

BAB IV

PERHITUNGAN KONSTRUKSI

4. 1. Perhitungan Rangka Atap

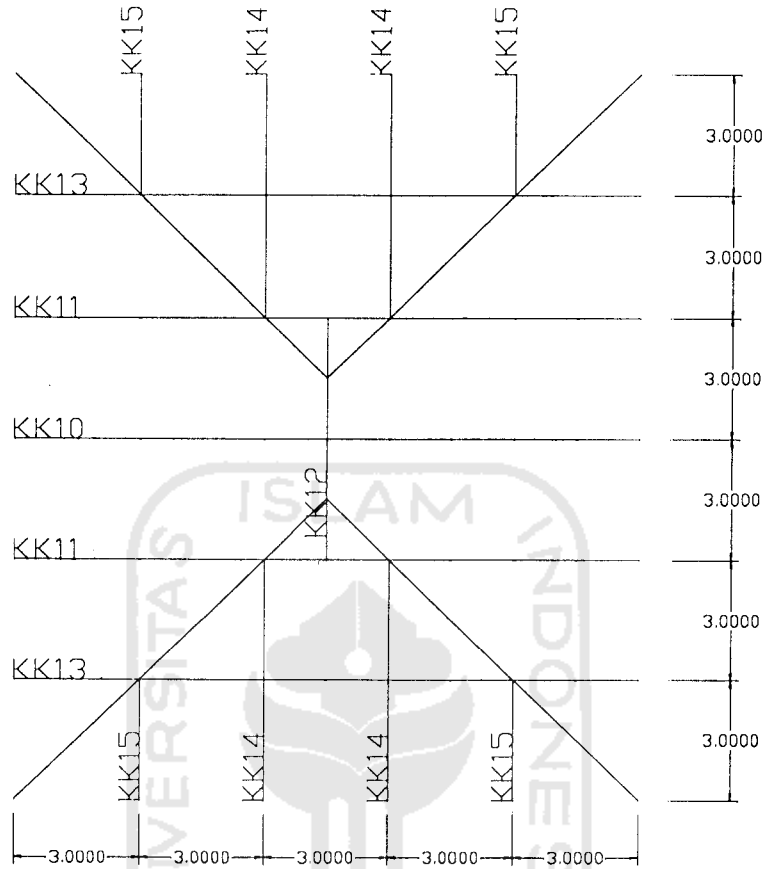
Perencanaan rangka atap dilakukan sebagai berikut ini.

4.1.1. Data Konstruksi Yang Di Pergunakan

- Mutu Baja Profil:
 - Tegangan Leleh, F_y : 36 ksi
 - Modulus Elastis, E_s : 29000 ksi
 - Profil yang digunakan : Siku (2L), Light Lip Channel (C)
- Alat Sambung Baut (U_{24}) non full drat:
 - Tegangan tarik minimum, F_u : 58 ksi
 - Tegangan ijin geser, F_v : 30 ksi
 - Tegangan leleh, F_y : 140 MPa
 - Diameter, ϕ : $\frac{1}{2}$ in
- Jenis Penutup Atap: Genteng

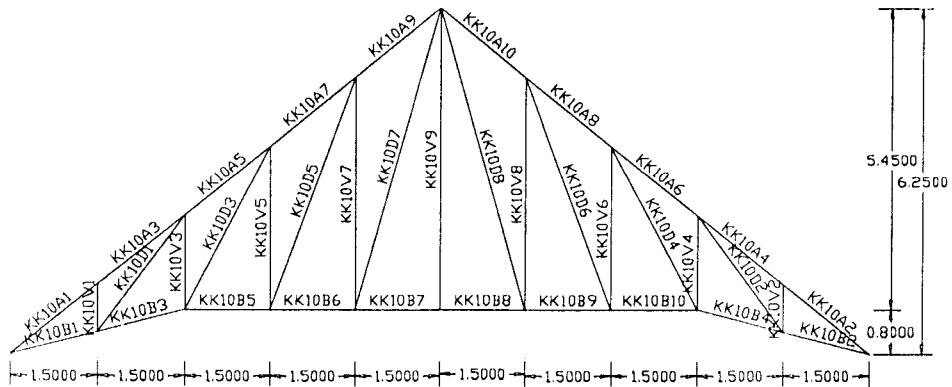
4.1.2. Perletakan Kuda-Kuda

Kuda-kuda yang terdiri atas beberapa rangka di letakkan dengan pengaturan sebagai berikut ini.

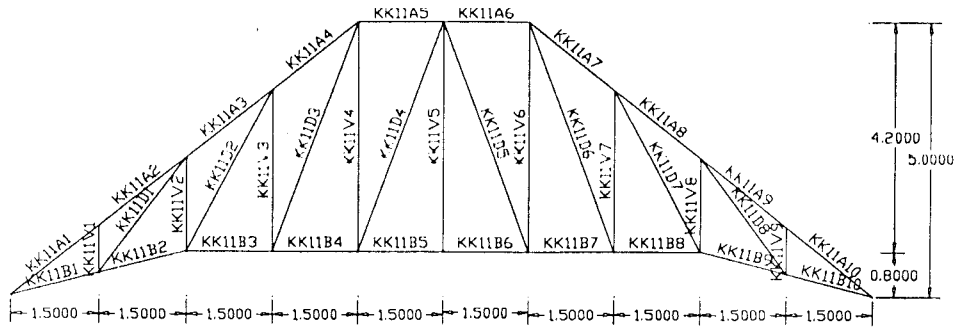


Gambar IV-1 Letak kuda-kuda

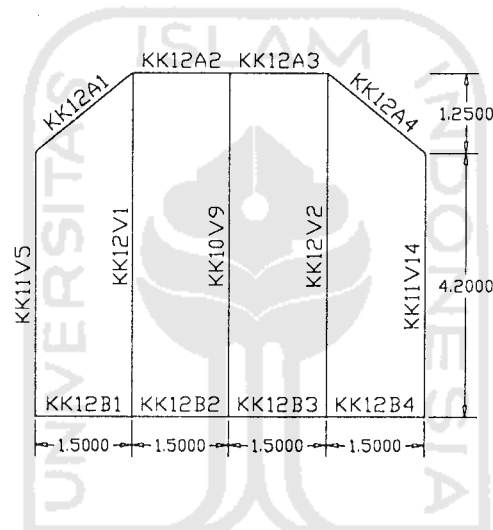
Berikut ini adalah detail kuda-kuda yang diberi kode elemen.



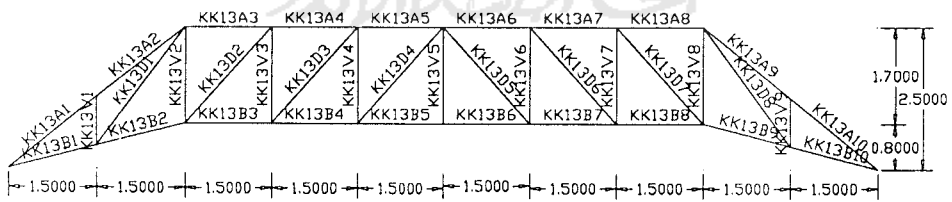
Gambar IV-2 Kuda-kuda KK10



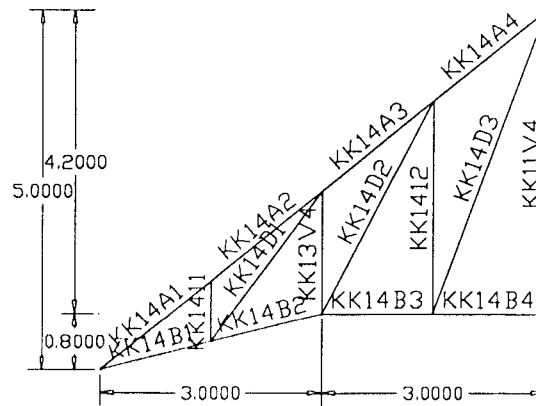
Gambar IV-3 Kuda-kuda KK11



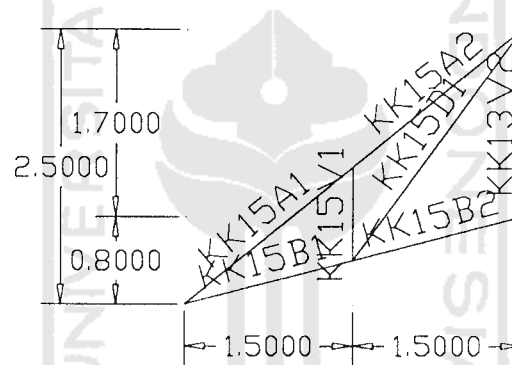
Gambar IV-4 Kuda-kuda KK12



Gambar IV-5 Kuda-kuda KK13



Gambar IV-6 Kuda-kuda KK14



Gambar IV-7 Kuda-kuda KK15

Kemudian elemen kuda-kuda di kelompokkan menjadi sebagai berikut ini.

Tabel IV-1 Pengelompokan elemen kuda-kuda

| Jenis | Elemen kuda-kuda |
|-------------|---|
| Batang atas | KK10A1-KK10A10, KK11A1-KK11A20, KK12A1-KK12A4, KK13A1-KK13A20, KK14A1-KK14A16, KK15A1-KK15A8, |

| Jenis | Elemen kuda-kuda |
|-----------------|--|
| Batang bawah | KK10B1-KK10B10, KK11B1-KK11B20, KK12B1-KK12B4, KK13B1-KK13B20, KK14B1-KK14B16, KK15B1-KK15B8 |
| Batang diagonal | KK10D1-KK10D8, KK11D1-KK11D16, KK13D1-KK13D16, KK14D1-KK14D12, KK15D1-KK15D4 |
| Batang vertikal | KK10V1-KK10V9, KK11V1-KK11V18, KK12V1-KK12V2, KK13V1-KK13V18, KK14V1-KK14V8, KK15V1-KK15V4 |

4.1.3. Perhitungan Beban

Beban yang di gunakan untuk merencanakan kuda-kuda adalah sebagai berikut:

- Beban atas, terdiri atas:
 - berat penutup atap,
 - berat gording.
- Beban bawah, terdiri atas:
 - berat sendiri,
 - berat plafond.
- Beban Angin, terdiri atas:
 - angin tekan,

- angin hisap.

Untuk detail perhitungan beban kuda-kuda dapat dilihat pada lampiran XVII Perhitungan beban kuda-kuda.

4.1.4. Analisis Struktur

Kemudian dari data-data yang ada dibuat model rangka kuda-kuda pada program SAP 2000. Kemudian dengan menggunakan program SAP 2000, dilakukan analisis struktur untuk memperoleh gaya-gaya batang yang terjadi.

Hasil gaya-gaya batang yang diperoleh kemudian diolah untuk mencari gaya batang yang akan di pergunakan dalam desain. Gaya-gaya batang yang di gunakan pada desain dapat dilihat pada Lampiran XVI Perhitungan gaya batang kuda-kuda.

4.1.5. Perhitungan Profil

Setelah gaya batang untuk desain di peroleh barulah di lakukan pemilihan profil yang akan di gunakan. Perhitungan profil yang akan digunakan, direncanakan per jenis batang. Berikut ini adalah perhitungan pemilihan profil untuk rangka atap.

