

## **BAB II**

### **PERANCANGAN STRUKTUR ATAS**

#### **2.1 Tinjauan Pustaka**

##### **2.1.1 Preliminary Design**

Dalam merancang suatu struktur bangunan wajib memenuhi peraturan-peraturan yang berlaku untuk mendapatkan bangunan yang aman secara konstruksi. Struktur gedung yang dirancang di haruskan teruji dan mampu menahan beban hidup, beban mati, beban gempa dan beban angin yang bekerja pada gedung tersebut. Oleh karena itu, ketelitian dalam perencanaan beban merupakan salah satu poin penting dalam perancangan struktur gedung, agar struktur tersebut aman dan nyaman saat digunakan sesuai dengan standar dan peruntukannya.

##### **2.1.2 Metode Sistem yang digunakan**

Metode perhitungan beton yang digunakan adalah kapasitas (Kekuatan batas), dengan perilaku daktilitas penuh, sedangkan struktur *open frame* dirancang menggunakan konsep *Strong Couolumn Weak Beam*, yang merancang kolom sedemikian rupa agar sendi plastis terjadi pada balok-balok kecuali pada kolom paling bawah, boleh terjadi sendi plastis dasar kolom.

##### **2.1.3 Perencanaan Beban Struktur**

Beban-beban yang bekerja pada struktur seperti beban mati (*dead load*), beban hidup (*live load*), beban gempa (*earthquake*), dan beban angin (*wind load*) menjadi bahan perhitungan awal dalam perencanaan struktur untuk mendapatkan besar dan arah gaya-gaya yang bekerja pada setiap komponen struktur, kemudian dapat dilakukan analisis struktur untuk mengetahui besarnya kapasitas penampang dan tulangan yang dibutuhkan oleh masing-masing struktur.

#### **2.1.4 Pembebanan**

Beban menurut SNI 1726-2019 adalah gaya-gaya atau aksi-aksi lainnya yang dihasilkan dari berat seluruh material bangunan, hunian dan pemanfaatannya, pengaruh-pengaruh lingkungan, pergerakan relatif, beda penurunan, dan perubahan-perubahan dimensi yang tertahan.

##### **A. Beban Statis**

###### **1. Beban Mati**

Beban mati adalah berat seluruh bahan konstruksi bangunan gedung yang terpasang, termasuk dinding, lantai, atap, plafon, tangga, dinding partisi tetap, finishing, klading gedung dan komponen arsitektural dan struktural lainnya serta peralatan layan terpasang lain termasuk berat keran (SNI 1726-2019).

###### **2. Beban Hidup**

Beban hidup merupakan beban yang diakibatkan oleh pengguna dan penghuni bangunan gedung atau struktur lain yang tidak termasuk beban konstruksi dan beban lingkungan, seperti beban angin, beban hujan, beban gempa, beban banjir, atau beban mati.

##### **B. Beban Dinamis**

###### **1. Beban Gempa**

Beban gempa adalah beban yang timbul akibat percepatan getaran tanah pada saat gempa terjadi. Faktor-faktor yang mempengaruhi besarnya beban gempa yang terjadi, yaitu massa dan kekakuan struktur, waktu getar alami dan pengaruh redaman pada struktur, kondisi tanah, dan wilayah kegempaan dimana struktur gedung tersebut berada.

### 2.1.5 Kombinasi Pembebanan

Di dalam peraturan SNI 03-1726-2019, dijelaskan mengenai Tata cara perencanaan ketahanan gempa untuk struktur bangunan gedung dan non gedung. Dinyatakan bahwa struktur lainnya dirancang memakai kombinasi pembebanan, kombinasi-kombinasi tersebut diantaranya adalah sebagai berikut:

1.  $1,4 D$
2.  $1,2 D + 1,6 L + 0,5(Lr \text{ atau } R)$
3.  $1,2 D + 1,6(Lr \text{ atau } R) + (L \text{ atau } 0,5W)$
4.  $1,2 D + 1,0 W + L + 0,5(Lr \text{ atau } R)$
5.  $0,9 D + 1,0 W$
6.  $1,2 D + E_v + E_h + L$
7.  $0,9 D - E_v + E_h$

Dimana:

- $D$  = Beban mati  
 $L$  = Beban hidup  
 $E_v$  = Beban gempa vertikal  
 $E_h$  = Beban gempa horizontal  
 $R$  = Faktor reduksi  
 $W$  = Beban angin

## 2.2 Struktur Rangka Atap Baja

### 2.2.1 Struktur atap Profil baja WF

Atap merupakan salah satu komponen utama dalam sebuah bangunan gedung untuk melindungi dari panas dan hujan. Selain itu, atap juga merupakan salah satu komponen arsitektural yang menambah keindahan

sebuah bangunan gedung. Maka dari itu setiap bangunan gedung harus memiliki atap.

Keuntungan memanfaatkan rangka baja untuk konstruksi bangunan adalah mudah dalam pemasangan, praktis, kuat dan tahan lama. Baja juga tidak akan terpengaruh oleh perubahan cuaca yang ekstrim. Baja bisa didesain menjadi tidak mudah karatan dan menjamur.

### 2.2.2 Sifat Mekanis Baja

Sifat Mekanis Baja dalam perencanaan struktur baja untuk bangunan gedung struktural yang digunakan dalam perencanaan harus memenuhi persyaratan minimum, Tegangan Leleh ( $f_y$ ) dan Tegangan Putus ( $f_u$ ). Untuk perencanaan tidak boleh diambil melebihi nilai mengenai sifat mekanis baja struktural. Sifat-sifat mekanis lainnya, Sifat-sifat mekanis lainnya baja struktural untuk maksud perencanaan ditetapkan sebagai berikut:

Modulus elastisitas :  $E = 200000\text{MPa}$

Modulus geser :  $G = 80.000\text{MPa}$

Nisbah poisson :  $\mu = 0,3$

Tegangan Putus ( $F_u$ )  $= 370\text{MPa}$

Tegangan leleh ( $F_y$ )  $= 240\text{MPa}$

### 2.2.3 Hitungan Perencanaan Gording

Pada Perencanaan digunakan plat genteng onduline sehingga digunakan kemiringan sudut atap sebesar  $30^\circ$ .

#### 1. Hitungan Denah Atap

Jarak gording  $= 1,2\text{ m}$

Bentang gording  $= 4\text{ m}$

Jarak sagrod  $= 50,27\text{ mm}$

#### 2. Hitungan Gording

Berat Plafond  $= 0,2\text{ kN/m}$

Berat Gording  $= 0,1\text{ kN/m}$

Berat Gording  $= 0,1\text{ kN/m}$

## 3. Rencana beban gording

$$\text{Berat sendiri} = 0,1 \text{ kN/m}$$

$$\text{Berat atap} = \frac{\text{Jarak gording} \times \text{berat genteng}}{\cos 30^\circ}$$

$$= \frac{1,2 \times 0,5}{\cos 30^\circ} = 0,69 \text{ kN/m}$$

$$\text{Berat Plafond} = \text{Jarak gording} \times \text{berat plafond}$$

$$= 1,2 \times 0,2$$

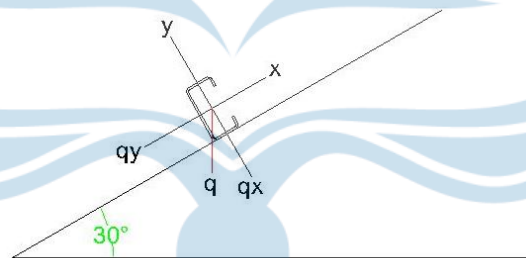
$$= 0,24 \text{ kN/m}$$

$$\text{Dead Load (P)} = 0,1 + 0,69 + 0,24$$

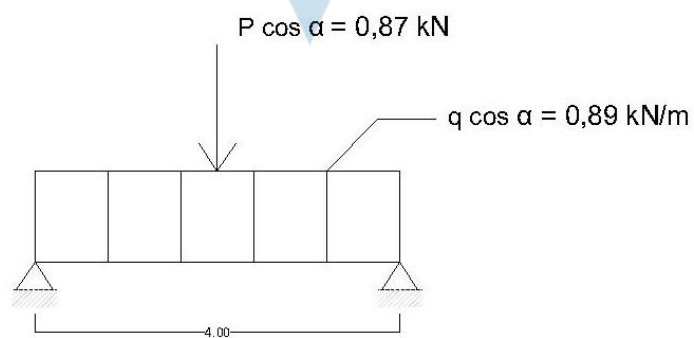
$$= 1,03 \text{ kN/m (q)}$$

$$\text{Berat Pekerja} = 1 \text{ kN/m}$$

$$\text{Live Load (L)} = 1 \text{ kN/m (p)}$$



Gambar 2. 1 Perencanaan Gording



Gambar 2. 2 Beban Gording Arah Sumbu -y

## 4. Rencana Momen Gording

$$M_D = \frac{1}{8} \times q \cos \alpha (L^2)$$

$$= \frac{1}{8} \times 0,89 \times (4)^2$$

$$= 1,78 \text{ kNm}$$

$$M_L = \frac{1}{4} \times p \cos \alpha \times (L)$$

$$= \frac{1}{4} \times 0,87 \times (4)$$

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

$$M_U = 1,4 M_D$$

$$= 1,4 (1,78)$$

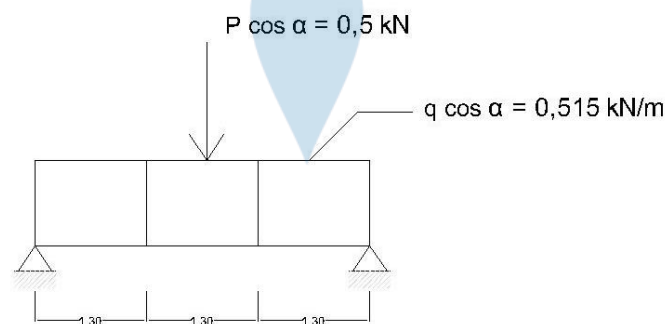
$$= 2,492 \text{ kNm}$$

$$M_U = 1,2 M_D + 1,6 M_L$$

$$= 1,2 (1,78) + 1,6 (0,87)$$

$$= 3,528 \text{ kNm}$$

Momen yang digunakan = 3,528 kNm



Gambar 2. 3 Beban gording arah sumbu -x

Rencana momen gording

$$M_D = \frac{1}{8} \times q \sin \alpha \left(\frac{L}{3}\right)^2$$

$$= \frac{1}{8} \times 0,515 \times (1,3)^2$$

$$= 0,109 \text{ kNm}$$

$$M_L = \frac{1}{4} \times p \sin \alpha \left(\frac{L}{3}\right)^2$$

$$= \frac{1}{4} \times 0,5 \times (1,3)^2$$

$$= 0,211 \text{ kNm}$$

$$M_U = \frac{1}{4} \times (0,109)$$

$$= 0,152 \text{ kNm}$$

$$M_U = 1,2 (0,109) + 1,6 (0,211)$$

$$= 0,469 \text{ kNm}$$

Momen yang digunakan = 0,469 kNm

Profil C 150 x 65 x 20

$$T = 3 \text{ mm} = 3140000 \text{ mm}$$

$$L_x = 314 \text{ cm}^4 = 510000 \text{ cm}^4$$

$$L_y = 51 \text{ cm}^4 = 41800 \text{ cm}^4$$

$$Z_x = 41,8 \text{ cm}^3 = 11600 \text{ cm}^3$$

$$Z_y = 11,6 \text{ cm}^3 = 3140000 \text{ cm}^3$$

Mutu Baja ST 37

$$F_u = 370 \text{ MPa}$$

$$F_y = 240 \text{ MPa}$$

$$E = 200000 \text{ MPa}$$

Cek Tegang Profil C =  $F_b < f_y$

$$= \frac{M_{uy}}{\phi Z_x} + \frac{M_{ux}}{\phi Z_y} < 240 \text{ MPa}$$

$$= \frac{3,528 \times 10^6}{0,9 \times 41,8 \times 10^3} + \frac{0,469 \times 10^6}{0,9 \times 11,6 \times 10^3} < 240 \text{ MPa}$$

$$= 138,70 \text{ MPa}$$

Cek defleksi gording

$$\begin{aligned} \delta_y &= \frac{5}{384} \times \frac{q \cos \alpha (L)^4}{EI} + \frac{1}{48} \times \frac{P \cos \alpha L^3}{EI} \\ &= \frac{5}{384} \times \frac{0,89 \times 4000^4}{2 \times 10^5 \times 314 \times 10^4} + \frac{1}{48} \times \frac{0,87 \times 4000^3}{2 \times 10^5 \times 314 \times 10^4} \\ &= 0,013 \times 36,28 + 0,021 \times 354,65 \\ &= 12,16 \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} \delta_x &= \frac{5}{384} \times \frac{q \sin \alpha}{EI} \times \left(\frac{L}{3}\right)^4 + \frac{1}{48} \times \frac{P \sin \alpha L^3}{EI} \times \left(\frac{L}{3}\right)^3 \\ &= \frac{5}{384} \times \frac{0,515}{2 \times 10^5 \times 314 \times 10^4} \times \left(\frac{1300}{3}\right)^4 + \\ &\quad \frac{1}{48} \times \frac{0,5}{2 \times 10^5 \times 314 \times 10^4} \times \frac{1300^3}{3} \\ &= 0,013 \times 2,342 + 0,021 \times 2,274 \\ &= 0,0782 \text{ mm}^2 \end{aligned}$$

$$\delta \leq \frac{1}{240} L$$

$$\sqrt{\delta y^2 + \delta x^2} \leq \frac{4}{240}$$

$$\sqrt{12,11^2 + 0,078^2} \leq 16,67 \text{ mm}$$

$$12,1103 \leq 16,67 \text{ mm}$$

##### 5. Hitungan Sa-grod

Digunakan sag-rod sebanyak 3 buah

$$\begin{aligned}
 Ft_D &= n \left( \frac{L}{3} \times q \times \sin \alpha \right) \\
 &= 3 \left( \frac{4}{3} \times 0,89 \right) \\
 &= 3,56 \text{ kN}
 \end{aligned}$$

$$\begin{aligned}
 Ft_L &= \frac{n}{2} (p \sin \alpha) \\
 &= \frac{3}{2} (0,5) \\
 &= 0,75 \text{ kN}
 \end{aligned}$$

$$\begin{aligned}
 Ft_u &= 1,4 \times Ft_D \\
 &= 1,4 \times 3,56 \\
 &= 4,984 \text{ kN}
 \end{aligned}$$

$$\begin{aligned}
 Ft_u &= 1,2 \times Ft_D + 1,6 \times Ft_L \\
 &= 1,2 \times 3,56 + 1,6 \times 0,75 \\
 &= 5,472 \text{ kN}
 \end{aligned}$$

