm}$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{320}{0,85 \cdot 25} = 15,058$$

$$\begin{aligned} \rho_b &= \frac{0,85 \cdot f'_c}{f_y} \beta \left(\frac{600}{600 + f_y} \right) \\ &= \frac{0,85 \cdot 25}{320} \cdot 0,85 \cdot \left(\frac{600}{600 + 320} \right) \\ &= 0,0368 \end{aligned}$$

$$\begin{aligned} R_n &= \frac{M_n}{b \cdot d^2} = \frac{7696250}{1000 \cdot (236)^2} \\ &= 0,138 \end{aligned}$$

$$\begin{aligned} \rho_{\max} &= 0,75 \cdot \rho_b \\ &= 0,75 \cdot 0,0368 \\ &= 0,0276 \end{aligned}$$

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

$$\begin{aligned} \rho_{\text{perlu}} &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2m \cdot R_n}{f_y}} \right) \\ &= \frac{1}{15,058} \cdot \left(1 - \sqrt{1 - \frac{2 \cdot 15,058 \cdot 0,138}{320}} \right) \\ &= 0,00132 \end{aligned}$$

$$\begin{aligned} \rho_{\text{perlu}} &< \rho_{\max} \\ &< \rho_{\min} \end{aligned}$$

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

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

$$= 0,004375 \cdot 1000 \cdot 235,5 = 1030,312 \text{ mm}^2$$

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

$$\text{Jumlah tulangan} = \frac{1030,312}{132,665} = 7,767 \approx 8 \text{ buah}$$

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

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

$$\begin{aligned} A_s \text{ yang timbul} &= 8 \times \frac{1}{4} \times \pi \times 13^2 \\ &= 1061,32 \text{ mm}^2 > A_s (915,86) \dots \text{OK. } \odot \end{aligned}$$

4.7.2 Perhitungan Tulangan Geser

$$\begin{aligned} V_u &= \sigma \times A_{\text{efektif}} \\ &= 13957,78 \times (0,55 \times 1) \\ &= 7676,779 \text{ N} \end{aligned}$$

$$\begin{aligned} V_c &= \frac{1}{6} \cdot \sqrt{f_c} \cdot b \cdot d \\ &= \frac{1}{6} \cdot \sqrt{25} \cdot 1000 \cdot 235,5 \\ &= 196250 \text{ N} \end{aligned}$$

$$\begin{aligned} \varnothing V_c &= 0,6 \cdot V_c \\ &= 0,6 \cdot 196250 \\ &= 117750 \text{ N} \end{aligned}$$

$$\begin{aligned} 3\varnothing V_c &= 3 \cdot \varnothing V_c \\ &= 3 \cdot 117750 \\ &= 353250 \text{ N} \end{aligned}$$

$V_u < \varnothing V_c < 3 \varnothing V_c = 7676,779 < 117750 < 353250$ tidak perlu tulangan geser

Dipakai tulangan geser minimum **$\varnothing 10 - 200 \text{ mm}$**

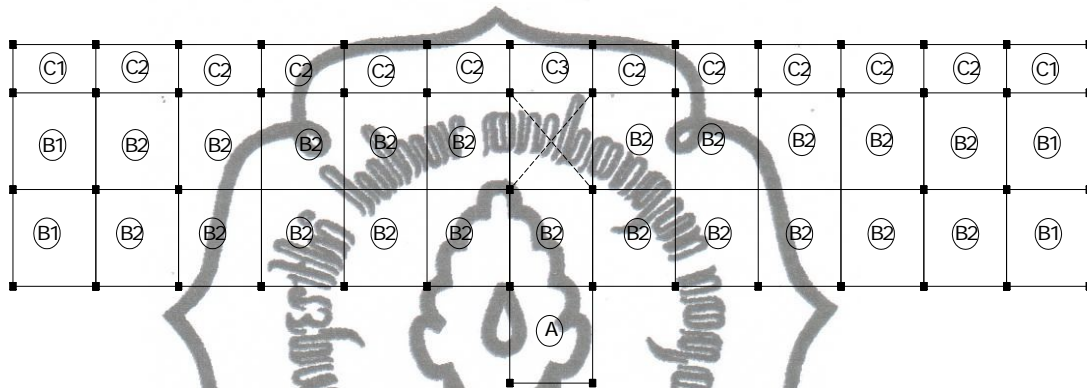
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BAB 5

PLAT LANTAI & PLAT ATAP

5.1. Perencanaan Plat Lantai



Gambar 5.1 Denah Plat lantai

5.2. Perhitungan Pembebanan Plat Lantai

a. Beban Hidup (qL)

Berdasarkan PPIUG 1989 yaitu :

$$\text{Beban hidup fungsi gedung sekolah} = 250 \text{ kg/m}^2$$

$$\text{Beban hidup atap Kanopi} = 100 \text{ kg/m}^2$$

b. Beban Mati (qD)

$$\text{Berat keramik (1 cm)} = 0,01 \times 2400 \times 1 = 24 \text{ kg/m}^2$$

$$\text{Berat Spesi (2 cm)} = 0,02 \times 2100 \times 1 = 42 \text{ kg/m}^2$$

$$\text{Berat Pasir (2 cm)} = 0,02 \times 1600 \times 1 = 32 \text{ kg/m}^2$$

$$\text{Berat plat sendiri} = 0,12 \times 2400 \times 1 = 288 \text{ kg/m}^2$$

$$\text{Berat plafond + instalasi listrik} = 25 \text{ kg/m}^2 +$$

$$qD = 411 \text{ kg/m}^2$$

c. Beban Ultimate (qU)

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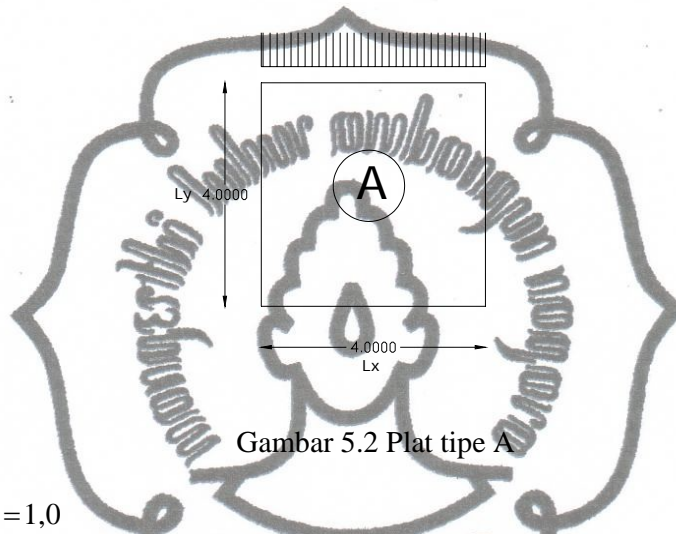


Untuk tinjauan lebar 1 m plat maka :

$$\begin{aligned} q_U &= 1,2 q_D + 1,6 q_L \\ &= 1,2 \cdot 411 + 1,6 \cdot 250 \\ &= 973,20 \text{ kg/m}^2 \end{aligned}$$

5.3. Perhitungan Momen

a. Tipe pelat A (kanopi)



Gambar 5.2 Plat tipe A

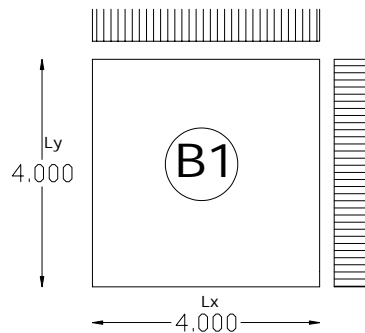
$$\frac{L_y}{L_x} = \frac{4,0}{4,0} = 1,0$$

$$M_{lx} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \cdot 653,2 \cdot (4,0)^2 \cdot 31 = 323,98 \text{ kg m}$$

$$M_{ly} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \cdot 653,2 \cdot (4,0)^2 \cdot 37 = 386,69 \text{ kg m}$$

$$M_{ty} = -0,001 \cdot q_u \cdot L_x^2 \cdot x = -0,001 \cdot 653,2 \cdot (4,0)^2 \cdot 84 = -877,9 \text{ kg}$$

b. Tipe pelat B1



Gambar 5.3 Plat tipe B1

$$\frac{L_y}{L_x} = \frac{4,0}{4,0} = 1,0$$

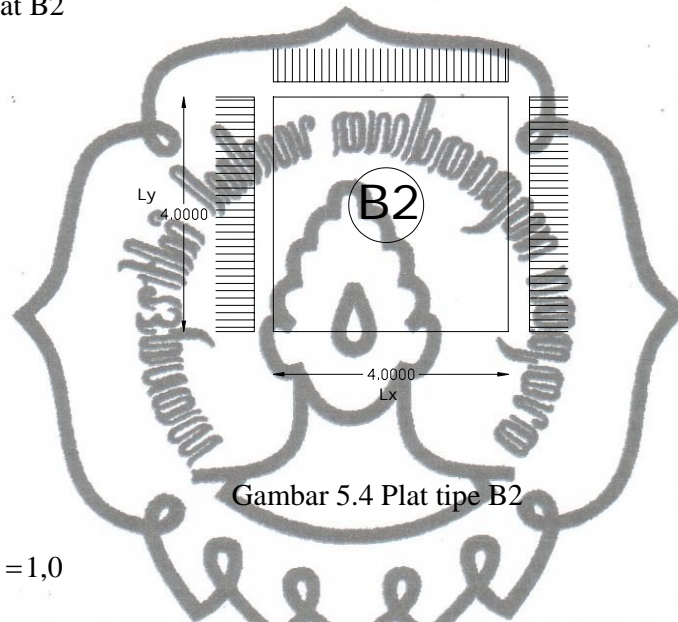
$$M_{lx} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \cdot 973,2 \cdot (4,0)^2 \cdot 28 = 435,99 \text{ kg m}$$

$$M_{ly} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \cdot 973,2 \cdot (4,0)^2 \cdot 28 = 435,99 \text{ kg m}$$

$$M_{tx} = -0,001 \cdot q_u \cdot L_x^2 \cdot x = -0,001 \cdot 973,2 \cdot (4,0)^2 \cdot 68 = -1058,84 \text{ kg m}$$

$$M_{ty} = -0,001 \cdot q_u \cdot L_x^2 \cdot x = -0,001 \cdot 973,2 \cdot (4,0)^2 \cdot 68 = -1058,84 \text{ kg m}$$

c. Tipe pelat B2



Gambar 5.4 Plat tipe B2

$$\frac{L_y}{L_x} = \frac{4,0}{4,0} = 1,0$$

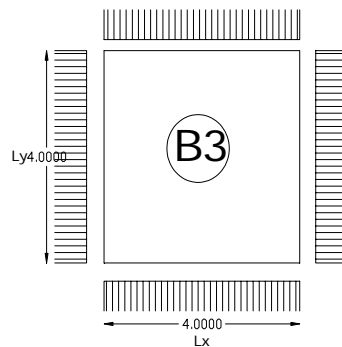
$$M_{lx} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \cdot 973,2 \cdot (4,0)^2 \cdot 26 = 404,85 \text{ kg m}$$

$$M_{ly} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \cdot 973,2 \cdot (4,0)^2 \cdot 21 = 327 \text{ kg m}$$

$$M_{tx} = -0,001 \cdot q_u \cdot L_x^2 \cdot x = -0,001 \cdot 973,2 \cdot (4,0)^2 \cdot 60 = -934,28 \text{ kg m}$$

$$M_{ty} = -0,001 \cdot q_u \cdot L_x^2 \cdot x = -0,001 \cdot 973,2 \cdot (4,0)^2 \cdot 55 = -856,42 \text{ kg m}$$

d. Tipe pelat B3



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Gambar 5.5 Plat tipe B3

$$\frac{L_y}{L_x} = \frac{4,0}{4,0} = 1,0$$

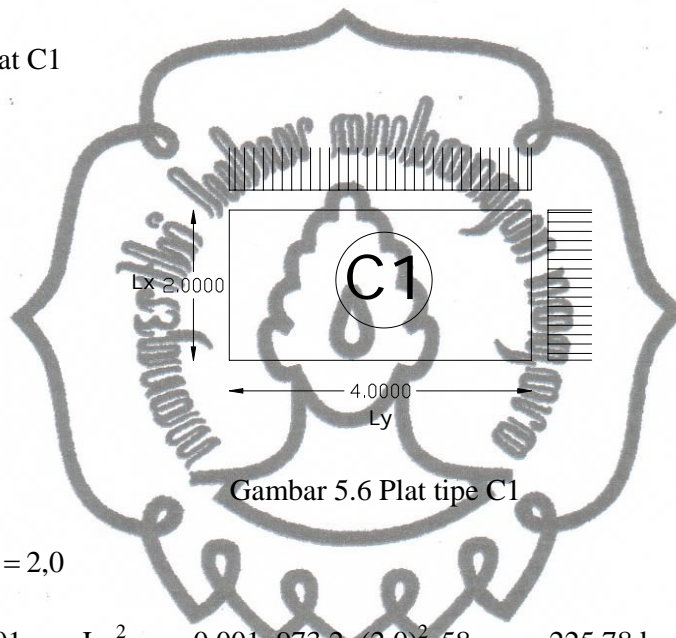
$$M_{lx} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \cdot 973,2 \cdot (4,0)^2 \cdot 21 = 327 \text{ kg m}$$

$$M_{ly} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \cdot 973,2 \cdot (4,0)^2 \cdot 21 = 327 \text{ kg m}$$

$$M_{tx} = -0,001 \cdot q_u \cdot L_x^2 \cdot x = -0,001 \cdot 973,2 \cdot (4,0)^2 \cdot 52 = -809,71 \text{ kg m}$$

$$M_{ty} = -0,001 \cdot q_u \cdot L_x^2 \cdot x = -0,001 \cdot 973,2 \cdot (4,0)^2 \cdot 52 = -809,71 \text{ kg m}$$

e. Tipe pelat C1



Gambar 5.6 Plat tipe C1

$$\frac{L_y}{L_x} = \frac{4,0}{2,0} = 2,0$$

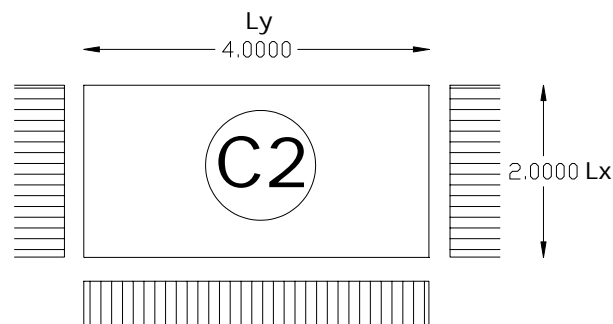
$$M_{lx} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \cdot 973,2 \cdot (2,0)^2 \cdot 58 = 225,78 \text{ kg m}$$

$$M_{ly} = 0,001 \cdot q_u \cdot L_x^2 \cdot x = 0,001 \cdot 973,2 \cdot (2,0)^2 \cdot 19 = 73,96 \text{ kg m}$$

$$M_{tx} = -0,001 \cdot q_u \cdot L_x^2 \cdot x = -0,001 \cdot 973,2 \cdot (2,0)^2 \cdot 118 = -459,75 \text{ kg m}$$

$$M_{ty} = -0,001 \cdot q_u \cdot L_x^2 \cdot x = -0,001 \cdot 973,2 \cdot (2,0)^2 \cdot 79 = -307,53 \text{ kg m}$$

f. Tipe pelat C2



Gambar 5.7 Plat tipe B3

$$\frac{Ly}{Lx} = \frac{4,0}{2,0} = 2,0$$

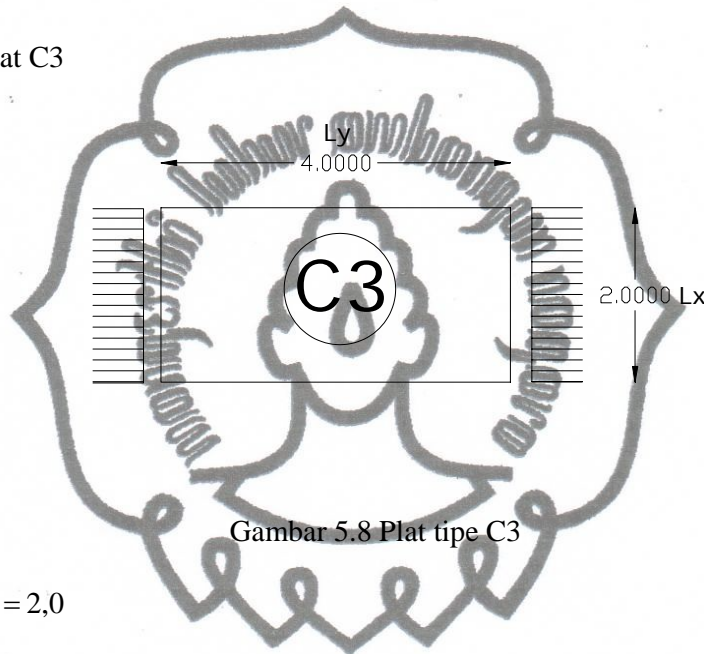
$$Mlx = 0,001 \cdot qu \cdot Lx^2 \cdot x = 0.001 \cdot 973,2 \cdot (2,0)^2 \cdot .55 = 214,104 \text{ kg m}$$

$$Mly = 0,001 \cdot qu \cdot Lx^2 \cdot x = 0.001 \cdot 973,2 \cdot (2,0)^2 \cdot .21 = 81,75 \text{ kg m}$$

$$Mtx = - 0,001 \cdot qu \cdot Lx^2 \cdot x = - 0.001 \cdot 973,2 \cdot (2,0)^2 \cdot .114 = - 443,78 \text{ kg m}$$

$$Mty = - 0,001 \cdot qu \cdot Lx^2 \cdot x = - 0.001 \cdot 973,2 \cdot (2,0)^2 \cdot .78 = - 303,64 \text{ kgm}$$

g. Tipe pelat C3



Gambar 5.8 Plat tipe C3

$$\frac{Ly}{Lx} = \frac{4,0}{2,0} = 2,0$$

$$Mlx = 0,001 \cdot qu \cdot Lx^2 \cdot x = 0.001 \cdot 973,2 \cdot (2,0)^2 \cdot .85 = 330,88 \text{ kg m}$$

$$Mly = 0,001 \cdot qu \cdot Lx^2 \cdot x = 0.001 \cdot 973,2 \cdot (2,0)^2 \cdot .39 = 151,82 \text{ kg m}$$

$$Mty = - 0,001 \cdot qu \cdot Lx^2 \cdot x = - 0.001 \cdot 973,2 \cdot (2,0)^2 \cdot .119 = - 463,24 \text{ kgm}$$

5.4. Penulangan Plat Lantai

Tabel 5.1. Perhitungan Plat Lantai

Tipe Plat	Ly/Lx (m)	Mlx (kgm)	Mly (kgm)	Mtx (kgm)	Mty (kgm)
A	4,0/4,0 = 1	323,98	386,69	-	-877,9
B1	4,0/4,0 = 1	435,99	435,99	- 1058,84	- 1058,84
B2	4,0/4,0 = 1	404,85	327	- 937,28	- 856,42
B3	4,0/4,0 = 1	327	327	- 809,71	- 809,71
C1	4,0/2,0= 2	205,78	73,96	- 459,75	- 307,53



C2	4,0/2,0= 2	214,104	81,75	- 443,78	- 303,64
C3	4,0/2,0= 2	330,88	151,82	-	- 463,24

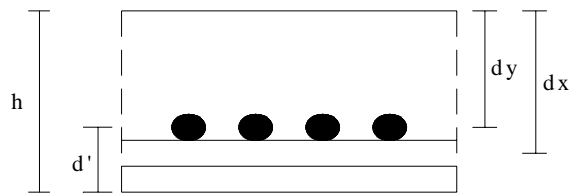
Dari perhitungan momen diambil momen terbesar yaitu:

- Mlx = 435,99 kgm
- Mly = 435,99 kgm
- Mtx = - 1058,84 kgm
- Mty = - 1058,84 kgm

Data – data plat :

- Tebal plat (h) = 12 cm = 120 mm
- Diameter tulangan (Ø) = 10 mm
- fy = 240 MPa
- f'c = 25 MPa
- b = 1000 mm
- p = 20 mm
- Tebal penutup (d') = p + ½Ø tul = 20 + 5 = 25 mm
- Tinggi Efektif (d) = h - d' = 120 - 25 = 95 mm

Tinggi efektif



Gambar 5.9 Perencanaan Tinggi Efektif

$$dx = h - p - \frac{1}{2}\phi$$

$$= 120 - 20 - 5 = 95 \text{ mm}$$

$$d_y = h - d' - \emptyset - \frac{1}{2} \emptyset$$

$$= 120 - 20 - 10 - \frac{1}{2} \cdot 10 = 85 \text{ mm}$$

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

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

$$= 0,05376$$

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

$$= 0,75 \cdot 0,05376$$

$$= 0,04032$$

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

5.5. Penulangan tumpuan arah x

$$M_u = 1058,84 \text{ kgm} = 10,5884 \cdot 10^6 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{10,5884 \cdot 10^6}{0,8} = 13,2355 \cdot 10^6 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d_x^2} = \frac{13,2355 \cdot 10^6}{1000 \cdot (95)^2} = 1,466 \text{ N/mm}^2$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{240}{0,85 \cdot 25} = 11,2942$$

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

$$= \frac{1}{11,2942} \cdot \left(1 - \sqrt{1 - \frac{2 \cdot 11,2942 \cdot 1,466}{240}} \right)$$

$$= 0,00633$$

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

$$\rho > \rho_{\min}, \text{ di pakai } \rho_{\text{perlu}} = 0,00633$$

$$A_{S_{\text{perlu}}} = \rho_{\text{perlu}} \cdot b \cdot d_x$$

$$= 0,00633 \cdot 1000 \cdot 95$$

commit to user



$$= 598,5 \text{ mm}^2$$

Digunakan tulangan $\varnothing 10$

$$A_s = \frac{1}{4} \cdot \pi \cdot (10)^2$$

$$= 78,5 \text{ mm}^2$$

$$S = \frac{A_s \cdot b}{A_{s_{\text{perlu}}}} = \frac{78,5 \cdot 1000}{598,5}$$

$$= 129,72 \sim 125 \text{ mm}$$

$$n = \frac{b}{s}$$

$$= \frac{1000}{125}$$

$$= 8$$

$$A_{s_{\text{ada}}} = 8 \cdot \frac{1}{4} \cdot \pi \cdot (10)^2$$

$$= 628 \text{ mm}^2 > A_{s_{\text{perlu}}} \dots \dots \text{OK} \text{ ☺}$$

Dipakai tulangan $\varnothing 10 - 120 \text{ mm}$

Cek kapasitas lentur :

$$a = \frac{A_{s_{\text{ada}}} \cdot f_y}{0,85 \cdot f'_c \cdot b} = \frac{628 \cdot 240}{0,85 \cdot 25 \cdot 1000}$$

$$= 7,093 \text{ mm}$$

$$M_n = A_{s_{\text{ada}}} \cdot f_y \cdot (d - a/2)$$

$$= 13,784 \cdot 10^6 \text{ Nmm}$$

$M_n \text{ ada} > M_n \rightarrow \text{OK} \text{ ☺}$

5.6. Penulangan tumpuan arah y

$$M_u = 1058,84 \text{ kgm} = 10,5884 \cdot 10^6 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{10,5884 \cdot 10^6}{0,8} = 13,2355 \cdot 10^6 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{13,2355 \cdot 10^6}{1000 \cdot (95)^2} = 1,466 \text{ N/mm}^2$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{240}{0,85 \cdot 25} = 11,2942$$

$$\begin{aligned}\rho_{\text{perlu}} &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2m \cdot Rn}{f_y}} \right) \\ &= \frac{1}{11,2942} \cdot \left(1 - \sqrt{1 - \frac{2 \cdot 11,2942 \cdot 1,466}{240}} \right) \\ &= 0,00633\end{aligned}$$

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

$$\rho > \rho_{\text{min}}, \text{ di pakai } \rho_{\text{perlu}} = 0,00633$$

$$\begin{aligned}A_{s_{\text{perlu}}} &= \rho_{\text{perlu}} \cdot b \cdot d_x \\ &= 0,00633 \cdot 1000 \cdot 95 \\ &= 598,5 \text{ mm}^2\end{aligned}$$

Digunakan tulangan $\varnothing 10$

$$\begin{aligned}A_s &= \frac{1}{4} \cdot \pi \cdot (10)^2 \\ &= 78,5 \text{ mm}^2\end{aligned}$$

$$\begin{aligned}S &= \frac{A_s \cdot b}{A_{s_{\text{perlu}}}} = \frac{78,5 \cdot 1000}{598,5} \\ &= 129,72 \sim 125 \text{ mm}\end{aligned}$$

$$\begin{aligned}n &= \frac{b}{s} \\ &= \frac{1000}{125} \\ &= 8\end{aligned}$$

$$\begin{aligned}A_{s_{\text{ada}}} &= 8 \cdot \frac{1}{4} \cdot \pi \cdot (10)^2 \\ &= 628 \text{ mm}^2 > A_{s_{\text{perlu}}} \dots \dots \text{ OK } \odot\end{aligned}$$

Cek kapasitas lentur :

$$\begin{aligned}a &= \frac{A_{s_{\text{ada}}} \cdot f_y}{0,85 \cdot f'c \cdot b} = \frac{628 \cdot 240}{0,85 \cdot 25 \cdot 1000} \\ &= 7,093 \text{ mm}\end{aligned}$$

$$\begin{aligned}M_n &= A_{s_{\text{ada}}} \cdot f_y \cdot (d - a/2) \\ &= 13,784 \cdot 10^6 \text{ Nmm}\end{aligned}$$

$$M_n \text{ ada} > M_n = 13,784 \cdot 10^6 > 13,2355 \cdot 10^6 \rightarrow \text{ OK } \odot$$

commit to user



5.7. Penulangan lapangan arah x

$$M_u = 435,99 \text{ kgm} = 4,35599 \cdot 10^6 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{4,35599 \cdot 10^6}{0,8} = 5,44 \cdot 10^6 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d x^2} = \frac{5,44 \cdot 10^6}{1000 \cdot (95)^2} = 0,602 \text{ N/mm}^2$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{240}{0,85 \cdot 25} = 11,294$$

$$\begin{aligned} \rho_{\text{perlu}} &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2m \cdot R_n}{f_y}} \right) \\ &= \frac{1}{11,294} \left(1 - \sqrt{1 - \frac{2 \cdot 11,294 \cdot 0,602}{240}} \right) \\ &= 0,00255 \end{aligned}$$

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

$$\rho > \rho_{\text{min}}, \text{ di pakai } \rho_{\text{perlu}} = 0,00255$$

$$\begin{aligned} A_s &= \rho_{\text{min}} \cdot b \cdot d x \\ &= 0,00255 \cdot 1000 \cdot 95 \\ &= 242,25 \text{ mm}^2 \end{aligned}$$

Digunakan tulangan $\varnothing 10$

$$\begin{aligned} A_s &= \frac{1}{4} \cdot \pi \cdot (10)^2 \\ &= 78,5 \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} S &= \frac{A_s \cdot b}{A_{s \text{ perlu}}} = \frac{78,5 \cdot 1000}{242,25} \\ &= 324,045 \sim 330 \text{ mm} \end{aligned}$$

$$\begin{aligned} \text{Jarak maksimum} &= 2 \times h \\ &= 2 \times 120 \\ &= 240 \text{ mm} \end{aligned}$$

$$\begin{aligned} n &= \frac{b}{s} \\ &= \frac{1000}{240} = 4,2 \sim 5 \end{aligned}$$

$$\begin{aligned} A_s \text{ ada} &= 5 \cdot \frac{1}{4} \cdot \pi \cdot (10)^2 \\ &= 392,5 \text{ mm}^2 > A_s \dots \dots \dots \text{OK} \text{ ☺} \end{aligned}$$

Dipakai tulangan $\varnothing 10 - 240 \text{ mm}$

Cek kapasitas lentur :

$$\begin{aligned} a &= \frac{A_s \text{ ada} \cdot f_y}{0,85 \cdot f'_c \cdot b} = \frac{392,5 \cdot 240}{0,85 \cdot 25 \cdot 1000} \\ &= 4,433 \text{ mm} \end{aligned}$$

$$\begin{aligned} M_n &= A_s \text{ ada} \cdot f_y \cdot (d - a/2) \\ &= 8,740 \cdot 10^6 \text{ Nmm} \end{aligned}$$

$$M_n \text{ ada} > M_n = 8,740 \cdot 10^6 > 5,44 \cdot 10^6 \rightarrow \text{OK} \text{ ☺}$$

5.8. Penulangan lapangan arah y

$$M_u = 435,99 \text{ kgm} = 4,35599 \cdot 10^6 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{4,35599 \cdot 10^6}{0,8} = 5,44 \cdot 10^6 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d x^2} = \frac{5,44 \cdot 10^6}{1000 \cdot (95)^2} = 0,602 \text{ N/mm}^2$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{240}{0,85 \cdot 25} = 11,294$$

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

$$= \frac{1}{11,294} \left(1 - \sqrt{1 - \frac{2 \cdot 11,294 \cdot 0,602}{240}} \right)$$

$$= 0,00255$$

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

$$\rho > \rho_{\text{min}}, \text{ di pakai } \rho_{\text{perlu}} = 0,00255$$

$$\begin{aligned} A_s &= \rho_{\text{min}} \cdot b \cdot d x \\ &= 0,00255 \cdot 1000 \cdot 95 \\ &= 242,25 \text{ mm}^2 \end{aligned}$$

Digunakan tulangan $\varnothing 10$

$$A_s = \frac{1}{4} \cdot \pi \cdot (10)^2$$



$$= 78,5 \text{ mm}^2$$

$$S = \frac{As \cdot b}{As_{\text{perlu}}} = \frac{78,5 \cdot 1000}{242,25}$$

$$= 324,045 \sim 330 \text{ mm}$$

$$\text{Jarak maksimum} = 2 \times h$$

$$= 2 \times 120$$

$$= 240 \text{ mm}$$

$$n = \frac{b}{s}$$

$$= \frac{1000}{240} = 4,2 \sim 5$$

$$\begin{aligned} \text{As ada} &= 5 \cdot \frac{1}{4} \cdot \pi \cdot (10)^2 \\ &= 392,5 \text{ mm}^2 > \text{As} \dots \dots \dots \text{OK} \text{ ☺} \end{aligned}$$

Dipakai tulangan $\text{Ø } 10 - 240 \text{ mm}$

Cek kapasitas lentur :

$$\begin{aligned} a &= \frac{As_{\text{ada}} \cdot fy}{0,85 \cdot f'c \cdot b} = \frac{392,5 \cdot 240}{0,85 \cdot 25 \cdot 1000} \\ &= 4,433 \text{ mm} \end{aligned}$$

$$M_n = As_{\text{ada}} \cdot fy \cdot (d - a/2)$$

$$= 8,740 \cdot 10^6 \text{ Nmm}$$

$$M_n \text{ ada} > M_n = 8,740 \cdot 10^6 > 5,44 \cdot 10^6 \rightarrow \text{OK} \text{ ☺}$$