Perencanaan Dimensi Batang.

Batang tarik

-Batang bawah

| | | |
|--------------------|-------------------------------------|-------------------------------|
| Panjang batang, L: | 1,552 m | = 155,242 cm |
| Gaya batang, T: | 4169,780 kg | |
| Fy: | 36,000 ksi | = 2531,050 kg/cm ² |
| Fu: | 58,000 ksi | = 4077,804 kg/cm ² |
| Ø Baut: | 4/8 " | |
| t profil: | 0,600 cm | |
| μ: | 0,750 | |
| jumlah lubang: | 2,000 | |
| Ø Lubang | = Ø Baut + 1/8" | |
| | = 4/8" + 1/8" | |
| | = 5/8 " | |
| | = 1,588 cm | |
| A lubang = | Ø Lubang × t profil × jumlah lubang | |
| | = 1,5875 × 0,6 × 2 | |
| | = 1,905 cm ² | |

$$\text{Ag 1 perlu} = \frac{T}{0,6 \times F_y} = \frac{4169,780}{0,6 \times 2531,050} = 2,746 \text{ cm}^2$$

$$\text{Ag 2 perlu} = \frac{T}{0,5 \times F_u \times \mu} = \frac{4169,780}{0,5 \times 4077,804 \times 0,75} = 2,727 \text{ cm}$$

$$r_{\min} = \frac{k L}{300,000} = \frac{330,946}{300,000} = 1,103 \text{ cm}$$

Dicoba profil: **2L55X55X6-10**

Data Profil 2L55X55X6-10: Berat, $w = 9,791 \text{ kg/m}$

$A = 12,500 \text{ cm}^2$

$t = 0,600 \text{ cm}$

$i_x = 1,685 \text{ cm}$

$i_y = 2,690 \text{ cm}$

$r_{\min} = 1,685 \text{ cm}$

Jumlah baut max = 2,543

A bruto = 12,500 cm²

A netto = A bruto - A lubang = 12,5 - 1,905 = 10,595 cm²

A efektif = μ A netto = 0,75 × 10,595 = 7,946 cm²

> Ag2 = 2,727 cm² -- OK --

$$\begin{aligned} \text{Check: } \frac{T}{A_{net}} &= \frac{4169,780}{43,400} \\ &= 333,582 \text{ kg/cm}^2 \\ &< 0,6 f_y = 1518,630 \text{ kg/cm}^2 \text{ -- OK --} \end{aligned}$$

$$\begin{aligned} \frac{T}{A_e} &= \frac{4169,780}{7,946} \\ &= 524,748 \text{ kg/cm}^2 \\ &< 0,5 f_u = 2038,902 \text{ kg/cm}^2 \text{ -- OK --} \end{aligned}$$

Jadi profil 2L55X55X6-10 aman dipakai.

Batang desak

- Batang atas

$$\begin{aligned} \text{Panjang batang, L: } & 1,953 \text{ m} = 195,256 \text{ cm} \\ \text{Gaya batang, T: } & 5319,182 \text{ kg} \\ F_y: & 36,000 \text{ ksi} = 2531,050 \text{ kg/cm}^2 \\ F_u: & 58,000 \text{ ksi} = 4077,804 \text{ kg/cm}^2 \\ E: & 29000 \text{ ksi} = 2038902 \text{ kg/cm}^2 \\ k: \text{ sendi-sendi} & = 1,0 \end{aligned}$$

$$\begin{aligned} r &= \frac{k L}{200,000} = \frac{1 \times 195,2562}{200} \\ &= 0,976281 \text{ cm} \end{aligned}$$

$$C_c = \sqrt{\frac{2\pi^2 E}{F_y}} = \sqrt{\frac{2 \times \pi^2 \times 2038901,781}{2531,050}}$$

$$= 126,0993$$

Dicoba profil: **2L55X55X6-10**

Data Profil 2L55X55X6-10: Berat, w = 9,791 kg/m

$$A = 12,500 \text{ cm}^2$$

$$t = 0,600 \text{ cm}$$

$$i_x = 1,685 \text{ cm}$$

$$i_y = 2,690 \text{ cm}$$

$$r_{\min} = 1,685 \text{ cm}$$

$$\frac{k L}{r} = \frac{1 \times 2531,050}{1,685}$$

$$= 115,8791 < C_c = 126,099 \text{ kg/cm}^2$$

untuk $Kl/r \leq C_c$:

$$FS = \frac{5}{3} + \frac{3}{8} \cdot \frac{kl}{r} \cdot \frac{1}{C_c} - \frac{1}{8} \cdot \left(\frac{kl}{r} \cdot \frac{1}{C_c} \right)^3$$

$$= 1,914$$

$$F_a = 763,921 \text{ kg/cm}^2$$

$$T = 9549,016 \text{ kg} > 5319,182 \text{ kg --OK--}$$

Jadi profil 2L55X55X6-10 aman dipakai.

4.1.6. Hasil Dari Perencanaan Rangka Atap

Setelah dilakukan perhitungan, rangkuman hasil ukuran profil yang digunakan dan jumlah alat sambung terdapat pada tabel berikut ini:

Tabel IV-2 Hasil perencanaan rangka atap

| Tipe Batang | Hasil sebelum perencanaan | | Hasil perencanaan ulang | |
|-------------|---------------------------|----------------------|-------------------------|----------------------|
| | Profil (mm) | Baut | Profil (mm) | Baut |
| Atas, A | 2L 50x50x5 | 2 \varnothing 16mm | 2L 55x55x6 | 2 \varnothing 1/2" |
| Bawah, B | 2L 50x50x5 | 2 \varnothing 16mm | 2L 55x55x6 | 2 \varnothing 1/2" |
| Diagonal, D | 2L 40x40x5 | 2 \varnothing 16mm | 2L 55x55x6 | 2 \varnothing 1/2" |
| Vertikal, V | 2L 40x40x5 | 2 \varnothing 16mm | 2L 55x55x6 | 2 \varnothing 1/2" |
| Jurai, J | 2C 125x50x20x2,3 | 2 \varnothing 16mm | 2L 55x55x6 | 2 \varnothing 1/2" |
| Gording | Bengkirai $\frac{8}{12}$ | | C 100x50x20x2,3 | |

▪ Sagrod : \varnothing 10 mm

▪ Tierod : \varnothing 10 mm

Untuk perhitungan gording, sagrod, tierod dan baut dapat dilihat pada lampiran XVII-XIX.

4. 2. Perhitungan Pelat

Perencanaan pelat dilakukan sebagai berikut ini.

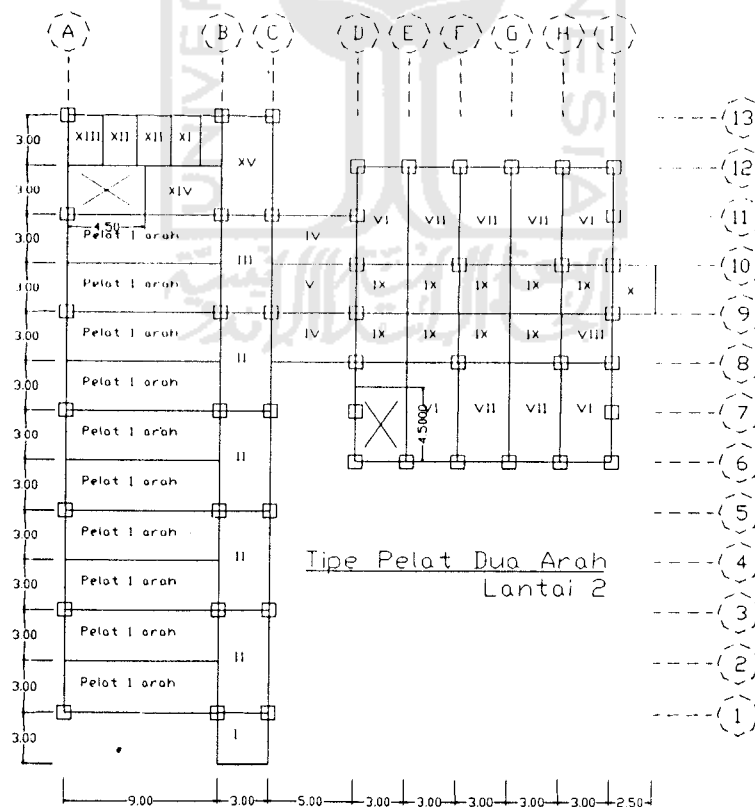
4.2.1. Data Konstruksi Yang Di Pergunakan

- tebal pasir : 0,05 m
- tebal spesi : 0,03 m
- tebal keramik : 0,01 m
- bj beton : 23 kN/m³

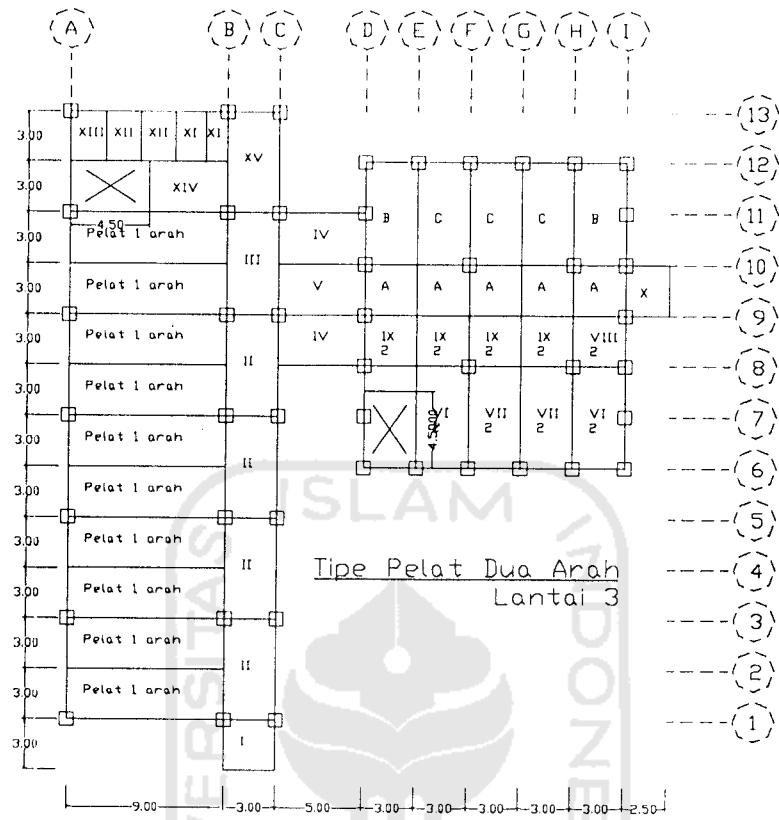
- bj pasir : 16 kN/m^3
- bj spesi : 22 kN/m^3
- bj keramik : 20 kN/m^3
- f_c' : 20 MPa
- $f_y \text{ polos}$ (untuk sengkang, dan pada plat lantai) : 240 MPa
- $f_y \text{ deform}$ (tulangan pokok balok dan kolom) : 400 MPa
- $\phi = 0,8$ (faktor reduksi kekuatan untuk pembebanan lentur tanpa aksial)

4.2.2. Perhitungan Pelat

Pelat lantai di bagi menjadi pelat satu arah dan pelat dua arah, dimana letak dari masing-masing tipe pelat dapat di lihat pada gambar berikut ini.