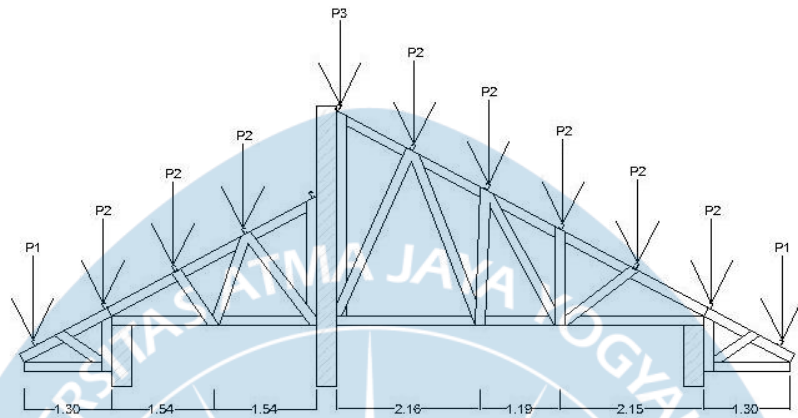
6. Luas Batang Sag-rod yang Diperlukan :

$$\begin{aligned}
 Asr &= \frac{Ft \times 10^3}{\phi Fy} \text{ mm}^2 \\
 &= \frac{5,472 \times 10^3}{0,9 \times 240} \text{ mm}^2 \\
 &= 25,3 \text{ mm}^2 \leq 50,27 \text{ mm}^2
 \end{aligned}$$

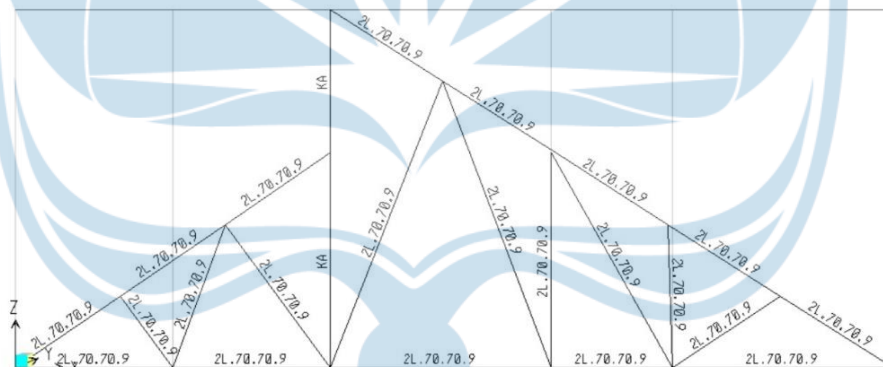
Menggunakan tulangan besi diameter 8 mm dengan luasan 50,27 mm<sup>2</sup>

## 2.2.4 Rencana Beban Kuda-Kuda

### 1. Rencana Beban Mati



Gambar 2. 4 Frame Kuda-Kuda



Gambar 2. 5 Beban Setiap Frame di Kuda - Kuda

Beban P1

$$\text{Berat Kuda-Kuda} = \frac{q}{w} \times \text{berat kuda - kuda}$$

$$= \frac{1,5}{w} \times 0,5$$

$$= 0,375 \text{ kN}$$

$$\text{Berat Gording} = 4 \times 0,07 = 0,28 \text{ kN}$$

$$\text{Berat Atap} = \frac{(a/2+b)}{\cos \alpha} \times L \times \text{berat atap}$$

$$= \frac{(2,33/2+1)}{\cos 30^\circ} \times 4 \times 0,5$$

$$= 4,04 \text{ kN}$$

$$\text{Berat Plafon} = (a/2 + b) \times L \times \text{berat plafon}$$

$$= (2,33/2 + 1) \times 4 \times 0,2$$

$$= 1,4 \text{ kN}$$

$$\text{Total Beban P1} = 6,095 \text{ kN}$$

Beban P2

$$\text{Berat Kuda-Kuda} = a \times \text{berat kuda-kuda}$$

$$= 1,5 \times 0,5$$

$$= 0,75 \text{ kN}$$

$$\text{Berat Gording} = L \times \text{berat gording per } m^1$$

$$= 4 \times 0,1$$

$$= 0,28 \text{ kN}$$

$$\text{Berat Atap} = \frac{a}{\cos \alpha} \times L \times \text{berat atap}$$

$$= \frac{2,33}{\cos 30^\circ} \times 4 \times 0,5$$

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

$$\text{Berat Plafon} = a \times L \times \text{berat plafon}$$

$$= 2,33 \times 4 \times 0,2$$

$$= 1,2 \text{ kN}$$

$$\text{Total beban P2} = 5,73 \text{ kN}$$

## Beban P3

$$\begin{aligned}
 \text{Berat kuda-kuda} &= a \times \text{berat kuda - kuda} \\
 &= 1,5 \times 0,5 \\
 &= 0,75 \text{ kN}
 \end{aligned}$$

$$\begin{aligned}
 \text{Berat gording} &= 2 \times L \times \text{berat gording per m}^1 \\
 &= 2 \times 4 \times 0,1 \\
 &= 0,56 \text{ kN}
 \end{aligned}$$

$$\begin{aligned}
 \text{Berat atap} &= \frac{a}{\cos \alpha} \times L \times \text{berat atap} \\
 &= \frac{2,33}{\cos 30^\circ} \times 4 \times 0,5 \\
 &= 3,5 \text{ kN}
 \end{aligned}$$

$$\begin{aligned}
 \text{Berat plafon} &= a \times L \times \text{berat plafon} \\
 &= 2,33 \times 4 \times 0,2 \\
 &= 1,2 \text{ kN}
 \end{aligned}$$

$$\text{Total beban P3} = 6,01 \text{ kN}$$

## 2. Rencana Beban Angin

Pada gedung yang tertutup atap segitiga, koefisien angin untuk sudut atap dengan Kemiringan sudut  $30^\circ$  bernilai sebesar  $0,02 \alpha$  sampai  $0,4$ . Sehingga koefisien untuk angin tiup ( $C_{ti}$ ) =  $0,3$  dan untuk angin isap ( $C_{is}$ ) =  $-0,6$  Besar tekanan tiup angin diasumsikan sebesar  $0,25 \text{ kN/m}^2$

$$\text{Beban W1} = \frac{1,5/2 + 1}{0,87} \times 0,3 \times 4 \times 0,25 = 0,603 \text{ kN}$$

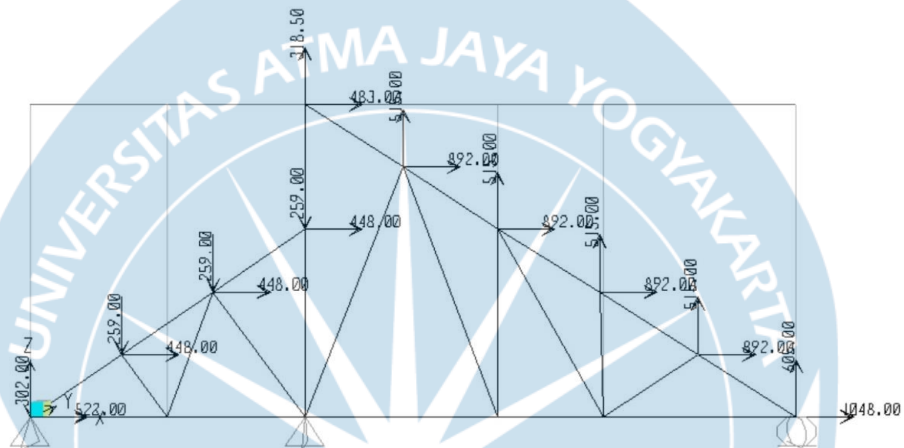
$$\text{Beban W2} = \frac{1,5}{0,87} \times 0,3 \times 4 \times 0,25 = 0,517 \text{ kN}$$

$$\text{Beban W3} = \frac{1}{2} \times \frac{1,5}{0,87} \times 0,3 \times 4 \times 0,25 = 0,259 \text{ kN}$$

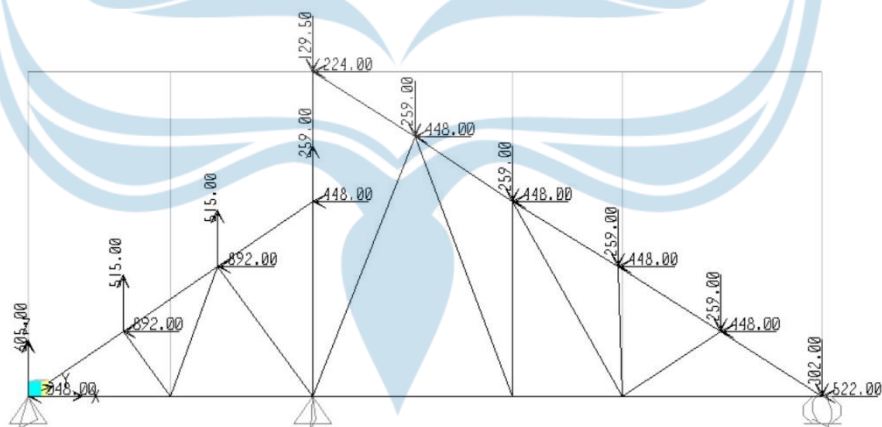
$$\text{Beban W4} = \frac{1}{2} \times \frac{1,5}{0,87} \times 0,6 \times 4 \times 0,25 = 0,517 \text{ kN}$$

$$\text{Beban W5} = \frac{1,5}{0,87} \times 0,6 \times 4 \times 0,25 = 1,03 \text{ kN}$$

$$\text{Beban W6} = \frac{1,5/2 + 1}{0,87} \times 0,6 \times 4 \times 0,25 = 1,21 \text{ kN}$$

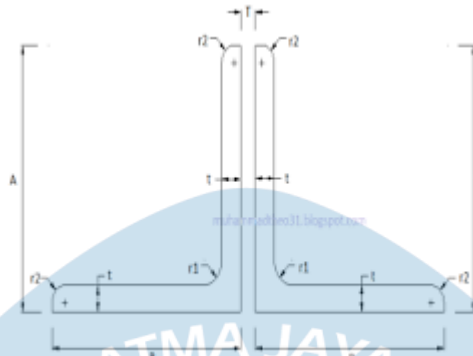


Gambar 2. 6 Beban Angin Kiri



Gambar 2. 7 Beban Angin Kanan

### 3. Perencanaan Elemen Kuda – Kuda



Gambar 2. 8 Profil Siku 2L75 x 75 x 9  
Menggunakan profil siku 2L75 x 75 x 9

$$A = 1296 \text{ mm}^2$$

$$I_x = I_y = 64,4 \times 10^4 = 644000 \text{ mm}^4$$

$$I_x = 22,5 \text{ mm}$$

$$C_x = C_y = 21,7 \text{ mm}$$

Properti profil gabungan

$$A_g = 2538 \text{ mm}^2$$

$$I_{x,g} = 2 (I_x)$$

$$= 2 (64,4 \times 10^4)$$

$$= 122,2 \times 10^4 \text{ mm}^4$$

$$I_{y,g} = 2 (I_y) + 2 (A)(d^2)$$

$$= 2 (64,4 \times 10^4) + 2 (1269)(21,7 + 11/2)^2$$

$$= 3.165.713,92 \text{ mm}^4$$

$$r_x = \sqrt{\frac{I_{x,g}}{2(A)}}$$

$$= \sqrt{\frac{1228000}{2(1269)}} = 22,53 \text{ mm}$$

$$r_y = \sqrt{\frac{3.165.713,92}{2(1269)}} = 35,32 \text{ mm}$$

Maka digunakan  $r = 22,53 \text{ mm}$

a) Tekan dominan

$$Nu = 164,002$$

$$Lk = 3008,32 \text{ mm}$$

$$\begin{aligned} \lambda c &= \frac{1}{\pi} \times \frac{Lk}{r} \sqrt{\frac{Fy}{e}} \\ &= \frac{1}{\pi} \times \frac{3008,32}{22,53} \sqrt{\frac{240}{200.000}} \\ &= 1,47 \quad 1,47 \geq 1,2 \end{aligned}$$

$$1,47 \geq 1,2$$

$$\begin{aligned} \text{Maka } w &= 1,25 \times (\lambda c)^2 \\ W &= 1,25 \times (1,47)^2 \\ W &= 2,7 \\ Fc &= \frac{W \times Nu}{\phi Ag} < fy, \phi 0,85 \end{aligned}$$

$$\begin{aligned} Fc &= \frac{2,7 \times 164,002 \times 10^3}{0,85 \times 2538} < 240, \phi 0,85 \\ &= 205,259 \text{ Mpa} < 240 \text{ (aman)} \end{aligned}$$