5.9. Rekapitulasi Tulangan

Dari perhitungan diatas diperoleh :

Tulangan lapangan arah x $\text{Ø } 10 - 240 \text{ mm}$

Tulangan lapangan arah y $\text{Ø } 10 - 240 \text{ mm}$

Tulangan tumpuan arah x $\text{Ø } 10 - 120 \text{ mm}$

Tulangan tumpuan arah y $\text{Ø } 10 - 120 \text{ mm}$

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	323,98	386,69	-	-877,9	Ø10-200	Ø10-240	Ø10-125	Ø10-125
B1	435,99	435,99	-	-	Ø10-200	Ø10-200	Ø10-125	Ø10-125
B2	404,85	327	- 937,28	- 856,42	Ø10-200	Ø10-200	Ø10-125	Ø10-125
B3	327	327	- 809,71	- 809,71	Ø10-200	Ø10-200	Ø10-125	Ø10-125
C1	205,78	73,96	- 459,75	- 307,53	Ø10-200	Ø10-200	Ø10-125	Ø10-125
C2	214,104	81,75	- 443,78	- 303,64	Ø10-200	Ø10-200	Ø10-125	Ø10-125
C3	330,88	151,82	-	- 463,24	Ø10-200	Ø10-200	Ø10-125	Ø10-125

5.10. Perencanaan Plat Atap

5.11. Perhitungan Pembebanan Plat Atap

d. Beban Hidup (qL)

Berdasarkan PPIUG 1989 yaitu :

$$\text{Beban hidup Atap Kanopi} = 100 \text{ kg/m}^2$$

e. Beban Mati (qD)

$$\text{Berat plat sendiri} = 0,10 \times 2400 \times 1 = 240 \text{ kg/m}^2$$

$$\text{Berat plafond + instalasi listrik} = 25 \text{ kg/m}^2 +$$

$$qD = 265 \text{ kg/m}^2$$

f. Beban Ultimate (qU)

Untuk tinjauan lebar 1 m plat maka :

$$qU = 1,2 qD + 1,6 qL$$

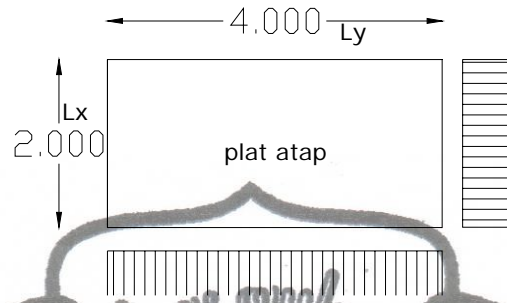
$$= 1,2 \cdot 265 + 1,6 \cdot 100$$



$$= 478 \text{ kg/m}^2$$

5.12. Perhitungan Momen

a. Tipe pelat 1



Gambar 5.10 Tipe plat

$$\frac{Ly}{Lx} = \frac{4,0}{2,0} = 2,0$$

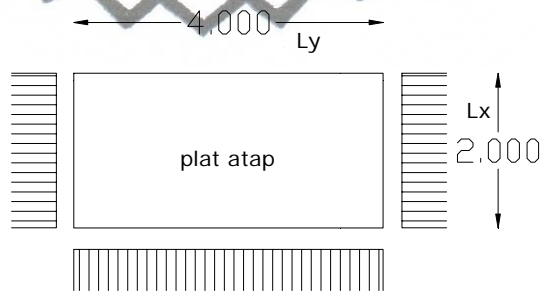
$$Mlx = 0,001 \cdot qu \cdot Lx^2 \cdot x = 0,001 \cdot 478 \cdot (2,0)^2 \cdot 58 = 110,896 \text{ kg m}$$

$$Mly = 0,001 \cdot qu \cdot Lx^2 \cdot x = 0,001 \cdot 478 \cdot (2,0)^2 \cdot 19 = 36,328 \text{ kg m}$$

$$Mtx = - 0,001 \cdot qu \cdot Lx^2 \cdot x = - 0,001 \cdot 478 \cdot (2,0)^2 \cdot 118 = - 225,616 \text{ kg m}$$

$$Mty = - 0,001 \cdot qu \cdot Lx^2 \cdot x = - 0,001 \cdot 478 \cdot (2,0)^2 \cdot 79 = - 151,048 \text{ kg m}$$

a. Tipe pelat 2



Gambar 5.11 Tipe plat

$$\frac{Ly}{Lx} = \frac{4,0}{2,0} = 2,0$$

$$Mlx = 0,001 \cdot qu \cdot Lx^2 \cdot x = 0,001 \cdot 478 \cdot (2,0)^2 \cdot 55 = 105,16 \text{ kg m}$$

$$Mly = 0,001 \cdot qu \cdot Lx^2 \cdot x = 0,001 \cdot 478 \cdot (2,0)^2 \cdot 21 = 40,152 \text{ kg m}$$

$$Mtx = - 0,001 \cdot qu \cdot Lx^2 \cdot x = - 0,001 \cdot 478 \cdot (2,0)^2 \cdot 114 = - 217,968 \text{ kg m}$$

$$M_{ty} = - 0,001 \cdot q_u \cdot Lx^2 \cdot x = - 0.001 \cdot 478 \cdot (2,0)^2 \cdot 78 = - 149,136 \text{ kgm}$$

Dari perhitungan momen diambil momen terbesar yaitu:

$$M_{lx} = 110,896 \text{ kgm}$$

$$M_{ly} = 40,152 \text{ kgm}$$

$$M_{tx} = 225,616 \text{ kgm}$$

$$M_{ty} = 151,048 \text{ kgm}$$

5.13. Penulangan plat atap

Data – data plat :

$$\text{Tebal plat (h)} = 10 \text{ cm}$$

$$= 100 \text{ mm}$$

$$\text{Diameter tulangan (} \varnothing \text{)} = 8 \text{ mm}$$

$$f_y = 240 \text{ MPa}$$

$$f'_c = 25 \text{ MPa}$$

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

$$\text{Tebal penutup (d')} = p + \frac{1}{2} \varnothing \text{ tul}$$

$$= 20 + 4$$

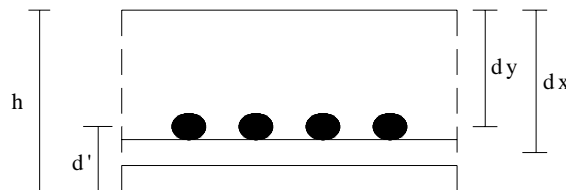
$$= 24 \text{ mm}$$

$$\text{Tinggi Efektif (d)} = h - d'$$

$$= 120 - 24$$

$$= 96 \text{ mm}$$

Tinggi efektif





Gambar 5.5 Perencanaan Tinggi Efektif

$$\begin{aligned} dx &= h - p - \frac{1}{2}\emptyset \\ &= 100 - 20 - 4 = 76 \text{ mm} \\ dy &= h - d' - \emptyset - \frac{1}{2}\emptyset \\ &= 100 - 20 - 8 - \frac{1}{2} \cdot 8 = 68 \text{ mm} \end{aligned}$$

$$\begin{aligned} \rho_b &= \frac{0,85 \cdot f_c}{f_y} \cdot \beta \cdot \left(\frac{600}{600 + f_y} \right) \\ &= \frac{0,85 \cdot 25}{240} \cdot 0,85 \cdot \left(\frac{600}{600 + 240} \right) \\ &= 0,05376 \\ \rho_{\max} &= 0,75 \cdot \rho_b \\ &= 0,75 \cdot 0,05376 \\ &= 0,04032 \\ \rho_{\min} &= 0,0025 \end{aligned}$$

5.14. Penulangan tumpuan arah x

$$\begin{aligned} M_u &= 225,616 \text{ kgm} = 2,528 \cdot 10^6 \text{ Nmm} \\ M_n &= \frac{M_u}{\phi} = \frac{2,528 \cdot 10^6}{0,8} = 3,16 \cdot 10^6 \text{ Nmm} \\ R_n &= \frac{M_n}{b \cdot dx^2} = \frac{3,16 \cdot 10^6}{1000 \cdot (76)^2} = 0,547 \text{ N/mm}^2 \\ m &= \frac{f_y}{0,85 \cdot f'_c} = \frac{240}{0,85 \cdot 25} = 11,2942 \\ \rho_{\text{perlu}} &= \frac{1}{m} \cdot \left(1 - \sqrt{1 - \frac{2m \cdot R_n}{f_y}} \right) \\ &= \frac{1}{11,2942} \cdot \left(1 - \sqrt{1 - \frac{2 \cdot 11,2942 \cdot 0,547}{240}} \right) \\ &= 0,002 \\ \rho &< \rho_{\max} \end{aligned}$$

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

$$\begin{aligned} A_{S\text{perlu}} &= \rho_{\min} \cdot b \cdot dx \\ &= 0,0025 \cdot 1000 \cdot 76 \\ &= 190 \text{ mm}^2 \end{aligned}$$

Digunakan tulangan $\varnothing 8$

$$\begin{aligned} A_s &= \frac{1}{4} \cdot \pi \cdot (8)^2 \\ &= 50,24 \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} S &= \frac{A_s \cdot b}{A_{S\text{perlu}}} = \frac{50,24 \cdot 1000}{190} \\ &= 264,42 \sim 200 \text{ mm} \rightarrow (S_{\max} = 2h) \end{aligned}$$

$$\begin{aligned} n &= \frac{b}{s} \\ &= \frac{1000}{200} \\ &= 5 \end{aligned}$$

$$\begin{aligned} A_{s\text{ada}} &= 5 \cdot \frac{1}{4} \cdot \pi \cdot (8)^2 \\ &= 251,2 \text{ mm}^2 > A_{S\text{perlu}} \dots \dots \text{OK} \text{ 😊} \end{aligned}$$

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

5.15. Penulangan tumpuan arah y

$$M_u = 151,048 \text{ kgm} = 1,6925 \cdot 10^6 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{1,6925 \cdot 10^6}{0,8} = 2,036 \cdot 10^6 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot dx^2} = \frac{2,036 \cdot 10^6}{1000 \cdot (76)^2} = 0,3525 \text{ N/mm}^2$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{240}{0,85 \cdot 25} = 11,2942$$

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



$$= \frac{1}{11,2942} \cdot \left(1 - \sqrt{1 - \frac{2.11,2942.0,3525}{240}} \right)$$

$$= 0,00148$$

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

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

$$A_{s\text{perlu}} = \rho_{\min} \cdot b \cdot dx$$

$$= 0,0025 \cdot 1000 \cdot 76$$

$$= 190 \text{ mm}^2$$

Digunakan tulangan $\varnothing 8$

$$A_s = \frac{1}{4} \cdot \pi \cdot (8)^2$$

$$= 50,24 \text{ mm}^2$$

$$S = \frac{A_s \cdot b}{A_{s\text{perlu}}} = \frac{50,24 \cdot 1000}{190}$$

$$= 264,42 \sim 200 \text{ mm} \rightarrow (S_{\max} = 2h)$$

$$n = \frac{b}{s}$$

$$= \frac{1000}{200}$$

$$= 5$$

$$A_{s\text{ada}} = 5 \cdot \frac{1}{4} \cdot \pi \cdot (8)^2$$

$$= 251,2 \text{ mm}^2 > A_{s\text{perlu}} \dots \dots \text{OK } \textcircled{\smile}$$

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

5.16. Penulangan lapangan arah x

$$M_u = 110,896 \text{ kgm} = 1,2426 \cdot 10^6 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{1,2426 \cdot 10^6}{0,8} = 1,55 \cdot 10^6 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot dx^2} = \frac{1,55 \cdot 10^6}{1000 \cdot (76)^2} = 0,268 \text{ N/mm}^2$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{240}{0,85 \cdot 25} = 11,294$$

$$\begin{aligned}\rho_{\text{perlu}} &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2m \cdot Rn}{f_y}} \right) \\ &= \frac{1}{11,294} \left(1 - \sqrt{1 - \frac{2 \cdot 11,294 \cdot 0,268}{240}} \right) \\ &= 0,001123\end{aligned}$$

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

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

$$\begin{aligned}A_{s_{\text{perlu}}} &= \rho_{\text{min}} \cdot b \cdot d_x \\ &= 0,0025 \cdot 1000 \cdot 76 \\ &= 190 \text{ mm}^2\end{aligned}$$

Digunakan tulangan $\varnothing 8$

$$\begin{aligned}A_s &= \frac{1}{4} \cdot \pi \cdot (8)^2 \\ &= 50,24 \text{ mm}^2\end{aligned}$$

$$\begin{aligned}S &= \frac{A_s \cdot b}{A_{s_{\text{perlu}}}} = \frac{50,24 \cdot 1000}{190} \\ &= 264,42 \sim 200 \text{ mm} \rightarrow (S_{\text{max}} = 2h)\end{aligned}$$

$$\begin{aligned}n &= \frac{b}{s} \\ &= \frac{1000}{200} \\ &= 5\end{aligned}$$

$$\begin{aligned}A_{s \text{ ada}} &= 5 \cdot \frac{1}{4} \cdot \pi \cdot (8)^2 \\ &= 251,2 \text{ mm}^2 > A_{s_{\text{perlu}}} \dots \dots \text{ OK } \odot\end{aligned}$$

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

5.17. Penulangan lapangan arah y

$$M_u = 40,152 \text{ kgm} = 0,4499 \cdot 10^6 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{0,4499 \cdot 10^6}{0,8} = 5,623 \cdot 10^5 \text{ Nmm}$$



$$R_n = \frac{M_n}{b \cdot d x^2} = \frac{5,623 \cdot 10^5}{1000 \cdot (95)^2} = 0,097 \text{ N/mm}^2$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{240}{0,85 \cdot 25} = 11,294$$

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

$$= \frac{1}{11,294} \left(1 - \sqrt{1 - \frac{2 \cdot 11,294 \cdot 0,097}{240}} \right)$$

$$= 0,000405$$

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

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

$$\begin{aligned} A_{s_{\text{perlu}}} &= \rho_{\text{min}} \cdot b \cdot d x \\ &= 0,0025 \cdot 1000 \cdot 76 \\ &= 190 \text{ mm}^2 \end{aligned}$$

Digunakan tulangan $\varnothing 8$

$$\begin{aligned} A_s &= \frac{1}{4} \cdot \pi \cdot (8)^2 \\ &= 50,24 \text{ mm}^2 \end{aligned}$$

$$S = \frac{A_s \cdot b}{A_{s_{\text{perlu}}}} = \frac{50,24 \cdot 1000}{190}$$

$$= 264,42 \sim 200 \text{ mm} \longrightarrow (S_{\text{max}} = 2h)$$

$$n = \frac{b}{s}$$

$$= \frac{1000}{200}$$

$$= 5$$

$$A_s \text{ ada} = 5 \cdot \frac{1}{4} \cdot \pi \cdot (8)^2$$

$$= 251,2 \text{ mm}^2 > A_{s_{\text{perlu}}} \dots \dots \text{ OK } \text{☺}$$

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

5.18. Rekapitulasi Tulangan

Dari perhitungan diatas diperoleh :

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

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

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

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

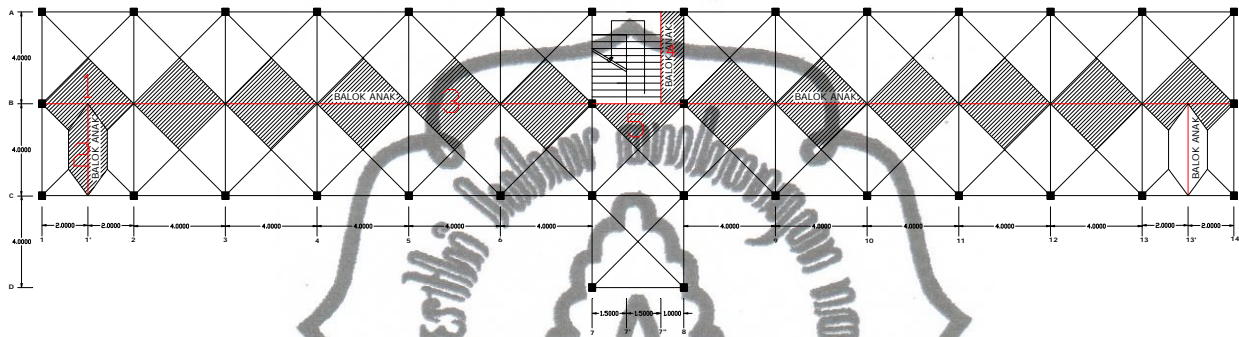




BAB 6

PERENCANAAN BALOK ANAK

6.1. Perencanaan Balok Anak



Gambar 6.1. Denah Rencana Balok Anak

Keterangan :

Balok Anak : As B(1-12)

Balok Anak : As 1'(B-C)

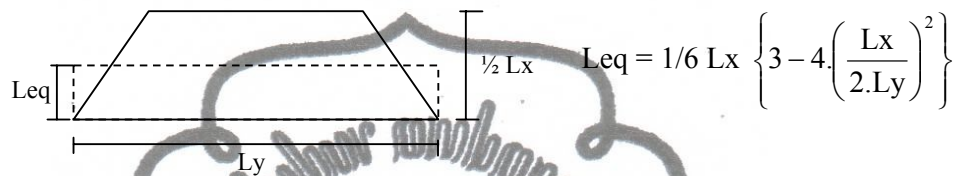
Balok Anak : As 7''(A-B)



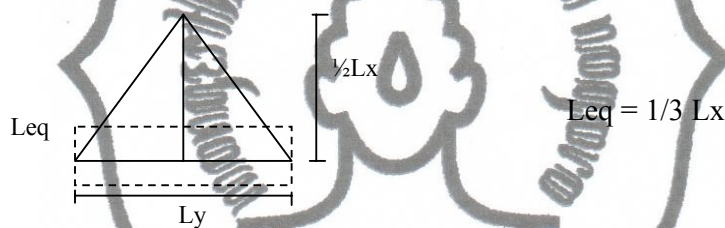
6.1.1. Perhitungan Lebar Equivalen

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. Perhitungan Lebar Equivalen

No.	Ukuran Plat (m ²)	Lx (m)	Ly (m)	Leq (segitiga)	Leq (trapesium)
1.	4 x 4	4	4	1,34	
2.	2 x 4	2	4		0,9167
3.	4 x 4	4	4	1,34	
4.	1 x 4	1	4	0,34	0,489



Beban Plat Lantai

➤ Beban Mati (qd)

$$\text{Beban plat sendiri} = 0,12 \cdot 2400 = 288 \text{ kg/m}^2$$

$$\text{Beban spesi pasangan} = 0,02 \cdot 2100 = 42 \text{ kg/m}^2$$

$$\text{Beban pasir} = 0,02 \cdot 1600 = 32 \text{ kg/m}^2$$

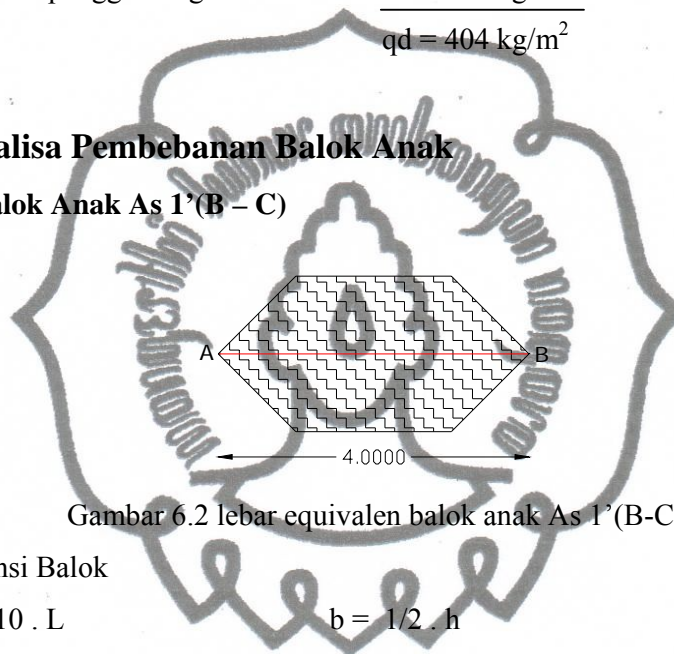
$$\text{Beban keramik} = 0,01 \cdot 2400 = 24 \text{ kg/m}^2$$

$$\text{Plafond + penggantung} = 11 + 7 = 18 \text{ kg/m}^2$$

$$\text{qd} = 404 \text{ kg/m}^2$$

6.2. Analisa Pembebanan Balok Anak

6.2.1. Balok Anak As 1'(B - C)



Gambar 6.2 lebar equivalen balok anak As 1'(B-C)

a. Dimensi Balok

$$h = 1/10 \cdot L$$

$$= 1/10 \cdot 4000$$

$$= 400 \text{ mm}$$

$$b = 1/2 \cdot h$$

$$= 1/2 \times 400$$

$$= 200 \text{ mm} - 250 \text{ mm}$$

b. Pembebanan Setiap Elemen

➤ Beban Mati (qd) → Bidang 2

$$\text{Berat sendiri balok} = 0,2 \times (0,4 - 0,12) \times 2400 = 168 \text{ kg/m'}$$

$$\text{Berat plat} = (2 \times 0,967) \times 404 = 781,336 \text{ kg/m'}$$

$$\text{Berat dinding} = 0,15 \times (3 - 0,2) \times 1700 = 714 \text{ kg/m'}$$

$$\text{qd} = 1663,336 \text{ kg/m'}$$

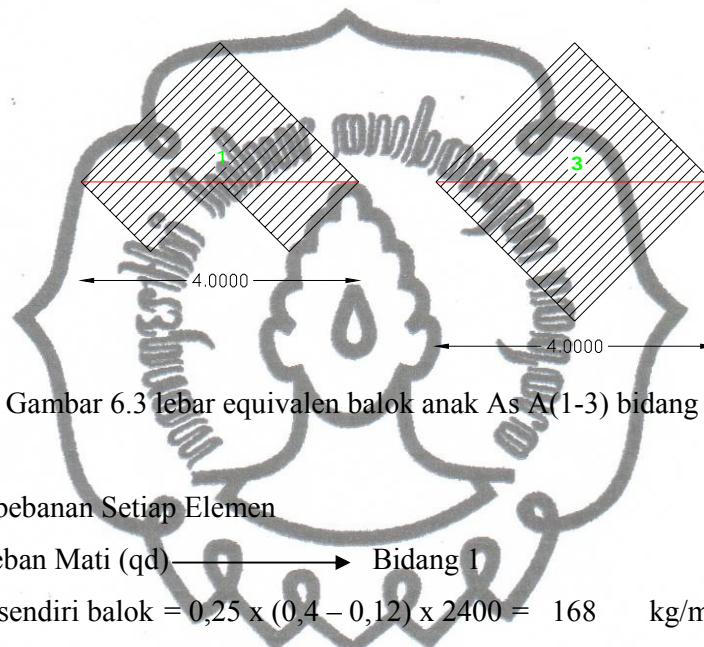
➤ Beban Hidup (ql) = 250.1,934 = 483,5 kg/m'



6.2.2. Balok Anak As B (1 - 7)=As B(8-14)

a. Dimensi Balok

$$\begin{aligned}
 h &= 1/10 \cdot L & b &= 1/2 \cdot h \\
 &= 1/10 \cdot 4000 & &= 1/2 \cdot 400 \\
 &= 400 \sim 400 \text{ mm} & &= 200 - 250 \text{ mm}
 \end{aligned}$$



Gambar 6.3 lebar equivalen balok anak As A(1-3) bidang 1 dan 3

b. Pembebanan Setiap Elemen

➤ Beban Mati (qd) → Bidang 1

$$\begin{aligned}
 \text{Berat sendiri balok} &= 0,25 \times (0,4 - 0,12) \times 2400 = 168 \text{ kg/m}^{\prime} \\
 \text{Berat plat} &= ((2 \times 0,67) + 1,34) \times 404 = 1082,72 \text{ kg/m}^{\prime} \\
 \text{Berat dinding} &= 0,15 \times (3 - 0,2) \times 1700 = 714 \text{ kg/m}^{\prime} \\
 \text{qd} &= 1964,72 \text{ kg/m}^{\prime}
 \end{aligned}$$

➤ Beban Mati (qd) → Bidang 3

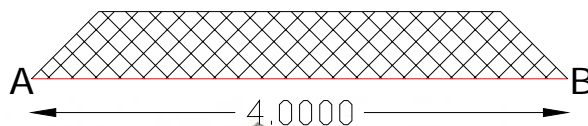
$$\begin{aligned}
 \text{Berat sendiri balok} &= 0,2 \times (0,4 - 0,12) \times 2400 = 168 \text{ kg/m}^{\prime} \\
 \text{Berat plat} &= (2 \times 1,34) \times 404 = 1082,72 \text{ kg/m}^{\prime} \\
 \text{qd} &= 1250,72 \text{ kg/m}^{\prime}
 \end{aligned}$$

➤ Beban Hidup (ql)

$$\begin{aligned}
 \text{Bidang 1} &= 250 \cdot ((2 \times 0,67) + 1,34) = 670 \text{ kg/m}^{\prime} \\
 \text{Bidang 3} &= 250 \cdot (2 \times 1,34) = 670 \text{ kg/m}^{\prime}
 \end{aligned}$$



6.2.3. Balok Anak As 7''(A-B)



Gambar 6.2 lebar equivalen balok anak As 7''(A-B)

a. Dimensi Balok

$$h = 1/10 \cdot L$$

$$= 1/10 \cdot 4000$$

$$= 400 \text{ mm}$$

$$b = 1/2 \cdot h$$

$$= 1/2 \times 400$$

$$= 200 \text{ mm} - 250 \text{ mm}$$

b. Pembebanan Setiap Elemen

➤ Beban Mati (qd)

$$\text{Berat sendiri balok} = 0,2 \times (0,4 - 0,12) \times 2400 = 168 \text{ kg/m}^2$$

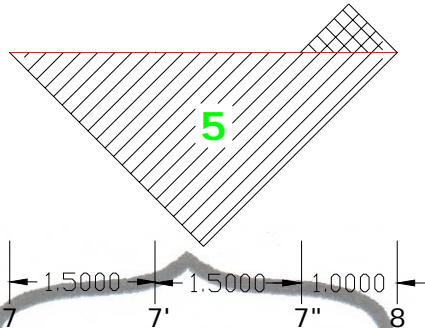
$$\text{Berat plat} = 0,489 \times 404 = 197,556 \text{ kg/m}^2$$

$$q_d = 365,556 \text{ kg/m}^2$$

➤ Beban Hidup (ql) = 250.0,489 = 122,25 kg/m²



6.2.4. Balok Anak As B(7-8)



Gambar 6.2 lebar ekuivalen balok anak As 1'(B-C)

a. Dimensi Balok

$$\begin{aligned}
 h &= 1/10 \cdot L & b &= 1/2 \cdot h \\
 &= 1/10 \cdot 4000 & &= 1/2 \times 400 \\
 &= 400 \text{ mm} & &= 200 \text{ mm} - 250 \text{ mm}
 \end{aligned}$$

b. Pembebanan Setiap Elemen

➤ Beban Mati (qd) → bidang 5/ As C(7-8)

$$\text{Berat sendiri balok} = 0,2 \times (0,4 - 0,12) \times 2400 = 168 \text{ kg/m'}$$

$$\text{Berat plat} = 1,34 \times 404 = 541,36 \text{ kg/m'}$$

$$qd = 709,36 \text{ kg/m'}$$

➤ Beban Mati (qd) → bidang 4/As D (7''-8)

$$\text{Berat sendiri balok} = 0,2 \times (0,4 - 0,12) \times 2400 = 168 \text{ kg/m'}$$

$$\text{Berat plat} = 0,34 \times 404 = 137,36 \text{ kg/m'}$$

$$qd = 305,36 \text{ kg/m'}$$

$$\begin{aligned}
 \text{➤ Beban reaksi tangga As D (7'-7'')} &= \frac{3018,62}{1,5} & &= 2012,413 \text{ kg/m'}
 \end{aligned}$$

$$\begin{aligned}
 \text{➤ Beban Hidup (ql)} &= 250 \cdot 1,34 & &= 335 \text{ kg/m'}
 \end{aligned}$$

$$\begin{aligned}
 \text{Beban hidup As C(6''-7)} &= 250 \cdot 0,34 & &= 85 \text{ kg/m'}
 \end{aligned}$$



6.3. Hitungan Tulangan

6.3.1. Balok anak As 1'(B – C)

Data-data:

$$b = 250 \text{ mm}$$

$$h = 400 \text{ mm}$$

$$f'_c = 25 \text{ MPa}$$

$$f_y = 360 \text{ Mpa (ulir)}$$

$$f_{ys} = 240 \text{ Mpa (polos)}$$

Dicoba :

$$\phi \text{ tulangan} = 16 \text{ mm}$$

$$\phi \text{ sengkang} = 8 \text{ mm}$$

$$\text{Tebal selimut (s)} = 40 \text{ mm}$$

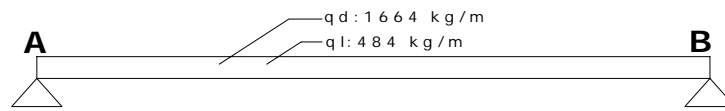
- $h = 400 \text{ mm}$
- $b = 250 \text{ mm}$
- $d' = 40 + 8 + \frac{1}{2} \cdot 16 = 56 \text{ mm}$
- $d = h - d' = 400 - 56 = 344 \text{ mm}$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{360}{0,85 \cdot 25} = 16,9412$$

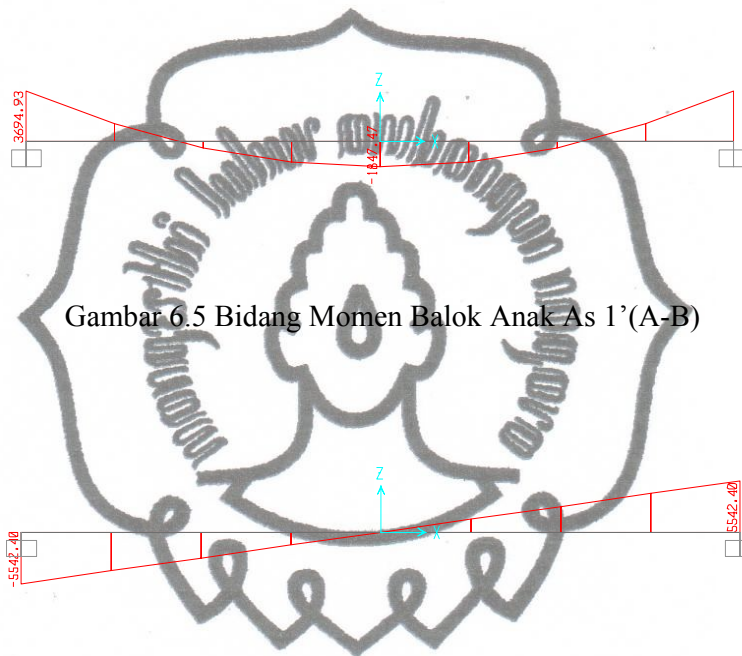
$$\begin{aligned} \rho_b &= \frac{0,85 \cdot f'_c}{f_y} \cdot \beta \cdot \left(\frac{600}{600 + f_y} \right) \\ &= \frac{0,85 \cdot 25}{360} \cdot 0,85 \cdot \left(\frac{600}{600 + 360} \right) \\ &= 0,03136 \end{aligned}$$

$$\begin{aligned} \rho_{\max} &= 0,75 \cdot \rho_b \\ &= 0,02352 \end{aligned}$$

$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{360} = 0,0039$$



Gambar 6.4 Bidang balok anak As 1' (A-B)



