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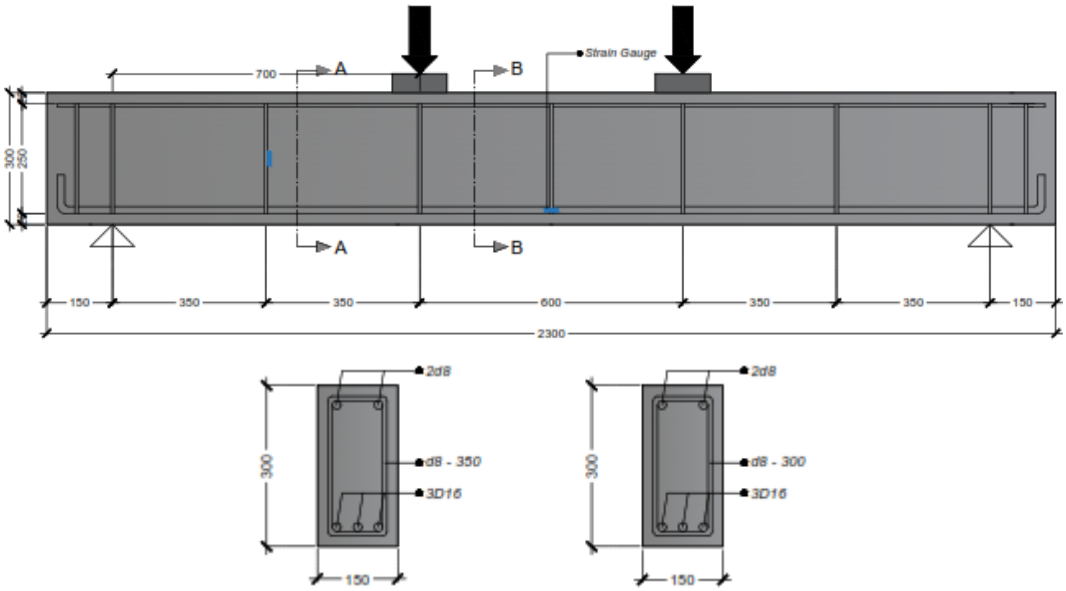
Perhitungan Kapasitas Lentur dan Kapasitas Geser Balok Beton Bertulang



Data Balok :

- Panjang Balok (L) = 2300 mm
- Tinggi Balok (h) = 300 mm
- Lebar Balok (b) = 150 mm
- Jarak serat tekan ke titik berat tulangan tarik (d) = 264 mm
- Kuat tekan beton (f'c) = 21.1 MPa
- Kuat leleh tulangan longitudinal
  - Tulangan tekan (fy') = 336.75 MPa
  - Tulangan Tarik (fy) = 384.82 MPa
- Luas tulangan balok
  - Tulangan tekan (As') = 100.53 mm^2

- Tulangan tarik (As) = 603.19 mm^2

a. Kapasitas Lentur (Mn)

$Cc + Cs = Ts$ ..... (7)

$(0.85 \times f'c \times a \times b) + (A'_s \times f'_y) = A_s \times f_y$ ..... (8)

$a = \frac{(A_s \times f_y) - (A'_s \times f_y')}{0.85 \times f_c' \times b}$ ..... (9)

Dimana:

Cc = Gaya tekan pada beton (kN)

Cs = Gaya tekan pada tulangan (kN)

Ts = Jumlah gaya total dari tulangan tarik (kN)

a = Tinggi blok tekan equivalen (mm)

Diperoleh:

$$a = \frac{(A_s \times f_y) - (A'_s \times f'_y)}{0.85 \times f_c' \times b}$$

$$a = \frac{(603.19\ mm^2 \times 384.82\ MPa) - (100{,}53\ mm^2 \times 336.75\ MPa)}{0.85 \times 21.1\ MPa \times 150\ mm}$$