Syarat kelangsingan

$$\lambda = \frac{Lk}{r} < 300$$

$$\lambda = \frac{3008,32}{22,53} = 133,52 < 300 \text{ (aman)}$$

b) Tarik dominan

$$Nu = 164,002$$

$$Lk = 3008,32 \text{ mm}$$

$$ft = \frac{Nu}{\phi Ag} \leq fy, \phi = 0,9$$

$$\frac{164,002 \times 10^3}{0,9 \times 2538} \leq 240$$

$$= 71,79 \leq 240 \text{ (aman)}$$

Syarat kelangsingan

$$\begin{aligned} \lambda &= \frac{Lk}{r} < 240 \\ &= \frac{3008,32}{22,53} < 240 \\ &= 133,52 < 240 \text{ (aman)} \end{aligned}$$

Rencana sambungan kuda-kuda

a. Profil 2L75 x 75 x 9

Data gaya batang dan profil siku

$$Nu = 164,002$$

$$H = 75$$

$$Ce = 21,7$$

Besar gaya rencana untuk sambungan las :

$$\begin{aligned} Nu11 &= \frac{Nu (h-Ce)}{h} \\ &= \frac{164,002 (75-21,7)}{75} \\ &= 11655,7 \text{ N} \end{aligned}$$

$$\begin{aligned} Nu12 &= \frac{Nu (Ce)}{h} \\ &= \frac{164,002 (21,7)}{75} \\ &= 47,45 \end{aligned}$$

Nu11 lebih besar dari Nu12, digunakan Nu11

Tebal bagian paling tebal, t=mm	Tebal minimum las sudut (mm)
$t \leq 7$	3
$7 < t \leq 10$	4
$10 < t \leq 15$	5
$15 < t$	6

Karena plat simpul 10 mm, digunakan  $t_w = 5 \text{ mm}$

$$\begin{aligned}
 t_l &= \frac{1}{2} \sqrt{2} \times t_w \\
 &= \frac{1}{2} \sqrt{2} \times 5 \\
 &= 3,5 \text{ mm}
 \end{aligned}$$

Kuat rencana

$$F_{uw} = 351 \text{ MPa}$$

$$F_u = 240 \text{ MPa}$$

$$F_{\text{reduksi}} = 0,75$$

$$\begin{aligned}
 R_u &= d_f \times 0,75 \times t_l \quad (0,6 \times f_{uw}) \\
 &= 0,75 \times 0,75 \times 3,5 \quad (0,6 \times 351) \\
 &= 414,62 \text{ MPa}
 \end{aligned}$$

$$\begin{aligned}
 R_u &= d_f \times 0,75 \times t_l \quad (0,6 \times f_u) \\
 &= 0,75 \times 0,75 \times 3,5 \quad (0,6 \times 240) \\
 &= 283,5 \text{ Mpa}
 \end{aligned}$$

Nilai  $R_u$  yang digunakan 283,5 MPa

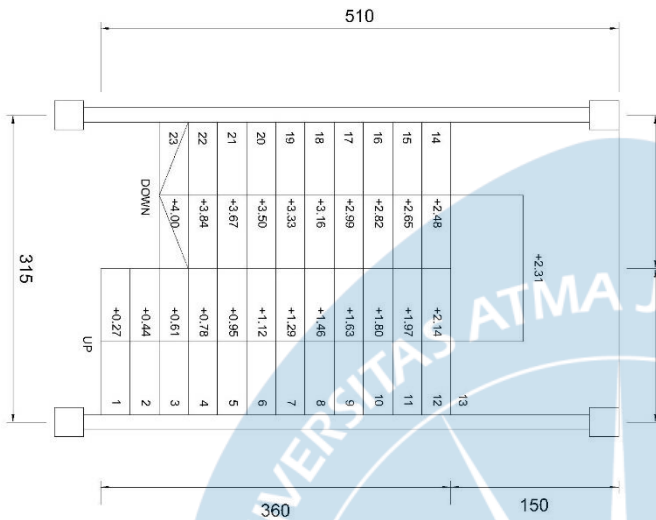
Panjang efektif las :

$$\begin{aligned}
 L_e &= \frac{Nu11}{2R_u} \\
 &= \frac{11655,7}{2(283,5)} \\
 &= 20,55
 \end{aligned}$$

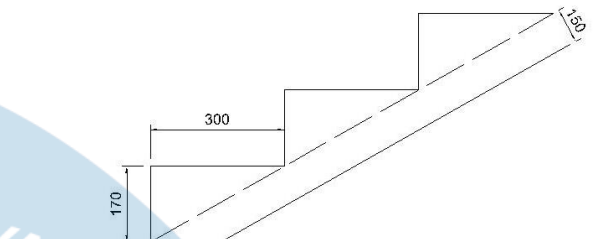
Maka, digunakan sambungan las sudut  $2\Delta 5 - 20$ .

## 2.3 Perencanaan Tangga dan Pelat

### 1. Rencana Ruang Tangga



Gambar 2. 9 Denah Ruang Tangga



Gambar 2. 10 Detail Anak Tangga

$$Lz = 3 \text{ m}$$

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

$$\text{htg} = 0,2 \text{ m}$$

$$\text{ltg} = 3,9 \text{ m}$$

$$\text{a. Lebar Bordes Minimum} = \frac{Lz}{2} = \frac{3}{2} = 1,5 \text{ m} = 1500 \text{ mm}$$

$$\text{b. Jumlah anak tangga} = 23 \text{ buah}$$

$$\text{c. Lebar Tangga} = \text{Ltg} = \left( \frac{1}{2} \times \text{ntg} - 1 \right) - A$$

$$= \left( \frac{1}{2} \times 23 - 1 \right) \times 0,3 = 3,2 \text{ m}$$

$$= 3200 \text{ mm}$$

$$\text{d. Sudut Kemiringan Tangga } \sigma = \tan^{-1} \left( \frac{180}{300} \right) = 29,5^\circ$$

$$\text{e. Ketebalan Plat Tangga} = 150 \text{ mm}$$

$$\text{beban railing} = 1 \text{ kN/m}$$

$$\text{beban volume beton} = 24 \text{ kN/m}$$

$$\text{berat volume vinyl} = 1,0718$$

$$\text{kN/m}$$

$$\text{optrade x antrade} = 510 \text{ cm}$$

## 2. Rencana Beban Tangga

Beban qtg

$$\text{Beban sendiri tangga} = \frac{0,2}{\cos(30)} \times 24 = 31,12 \text{ kN/m}$$

$$\text{Berat anak tangga} = \frac{1}{2} \times 0,17 \times 24 = 2,04 \text{ kN/m}$$

$$\text{Berat ubin dan spesi} = 0,05 \times 1,0718 = 0,0536 \text{ kN/m}$$

$$\text{Berat railing (diperkirakan)} = 1,00 \text{ kN/m}$$

$$\text{BEBAN qtg} = 34,21 \text{ kN/m}$$

Beban qbd

$$\text{Beban sendiri tangga} = 0,2 \times 23 = 4,8 \text{ kN/m}$$

$$\text{Beban ubin dan spesi} = 0,05 \times 1,0718 = 0,05 \text{ kN/m}$$

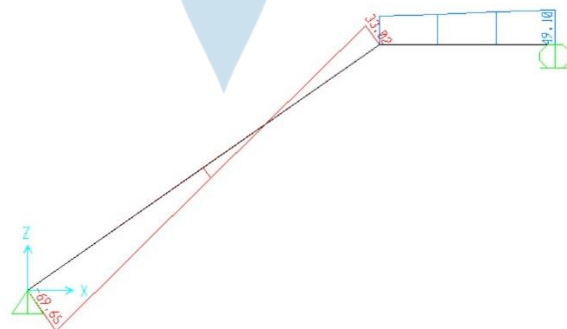
$$\text{Beban railing (diperkirakan)} = 1,00 \text{ kN/m}$$

$$\text{BEBAN qbd} = 5,85 \text{ kN/m}$$

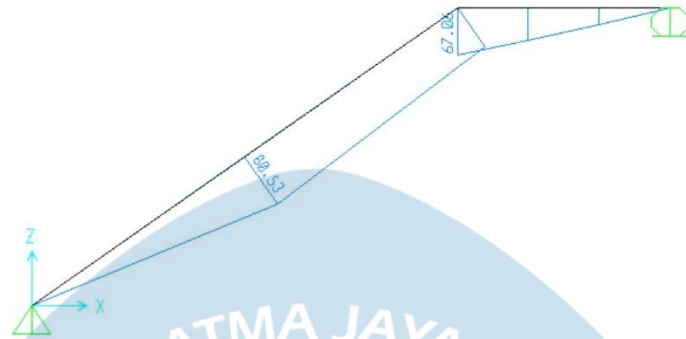
$$\text{Beban Hidup} = 4,79 \text{ kN/m}$$

## 3. Rencana Penulangan tangga

Akibat *Dead Load*

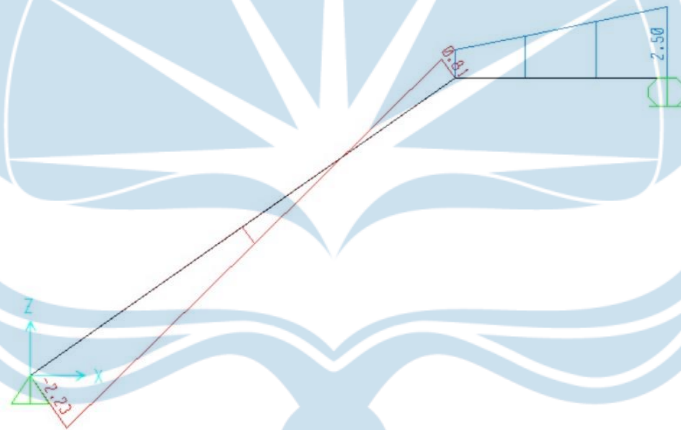


Gambar 2. 11 SFD dari *Dead load*

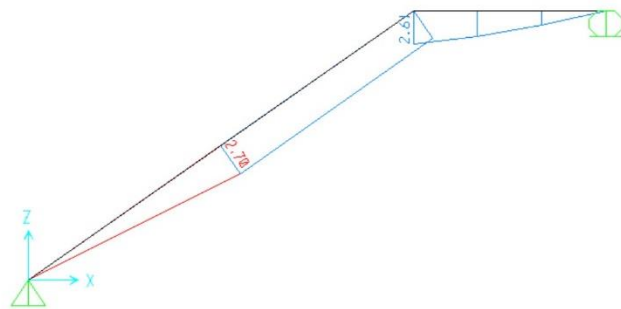


Gambar 2. 12 BMD dari *Dead load*

Akibat *Live Load*



Gambar 2. 13 SFD dari *Live load*



Gambar 2. 14 BMD dari *Live load*

$$\text{MDL} = 67,06 \text{ kN/m}$$

$$\text{MLL} = 2,61 \text{ kN/m}$$

$$\text{VDL} = 69,65 \text{ kN/m}$$

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

$$M_u = 1,4 \text{ MDL} = 1,4 \times 67,06 = 93,884 \text{ kN/m}$$

$$M_u = 1,2 \text{ MDL} + 67,06 + 1,6 \times 2,61 = 84,648 \text{ kN/m}$$

$$V_u = 1,4 \text{ VDL} = 1,4 \times 69,65 = 97,51 \text{ kN/m}$$

$$V_u = 1,2 \text{ VDL} + 1,6 \text{ VLL} = 1,2 \times 69,65 + 1,6 \times 2,5 = 87,58 \text{ kN/m}$$

$$\text{Maka : } \quad \text{Mur} : 93,884 \text{ kN/m}$$

$$\quad \quad \quad \text{Vur} : 97,51 \text{ kN/m}$$

#### 4. Rencana Penulangan Tangga Tumpuan

$$\begin{aligned} M_{ux} &= 0,5 \times \text{Mur} \\ &= 0,4 \times 93,884 \\ &= 46,942 \text{ kN/m} \end{aligned}$$