Gambar 6.5 Bidang Momen Balok Anak As 1'(A-B)

Gambar 6.6 Bidang geser balok anak As 1'(A-B)

a) Penulangan Daerah lapangan

$$M_u = 1847,47 \text{ kgm} = 1,8475 \cdot 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{1,8475 \cdot 10^7}{0,8} = 2,3094 \cdot 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{2,3094 \cdot 10^7}{250 \cdot (344)^2} = 0,780 \text{ N/mm}^2$$

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



$$= \frac{1}{16,9412} \cdot \left(1 - \sqrt{1 - \frac{2.16,9412 \cdot 0,780}{360}} \right)$$

$$= 0,002207$$

$$\rho_{\text{ada}} < \rho_{\text{min}}$$

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

$$\text{As perlu} = \rho_{\text{min}} \cdot b \cdot d$$

$$= 0,0039 \times 250 \times 344$$

$$= 335,4 \text{ mm}^2$$

$$n = \frac{\text{As perlu}}{\frac{1}{4} \cdot \pi \cdot 22^2} = \frac{335,4}{200,96} = 1,668 \approx 3 \text{ tulangan}$$

$$\text{As ada} = n \cdot \frac{1}{4} \cdot \pi \cdot d^2$$

$$= 3 \cdot \frac{1}{4} \cdot \pi \cdot 16^2$$

$$= 602,88 > \text{As perlu} \rightarrow \text{Aman..!!}$$

$$a = \frac{\text{As ada} \cdot f_y}{0,85 \cdot f'c \cdot b} = \frac{602,88 \times 360}{0,85 \times 25 \times 250} = 40,854 \text{ mm}$$

$$\text{Mn ada} = \text{As ada} \cdot f_y \cdot (d - a/2)$$

$$= 602,88 \cdot 360 \cdot (344 - 40,854/2)$$

$$= 7,0227 \times 10^7 \text{ Nmm}$$

$$\text{Mn ada} > \text{Mn} \rightarrow 7,0227 \times 10^7 \text{ Nmm} > 2,3094 \cdot 10^7 \text{ Nmm} \dots \text{OK} \odot$$

Kontrol Spasi :

$$S = \frac{b - 2s - n\phi \text{ tulangan} - 2\phi \text{ sengkang}}{n - 1}$$

$$= \frac{250 - 2 \cdot 40 - 3 \cdot 16 - 2 \cdot 8}{3 - 1} = 53 > 25 \text{ mm. (dipakai tulangan 1 lapis)}$$

Jadi, digunakan tulangan **3 D 16**



b) Penulangan Daerah Tumpuan

$$M_u = 3694,93 \text{ kgm} = 3,695 \cdot 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{3,695 \cdot 10^7}{0,8} = 4,6188 \cdot 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{4,6188 \cdot 10^7}{250 \cdot (344)^2} = 1,562 \text{ N/mm}^2$$

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

$$= \frac{1}{16,9412} \cdot \left(1 - \sqrt{1 - \frac{2 \cdot 16,9412 \cdot 1,562}{360}} \right)$$

$$= 0,004512$$

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

$$< \rho_{max}$$

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

$$= 0,004512 \times 250 \times 344$$

$$= 388,032 \text{ mm}^2$$

$$n = \frac{A_s \text{ perlu}}{\frac{1}{4} \cdot \pi \cdot 22^2} = \frac{388,032}{200,96} = 1,931 \approx 4 \text{ tulangan}$$

$$A_s \text{ ada} = n \cdot \frac{1}{4} \cdot \pi \cdot d^2$$

$$= 4 \cdot \frac{1}{4} \cdot \pi \cdot 16^2$$

$$= 803,84 > A_s \text{ perlu} \rightarrow \text{Aman..!!}$$

$$a = \frac{A_s \text{ ada} \cdot f_y}{0,85 \cdot f'c \cdot b} = \frac{803,84 \times 360}{0,85 \times 25 \times 250} = 54,47 \text{ mm}$$

$$M_n \text{ ada} = A_s \text{ ada} \cdot f_y (d - a/2)$$

$$= 803,84 \cdot 360 (344 - 54,47/2)$$

$$= 9,1667 \times 10^7 \text{ Nmm}$$

$$M_n \text{ ada} > M_n \rightarrow 9,1667 \times 10^7 \text{ Nmm} > 4,6188 \cdot 10^7 \text{ Nmm... OK ☺}$$



Kontrol Spasi :

$$S = \frac{b - 2s - n\phi \text{ tulangan} - 2\phi \text{ sengkang}}{n - 1}$$

$$= \frac{250 - 2 \cdot 40 - 3 \cdot 16 - 2 \cdot 8}{3 - 1} = 53 > 25 \text{ mm. (dipakai tulangan 1 lapis)}$$

Jadi, digunakan tulangan **3 D 16**

c) Hitungan Tulangan Geser

$$V_u = 5542,40 \text{ kg} = 5,5424 \cdot 10^4 \text{ N (Perhitungan SAP)}$$

$$V_c = 1/6 \cdot b \cdot d \cdot \sqrt{f_c}$$

$$= 1/6 \cdot 250 \cdot 344 \cdot \sqrt{25}$$

$$= 7,167 \cdot 10^4 \text{ N}$$

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

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

$$3\phi V_c = 3 \cdot \phi V_c$$

$$= 12,9 \cdot 10^4 \text{ N}$$

➤ $\phi V_c < V_u < 3\phi V_c \rightarrow$ perlu tulangan geser

$$\phi V_s = V_u - \phi V_c = 1,2424 \cdot 10^4 \text{ N}$$

$$V_{s \text{ perlu}} = \frac{\phi v_s}{\phi} = \frac{1,2424 \cdot 10^4}{0,6} = 2,071 \cdot 10^4 \text{ N}$$

Digunakan sengkang $\phi 8$,

$$A_v = 2 \cdot A = 100,48 \text{ mm}^2$$

$$S = \frac{A_v \cdot f_y \cdot d}{V_{s \text{ perlu}}} = \frac{100,48 \cdot 240 \cdot 344}{2,071 \cdot 10^4} = 400,56 \text{ mm}$$

$$S_{\text{maks}} = \frac{d}{2} = \frac{344}{2} = 172 \text{ mm} - 100 \text{ mm}$$

Dicoba menggunakan sengkang $\phi 8 - 100 \text{ mm}$

$$V_{s \text{ ada}} = \frac{A_v \cdot f_y \cdot d}{S} = \frac{100,48 \times 240 \times 344}{100} = 8,2956 \cdot 10^4 \text{ N}$$



$V_s \text{ ada} > V_s \text{ perlu}$

$$8,2956 \cdot 10^4 \text{ N} > 2,894 \cdot 10^4 \text{ N} \dots\dots \text{OK} \odot$$

Jadi, dipakai sengkang $\varnothing 8 - 100 \text{ mm}$

6.3.2. Balok anak As B(1 -12)

Data-data:

$$b = 250 \text{ mm}$$

$$h = 400 \text{ mm}$$

$$f'_c = 25 \text{ MPa}$$

$$f_y = 360 \text{ Mpa (ulir)}$$

$$f_{ys} = 240 \text{ Mpa (polos)}$$

Dicoba :

$$\phi \text{ tulangan} = 16 \text{ mm}$$

$$\phi \text{ sengkang} = 8 \text{ mm}$$

$$\text{Tebal selimut (s)} = 40 \text{ mm}$$

- $h = 400 \text{ mm}$
- $b = 250 \text{ mm}$
- $d' = 40 + 8 + \frac{1}{2} \cdot 16 = 56 \text{ mm}$
- $d = h - d' = 400 - 56 = 344 \text{ mm}$

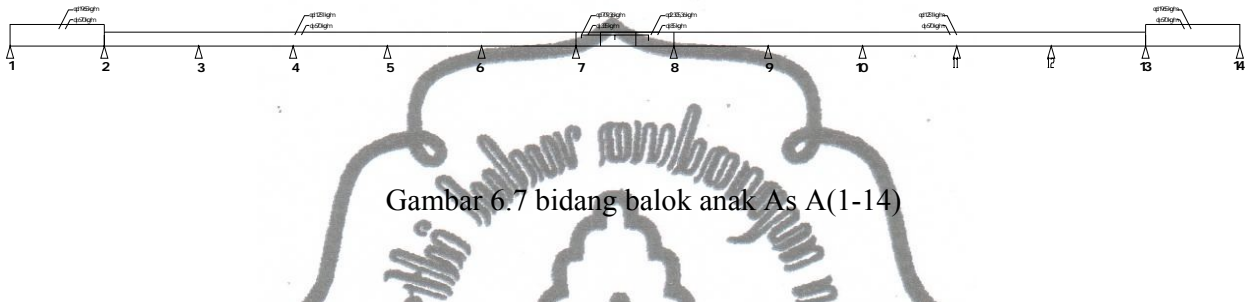
$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{360}{0,85 \cdot 25} = 16,9412$$

$$\begin{aligned} \rho_b &= \frac{0,85 \cdot f'_c}{f_y} \cdot \beta \cdot \left(\frac{600}{600 + f_y} \right) \\ &= \frac{0,85 \cdot 25}{360} \cdot 0,85 \cdot \left(\frac{600}{600 + 360} \right) \\ &= 0,03136 \end{aligned}$$

$$\begin{aligned} \rho_{\max} &= 0,75 \cdot \rho_b \\ &= 0,02352 \end{aligned}$$



$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{360} = 0,0039$$



Gambar 6.7 bidang balok anak As A(1-14)



Gambar 6.8 bidang momen balok anak As A(1-14)



Gambar 6.8 bidang geser balok anak As A(1-14)



a) Penulangan Daerah lapangan

$$M_u = 4470,03 \text{ kgm} = 4,47003 \cdot 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{4,47003 \cdot 10^7}{0,8} = 5,5875 \cdot 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{5,5875 \cdot 10^7}{250 \cdot (344)^2} = 1,89 \text{ N/mm}^2$$

$$\begin{aligned} \rho_{\text{ada}} &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot R_n}{f_y}} \right) \\ &= \frac{1}{16,9412} \cdot \left(1 - \sqrt{1 - \frac{2 \cdot 16,9412 \cdot 1,89}{360}} \right) \\ &= 0,00551 \end{aligned}$$

$$\begin{aligned} \rho_{\text{ada}} &> \rho_{\text{min}} \\ &< \rho_{\text{max}} \end{aligned}$$

$$\begin{aligned} A_s \text{ perlu} &= \rho_{\text{ada}} \cdot b \cdot d \\ &= 0,00551 \times 250 \times 344 \\ &= 473,86 \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} n &= \frac{A_s \text{ perlu}}{\frac{1}{4} \cdot \pi \cdot 22^2} \\ &= \frac{473,86}{200,96} = 2,357 \approx 3 \text{ tulangan} \end{aligned}$$

$$\begin{aligned} A_s \text{ ada} &= n \cdot \frac{1}{4} \cdot \pi \cdot d^2 \\ &= 3 \cdot \frac{1}{4} \cdot \pi \cdot 16^2 \\ &= 602,88 > A_s \text{ perlu} \rightarrow \text{Aman..!!} \end{aligned}$$

$$a = \frac{A_s \text{ ada} \cdot f_y}{0,85 \cdot f'c \cdot b} = \frac{602,88 \times 360}{0,85 \times 25 \times 250} = 40,854$$

$$\begin{aligned} M_n \text{ ada} &= A_s \text{ ada} \cdot f_y (d - a/2) \\ &= 602,88 \cdot 360 (344 - 40,854/2) \\ &= 7,023 \times 10^7 \text{ Nmm} \end{aligned}$$



$M_n \text{ ada} > M_n \rightarrow \text{Aman..!!}$

Kontrol Spasi :

$$S = \frac{b - 2s - n\phi \text{ tulangan} - 2\phi \text{ sengkang}}{n - 1}$$

$$= \frac{250 - 2 \cdot 40 - 3 \cdot 16 - 2 \cdot 8}{3 - 1} = 53 > 25 \text{ mm. (dipakai tulangan 1 lapis)}$$

Jadi, digunakan tulangan **3 D 16**

b) Penulangan Daerah Tumpuan

$$M_u = 5228,23 \text{ kgm} = 5,22823 \cdot 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{5,22823 \cdot 10^7}{0,8} = 6,5353 \cdot 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{6,5353 \cdot 10^7}{250 \cdot (344)^2} = 2,301 \text{ N/mm}^2$$

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

$$= \frac{1}{16,9412} \cdot \left(1 - \sqrt{1 - \frac{2 \cdot 16,9412 \cdot 2,301}{360}} \right)$$

$$= 0,00678$$

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

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

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

$$= 0,00678 \times 250 \times 344$$

$$= 583,08 \text{ mm}^2$$

$$n = \frac{A_s \text{ perlu}}{\frac{1}{4} \cdot \pi \cdot 22^2}$$

$$= \frac{583,08}{200,96} = 2,902 \approx 4 \text{ tulangan}$$



$$\begin{aligned} \text{As ada} &= n \cdot \frac{1}{4} \cdot \pi \cdot d^2 \\ &= 4 \cdot \frac{1}{4} \cdot \pi \cdot 16^2 = 803,84 > \text{As perlu} \rightarrow \text{OK} \odot \end{aligned}$$

$$a = \frac{As_{ada} \cdot f_y}{0,85 \cdot f'_{c,b}} = \frac{803,84 \times 360}{0,85 \times 25 \times 250} = 54,472 \text{ mm}$$

$$\begin{aligned} \text{Mn ada} &= \text{As ada} \cdot f_y (d - a/2) \\ &= 803,84 \cdot 360 (344 - 54,472/2) \\ &= 9,167 \times 10^7 \text{ Nmm} \end{aligned}$$

$$\text{Mn ada} > \text{Mn} = 9,167 \times 10^7 > 6,550 \cdot 10^7 \rightarrow \text{OK} \odot$$

Kontrol Spasi :

$$\begin{aligned} S &= \frac{b - 2s - n\phi_{\text{tulangan}} - 2\phi_{\text{sengkang}}}{n - 1} \\ &= \frac{250 - 2 \cdot 40 - 4 \cdot 16 - 2 \cdot 8}{4 - 1} = 30 > 25 \text{ mm. (dipakai tulangan 1 lapis)} \end{aligned}$$

Jadi, digunakan tulangan **4 D 16**

c) Hitungan Tulangan Geser

$$V_u = 8166,39 \text{ kg} = 8,1664 \cdot 10^4 \text{ N (Perhitungan SAP)}$$

$$\begin{aligned} V_c &= 1/6 \cdot b \cdot d \cdot \sqrt{f'_c} \\ &= 1/6 \cdot 250 \cdot 344 \cdot \sqrt{25} \\ &= 7,167 \cdot 10^4 \text{ N} \end{aligned}$$

$$\begin{aligned} \phi V_c &= 0,6 \cdot V_c \\ &= 4,3 \cdot 10^4 \text{ N} \end{aligned}$$

$$\begin{aligned} 3\phi V_c &= 3 \cdot \phi V_c \\ &= 12,9 \cdot 10^4 \text{ N} \end{aligned}$$

➤ $\phi V_c < V_u < 3\phi V_c \rightarrow$ perlu tulangan geser

$$\phi V_s = V_u - \phi V_c = 3,8664 \cdot 10^4 \text{ N}$$

$$V_{s \text{ perlu}} = \frac{\phi V_s}{\phi} = \frac{3,8664 \cdot 10^4}{0,6} = 6,4440 \cdot 10^4 \text{ N}$$

Digunakan sengkang $\phi 8$, $As = 50,24 \text{ mm}^2$



$$A_v = 2 \cdot A = 100,48 \text{ mm}^2$$

$$S = \frac{A_v \cdot f'_y \cdot d}{V_{s_{\text{perlu}}}} = \frac{100,48 \cdot 240 \cdot 344}{6,4440 \cdot 10^4} = 128,757 \text{ mm}$$

$$S_{\text{maks}} = \frac{d}{2} = \frac{344}{2} = 172 \text{ mm}$$

Dicoba menggunakan sengkang $\varnothing 8 - 125 \text{ mm}$

$$V_{s \text{ ada}} = \frac{A_v \cdot f_y \cdot d}{S} = \frac{100,48 \times 240 \times 344}{125} = 6,6365 \cdot 10^4 \text{ N}$$

$V_{s \text{ ada}} > V_{s \text{ perlu}}$

$$6,6365 \cdot 10^4 \text{ N} > 6,4440 \cdot 10^4 \text{ N} \dots \dots \text{ (aman)}$$

Jadi, dipakai sengkang $\varnothing 8 - 125 \text{ mm}$

6.3.3. Balok anak As 7''(B - C)

Data-data:

$$b = 200 \text{ mm}$$

$$h = 300 \text{ mm}$$

$$f'_c = 25 \text{ MPa}$$

$$f_y = 360 \text{ Mpa (ulir)}$$

$$f_{ys} = 240 \text{ Mpa (polos)}$$

Dicoba :

$$\phi \text{ tulangan} = 16 \text{ mm}$$

$$\phi \text{ sengkang} = 8 \text{ mm}$$

$$\text{Tebal selimut (s)} = 40 \text{ mm}$$

- $h = 300 \text{ mm}$
- $b = 200 \text{ mm}$
- $d' = 40 + 8 + \frac{1}{2} \cdot 16 = 56 \text{ mm}$
- $d = h - d' = 300 - 56 = 244 \text{ mm}$

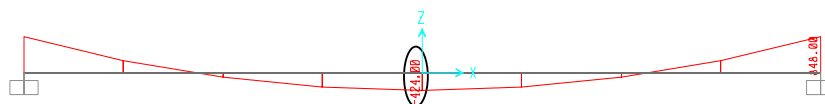
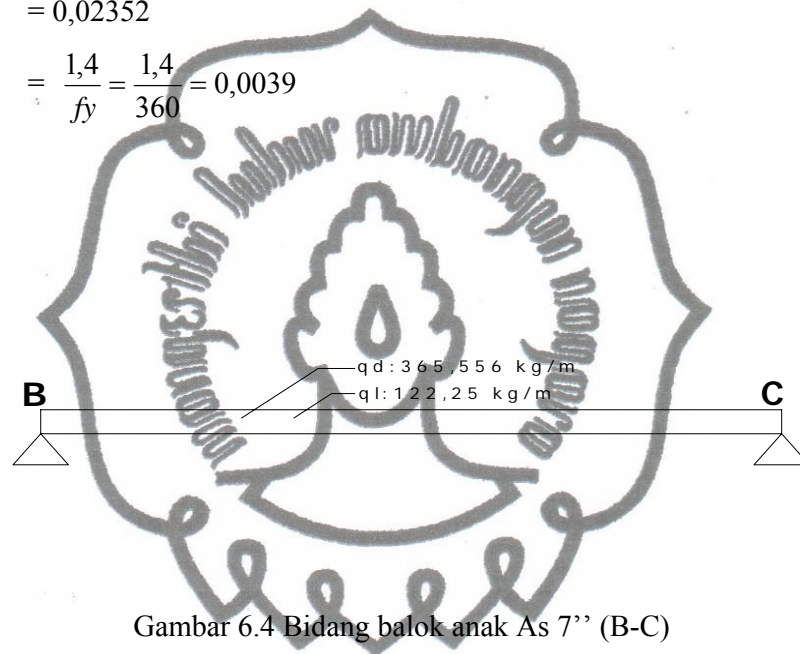
$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{360}{0,85 \cdot 25} = 16,9412$$



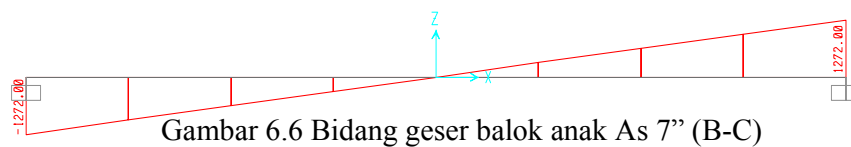
$$\begin{aligned} \rho_b &= \frac{0,85 \cdot f_c}{f_y} \cdot \beta \cdot \left(\frac{600}{600 + f_y} \right) \\ &= \frac{0,85 \cdot 25}{360} \cdot 0,85 \cdot \left(\frac{600}{600 + 360} \right) \\ &= 0,03136 \end{aligned}$$

$$\begin{aligned} \rho_{max} &= 0,75 \cdot \rho_b \\ &= 0,02352 \end{aligned}$$

$$\rho_{min} = \frac{1,4}{f_y} = \frac{1,4}{360} = 0,0039$$



Gambar 6.5 Bidang Momen Balok Anak As 7'' (B-C)



Gambar 6.6 Bidang geser balok anak As 7'' (B-C)



a) Penulangan Daerah lapangan

$$M_u = 424 \text{ kgm} = 4,24 \cdot 10^6 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{4,24 \cdot 10^6}{0,8} = 5,3 \cdot 10^6 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{5,3 \cdot 10^6}{200 \cdot (244)^2} = 0,445 \text{ N/mm}^2$$

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

$$= \frac{1}{16,9412} \cdot \left(1 - \sqrt{1 - \frac{2 \cdot 16,9412 \cdot 0,445}{360}} \right)$$

$$= 0,00125$$

$$\rho_{\text{ada}} < \rho_{\text{min}}$$

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

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

$$= 0,0039 \times 200 \times 244$$

$$= 190,32 \text{ mm}^2$$

$$n = \frac{A_s \text{ perlu}}{\frac{1}{4} \cdot \pi \cdot 16^2} = \frac{190,32}{200,96} = 0,947 \rightarrow 2 \text{ tulangan}$$

$$A_s \text{ ada} = n \cdot \frac{1}{4} \cdot \pi \cdot d^2$$

$$= 2 \cdot \frac{1}{4} \cdot \pi \cdot 16^2$$

$$= 401,92 > A_s \text{ perlu} \rightarrow \text{Aman..!!}$$

$$a = \frac{A_s \text{ ada} \cdot f_y}{0,85 \cdot f'c \cdot b} = \frac{401,92 \times 360}{0,85 \times 25 \times 200} = 34,045 \text{ mm}$$

$$M_n \text{ ada} = A_s \text{ ada} \cdot f_y (d - a/2)$$

$$= 401,92 \cdot 360 (244 - 34,045/2)$$

$$= 32,841 \times 10^6 \text{ Nmm}$$



$$M_n \text{ ada} > M_n \rightarrow = 32,841 \times 10^6 \text{ Nmm} > 5,3 \cdot 10^6 \text{OK } \odot$$

Kontrol Spasi :

$$S = \frac{b - 2s - n\phi \text{ tulangan} - 2\phi \text{ sengkang}}{n - 1}$$

$$= \frac{200 - 2 \cdot 40 - 2 \cdot 16 - 2 \cdot 8}{2 - 1} = 72 \text{ mm} > 25 \text{ mm. (dipakai tulangan 1 lapis)}$$

Jadi, digunakan tulangan **2 D 16**

b) **Penulangan Daerah Tumpuan**

$$M_u = 848 \text{ kgm} = 8,48 \cdot 10^6 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{8,48 \cdot 10^6}{0,8} = 10,6 \cdot 10^6 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{10,6 \cdot 10^6}{200 \cdot (244)^2} = 0,890 \text{ N/mm}^2$$

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

$$= \frac{1}{16,9412} \cdot \left(1 - \sqrt{1 - \frac{2 \cdot 16,9412 \cdot 0,890}{360}} \right)$$

$$= 0,00252$$

$$\rho_{\text{ada}} < \rho_{\text{min}}$$

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

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

$$= 0,0039 \times 200 \times 244$$

$$= 190,32 \text{ mm}^2$$

$$n = \frac{A_s \text{ perlu}}{\frac{1}{4} \cdot \pi \cdot 16^2} = \frac{190,32}{200,96} = 0,947 - 2 \text{ tulangan}$$

$$A_s \text{ ada} = n \cdot \frac{1}{4} \cdot \pi \cdot d^2$$



$$= 2 \cdot \frac{1}{4} \cdot \pi \cdot 16^2$$

$$= 401,92 > \text{As perlu} \rightarrow \text{Aman..!!}$$

$$a = \frac{As_{ada} \cdot f_y}{0,85 \cdot f'_{c,b}} = \frac{401,92 \times 360}{0,85 \times 25 \times 200} = 34,045 \text{ m}$$

$$\begin{aligned} M_n \text{ ada} &= A_s \text{ ada} \cdot f_y (d - a/2) \\ &= 401,92 \cdot 360 (244 - 34,045/2) \\ &= 32,841 \times 10^6 \text{ Nmm} \end{aligned}$$

$$M_n \text{ ada} > M_n \rightarrow = 32,841 \times 10^6 \text{ Nmm} > 5,3 \cdot 10^6 \dots \text{OK} \odot$$

Kontrol Spasi :

$$\begin{aligned} S &= \frac{b - 2s - n\phi \text{ tulangan} - 2\phi \text{ sengkang}}{n - 1} \\ &= \frac{200 - 2 \cdot 40 - 2 \cdot 16 - 2 \cdot 8}{2 - 1} = 72 \text{ mm} > 25 \text{ mm. (dipakai tulangan 1 lapis)} \end{aligned}$$

Jadi, digunakan tulangan **2 D 16**

c) Hitungan Tulangan Geser

$$V_u = 1272 \text{ kg} = 1,272 \cdot 10^4 \text{ N (Perhitungan SAP)}$$

$$\begin{aligned} V_c &= 1/6 \cdot b \cdot d \cdot \sqrt{f'_c} \\ &= 1/6 \cdot 250 \cdot 344 \cdot \sqrt{25} \\ &= 7,167 \cdot 10^4 \text{ N} \end{aligned}$$

$$\begin{aligned} \phi V_c &= 0,6 \cdot V_c \\ &= 4,3 \cdot 10^4 \text{ N} \end{aligned}$$

$$\begin{aligned} 3\phi V_c &= 3 \cdot \phi V_c \\ &= 12,9 \cdot 10^4 \text{ N} \end{aligned}$$

➤ $V_u < \phi V_c < 3\phi V_c \rightarrow$ tidak perlu tulangan geser

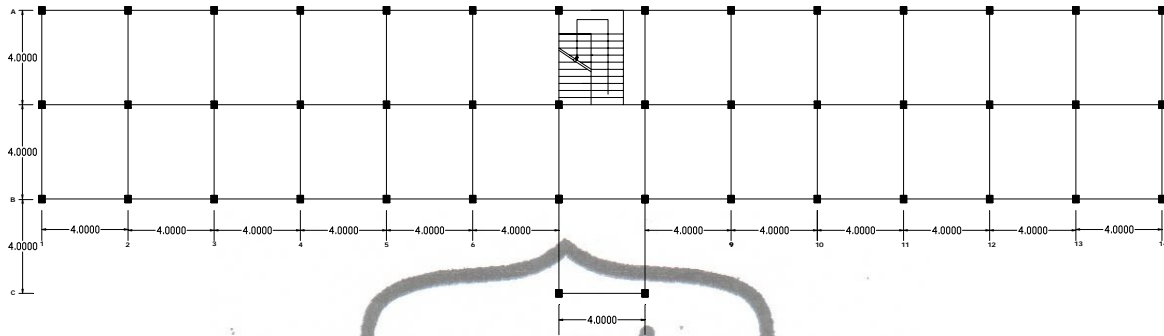
Dipakai tulangan geser minimum $\phi 8 - 200 \text{ mm}$





Tugas Akhir
Perencanaan Struktur Gedung Sekolah 2 lantai

BAB 7
PORTAL



Gambar 7.1. Gambar Denah Portal

Keterangan:

Balok Portal : As 1	Balok Portal : As 10
Balok Portal : As 2	Balok Portal : As 11
Balok Portal : As 3	Balok Portal : As 12
Balok Portal : As 4	Balok Portal : As 13
Balok Portal : As 5	Balok Portal : As 14
Balok Portal : As 6	Balok Portal : As A
Balok Portal : As 7	Balok Portal : As B
Balok Portal : As 8	Balok Portal : As C
Balok Portal : As 9	

7.1. Perencanaan Portal

7.1.1. Dasar perencanaan

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

- Bentuk denah portal : Seperti tergambar(gambar 7.1)
- Model perhitungan : SAP 2000 (3 D)
- Perencanaan dimensi rangka : b (mm) x h (mm)

commit to user



Tugas Akhir

Perencanaan Struktur Gedung Sekolah 2 lantai

Dimensi kolom	: 400mm x 400mm
Dimensi sloof	
Sloof 1	: 250mm x 400mm
Sloof 2	: 200mm x 300mm
Dimensi balok	
Balok 1	: 400mm x 700mm
Balok 2	: 250mm x 400mm
Balok 3	: 200mm x 300mm
Dimensi ring balk	: 200mm x 200mm
d. Kedalaman pondasi	: 2 m
e. Mutu beton	: $f_c' = 25 \text{ MPa}$
f. Mutu baja tulangan	: U36 ($f_y = 320 \text{ MPa}$)
g. Mutu baja sengkang	: U24 ($f_y = 240 \text{ MPa}$)
h. Koefisien reduksi beban hidup untuk perencanaan portal adalah	0.9

7.1.2 Perencanaan pembebanan

Secara umum data pembebanan portal adalah sebagai berikut:

- Berat sendiri balok 1 = $0,4 \times (0,7-0,12) \times 2400 = 556,8 \text{ kg/m}$
- balok 2 = $0,25 \times (0,4-0,12) \times 2400 = 168 \text{ kg/m}$
- balok 3 = $0,15 \times (0,3-0,10) \times 2400 = 72 \text{ kg/m}$

- Plat Lantai

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		= 25 kg/m
Berat Pasir (2 cm)	= $0,02 \times 1600 \times 1$	= 32 kg/m
	qD	= 411 kg/m

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Tugas Akhir

Perencanaan Struktur Gedung Sekolah 2 lantai

➤ Atap

Reaksi Kuda kuda Utama A = 3387.64 kg (SAP 2000)

Reaksi Kuda kuda Utama B = 9109.48 kg (SAP 2000)

Reaksi Tumpuan Setengah Kuda-kuda = 1441.07 kg (SAP 2000)

Reaksi Tumpuan Jurai = 1723.67 kg (SAP 2000)

➤ Beban rink balk

Beban Mati (qD)

$$\begin{aligned} \text{Beban sendiri balok} &= 0,2 \cdot 0,3 \cdot 2400 \\ &= 144 \text{ kg/m} \end{aligned}$$

➤ Beban Sloof

Beban Mati (qD)

$$\text{Beban sendiri balok} = 0,2 \cdot 0,3 \cdot 2400 = 144 \text{ kg/m}$$

$$\begin{aligned} \text{Beban dinding} &= 0,15 \cdot (4-0,35) \cdot 1700 = 930,75 \text{ kg/m} + \\ qD &= 1164 \text{ kg/m} \end{aligned}$$