Gambar IV-8 Perletakan Pelat Lantai 2



Gambar IV-9 Perletakan Pelat Lantai 3

Berikut ini adalah contoh perhitungan yang digunakan untuk perencanaan tulangan pelat.

a) Perencanaan Pelat Satu Arah

Pelat lantai

$$R. \text{Kuliah} = wL = 250 \text{ kg/cm}^2 = 2,5 \text{ kN/m}^2$$

$$\text{Selasar} = wL = 300 \text{ kg/cm}^2 = 3 \text{ kN/m}^2$$

$$L_x = 300 \text{ cm} = 3000 \text{ mm}$$

$$L_y = 900 \text{ cm} = 9000 \text{ mm}$$

$$F_y = 36 \text{ Ksi} = 248,21126 \text{ MPa}$$

$$L_y/L_x = 3$$

$L_y/L_x > 2$ maka dianggap pelat 1 arah

Tebal Pelat:

Pelat dengan satu ujung menerus

$$h_{\min} = \frac{L_x}{24} \left(0.4 + \frac{F_y}{700} \right)$$

$$= 94,32344 \text{ mm}$$

Pelat dengan dua ujung menerus

$$h_{\min} = \frac{L_x}{28} \left(0.4 + \frac{F_y}{700} \right)$$

$$= 80,848663 \text{ mm}$$

Diambil $h = 120 \text{ mm}$

Beban pelat per lebar 1 meter

Berat pelat

$$= t. \text{pelat} \times b_j \text{ beton} = 0,12 \times 23 = 2,76 \text{ kN/m}^2$$

Pasir (5 cm)

$$= t. \text{pasir} \times b_j \text{ beton} = 0,05 \times 16 = 0,8 \text{ kN/m}^2$$

Spesi (3 cm)

$$= t. \text{spesi} \times b_j \text{ beton} = 0,03 \times 23 = 0,69 \text{ kN/m}^2$$

Keramik (1 cm)

$$= t. \text{krmk} \times b_j \text{ krmk} = 0,01 \times 20 = 0,2 \text{ kN/m}^2 +$$

$$wD = 4,45 \text{ kN/m}^2$$

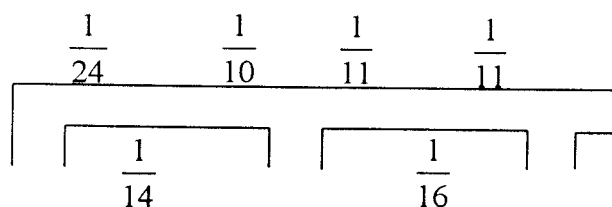
$$\text{Ruang kuliah (wL)} = 2,5 \text{ kN/m}^2$$

$$w_u = 1,2wD + 1,6wL = 9,34 \text{ kN/m}^2$$

$$\text{Untuk lebar 1 m, } W_u = 9,34 \text{ kN/m}^2$$

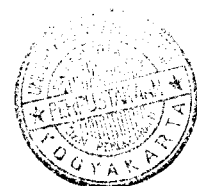
$$\text{Asumsi lebar balok} = 300 \text{ mm}$$

$$L_n = 2700 \text{ mm}$$



$$M_u = X \cdot w_u \cdot L_n^2$$

$$M_u \text{ 1/24} = \frac{1}{24} \times 9,340 \times (2,7)^2 = 2,837025 \text{ kNm}$$



$$M_u \text{ 1/10} = 1/10 \times 9,340 \times (2,7)^2 = 6,80886 \text{ kNm}$$

$$M_u \text{ 1/14} = 1/14 \times 9,340 \times (2,7)^2 = 4,863471 \text{ kNm}$$

$$M_u \text{ 1/11} = 1/11 \times 9,340 \times (2,7)^2 = 6,189873 \text{ kNm}$$

$$M_u \text{ 1/16} = 1/16 \times 9,340 \times (2,7)^2 = 4,255538 \text{ kNm}$$

$$V_u = 1,15 \cdot \frac{1}{2} \cdot W_u \cdot L_n$$

$$= 1,15 \times \frac{1}{2} \times 9,340 \times 2,7$$

$$= 14,50035 \text{ kN}$$

$$V_u = \frac{1}{2} \times W_u \times L_n$$

$$= \frac{1}{2} \times 9,340 \times 2,7$$

$$= 12,609 \text{ kN}$$

tulangan \emptyset 10 asumsi awal

dan 20 mm penutup beton

$f_c' = 20$ MPa

$$d = 120 - 20 - (\frac{1}{2} \times 10) = 95 \text{ mm}$$

Kuat geser (tanpa tulangan geser)

$$\phi \cdot V_n = \phi \cdot \left(\frac{1}{6} \sqrt{f_c'} x b_w x d \right)$$

$$\phi = 0,6$$

$$\begin{aligned}\phi \cdot V_n &= 0,6 \cdot \left(\frac{1}{6} \sqrt{20 \times 1000 \times 95} \right) = 42485,292 \text{ N} \\ &= 42,485292 \text{ kN} \\ &> 14,50035 \text{ OK}\end{aligned}$$

Tulangan Susut:

$$A_{sst} = 0,0020 b h$$

$$= 0,002 \times 1000 \times 120$$

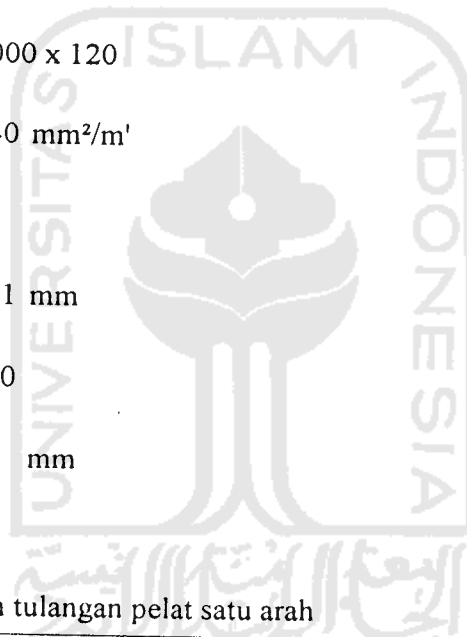
$$= 240 \text{ mm}^2/\text{m}'$$

pakai P8

$$s = 209,43951 \text{ mm}$$

$$5 h = 600$$

pakai P8 - 200



Tabel IV-3 Perhitungan tulangan pelat satu arah

| Nilai | Bagian | | | | |
|--------------|--------|--------|--------|--------|--------|
| | 1/24 | 1/10 | 1/14 | 1/11 | 1/16 |
| f_y , Mpa | 240 | 240 | 240 | 240 | 240 |
| f_c' , Mpa | 20 | 20 | 20 | 20 | 20 |
| β_1 | 0,85 | 0,85 | 0,85 | 0,85 | 0,85 |
| m | 14,118 | 14,118 | 14,118 | 14,118 | 14,118 |
| ρ_b | 0,0430 | 0,0430 | 0,0430 | 0,0430 | 0,0430 |
| ρ_{max} | 0,0323 | 0,0323 | 0,0323 | 0,0323 | 0,0323 |
| ρ_{min} | 0,0058 | 0,0058 | 0,0058 | 0,0058 | 0,0058 |

| Nilai | Bagian | | | | |
|-----------------------------------|-----------|-----------|----------|-----------|-----------|
| | 1/24 | 1/10 | 1/14 | 1/11 | 1/16 |
| Mu, kNm | 2,837 | 6,809 | 4,863 | 6,190 | 4,256 |
| ϕ | 0,8 | 0,8 | 0,8 | 0,8 | 0,8 |
| Mn, kNm | 3,546 | 8,511 | 6,079 | 7,737 | 5,319 |
| b, mm | 1000 | 1000 | 1000 | 1000 | 1000 |
| d, mm | 95 | 95 | 95 | 95 | 95 |
| Rn, Mpa | 0,393 | 0,943 | 0,674 | 0,857 | 0,589 |
| ρ | 0,0017 | 0,0040 | 0,0029 | 0,0037 | 0,0025 |
| 1,33 ρ | 0,0022 | 0,0054 | 0,0038 | 0,0049 | 0,0033 |
| ρ pakai | 0,0058 | 0,0058 | 0,0058 | 0,0058 | 0,0058 |
| As, mm ² | 554,16667 | 554,16667 | 554,1667 | 554,16667 | 554,16667 |
| \emptyset pakai, mm | 10 | 10 | 10 | 10 | 10 |
| A 1 \emptyset , mm ² | 78,539816 | 78,539816 | 78,53982 | 78,539816 | 78,539816 |
| s, mm | 141,72598 | 141,72598 | 141,726 | 141,72598 | 141,72598 |
| 3 h, mm | 360 | 360 | 360 | 360 | 360 |
| s pakai, mm | 140 | 140 | 140 | 140 | 140 |
| As ada, mm ² | 560,99869 | 560,99869 | 560,9987 | 560,99869 | 560,99869 |
| a, mm | 7,9199815 | 7,9199815 | 7,919981 | 7,9199815 | 7,9199815 |
| Mn ada, kNm | 12,257598 | 12,257598 | 12,2576 | 12,257598 | 12,257598 |
| kontrol | aman | aman | aman | aman | aman |
| jadi pakai | P10-140 | P10-140 | P10-140 | P10-140 | P10-140 |

b) Perencanaan Pelat Dua Arah

Pelat lantai tipe

II

$$L_x = 300 \text{ cm}$$

$$= 3000 \text{ mm}$$

$$F_y = 36 \text{ Ksi}$$

$$= 248,2113 \text{ MPa}$$

$$L_y/L_x = 2$$

$L_y/L_x = 2$ maka dianggap pelat 2 arah

Tebal Pelat:

Diperkirakan balok tepi pelat mempunyai lebar $b = 300 \text{ mm}$

Bentang bersih arah -x : $L_{nx} = L_x - b = 3000 - 300 = 2700 \text{ mm}$

Bentang bersih arah -y : $L_{ny} = L_y - b = 6000 - 300 = 5700 \text{ mm}$

$$\beta = L_{ny}/L_{nx} = 5700 / 2700 = 2,111111$$

$$h_{\min} = \frac{L_n (0,8 + f_y/1500)}{36 + 9\beta} = 100,0582$$

$$h_{\max} = \frac{L_n (0,8 + f_y/1500)}{36} = 152,8667$$

$h = 120 \text{ mm}$ dan $h_{\min} < h < h_{\max}$, maka dipakai $h = 120 \text{ mm}$