Direncanakan :

$$\text{Tulangan Pokok (D13)} \rightarrow A_s = \frac{1}{4} \cdot \pi \cdot 13^2 = 132,665 \text{ mm}^2$$

$$\text{Tulangan susut (P8)} \rightarrow A_s = \frac{1}{4} \times \pi \cdot 8^2 = 50,24 \text{ mm}^2$$

$$f'_c = 30 \text{ Mpa} ; b = 1000 \text{ mm} ; h = 150 \text{ mm}$$

$$f_y \text{ Tulangan Pokok} = 420 \text{ Mpa}$$

$$f_y \text{ Tulangan Susut} = 240 \text{ Mpa}$$

$$\text{Selimut Beton} = 20 \text{ mm}$$

$$d_s = 20 + 8 + \frac{13}{2} = 34,5 \text{ mm}$$

$$d = 150 - 34,5 = 115,5 \text{ mm}$$

## Perhitungan

$$k = \frac{Mu}{\phi b x d^2} = \frac{46,942 \times 10^6}{0,9 (1000) \times 115,5^2} = 4$$

$$\begin{aligned} \rho \text{ perlu} &= 0,85 \times \frac{f'c}{fy} \left( 1 - \sqrt{1 - \frac{2k}{(0,85)(f'c)}} \right) \\ &= 0,85 \times \frac{30}{420} \left( 1 - \sqrt{1 - \frac{2(3,909)}{(0,85)(30)}} \right) \\ &= 0,012 \end{aligned}$$

$$\rho \text{ min} = \frac{1,4}{Fy} = \frac{1,4}{420} = 0,003$$

$$\begin{aligned} \rho \text{ max} &= 0,75 \left( \frac{0,85 \times \beta \times f'c}{fy} \right) \left( \frac{600}{600 + fy} \right) \\ &= 0,75 \left( \frac{0,85 \times 0,85 \times 30}{420} \right) \left( \frac{600}{600 + 420} \right) \\ &= 0,023 \end{aligned}$$

$$\rho \text{ min} < \rho \text{ perlu} < \rho \text{ max} \text{ (ok)}$$

$$\begin{aligned} \text{As Perlu} &= \rho \text{ perlu} \times b \times d \\ &= 0,0101566 \times 1000 \times 115,5 = 1173,0872 \text{ mm}^2 \end{aligned}$$

$$n = \frac{\text{As perlu}}{\frac{1}{4}\pi 13^2} = \frac{1173,0872}{\frac{1}{4}\pi 13^2} = 8,84$$

## Cek Terhadap Geser

$$\begin{aligned} Vc &= \frac{1}{6} \sqrt{f'c} \times b \times d = \frac{1}{6} \sqrt{30} \times 1000 \times 115,5 \\ &= 105436,5923 \text{ N} = 105,436 \text{ kN} \end{aligned}$$

$$\phi Vc = 0,75 \times Vc = 0,75 \times 105,436$$

$$= 79,077 \text{ Kn} < Vu \text{ (tidak perlu tulangan geser)}$$

## 5. Penulangan Tangga Lapangan

$$\begin{aligned} M_{ux} &= 0,8 \times M_{ur} \\ &= 0,8 \times 93,884 \\ &= 75,1072 \text{ kNm} \end{aligned}$$

$$V_u = 97,51 \text{ kNm}$$

Direncanakan :

Tulangan D13, dengan  $f_y = 420$

$$b = 1000$$

$$\text{selimut} = 20$$

$$k = \frac{M_u}{\phi b \times d^2} = 2,736$$

$$\begin{aligned} \rho_{\text{perlu}} &= \frac{0,85 \times 25}{420} \left( 1 - \sqrt{1 - \frac{2(2,531)}{0,85 \times 25}} \right) \\ &= 5,3414 \times 10^{-3} \end{aligned}$$

$$\begin{aligned} \rho_{\text{min}} &= \frac{1/4}{f_y} \\ &= \frac{1/4}{420} = 0,333 \end{aligned}$$

$$\begin{aligned} \rho_{\text{max}} &= 0,75 \times \left( \frac{0,85 \times 30}{420} \right) \left( \frac{600}{600+420} \right) \\ &= 0,03 \end{aligned}$$

$$\begin{aligned} A_s \text{ perlu} &= \rho \text{ perlu} \times b \times d \\ &= 5,3414 \times 10^{-3} \times 1000 \times 123,5 \\ &= 659,6629 \text{ mm}^2 \end{aligned}$$

$$n = \frac{A_s}{\frac{1}{4}\pi 13^2}$$

$$= \frac{659,6629}{\frac{1}{4}\pi 13^2}$$

$$= 5,0203611 = 6$$

Cek terhadap geser

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

$$= \frac{1}{6} \sqrt{30} \times 1000 \times 115,5$$

$$= 105436,5923 \text{ N} = 105,436 \text{ kN}$$

$$\phi V_c = 0,75 \times V_c = 0,75 \times 105,436$$

$$= 79,077$$

#### 6. Rencana Penulangan Bordes Lapangan

$$M_{ux} = 0,5 (96,32)$$

$$= 48,16 \text{ kNm}$$

$$R_n \text{ Perlu} = \frac{48,16 \times 10^6}{0,9 \times 100 \times 150^2}$$

$$= 4,37 \text{ N/mm}$$

$$\rho \text{ min} = 0,003$$

$$\rho \text{ perlu} = \frac{0,85 \times 20,75}{420} \left( 1 - \sqrt{1 - \frac{2 \times 4,37}{0,85 \times 20,74}} \right)$$

$$= 0,0124$$

$$\rho \text{ max} = 0,019$$

$$A_s = 0,0124 \times 150 \times 295,5$$

$$= 549,63 \text{ mm}^2$$

$$\text{Digunakan tulangan} = \frac{549,63}{\pi \times 0,25 \times 13^2} = 4,14 \text{ (5 tulangan D13)}$$

## 7. Rencana Penulangan Bordes Tumpuan

$$\begin{aligned} M_{ux} &= 0,8 (96,32) \\ &= 77,056 \text{ kNm} \end{aligned}$$

$$\begin{aligned} R_n \text{ Perlu} &= \frac{77,056 \times 10^6}{0,9 \times 100 \times 295,5^2} \\ &= 9,8 \text{ N/mm} \end{aligned}$$

$$\rho \text{ min} = 0,003$$

$$\begin{aligned} \rho \text{ perlu} &= \frac{0,85 \times 30}{420} \left( 1 - \sqrt{1 - \frac{2 \times 9,8}{0,85 \times 30}} \right) \\ &= 0,032 \end{aligned}$$

$$\rho \text{ max} = 0,019$$

$$\begin{aligned} A_s &= 0,0224 \times 150 \times 295,5 \\ &= 992,88 \text{ mm}^2 \end{aligned}$$

Digunakan D13

$$\begin{aligned} n &= \frac{992,88}{\pi \times 0,25 \times 13^2} \\ &= 7,48 \text{ ( 8 Tulangan D13)} \end{aligned}$$

## 8. Rencana Sengkang Bordes

Sengkang tumpuan

$$d_s = 40 + 8 + \frac{13}{2} = 54,5 \text{ mm}$$

$$\begin{aligned} d &= h - d_s \\ &= 150 - 54,5 = 95,5 \text{ mm} \end{aligned}$$

$$V_c = 84,37 \text{ kN}$$

$$\phi V_c = 0,75 \times 84,37 = 63,2775 \text{ kN}$$

$$V_u = \frac{1}{2} \times q_u \times L = \frac{1}{2} \times 69,686 \times 4 = 77,277 \text{ kN}$$

$$V_s = \left( \frac{V_u}{\phi} \right) - V_c = \left( \frac{77,277}{0,75} \right) - 63,2775 = 18,66 \text{ kN}$$

$$\begin{aligned} V_{smax} &= 0,66 \times \sqrt{f'c} \times b \times d \\ &= 0,66 \times \sqrt{30} \times 250 \times 95,5 \\ &= 8307,381 \text{ (} V_s < V_{smax} \text{)} \end{aligned}$$

Digunakan Tulangan Senggang 2p8

$$\begin{aligned} s &= \frac{A_v \times f_y \times d}{V_s} \\ &= \frac{2(50,265)240 \times 95,5}{18,66} = 192,02 \text{ mm} \end{aligned}$$

$$\text{Spasi maksimum} = \frac{95,5}{2} = 157,75$$

Maka digunakan senggang tumpuan P8-100

Tulangan Senggang lapangan

$$\begin{aligned} ds &= 40 + 8 + \frac{13}{2} \\ &= 54,5 \text{ mm} \end{aligned}$$

$$d = 95,5 \text{ kN}$$

$$V_c = 84,37 \text{ kN}$$

$$\phi V_c = 63,2775 \text{ kN}$$

$$V_u = 77,277 \text{ kN}$$

$$V_s = \frac{77,277}{0,75} - 63,2775 = 18,66$$

$$\begin{aligned} V_{sMax} &= 0,66 \sqrt{f'c} \times b \times d \\ &= 0,66 \sqrt{30} \times 200 \times 95,5 \\ &= 69,046 \text{ kN} \end{aligned}$$

$$\begin{aligned} S &= \frac{A_v \times f_y \times d}{V_s} \\ &= \frac{50,265 \times 420 \times 95,5}{18,66 \times 10^{-3}} = 191,03 \text{ mm} \end{aligned}$$

$$\text{Spasi max} = 147,75$$

Maka digunakan Senggang lapangan P8- 125

- Tulangan susut direncanakan 2P10

$$A_v = \frac{1}{4} \times 3,14 \times 10^2 \times 2$$

$$= 157 \text{ mm}^2$$

$$S = \frac{A_v \times f_y \times d}{V_s} = \frac{157 \times 420 \times 95,5}{18,66} = 337,474 \text{ mm}$$

## 9. Perencanaan Pondasi Tangga

diketahui :

$$\gamma_{\text{tanah}} = 18 \text{ kN/m}^2$$

$$\sigma_{\text{tanah}} = 225 \text{ kN/m}^2$$

$$\gamma_{\text{beton}} = 24 \text{ kN/m}^3$$

beban tangga pada pondasi :

$$\text{beban mati (DL)} = 67,06 \text{ kN/m}$$

$$\text{beban hidup (LL)} = 69,65 \text{ kN/m}$$

$$\text{beban dinding} = 0,864 \text{ kN/m}$$

$$\text{beban qtg} = 34,21 \text{ kN/m}$$

direncanakan :

$$B = 1 = 1000 \text{ mm}$$

$$e = 1/6 \times B = 1/6 \times 1 = 0,167 \text{ m}$$

tegangan tanah netto

$$\text{netto (beton)} = \sigma_{\text{tanah}} - (d-h \text{ pondasi}) (\gamma_{\text{tanah}}) - h \text{ pondasi} (\gamma_{\text{beton}})$$

$$= 225 - (1,8 - 0,15) (18) - 0,15 (24)$$

$$= 191,7 \text{ kN/m}^2$$

cek tegangan pada tanah

$$\text{max} = Q_{tg}/b + 6. Q_{tg}(e)/B^2$$

$$= \frac{36,33}{1} + 6 \frac{36,33(0,167)}{1^2} = 191,7 \text{ kN/m}^2$$

$$\text{Min} = Q_{tg}/b - 6 \cdot Q_{tg}(e)/B^2$$

$$= \frac{36,33}{1} - 6 \cdot \frac{36,33(0,167)}{1^2}$$

Untuk merencanakan penulangan plat pondasi tangga, dihitung tegangan terfaktor sebagai berikut :

$$\text{beban mati (DL) tangga} \times 1,2 = 20,832 \text{ kN/m}$$

$$\text{beban hidup (LL) tangga} \times 1,6 = 16,528 \text{ kN/m}$$

$$\text{beban dinding} \times 1,2 = 10,368 \text{ kN/m}$$

cek tegangan pada tanah :

$$\begin{aligned} \text{max} &= \frac{47,728}{1} + 6 \cdot \frac{47,728(0,167)}{1^2} \leq 191,7 \text{ kN/kN/m}^2 \\ &= 95,551 \leq 191,7 \end{aligned}$$

Momen dan geser pada pelat pondasi :

$$\begin{aligned} \text{Mu} &= \frac{1}{2} \left( \frac{u_{\text{max}} + u_{\text{min}}}{2} \right) \left( \frac{B}{2} + e - \frac{1}{2} b + g \right)^2 \\ &= 7,68 \text{ KNm} \end{aligned}$$

$$\begin{aligned} \text{Vu} &= \left( \frac{u_{\text{Max}} + u_{\text{Min}}}{2} \right) \left( \frac{B}{2} + e - \frac{1}{2} b + g \right) \\ &= 27,089 \text{ kN} \end{aligned}$$

$$\text{Direncanakan D13 tulangan pokok, } f_y = 420 \text{ Mpa}$$

$$\text{P8 untuk tulangan sudut, } F_y = 240 \text{ Mpa}$$

$$\text{Selimut pondasi} = 20 \text{ mm}$$

$$h = 150$$

$$d = 123,5$$

## 10. Menentukan Tulangan Susut

$$\begin{aligned} \text{As min} &= 3,590 \times 10^3 \times 1000 \times 123,5 \\ &= 443,365 \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} \text{As tulangan} &= \frac{1}{4} \times 3,4 \times 8^2 \\ &= 50,625 \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} \text{Jarak antar tulangan} &= \frac{50,625}{443,365} \times 1000 \\ &= 113,373 \text{ mm} \end{aligned}$$

