LAPORAN PERHITUNGAN STRUKTUR BALOK LANTAI

A. DATA BALOK LANTAI

1. Data Material dan Dimensi

Parameter	Simbol	Nilai	Satuan
Mutu Beton	f_c'	20	MPa
Mutu Baja Tulangan	f_y	400	MPa
Mutu Baja Sengkang	f_{ys}	240	MPa
Tinggi Balok	h	400	mm
Lebar Balok	b	250	mm
Tebal Selimut Beton	s	40	mm
Diameter Tulangan Utama	D	19	mm
Diameter Tulangan Sengkang	D_s	10	mm
Tinggi Efektif Balok	d	340.5	mm
Panjang Bentang Balok	L	6.7	m

2. Beban Ultimit Desain

Parameter	Simbol	Nilai	Satuan
Momen Ultimit Positif	M_u^+	104.4	kNm
Momen Ultimit Negatif	M_u^-	139.2	kNm
Gaya Geser Ultimit	V_u	84.15	kN

3. Parameter Konstan

$$\begin{aligned}
\text{Tinggi Efektif:}\quad d &= h - s - D_s - 0.5 \cdot D \\
&= 400 - 40 - 10 - 0.5 \cdot 19 = \mathbf{340.5}\ \text{mm} \\
\beta_1 &= 0.85 \quad (\text{karena } f'_c = 20\ \text{MPa} \leq 28\ \text{MPa}) \\
\phi &= 0.80 \quad (\text{Faktor Reduksi Kekuatan Lentur}) \\
\phi_v &= 0.75 \quad (\text{Faktor Reduksi Kekuatan Geser})
\end{aligned}$$

B. PERHITUNGAN TULANGAN LENTUR

1. Batasan Rasio Tulangan

$$\rho_{\min} = \frac{1.4}{f_y} = \frac{1.4}{400} = \mathbf{0.0035}$$

$$\begin{aligned}
\rho_{\text{balanced}}(\rho_b) &= \frac{0.85 f'_c \beta_1}{f_y}\left(\frac{600}{600 + f_y}\right) \\
&= \frac{0.85 \cdot 20 \cdot 0.85}{400}\left(\frac{600}{600+400}\right) = \mathbf{0.02167}
\end{aligned}$$

$$\rho_{\max} = 0.75 \cdot \rho_b = 0.75 \cdot 0.02167 = \mathbf{0.01625}$$

2. Tulangan Momen Positif ($M_u^+ = 104.4\ \text{kNm}$)

$$\begin{aligned}
\text{Koefisien Ketahanan Balok } (R_n) &= \frac{M_u}{\phi \cdot b \cdot d^2} \\
&= \frac{104.4 \times 10^6\ \text{Nmm}}{0.80 \cdot 250\ \text{mm} \cdot (340.5\ \text{mm})^2} \approx \mathbf{3.585}\ \text{MPa}
\end{aligned}$$

$$\begin{aligned}
\text{Rasio Tulangan } (\rho) &= \frac{0.85 f'_c}{f_y}\left(1 - \sqrt{1 - \frac{2R_n}{0.85 f'_c}}\right) \\
&= \frac{0.85 \cdot 20}{400}\left(1 - \sqrt{1 - \frac{2 \cdot 3.585}{0.85 \cdot 20}}\right) \approx \mathbf{0.00962}
\end{aligned}$$

$$\text{Cek Batas:}\quad \rho_{\min} = 0.0035 < \rho = 0.00962 < \rho_{\max} = 0.01625 \quad (\text{OK})$$

$$\begin{aligned}
\text{Luas Tulangan Perlu } (A_s) &= \rho \cdot b \cdot d \\
&= 0.00962 \cdot 250\ \text{mm} \cdot 340.5\ \text{mm} \approx \mathbf{818.57}\ \text{mm}^2
\end{aligned}$$

$$\text{Jumlah Tulangan:}\quad n = \frac{A_s}{A_{D19}} = \frac{818.57\ \text{mm}^2}{283.53\ \text{mm}^2} \approx 2.88 \rightarrow \text{Dipilih } \mathbf{3D19}$$

$$\text{Luas Terpasang } (A_{s,\text{tp}}) = 3 \cdot 283.53\ \text{mm}^2 \approx \mathbf{850.59}\ \text{mm}^2$$