7.1.3. Perhitungan luas equivalen untuk plat lantai

$$\text{Luas equivalent segitiga} : \frac{1}{3} \cdot lx$$

$$\text{Luas equivalent trapezium} : \frac{1}{6} \cdot lx \left(3 - 4 \left(\frac{lx}{2 \cdot ly} \right)^2 \right)$$

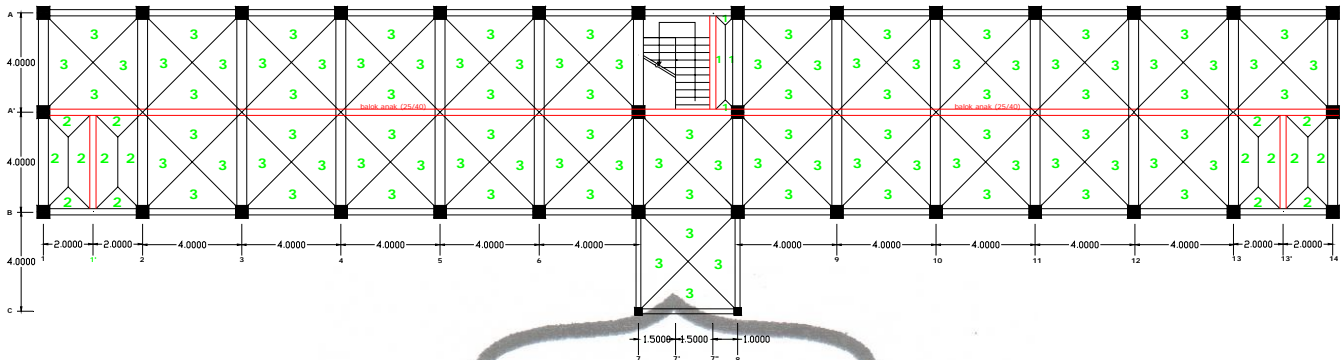
Table 7.1. Hitungan Lebar Equivalen

No.	Ukuran Plat (m ²)	Lx (m)	Ly (m)	Leq (segitiga)	Leq (trapesium)
1.	1 × 4	1	4	0,34	0,489
2.	2 × 4	2	4	0,67	0,9167
3.	4 × 4	4	4	1,34	1,34

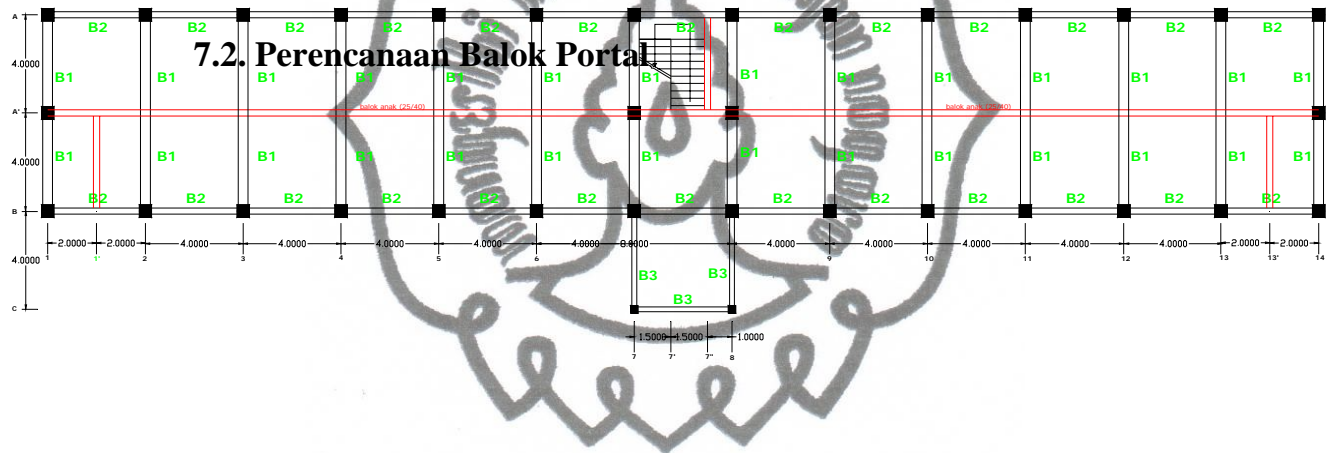
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Tugas Akhir
Perencanaan Struktur Gedung Sekolah 2 lantai



Gambar 7.2. Gambar Daerah Pembebanan



7.2. Perencanaan Balok Portal

Gambar 7.3 Denah Balok Portal

Keterangan :

Balok Portal : As A, B, C, 1,2,3,4,5,6,7,8,9,10,11,12,13,14

Balok Anak : As A'(1-14),
As 1' (A'-B), As 13' (A'-B)
As 7'' (A-A')

commit to user



Tugas Akhir

Perencanaan Struktur Gedung Sekolah 2 lantai

7.3. Perhitungan Pembebanan Balok

7.3.1. Perhitungan Pembebanan Balok Memanjang

1.) Pembebanan balok Portal As A Bentang 1 – 14

- Pembebanan balok induk As A Bentang 1-7 dan 8-14

Beban Mati (qd):

$$\text{Berat sendiri} = 168 \text{ kg/m}$$

$$\text{Berat plat lantai} = 411 \cdot (0,9167 + 1,34) = 927,51 \text{ kg/m}$$

$$\text{Berat dinding} = 930,75 \text{ kg/m}$$

$$\text{Jumlah} = 2026,26 \text{ kg/m}$$

Koefisien reduksi beban hidup untuk perencanaan portal = 0.9

$$\text{Beban hidup (ql)} : 250 \cdot (0,9167 + 1,34) \cdot 0,9 = 507,75 \text{ kg/m}$$

- Pembebanan balok induk As A Bentang 7-7''

Beban Mati (qd):

$$\text{Berat sendiri} = 168 \text{ kg/m}$$

$$\text{Berat plat lantai} = 411 \cdot (0,9167) = 376,76 \text{ kg/m}$$

$$\text{Jumlah} = 544,6 \text{ kg/m}$$

Koefisien reduksi beban hidup untuk perencanaan portal = 0.9

$$\text{Beban hidup (ql)} : 250 \cdot (0,9167) \cdot 0,9 = 206,258 \text{ kg/m}$$

- Pembebanan balok induk As A Bentang 7''-8

Beban Mati (qd):

$$\text{Berat sendiri} = 168 \text{ kg/m}$$

$$\text{Berat plat lantai} = 411 \cdot (0,34) = 139,74 \text{ kg/m}$$

$$\text{Jumlah} = 307,74 \text{ kg/m}$$

Koefisien reduksi beban hidup untuk perencanaan portal = 0.9

$$\text{Beban hidup (ql)} : 250 \cdot (0,34) \cdot 0,9 = 76,5 \text{ kg/m}$$

commit to user



Tugas Akhir Perencanaan Struktur Gedung Sekolah 2 lantai

2.) Pembebanan balok Portal **As A' Bentang 1 -14**

Beban reaksi dari balok anak pada :

• Tumpuan 1	= 5552,27	kg
• Tumpuan 2	= 13879,03	kg
• Tumpuan 3	= 9573,50	kg
• Tumpuan 4	= 10496,56	kg
• Tumpuan 5	= 10166,17	kg
• Tumpuan 6	= 10601,46	kg
• Tumpuan 7	= 8106,74	kg
• Tumpuan 8	= 8530,18	kg
• Tumpuan 9	= 10578,77	kg
• Tumpuan 10	= 10172,06	kg
• Tumpuan 11	= 10495,03	kg
• Tumpuan 12	= 9573,90	kg
• Tumpuan 13	= 13878,93	kg
• Tumpuan 14	= 5552,29	kg

3.) Pembebanan balok Portal **As B Bentang 1 -14**

- Pembebanan balok induk As B Bentang 1 – 7 dan 8 - 14

Beban Mati (qd):

Berat sendiri		= 168	kg/m
Berat plat lantai	= 411 . (1,34)	= 550,74	kg/m
Berat dinding		= 930,75	kg/m
Jumlah		<u>1649,49</u>	kg/m

Koefisien reduksi beban hidup untuk perencanaan portal =0.9

$$\text{Beban hidup (ql)} : 250 . (1,34) . 0,9 = 301,5 \text{ kg/m}$$

$$\text{Beban titik pada 1' dan 11'} = 5542 \text{ kg}$$

commit to user



Tugas Akhir Perencanaan Struktur Gedung Sekolah 2 lantai

- Pembebanan balok induk As B Bentang 1-1', dan 13-13'

Beban Mati (qd):

$$\text{Berat sendiri} = 168 \text{ kg/m}$$

$$\text{Berat dinding} = 930,75 \text{ kg/m}$$

$$\text{Berat plat lantai} = 411 \cdot (0,9167) = 376,76 \text{ kg/m}$$

$$\text{Jumlah} = 1475,51 \text{ kg/m}$$

Koefisien reduksi beban hidup untuk perencanaan portal = 0.9

$$\text{Beban hidup (ql)} : 250 \cdot (0,9167) \cdot 0,9 = 206,258 \text{ kg/m}$$

- Pembebanan balok induk As D Bentang 7 – 8

Beban Mati (qd):

$$\text{Berat sendiri} = 168 \text{ kg/m}$$

$$\text{Berat plat lantai} = 411 \cdot (2 \cdot 1,34) = 1101,48 \text{ kg/m}$$

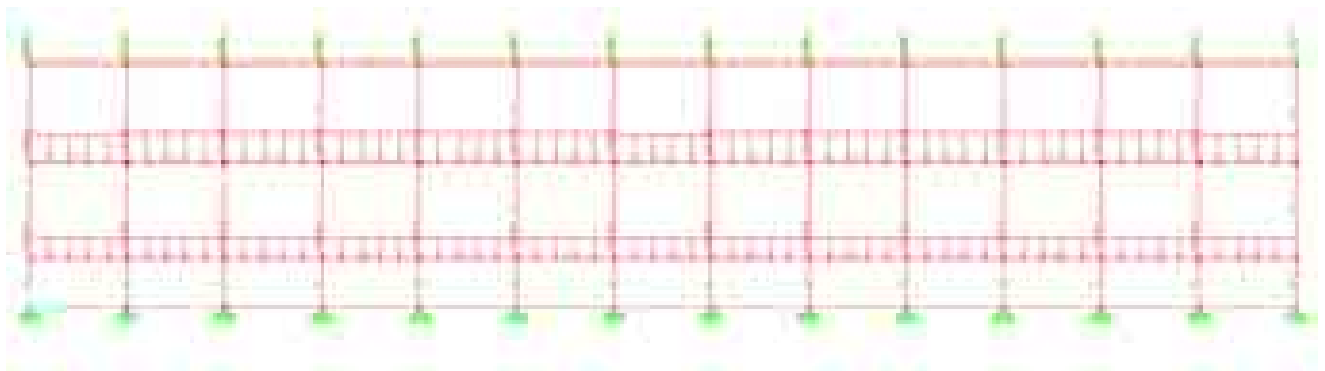
$$\text{Berat dinding} = 0,15 \cdot (1 - 0,2) \cdot 1700 = 204 \text{ kg/m}$$

$$\text{Jumlah} = 1473,48 \text{ kg/m}$$

Koefisien reduksi beban hidup untuk perencanaan portal = 0.9

$$\text{Beban hidup (ql)} : (250 \cdot 1,34) + (100 \cdot 1,34) \cdot 0,9 = 422,1 \text{ kg/m}$$

- Beban reaksi dari balok anak pada titik D 1' = 5542,40 kg



commit to user



Tugas Akhir
Perencanaan Struktur Gedung Sekolah 2 lantai

Gambar 7.5. Daerah pembebanan portal As B (1-14)

5.) Pembebanan balok Portal As C Bentang 7 – 8

- Pembebanan balok induk As C Bentang 7 – 8

Beban Mati (qd):

$$\text{Berat sendiri} = 72 \text{ kg/m}$$

$$\text{Berat plat atap} = 265 \cdot (1,34) = 355,1 \text{ kg/m}$$

$$\text{Jumlah} = 427,1 \text{ kg/m}$$

Koefisien reduksi beban hidup untuk perencanaan portal = 0.9

$$\text{Beban hidup (ql)} = 100 \cdot (1,34) \cdot 0,9 = 120,6 \text{ kg/m}$$

7.3.2. Perhitungan Pembebanan Balok Melintang

1.) Pembebanan balok Portal As 1 Bentang A-B

- Pembebanan balok induk As 1 dan 14 Bentang A- A'

Beban Mati (qd):

$$\text{Berat sendiri} = 556,8 \text{ kg/m}$$

$$\text{Berat plat lantai} = 411 \cdot (1,34) = 550,8 \text{ kg/m}$$

$$\text{Berat dinding} = 930,75 \text{ kg/m}$$

$$\text{Jumlah} = 1949,1 \text{ kg/m}$$

Koefisien reduksi beban hidup untuk perencanaan portal = 0.9

$$\text{Beban hidup (ql)} = 250 \cdot (1,34) \cdot 0,9 = 301,5 \text{ kg/m}$$

- Pembebanan balok induk As 1 dan 14 Bentang A'- B

Beban Mati (qd):

$$\text{Berat sendiri} = 556,8 \text{ kg/m}$$

$$\text{Berat plat lantai} = 411 \cdot (0,9167) = 376,76 \text{ kg/m}$$

$$\text{Berat dinding} = 930,75 \text{ kg/m}$$

$$\text{Jumlah} = 1864,31 \text{ kg/m}$$

Koefisien reduksi beban hidup untuk perencanaan portal = 0.9

$$\text{Beban hidup (ql)} = 250 \cdot (0,9167) \cdot 0,9 = 206,258 \text{ kg/m}$$

commit to user



Tugas Akhir Perencanaan Struktur Gedung Sekolah 2 lantai

2.) Pembebanan balok Portal As 2 dan 13 Bentang A-B

- Pembebanan balok induk As 2 dan 11 Bentang A – A'

Beban Mati (qd):

Berat sendiri		= 556,8 kg/m
Berat plat lantai	= 411 .(2.1,34)	= 1101,48 kg/m
Berat dinding		= 930,75 kg/m
Jumlah		= 2589,03 kg/m

Koefisien reduksi beban hidup untuk perencanaan portal =0.9

Beban hidup (ql) : 250 . (2.1,34) .0,9 = 603 kg/m

- Pembebanan balok induk As 2 dan 12 Bentang A' - B

Beban Mati (qd):

Berat sendiri		= 556,8 kg/m
Berat plat lantai	= 411 .(0,9167+ 1,34)	= 927,504 kg/m
Berat dinding		= 930,75 kg/m
Jumlah		= 2415,054 kg/m

Koefisien reduksi beban hidup untuk perencanaan portal =0.9

Beban hidup (ql) : 250 . (0,9167+ 1,34) .0,9 = 508 kg/m

3.) Pembebanan balok Portal As 3,5,9 dan 11 Bentang A-B

- Pembebanan balok induk As 3 Bentang A- B

Beban Mati (qd):

Berat sendiri		= 556,8 kg/m
Berat plat lantai	= 411 . (4.1,34)	= 2202,96 kg/m
Jumlah		= 2759,76 kg/m

Koefisien reduksi beban hidup untuk perencanaan portal =0.9

Beban hidup (ql) : 250 . (4.1,34) .0,9 = 1206 kg/m

commit to user



Tugas Akhir

Perencanaan Struktur Gedung Sekolah 2 lantai

4.) Pembebanan balok Portal As 5 dan 10 Bentang A-B

- Pembebanan balok induk As 5 Bentang A-B

Beban Mati (qd):

$$\text{Berat sendiri} = 556,8 \text{ kg/m}$$

$$\text{Berat plat lantai} = 411 \cdot (4,1,34) = 2202,96 \text{ kg/m}$$

$$\text{Berat dinding} = 930,75 \text{ kg/m}$$

$$\text{Jumlah} = 3690,51 \text{ kg/m}$$

Koefisien reduksi beban hidup untuk perencanaan portal = 0.9

$$\text{Beban hidup (ql)} : 250 \cdot (4,1,34) \cdot 0,9 = 1206 \text{ kg/m}$$

5.) Pembebanan balok Portal As 7 dan 8 Bentang A-B

- Pembebanan balok induk As 7 Bentang A-A'

Beban Mati (qd):

$$\text{Berat sendiri} = 556,8 \text{ kg/m}$$

$$\text{Berat plat lantai As 6} = 411 \cdot 1,34 = 550,74 \text{ kg/m}$$

$$\text{Berat dinding} = 930,75 \text{ kg/m}$$

$$\text{Jumlah} = 2038,29 \text{ kg/m}$$

Koefisien reduksi beban hidup untuk perencanaan portal = 0.9

$$\text{Beban hidup (ql)} : 250 \cdot 1,34 \cdot 0,9 = 301,5 \text{ kg/m}$$

- Pembebanan balok induk As 7 Bentang A-A'

Beban Mati (qd):

$$\text{Berat sendiri} = 556,8 \text{ kg/m}$$

$$\text{Berat plat lantai As 7} = 411 \cdot (1,34 + 0,489) = 751,72 \text{ kg/m}$$

$$\text{Berat dinding} = 930,75 \text{ kg/m}$$

$$\text{Jumlah} = 2239,27 \text{ kg/m}$$

Koefisien reduksi beban hidup untuk perencanaan portal = 0.9

$$\text{Beban hidup (ql)} : 250 \cdot (1,34 + 0,489) \cdot 0,9 = 411,525 \text{ kg/m}$$

commit to user



Tugas Akhir Perencanaan Struktur Gedung Sekolah 2 lantai

➤ Pembebanan balok induk As 7 Bentang A'-B

Beban Mati (qd):

Berat sendiri		= 556,8	kg/m
Berat plat lantai	= 411 .(2.1,34)	= 1101,48	kg/m
Berat dinding		= 930,75	kg/m
	Jumlah	= 2589,03	kg/m

Koefisien reduksi beban hidup untuk perencanaan portal =0.9

$$\text{Beban hidup (ql)} : 250 . (2.1,34) .0,9 = 603 \text{ kg/m}$$

➤ Pembebanan balok induk As 7 Bentang B-C

Beban Mati (qd):

Berat sendiri		= 72	kg/m
Berat plat lantai	= 265 .1,34	= 355,1	kg/m
	Jumlah	= 427,1	kg/m

Koefisien reduksi beban hidup untuk perencanaan portal =0.9

$$\text{Beban hidup (ql)} : 100 . 1,34 .0,9 = 120,6 \text{ kg/m}$$

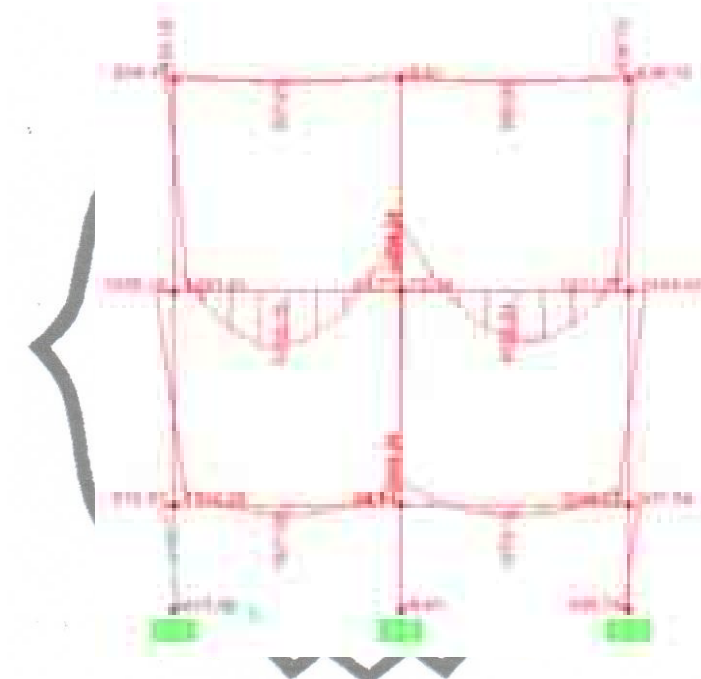


Tugas Akhir
Perencanaan Struktur Gedung Sekolah 2 lantai

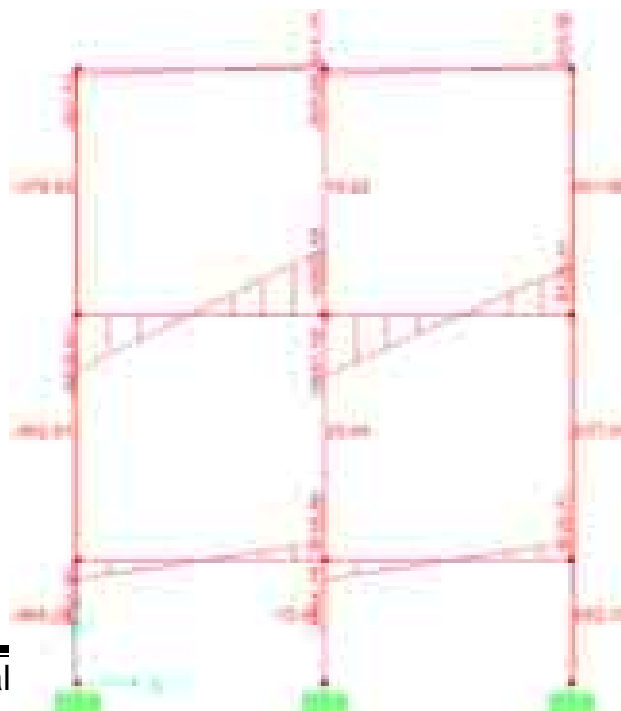
7.4 Penulangan Balok Portal

7.4.1 Perhitungan Tulangan Lentur Rink Balk

Gambar bidang momen ringbalk as 2 (A-B):



Gambar bidang geser ringbalk As 2(A-D):





Tugas Akhir

Perencanaan Struktur Gedung Sekolah 2 lantai

Data perencanaan :

$$h = 300 \text{ mm}$$

$$b = 200 \text{ mm}$$

$$p = 40 \text{ mm}$$

$$f_y = 320 \text{ Mpa}$$

$$f'_c = 25 \text{ MPa}$$

$$\phi_t = 13 \text{ mm}$$

$$\phi_s = 8 \text{ mm}$$

$$d = h - p - \phi_s - \frac{1}{2} \phi_t$$

$$= 300 - 40 - 8 - \frac{1}{2} \cdot 13$$

$$= 245,5 \text{ mm}$$

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

$$= \frac{0,85 \times 25 \times 0,85 \left(\frac{600}{600 + 320} \right)}{320}$$

$$= 0,03136$$

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

$$= 0,75 \cdot 0,03136$$

$$= 0,02352$$

$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{360} = 0,003889$$

a. Daerah Tumpuan :

Dari Perhitungan **SAP 2000** diperoleh momen terbesar pada **batang As 2 bentang A - B**.

$$M_u = \mathbf{636,15 \text{ kgm}} = 6,3615 \times 10^6 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{6,3615 \times 10^6}{0,8} = 7,952 \times 10^6 \text{ Nmm}$$

commit to user



Tugas Akhir

Perencanaan Struktur Gedung Sekolah 2 lantai

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{7,952 \times 10^6}{200 \times 245,5^2} = 0,6597$$

$$m = \frac{f_y}{0,85 \cdot f_c} = \frac{320}{0,85 \times 25} = 16,9412$$

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

$$= \frac{1}{16,9412} \left(1 - \sqrt{1 - \frac{2 \times 16,9412 \times 0,6597}{360}} \right)$$

$$= 0,001862$$

$$\rho < \rho_{\min}$$

$\rho < \rho_{\max} \rightarrow$ dipakai tulangan tunggal

Digunakan $\rho_{\min} = 0,003889$

$$\begin{aligned} \text{As perlu} &= \rho_{\min} \cdot b \cdot d \\ &= 0,003889 \times 200 \times 245,5 \\ &= 190,9499 \text{ mm}^2 \end{aligned}$$

Digunakan tulangan D 8

$$\begin{aligned} n &= \frac{\text{As perlu}}{\frac{1}{4} \pi \cdot 8^2} = \frac{190,9499}{50,266} \\ &= 3,79 \approx 4 \text{ tulangan} \end{aligned}$$

$$\text{As}' = 4 \times 50,266 = 201,064 \text{ mm}^2$$

$\text{As}' > \text{As} \dots \dots \dots$ aman Ok !

Jadi dipakai tulangan **4 D 8 mm**

b. Daerah Lapangan

Dari Perhitungan **SAP 2000** diperoleh momen terbesar pada **batang As 2 bentang A - B.**

$$M_u = 309,00 \text{ kgm} = 3,09 \times 10^6 \text{ Nmm}$$

$$M_n = \frac{M_u}{\phi} = \frac{3,09 \times 10^6}{0,8} = 3,863 \times 10^6 \text{ Nmm}$$

commit to user



Tugas Akhir

Perencanaan Struktur Gedung Sekolah 2 lantai

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{3,863 \times 10^6}{200 \times 245,5^2} = 0,3204$$

$$m = \frac{f_y}{0,85 \cdot f_c} = \frac{320}{0,85 \times 25} = 16,9412$$

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

$$= \frac{1}{16,9412} \left(1 - \sqrt{1 - \frac{2 \times 16,9412 \times 0,3204}{320}} \right)$$

$$= 0,000897$$

$$\rho < \rho_{\min}$$

$\rho < \rho_{\max} \rightarrow$ dipakai tulangan tunggal

Digunakan $\rho_{\min} = 0,003889$

$$\begin{aligned} \text{As perlu} &= \rho_{\min} \cdot b \cdot d \\ &= 0,003889 \times 200 \times 245,5 \\ &= 190,94 \text{ mm}^2 \end{aligned}$$

Digunakan tulangan D 13

$$\begin{aligned} n &= \frac{\text{As perlu}}{\frac{1}{4} \pi \cdot 13^2} = \frac{190,94}{132,665} \\ &= 1,439 \approx 2 \text{ tulangan} \end{aligned}$$

$$\text{As}' = 2 \times 132,665 = 265,3 \text{ mm}^2$$

$\text{As}' > \text{As} \dots \dots \dots$ aman Ok !

Jadi dipakai tulangan **2 D 13 mm**

7.4.2 Perhitungan Tulangan Geser Ring Balk

Dari Perhitungan **SAP 2000** diperoleh gaya geser terbesar pada **batang As 2 bentang A - D**.

$$V_u = 933,39 \text{ kg} = 9333,9 \text{ N}$$

$$\begin{aligned} V_c &= 1/6 \cdot \sqrt{f'_c} \cdot b \cdot d \\ &= 1/6 \times \sqrt{25} \times 300 \times 345,5 = 86375 \text{ N} \end{aligned}$$

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Tugas Akhir Perencanaan Struktur Gedung Sekolah 2 lantai

$$\phi V_c = 0,6 \times 86375 \text{ N} = 51825 \text{ N}$$

$$3 \phi V_c = 3 \times 51825 \text{ N} \\ = 155475 \text{ N}$$

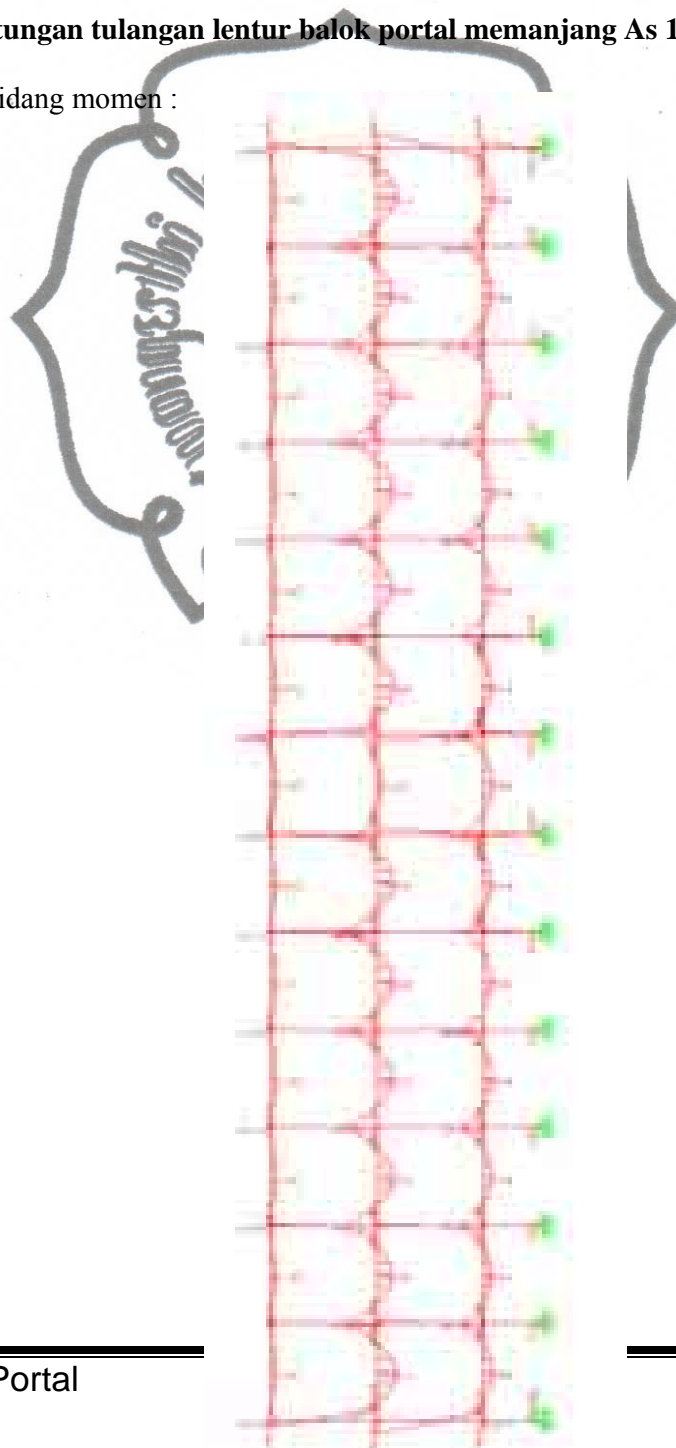
$V_u < \phi V_c < 3 \phi V_c$ (tidak perlu tulangan geser)

dipakai tulangan geser minimum $\phi 8 - 200 \text{ mm}$

7.4.2 Hitungan Tulangan Lentur Balok Portal memanjang

7.4.2.1 hitungan tulangan lentur balok portal memanjang As 1-14

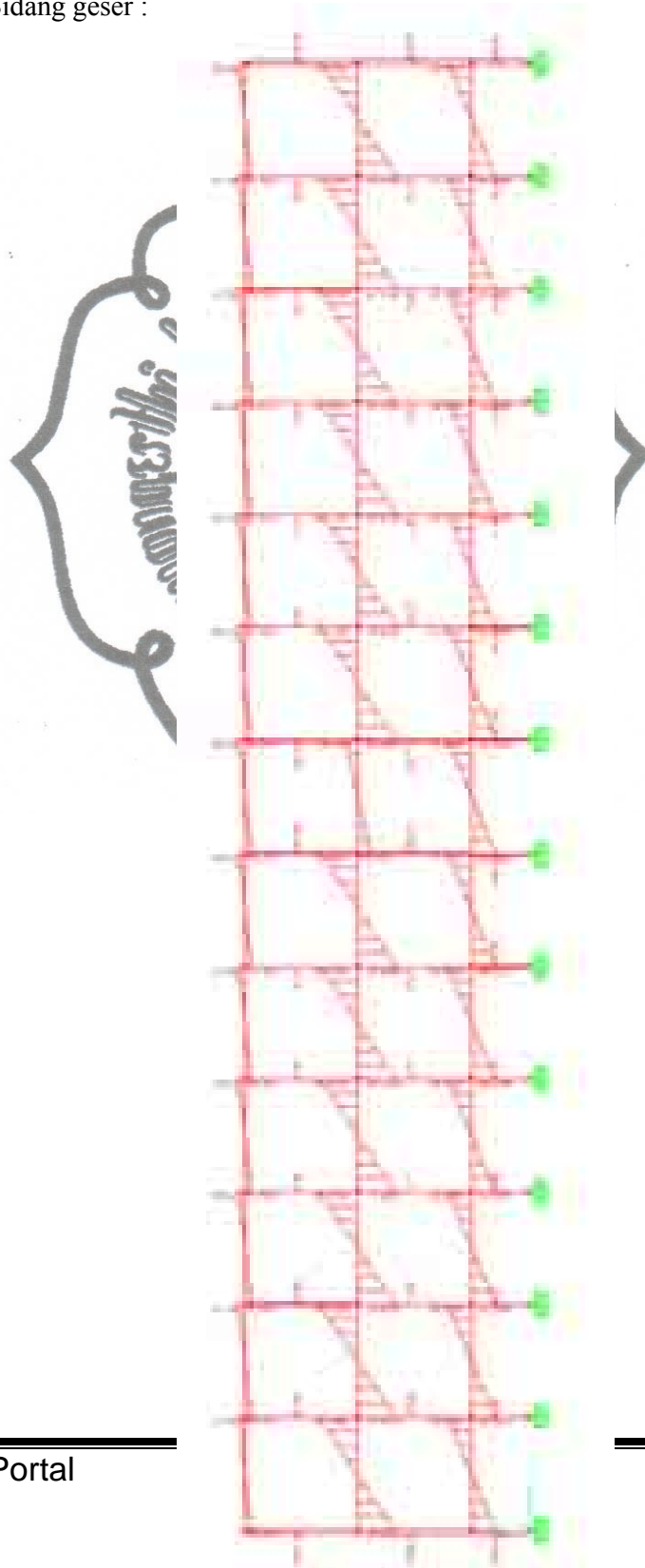
Gambar bidang momen :