Maka digunakan p8-100

## 2.4 Perencanaan Penulangan Pelat Lantai

### 1. Rencana pembebanan pelat

Rencana beban mati pada tiap lantai

Beban sendiri	= 3,6 kN/m <sup>2</sup>
Beban pasir	= 0,9 kN/m <sup>2</sup>
Beban ubin	= 0,24 kN/m <sup>2</sup>
Beban spesi	= 0,21 kN/m <sup>2</sup>
Beban Plafond	= 0,2 kN/m <sup>2</sup>
<b>Total Beban Mati</b>	<b>= 5,15 kN/m<sup>2</sup></b>

Rencana Beban Hidup Tiap Lantai

$$\begin{aligned} \text{Total Beban Hidup} &= 2,5 \text{ kN/m}^2 \\ \text{Wu} &= 1,2 D + 1,6 L \\ &= 1,2 (5,15) + 1,6 (2,5) \\ &= 10,18 \text{ kN/m}^2 \end{aligned}$$

### 2. Rencana penulangan pelat

$$\begin{aligned} \text{Pelat Lantai A} &= \frac{Ly}{Lx} = \frac{5500}{4000} \\ &= 1,375 \text{ (Pelat 2 arah)} \end{aligned}$$

Berdasarkan table momen pada pelat persegi, digunakan tipe II, oleh karena itu pada nilai 1,375 diperoleh nilai koefisien untuk arah X = 50 dan untuk arah Y = 38

$$\begin{aligned} M_{lx} &= 0,001 \times 10,18 \times 5,5^2 \times 50 \\ &= 15,40 \text{ kNm} \end{aligned}$$

$$\begin{aligned} M_{ly} &= 0,001 \times 10,16 \times 4^2 \times 5,5 \\ &= 6,20 \text{ kNm} \end{aligned}$$

Tebal pelat 150 mm, diameter tulangan utama 8 mm, dan selimut beton 40mm ( $A_s = 50,29 \text{ mm}^2$ )

$$b = 1000 \text{ mm}$$

$$F'_c = 30 \text{ MPa}$$

$$dx = \text{tinggi efektif arah sumbu x}$$

$$= 150 - p - \frac{1}{2} \times \phi_x$$

$$= 150 - 40 - \frac{1}{2} \times 8$$

$$= 106 \text{ mm}$$

$$dy = \text{Tinggi efektif arah sumbu y}$$

$$= 150 - p - \phi_x - \frac{1}{2} \phi_y$$

$$= 150 - 40 - 8 - \frac{1}{2} \times 8$$

$$= 98 \text{ mm}$$

Penulangan arah X

$$R_n \text{ Perlu} = \frac{5,5 \times 10^6}{0,8 \times 1000 \times 106^2}$$

$$= 1,71$$

$$\rho \text{ mm} = 0,002$$

$$\rho \text{ perlu} = \frac{0,85 \times 25}{250} \times \left( 1 - \sqrt{\frac{1-2 \times 1,71}{0,85 \times 25}} \right)$$

$$= 0,0021$$

$$\rho \text{ max} = 0,75 \times \frac{0,85 \times 25}{250} \times 0,85 \left( \frac{600}{600+250} \right)$$

$$= 0,038$$

$\rho \text{ perlu} < \rho \text{ min} < \rho \text{ max}$  maka digunakan  $P \text{ mm} = 0,002$

$$\text{As Perlu} = 0,002 \times 1000 \times 106$$

$$= 212 \text{ mm}$$

$$\text{Jarak Tulangan} = \left( \frac{50,29}{212} \right) \times 1000$$

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

(digunakan tulangan P8 – 200 mm)

Penulangan arah Y

$$R_n \text{ Perlu} = \frac{1,75 \times 10^6}{0,8 \times 1000 \times 98^2}$$

$$= 78,92$$

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

$$\rho \text{ perlu} = \frac{0,85 \times 25}{250} \times \left( 1 - \sqrt{\frac{1-2 \times 0,228}{0,85 \times 25}} \right)$$

$$= 0,001$$

$$\rho_{\text{max}} = 0,038$$

$\rho \text{ perlu} < \rho \text{ min} < \rho \text{ max}$  maka digunakan  $\rho \text{ min} = 0,002$

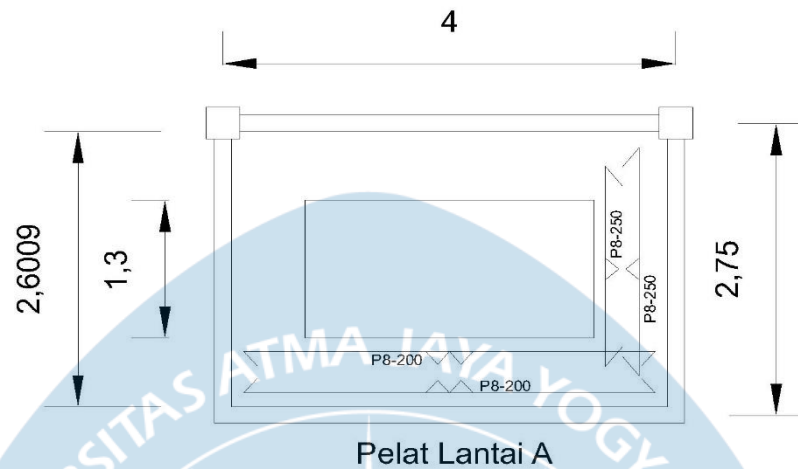
$$\text{As Perlu} = 0,002 \times 1000 \times 98$$

$$= 196 \text{ mm}^2$$

$$\text{Jarak Tulangan} = \left( \frac{50,29}{196} \right) \times 1000$$

$$= 256,58 \text{ mm} \rightarrow \text{digunakan tulangan}$$

$$\text{P8} - 250 \text{ mm}$$



Gambar 2. 15 Detail Plat A

Pelat Lantai B

$$= \frac{L_y}{L_x} = \frac{4000}{3,075}$$

$$= 1,3 = \text{Pelat 2 arah}$$

Berdasarkan Tablem momen pada pelat persegi, digunakan pelat tipe II, sehingga pada nilai 1,3 diperoleh nilai koef untuk arah X = 50 dan arah Y = 38

$$M_{lx} = 0,001 \times 10,18 \times 3,075^2 \times 50 = 1,56 \text{ kNm}$$

$$M_{ly} = 0,001 \times 10,16 \times 4^2 \times 38 = 1,55 \text{ kNm}$$

$$d_x = 106 \text{ mm}$$

$$d_y = 98 \text{ mm}$$

Penulangan arah X

$$R_n \text{ Perlu} = \frac{1,56 \times 10^6}{0,8 \times 1000 \times 106^2} = 18,86$$

$$\rho \text{ min} = 0,002$$

$$\begin{aligned}\rho \text{ perlu} &= \frac{0,85 \times 25}{250} \times \left( 1 - \sqrt{\frac{1-2 \times 0,344}{0,85 \times 25}} \right) \\ &= 0,001\end{aligned}$$

$$\begin{aligned}\rho \text{ max} &= 0,75 \times \frac{0,85 \times 25}{250} \times 0,85 \left( \frac{600}{600+250} \right) \\ &= 0,038\end{aligned}$$

$\rho \text{ perlu} < \rho \text{ min} < \rho \text{ max}$  maka digunakan  $\rho \text{ mm} = 0,002$

$$\begin{aligned}\text{As Perlu} &= 0,002 \times 1000 \times 106 \\ &= 212 \text{ mm}\end{aligned}$$

$$\begin{aligned}\text{Jarak Tulangan} &= \left( \frac{50,29}{212} \right) \times 1000 \\ &= 237,2 \text{ mm} \\ &\text{(digunakan tulangan P8 – 200 mm)}\end{aligned}$$

Penulangan arah Y

$$\begin{aligned}R_n \text{ Perlu} &= \frac{1,3 \times 10^6}{0,8 \times 1000 \times 98^2} \\ &= 0,2\end{aligned}$$

$$\rho \text{ min} = 0,002$$

$$\begin{aligned}\rho \text{ perlu} &= \frac{0,85 \times 25}{250} \times \left( 1 - \sqrt{\frac{1-2 \times 0,228}{0,85 \times 25}} \right) \\ &= 0,001\end{aligned}$$

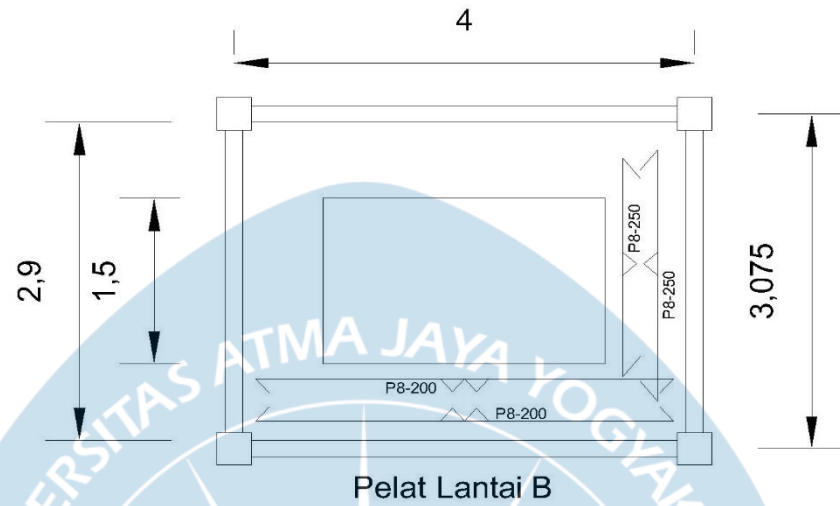
$$\rho \text{ max} = 0,038$$

$\rho \text{ perlu} < \rho \text{ min} < \rho \text{ max}$  maka digunakan  $\rho \text{ min} = 0,002$

$$\begin{aligned}\text{As Perlu} &= 0,002 \times 1000 \times 98 \\ &= 196 \text{ mm}^2\end{aligned}$$

$$\begin{aligned}\text{Jarak Tulangan} &= \left( \frac{50,29}{196} \right) \times 1000 \\ &= 256,58 \text{ mm}\end{aligned}$$

(digunakan tulangan P8 – 250 mm)



Gambar 2. 16 Detail Plat B

Pelat Lantai C

$$= \frac{L_y}{L_x} = \frac{4000}{3,075}$$

$$= 1 = \text{Pelat 2 arah}$$

$$M_{lx} = 0,001 \times 10,18 \times 5,5^2 \times 36 = 2,016 \text{ kN/m}$$

$$M_{ly} = 0,001 \times 10,16 \times 5,5^2 \times 36 = 2,016 \text{ kN/m}$$

$$d_x = 106 \text{ mm}$$

$$d_y = 98 \text{ mm}$$

Penulangan arah X

$$R_n \text{ Perlu} = \frac{2,016 \times 10^6}{0,8 \times 1000 \times 106^2}$$

$$= 0,225$$

$$\rho \text{ min} = 0,002$$

$$\rho \text{ perlu} = \frac{0,85 \times 25}{250} \times \left( 1 - \sqrt{\frac{1-2 \times 0,344}{0,85 \times 25}} \right)$$

$$= 0,001$$

$$\rho \text{ max} = 0,75 \times \frac{0,85 \times 25}{250} \times 0,85 \left( \frac{600}{600+250} \right)$$

$$= 0,038$$

$\rho \text{ perlu} < \rho \text{ min} < \rho \text{ max}$  maka digunakan  $P \text{ mm} = 0,002$

$$\text{As Perlu} = 0,002 \times 1000 \times 106$$

$$= 212 \text{ mm}$$

$$\text{Jarak Tulangan} = \left( \frac{50,29}{212} \right) \times 1000$$

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

(digunakan tulangan P8 – 200 mm)

Penulangan arah Y

$$R_n \text{ Perlu} = \frac{2,016 \times 10^6}{0,8 \times 1000 \times 98^2}$$

$$= 0,26$$

$$\rho \text{ min} = 0,002$$

$$\rho \text{ perlu} = \frac{0,85 \times 25}{250} \times \left( 1 - \sqrt{\frac{1-2 \times 0,228}{0,85 \times 25}} \right)$$

$$= 0,001$$

$$\rho \text{ max} = 0,038$$

$\rho \text{ perlu} < \rho \text{ min} < \rho \text{ max}$  maka digunakan  $P \text{ min} = 0,002$