Menentukan momen

$L_y/L_x = 2$ dari tabel pelat 4.2.b Gideon

skema VI^a



$$x L_x = 70$$

$$x t_x = 114$$

$$x L_y = 17$$

$$x t_y = 76$$

$$b_j \text{ beton} = 23 \text{ kN/m}^3$$

$$b_j \text{ pasir} = 16 \text{ kN/m}^3$$

$$b_j \text{ spesi} = 22 \text{ kN/m}^3$$

$$b_j \text{ keramik} = 20 \text{ kN/m}^3$$

Beban pelat per lebar 1 meter

$$\text{Berat pelat} = t. \text{pelat} \times b_j \text{ beton} = 0,12 \times 23 = 2,76 \text{ kN/m}$$

$$\text{Pasir (5 cm)} = t. \text{pasir} \times b_j \text{ pasir} = 0,05 \times 16 = 0,8 \text{ kN/m}$$

$$\text{Spesi (3 cm)} = t. \text{spesi} \times b_j \text{ spesi} = 0,03 \times 22 = 0,66 \text{ kN/m}$$

$$\text{Tegel (1cm)} = t. \text{krmk} \times b_j \text{ krmk} = 0,01 \times 20 = 0,2 \text{ kN/m}$$

$$\text{Beban mati (Wd)} = 4,42 \text{ kN/m}$$

$$\text{Selasar (wL)} = 3 \text{ kN/m}$$

$$w_u = 1,2w_D + 1,6w_L = 10,104 \text{ kN/m}$$

$$\begin{aligned} \text{MuLx} &= 0,001 \times \text{Wu} \times \text{Lx}^2 \times \text{xLx} \\ &= 0,001 \times 10,104 \times 3^2 \times 70 = 6,36552 \text{ kNm} \end{aligned}$$

$$\begin{aligned} \text{Mutx} &= 0,001 \times \text{Wu} \times \text{Lx}^2 \times \text{xtx} \\ &= 0,001 \times 10,104 \times 3^2 \times 114 = 10,3667 \text{ kNm} \end{aligned}$$

$$\begin{aligned} \text{MuLy} &= 0,001 \times \text{Wu} \times \text{Lx}^2 \times \text{xLy} \\ &= 0,001 \times 10,104 \times 3^2 \times 17 = 1,54591 \text{ kNm} \end{aligned}$$

$$\begin{aligned} \text{Muty} &= 0,001 \times \text{Wu} \times \text{Lx}^2 \times \text{xty} \\ &= 0,001 \times 10,104 \times 3^2 \times 76 = 6,91114 \text{ kNm} \end{aligned}$$

$$\Phi = 0,8$$

$$\text{MuLx}/\Phi = 7,9569 \text{ kNm}$$

$$\text{Mutx}/\Phi = 12,9584 \text{ kNm}$$

$$\text{MuLy}/\Phi = 1,93239 \text{ kNm}$$

$$\text{Muty}/\Phi = 8,63892 \text{ kNm}$$

Tulangan Lx:

$$\text{Asumsi d tul.} = 10 \text{ mm}$$

$$\text{Penutup beton} = 20 \text{ mm}$$

$$\text{dx} = \text{t plat} - \text{penutup beton} - 1/2 \text{ d tul.}$$

$$= 120 - 20 - 1/2 \times 10$$

$$= 95 \text{ mm}$$

$$\beta_1 = 0,85$$

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

$$= \frac{7,9569 \times 1000000}{1000 \times 95^2}$$

$$= 0,881651 \text{ MPa}$$

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

$$= \frac{248,2113}{0,85 \times 20}$$

$$= 14,60066$$

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

$$\rho = \frac{1}{14,60066} \left(1 - \sqrt{1 - \frac{2 \cdot 14,60066 \cdot 0,881651}{248,2113}} \right)$$

$$= 0,003649$$

$$\begin{aligned}\rho_b &= \frac{0,85 \times f_c'}{f_y} \times \beta_1 \times \frac{600}{600 + f_y} \\ &= \frac{0,85 \times 20,000}{248,211} \times 0,850 \times \frac{600}{600 + 248,211} \\ &= 0,04118\end{aligned}$$

$$\rho_{\max} = 0,75 \times \rho_b = 0,75 \times 0,041181 = 0,03089$$

$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{248,211} = 0,00564$$

$$\rho_{\text{ambil}} = 0,00485 \text{ (1,33 } \rho \text{ perlu)}$$

$$\begin{aligned}A_s &= \rho \times b \times d \\ &= 0,004853 \times 1000 \times 95,000 = 461,081 \text{ mm}^2\end{aligned}$$

$$\begin{aligned}A_{s\text{st}} &= 0,0020 \times b \times h \\ &= 0,0020 \times 1000 \times 120,000 = 240 \text{ mm}^2\end{aligned}$$

$$A_{s \text{ ambil}} = 461,081 \text{ mm}^2$$

$$A_1 \text{ tul} = \frac{1}{4} \times \pi \times d^2 = \frac{1}{4} \times \pi \times 10,000^2 = 78,5398 \text{ mm}^2$$

$$s \leq \frac{A_1 d \times 100}{A_s} = \frac{78,540 \times 1000}{461,081}$$

$$= 170,338 \text{ mm}$$

jadi pakai **P10 - 160**

cek Mn:

$$As \text{ ada} = \frac{A1d \times 1000}{s}$$

$$= \frac{78,540 \times 1000}{160}$$

$$= 490,8739 \text{ mm}^2$$

$$a = \frac{As \text{ ada} \times fy}{0,85 \times fc \times 1000}$$

$$= \frac{490,874 \times 248,211}{0,85 \times 20 \times 1000}$$

$$= 7,167083 \text{ mm}$$

$$Mn \text{ ada} = As \times fy \times (d - a/2)$$

$$= 490,874 \times 248,211 \times (95,000 - 7,167/2)$$

$$= 11138220 \text{ Nmm}$$

$$= 11,13822 \text{ kNm}$$

$$\geq 1,33 \text{ Mn perlu -- OK --}$$

$$= 10,58268 \text{ kNm}$$

Tulangan Susut & Bagi:

pakai P8

$$As = 0,0020 \text{ b h}$$

$$s = 209,4395 \text{ mm}$$

$$= 0,002 \times 1000 \times 120$$

$$5 \text{ h} = 600 \text{ mm}$$

$$= 240 \text{ mm}^2/\text{m}'$$

$$\text{pakai P8 - 200 mm}$$

Tabel IV-4 Perhitungan tulangan pelat dua arah

| Ket. | Satuan | Bagian | | | |
|----------------|-----------------|-------------------|----------------|-------------------|-------------------|
| | | lx | tx | ly | ty |
| Mu | kNm | 6,36552 | 10,3667 | 1,54591 | 6,91114 |
| Φ | - | 0,8 | 0,8 | 0,8 | 0,8 |
| Mu/ Φ | kNm | 7,9569 | 12,9584 | 1,93239 | 8,63892 |
| asumsi d t | mm | 10 | 10 | 10 | 10 |
| b | mm | 1000 | 1000 | 1000 | 1000 |
| d | mm | 95 | 95 | 85 | 95 |
| β_1 | - | 0,85 | 0,85 | 0,85 | 0,85 |
| m | - | 14,6007 | 14,6007 | 14,6007 | 14,6007 |
| Rn | Mpa | 0,88165 | 1,43583 | 0,26746 | 0,95722 |
| ρ | - | 0,00365 | 0,00605 | 0,00109 | 0,00397 |
| ρ_b | - | 0,04118 | 0,04118 | 0,04118 | 0,04118 |
| ρ_{max} | - | 0,03089 | 0,03089 | 0,03089 | 0,03089 |
| ρ_{min} | - | 0,00564 | 0,00564 | 0,00564 | 0,00564 |
| ρ_{ambil} | - | 0,00485 | 0,00605 | 0,00144 | 0,00528 |
| | | $1,33\rho_{perl}$ | ρ_{perlu} | $1,33\rho_{perl}$ | $1,33\rho_{perl}$ |
| As | mm ² | 461,081 | 574,951 | 122,79 | 501,816 |
| Asst | mm ² | 240 | 240 | 240 | 240 |

| Ket. | Satuan | Bagian | | | |
|------------|-----------------|-----------|-----------|-----------|-----------|
| | | lx | tx | ly | ty |
| As ambil | mm ² | 461,081 | 574,951 | 240 | 501,816 |
| A l tul | mm ² | 78,5398 | 78,5398 | 78,5398 | 78,5398 |
| s | mm | 170,338 | 136,603 | 327,249 | 156,511 |
| s pakai | mm | 170 | 130 | 320 | 150 |
| As ada | mm ² | 461,999 | 604,152 | 245,437 | 523,599 |
| a | mm | 6,74549 | 8,82103 | 3,58354 | 7,64489 |
| Mn ada | kNm | 10,5072 | 13,5846 | 5,06906 | 11,8497 |
| Pakai Tul. | | P10 - 170 | P10 - 130 | P10 - 320 | P10 - 150 |

Hasil dari perhitungan pelat lantai dua arah dapat di lihat pada tabel berikut ini.