$a = 73.70$

$Mn = A_s \times f_y \times \left(d - \frac{a}{2}\right)$ ..... (10)

$Mn = A_s \times f_y \times \left(d - \frac{a}{2}\right) + A'_s \times f'_s(d - d')$ ..... (11)

Diperoleh:

$$Mn = A_s \times f_y \times \left(d - \frac{a}{2}\right)$$

$$Mn = 603.19\ mm^2 \times 384.82\ MPa \times \left(264\ mm - \frac{73.70}{2}\right)$$

$$Mn = 52.73\ kNm$$

Sehingga,

$$P_n = \frac{M_n}{0.35}$$

$$P_n = \frac{M_n}{0.35}$$

$$P_n = \frac{52.73\ kNm}{0.35\ m}$$

$$P_n = 150.65\ kN$$

b. Kapasitas Geser (Vn)

$$V_c = \frac{1}{6}\sqrt{f_c'} \cdot b_w \cdot d$$ .....(12)

Diperoleh:

$$V_c = \frac{1}{6}\sqrt{f_c'} \cdot b_w \cdot d$$

$$V_c = \frac{1}{6}\sqrt{21.1\ kN} \cdot 150\ mm \cdot 264\ mm$$

$$V_c = 30.32\ kNm^2$$

$$V_s = \frac{A_s \times f_y \times d}{s}$$ ..... (13)

Diperoleh:

$$V_s = \frac{A_s \times f_y \times d}{s}$$

$$V_s = \frac{100.53\ mm^2 \times 384.82\ MPa \times 264\ mm}{350\ mm}$$

$$V_s = 29.18\ kNm^2$$

Jadi, kuat geser nominal (Vn):

$$V_n = V_c + V_s$$

$$V_n = 30.32\ kNm^2 + 29.18\ kNm^2$$

$$V_n = 59.50\ kN$$

Sehingga,

$$P_n = 2V_n \quad \text{..... (14)}$$

$$P_n = 2 \times 59.50\ kN$$

$$P_n = 118.99\ kN$$

Perhitungan Kebutuhan Angkur Baut dan Jarak Antar Baut

Diketahui :

- Beban maksimum GM-W-200 (p_u) = 168.40 kN
- Beban maksimum GM-W-300 (p_u) = 153.21 kN
- Jumlah bidang geser (m) = 2
- Baut dengan ulir pada bid. Geser (r_1) = 0.4
- Kuat tarik putus baut (f_u^b) = 370 MPa
- Luas baut (A_b) = 50.24 mm^2
- Untuk semua jenis lubang(n) = 2.4
- Tebal pelat (t_p) = 15 mm
- Diameter lubang baut (d_b) = 14 mm
- Kuat tekan rata-rata geopolimer (f_u) = 21.9 MPa

a. Tahanan nominal baut ditinjau terhadap kuat geser

$$R_n = m \cdot r_1 \cdot f_u^b \cdot A_b \quad \text{..... (15)}$$

Dimana :

R_n = Tahanan nominal baut (kN)

Diperoleh :

$$R_n = m \cdot r_1 \cdot f_u^b \cdot A_b$$

$$R_n = 2 \cdot 0.4 \cdot 370\ \text{MPa} \cdot 50.24\ \text{mm}^2$$

$$R_n = 14871.04\ \text{N} \rightarrow 14.87\ \text{kN}$$

b. Tahanan nominal baut ditinjau terhadap kuat tumpu

$R_n = n \cdot d_b \cdot t_p \cdot f_u$ ..... (16)

$R_n = 2.4 \cdot 14 \cdot 15 \cdot 21.9$

$R_n = 11037.60\ N \rightarrow 11.07\ kN$

Tahanan nominal baut yang digunakan adalah nilai tahanan nominal baut terkecil. Sehingga nilai Rn yang digunakan yaitu tahanan nominal baut yang ditinjau terhadap kuat tumpu sebesar 11.04 kN