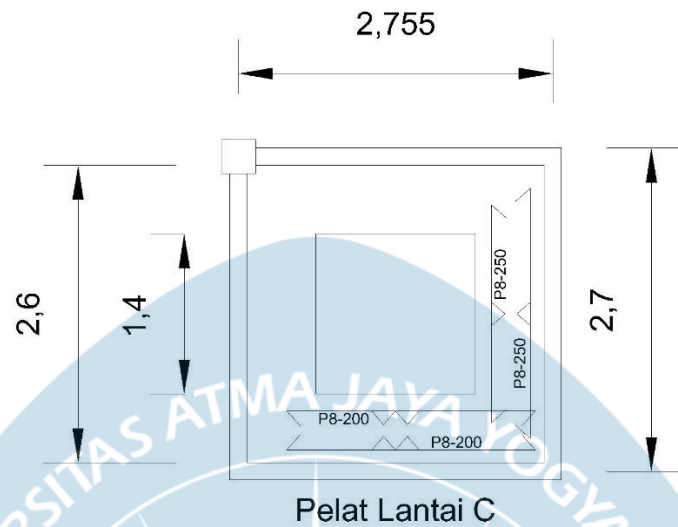
$$\text{As Perlu} = 0,002 \times 1000 \times 98$$

$$= 196 \text{ mm}^2$$

$$\text{Jarak Tulangan} = \left( \frac{50,29}{196} \right) \times 1000$$

$$= 256,58 \text{ mm}$$

(digunakan tulangan P8 – 250 mm)



Pelat Lantai C

Gambar 2. 17 Detail Plat C

## 2.5 Perencanaan beban gempa

### 1. Perencanaan beban tiap lantai

Panjang bangunan	= 71,8 m
Lebar bangunan	= 8,57 m
Tinggi kolom lantai	= 4 m
Panjang total balok	
Lantai 1	= 431,25 m
Lantai 2	= 431,25 m
Lantai 3	= 431,25 m
Jumlah kolom	= 57 buah
Dimensi balok 1	= 0,3 x 0,2 m
Dimensi balok 2	= 0,3 x 0,15 m
Tebal pelat	= 0.15 m
Berat volume beton	= 20,75 kN/m
Berat dinding	= 0,06 kN/m
Berat plafond	= 0,2 kN/m <sup>2</sup>
Berat spesi	= 0,21 kN/m <sup>2</sup>
Berat ubin	= 0,24 kN/m <sup>2</sup>

## 2. Perhitungan berat lantai 1

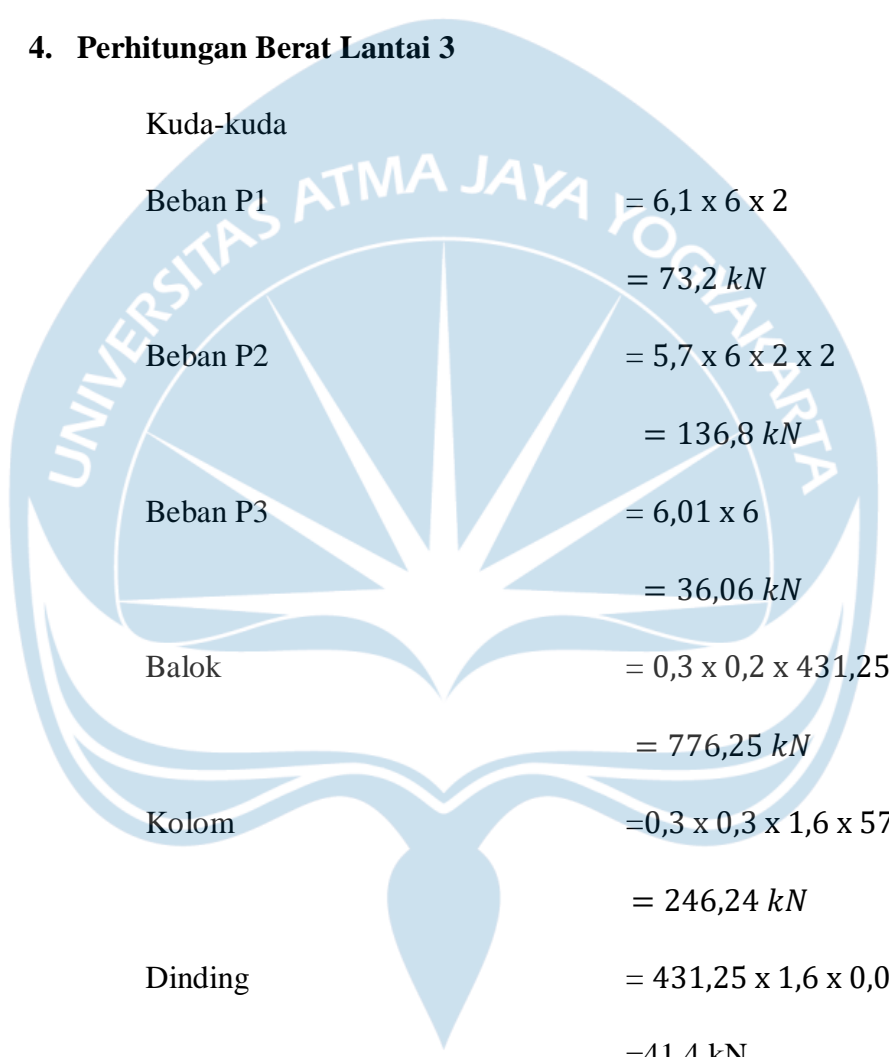
Pelat	$= 71,8 \times 8,57 \times 0,15 \times 30$ $= 18459,78 \text{ kN}$
Balok	$= 0,3 \times 0,2 \times 431,25 \times 30$ $= 776,25 \text{ kN}$
Kolom	$= 0,3 \times 0,3 \times 7,6 \times 57 \times 30$ $= 1169,64 \text{ kN}$
Dinding	$= 431,25 \times 7,6 \times 0,06$ $= 196,65 \text{ kN}$
Plafond	$= 71,8 \times 8,57 \times 0,2$ $= 123,06 \text{ kN}$
Spesi	$= 71,8 \times 8,57 \times 0,21$ $= 129,22 \text{ kN}$
Ubin	$= 8,57 \times 71,8 \times 0,24$ $= 147,68 \text{ kN}$
Total berat lantai 1	$= 21002,28 \text{ kN}$

## 3. Perhitungan Berat Lantai 2

Pelat	$= 71,8 \times 8,57 \times 0,15 \times 30$ $= 2768,97 \text{ kN}$
Balok	$= 0,3 \times 0,2 \times 431,25 \times 30$ $= 776,25 \text{ kN}$
Kolom	$= 0,3 \times 0,3 \times 3,6 \times 57 \times 30$ $= 554,04 \text{ kN}$
Dinding	$= 431,25 \times 3,6 \times 0,06$ $= 93,15 \text{ kN}$
Plafond	$= 71,8 \times 8,57 \times 0,2$ $= 123,065 \text{ kN}$
Spesi	$= 71,8 \times 8,57 \times 0,21$

$$\begin{aligned}
 &= 129,22 \text{ kN} \\
 \text{Ubin} &= 8,57 \times 71,8 \times 0,24 \\
 &= 147,68 \text{ kN} \\
 \text{Total berat lantai 2} &= 4592,375 \text{ kN}
 \end{aligned}$$

#### 4. Perhitungan Berat Lantai 3



$$\begin{aligned}
 \text{Kuda-kuda} & \\
 \text{Beban P1} &= 6,1 \times 6 \times 2 \\
 &= 73,2 \text{ kN} \\
 \text{Beban P2} &= 5,7 \times 6 \times 2 \times 2 \\
 &= 136,8 \text{ kN} \\
 \text{Beban P3} &= 6,01 \times 6 \\
 &= 36,06 \text{ kN} \\
 \text{Balok} &= 0,3 \times 0,2 \times 431,25 \times 30 \\
 &= 776,25 \text{ kN} \\
 \text{Kolom} &= 0,3 \times 0,3 \times 1,6 \times 57 \times 30 \\
 &= 246,24 \text{ kN} \\
 \text{Dinding} &= 431,25 \times 1,6 \times 0,06 \\
 &= 41,4 \text{ kN} \\
 \text{Plafond} &= 71,8 \times 8,57 \times 0,2 \\
 &= 123,0652 \text{ kN} \\
 \text{Total berat lantai 3} &= 1433,02 \text{ kN}
 \end{aligned}$$

Bangunan Terletak di Sleman Kategori Resiko IV dengan:

$$S_s : 0,995 \qquad \text{Periode} : 0,2 \text{ detik}$$

$$S_i : 0,4634 \qquad \text{Periode} : 1 \text{ detik}$$

Situs Kelas:

$$F_a : 1,02$$

$$F_v : 1,56$$

$$\begin{aligned} S_{ms} &= F_a \times F_v \\ &= 1,02 \times 0,995 \\ &= 1,015 \text{ g} \end{aligned}$$

$$\begin{aligned} S_{mi} &= F_v \times S_i \\ &= 1,56 \times 0,4634 \\ &= 0,7229 \text{ g} \end{aligned}$$

$$\begin{aligned} S_{DS} &= \frac{2}{3} \times S_{ms} \\ &= \frac{2}{3} \times 1,015 \\ &= 0,676668 \text{ g} \end{aligned}$$

$$\begin{aligned} S_{DI} &= \frac{2}{3} \times S_{mi} \\ &= \frac{2}{3} \times 0,722904 \text{ g} \\ &= 0,481936 \text{ g} \end{aligned}$$

Kategori resiko IV

Dengan jenis pemanfaatan sebagai gedung asrama laki-laki pusat rehabilitasi narkoba Kategori desain seismic Kds terpakai D

Faktor keutamaan gempa

Kategori resiko IV maka  $I_3 = 1,5$

Sistem rangka beton bertulang

$$R = 8$$

$$C_d = 5,5$$

$$\Omega_0 = 3$$

Periode fundamental

$$T_a = C_t \times H^x$$

$$= 0,0466 \times 11,2^{0,9}$$

$$= 0,41 \text{ detik}$$

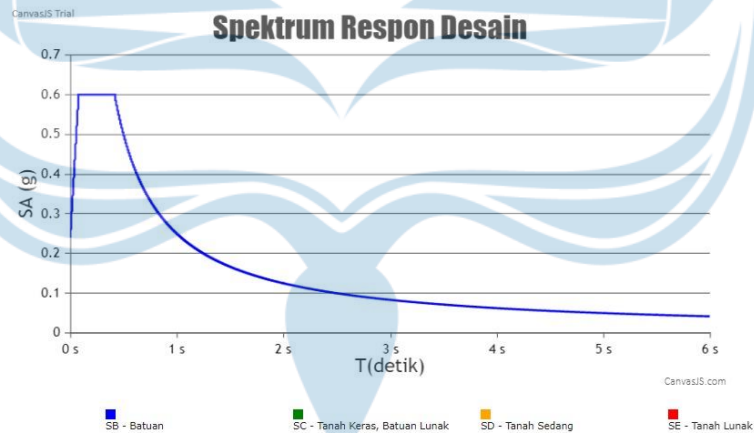
Faktor resiko gempa

$$\begin{aligned} C_s &= \frac{S_{DS}}{R/I_3} \\ &= \frac{0,68}{8/1,5} \\ &= 0,12 \end{aligned}$$

$$\begin{aligned} C_s &= \frac{S_{DI}}{R/I_3} \\ &= \frac{0,482}{8/1,5} \\ &= 0,09 \end{aligned}$$

Sehingga  $C_s$  yang digunakan adalah 0,09

$$\begin{aligned} C_{s \text{ min}} &= 0,044 \times S_{DI} \times I_3 \\ &= 0,044 \times 0,48 \times 1,5 \\ &= 0,03 \text{ dengan } I_3 \geq 0,01 \end{aligned}$$



Gambar 2. 18 Grafik Spektrum Daerah Sleman

Berat efektif bangunan

$$\begin{aligned} W_{\text{total}} &= \text{Lantai 1} + \text{Lantai 2} + \text{Lantai 3} \\ &= 3588,05 + 3200,69 + 1060,97 \\ &= 7849,7241 \text{ kN} \end{aligned}$$

Gaya geser gempa

$$\begin{aligned} V &= C_s \times W \\ &= 0,09 \times 7849,7241 \\ &= 706,47 \text{ kN} \end{aligned}$$

Distribusi beban lateral

$$\begin{aligned} K &= 0,5 (Ta) + 0,75 \\ &= 0,5 (0,48) + 0,75 \\ &= 1,0 \end{aligned}$$

Tabel 2. 1 Total Beban Gempa

Lantai	W1 (kN)	H1 (m)	W1 x h1 <sup>k</sup> (kNm)
1	3,588.054	4	14,352.217
2	3,200.694	8	25,605.555
3	1,060.975	11,2	11,882.925
Σ	7,849.724	-	51,840.697

## 2.5 Perencanaan Penulangan Balok

### 1. Perencanaan Balok B1

Diketahui:

$$\begin{aligned} f_c &= 30 \text{ Mpa} \\ f_y &= 420 \text{ Mpa} \\ b &= 200 \text{ mm} \\ h &= 300 \text{ mm} \\ d \text{ tulangan} &= 19 \text{ mm} \\ A_s \text{ tulangan} &= 380,133 \text{ mm}^2 \\ d \text{ sengkang} &= 8 \text{ mm} \\ \text{selimut beton} &= 40 \text{ mm} \\ d' &= 294 \text{ mm} \\ Mut &= 92,49 \text{ kNm} \\ Mul &= 11,3045 \text{ kNm} \\ Vu &= 75,6511 \text{ kNm} \end{aligned}$$