Tugas Akhir
Perencanaan Struktur Gedung Sekolah 2 lantai

Gambar Bidang geser :





Tugas Akhir Perencanaan Struktur Gedung Sekolah 2 lantai

Untuk perhitungan tulangan lentur balok portal memanjang, diambil pada bentang dengan moment terbesar dari perhitungan SAP 2000, yaitu **Portal As-A bentang 1-2**

Data perencanaan:

$$b = 250 \text{ mm} \quad f_y = 320 \text{ MPa}$$

$$h = 400 \text{ mm} \quad f_{ys} = 240 \text{ MPa}$$

$$f'_c = 25 \text{ MPa}$$

$$\text{\textcircled{O}} \text{ tulangan} = 19 \text{ mm}$$

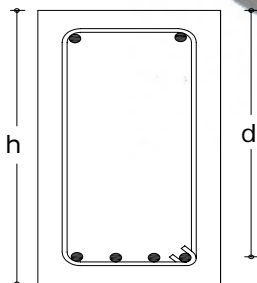
$$\text{\textcircled{O}} \text{ sengkang} = 10 \text{ mm}$$

$$\text{Tebal selimut (s)} = 40 \text{ mm}$$

$$d = h - s - \text{\textcircled{O}} \text{ sengkang} - \frac{1}{2} \text{\textcircled{O}} \text{ tul. utama}$$

$$= 400 - 40 - 10 - \frac{1}{2} \cdot 19$$

$$= 341,5 \text{ mm}$$



$$\begin{aligned} \rho_b &= \frac{0,85 \cdot f'_c \cdot \beta}{f_y} \left[\frac{600}{600 + f_y} \right] \\ &= \frac{0,85 \cdot 25 \cdot 0,85}{320} \left[\frac{600}{600 + 320} \right] = 0,03136 \end{aligned}$$

$$\rho_{\max} = 0,75 \rho_b = 0,2325$$

$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{360} = 0,003889$$

commit to user



Tugas Akhir Perencanaan Struktur Gedung Sekolah 2 lantai

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{320}{0,85 \times 25} = 16,9412$$

a. Penulangan Daerah Tumpuan :

$$M_u = 1715,32 \text{ kgm} = 1,7153 \times 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\Phi} = \frac{1,7153 \times 10^7}{0,8} = 2,1442 \times 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{2,1442 \times 10^7}{250 \times 341,5^2} = 0,7354 \text{ Nmm}^2$$

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

$$= \frac{1}{16,9412} \left[1 - \sqrt{1 - \frac{2 \times 16,9412 \times 0,7354}{320}} \right]$$

$$= 0,002079$$

$$\rho < \rho_{\min}$$

$\rho < \rho_{\max} \rightarrow$ dipakai tulangan tunggal

Digunakan $\rho_{\min} = 0,003889$

$$A_{s_{\text{perlu}}} = \rho_{\min} \cdot b \cdot d$$

$$= 0,003889 \times 250 \times 341,5$$

$$= 332,20248 \text{ mm}^2$$

Digunakan tulangan **D 16**

$$n = \frac{A_{s_{\text{perlu}}}}{1/4 \times \pi \times 16^2}$$

$$= \frac{332,20248}{201,062} = 1,65 \sim 2 \text{ tulangan}$$

$$A_s' = 2 \times 201,062 = 402,124 > 332,2025 \text{ mm}^2$$

$A_s' > A_s$ OK ☺

Digunakan tulangan **2 D 16**

commit to user



Tugas Akhir
Perencanaan Struktur Gedung Sekolah 2 lantai

b. Penulangan Daerah Lapangan

$$M_u = 1650,645 \text{ kgm} = 1,6506 \times 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\Phi} = \frac{1,6506 \times 10^7}{0,8} = 2,0633 \times 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{2,0633 \times 10^7}{250 \times 341,5^2} = 0,7077 \text{ Nmm}^2$$

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

$$= \frac{1}{16,9412} \left[1 - \sqrt{1 - \frac{2 \times 16,9412 \times 0,7077}{320}} \right]$$

$$= 0,001999$$

$$\rho > \rho_{\min}$$

$$\rho < \rho_{\max} \rightarrow \text{dipakai tulangan tunggal}$$

$$\text{Digunakan } \rho_{\text{ada}} = 0,003889$$

$$A_{s\text{perlu}} = \rho_{\min} \cdot b \cdot d$$

$$= 0,003889 \times 250 \times 341,5$$

$$= 332,20248 \text{ mm}^2$$

Digunakan tulangan **D 16**

$$n = \frac{A_{s\text{perlu}}}{1/4 \times \pi \times 16^2}$$

$$= \frac{332,20248}{201,062} = 1,65 \sim 2 \text{ tulangan}$$

$$A_s' = 2 \times 201,062 = 402,124 > 332,2025 \text{ mm}^2$$

$$A_s' > A_s \dots \dots \dots \text{OK } \odot$$

Kontrol Spasi :

commit to user



Tugas Akhir Perencanaan Struktur Gedung Sekolah 2 lantai

$$S = \frac{b - 2p - n\phi \text{ tulangan} - 2\phi \text{ sengkang}}{n - 1}$$

$$= \frac{250 - 2 \cdot 40 - 3 \cdot 16 - 2 \cdot 10}{3 - 1} = 51 > 25 \text{ mm} \dots \text{OK} \odot$$

Digunakan tulangan **2 D 16**

c. Perhitungan Tulangan Geser Balok Portal Memanjang

$$V_u = 4683,53 = 46835,3 \text{ N}$$

$$V_c = 1/6 \cdot \sqrt{f'_c} \cdot b \cdot d = 1/6 \cdot \sqrt{25} \cdot 250 \cdot 341,5 = 71145,8 \text{ N}$$

$$\phi V_c = 0,6 \cdot V_c = 42687,5 \text{ N}$$

$$3 \phi V_c = 128062,5 \text{ N}$$

Syarat tulangan geser : $\phi V_c < V_u < 3 \phi V_c$

Karena : $V_u < \phi V_c < 3 \phi V_c$ (tidak perlu tulangan geser)

Jadi dipakai tulangan geser minimum **$\phi 8 - 200 \text{ mm}$**

7.4.3.2 Hitungan tulangan lentur balok portal memanjang As C (7-8)

Untuk pehitungan tulangan lentur balok portal memanjang, diambil pada bentang dengan moment terbesar dari perhitungan SAP 2000

Data perencanaan:

$$b = 200 \text{ mm} \quad f_y = 320 \text{ MPa}$$

$$h = 300 \text{ mm} \quad f_{ys} = 240 \text{ MPa}$$

$$f'_c = 25 \text{ MPa}$$

$$\phi \text{ tulangan} = 16 \text{ mm}$$

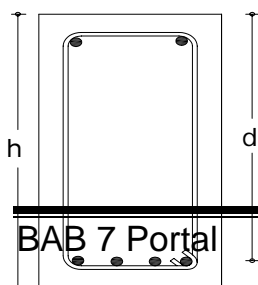
$$\phi \text{ sengkang} = 10 \text{ mm}$$

$$\text{Tebal selimut (s)} = 40 \text{ mm}$$

$$d = h - s - \phi \text{ sengkang} - \frac{1}{2} \phi \text{ tul. utama}$$

$$= 300 - 40 - 8 - \frac{1}{2} \cdot 16$$

$$= 244 \text{ mm}$$



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Tugas Akhir
Perencanaan Struktur Gedung Sekolah 2 lantai

$$\rho_b = \frac{0,85 \cdot f'c \cdot \beta}{f_y} \left[\frac{600}{600 + f_y} \right]$$

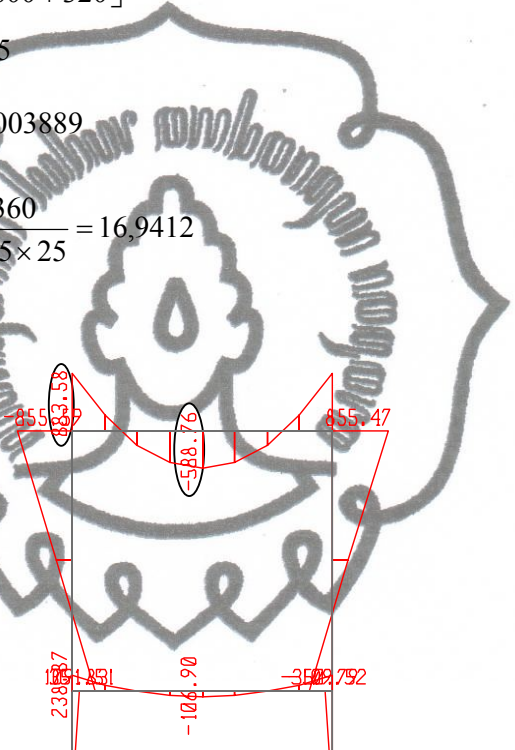
$$= \frac{0,85 \cdot 25 \cdot 0,85}{320} \left[\frac{600}{600 + 320} \right] = 0,03136$$

$$\rho_{max} = 0,75 \rho_b = 0,2325$$

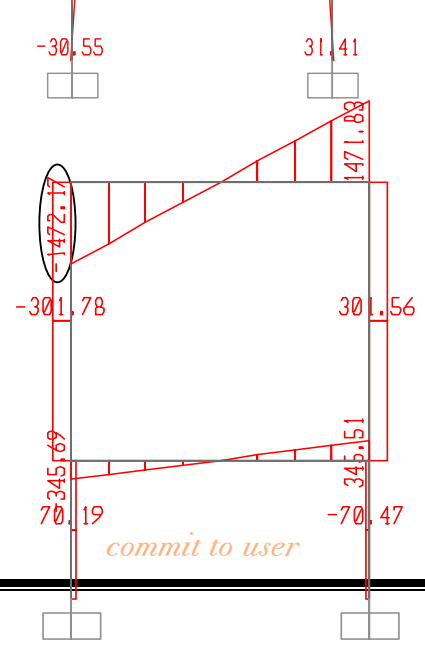
$$\rho_{min} = \frac{1,4}{f_y} = \frac{1,4}{360} = 0,003889$$

$$m = \frac{f_y}{0,85 \cdot f'c} = \frac{360}{0,85 \times 25} = 16,9412$$

gambar bidang momen:



Gambar bidang geser :



commit to user



Tugas Akhir

Perencanaan Struktur Gedung Sekolah 2 lantai

a. Penulangan Daerah Tumpuan :

Dari Perhitungan SAP 2000 diperoleh momen terbesar pada **batang As-C bentang 7-8**

$$Mu = 883,58 \text{ kgm} = 8,8358 \times 10^6 \text{ Nmm}$$

$$Mn = \frac{Mu}{\Phi} = \frac{8,8358 \times 10^6}{0,8} = 11,045 \times 10^6 \text{ Nmm}$$

$$Rn = \frac{Mn}{b.d^2} = \frac{11,045 \times 10^6}{200 \times 244^2} = 0,9276 \text{ Nmm}^2$$

$$\rho = \frac{1}{m} \left[1 - \sqrt{1 - \frac{2.m.Rn}{fy}} \right]$$

$$= \frac{1}{16,9412} \left[1 - \sqrt{1 - \frac{2 \times 16,9412 \times 0,9276}{320}} \right]$$

$$= 0,002635$$

$$\rho < \rho_{\min}$$

$\rho < \rho_{\max} \rightarrow$ dipakai tulangan tunggal

Digunakan $\rho_{\min} = 0,003889$

$$As_{\text{perlu}} = \rho_{\min} \cdot b \cdot d$$

$$= 0,003889 \times 200 \times 244 = 189,78 \text{ mm}^2$$

Digunakan tulangan **D 16**

$$n = \frac{As_{\text{perlu}}}{1/4 \times \pi \times 19^2}$$

$$= \frac{189,78}{200,96} = 0,94 \sim 2 \text{ tulangan}$$

$$As' = 2 \times 283,385 = 401,92 > 189,78 \text{ mm}^2$$

$As' > As$aman Ok !

commit to user



Tugas Akhir Perencanaan Struktur Gedung Sekolah 2 lantai

Kontrol Spasi :

$$S = \frac{b - 2p - n\phi \text{ tulangan} - 2\phi \text{ sengkang}}{n - 1}$$

$$= \frac{200 - 2 \cdot 40 - 2 \cdot 16 - 2 \cdot 8}{2 - 1} = 72 > 25 \text{ mm} \dots \text{OK} \odot$$

Digunakan tulangan **2 D 16**

b. Penulangan Daerah Lapangan

$$M_u = 588,76 \text{ kgm} = 5,8876 \times 10^6 \text{ Nmm}$$

$$M_n = \frac{M_u}{\Phi} = \frac{5,8876 \times 10^6}{0,8} = 7,36 \times 10^6 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{7,36 \times 10^6}{200 \times 244^2} = 0,618 \text{ Nmm}^2$$

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

$$= \frac{1}{16,9412} \left[1 - \sqrt{1 - \frac{2 \times 16,9412 \times 0,618}{320}} \right]$$

$$= 0,00174$$

$$\rho < \rho_{\min}$$

$\rho < \rho_{\max} \rightarrow$ dipakai tulangan tunggal

Digunakan $\rho_{\min} = 0,003889$

$$A_{s\text{perlu}} = \rho_{\min} \cdot b \cdot d$$

$$= 0,003889 \times 200 \times 244 = 189,783 \text{ mm}^2$$

$$n = \frac{A_{s\text{perlu}}}{1/4 \times \pi \times 16^2}$$

$$= \frac{189,783}{200,96} = 0,944 \sim 2 \text{ tulangan}$$

$$A_s' = 2 \times 200,96 = 401,92 > 996,37 \text{ mm}^2$$

$A_s' > A_s \dots \dots \dots$ aman Ok !

Kontrol Spasi :

commit to user



Tugas Akhir
Perencanaan Struktur Gedung Sekolah 2 lantai

$$S = \frac{b - 2p - n\phi \text{ tulangan} - 2\phi \text{ sengkang}}{n - 1}$$

$$= \frac{200 - 2 \cdot 40 - 2 \cdot 16 - 2 \cdot 8}{2 - 1} = 72 > 25 \text{ mm} \dots \text{ OK } \textcircled{\smile}$$

Digunakan tulangan **2 D 16**

c. Perhitungan Tulangan Geser Balok Portal Memanjang

$$V_u = 1472,17 \text{ kg} = 14721,7 \text{ N}$$

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

$$= \frac{1}{6} \cdot \sqrt{25} \cdot 200 \cdot 244$$

$$= 40666,67 \text{ N}$$

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

$$= 24400 \text{ N}$$

$$3 \phi V_c = 73200 \text{ N}$$

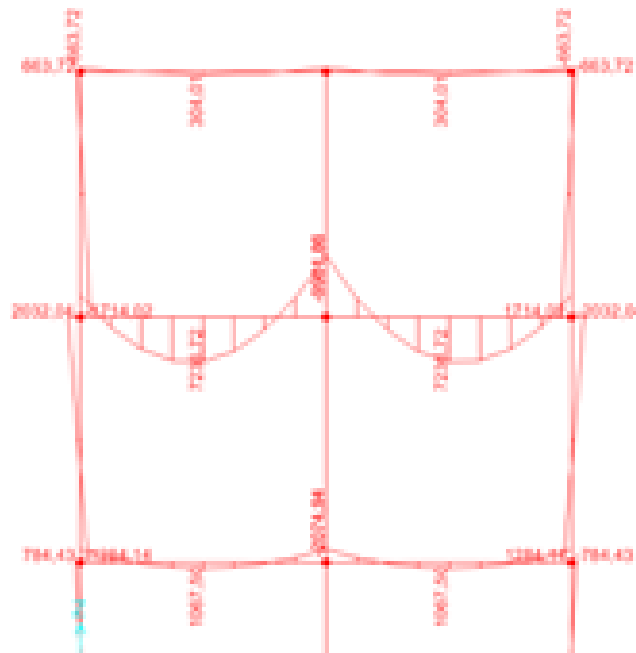
$V_u < \phi V_c < 3 \phi V_c$ (tidak perlu tulangan geser)

dipakai tulangan geser minimum $\phi 8 - 200 \text{ mm}$

7.4.4. Hitungan Tulangan Lentur Balok Portal Melintang

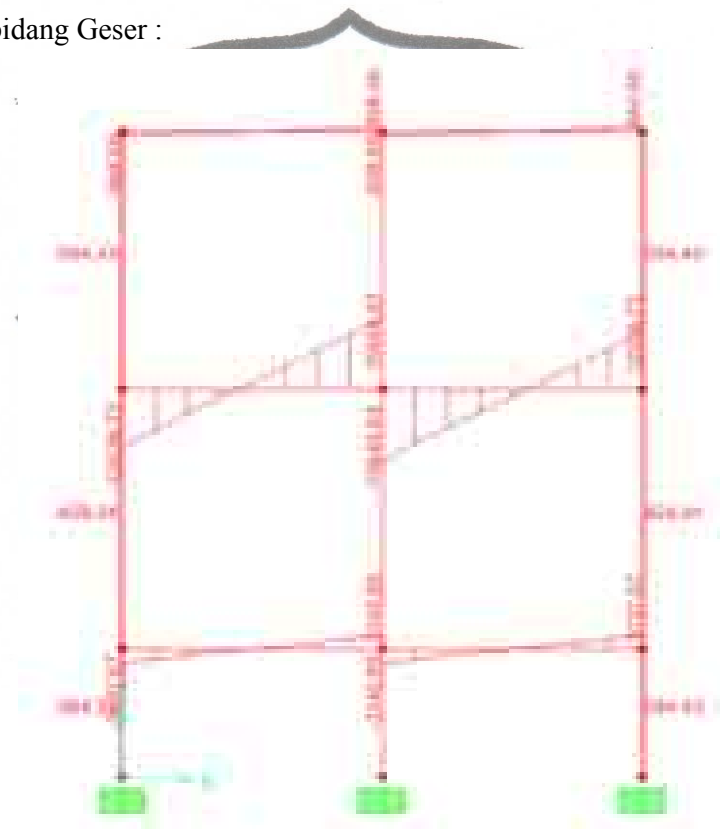
7.4.4.1 Hitungan tulangan Lentur Balok Portal Melintang As 10 bentang A-B

Gambar bidang momen :





Gambar bidang Geser :



Untuk perhitungan tulangan lentur balok portal, diambil pada bentang dengan momen terbesar dari perhitungan SAP 2000, yaitu **Portal As-10 bentang A-B**

Data perencanaan:

$$b = 400 \text{ mm} \quad f_y = 320 \text{ MPa}$$

$$h = 700 \text{ mm} \quad f_{ys} = 240 \text{ MPa}$$

$$d = 640,5 \text{ mm} \quad f'_c = 25 \text{ MPa}$$

$$\text{\textcircled{O}} \text{ tulangan} = 19 \text{ mm}$$

commit to user

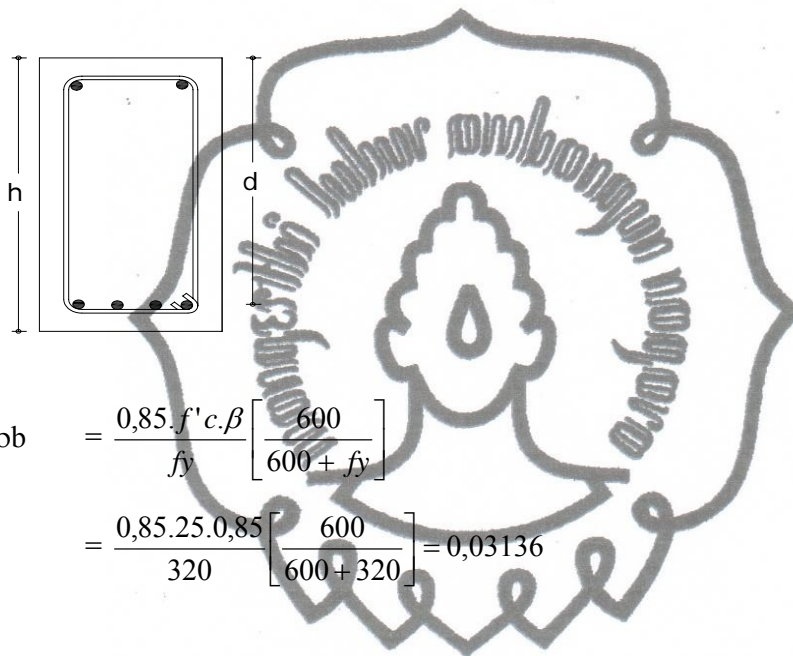


Tugas Akhir Perencanaan Struktur Gedung Sekolah 2 lantai

$$\emptyset \text{ sengkang} = 10 \text{ mm}$$

$$\text{Tebal selimut (s)} = 40 \text{ mm}$$

$$\begin{aligned} d &= h - s - \emptyset \text{ sengkang} - \frac{1}{2} \emptyset \text{ tul. utama} \\ &= 700 - 40 - 10 - \frac{1}{2} \cdot 19 \\ &= 640,5 \text{ mm} \end{aligned}$$



$$\begin{aligned} \rho_b &= \frac{0,85 \cdot f'_c \cdot \beta}{f_y} \left[\frac{600}{600 + f_y} \right] \\ &= \frac{0,85 \cdot 25 \cdot 0,85}{320} \left[\frac{600}{600 + 320} \right] = 0,03136 \end{aligned}$$

$$\rho_{\max} = 0,75 \rho_b = 0,2325$$

$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{360} = 0,003889$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{360}{0,85 \times 25} = 16,9412$$

a. Penulangan Daerah Tumpuan

Dari Perhitungan **SAP 2000** diperoleh momen terbesar pada **Portal As- 10**
bentang A-B

$$M_u = 2032,24 \text{ kgm} = 2,03224 \times 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\Phi} = \frac{2,03224 \times 10^7}{0,8} = 2,5403 \times 10^7 \text{ Nmm}$$

commit to user



Tugas Akhir

Perencanaan Struktur Gedung Sekolah 2 lantai

$$R_n = \frac{Mn}{b.d^2} = \frac{2,5403 \times 10^7}{400 \times 640,5^2} = 0,1548 \text{ Nmm}^2$$

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

$$= \frac{1}{16,9412} \left[1 - \sqrt{1 - \frac{2 \times 16,9412 \times 0,1548}{320}} \right]$$

$$= 0,0004316$$

$$\rho < \rho_{\min}$$

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

$$\text{Digunakan } \rho_{\min} = 0,003889$$

$$A_{s\text{perlu}} = \rho \cdot b \cdot d$$

$$= 0,003889 \times 400 \times 640,5 = 996,362 \text{ mm}^2$$

$$n = \frac{A_{s\text{perlu}}}{\frac{1}{4} \times \pi \times 19^2}$$

$$= \frac{996,362}{283,385} = 3,515 \sim 6 \text{ tulangan}$$

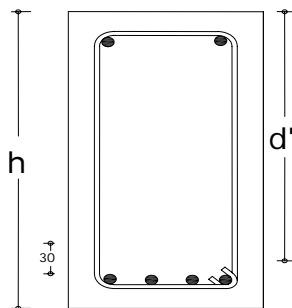
$$A_{s'} = 6 \times 283,385 = 1700,31 \text{ mm}^2$$

$$A_{s'} > A_s \dots \dots \dots \text{OK } \text{☺}$$

Kontrol Spasi :

$$S = \frac{b - 2p - n\phi \text{ tulangan} - 2\phi \text{ sengkang}}{n - 1}$$

$$= \frac{400 - 2 \cdot 40 - 6 \cdot 19 - 2 \cdot 10}{6 - 1} = 37,2 > 25 \text{ mm}$$



commit to user



Tugas Akhir Perencanaan Struktur Gedung Sekolah 2 lantai

Jadi, digunakan tulangan **6 D 19**

b. Penulangan Daerah Lapangan

Dari Perhitungan **SAP 2000** diperoleh momen terbesar pada **Portal As- 10**
bentang B-C

$$M_u = 7236,72 \text{ tm} = 7,2367 \times 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\Phi} = \frac{7,2367 \times 10^7}{0,8} = 9,0459 \times 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{9,0459 \times 10^7}{400 \times 640,5^2} = 0,5513 \text{ Nmm}^2$$

$$\begin{aligned} \rho &= \frac{1}{m} \left[1 - \sqrt{1 - \frac{2 \cdot m \cdot R_n}{f_y}} \right] \\ &= \frac{1}{16,9412} \left[1 - \sqrt{1 - \frac{2 \times 16,9412 \times 0,5513}{320}} \right] \\ &= 0,001552 \end{aligned}$$

$$\rho < \rho_{\min}$$

$\rho < \rho_{\max} \rightarrow$ dipakai tulangan tunggal

Digunakan $\rho_{\min} = 0,003889$

$$\begin{aligned} A_{s\text{perlu}} &= \rho \cdot b \cdot d \\ &= 0,003889 \times 400 \times 640,5 = 996,362 \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} n &= \frac{A_{s\text{perlu}}}{1/4 \times \pi \times 19^2} \\ &= \frac{996,362}{283,385} = 3,515 \sim 6 \text{ tulangan} \end{aligned}$$

$$A_s' = 6 \times 283,385 = 1700,31 \text{ mm}^2$$

commit to user



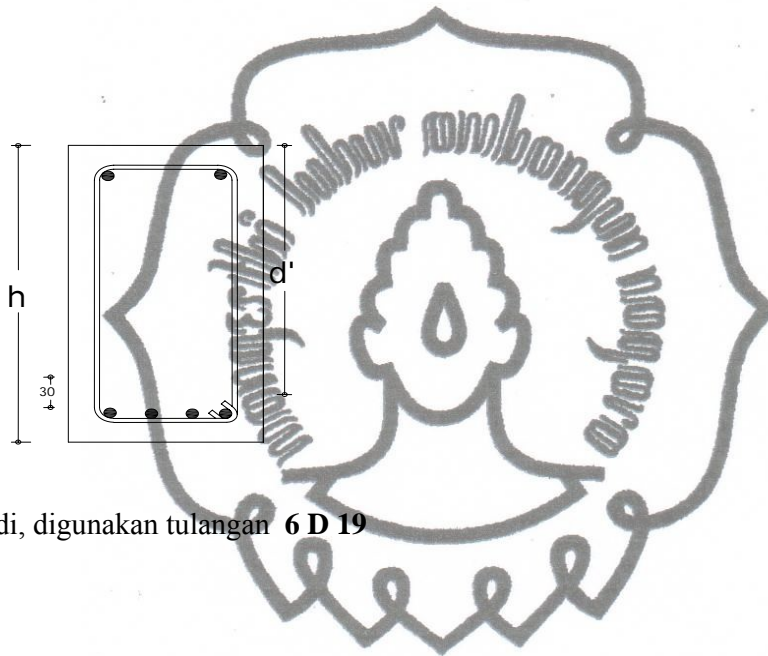
Tugas Akhir Perencanaan Struktur Gedung Sekolah 2 lantai

As' > As.....OK ☺

Kontrol Spasi :

$$S = \frac{b - 2p - n\phi \text{ tulangan} - 2\phi \text{ sengkang}}{n - 1}$$

$$= \frac{400 - 2 \cdot 40 - 6 \cdot 19 - 2 \cdot 10}{6 - 1} = 37,2 > 25 \text{ mm}$$



Jadi, digunakan tulangan **6 D 19**

c. Perhitungan Tulangan Geser

Dari Perhitungan SAP 2000 diperoleh momen terbesar pada **Portal As-10** bentang **A-B**

$$V_u = 15644,63 \text{ kg} = 156446,3 \text{ N}$$

$$V_c = 1/6 \cdot \sqrt{f'c} \cdot b \cdot d = 1/6 \cdot \sqrt{25} \cdot 400 \cdot 640,5 = 213500 \text{ N}$$

$$\phi V_c = 0,6 \cdot V_c = 128100 \text{ N}$$

$$3 \phi V_c = 384300 \text{ N}$$

$$\phi V_c < V_u < 3 \phi V_c \quad (\text{perlu tulangan geser})$$

$$\phi V_s = V_u - \phi V_c = 2,8346 \cdot 10^4 \text{ N}$$

$$V_{s \text{ perlu}} = \frac{\phi v_s}{\phi} = \frac{2,8346 \cdot 10^4}{0,6} = 4,7244 \cdot 10^4 \text{ N}$$

commit to user



Tugas Akhir Perencanaan Struktur Gedung Sekolah 2 lantai

Digunakan sengkang $\varnothing 10$,

$$A_v = 2 \cdot A = 157 \text{ mm}^2$$

$$S = \frac{A_v \cdot f'_y \cdot d}{V_{s \text{ perlu}}} = \frac{157 \cdot 360 \cdot 640,5}{4,7244 \cdot 10^4} = 766,26 \text{ mm}$$

$$S_{\text{maks}} = \frac{d}{2} = \frac{640,5}{2} = 320,25 \text{ mm}$$

Jadi, dipakai sengkang $\varnothing 10 - 200 \text{ mm}$

$$V_{s \text{ ada}} = \frac{A_v \cdot f_y \cdot d}{S} = \frac{157 \times 360 \times 640,5}{760} = 4,7633 \cdot 10^4 \text{ N}$$

$$V_{s \text{ ada}} > V_{s \text{ perlu}} \\ 4,7633 \cdot 10^4 \text{ N} > 4,7244 \cdot 10^4 \text{ N} \dots \dots \text{ (aman)}$$

7.4.4.2 Hitungan Tulangan Lentur Balok Pada Plat Atap

Untuk perhitungan tulangan lentur balok portal memanjang, diambil pada bentang dengan moment terbesar dari perhitungan SAP 2000, yaitu **Portal As-2 bentang A-B**

A-B

Data perencanaan:

$$b = 200 \text{ mm} \quad f_y = 320 \text{ MPa}$$

$$h = 300 \text{ mm} \quad f_{ys} = 240 \text{ MPa}$$

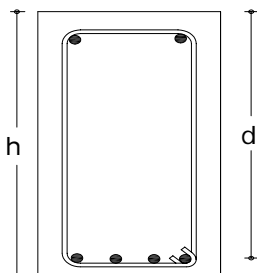
$$f'_c = 25 \text{ MPa}$$

$$\varnothing \text{ tulangan} = 16 \text{ mm}$$

$$\varnothing \text{ sengkang} = 10 \text{ mm}$$

$$\text{Tebal selimut (s)} = 40 \text{ mm}$$

$$d = h - s - \varnothing \text{ sengkang} - \frac{1}{2} \varnothing \text{ tul. utama} \\ = 300 - 40 - 8 - \frac{1}{2} \cdot 16 \\ = 244 \text{ mm}$$



commit to user



Tugas Akhir Perencanaan Struktur Gedung Sekolah 2 lantai

$$\begin{aligned}\rho_b &= \frac{0,85 \cdot f'_c \cdot \beta}{f_y} \left[\frac{600}{600 + f_y} \right] \\ &= \frac{0,85 \cdot 25 \cdot 0,85}{320} \left[\frac{600}{600 + 320} \right] = 0,03136\end{aligned}$$

$$\rho_{\max} = 0,75 \rho_b = 0,2325$$

$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{360} = 0,003889$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{320}{0,85 \times 25} = 16,9412$$

a. Penulangan Daerah Tumpuan :

Dari Perhitungan SAP 2000 diperoleh momen terbesar pada batang As-C bentang 6-7

$$M_u = 1701,87 \text{ kgm} = 1,702 \times 10^7 \text{ Nmm}$$

$$M_n = \frac{M_u}{\Phi} = \frac{1,702 \times 10^7}{0,8} = 2,1275 \times 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{2,1275 \times 10^7}{200 \times 244^2} = 1,786 \text{ Nmm}^2$$

$$\begin{aligned}\rho &= \frac{1}{m} \left[1 - \sqrt{1 - \frac{2 \cdot m \cdot R_n}{f_y}} \right] \\ &= \frac{1}{16,9412} \left[1 - \sqrt{1 - \frac{2 \times 16,9412 \times 1,786}{320}} \right] \\ &= 0,005189\end{aligned}$$

$$\rho > \rho_{\min}$$

$\rho < \rho_{\max} \rightarrow$ dipakai tulangan tunggal

Digunakan $\rho_{\min} = 0,005189$

$$\begin{aligned}A_{s_{\text{perlu}}} &= \rho_{\min} \cdot b \cdot d \\ &= 0,005189 \times 200 \times 244\end{aligned}$$

commit to user



Tugas Akhir Perencanaan Struktur Gedung Sekolah 2 lantai

$$= 253,22 \text{ mm}^2$$

Digunakan tulangan **D 16**

$$n = \frac{As \text{ perlu}}{1/4 \times \pi \times 19^2}$$

$$= \frac{253,22}{200,96} = 1,26 \sim 2 \text{ tulangan}$$

$$As' = 2 \times 283,385 = 401,92 > 253,22 \text{ mm}^2$$

$As' > As$aman Ok !