3. Tulangan Momen Negatif ($M_u^- = 139.2\ \text{kNm}$)

$$\text{Koefisien Ketahanan Balok } (R_n) = \frac{139.2 \times 10^6\ \text{Nmm}}{0.80 \cdot 250\ \text{mm} \cdot (340.5\ \text{mm})^2} \approx \mathbf{4.787}\ \text{MPa}$$

$$\text{Rasio Tulangan } (\rho) = \frac{0.85 \cdot 20}{400}\left(1 - \sqrt{1 - \frac{2 \cdot 4.787}{0.85 \cdot 20}}\right) \approx \mathbf{0.01308}$$

$$\text{Cek Batas:} \quad \rho_{\min} = 0.0035 < \rho = 0.01308 < \rho_{\max} = 0.01625 \quad \text{(OK)}$$

$$\text{Luas Tulangan Perlu } (A_s) = \rho \cdot b \cdot d$$

$$= 0.01308 \cdot 250\ \text{mm} \cdot 340.5\ \text{mm} \approx \mathbf{1113.16}\ \text{mm}^2$$

$$\text{Jumlah Tulangan:} \quad n = \frac{A_s}{A_{D19}} = \frac{1113.16\ \text{mm}^2}{283.53\ \text{mm}^2} \approx 3.93 \rightarrow \text{Dipilih } \mathbf{4D19}$$

$$\text{Luas Terpasang } (A_{s,\text{tp}}) = 4 \cdot 283.53\ \text{mm}^2 \approx \mathbf{1134.12}\ \text{mm}^2$$

C. PERHITUNGAN TULANGAN GESER (Sengkang)

Gaya Geser Ultimit $V_u = 84.15\ \text{kN}$. Digunakan sengkang D10 dengan 2 kaki.

1. Kekuatan Geser Beton dan Pengecekan

$$\text{Kekuatan Geser Nominal Beton } (V_c) = \frac{1}{6}\lambda\sqrt{f_c'} \cdot b \cdot d \quad (\lambda = 1.0)$$

$$= \frac{1}{6} \cdot 1.0 \cdot \sqrt{20\ \text{MPa}} \cdot 250\ \text{mm} \cdot 340.5\ \text{mm}$$

$$\approx 63102\ \text{N} \approx \mathbf{63.10}\ \text{kN}$$

$$\text{Kekuatan Geser Terfaktor } (\phi V_c) = 0.75 \cdot 63.10\ \text{kN} \approx \mathbf{47.33}\ \text{kN}$$

$$\text{Batas Minimum} \quad \frac{1}{2}\phi V_c = 0.5 \cdot 47.33\ \text{kN} \approx \mathbf{23.67}\ \text{kN}$$

*Karena $V_u = 84.15\ \text{kN} > \phi V_c = 47.33\ \text{kN}$, maka **tulangan geser diperlukan** dan harus dihitung.*

2. Perhitungan Jarak Sengkang

$$\text{Kekuatan Geser Tulangan Perlu } (V_s) \geq \frac{V_u - \phi V_c}{\phi_v}$$

$$\geq \frac{84.15\ \text{kN} - 47.33\ \text{kN}}{0.75} \approx \mathbf{49.09}\ \text{kN}$$

$$\text{Luas Sengkang } (A_v) = 2 \cdot \frac{1}{4}\pi D_s^2 = 2 \cdot \frac{1}{4}\pi (10\ \text{mm})^2 \approx \mathbf{157.08}\ \text{mm}^2$$

$$\text{Jarak Sengkang Hitungan } (s_{\text{hitungan}}) = \frac{A_v \cdot f_{ys} \cdot d}{V_s}$$

$$= \frac{157.08\ \text{mm}^2 \cdot 240\ \text{MPa} \cdot 340.5\ \text{mm}}{49.09 \times 10^3\ \text{N}} \approx \mathbf{261.2}\ \text{mm}$$

3. Kontrol Jarak Maksimum

$$s_{\text{max},1} = \frac{d}{2} = \frac{340.5}{2} = \mathbf{170.25}\ \text{mm}$$

$$s_{\text{max},2} = 600\ \text{mm}$$

> *Karena $s_{\text{hitungan}} (\mathbf{261.2\ \text{mm}}) > s_{\text{max},1} (\mathbf{170.25\ \text{mm}})$, maka jarak sengkang yang dipakai adalah ** $s_{\text{max},1}$**. Dipilih untuk dibulatkan menjadi $\mathbf{170\ \text{mm}}$ agar mudah di lapangan.*

Tulangan Geser Terpasang: D10 - 170 mm

D. REKAPITULASI HASIL DESAIN

Parameter Desain		Hasil Tulangan Terpasang
Tinggi Efektif Balok (d)		**340.5 mm**
Tulangan Lentur Utama	Positif (Lapangan)	**3D19**
	Negatif (Tumpuan)	**4D19**
Tulangan Geser (Sengkang)		**D10 – 170 mm**