## Perencanaan Tulangan Tumpuan

$$\begin{aligned}
 R_n &= \frac{M_u}{\phi \cdot b \times d^2} = 5,35 \\
 \rho_{\min} &= \frac{1,4}{f_y} = \frac{1,4}{420} = 0,003 \\
 \rho_{\text{perlu}} &= \frac{0,85 \times f'_c}{f_y} \left( 1 - \sqrt{1 - \frac{2R_n}{0,85 \times f'_c}} \right) \\
 &= \frac{0,85 \times 30}{420} \left( 1 - \sqrt{1 - \frac{2,7,421}{0,85 \times 30}} \right) \\
 &= 0,021462 \\
 \rho_{\max} &= 0,75 \cdot \frac{0,85 \times f'_c \times \beta_1}{f_y} \\
 &= 0,75 \cdot \frac{0,85 \times 30 \times 0,85}{420} = 0,0387 \\
 \rho_{\min} < \rho_{\text{perlu}} < \rho_{\max} &< \rho_{\max} \text{ digunakan } \rho_{\text{perlu}} = 0,0387 \\
 A_{\text{perlu}} &= b \times d \times \rho_{\text{perlu}} \\
 &= 200 \cdot 294 \cdot 0,0387 \\
 &= 563,3 \text{ mm}^2 \\
 N_{\text{tulangan}} &= \frac{A_{\text{perlu}}}{A_{\text{stulangan}}} = \frac{563,3}{380,133} = 3 \\
 &\text{(Digunakan 3D-22 mm)} \\
 X &= 47 > 25 \text{ (OK)} \\
 A_{\text{s aktual}} &= A_{\text{stulangan pokok}} \times 3 \\
 &= 380,133 \times 3 \\
 &= 1140,399 \text{ mm}^2 \\
 D_s &= 56 \text{ mm} \\
 a &= \frac{A_{\text{s aktual}} \times f_y}{0,85 \times f'_c \times b} = \frac{1140,399 \times 420}{0,85 \times 30 \times 200} \\
 &= 93,915 \text{ mm} \\
 z &= d - \frac{a}{2} = 294 - \frac{93,915}{2} \\
 &= 252,1409 \text{ mm} \\
 T_s &= A_{\text{s aktual}} \cdot f_y \\
 &= 1140,399 \cdot 420
 \end{aligned}$$

$$\begin{aligned}
 &= 478967,58 \text{ N} \\
 \phi Mn &= 0,9 \cdot z \cdot Ts \\
 &= 0,9 \cdot 478967,58 \cdot 252,1409 \\
 &= 108,69 \text{ kNm}
 \end{aligned}$$

#### Perencanaan Penulangan Lapangan

$$M_{ui} = 11,3045 \text{ kNm}$$

$$\begin{aligned}
 R_n &= \frac{11,3045 \times 10^6}{8.200 \times 294^2} \\
 &= 0,0817
 \end{aligned}$$

$$\rho_{\min} = 0,003$$

$$\begin{aligned}
 \rho_{\text{perlu}} &= \frac{0,85 \times 25}{420} \left( 1 - \sqrt{\frac{2 \times 4,66}{0,85 \times 25}} \right) \\
 &= 0,0025
 \end{aligned}$$

$$\rho_{\max} = 0,02105$$

$$\rho_{\min} < \rho_{\text{perlu}} < \rho_{\max} \text{ digunakan } \rho_{\text{perlu}} = 0,0025$$

$$\begin{aligned}
 A_{\text{sperlu}} &= 0,0025 \times 200 \times 294 \\
 &= 147 \text{ mm}^2
 \end{aligned}$$

$$\text{Jumlah tulangan} = \frac{147}{180,133} = 0,82 = 2 \text{ buah}$$

$$= \text{digunakan } 2D-22\text{mm}$$

$$A_s \text{ aktual} = 760,266 \text{ mm}^2$$

$$a = \frac{760,266 \times 420}{0,85 \times 30 \times 200} = 62,61 \text{ mm}$$

$$z = 294 - \frac{62,61}{2} = 262,7 \text{ mm}$$

$$T_s = 760,266 \times 420$$

$$= 319311,72 \text{ N}$$

### Perencanaan Tulangan Geser

$$V_c = 66,96168 \text{ kN}$$

$$V_u = 75,6511 \text{ kN}$$

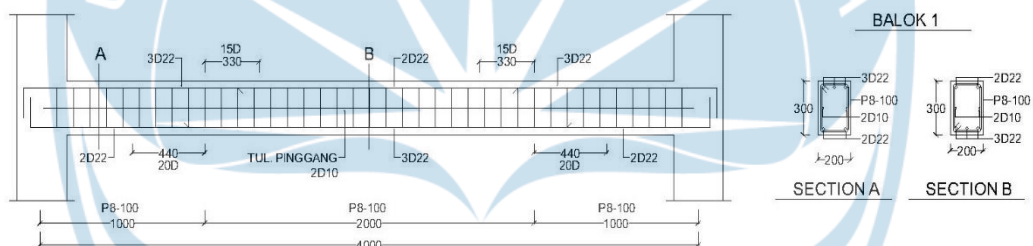
$$V_s = \frac{V_u}{\phi} - V_c = \frac{75,6511}{0,75} - 66,97$$

$$= 33,906 \text{ kN}$$

$$V_s \text{ Max} = 133,92 \text{ kN}$$

$$A_v = 157,08$$

$$S \text{ max} = 147 \text{ mm}$$



Gambar 2. 19 Detail Balok 1

## 2. Perencanaan Balok B2

Diketahui:

$$f'_c = 30 \text{ MPa}$$

$$f_y = 420 \text{ MPa}$$

$$f_{ys} = 200 \text{ MPa}$$

$$b = 250 \text{ mm}$$

$$h = 500 \text{ mm}$$

$$d \text{ tulangan} = 22 \text{ mm}$$

$$A_s \text{ tulangan} = 380,133 \text{ mm}^2$$

$$d \text{ sengkang} = 8 \text{ mm}$$

selimut beton	= 40 mm
d'	= 519 mm
Mut	= 417,476 kNm
Mul	= 303,412 kNm
Vu	= 277,5 kNm

#### Perencanaan Tulangan Tumpuan

$$R_n = \frac{M_u}{\phi \cdot b \cdot d^2} = 7,421$$

$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{420} = 0,003$$

$$\rho_{\text{perlu}} = \frac{0,85 \times f'c}{f_y} \left( 1 - \sqrt{1 - \frac{2R_n}{0,85 \times f'c}} \right)$$

$$= \frac{0,85 \times 30}{420} \left( 1 - \sqrt{1 - \frac{2 \times 7,421}{0,85 \times 30}} \right)$$

$$= 0,021$$

$$\rho_{\max} = 0,75 \cdot \frac{0,85 \times f'c \times \beta_1}{f_y}$$

$$= 0,75 \times \frac{0,85 \times 30 \times 0,85}{420} = 0,0387$$

$\rho_{\min} < \rho_{\text{perlu}} < \rho_{\max}$  digunakan  $\rho_{\text{perlu}} = 0,0252$

$$A_{\text{perlu}} = b \times d \times \rho_{\text{perlu}}$$

$$= 250 \times 519 \times 0,0252$$

$$= 3269,7 \text{ mm}^2$$

$$N \text{ tulangan} = \frac{A_{\text{perlu}}}{A_{\text{tulangan}}} = \frac{3269,7}{380,133} = 8,6$$

(Digunakan 10D-22 mm)

$$X = 47 > 25 \text{ (OK)}$$

$$A_s \text{ aktual} = A_s \text{ tulangan pokok} \times 8$$

$$= 380,133 \times 8$$

$$= 3041,064 \text{ mm}^2$$

$$D_s = 81 \text{ mm}$$

$$a = \frac{A_s \text{ aktual} \times f_y}{0,85 \times f'c \times b} = \frac{3041,064 \times 420}{0,85 \times 30 \times 250}$$

$$= 200,3524 \text{ mm}$$

$$z = d - \frac{a}{2} = 519 - \frac{200,3524}{2}$$

$$= 418,8238 \text{ mm}$$

$$T_s = A_s \text{ aktual} \times f_y = 3041,064 \times 420$$

$$= 1277246,88 \text{ N}$$

$$\phi M_n = 0,9 \times z \times T_s$$

$$= 0,9 \times 1277246,88 \times 374,166$$

$$= 430,1131 \text{ kNm}$$

#### Perencanaan Penulangan Lapangan

$$M_{ui} = 303,412 \text{ kNm}$$

$$R_n = \frac{303,412 \times 10^6}{0,9 \times 250 \times 519^2}$$

$$= 5,006$$

$$\rho_{\min} = 0,003$$

$$\rho_{\text{perlu}} = 0,0143$$

$$\rho_{\max} = 0,0157$$

$$\rho_{\min} < \rho_{\text{perlu}} < \rho_{\max} \text{ digunakan } \rho_{\text{perlu}} = 0,0143$$

$$A_{s\text{perlu}} = 0,01438 \times 250 \times 519$$

$$= 1865,805 \text{ mm}^2$$

$$\text{Jumlah tulangan} = \frac{1865,805}{380,133} = 4,9 = 5 \text{ buah}$$

$$= \text{digunakan } 5D-22\text{mm}$$

$$A_s \text{ aktual} = 2280,798 \text{ mm}^2$$

$$a = \frac{2280,798 \times 420}{0,85 \times 30 \times 250} = 150,264 \text{ mm}$$

$$z = 519 - \frac{150,264}{2} = 443,87 \text{ mm}$$

$$T_s = 2280,798 \times 420 = 957935,16 \text{ N}$$

$$\phi M_n = 0,9 \times z \times T_s$$

$$= 0,9 \times 443,87 \times 957935,16$$

$$= 382,6789 \text{ kNm}$$

### Perencanaan Tulangan Geser

$$V_c = 98,506 \text{ kN}$$

$$V_u = 277,5 \text{ kN}$$

$$V_s = \frac{V_u}{\phi} - V_c = \frac{277,5}{0,75} - 98,506$$

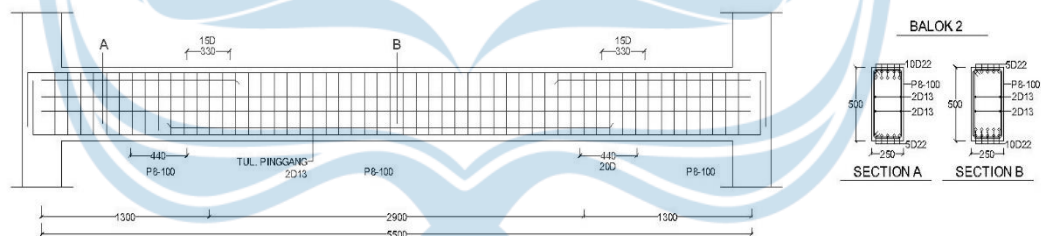
$$= 271,494 \text{ kN}$$

$$V_s \text{ Max} = 197,01 \text{ kN}$$

$$A_v = 157,08$$

$$S = 84,078 \text{ mm}$$

$$S \text{ max} = 262,5 \text{ mm}$$



Gambar 2. 20 Detail Balok 2

### 3. Perencanaan Balok B3

Diketahui :

$$f_c = 30 \text{ MPa}$$

$$f_y = 420 \text{ MPa}$$

$$f_{ys} = 280 \text{ MPa}$$

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

$$h = 300 \text{ mm}$$

$$d \text{ tulangan} = 16 \text{ mm}$$

$$\begin{aligned}
 \text{As tulangan} &= 201,062 \text{ mm}^2 \\
 d \text{ sengkang} &= 10 \text{ mm} \\
 \text{selimut beton} &= 40 \text{ mm} \\
 d' &= 297 \text{ mm} \\
 \text{Mut} &= 24,108 \text{ kNm} \\
 \text{Mul} &= 4,655 \text{ kNm} \\
 \text{Vu} &= 21,3355 \text{ kNm}
 \end{aligned}$$

#### Perencanaan Tulangan Tumpuan

$$\begin{aligned}
 R_n &= \frac{M_u}{\phi \cdot b \cdot d^2} = 2,02 \\
 \rho_{\min} &= \frac{1,4}{f_y} = \frac{1,4}{420} = 0,003 \\
 \rho_{\text{perlu}} &= \frac{0,85 \times f'c}{f_y} \left( 1 - \sqrt{1 - \frac{2R_n}{0,85 \times f'c}} \right) \\
 &= \frac{0,85 \times 30}{420} \left( 1 - \sqrt{1 - \frac{2 \times 2,02}{0,85 \times 30}} \right) \\
 &= 0,005016
 \end{aligned}$$

$$\rho_{\max} = 0,01574$$

$\rho_{\min} < \rho_{\text{perlu}} < \rho_{\max}$  digunakan  $\rho_{\text{perlu}} = 0,00513$

$$\begin{aligned}
 A_{\text{perlu}} &= b \times d \times \rho_{\text{perlu}} \\
 &= 150 \times 297 \times 0,00513 \\
 &= 228,5415 \text{ mm}^2
 \end{aligned}$$

$$\begin{aligned}
 N \text{ tulangan} &= \frac{A_{\text{perlu}}}{A_{\text{tulangan}}} = \frac{3228,5415}{201,062} \\
 &= 1,1366 = 2 \text{ buah}
 \end{aligned}$$