Kontrol Spasi :

$$S = \frac{b - 2p - n\phi \text{ tulangan} - 2\phi \text{ sengkang}}{n - 1}$$

$$= \frac{200 - 2 \cdot 40 - 2 \cdot 16 - 2 \cdot 8}{2 - 1} = 72 > 25 \text{ mm} \dots \text{OK} \odot$$

Digunakan tulangan **2 D 16**

b. Penulangan Daerah Lapangan

Pada daerah lapangan digunakan tulangan 2 D 16 sebagai tulangan pembentuk

c. Perhitungan Tulangan Geser Balok Portal Memanjang

$$V_u = 2134,37 \text{ kg} = 213437 \text{ N}$$

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

$$= 1/6 \cdot \sqrt{25} \cdot 200 \cdot 244$$

$$= 40666,67 \text{ N}$$

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

$$= 24400 \text{ N}$$

$$3 \emptyset V_c = 73200 \text{ N}$$

$V_u < \emptyset V_c < 3 \emptyset V_c$ (tidak perlu tulangan geser)

dipakai tulangan geser minimum $\emptyset 8 - 200 \text{ mm}$

commit to user

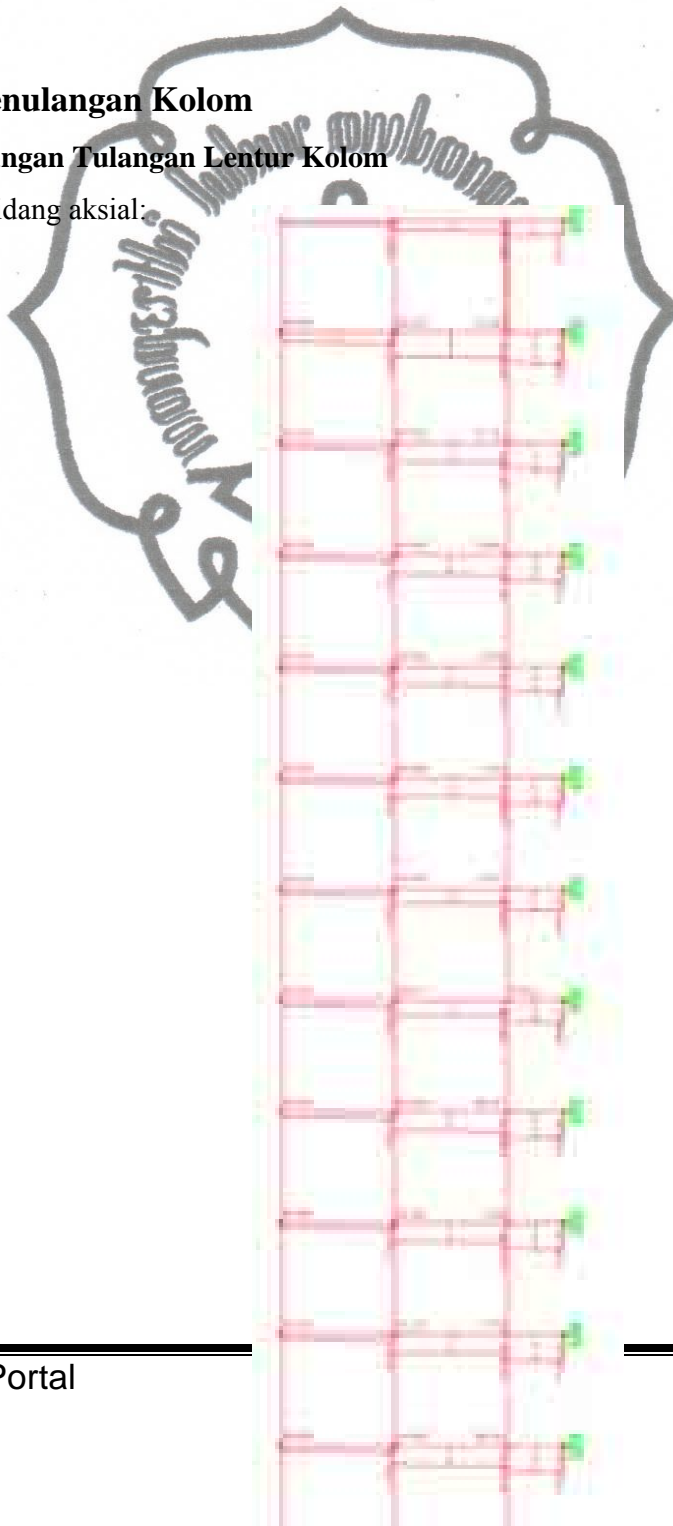


Tugas Akhir
Perencanaan Struktur Gedung Sekolah 2 lantai

7.5. Penulangan Kolom

7.5.1. Hitungan Tulangan Lentur Kolom

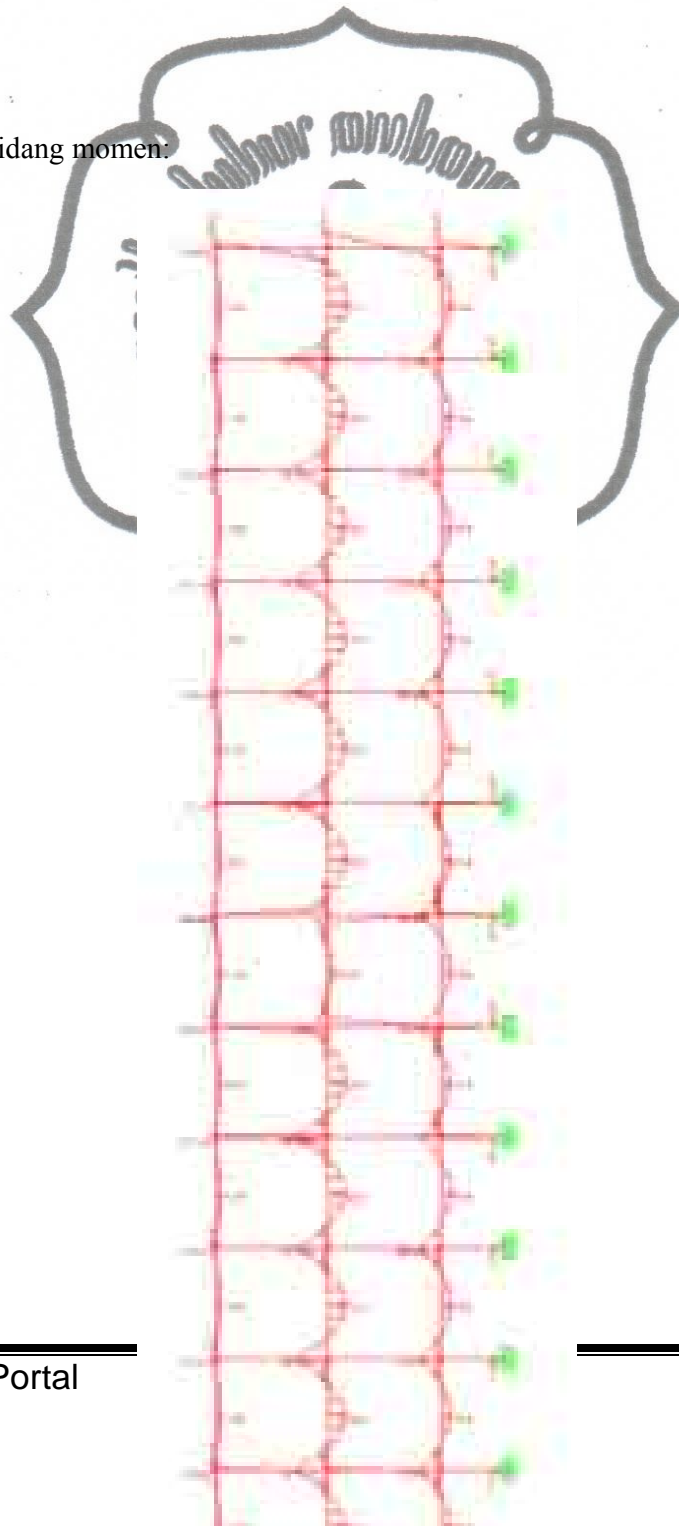
Gambar bidang aksial:





Tugas Akhir
Perencanaan Struktur Gedung Sekolah 2 lantai

Gambar bidang momen:





Tugas Akhir

Perencanaan Struktur Gedung Sekolah 2 lantai

Untuk contoh perhitungan tulangan lentur kolom diambil momen terbesar dari perhitungan dengan SAP 2000, yaitu As **B 2**

Data perencanaan :

b = 500 mm	Ø tulangan = 16 mm
h = 500 mm	Ø sengkang = 10 mm
f'c = 25 MPa	s (tebal selimut) = 40 mm
fy = 320 MPa	

Dari perhitungan SAP didapat :

$$P_u = 36182,68 \text{ kg} = 361826,8 \text{ N}$$

$$M_u = 3119,43 \text{ kgm} = 3,119 \times 10^7 \text{ Nmm}$$

$$d = h - s - \text{Ø sengkang} - \frac{1}{2} \text{Ø tulangan utama}$$

$$= 400 - 40 - 10 - \frac{1}{2} \cdot 16$$

$$= 344 \text{ mm}$$

$$d' = h - d = 400 - 344 = 56 \text{ mm}$$

$$e = \frac{M_u}{P_u} = \frac{3,119 \times 10^7}{361826,8}$$

$$= 86,202 \text{ mm}$$

$$e_{\min} = 0,1 \cdot h = 0,1 \cdot 500 = 50 \text{ mm}$$

$$C_b = \frac{600}{600 + f_y} \cdot d = \frac{600}{600 + 320} \cdot 344$$

commit to user



Tugas Akhir Perencanaan Struktur Gedung Sekolah 2 lantai

$$= 215$$

$$ab = \beta_1 \cdot cb$$

$$= 0,85 \times 215$$

$$= 182,75$$

$$P_{nb} = 0,85 \times f'_c \times ab \times b$$

$$= 0,85 \times 25 \times 182,75 \times 400$$

$$= 15,533 \times 10^5 \text{ N}$$

$$P_n \text{ Perlu} = \frac{P_{nb}}{0,65} = \frac{15,533 \times 10^5}{0,65} = 23,898 \times 10^5 \text{ N}$$

$$P_{n\text{perlu}} > P_{nb} \rightarrow \text{analisis keruntuhan tekan}$$

$$K_1 = \frac{e}{d - d'} + 0,5$$

$$= \frac{86,202}{344 - 56} + 0,5 = 0,799$$

$$K_2 = \frac{3 \times h \times e}{d^2} + 1,18$$

$$= \frac{3 \times 400 \times 86,202}{344^2} + 1,18 = 2,054$$

$$y = b \times h \times f_c'$$

$$= 400 \times 400 \times 25$$

$$= 4 \times 10^6 \text{ N}$$

$$A_s' = \frac{1}{f_y} \left(K_1 \cdot P_n \text{ Perlu} - \frac{K_1}{K_2} \cdot y \right)$$

$$= \frac{1}{320} \left(0,799 \times 23,898 \times 10^5 - \frac{0,799}{2,054} \times 4 \times 10^6 \right)$$

$$= 981,838 \text{ mm}^2$$

$$\text{Dipakai } A_s' = 981,838 \text{ mm}^2$$

Menghitung jumlah tulangan :

$$n = \frac{981,838}{\frac{1}{4} \cdot \pi \cdot (22)^2} = 2,583 \approx 4 \text{ tulangan}$$

$$\text{As ada} = 4 \cdot \frac{1}{4} \cdot \pi \cdot 25^2$$

$$= 1520,53 \text{ mm}^2$$

commit to user



Tugas Akhir
Perencanaan Struktur Gedung Sekolah 2 lantai

As ada > As perlu..... OK ☺

Jadi dipakai tulangan **4 D 22**

7.5.2. Hitungan Tulangan Geser Kolom

$$V_u = 589,35 \text{ kg} = 5,894 \times 10^3 \text{ N}$$

$$P_u = 36182,68 \text{ kg} = 361826,8 \text{ N}$$

$$V_c = \left(1 + \frac{P_u}{14.A_g}\right) \sqrt{\frac{f'_c}{6}} . b.d$$

$$= \left(1 + \frac{361826,8}{14 \times 500 \times 500}\right) \sqrt{\frac{25}{6}} \times 500 \times 442 = 49,775 \times 10^4 \text{ N}$$

$$\phi V_c = 0,6 \times V_c = 29,865 \times 10^4 \text{ N}$$

$$0,5 \phi V_c = 14,9325 \times 10^4 \text{ N}$$

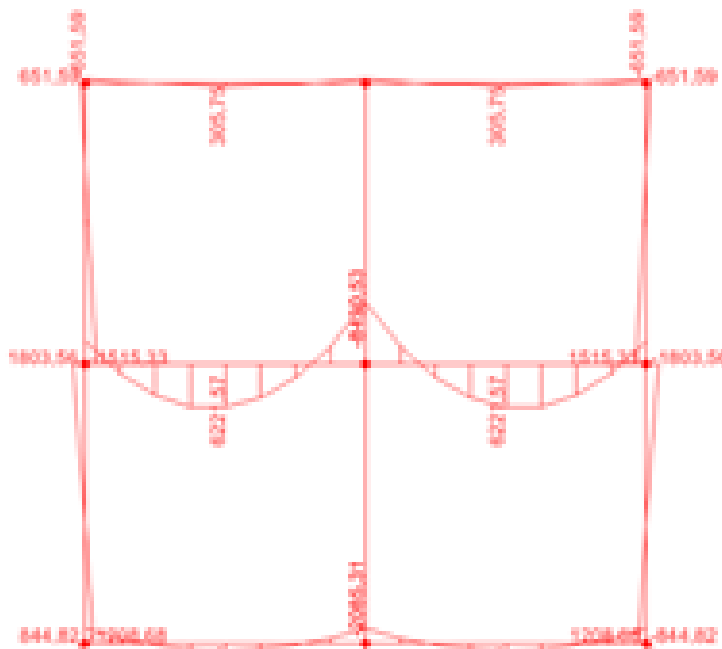
$V_u < 0,5 \phi V_c \Rightarrow$ tanpa diperlukan tulangan geser.

Dipakai sengkang praktis untuk penghubung tulangan memanjang : **Ø10 – 200**
mm.

7.6 PENULANGAN SLOOF

7.6.1. Perhitungan Tulangan Lentur Sloof Melintang

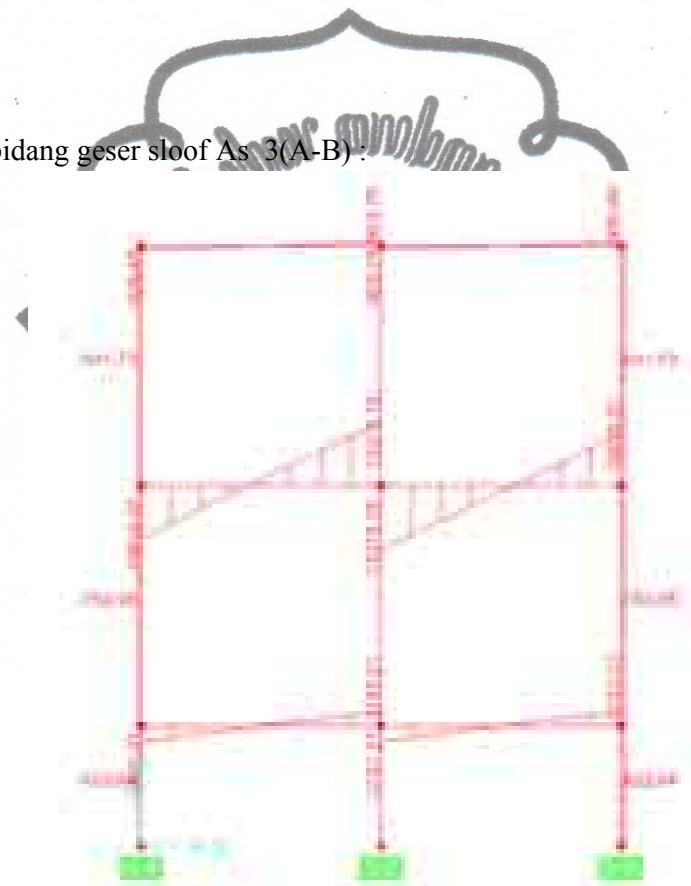
Gambar bidang momen sloof As 3(A-B) :





Tugas Akhir
Perencanaan Struktur Gedung Sekolah 2 lantai

Gambar bidang geser sloof As 3(A-B):



Data perencanaan :

$$b = 250 \text{ mm}$$

$$h = 400 \text{ mm}$$

$$f'c = 25 \text{ MPa}$$

$$fy = 320 \text{ MPa}$$

$$d = h - p - \varnothing_s - \frac{1}{2}\varnothing_t$$

$$= 400 - 40 - 8 - \frac{1}{2} \cdot 16$$

$$= 344 \text{ mm}$$

commit to user



Tugas Akhir

Perencanaan Struktur Gedung Sekolah 2 lantai

$$\begin{aligned}\rho_b &= \frac{0,85 \cdot f'c \cdot \beta}{f_y} \left[\frac{600}{600 + f_y} \right] \\ &= \frac{0,85 \cdot 25 \cdot 0,85}{320} \left[\frac{600}{600 + 320} \right] = 0,03136\end{aligned}$$

$$\rho_{\max} = 0,75 \rho_b = 0,02352$$

$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{360} = 0,003889$$

$$m = \frac{f_y}{0,85 \cdot f'c} = \frac{320}{0,85 \times 25} = 16,9412$$

a. Daerah Tumpuan :

Dari Perhitungan SAP 2000 diperoleh momen terbesar pada **batang As 3 bentang A-B.**

$$M_u = 1208,68 \text{ kgm} = 1,2087 \times 10^7 \text{ Nmm}$$

$$\begin{aligned}M_n &= \frac{M_u}{\phi} = \frac{1,2087 \times 10^7}{0,8} \\ &= 1,5109 \times 10^7 \text{ Nmm}\end{aligned}$$

$$\begin{aligned}R_n &= \frac{M_n}{b \cdot d^2} = \frac{1,5109 \times 10^7}{250 \times 344^2} \\ &= 0,517\end{aligned}$$

$$m = \frac{f_y}{0,85 \cdot f'c} = \frac{320}{0,85 \times 25} = 16,9412$$

$$\begin{aligned}\rho &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot R_n}{f_y}} \right) \\ &= \frac{1}{16,9412} \left(1 - \sqrt{1 - \frac{2 \times 16,9412 \times 0,517}{320}} \right) \\ &= 0,001436\end{aligned}$$

$$\rho < \rho_{\min}$$

$\rho < \rho_{\max} \rightarrow$ dipakai tulangan tunggal

Digunakan $\rho_{\min} = 0,003889$

$$A_{S_{\text{perlu}}} = \rho \cdot b \cdot d$$

commit to user



Tugas Akhir Perencanaan Struktur Gedung Sekolah 2 lantai

$$= 0,003889 \times 250 \times 344 = 334,454 \text{ mm}^2$$

$$n = \frac{A_{s \text{ perlu}}}{1/4 \times \pi \times 12^2}$$

$$n = \frac{334,454}{113,097} = 2,957 \sim 4 \text{ tulangan}$$

$$A_{s'} = 4 \times 113,097 = 452,388 > 334,454 \text{ mm}^2$$

$A_{s'} > A_s$OK ☺

Jadi, digunakan tulangan **4 D 12**

b. Daerah Lapangan:

Dari Perhitungan SAP 2000 diperoleh momen terbesar pada **batang As 3 bentang A - B.**

$$M_u = 1069,85 \text{ kgm} = 1,0699 \times 10^7 \text{ Nmm}$$

$$M_n = \frac{1,0699 \times 10^7}{0,8} = 1,3374 \times 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{1,3374 \times 10^7}{250 \times 344^2} = 0,452$$

$$m = \frac{f_y}{0,85 f'_c} = \frac{320}{0,85 \times 25} = 16,9412$$

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

$$= \frac{1}{16,9412} \left(1 - \sqrt{1 - \frac{2 \times 16,9412 \times 0,452}{320}} \right)$$

$$= 0,001269$$

$$\rho < \rho_{\min}$$

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

Digunakan $\rho_{\min} = 0,003889$

$$A_{s \text{ perlu}} = \rho \cdot b \cdot d$$

$$= 0,003889 \times 250 \times 344 = 334,454 \text{ mm}^2$$

commit to user



Tugas Akhir Perencanaan Struktur Gedung Sekolah 2 lantai

$$n = \frac{As \text{ perlu}}{1/4 \times \pi \times 12^2}$$

$$n = \frac{334,454}{113,097} = 2,957 \sim 4 \text{ tulangan}$$

$$As' = 4 \times 113,097 = 452,388 > 334,454 \text{ mm}^2$$

As' > As.....OK ☺

Jadi, digunakan tulangan **4 D 12**

c. Perhitungan Tulangan Geser

Dari Perhitungan SAP 2000 diperoleh gaya geser terbesar pada **batang As D bentang 1 - 2.**

$$Vu = 3147,21 \text{ kg} = 31472,1 \text{ N}$$

$$\begin{aligned} Vc &= 1/6 \cdot \sqrt{f'c} \cdot b \cdot d \\ &= 1/6 \times \sqrt{25} \times 250 \times 344 \\ &= 71666,67 \text{ N} \end{aligned}$$

$$\begin{aligned} \emptyset Vc &= 0,6 \times 71666,67 \text{ N} \\ &= 43000 \text{ N} \end{aligned}$$

$$\begin{aligned} 3 \emptyset Vc &= 3 \times 43000 \text{ N} \\ &= 129000 \text{ N} \end{aligned}$$

Syarat tulangan geser : $Vu < \emptyset Vc < 3 \emptyset Vc$

$$: 52323,1 \text{ N} < 43000 \text{ N} < 129000 \text{ N}$$

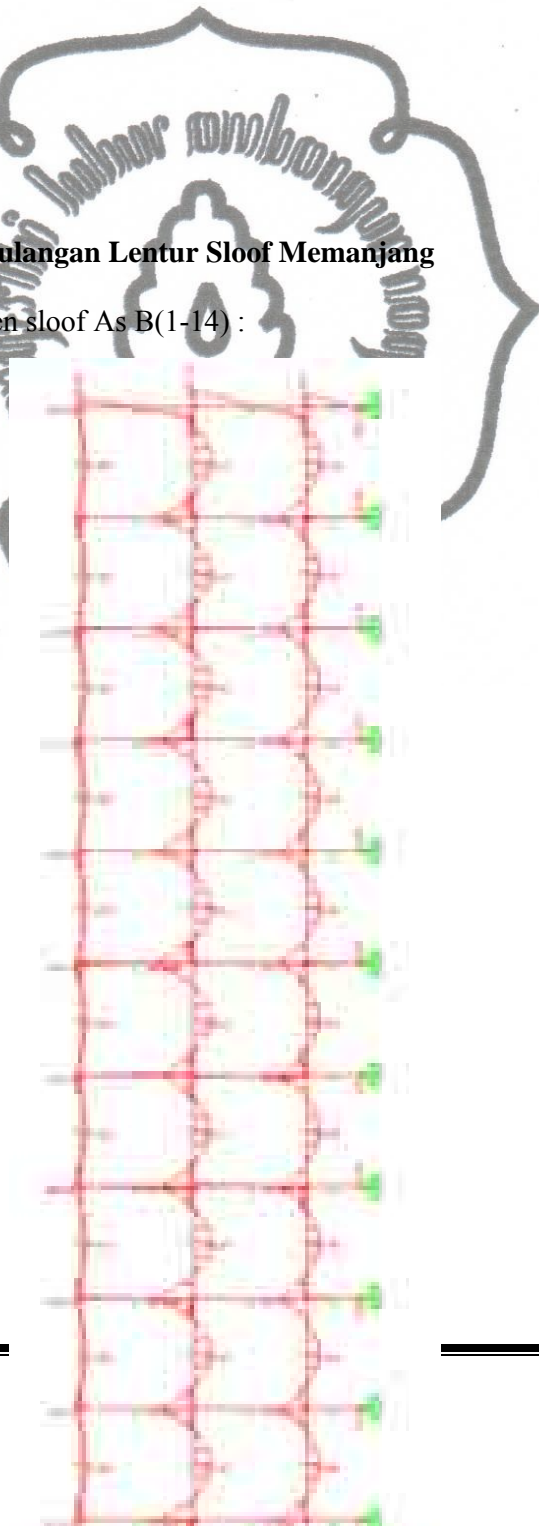
dipakai tulangan geser minimum **Ø 8 – 200 mm**

commit to user



7.6.2. Perhitungan Tulangan Lentur Sloof Memanjang

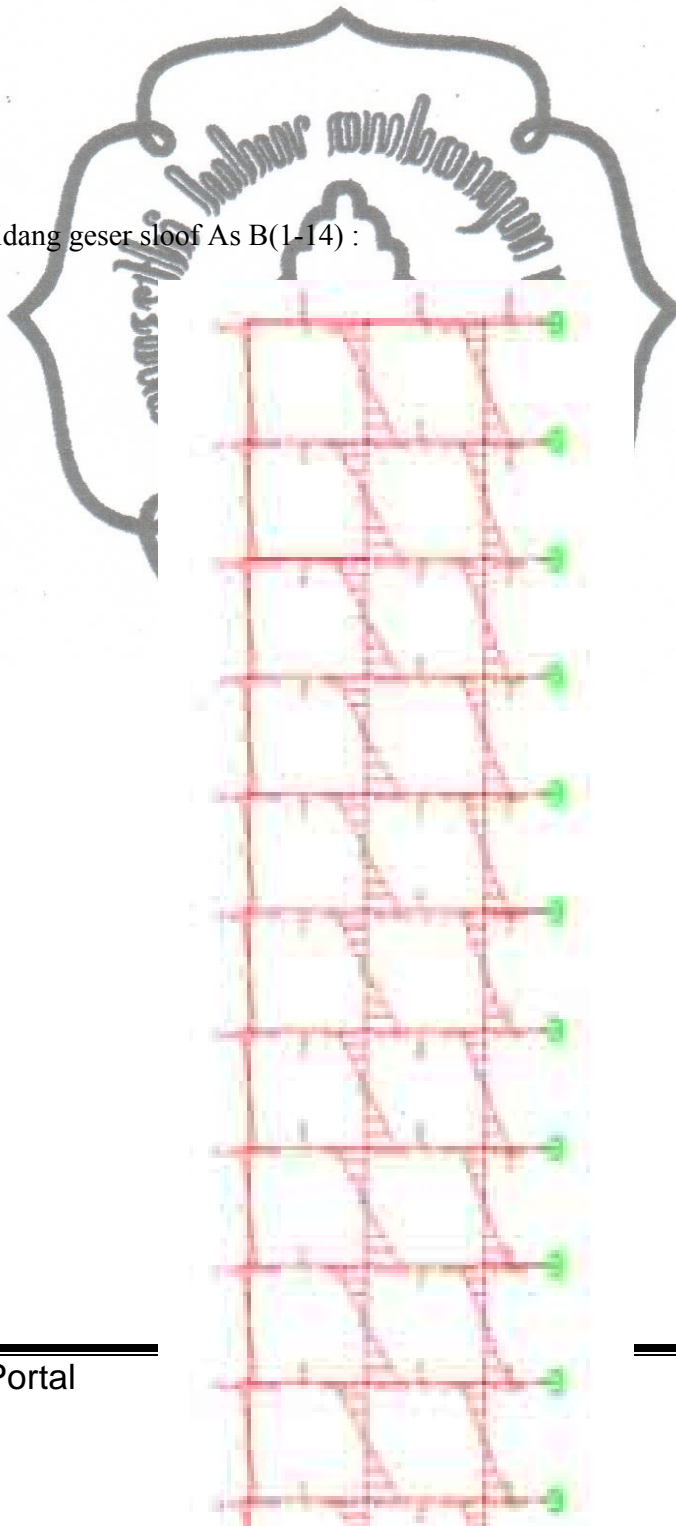
Gambar bidang momen sloof As B(1-14) :