Tabel IV-5 Hasil perhitungan pelat dua arah

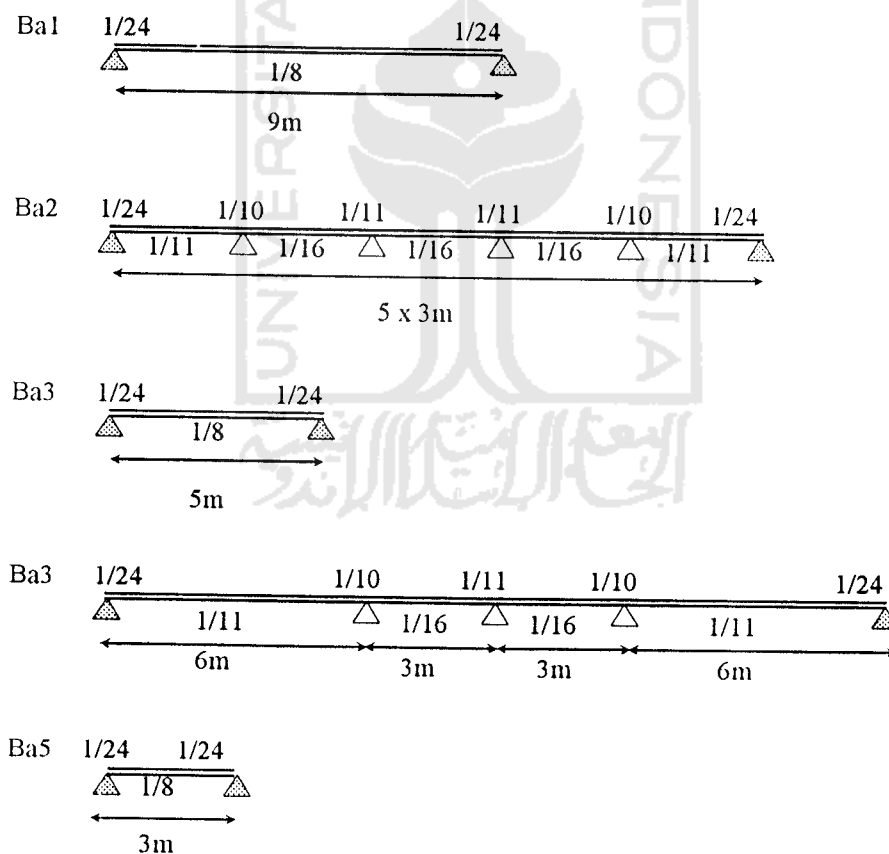
| Kode | Ukuran Ly×Lx, mm | beban(wu) kN/m | | Tulangan pelat di perlukan | | | | | | Sebelum perencanaan ulang | | | | | |
|------|------------------------|-------------------|-----------|----------------------------|-----------|-----------|-----------|-----------|-----------|---------------------------|-----------|-----------|-----------|-----------|-----------|
| | | LX | LY | LX | LY | TX | TY | LX | LY | TX | TY | LX | LY | TX | TY |
| I | 300×300 | 10,104 | P10 - 300 | P10 - 140 | P10 - 320 | P10 - 140 | P10 - 320 | P10 - 125 | P10 - 320 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 |
| II | 600×300 | 10,104 | P10 - 170 | P10 - 130 | P10 - 320 | P10 - 130 | P10 - 320 | P10 - 125 | P10 - 150 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 |
| III | 600×300 | 10,104 | P10 - 200 | P10 - 140 | P10 - 320 | P10 - 140 | P10 - 320 | P10 - 125 | P10 - 220 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 |
| IV | 500×300 | 10,104 | P10 - 200 | P10 - 140 | P10 - 320 | P10 - 140 | P10 - 320 | P10 - 125 | P10 - 150 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 |
| V | 500×300 | 10,104 | P10 - 230 | P10 - 150 | P10 - 320 | P10 - 150 | P10 - 320 | P10 - 125 | P10 - 220 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 |
| VI | 600×300 | 11,704 | P10 - 140 | P10 - 110 | P10 - 320 | P10 - 110 | P10 - 320 | P10 - 125 | P10 - 140 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 |
| VII | 600×300 | 11,704 | P10 - 170 | P10 - 140 | P10 - 320 | P10 - 140 | P10 - 320 | P10 - 125 | P10 - 190 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 |
| VIII | 300×300 | 11,704 | P10 - 320 | P10 - 170 | P10 - 320 | P10 - 170 | P10 - 320 | P10 - 125 | P10 - 190 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 |
| IX | 300×300 | 11,704 | P10 - 320 | P10 - 200 | P10 - 320 | P10 - 200 | P10 - 320 | P10 - 125 | P10 - 200 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 |
| X | 300×250 | 13,304 | P10 - 280 | P10 - 140 | P10 - 320 | P10 - 140 | P10 - 320 | P10 - 125 | P10 - 320 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 |
| XI | 300×175 | 9,304 | P10 - 320 | P10 - 320 | P10 - 320 | P10 - 320 | P10 - 320 | P10 - 125 | P10 - 320 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 |
| XII | 300×200 | 9,304 | P10 - 320 | P10 - 320 | P10 - 320 | P10 - 320 | P10 - 320 | P10 - 125 | P10 - 320 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 | P10 - 125 |

| Kode | Ukuran Ly×Lx, mm | beban(wu) | | Tulangan pelat di perlukan | | | Sebelum perencanaan ulang | | | | | |
|--------|------------------------|-----------|-----------|----------------------------|-----------|-----------|---------------------------|---------|---------|---------|--|--|
| | | kN/m | LX | TX | LY | TY | LX | TX | LY | TY | | |
| XIII | 250×200 | 9,304 | P10 - 320 | P10 - 320 | P10 - 320 | P10 - 320 | P10-125 | P10-125 | P10-125 | P10-125 | | |
| XIV | 400×300 | 10,104 | P10 - 280 | P10 - 160 | P10 - 320 | P10 - 210 | P10-125 | P10-125 | P10-125 | P10-125 | | |
| XV | 600×300 | 10,104 | P10 - 160 | P10 - 130 | P10 - 320 | P10 - 150 | P10-125 | P10-125 | P10-125 | P10-125 | | |
| VI 2 | 600×300 | 9,304 | P10 - 180 | P10 - 140 | P10 - 320 | P10 - 170 | P10-125 | P10-125 | P10-125 | P10-125 | | |
| VII 2 | 600×300 | 9,304 | P10 - 220 | P10 - 150 | P10 - 320 | P10 - 240 | P10-125 | P10-125 | P10-125 | P10-125 | | |
| VIII 2 | 300×300 | 9,304 | P10 - 320 | P10 - 210 | P10 - 320 | P10 - 240 | P10-125 | P10-125 | P10-125 | P10-125 | | |
| IX 2 | 300×300 | 9,304 | P10 - 320 | P10 - 250 | P10 - 320 | P10 - 250 | P10-125 | P10-125 | P10-125 | P10-125 | | |
| A | 300×300 | 10,104 | P10 - 320 | P10 - 230 | P10 - 320 | P10 - 230 | P10-125 | P10-125 | P10-125 | P10-125 | | |
| B | 600×300 | 9,304 | P10 - 220 | P10 - 150 | P10 - 320 | P10 - 240 | P10-125 | P10-125 | P10-125 | P10-125 | | |
| C | 600×300 | 9,304 | P10 - 220 | P10 - 150 | P10 - 320 | P10 - 240 | P10-125 | P10-125 | P10-125 | P10-125 | | |
| Susut | | | | P8-200 | | | P8-200 | | | P8-200 | | |
| Bagi | | | | P8-200 | | | P8-200 | | | P8-200 | | |

4.3. Perencanaan Balok Anak

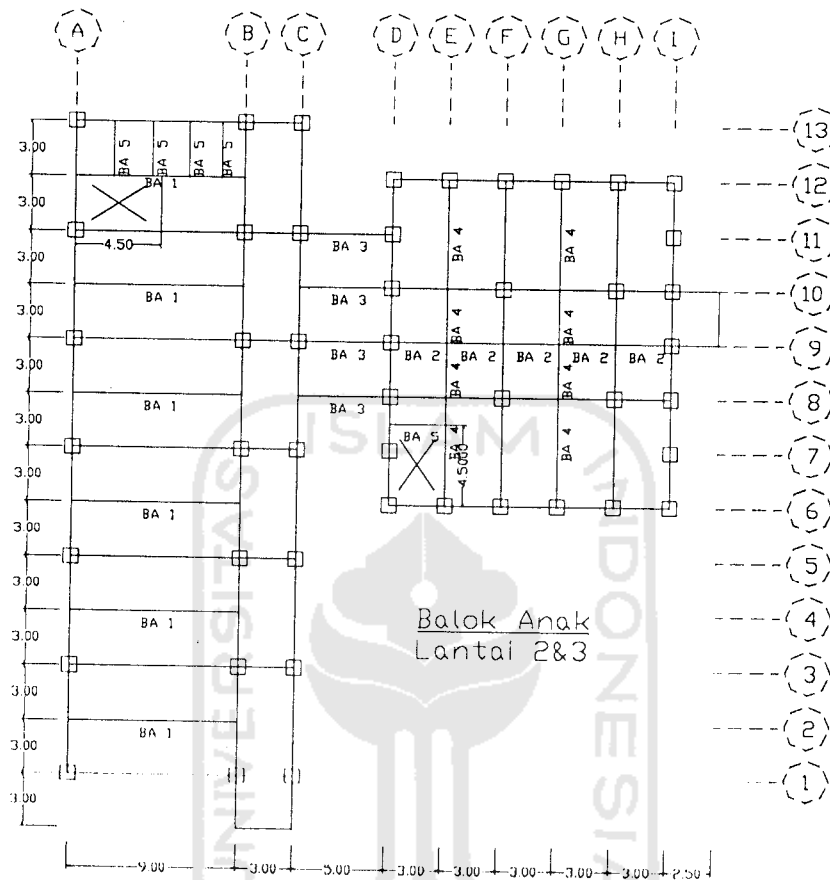
Balok anak di rencanakan sebagai balok persegi dengan tulangan sebelah, dengan mengambil beban dari perhitungan pelat. Beban pelat didistribusikan ke balok anak dengan menggunakan metode trapesium. Kemudian untuk menentukan momen balok anak digunakan koefisien momen untuk balok yang terdapat pada tabel 4.1 dari buku Gideon seri 4.

Pada perencanaan ulang di gunakan 5 tipe balok anak yang dapat di lihat pada gambar berikut ini.



Gambar IV-10 Tipe Balok Anak

Sedangkan letak dari balok anak dapat di lihat pada denah berikut ini.

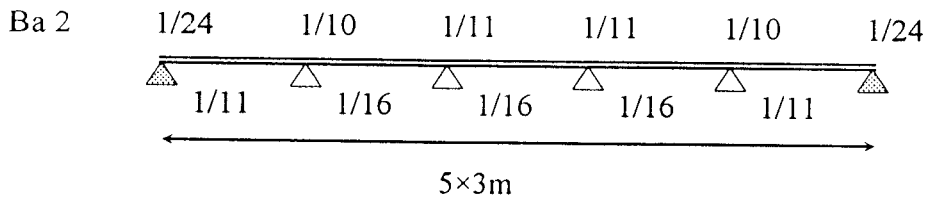


Gambar IV-11 Letak Balok Anak

Berikut ini adalah contoh perhitungan untuk balok anak.

Perencanaan Balok Anak

Balok Ba 2 lt. 2

Beban

Plat

$$L_y = 5 \text{ m}$$

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

$$t = 1/2 \times L_x = 1/2 \times 3 = 1,5 \text{ m}$$

$$h_{eq} = \frac{2t}{3} = \frac{2 \times 1,500}{3}$$

$$= 1 \text{ m}$$

$$W_u = 11,704 \text{ kN/m}^2$$

$$q_{upl} = 2 \times h_{eq} \times W_u = 2 \times 1,000 \times 11,704$$

$$= 23,408 \text{ kN/m}$$

Berat Sendiri

$$b, \text{ pakai} = 0,3 \text{ m}$$

$$\text{asumsi, } h = L / 12 = 5,000 / 12$$

$$= 0,416667 \text{ m}$$

$$b_j \text{ beton} = 23 \text{ kN/m}^3$$

$$q_D \text{ bs} = b \times h \times b_j = 0,3 \times 0,417 \times 23$$

$$= 2,875 \text{ kN/m}$$

Partisi

$$\text{tinggi, } h_t = 4 \text{ m}$$

$$q_D \text{ pt} = 2,5 \text{ kN/m}^2$$

| Beban | q, kN/m | faktor | qu, kN/m |
|------------|---------|---------|----------|
| Pelat | - | - | 23,408 |
| Brt sendir | 2,875 | 1,2 | 3,45 |
| Partisi | 2,5 | 1,2 | 3 |
| | | qu Ba 2 | 29,858 |

Perhitungan Momen

| Lapangan | L, m | Koef. | qu, kN/m | Mu = koef \times qu \times L ² , kNm | |
|----------|------|-------|----------|---|-----------------------------------|
| | | 5 | 1/16 | 29,858 | $1/16 \times 29,858 \times 5^2 =$ |
| | 5 | 1/11 | 29,858 | $1/11 \times 29,858 \times 5^2 =$ | 67,85909 |
| | | | | Mu max | 67,85909 |

| Tumpuan | L, m | Koef. | qu, kN/m | Mu = koef \times qu \times L ² , kNm | |
|---------|------|-------|----------|---|-----------------------------------|
| | | 5 | 1/24 | 29,858 | $1/24 \times 29,858 \times 5^2 =$ |
| | 5 | 1/10 | 29,858 | $1/10 \times 29,858 \times 5^2 =$ | 74,645 |
| | 5 | 1/11 | 29,858 | $1/11 \times 29,858 \times 5^2 =$ | 67,85909 |
| | | | | Mu max | 74,645 |