(Digunakan 2D-22 mm)

$$X = 47 > 25 \text{ (OK)}$$

$$\begin{aligned}
 \text{As aktual} &= A_{\text{tulangan}} \text{ pokok} \times 2 \\
 &= 201,062 \times 2 \\
 &= 402,124 \text{ mm}^2
 \end{aligned}$$

$$D_s = 53 \text{ mm}$$

$$a = \frac{A_{\text{aktual}} \times f_y}{0,85 \times f'c \times b} = \frac{402,124 \times 420}{0,85 \times 30 \times 150}$$

$$\begin{aligned}
 &= 44,1547 \text{ mm} \\
 z &= d - \frac{a}{2} = 300 - \frac{44,1547}{2} \\
 &= 277,922 \text{ mm} \\
 T_s &= A_{\text{saktual}} \times f_y \\
 &= 402,124 \times 420 \\
 &= 168892,08 \text{ N} \\
 \phi M_n &= 0,9 \times z \times T_s \\
 &= 0,9 \times 268,0808 \times 168892,08 \\
 &= 40,749 \text{ kNm}
 \end{aligned}$$

#### Perencanaan Penulangan Lapangan

$$\begin{aligned}
 R_n &= \frac{4,655 \times 10^6}{0,9 \times 150 \times 297^2} \\
 &= 0,3909
 \end{aligned}$$

$$\rho_{\text{min}} = 0,003$$

$$\rho_{\text{perlu}} = 0,009$$

$$\rho_{\text{max}} = 0,0157$$

$\rho_{\text{min}} < \rho_{\text{perlu}} < \rho_{\text{max}}$  digunakan  $\rho_{\text{perlu}} = 0,009$

$$\begin{aligned}
 A_{\text{sperlu}} &= 0,009 \times 150 \times 297 \\
 &= 133,65 \text{ mm}^2
 \end{aligned}$$

$$\begin{aligned}
 \text{Jumlah tulangan} &= \frac{133,65}{201,062} = 0,6647 = 2 \text{ buah} \\
 &= \text{digunakan 2D-22mm}
 \end{aligned}$$

$$A_{\text{s aktual}} = 402,124 \text{ mm}^2$$

$$a = \frac{402,124 \times 420}{0,85 \times 30 \times 150} = 44,155 \text{ mm}$$

$$z = 300 - \frac{63,83825}{2} = 268,0808 \text{ mm}$$

$$T_s = 402,124 \times 420 = 168892,08 \text{ N}$$

$$\begin{aligned} \phi M_n &= 0,9 \times z \times T_s \\ &= 0,9 \times 268,0808 \times 168892,08 \\ &= 40,7490 \text{ kNm} \end{aligned}$$

### Perencanaan Tulangan Geser

$$V_c = 50 \text{ Kn}$$

$$V_u = 21,3355 \text{ kN}$$

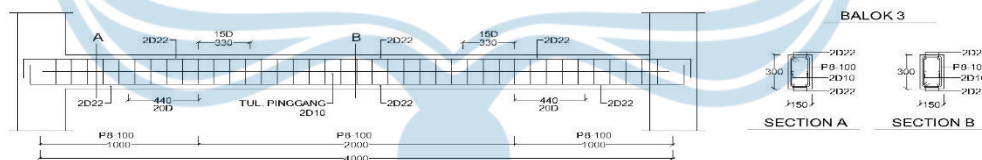
$$\begin{aligned} V_s &= \frac{V_u}{\phi} - V_c = \frac{21,3355}{0,75} - 50 \\ &= 21,552 \text{ kN} \end{aligned}$$

$$V_s \text{ Max} = 67,644 \text{ kN}$$

$$A_v = 157,08$$

$$S = 606,086 \text{ mm}$$

$$S \text{ max} = 148,5 \text{ mm}$$



Gambar 2. 21 Detail Balok 3

## 2.6 Perencanaan Kolom

### 1. Perencanaan Kolom K1

Data Kolom K1

$$b = 300 \text{ mm}$$

$$h = 300 \text{ mm}$$

$$\text{diameter tulangan} = 16 \text{ mm}$$

$$\text{diameter sengkang} = 8 \text{ mm}$$

selimut beton	= 40 mm
$f_c$	= 30 MPa
$f_y$	= 420 MPa
$V_u$	= 4,314 kN
$M_{ux}$	= 13,6324 kN
$M_{uy}$	= 13,1573 kNm
$P_u$	= 9,738 kN

Dari data ikolat diperoleh  $p = 2,01 \%$

$$\begin{aligned} A_s \text{ total} &= 2,01 \% \times (300.300) \\ &= 1809,1 \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} A_s \text{ tulangan} &= \frac{1}{4} \times 16 \times 16 \times 16 \\ &= 201,14 \text{ mm}^2 \end{aligned}$$

$$\text{Jumlah tulangan} = \frac{1809,1}{201,14} = 8,9942 = 10D16$$

Tinjauan terhadap geser

$$\begin{aligned} V_c &= \left( 1 + \frac{P_u}{14.A_g} \right) \times \frac{\sqrt{f_c}}{6} \times b \times d \\ &= \left( 1 + \frac{9,738}{14.(300.300)} \right) \times \frac{\sqrt{30}}{6} \times 300 \times 244.10^{-3} \\ &= 164,059 \text{ kN} \end{aligned}$$

$$\emptyset V_c > V_u$$

$$0,75 (164,059) > 4,314$$

$$123,044 > 4,314 \text{ OK!}$$

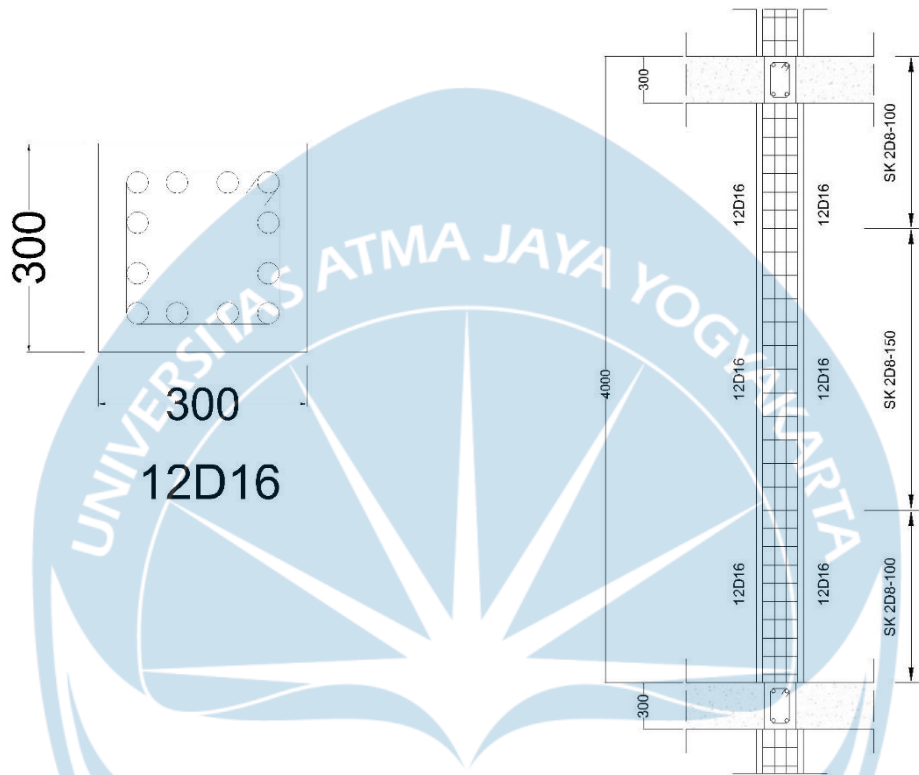
Kuat geser Sengkang

$$\begin{aligned} V_s &= \frac{V_u}{\emptyset} - V_c \\ &= \frac{4,314}{0,75} - 164,059 \\ &= -158,307 \text{ kN} \end{aligned}$$

$$S_{\max} = \frac{d}{2} = \frac{344}{2}$$

= 172 mm

(Digunakan Sengkang 2p8 – 150mm)



Gambar 2. 22 Detail kolom 1

## 2. Perencanaan Kolom K2

Data Kolom K2

b	= 150 mm
h	= 150 mm
diameter tulangan	= 12 mm
diameter Sengkang	= 8 mm
selimut beton	= 40 mm
$f'_c$	= 30 MPa
$f_y$	= 420 MPa
$V_u$	= 1,006 kN
$M_{ux}$	= 0,5087 kN

$$M_{uy} = 2,447 \text{ kNm}$$

$$P_u = 275 \text{ kNm}$$

Dari data ikolat diperoleh  $\rho = 2,01 \%$

$$A_s \text{ total} = 2,01 \% \times (150 \cdot 150)$$

$$= 452,16 \text{ mm}^2$$

$$A_s \text{ tulangan} = \frac{1}{4} \times 12 \times 12 \times 12$$

$$= 113,14 \text{ mm}^2$$

$$\text{Jumlah tulangan} = \frac{452,16}{113,14} = 3,99 = 4D12$$

Tinjauan terhadap geser

$$V_c = \left( 1 + \frac{P_u}{14 \cdot A_g} \right) \times \frac{\sqrt{f'_c}}{6} \times b \times d$$

$$= \left( 1 + \frac{275}{14 \cdot (150 \cdot 150)} \right) \times \frac{\sqrt{30}}{6} \times 150 \times 244 \cdot 10^{-3}$$

$$= 33,44 \text{ kN}$$

$$\phi V_c > V_u$$

$$0,75 (33,44) > 1,006$$

$$25,08 > 1,006 \text{ OK!}$$

Kuat geser Sengkang

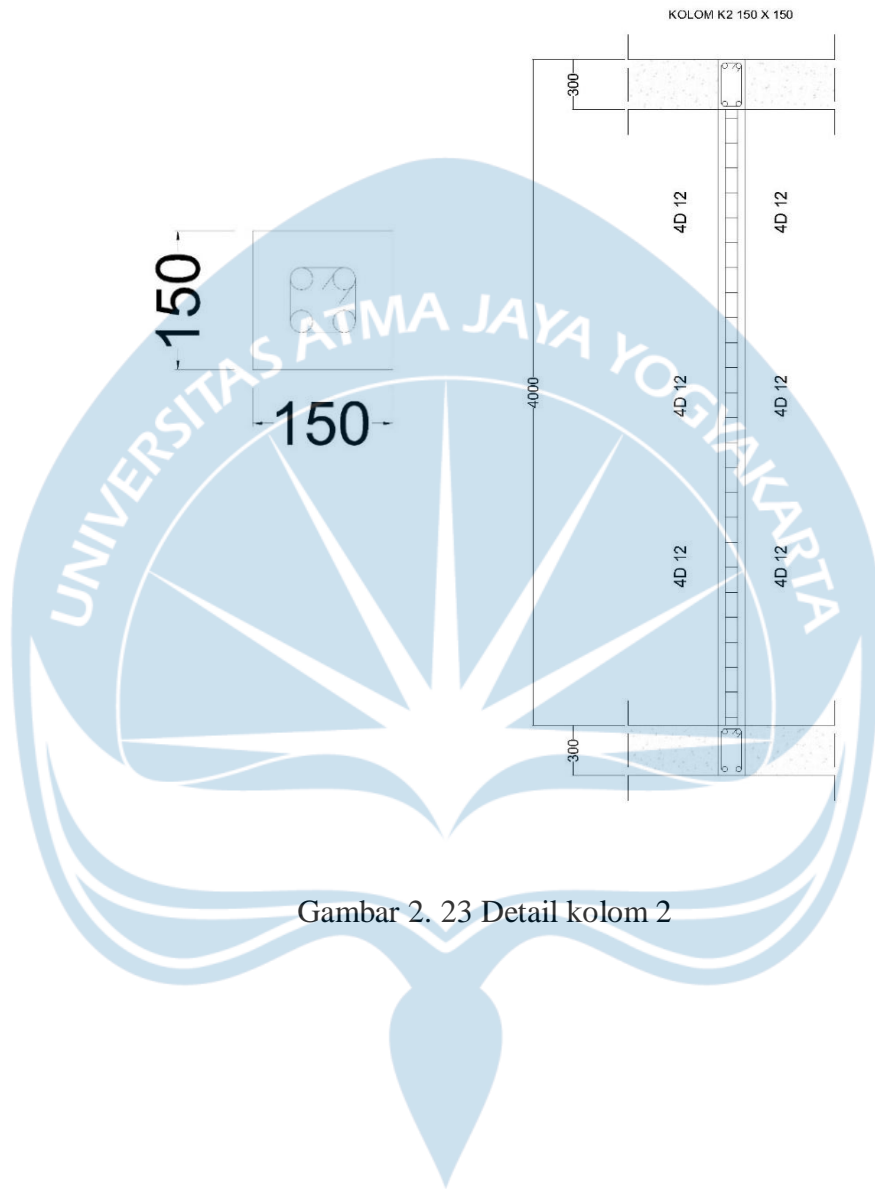
$$V_s = \frac{V_u}{\phi} - V_c$$

$$= \frac{1,006}{0,75} - 33,44$$

$$= -32,098 \text{ kN}$$

$$S_{\text{max}} = 48 \text{ mm}$$

(Digunakan Sengkang 2p8 – 150mm)



Gambar 2. 23 Detail kolom 2