1. Kebutuhan jumlah baut

$n_b = \frac{P_u/_2}{R_n}$ ..... (17)

Dimana:

n_b = Jumlah angkur baut

P_u = Beban maksimum benda uji (kN)

R_n = Tahanan nominal baut (kN)

Diperoleh:

- Benda uji GM-W-200

  $n_b = \frac{P_u/_2}{R_n}$

  $n_b = \frac{168.40/_2}{11.04}$

  $n_b = 7.63 \rightarrow 8$ Buah

- Benda uji GM-W-300

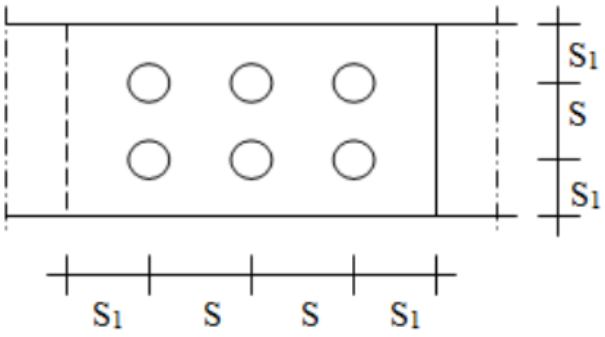
  $n_b = \frac{P_u/_2}{R_n}$

$$n_b = \frac{153.21/2}{11.04}$$

$n_b = 6.93 \rightarrow 7$ Buah

2. Jarak antar angkur baut

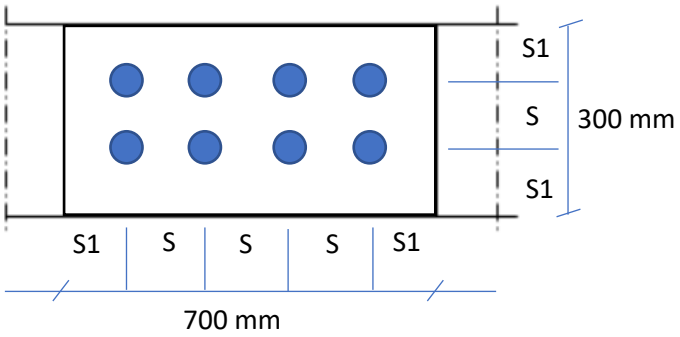
Berdasarkan SNI 1729:2002 Terdapat beberapa persyaratan penempatan angkur baut pada pelat diantaranya:



$3d_b < S < 15t_p$ atau 200 mm
$1{,}5d_b < S_1 < (4t_p + 100\text{mm})$ atau 200 mm

- Jarak antar pusat lubang baut harus diambil tidak kurang dari 3 kali diameter nominal baut dan jarak antara baut tepi dengan ujung pelat harus sekurang-kurangnya 1.5 diameter nominal baut.
- Jarak maksimum antar pusat lubang baut tak boleh melebihi $15t_p$(dengan t_p adalah tebal pelat lapis tertipis dalam sambungan) atau 200 mm, sedangkan jarak tepi maksimum harus tidak melebihi $(4t_p + 100\text{mm})$ atau 200 mm.

Direncanakan:



$3d_b < S < 15t_p \; atau \; 200 \; mm$

$(3 \cdot 12) < S < (15 \cdot 15) atau \; 200 mm$

$36 \text{ mm} < S < 225 \text{ mm atau } 200 \text{ mm}$

Maka, diambil nilai S sebesar 200 mm

$1.5d_b < S_1 < (4t_p + 100 \text{ mm}) \text{ atau } 200 \text{ mm}$

$1.5 \cdot 12 < S_1 < (4 \cdot 15 + 100 mm) atau 200 mm$

$18 \text{ mm} < S_1 < (160 \text{ mm}) \text{ atau } 200 \text{ mm}$

Maka, diambil nilai S_1 sebesar 50 mm