Tugas Akhir
Perencanaan Struktur Gedung Sekolah 2 lantai

Gambar bidang geser sloof As B(1-14) :





Tugas Akhir Perencanaan Struktur Gedung Sekolah 2 lantai

Data perencanaan :

$$b = 200 \text{ mm}$$

$$h = 300 \text{ mm}$$

$$f'c = 25 \text{ MPa}$$

$$fy = 320 \text{ MPa}$$

$$\begin{aligned} d &= h - p - \phi_s - \frac{1}{2}\phi_t \\ &= 300 - 40 - 8 - \frac{1}{2} \cdot 16 \\ &= 244 \text{ mm} \end{aligned}$$

$$\begin{aligned} \rho_b &= \frac{0,85 \cdot f'c \cdot \beta}{fy} \left[\frac{600}{600 + fy} \right] \\ &= \frac{0,85 \cdot 25 \cdot 0,85}{320} \left[\frac{600}{600 + 320} \right] = 0,03136 \end{aligned}$$

$$\rho_{\max} = 0,75 \rho_b = 0,02352$$

$$\rho_{\min} = \frac{1,4}{fy} = \frac{1,4}{360} = 0,003889$$

$$m = \frac{fy}{0,85 \cdot f'c} = \frac{320}{0,85 \times 25} = 16,9412$$

a. Daerah Tumpuan :

Dari Perhitungan **SAP 2000** diperoleh momen terbesar pada **batang As D bentang 11-12**

$$Mu = 1766,92 \text{ kgm} = 1,767 \times 10^7 \text{ Nmm}$$

commit to user



Tugas Akhir

Perencanaan Struktur Gedung Sekolah 2 lantai

$$M_n = \frac{M_u}{\phi} = \frac{1,767 \times 10^7}{0,8}$$

$$= 2,2088 \times 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{2,2088 \times 10^7}{200 \times 244^2}$$

$$= 1,855$$

$$m = \frac{f_y}{0,85 \cdot f'_c} = \frac{320}{0,85 \times 25} = 16,9412$$

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

$$= \frac{1}{16,9412} \left(1 - \sqrt{1 - \frac{2 \times 16,9412 \times 1,855}{320}} \right)$$

$$= 0,00539$$

$$\rho > \rho_{\min}$$

$$\rho < \rho_{\max} \text{ Digunakan } \rho = 0,00539$$

$$A_s = \rho \cdot b \cdot d$$

$$= 0,00539 \times 200 \times 244$$

$$= 263,032 \text{ mm}^2$$

$$n = \frac{A_s \text{ perlu}}{1/4 \times \pi \times 16^2}$$

$$n = \frac{263,032}{200,96} = 1,308 \sim 2 \text{ tulangan}$$

$$A_s' = 2 \times 200,96 = 401,92 > 263,032 \text{ mm}^2$$

$$A_s' > A_s \dots \dots \dots \text{OK } \text{☺}$$

Jadi, digunakan tulangan **2D 16**

b. Daerah Lapangan:

commit to user



Tugas Akhir Perencanaan Struktur Gedung Sekolah 2 lantai

Dari Perhitungan SAP 2000 diperoleh momen terbesar pada **batang As D bentang 11-12.**

$$M_u = 1028,31 \text{ kgm} = 1,02831 \times 10^7 \text{ Nmm}$$

$$M_n = \frac{1,02831 \times 10^7}{0,8} = 1,2854 \times 10^7 \text{ Nmm}$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{1,2854 \times 10^7}{200 \times 244^2} = 1,079$$

$$m = \frac{f_y}{0,85 f'c} = \frac{320}{0,85 \times 25} = 16,9412$$

$$\begin{aligned} \rho &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \cdot m \cdot R_n}{f_y}} \right) \\ &= \frac{1}{16,9412} \left(1 - \sqrt{1 - \frac{2 \times 16,9412 \times 1,079}{320}} \right) \\ &= 0,00307 \end{aligned}$$

$$\rho < \rho_{\min}$$

$$\rho < \rho_{\max} \text{ Digunakan } \rho_{\min} = 0,003889$$

$$\begin{aligned} A_s &= \rho \cdot b \cdot d \\ &= 0,003889 \times 200 \times 244 \\ &= 189,78 \text{ mm}^2 \end{aligned}$$

$$n = \frac{189,78}{\frac{1}{4} \pi \cdot (16^2)} = 0,94 \approx 2 \text{ tulangan}$$

Digunakan tulangan D 16

$$A_s' = 2 \times 200,96 = 401,92$$

$A_s' > A_s$ maka sloof aman OK ☺

Jadi dipakai tulangan 2 D 16 mm

c. Perhitungan Tulangan Geser

commit to user



Tugas Akhir Perencanaan Struktur Gedung Sekolah 2 lantai

Dari Perhitungan SAP 2000 diperoleh gaya geser terbesar pada **batang As D**

bentang 1 - 2.

$$V_u = 2468,61 \text{ kg} = 2,46861 \cdot 10^4 \text{ N}$$

$$\begin{aligned} V_c &= 1/6 \cdot \sqrt{f'c} \cdot b \cdot d \\ &= 1/6 \times \sqrt{25} \times 200 \times 244 \\ &= 40666,67 \text{ N} \end{aligned}$$

$$\begin{aligned} \emptyset V_c &= 0,6 \times 40666,67 \text{ N} \\ &= 24400 \text{ N} \end{aligned}$$

$$\begin{aligned} 3 \emptyset V_c &= 3 \times 24400 \text{ N} \\ &= 73200 \text{ N} \end{aligned}$$

$$\begin{aligned} \text{Syarat tulangan geser : } \emptyset V_c < V_u < 3 \emptyset V_c \\ : 24400 \text{ N} < 24686,1 \text{ N} < 73200 \text{ N} \end{aligned}$$

$$\begin{aligned} \emptyset V_s &= V_u - \emptyset V_c \\ &= 286,1 \text{ N} \end{aligned}$$

$$\begin{aligned} V_s \text{ perlu} &= \frac{\emptyset V_s}{0,6} = \frac{286,1}{0,6} \\ &= 476,83 \text{ N} \end{aligned}$$

$$\begin{aligned} A_v &= 2 \cdot \frac{1}{4} \cdot \pi \cdot (8)^2 \\ &= 2 \times \frac{1}{4} \times 3,14 \times 64 \\ &= 100,531 \text{ mm}^2 \end{aligned}$$

$$S = \frac{A_v \cdot f_y \cdot d}{V_{s \text{ perlu}}} = \frac{100,531 \times 240 \times 244}{476,83} = 12346,3 \text{ mm}$$

$$\begin{aligned} S_{\text{max}} &= d/2 = 344/2 \\ &= 172 \text{ mm} \end{aligned}$$

Jadi dipakai sengkang dengan tulangan $\emptyset 8 - 100 \text{ mm}$

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

$$V_s \text{ ada} = \frac{A_v \cdot f_y \cdot d}{S} = \frac{100,531 \times 240 \times 344}{100} = 82998,39 \text{ N}$$

$$V_s \text{ ada} > V_s \text{ perlu}$$

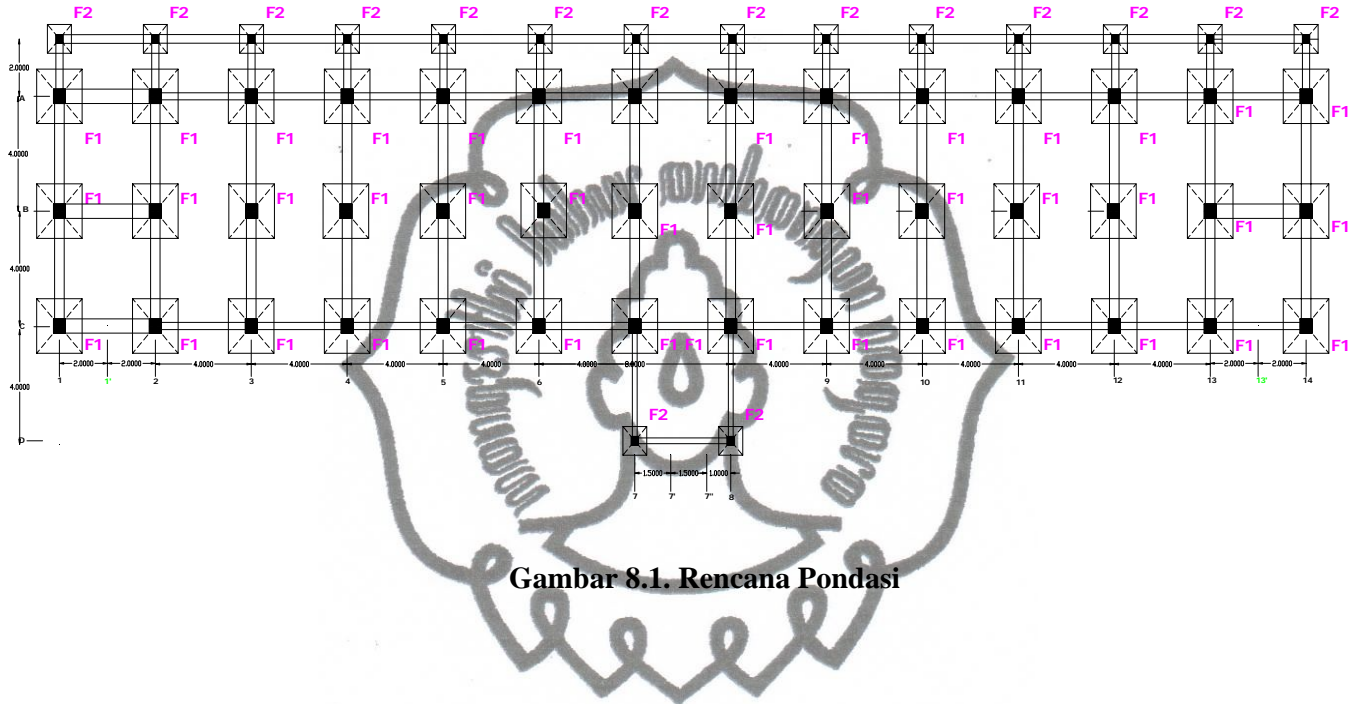
$$82998,39 > 476,83 \text{ N} \dots \dots \text{ OK } \textcircled{\smile}$$

commit to user



BAB 8

PERENCANAAN PONDASI



Gambar 8.1. Rencana Pondasi

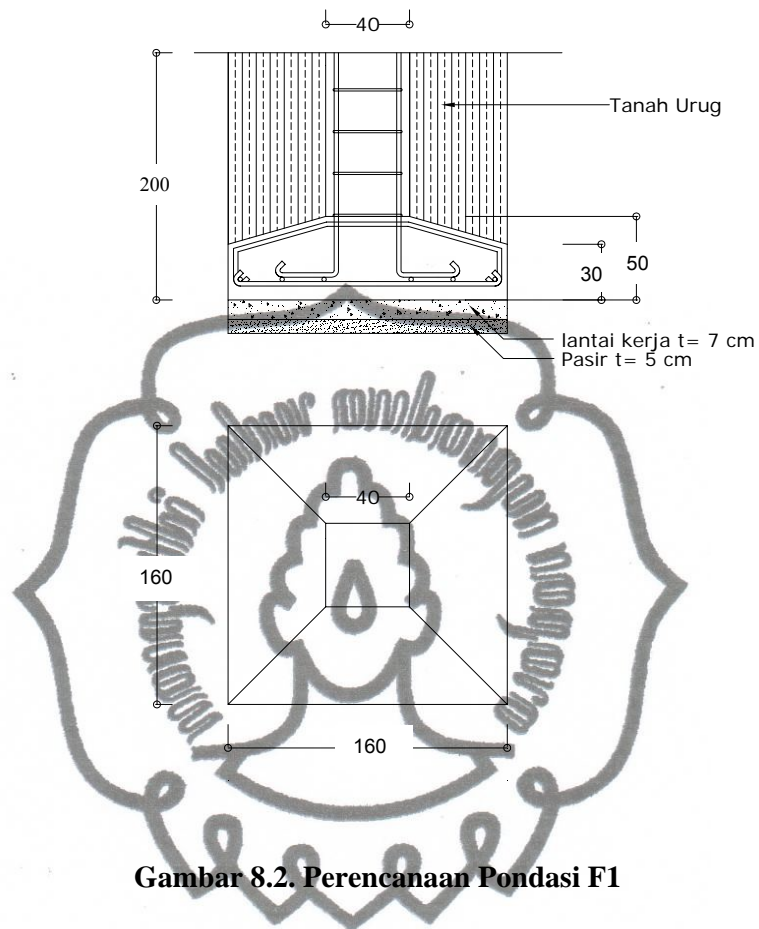
Keterangan :

F1 = Footplat 1 160X160

F2 = Footplat 2 120x120



8.1. Data Perencanaan Pondasi F1



Gambar 8.2. Perencanaan Pondasi F1

Dari perhitungan SAP 2000 pada Frame B 2 diperoleh :

- $P_u = 53594,12 \text{ kg}$
- $M_u = 1201,75 \text{ kgm}$

Dimensi Pondasi :

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

$$A = \frac{P_u}{\sigma_{\text{tanah}}} = \frac{53594,12}{30000}$$

$$= 1,78 \text{ m}^2$$

$$B = L = \sqrt{A} = \sqrt{1,78}$$

$$= 1,3 \text{ m} \sim 1,6 \text{ m}$$



Direncanakan pondasi telapak dengan kedalaman 2 m ukuran $1,60 \text{ m} \times 1,60 \text{ m}$

- $f'c$ = 25 Mpa
- f_y = 320 Mpa
- σ_{tanah} = $3 \text{ kg/cm}^2 = 30.000 \text{ kg/m}^2$
- γ_{tanah} = $1,7 \text{ t/m}^3 = 1700 \text{ kg/m}^3$
- γ_{beton} = 2400 kg/m^3

$$\begin{aligned} d &= h - p - \frac{1}{2} \text{Ø tul. utama} \\ &= 500 - 50 - 9 \\ &= 441 \text{ mm} \end{aligned}$$

8.2. Perencanaan Kapasitas Dukung Pondasi

8.2.1. Perhitungan kapasitas dukung pondasi

➤ Pembebanan pondasi			
Berat telapak pondasi	$= 1,6 \times 1,6 \times 0,50 \times 2400$	$=$	3072 kg
Berat kolom pondasi	$= 0,4 \times 0,4 \times 1,5 \times 2400$	$=$	576 kg
Berat tanah	$= 2 (0,75 \times 1,5 \times 1,6) \times 1700$	$=$	6120 kg
Pu		$=$	53594,12 kg
		$\Sigma P =$	63362,12 kg

$$\begin{aligned} e &= \frac{\sum Mu}{\sum P} = \frac{1201,75}{63362,12} \\ &= 0,018 \text{ kg} < 1/6 \cdot B = 0,316 \end{aligned}$$

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

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



$$\begin{aligned}
 &= \frac{63362,12}{1,6 \times 1,6} + \frac{1201,75}{\frac{1}{6} \times 1,6 \times (1,6)^2} \\
 &= 26518,09 \text{ kg/m}^2 \\
 \sigma_{\text{min}} \text{ yang terjadi} &= \frac{\sum P}{A} - \frac{M_u}{\frac{1}{6} \cdot b \cdot L^2} \\
 &= \frac{63362,12}{1,6 \times 1,6} + \frac{1201,75}{\frac{1}{6} \times 1,6 \times (1,6)^2} \\
 &= 22983,55 \text{ kg/m}^2 \\
 &= \sigma_{\text{tanah yang terjadi}} < \sigma_{\text{ijin tanah}} \dots \dots \dots \text{OK} \odot
 \end{aligned}$$

8.2.2. Perhitungan Tulangan Lentur

$$\begin{aligned}
 M_u &= \frac{1}{2} \cdot \sigma \cdot t^2 = \frac{1}{2} \times (26518,09) \times (0,7)^2 \\
 &= 6496,93 \text{ kgm} = 6,49693 \times 10^7 \text{ Nmm}
 \end{aligned}$$

$$M_n = \frac{6,49693 \times 10^7}{0,8} = 8,1211 \times 10^7 \text{ Nmm}$$

$$m = \frac{f_y}{0,85 \cdot f_c} = \frac{320}{0,85 \times 25} = 15,058$$

$$\begin{aligned}
 \rho_b &= \frac{0,85 \cdot f_c}{f_y} \beta \left(\frac{600}{600 + f_y} \right) \\
 &= \frac{0,85 \times 25}{320} \cdot 0,85 \left(\frac{600}{600 + 320} \right) \\
 &= 0,033
 \end{aligned}$$

$$\begin{aligned}
 \rho_{\text{max}} &= 0,75 \cdot \rho_b \\
 &= 0,75 \times 0,033 \\
 &= 0,024
 \end{aligned}$$

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



$$R_n = \frac{M_n}{b \cdot d^2} = \frac{8,1211 \times 10^7}{1600 \times (441)^2} = 0,26$$

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

$$= \frac{1}{15,058} \left(1 - \sqrt{1 - \frac{2 \times 15,058 \times 0,26}{320}} \right)$$

$$\rho = 0,00048$$

$$\rho < \rho_{\min}$$

$\rho < \rho_{\max} \rightarrow$ dipakai tulangan tunggal

$$\text{Digunakan } \rho_{\min} = 0,004375$$

$$\text{As perlu} = \rho \cdot b \cdot d$$

$$= 0,004375 \times 1600 \times 441$$

$$= 3087 \text{ mm}^2$$

$$\text{Digunakan tul D 19} = \frac{1}{4} \cdot \pi \cdot d^2$$

$$= \frac{1}{4} \times 3,14 \times (19)^2$$

$$= 283,385 \text{ mm}^2$$

$$\text{Jumlah tulangan (n)} = \frac{3087}{283,385} = 10,89 \approx 12 \text{ buah}$$

$$\text{Jarak tulangan} = \frac{1600}{12} = 133,33 \text{ mm} \approx 150$$

dipakai tulangan D 19 - 150 mm

$$\text{As yang timbul} = 19 \times 283,385 = 5384,315 > 3259,431 \text{ As} \dots \dots \dots \text{OK } \odot$$

Maka, digunakan tulangan **D 19 - 150mm**

8.2.3. Perhitungan Tulangan Geser

$$V_u = \sigma \times A_{\text{efektif}}$$

$$= 26518,09 \times (0,50 \times 1,6)$$

$$= 21,2 \times 10^3 \text{ N}$$



$$\begin{aligned} V_c &= 1/6 \cdot \sqrt{f_c} \cdot b \cdot d \\ &= 1/6 \times \sqrt{25} \times 1600 \times 441 \\ &= 58,80 \times 10^4 \text{ N} \end{aligned}$$

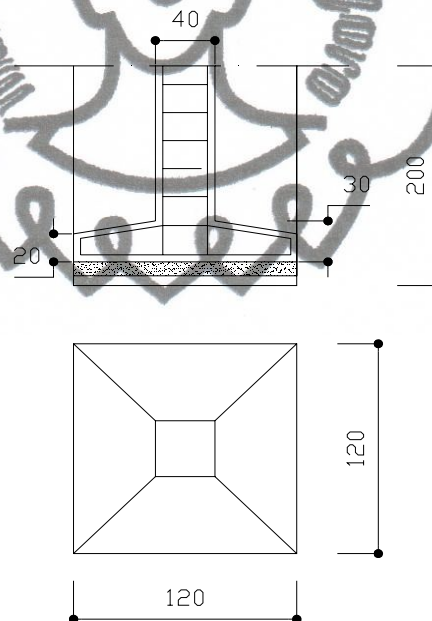
$$\begin{aligned} \phi V_c &= 0,6 \cdot V_c \\ &= 0,6 \times 58,80 \times 10^4 \text{ N} \\ &= 35,28 \times 10^4 \text{ N} \end{aligned}$$

$$\begin{aligned} 0,5 \phi V_c &= 0,5 \times 35,28 \times 10^4 \text{ N} \\ &= 17,64 \times 10^4 \text{ N} \end{aligned}$$

$0,5 \phi V_c < V_u < \phi V_c \rightarrow$ tulangan geser minimum.

Jadi dipakai sengkang dengan tulangan $\phi 12 - 200 \text{ mm}$

8.3. Data Perencanaan Pondasi F2



Gambar 8.3. Perencanaan Pondasi F2

Dari perhitungan SAP 2000 pada Frame diperoleh :

- $P_u = 21020,33 \text{ kg}$
- $M_u = 160,94 \text{ kgm}$



Dimensi Pondasi :

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

$$A = \frac{P_u}{\sigma_{\text{tanah}}} = \frac{21020,33}{30000}$$

$$= 0,70 \text{ m}^2$$

$$B = L = \sqrt{A} = \sqrt{0,70}$$

$$= 0,83 \text{ m} \sim 1,2 \text{ m}$$

Direncanakan pondasi telapak dengan kedalaman 2 m ukuran $1,2 \text{ m} \times 1,2 \text{ m}$

- $f'c$ = 25 Mpa
- f_y = 320 Mpa
- σ_{tanah} = 30.000 kg/m²
- γ tanah = 1,7 t/m³ = 1700 kg/m³
- γ beton = 2,4 t/m³

$$d = h - p - \frac{1}{2} \text{ } \varnothing \text{ tul. utama}$$

$$= 300 - 50 - 8$$

$$= 242 \text{ mm}$$

8.4. Perencanaan Kapasitas Dukung Pondasi

8.4.1 Perhitungan kapasitas dukung pondasi

➤ Pembebanan pondasi

$$\text{Berat telapak pondasi} = 1,2 \times 1,2 \times 0,30 \times 2400 = 1036,8 \text{ kg}$$

$$\text{Berat kolom pondasi} = 0,4 \times 0,4 \times 1,7 \times 2400 = 652,8 \text{ kg}$$

$$\text{Berat tanah} = 2 (0,3 \times 1,7 \times 1,2) \times 1700 = 1734 \text{ kg}$$

$$P_u = 21020,33 \text{ kg}$$

$$\Sigma P = 24443,93 \text{ kg}$$

$$e = \frac{\Sigma M_u}{\Sigma P} = \frac{160,94}{24443,93}$$

$$= 0,0065 \text{ kg} < 1/6 \cdot B = 0,16$$



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

$$\begin{aligned} \sigma_{\text{max yang terjadi}} &= \frac{\sum P}{A} + \frac{Mu}{\frac{1}{6} \cdot b \cdot L^2} \\ &= \frac{24443,93}{1,2 \times 1,2} + \frac{160,94}{\frac{1}{6} \times 1,2 \times (1,2)^2} \\ &= 17533,76 \text{ kg/m}^2 \end{aligned}$$

$$\begin{aligned} \sigma_{\text{min yang terjadi}} &= \frac{\sum P}{A} - \frac{Mu}{\frac{1}{6} \cdot b \cdot L^2} \\ &= \frac{24443,93}{1,2 \times 1,2} - \frac{160,94}{\frac{1}{6} \times 1,2 \times (1,2)^2} \\ &= 16416,14 \text{ kg/m}^2 \\ &= \sigma_{\text{tanah yang terjadi}} < \sigma_{\text{ijin tanah}} \dots \text{OK} \odot \end{aligned}$$

8.4.2 Perhitungan Tulangan Lentur

$$\begin{aligned} Mu &= \frac{1}{2} \cdot \sigma \cdot t^2 = \frac{1}{2} \times (17533,76) \times (0,5)^2 \\ &= 2191,7 \text{ kgm} = 21,917 \times 10^6 \text{ Nmm} \end{aligned}$$

$$Mn = \frac{21,917 \times 10^6}{0,8} = 27,396 \times 10^6 \text{ Nmm}$$

$$m = \frac{fy}{0,85 \cdot fc} = \frac{320}{0,85 \times 25} = 15,058$$

$$\begin{aligned} \rho_b &= \frac{0,85 \cdot fc}{fy} \beta \left(\frac{600}{600 + fy} \right) \\ &= \frac{0,85 \times 25}{320} \cdot 0,85 \left(\frac{600}{600 + 320} \right) \\ &= 0,0365 \end{aligned}$$



Tugas Akhir

Perencanaan Struktur & RAB Gedung Sekolah 2 lantai

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

$$= 0,75 \times 0,0365$$

$$= 0,0273$$

$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{320} = 0,00437$$

$$R_n = \frac{M_n}{b \cdot d^2} = \frac{27,396 \times 10^6}{1000 \times (242)^2} = 0,46$$

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

$$= \frac{1}{15,058} \left(1 - \sqrt{1 - \frac{2 \times 15,058 \times 0,46}{320}} \right)$$

$$\rho = 0,00198$$

$$\rho < \rho_{\min}$$

$\rho < \rho_{\max} \rightarrow$ dipakai tulangan tunggal

Digunakan $\rho_{\min} = 0,00437$

$$\text{As perlu} = \rho \cdot b \cdot d$$

$$= 0,00437 \times 1200 \times 242$$

$$= 1269,048 \text{ mm}^2$$

$$\text{Digunakan tul D 16} = \frac{1}{4} \cdot \pi \cdot d^2$$

$$= \frac{1}{4} \times 3,14 \times (16)^2$$

$$= 200,96 \text{ mm}^2$$

$$\text{Jumlah tulangan (n)} = \frac{1269,048}{200,96} = 6,31 \approx \mathbf{8 \text{ buah}}$$

$$\text{Jarak tulangan} = \frac{1269,048}{8} = 158,631 \text{ mm} \approx 200$$

dipakai tulangan D 16 - 200 mm

$$\text{As yang timbul} = 6 \times 200,96 = 1205,76 > \text{As} \dots \dots \dots \text{OK } \odot$$

Maka, digunakan tulangan **D 16 - 200 mm**



8.4.3 Perhitungan Tulangan Geser

$$\begin{aligned} V_u &= \sigma \times A_{\text{efektif}} \\ &= 14207,1 \times (0,30 \times 1) \\ &= 4,26213 \times 10^3 \text{ N} \end{aligned}$$

$$\begin{aligned} V_c &= 1/6 \cdot \sqrt{f_c} \cdot b \cdot d \\ &= 1/6 \times \sqrt{25} \times 1000 \times 242 \\ &= 20,16 \times 10^4 \text{ N} \end{aligned}$$

$$\begin{aligned} \phi V_c &= 0,6 \cdot V_c \\ &= 0,6 \times 20,16 \times 10^4 \text{ N} \\ &= 12,1 \times 10^4 \text{ N} \end{aligned}$$

$$\begin{aligned} 0,5\phi V_c &= 0,5 \times 12,1 \times 10^4 \text{ N} \\ &= 6,05 \times 10^4 \text{ N} \end{aligned}$$

$0,5\phi V_c < V_u < \phi V_c \rightarrow$ tulangan geser minimum.