Design penampang

$$f_c' = 20 \text{ MPa}$$

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

$$\beta_1 = 0,85$$

$$\Phi = 0,8$$

$$M_u \text{ design} = 74,645 \text{ kNm}$$

$$M_n \text{ desain} = \frac{M_u}{\Phi} = \frac{74,645}{0,8}$$

$$= 93,30625 \text{ kNm}$$

$$m = \frac{f_y}{0,85 f_c'} = \frac{240}{0,85 \times 20} = 14,11765$$

$$\rho_b = \frac{0,85 \times f_c'}{f_y} \times \beta_1 \times \frac{600}{600 + f_y}$$

$$= \frac{0,85 \times 20,000}{240} \times 0,85 \times \frac{600}{600 + 240,000}$$

$$= 0,043006$$

$$\rho_{\max} = 0,75 \times \rho_b = 0,75 \times 0,043006 = 0,032254$$

$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{240} = 0,005833$$

$$\rho = 0,5 \times \rho_{\max} = 0,5 \times 0,03225 = 0,016127$$

$$\begin{aligned}
 R_n &= \rho \times f_y \times (1 - 0,5 \times \rho \times m) \\
 &= 0,01613 \times 240,000 \times (1 - 0,5 \times 0,01613 \times 14,118) \\
 &= 3,429917 \text{ MPa}
 \end{aligned}$$

$$\begin{aligned}
 b d^2 &= \frac{M_n \text{ desain}}{R_n} = \frac{93,30625 \times 1000000}{3,429916693} \\
 &= 27203649 \text{ mm}^3
 \end{aligned}$$

| b, mm | d, mm | b pakai = | 300 mm |
|-------|----------|----------------------|-------------|
| 200 | 368,8065 | d = | 301,1293 mm |
| 250 | 329,8706 | d tulangan = | 16 mm |
| 300 | 301,1293 | d sengkang = | 10 mm |
| 350 | 278,7915 | penutup beton = | 40 mm |
| 400 | 260,7856 | rak antar tulangan = | 25 mm |

$$\begin{aligned}
 d_s &= \text{tebal penutup beton} + d \text{ sengkang} + d \text{ tulangan} / 2 + \text{spasi} \\
 &= 40 + 10 + 16/2 + 25,000 \\
 &= 83 \text{ mm}
 \end{aligned}$$

$$\begin{aligned}
 h \text{ pakai} &= d + d_s & d \text{ ada} &= h - d_s \\
 &= 301,129 + 83,000 & &= 400 - 83,000 \\
 &= 384,1293 \text{ mm} & &= 317 \text{ mm} \\
 &= 400 \text{ mm}
 \end{aligned}$$

Jadi dimensi balok anak ba 2: 300 / 400 (mm)

Penulangan balok

b = 300 mm

h = 400 mm

d = 317 mm

Penulangan daerah Mu max

Mu max = 74,645 kNm

Mu / Φ = 93,30625 kNm

bd² = 300 × 317² = 30146700 mm³

$$R_n \text{ baru} = \frac{Mu / \Phi}{bd^2} = \frac{93,30625 \times 1000000}{30146700}$$

= 3,095073 MPa

$$\rho \text{ baru} = \rho \times \frac{R_n \text{ baru}}{R_n} = 0,01613 \times \frac{3,095073}{3,429917}$$

= 0,014553

As perlu = ρ × b × d = 0,01455 × 300 × 317 = 1383,973 mm²

| | | | | | |
|-----------|----|----|-----------|----|----|
| d | 14 | 12 | 16 | 19 | 20 |
| jml perlu | 9 | 13 | 7 | 5 | 5 |

d tulangan = 16 mm tul. per baris = 5

jml perlu = 7 jml baris = 2

As ada = 1407,434 mm² tul. baris terakhir = 2

titik pusat luas tulangan:

$$x_1 = \frac{(\text{jml tul. per brs}) \times [(\text{jml brs}-1)(\text{spasi}+d/2)] + (\text{tul. brs terakhir}) \times [d/2]}{\text{jml tul.}}$$

$$= \frac{5 \times [(2-1)(25+16/2)] + 2 \times [16/2]}{7}$$

$$= 25,85714 \text{ mm}$$

$$d_s = x_1 + d \text{ sengkang} + \text{penutup beton}$$

$$= 25,857 + 10 + 40$$

$$= 75,85714 \text{ mm} \leq 83,000 \text{ mm} \text{ -- OK --}$$

$$j_{bd} = \frac{b - 2 \times (\text{penutup beton} + d \text{ sengkang}) - (\text{tul. per baris} \times d \text{ tul})}{\text{tul. per baris} - 1}$$

$$= \frac{300 - 2 \times (40 + 10) - (5 \times 16)}{5 - 1}$$

$$= 30 \text{ mm} > 25 \text{ mm} \text{ -- OK --}$$

Berikut ini adalah rangkuman hasil perhitungan balok anak

Tabel IV-6 Hasil perhitungan balok anak

Ba 1 lt. 2 & 3 400 / 650 $q_u = 31,488 \text{ kN/m}$

| | | |
|--------|-------|------|
| bagian | 1/8 | 1/24 |
| | 12D19 | 4D19 |

Ba 2 lt. 2 300 / 400 $q_u = 29,858 \text{ kN/m}$

| | | | | | |
|--------|------|------|------|------|------|
| bagian | 1/16 | 1/11 | 1/24 | 1/10 | 1/11 |
| | 5D16 | 7D16 | 3D16 | 7D16 | 7D16 |

Ba 2 lt. 3 300 / 400 $q_u = 25,058 \text{ kN/m}$

| | | | | | |
|--------|------|------|------|------|------|
| bagian | 1/16 | 1/11 | 1/24 | 1/10 | 1/11 |
| | 4D16 | 6D16 | 3D16 | 6D16 | 6D16 |

Ba 3 lt. 2 & 3 300 / 450 $q_u = 26,658 \text{ kN/m}$

| | | |
|--------|------|------|
| bagian | 1/8 | 1/24 |
| | 7D16 | 3D16 |

Ba 4 lt. 2 300 / 450 $q_u = 29,858 \text{ kN/m}$

| | | | | | |
|--------|------|------|------|------|------|
| bagian | 1/16 | 1/11 | 1/24 | 1/10 | 1/11 |
| | 2D16 | 8D16 | 4D16 | 9D16 | 2D16 |

Ba 4 lt. 3 300 / 450 $q_u = 25,058 \text{ kN/m}$

| | | | | | |
|--------|------|------|------|------|------|
| bagian | 1/16 | 1/11 | 1/24 | 1/10 | 1/11 |
| | 2D16 | 7D16 | 3D16 | 7D16 | 2D16 |

Ba 5 lt. 2 250 / 300 $q_u = 24,933 \text{ kN/m}$

| | | |
|--------|------|------|
| bagian | 1/8 | 1/24 |
| | 4D16 | 2D16 |

4. 4. Analisis Struktur

Untuk memperoleh gaya-gaya yang terjadi pada struktur dilakukan analisis struktur dengan bantuan program komputer yaitu SAP 2000. Dengan program ini nantinya dapat di peroleh hasil berupa gaya aksial, geser, dan momen yang terjadi pada struktur. Adapun data yang dipergunakan untuk menghasilkan gaya-gaya tersebut, diperoleh dari beberapa sumber yaitu:

- Data geometri struktur, diambil dari gambar-gambar struktur seperti denah dan potongan.
- Data beban atap, diambil dari perhitungan perencanaan atap.
- Data beban balok, diambil dari perhitungan pelat dan beban tembok
- Data beban gempa berupa riwayat waktu, diambil dari data gempa Elcentro yang dimiliki oleh SAP 2000.
- Serta beberapa data pendukung lainnya.

Data geometri struktur di pergunakan untuk membuat model struktur, kemudian data beban di masukkan ke model struktur, lalu di buat kombinasi-kombinasi beban. Untuk output digunakan gaya dari kombinasi beban ULTBLK dan ULTKLM yang merupakan hasil maximum dan minimum dari kombinasi lainnya yaitu kombinasi:

- 1,4 M
- 1,2 M + 1,6 H
- 1,05 (M + Hr + G)

dimana: M adalah gaya akibat beban mati.

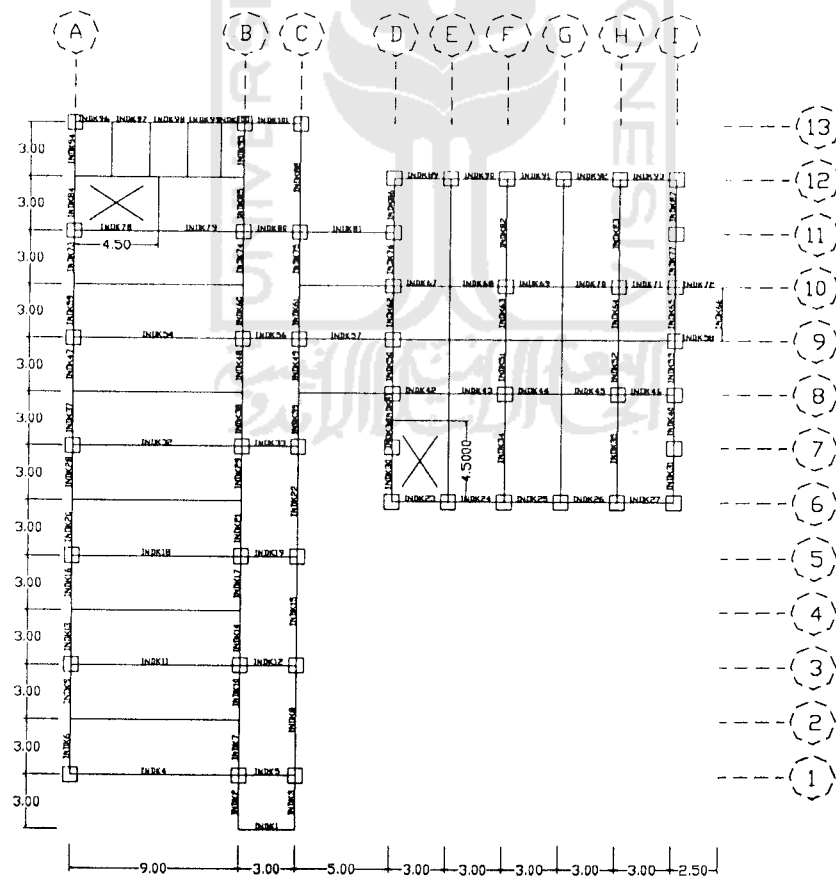
H adalah gaya akibat beban hidup.

Hr adalah gaya akibat beban hidup yang tereduksi factor 0,6.