Jadi dipakai sengkang dengan tulangan $\phi 12 - 200 \text{ mm}$



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

$$\begin{aligned}\text{Volume} &= \text{panjang} \times \text{lebar} \\ &= 46 \times 12 = 552 \text{ m}^2\end{aligned}$$

B. Pekerjaan pembuatan pagar setinggi 2m

$$\begin{aligned}\text{Volume} &= \sum \text{panjang} \\ &= 136 \text{ m}\end{aligned}$$

C. Pekerjaan pembuatan bedeng dan gudang



$$\begin{aligned} \text{Volume} &= \text{panjang} \times \text{lebar} \\ &= (3 \times 4) + (3 \times 3) = 21 \text{ m}^2 \end{aligned}$$

D. Pekerjaan *bouwplank*

$$\begin{aligned} \text{Volume} &= (\text{panjang} \times 2) \times (\text{lebar} \times 2) \\ &= (46 \times 2) + (12 \times 2) = 116 \text{ m}^2 \end{aligned}$$

9.3.2 Pekerjaan Pondasi

A. Galian pondasi

➤ Footplat 1 (F1)

$$\begin{aligned} \text{Volume} &= (\text{panjang} \times \text{lebar} \times \text{tinggi}) \times \sum n \\ &= (2 \times 2 \times 1,5) \times 28 = 168 \text{ m}^3 \end{aligned}$$

➤ Footplat 2 (F2)

$$\begin{aligned} \text{Volume} &= (\text{panjang} \times \text{lebar} \times \text{tinggi}) \times \sum n \\ &= (1,2 \times 1,2 \times 1,5) \times 14 = 30,24 \text{ m}^3 \end{aligned}$$

➤ Pondasi batu kali

$$\begin{aligned} \text{Volume} &= (\text{lebar} \times \text{tinggi}) \times \sum \text{panjang} \\ &= (0,8 \times 0,8) \times 92 = 58,88 \text{ m}^3 \end{aligned}$$

➤ Pondasi tangga

$$\begin{aligned} \text{Volume} &= (\text{lebar} \times \text{tinggi}) \times \sum \text{panjang} \\ &= (1 \times 1) \times 1,5 = 1,5 \text{ m}^3 \end{aligned}$$

B. Urugan Pasir bawah Pondasi dan bawah lantai ($t = 5 \text{ cm}$)

➤ Footplat 1 (F1)

$$\begin{aligned} \text{Volume} &= (\text{panjang} \times \text{lebar} \times \text{tinggi}) \times \sum n \\ &= (2 \times 2 \times 0,05) \times 28 = 5,6 \text{ m}^3 \end{aligned}$$

➤ Footplat 2 (F2)

$$\begin{aligned} \text{Volume} &= (\text{panjang} \times \text{lebar} \times \text{tinggi}) \times \sum n \\ &= (1,2 \times 1,2 \times 0,05) \times 14 = 1,01 \text{ m}^3 \end{aligned}$$

➤ Pondasi batu kali

$$\begin{aligned} \text{Volume} &= (\text{lebar} \times \text{tinggi}) \times \sum \text{panjang} \\ &= (0,8 \times 0,05) \times 92 = 3,68 \text{ m}^3 \end{aligned}$$



➤ Pondasi tangga

$$\begin{aligned} \text{Volume} &= (\text{lebar} \times \text{tinggi}) \times \sum \text{panjang} \\ &= (1 \times 0,05) \times 1,5 = 0,075 \text{ m}^3 \end{aligned}$$

➤ Lantai

$$\begin{aligned} \text{Volume} &= \text{tinggi} \times \text{luas lantai} \\ &= 0,05 \times 440 = 22 \text{ m}^2 \end{aligned}$$

C. Lantai kerja (t=3cm)

➤ Footplat 1 (F1)

$$\begin{aligned} \text{Volume} &= (\text{panjang} \times \text{lebar} \times \text{tinggi}) \times \sum n \\ &= (2 \times 2 \times 0,03) \times 28 = 3,36 \text{ m}^3 \end{aligned}$$

➤ Footplat 2 (F2)

$$\begin{aligned} \text{Volume} &= (\text{panjang} \times \text{lebar} \times \text{tinggi}) \times \sum n \\ &= (1,2 \times 1,2 \times 0,03) \times 14 = 0,605 \text{ m}^3 \end{aligned}$$

➤ Pondasi batu kali

$$\begin{aligned} \text{Volume} &= (\text{lebar} \times \text{tinggi}) \times \sum \text{panjang} \\ &= (0,8 \times 0,03) \times 92 = 2,208 \text{ m}^3 \end{aligned}$$

D. Pasangan pondasi batu kosong (1pc:3psr:10kpr)

$$\begin{aligned} \text{Volume} &= \sum \text{panjang} \times \text{lebar} \times \text{tinggi} \\ &= 92 \times 0,8 \times 0,15 = 11,04 \text{ m}^3 \end{aligned}$$

E. Pasangn pondasi batu kali (1pc:3psr:10kpr)

$$\begin{aligned} \text{Volume} &= (\sum \text{panjang} \times \text{lebar} \times \text{tinggi}) + (\sum \text{panjang} \cdot 2.1/2.a.t) \\ &= (92 \times 0,4 \times 0,8) + (92 \times 2.1/2.0,2.0,8) = 44,16 \text{ m}^3 \end{aligned}$$

F. Urugan Tanah Galian

$$\begin{aligned} \text{Volume} &= V.\text{tanah galian} - \text{batukali} - \text{lantai kerja} - \text{pasir urug} \\ &= (168 + 30,24 + 58,88) - 44,16 - (3,36 + 0,605 + 2,208) - (5,6 + 1,01 + 3,68) \\ &= 196,497 \text{ m}^3 \end{aligned}$$



G. Peniggian elevasi lantai

$$\begin{aligned}\text{Volume} &= \text{panjang} \times \text{lebar} \times \text{tinggi} \\ &= 44 \times 10 \times 0,4 = 176 \text{ m}^3\end{aligned}$$

H. Pondasi telapak (*footplat*)

Footplat 1 (F1)

$$\begin{aligned}\text{Volume} &= (\text{panjang} \times \text{lebar} \times \text{tinggi}) \times \sum n \\ &= \{ (2,2 \cdot 0,3) + (0,4 \cdot 0,4 \cdot 1,5) + (2, \frac{1}{2} \cdot 1,0 \cdot 2) \} \times 28 \\ &= 45,92 \text{ m}^3\end{aligned}$$

Footplat 2 (F2)

$$\begin{aligned}\text{Volume} &= (\text{panjang} \times \text{lebar} \times \text{tinggi}) \times \sum n \\ &= \{ (1,2 \cdot 1,2 \cdot 0,2) + (0,4 \cdot 0,4 \cdot 1,7) + (2, \frac{1}{2} \cdot 1,0 \cdot 1) \} \times 14 \\ &= 9,24 \text{ m}^3\end{aligned}$$

Footplat tangga

$$\begin{aligned}\text{Volume} &= \text{panjang} \times \text{lebar} \times \text{tinggi} \\ &= \{ (1,5 \cdot 1,0 \cdot 2) + (0,4 \cdot 1,5 \cdot 0,7) + (2, \frac{1}{2} \cdot 1,0 \cdot 1) \} \\ &= 0,82 \text{ m}^3\end{aligned}$$

9.3.3 Pekerjaan Beton

A. Beton *Sloof*

➤ *sloof* 1 (S1)

$$\begin{aligned}\text{Volume} &= (\text{panjang} \times \text{lebar}) \times \sum \text{panjang} \\ &= (0,2 \times 0,3) \times 144 = 8,64 \text{ m}^3\end{aligned}$$

➤ *sloof* 2 (S2)

$$\begin{aligned}\text{Volume} &= (\text{panjang} \times \text{lebar}) \times \sum \text{panjang} \\ &= (0,25 \times 0,4) \times 120 = 12 \text{ m}^3\end{aligned}$$

B. Balok 40/70

$$\begin{aligned}\text{Volume} &= (\text{tinggi} \times \text{lebar} \times \text{panjang}) \times \sum n \\ &= (0,7 \times 0,4 \times 10) \times 12 = 33,6 \text{ m}^3\end{aligned}$$

C. Balok 25/40

$$\begin{aligned}\text{Volume} &= (\text{tinggi} \times \text{lebar} \times \text{panjang}) \times \sum n \\ &= (0,4 \times 0,25 \times 44) \times 3 = 13,2 \text{ m}^3\end{aligned}$$



D. Balok 20/30

$$\begin{aligned} \text{Volume} &= \text{tinggi} \times \text{lebar} \times \sum \text{panjang} \\ &= 0,3 \times 0,2 \times 80 = 4,8 \text{ m}^3 \end{aligned}$$

E. Kolom utama

➤ Kolom 40/40

$$\begin{aligned} \text{Volume} &= (\text{panjang} \times \text{lebar} \times \text{tinggi}) \times \sum n \\ &= (0,4 \times 0,4 \times 8) \times 40 = 51,2 \text{ m}^3 \end{aligned}$$

➤ Kolom 20/30

$$\begin{aligned} \text{Volume} &= (\text{panjang} \times \text{lebar}) \times \sum \text{panjang} \\ &= (0,2 \times 0,3 \times 8) \times 14 = 6,72 \text{ m}^3 \end{aligned}$$

F. Ringbalk

$$\begin{aligned} \text{Volume} &= (\text{tinggi} \times \text{lebar}) \times \sum \text{panjang} \\ &= (0,2 \times 0,3) \times 180 = 10,8 \text{ m}^3 \end{aligned}$$

G. Plat lantai (t=12cm)

$$\begin{aligned} \text{Volume} &= \text{luas lantai} \times 2 \times \text{tebal} \\ &= 440 \times 0,12 = 52,8 \text{ m}^3 \end{aligned}$$

H. Plat Atap (t=10cm)

$$\begin{aligned} \text{Volume} &= \text{luas plat atap} \times \text{tebal} \\ &= (88 \times 0,10) + (16 \times 0,10) = 10,4 \text{ m}^3 \end{aligned}$$

I. Plat kanopi (t=8cm)

$$\begin{aligned} \text{Volume} &= (\text{luas plat kanopi} \times \text{tebal}) \times \sum n \\ &= (1,32 \times 0,08) \times 28 = 2,957 \text{ m}^3 \end{aligned}$$

J. Sirip kanopi (t=8cm)

$$\begin{aligned} \text{Volume} &= (\text{luas sirip kanopi} \times \text{tebal}) \times \sum n \\ &= (0,59875 \times 0,08) \times 28 = 1,34 \text{ m}^3 \end{aligned}$$

K. Balok praktis 15/15

$$\begin{aligned} \text{Volume} &= (\text{tinggi} \times \text{lebar}) \times \sum \text{panjang} \\ &= (0,15 \times 0,15) \times 160 = 3,6 \text{ m}^3 \end{aligned}$$

L. Tangga

$$\begin{aligned} \text{Volume} &= ((\text{luas plat tangga} \times \text{tebal}) \times 2) + \text{plat bordes} \\ &= (5,408 \times 0,12) \times 2 + (3 \times 0,15) \\ &= 1,748 \text{ m}^3 \end{aligned}$$



9.3.4 Pekerjaan pemasangan Bata merah dan Pemlesteran

A. Pasangan dinding bata merah

$$\text{➤ Luas jendela} = J1 + J2 + BV$$

$$= 61,44 + 15,47 + 9,1584$$

$$= 86,0684 \text{ m}^2$$

$$\text{➤ Luas Pintu} = P1 + P2 + P3 + P4 + P5$$

$$= 5,74 + 4,24 + 33,2108 + 4,0724 + 7,9488$$

$$= 55,212 \text{ m}^2$$

$$\text{➤ Luas dinding WC dan dinding teras} = 48 + 36$$

$$= 84 \text{ m}^2$$

$$\text{Volume} = \text{tinggi} \times \sum \text{panjang} - (\text{L.pintu} + \text{L.jendela} + \text{L.dinding WC})$$

$$= (8 \times 104) - (86,0684 + 55,212 + 84)$$

$$= 606,72 \text{ m}^2$$

B. Pemlesteran dan pengacian

$$\text{➤ Luas dinding yang tidak dapat diplester} = (\text{lebar} \times \text{tinggi}) \times \sum n$$

$$= (0,4 \times 8) \times 36$$

$$= 115,2 \text{ m}^2$$

$$\text{Volume} = (\text{volume dinding bata merah} - 115,2 \text{ m}^2) \times 2 \text{ sisi}$$

$$= (606,72 - 115,2) \times 2 = 983,04 \text{ m}^2$$

9.3.5. Pekerjaan Pemasangan Kusen dan Pintu

A. Pemasangan kusen dan Pintu kayu kamper 6/12

$$\text{Jumlah panjang} = J1 + J2 + P1 + P2 + P3 + P4 + P5$$

$$= 266,88 + 60,48 + 8,298 + 5,88 + 220,22 + 14,42 + 38,4$$

$$= 576,178 \text{ m}$$

$$\text{Volume} = (\text{tinggi} \times \text{lebar}) \times \sum \text{panjang}$$

$$= (0,12 \times 0,06) \times 576,178$$

$$= 4,15 \text{ m}^3$$

B. Pemasangan daun pintu dan jendela

$$\text{Luas daun pintu} = P1 + P2 + P3 + P4$$

$$= (2,2 \times 2,6) + (2,2 \times 1,95) + (2,11 \times 1,22) \cdot 7 + (2,11 \times 0,80)$$



$$= 29,7174 \text{ m}^2$$

Luas daun jendela = J1+ J2

$$= (0,90 \times 1,1) \times 32 + (0,88 \times 1,52) \times 15$$

$$= 51,744 \text{ m}^2$$

Volume = Luas daun pintu+ Luas daun jendela

$$= 81,462 \text{ m}^2$$

C. Pasang jalusi kaca (t=5mm)

$$\text{Luas tipe P3} = ((0,76 \times 0,24 \times 2) + (1,12 \times 0,24)) \times 7 = 4,435 \text{ m}^2$$

$$\text{P4} = (0,76 \times 0,24 \times 2) + (0,8 \times 0,24) = 0,557 \text{ m}^2$$

$$\text{J1} = (1,1 \times 0,42) \times 32 = 14,784 \text{ m}^2$$

$$\text{J2} = (1,52 \times 0,24) \times 7 = 2,554 \text{ m}^2$$

Volume = luas P3+P4+J1+J2

$$= 22,330 \text{ m}^2$$

D. Pasang kaca polos (t=5mm)

$$\text{Luas tipe P1} = (1,5 \times 1,52) + (0,25 \times 0,73) = 2,463 \text{ m}^2$$

$$\text{P2} = 1,5 \times 1,52 = 2,28 \text{ m}^2$$

$$\text{P3} = ((0,52 \times 0,64) \times 2) \times 7 = 4,659 \text{ m}^2$$

$$\text{P4} = (0,52 \times 0,64) \times 2 = 0,665 \text{ m}^2$$

$$\text{J1} = ((0,31 \times 0,66) \times 2) \times 32 = 13,095 \text{ m}^2$$

$$\text{J2} = ((0,52 \times 0,64) \times 2) \times 7 = 4,659 \text{ m}^2$$

Volume = luas P1+P2+P3+P4+J1+J2

$$= 27,822 \text{ m}^2$$

E. Pasang kaca es

$$\text{Volume} = (0,3 \times 0,96) \times 2 \times 16$$

$$= 9,216 \text{ m}^2$$

F. Pekerjaan Perlengkapan pintu

Tipe p1= 1 unit

Tipe p2= 1 unit

Tipe p3= 4 unit

Tipe p4= 1 unit

Tipe p5= 4 unit

Tipe ps= 4 unit



G. Pekerjaan Perlengkapan daun jendela

Tipe j1= 32 unit

Tipe j2= 15 unit

9.3.6. Pekerjaan Atap

A. Pekerjaan kuda kuda

- Setengah kuda-kuda (doble siku 45.45.5)

Σ panjang profil under = 5,604 m

Σ panjang profil tarik = 3,999 m

Σ panjang profil kaki kuda-kuda = 4,884 m

Σ panjang profil sokong = 3,925 m

$$\begin{aligned} \text{Volume} &= \Sigma \text{panjang} \times \Sigma n \\ &= 18,412 \times 2 = 36,824 \text{ m} \end{aligned}$$

- Jurai kuda-kuda (doble siku 45.45.5)

Σ panjang profil under = 5,6 m

Σ panjang profil tarik = 5,658 m

Σ panjang profil kaki kuda-kuda = 6,312m

Σ panjang profil sokong = 4,757 m

$$\begin{aligned} \text{Volume} &= \Sigma \text{panjang} \times \Sigma n \\ &= 22,327 \times 4 = 89,308 \text{ m} \end{aligned}$$

- Kuda-kuda B (doble siku 45.45.5)

Σ panjang profil under = 11,208 m

Σ panjang profil tarik = 7,998 m

Σ panjang profil kaki kuda-kuda = 9,768 m

Σ panjang profil sokong = 7,85 m

$$\begin{aligned} \text{Volume} &= \Sigma \text{panjang} \times \Sigma n \\ &= 36,824 \times 8 = 294,592 \text{ m} \end{aligned}$$



- Kuda-kuda utama (A) (doble siku 55.55.6)

$$\sum \text{panjang profil under} = 11,208 \text{ m}$$

$$\sum \text{panjang profil tarik} = 7,998 \text{ m}$$

$$\sum \text{panjang profil kaki kuda-kuda} = 9,768 \text{ m}$$

$$\sum \text{panjang profil sokong} = 7,85 \text{ m}$$

$$\begin{aligned} \text{Volume} &= \sum \text{panjang} \times \sum n \\ &= 36,824 \times 2 = 73,648 \text{ m} \end{aligned}$$

- Gording (150.75.20.4,5)

$$\sum \text{panjang profil gording} = 176,573 + 111 = 287,573 \text{ m}$$

$$\text{Volume total profil kuda-kuda } 45.45.5 = 420,724 \text{ m}$$

$$\text{Volume total profil kuda-kuda } 55.55.6 = 73,648 \text{ m}$$

$$\text{Volume gording} = 287,573 \text{ m}$$

- B. Pekerjaan konsul emperan balok 6/12

$$\begin{aligned} \text{Volume} &= (\text{tinggi} \times \text{lebar} \times \sum \text{panjang}) \\ &= \{(0,12 \times 0,06 \times (2,75 \times 30))\} \\ &= 0,594 \text{ m}^3 \end{aligned}$$

- C. Pekerjaan pasang kaso 5/7 dan reng 3/4

$$\begin{aligned} \text{Volume} &= \text{luas atap} + \text{luas emperan} \\ &= 561,439 + 130 \\ &= 691,439 \text{ m}^2 \end{aligned}$$

- D. Pekerjaan pasang Listplank

$$\begin{aligned} \text{Volume} &= \sum \text{keliling atap} \\ &= 222 \text{ m} \end{aligned}$$

- E. Pekerjaan pasang genting

$$\begin{aligned} \text{Volume} &= \text{luas atap} \\ &= 691,439 \text{ m}^2 \end{aligned}$$

- F. Pasang bubungan genting

$$\begin{aligned} \text{Volume} &= \sum \text{panjang} \\ &= 63,508 \text{ m} \end{aligned}$$



9.3.7. Pekerjaan Plafon

- A. Pembuatan dan pemasangan rangka plafon

$$\begin{aligned} \text{Volume} &= (\text{panjang} \times \text{lebar}) \times 2 \\ &= (44 \times 12) \times 2 = 1056 \text{ m}^2 \end{aligned}$$

- B. Pasang plafon

$$\begin{aligned} \text{Volume} &= \text{luas rangka plafon} \\ &= 1056 \text{ m}^2 \end{aligned}$$

9.3.8. Pekerjaan keramik

- A. Pasang keramik 40/40

$$\begin{aligned} \text{Volume} &= \text{luas lantai} \\ &= ((44 \times 2) \times 2 + (36 \times 8) \times 2) \\ &= 752 \text{ m}^2 \end{aligned}$$

- B. Pasang keramik 20/20

$$\begin{aligned} \text{Volume} &= \text{luas lantai} \\ &= ((4 \times 8) \times 4) \\ &= 128 \text{ m}^2 \end{aligned}$$

- C. Pasang keramik dinding 20/25

$$\begin{aligned} \text{Volume} &= \text{tinggi dinding keramik} \times \text{lebar ruang} \\ &= 1,5 \times 48 \\ &= 72 \text{ m}^2 \end{aligned}$$

9.3.9. Pekerjaan sanitasi

- A. Pasang kloset jongkok

$$\begin{aligned} \text{Volume} &= \sum n \\ &= 8 \text{ unit} \end{aligned}$$

- B. Pasang bak fiber

$$\begin{aligned} \text{Volume} &= \sum n \\ &= 8 \text{ unit} \end{aligned}$$

- C. Pasang wastafel

$$\begin{aligned} \text{Volume} &= \sum n \\ &= 20 \text{ unit} \end{aligned}$$



D. Pasang floordrain

$$\begin{aligned} \text{Volume} &= \sum n \\ &= 8 \text{ unit} \end{aligned}$$

E. Pasang tangki air 550l

$$\begin{aligned} \text{Volume} &= \sum n \\ &= 2 \text{ unit} \end{aligned}$$

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

$$\begin{aligned} \text{Volume} &= \sum \text{panjang pipa} \\ &= 158 \text{ m} \end{aligned}$$

C. Pekerjaan saluran air bersih

$$\begin{aligned} \text{Volume} &= \sum \text{panjang pipa} \\ &= 140 \text{ m} \end{aligned}$$

D. Pekerjaan pembuatan septictank dan rembesan

$$\begin{aligned} \text{Galian tanah} &= \text{septictank} + \text{rembesan} \\ &= (2,35 \times 1,85) \times 2 + (0,3 \times 1,5 \times 1,25) \\ &= 9,2575 \text{ m}^3 \end{aligned}$$

Pemasangan bata merah

$$\begin{aligned} \text{Volume} &= \sum \text{panjang} \times \text{tinggi} \\ &= 8,4 \times 2 = 1,68 \text{ m}^2 \end{aligned}$$

9.3.11. Pekerjaan instalasi Listrik

A. Instalasi stop kontak

$$\begin{aligned} \text{Volume} &= \sum n \\ &= 11 \text{ unit} \end{aligned}$$

B. Titik lampu

➤ TL 36 watt

$$\begin{aligned} \text{Volume} &= \sum n \\ &= 85 \text{ unit} \end{aligned}$$



➤ pijar 25 watt

$$\begin{aligned} \text{Volume} &= \sum n \\ &= 20 \text{ unit} \end{aligned}$$

C. Instalasi saklar

➤ Saklar single

$$\begin{aligned} \text{Volume} &= \sum n \\ &= 5 \text{ unit} \end{aligned}$$

➤ Saklar double

$$\begin{aligned} \text{Volume} &= \sum n \\ &= 19 \text{ unit} \end{aligned}$$

9.3.11. Pekerjaan pengecatan

A. Pengecatan dinding dalam dan plafon

$$\begin{aligned} \text{Volume dinding dalam} &= (\sum \text{panjang} \times \text{tinggi bidang cat}) - (\text{l.dinding} \\ &\quad \text{keramik} + \text{l.jendela} + \text{l.pintu}) \\ &= ((148 \times 8) + (8 \times 4)) - (72 + 29,7174 + 51,744) \\ &= 1062,538 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \text{volume plafon} &= \text{luas plafon} \\ &= 1056 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \text{Total volume} &= 1062,538 + 1056 \\ &= 2118,538 \text{ m}^2 \end{aligned}$$

B. Pengecatan dinding luar

$$\begin{aligned} \text{Volume tampak depan \& samping} &= ((\sum \text{panjang} \times \text{tinggi bidang} \\ &\quad \text{cat}) + (\text{l.sirip} \times \sum n)) - (\text{l.jendela} + \text{l.pintu}) \\ &= ((64 \times 6,75) + (1,975 \times 28)) - (29,7174 + 51,744) \\ &= 384,069 \text{ m}^2 \end{aligned}$$

$$\begin{aligned} \text{Volume tampak belakang} &= (\sum \text{panjang} \times \text{tinggi bidang cat}) - \\ &\quad (\text{l.jendela} + \text{l.pintu}) \\ &= \{(44 \times 8) + (88 \times 2,75)\} - (29,7174 + 51,744) \\ &= 512,539 \text{ m}^2 \end{aligned}$$



Tugas Akhir

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$$\begin{aligned}\text{Total volume} &= 384,069 + 512,539 \\ &= 896,608 \text{ m}^2\end{aligned}$$

C. Pengecatan menggunakan Cat minyak (pada listplank)

$$\begin{aligned}\text{Volume} &= \sum \text{panjang} \times \text{lebar papan} \\ &= 222 \times 0,15 = 33,3 \text{ m}^2\end{aligned}$$

D. Pengecatan menggunakan melamik (pada kusen)

$$\begin{aligned}\text{Luas kusen} &= \sum \text{panjang} \times \text{kayu } 6/12 \\ &= 576,178 \times 0,24 \\ &= 138,2827 \text{ m}^2\end{aligned}$$

$$\text{Luas daun pintu} = 29,7174 \text{ m}^2$$

$$\text{Luas daun jendela} = 51,744 \text{ m}^2$$

$$\begin{aligned}\text{Total volume} &= 138,2827 + 29,7174 + 51,744 \\ &= 219,744 \text{ m}^2\end{aligned}$$



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BAB 10

REKAPITULASI PERENCANAAN

10.1. Perencanaan Atap

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

- a. Jarak antar kuda-kuda : 4 m
 - b. Kemiringan atap (α) : 35°
 - c. Bahan gording : baja profil *lip channels* (□)
 - d. Bahan rangka kuda-kuda : baja profil *double* siku sama kaki (⊥).
 - e. Bahan penutup atap : genteng.
 - f. Alat sambung : baut-mur.
 - g. Jarak antar gording : 1,628 m
 - h. Bentuk atap : limasan.
 - j. Mutu baja profil : Bj-37
- $\sigma_{ijin} = 1600 \text{ kg/cm}^2$
 $\sigma_{leleh} = 2400 \text{ kg/cm}^2$ (SNI 03-1729-2002)

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Perencanaan Struktur Gedung Sekolah 2 lantai

Berikut adalah hasil rekapitulasi profil baja yang direncanakan :

1. Jurai

Tabel 10.1 Rekapitulasi perencanaan profil jurai

Nomor 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	76,3 . 2,8	2 Ø 12,7

2. Setengah kuda-kuda

Tabel 10.2 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	76,3 . 2,8	2 Ø 12,7

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Tugas Akhir

Perencanaan Struktur Gedung Sekolah 2 lantai

3. Kuda Kuda Utama

Tabel 10.4 Rekapitulasi perencanaan profil kuda kuda utama 1

Nomer Batang	Dimensi Profil	Baut (mm)
1	┘ 45 . 45 . 5	3 Ø 12,7
2	┘ 45 . 45 . 5	2 Ø 12,7
3	┘ 45 . 45 . 5	3 Ø 12,7
4	┘ 45 . 45 . 5	3 Ø 12,7
5	┘ 45 . 45 . 5	2 Ø 12,7
6	┘ 45 . 45 . 5	3 Ø 12,7
7	┘ 45 . 45 . 5	3 Ø 12,7
8	┘ 45 . 45 . 5	2 Ø 12,7
9	┘ 45 . 45 . 5	3 Ø 12,7
10	┘ 45 . 45 . 5	3 Ø 12,7
11	┘ 45 . 45 . 5	2 Ø 12,7
12	┘ 45 . 45 . 5	3 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
17	┘ 45 . 45 . 5	3 Ø 12,7
18	┘ 45 . 45 . 5	2 Ø 12,7
19	┘ 45 . 45 . 5	2 Ø 12,7
20	┘ 45 . 45 . 5	2 Ø 12,7
21	┘ 45 . 45 . 5	2 Ø 12,7

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Perencanaan Struktur Gedung Sekolah 2 lantai

Tabel 10.5 Rekapitulasi perencanaan profil kuda kuda utama 2

Nomer Batang	Dimensi Profil	Baut (mm)
1	┘ 55. 55. 5	3 Ø 12,7
2	┘ 55. 55. 5	3 Ø 12,7
3	┘ 55. 55. 5	3 Ø 12,7
4	┘ 55. 55. 5	3 Ø 12,7
5	┘ 55. 55. 5	3 Ø 12,7
6	┘ 55. 55. 5	3 Ø 12,7
7	┘ 55. 55. 5	3 Ø 12,7
8	┘ 55. 55. 5	3 Ø 12,7
9	┘ 55. 55. 5	3 Ø 12,7
10	┘ 55. 55. 5	3 Ø 12,7
11	┘ 55. 55. 5	3 Ø 12,7
12	┘ 55. 55. 5	3 Ø 12,7
13	┘ 55. 55. 5	3 Ø 12,7
14	┘ 55. 55. 5	3 Ø 12,7
15	┘ 55. 55. 5	3 Ø 12,7
16	┘ 55. 55. 5	3 Ø 12,7
17	76,3. 2,8	3 Ø 12,7
18	┘ 55. 55. 5	3 Ø 12,7
19	┘ 55. 55. 5	3 Ø 12,7
20	┘ 55. 55. 5	3 Ø 12,7
21	┘ 55. 55. 5	3 Ø 12,7

10.2. Perencanaan Tangga

- ✓ Tebal plat = 12 cm
- ✓ Bordes tangga = 15 cm
- ✓ Panjang datar = 400 cm
- ✓ Lebar tangga rencana = 150 cm
- ✓ Dimensi bordes = 100 x 300 cm
- ✓ Kemiringan tangga α = 34°
- ✓ Jumlah antrede = 10 buah
- ✓ Jumlah optrede = 11 buah

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Tugas Akhir

Perencanaan Struktur Gedung Sekolah 2 lantai

10.2.1. Penulangan Tangga

a. Penulangan tangga dan bordes

Tumpuan = $\varnothing 12 \text{ mm} - 100 \text{ mm}$

Lapangan = $\varnothing 12 \text{ mm} - 150 \text{ mm}$

b. Penulangan balok bordes

Dimensi balok 100 mm x 300 mm

Lentur = 3 $\varnothing 12 \text{ mm}$

Geser = $\varnothing 8 - 120 \text{ mm}$

10.2.2. Pondasi Tangga

- Kedalaman = 1 m
- Ukuran alas = 1000 x 1500 mm
- γ tanah = 1,7 t/m³ = 1700 kg/m³
- σ tanah = 3 kg/cm²
- Penulangan pondasi
 - a. arah sumbu pendek = $\varnothing 13 \text{ mm} - 125 \text{ mm}$
 - b. arah sumbu panjang = $\varnothing 13 \text{ mm} - 125 \text{ mm}$

10.3. Perencanaan Plat

Rekapitulasi penulangan plat

Tulangan lapangan arah x $\varnothing 10 - 240 \text{ mm}$

Tulangan lapangan arah y $\varnothing 10 - 240 \text{ mm}$

Tulangan tumpuan arah x $\varnothing 10 - 120 \text{ mm}$

Tulangan tumpuan arah y $\varnothing 10 - 120 \text{ mm}$

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Tugas Akhir

Perencanaan Struktur Gedung Sekolah 2 lantai

10.4. Perencanaan Balok Anak

- Penulangan balok anak

a. Tulangan balok anak **As 1'(B – C)** dimensi 250 x 400 mm

Tumpuan = 3 D 16 mm
 Lapangan = 3 D 16 mm
 Geser = Ø 8 – 100 mm

b. Tulangan balok anak **B (1-14)** dimensi 250 x 400 mm

Tumpuan = 2 D 16 mm
 Lapangan = 4 D 16 mm
 Geser = Ø 8 – 125 mm

c. Tulangan balok anak **As 7''(B-C)** dimensi 200 x 300 mm

Tumpuan = 2 D 16 mm
 Lapangan = 2 D 16 mm
 Geser = Ø 8 – 200 mm

10.5. Perencanaan Portal

Perencanaan	Tulangan Tumpuan	Tulangan Lapangan	Tulangan Geser
Balok 25/40	2 D 16 mm	2 D 16 mm	Ø8 –200 mm
Balok 40/70	6 D 19 mm	6 D 19 mm	Ø10 –200 mm
Kolom	4 D 22 mm	4 D 22 mm	Ø10 –120 mm
Rink Balk	2 D 16 mm	2 D 16 mm	Ø 8 – 200 mm
Sloof	4 D 12 mm	4 D 12 mm	Ø 8 –200 mm
Sloof 2	2 D 16 mm	2 D 16 mm	Ø 8 – 100 mm

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Tugas Akhir

Perencanaan Struktur Gedung Sekolah 2 lantai

10.6. Perencanaan Pondasi Footplat

a. Pondasi Footplat 1

f'_c	= 25 Mpa
F_y	= 240 Mpa
tanah	= 30000 kg/m ²
γ tanah	= 1700 kg/m ³
Kedalaman	= 2,0 m
Ukuran alas	= 1600 x 1600 mm
Tebal	= 50 cm
Tul lentur	= \varnothing 16 – 160mm
Tul geser	= \varnothing 12 – 200mm

b. Pondasi Footplat 2

f'_c	= 25 Mpa
F_y	= 360 Mpa
tanah	= 30000 kg/m ²
γ tanah	= 1700 kg/m ³
Kedalaman	= 2,0 m
Ukuran alas	= 1200 x 1200 mm
Tebal	= 30 cm
Tul lentur	= \varnothing 16 – 200mm
Tul geser	= \varnothing 12 – 200mm

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Tugas Akhir

Perencanaan Struktur Gedung Sekolah 2 lantai

10.7. Rekapitulasi Rencana Anggaran Biaya

REKAPITULASI RENCANA ANGGARAN BIAYA

KEGIATAN : PEMBANGUNAN GEDUNG SEKOLAH 2 LANTAI
 LOKASI : SURAKARTA
 TAHUN ANGGARAN : 2010

NO.	JENIS PEKERJAAN	JUMLAH HARGA (Rp.)
A	PEKERJAAN PERSIAPAN	113,790,661.00
B	PEKERJAAN TANAH	35,295,304.32
C	PEKERJAAN PONDASI	29,335,363.96
D	PEKERJAAN BETON	1,140,078,317.00
E	PEKERJAAN PASANGAN DINDING	103,030,579.20
F	PEKERJAAN KUSEN DAN PINTU	181,852,832.60
G	PEKERJAAN ATAP	16,629,707.05
H	PEKERJAAN PLAFON	37,444,000.00
I	PEKERJAAN KERAMIK	121,515,969.00
J	INSTALASI AIR	29,793,503.00
K	INSTALASI LISTRIK	7,500,500.00
L	PEKERJAAN PENGECATAN	37,500,500.00
M	PEKERJAAN LAIN-LAIN	150,000,000.00
JUMLAH		Rp 2,003,946,269.00

Biaya konstruksi 10% Rp 200,394,626.00

Jumlah Rp 2,204,304,896.00

ppn 10% Rp 220,434,089.60

Jumlah keseluruhan Rp 2,424,774,986.00

Terbilang: Dua milyar empat ratus dua puluh empat juta tujuh ratus tujuh puluh empat ribu sembilan ratus delapan puluh enam rupiah

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