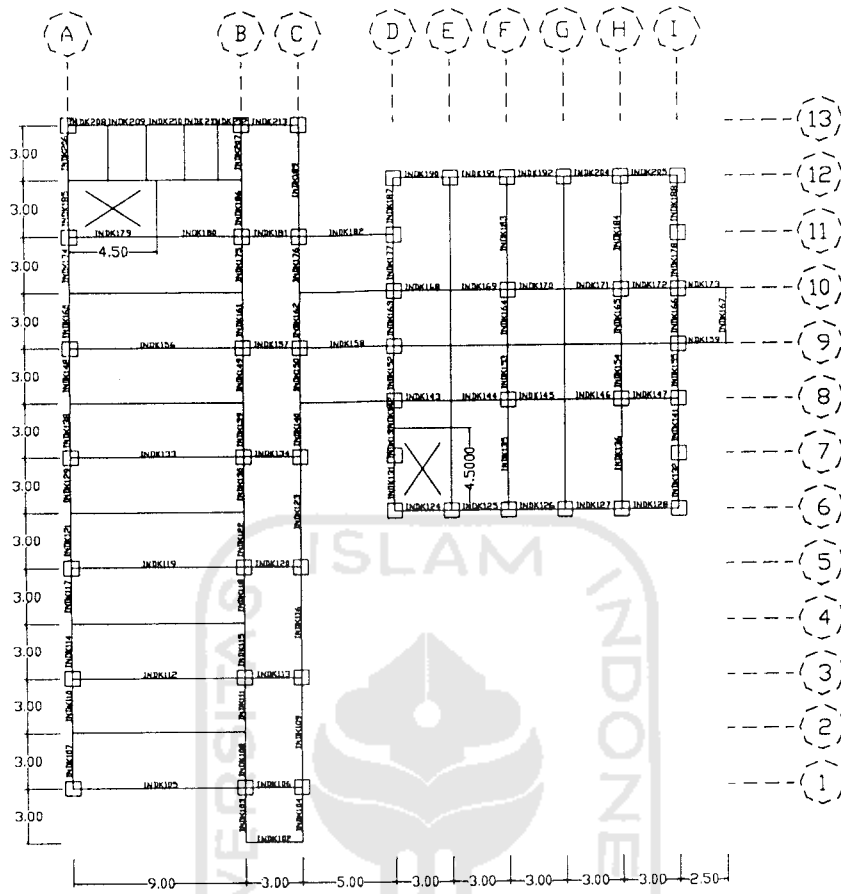
G adalah gaya akibat beban gempa dinamis.

4. 5. Perencanaan Balok Induk

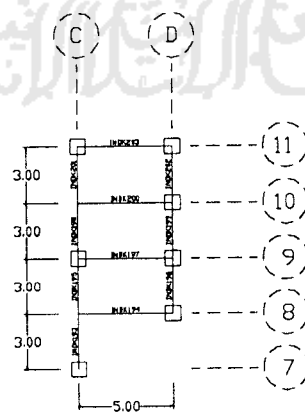
Balok induk direncanakan sebagai balok dengan tulangan rangkap, dengan dimensi awal berdasarkan perencanaan balok dengan tulangan sebelah. Perencanaan menggunakan hasil-hasil yang di peroleh dari analisis struktur, seperti halnya momen dan gaya geser. Perletakkan dari balok-balok induk dapat di lihat pada gambar berikut ini.



Gambar IV-12 Letak Balok Induk Pada Lantai 2



Gambar IV-13 Letak Balok Induk Pada Lantai 3



Gambar IV-14 Letak Balok Induk Pada Atap

Berikut ini adalah contoh perhitungan balok induk.

Perencanaan Balok Induk

Hasil SAP Balok INDK54

FRAME

LOC P V2 V3 T M2 M3

INDK54 ULTBLK MAX

| | | | | | | |
|-----|---|---------|---|--------|---|--------|
| 0,2 | 0 | 6,96 | 0 | 0,2241 | 0 | 214,78 |
| 4,5 | 0 | 62,4364 | 0 | 0,2241 | 0 | 102,96 |
| 8,8 | 0 | 128,018 | 0 | 0,2241 | 0 | 142,3 |

INDK54 ULTBLK MIN

| | | | | | | |
|-----|---|---------|---|---------|---|---------|
| 0,2 | 0 | -123,45 | 0 | -0,1195 | 0 | -355,33 |
| 4,5 | 0 | -57,86 | 0 | -0,1195 | 0 | 27,84 |
| 8,8 | 0 | -3,9 | 0 | -0,1195 | 0 | -322,05 |

Momen

M tumpuan max, $M_{tmp} = 355,33$ kNm

M lapangan max, $M_{lap} = 102,96$ kNm

Geser

V1 = 128,0183 kNm di: 0,2 m

V2 = 62,43635 kNm di: 4,5 m

Design penampang

$f_c' = 20$ MPa

$f_y = 58,0151$ ksi = 400 MPa

$\beta_1 = 0,85$

$\Phi = 0,8$

$E_c = 4700\sqrt{f_c'} = 4700\sqrt{20} = 21019,04$ MPa

$$E_s = 29000 \text{ ksi} = 199948 \text{ MPa}$$

$$M_u \text{ design} = 355,33 \text{ kNm}$$

$$M_n \text{ desain} = \frac{M_u}{\Phi} = \frac{355,33}{0,8}$$

$$= 444,163 \text{ kNm}$$

$$m = \frac{f_y}{0,85 f_c'} = \frac{400}{0,85 \times 20} = 23,52941$$

$$\rho_b = \frac{0,85 \times f_c'}{f_y} \times \beta_1 \times \frac{600}{600 + f_y}$$

$$= \frac{0,85 \times 20,000}{400} \times 0,850 \times \frac{600}{600 + 400,000}$$

$$= 0,02168$$

$$\rho_{\max} = 0,75 \times \rho_b = 0,75 \times 0,021675 = 0,016256$$

$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{400} = 0,0035$$

$$\rho = \rho_{\max} = 0,016256$$

$$R_n = \rho \times f_y \times (1 - 0,5 \times \rho \times m)$$

$$= 0,01626 \times 400,000 \times (1 - 0,5 \times 0,01626 \times 23,529)$$

$$= 5,2589 \text{ MPa}$$

$$b d^2 = \frac{M_n \text{ desai}}{R_n} = \frac{444,1625 \times 1000000}{5,258896875}$$

$$= 8,4E+07 \text{ mm}^3$$

| b, mm | d, mm |
|------------|----------------|
| 300 | 530,595 |
| 350 | 491,235 |
| 400 | 459,509 |
| 450 | 433,229 |
| 500 | 410,997 |

$$b \text{ pakai} = 400 \text{ mm}$$

$$d = 459,5086 \text{ mm}$$

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

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

$$d \text{ sengkang} = 10 \text{ mm}$$

$$\text{penutup beton} = 40 \text{ mm}$$

$$\text{jarak antar tulangan} = 25 \text{ mm}$$

$$d \text{ pakai} = 0,8 d$$

$$d \text{ pakai} = 0,8 \times 459,509 = 367,6069 \text{ mm}$$

$$d_s = \text{tebal penutup beton} + d \text{ sengkang} + d \text{ tulangan} / 2 + \text{spasi}$$

$$= 40 + 10 + 22/2 + 25,000$$

$$= 86 \text{ mm}$$

$$d' = \text{tebal penutup beton} + d \text{ sengkang} + d \text{ tulangan} / 2$$

$$= 40 + 10 + 22/2$$

$$= 61 \text{ mm}$$

$$h \text{ pakai} = d + d_s$$

$$d \text{ ada} = h - d_s$$

$$= 367,607 + 86,000$$

$$= 650 - 86,000$$

$$= 453,607 \text{ mm}$$

$$= 564 \text{ mm}$$

$$= 650 \text{ mm}$$

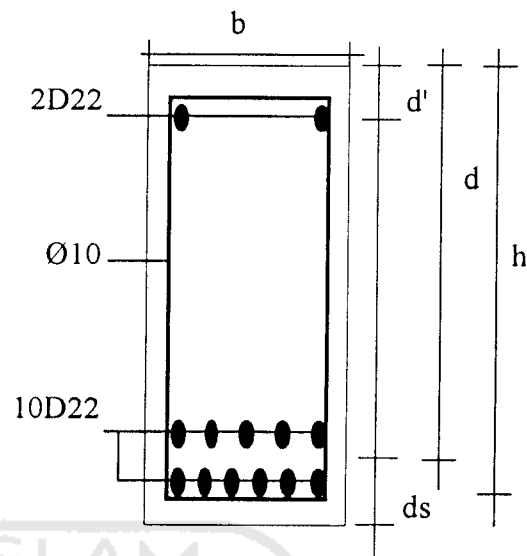
Jadi dimensi balok induk INDK54 : **400 / 650 (mm)**

Penulangan daerah Mu max

$$b = 400 \text{ mm}$$

$$h = 650 \text{ mm}$$

$$d = 564 \text{ mm}$$



$$x = \frac{600 d}{600 + f_y} = \frac{600 \times 564,000}{600 + 400,000}$$

$$= 338,4 \text{ mm}$$

$$a = \beta_1 x = 0,85 \times 338,400 = 287,64 \text{ mm}$$

$$M_n \text{ desain} = 444,163 \text{ kNm}$$

$$A_s 1 = \rho \times b \times d$$

$$0,01626 \times 400 \times 564 = 3667,41 \text{ mm}^2$$

$$T_1 = A_s 1 \times f_y = 3667,410 \times 400,000$$

$$= 1466964 \text{ Nmm}$$

$$M_{n1} = T_1 \times \left(d - \frac{a}{2} \right)$$

$$= 1466964 \times \left(564 - \frac{287,64}{2} \right)$$

$$= 6,2E+08 \text{ Nmm}$$

$$= 616,389 \text{ kNm}$$

$$Mn2 = Mn - Mn1 = 444,163 - 616,389$$

$$= -172,226 \text{ kNm}$$

$$= 0 \text{ Nmm}$$

$$T2 = Cs = \frac{Mn2}{d - d'} = \frac{0}{564,000 - 61,000}$$

$$= 0 \text{ Nmm}$$

periksa regangan:

$$\epsilon_{cu} = 0,003$$

$$\epsilon_y = \frac{f_y}{E_s} = \frac{400}{199948}$$

$$= 0,002$$

$$\epsilon_s = \frac{(d - x)\epsilon_{cu}}{x} = \frac{(564,000 - 338,400) \times 0,003}{338,4}$$

$$= 0,002 < \epsilon_y = 0,002001 \text{ -- belum leleh --}$$

$$\epsilon_{s'} = \frac{(x - d')\epsilon_c}{x} = \frac{(338,400 - 61,000) \times 0,003}{338,4}$$

$$= 0,00246 \geq \epsilon_y = 0,002001 \text{ -- sudah leleh --}$$

$$f_{s'} = \epsilon_{s'} \times E_s$$

$$\epsilon_{s'} = 0,002$$

$$f_s' = \epsilon_s' \times E_s = 0,00200 \times 199947,962$$

$$= 400 \text{ MPa}$$

$$A_s' = \frac{C_s}{f_s'} = \frac{0}{400}$$

$$= 0 \text{ mm}^2$$

$$A_{s2} = \frac{T_2}{f_y} = \frac{0}{400}$$

$$= 0 \text{ mm}^2$$

$$A_s = A_{s1} + A_{s2} = 3667,410 + 0,000$$

$$= 3667,41 \text{ mm}^2$$

pilih tulangan pakai:

$$A_s' = 0 \text{ mm}^2$$

| | | | | | |
|-----------|----|----|-----------|----|----|
| d | 19 | 20 | 22 | 25 | 28 |
| jml perlu | 1 | 1 | 1 | 1 | 1 |

$$d \text{ tulangan} = 22 \text{ mm} \quad \text{tul. per baris} = 6$$

$$\text{jml pakai} = 2 \quad \text{jml baris} = 1$$

$$A_s' \text{ ada} = 760,265 \text{ mm}^2 \quad \text{tul. baris terakhir} = 2$$

titik pusat luas tulangan:

$$\frac{(\text{jml tul. per brs}) \times [(\text{jml brs}-1)(\text{spasi}+d/2)] + (\text{tul. brs terakhir}) \times [d/2]}{\text{jml tul.}}$$

$$\begin{aligned}
 & 6 \times [(1-1)(25+22/2)] \\
 & = + 2 \times [22/2] \\
 & \hline
 & \qquad \qquad \qquad 2 \\
 & = \qquad \qquad 11 \text{ mm}
 \end{aligned}$$

$$d' = x_1 + d \text{ sengkang} + \text{penutup beton}$$

$$= 11,000 + 10 + 40$$

$$= \qquad 61 \text{ mm} \qquad \leq 61,000 \text{ mm -- OK --}$$

$$As = 3667,41 \text{ mm}^2$$

| | | | | | |
|-----------|----|----|-----------|----|----|
| d | 19 | 20 | 22 | 25 | 28 |
| jml perlu | 13 | 12 | 10 | 8 | 6 |

$$d \text{ tulangan} = \qquad 22 \text{ mm} \qquad \qquad \text{tul. per baris} = \qquad 6$$

$$\text{jml pakai} = \qquad 10 \qquad \qquad \text{jml baris} = \qquad 2$$

$$As \text{ ada} = 3801,33 \text{ mm}^2 \qquad \text{tul. baris terakhir} = \qquad 4$$

titik pusat luas tulangan:

$$\begin{aligned}
 & (\text{jml tul. per brs}) \times [(\text{jml brs}-1)(\text{spasi}+d/2)] \\
 x_1 = & +(\text{tul. brs terakhir}) \times [d/2] \\
 & \hline
 & \qquad \qquad \qquad \text{jml tul.}
 \end{aligned}$$

$$\begin{aligned}
 & 6 \times [(2-1)(25+22/2)] \\
 & = + 4 \times [22/2] \\
 & \hline
 & \qquad \qquad \qquad 10 \\
 & = \qquad \qquad 26 \text{ mm}
 \end{aligned}$$

$$\begin{aligned}
 ds &= x_1 + d \text{ sengkang} + \text{penutup beton} \\
 &= 26,000 + 10 + 40 \\
 &= 76 \text{ mm} \leq 86,000 \text{ mm -- OK --}
 \end{aligned}$$

$$\begin{aligned}
 d \text{ ada} &= h - ds \\
 &= 650 - 76,000 \\
 &= 574 \text{ mm}
 \end{aligned}$$

$$As_1 = As - As' \quad 3801,327 - 760,265$$

$$= 3041,06 \text{ mm}^2$$

$$\begin{aligned}
 \rho &= \frac{As_1}{b d} = \frac{3041,061689}{400,000 \times 574,000} \\
 &= 0,01325 \leq \rho \text{ max} = 0,016256 \text{ -- Ok --}
 \end{aligned}$$

periksa kapasitas penampang:

$$\begin{aligned}
 C_c &= 0,85 \times f_c' \times b \times a = 0,85 \times 20,000 \times 400,000 \times a \\
 &= 6800 a
 \end{aligned}$$

$$\begin{aligned}
 C_s &= As' (f_y - 0,85 \times f_c') \\
 &= 760,265 \times (400,000 - 0,85 \times 20,000) \\
 &= 291182 \text{ N}
 \end{aligned}$$

$$T = As \times f_y = 3801,327 \times 400,000$$

$$= 1520531 \text{ N}$$

$$a = \frac{1520530,844 - 291181,657}{6800}$$

$$= 180,787 \text{ mm}$$

$$x = \frac{a}{\beta_1} = \frac{180,7866}{0,85}$$

$$= 212,69 \text{ mm}$$

periksa regangan:

$$\epsilon_{cu} = 0,003$$

$$\epsilon_y = \frac{f_y}{E_s} = \frac{400}{199948}$$

$$= 0,002$$

$$\epsilon_s = \frac{(d - x)\epsilon_{cu}}{x} = \frac{(564,000 - 212,690) \times 0,003}{212,6902}$$

$$= 0,00496 \geq \epsilon_y = 0,002001 \text{ -- sudah leleh --}$$

$$\epsilon_s' = \frac{(x - d')\epsilon_c}{x} = \frac{(212,690 - 61,000) \times 0,003}{212,6902}$$

$$= 0,00214 \geq \epsilon_y = 0,002001 \text{ -- sudah leleh --}$$

hitung momen nominal:

$$C_c = 6800 a = 6800,000 \times 180,787$$

$$= 1229349 \text{ N}$$

$$M_n = C_c (d - a/2) + C_s (d - d')$$

$$= 1229349,188 \times (564,000 - 180,787/2) +$$

$$291181,657 \times (564,000 - 61,000)$$

$$= 7,3E+08 \text{ Nmm} = 728,6924 \text{ kNm}$$

$$\geq M_n \text{ design} = 444,1625 \text{ kNm} \text{ -- Ok --}$$

Perencanaan tulangan geser balok induk

Dari data sap 2000, gaya geser penampang kritis:

$$V_1 = 128,0183 \text{ kNm} \quad \text{di:} \quad 0,2 \text{ m} = \quad 200 \text{ mm}$$

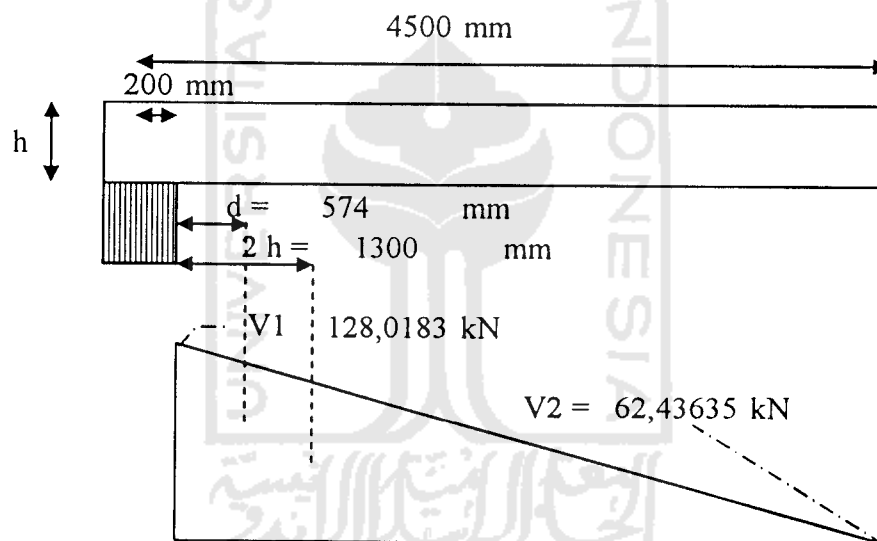
$$V_2 = 62,43635 \text{ kNm} \quad \text{di:} \quad 4,5 \text{ m} = \quad 4500 \text{ mm}$$

$$b = \quad 400 \text{ mm} \quad \quad \quad d \text{ sengkang} = \quad 10 \text{ mm}$$

$$h = \quad 650 \text{ mm} \quad \quad \text{jml kaki sengkang} = \quad 2 \text{ (vertikal)}$$

$$d = \quad 574 \text{ mm} \quad \quad \quad F_y = \quad 240 \text{ MPa}$$

$$\Phi = \quad 0,6$$



$$V_c = 1/6 \times \sqrt{f_c'} \times b \times d$$

$$= 171133,7 \text{ N}$$

$$= 171,1337 \text{ kN}$$

$$d/2 = 574,000/2$$

$$= \quad 287 \text{ mm}$$

$$d/4 = 574,000/4$$

$$= \quad 143,5 \text{ mm}$$

$$V_{s1} = 2 V_c = \quad 2 \times 171,134 = \quad 342,2675 \text{ kN}$$

$$V_{s2} = 4 V_c = \quad 4 \times 171,134 = \quad 684,5349 \text{ kN}$$

$$\Phi V_c = 0,6 \times 171,134 = 102,6802 \text{ kN}$$

$$\Phi 1/2 V_c = 1/2 \times 102,680 = 51,34012 \text{ kN}$$

$$\Phi V_{s1} = 0,6 \times 342,267 = 205,3605 \text{ kN}$$

$$\Phi V_{s2} = 0,6 \times 684,535 = 410,721 \text{ kN}$$

$$\Phi(V_c + V_{s1}) = \Phi 3 V_c = 0,6 \times (102,680 + 205,360) = 184,8244 \text{ kN}$$

$$\Phi(V_c + V_{s2}) = \Phi 5 V_c = 0,6 \times (102,680 + 410,721) = 308,0407 \text{ kN}$$

$$l_1 = 4500,000 - 200,000$$

$$= 4300 \text{ mm}$$

$$\Delta V_u = 128,018 - 62,436 = 65,58195 \text{ kN}$$

$$V_u \text{ pada jarak } d = 62,436 + \frac{4300,000 - 574,000}{4300} \times 65,582$$

$$= 119,264 \text{ kN}$$

$$\geq 1/2 V_c = 51,34012 \text{ kN} \quad \text{-- OK --}$$

$$\leq \Phi 5 V_c = 308,0407 \text{ kN} \quad \text{-- OK --}$$

V_u berada pada daerah:

$$\Phi 1/2 V_c \quad \text{s.d.} \quad \Phi 3 V_c$$

$$2h = 1300 \text{ mm}$$

$$V_u \text{ pada jarak } 2h = 62,436 + \frac{4300,000 - 1300,000}{4300} \times 65,582$$

$$= 108,191 \text{ kN}$$

$$A_v = k_s \frac{1}{4} \pi d^2 \quad 2 \times \frac{1}{4} \pi \times 10^2$$

$$= 157,08 \text{ mm}$$

Daerah: ΦV_c s/d $\Phi 3 V_c$

$$V_u = 184,824 \text{ kN}$$

$$\Phi V_s = V_u - \Phi V_c = 184,824 - 102,680$$

$$= 82,1442 \text{ kN}$$

$$V_s \text{ perlu} = 82,1442 / 0,6$$

$$= 136,907 \text{ kN}$$

$$= 136907 \text{ N}$$

$$s = \frac{A_v \times f_y \times d}{V_s} = \frac{157,080 \times 240,000 \times 574,000}{136907}$$

$$V_s$$

$$= 158,058 \text{ mm}$$

$$s \text{ pakai} = 155 \text{ mm}$$

$$\leq d / 2 = 287 \text{ mm} \quad \text{-- OK --}$$

$$\leq 600 \text{ mm} \quad \text{-- OK --}$$

$$x = \frac{(\Phi V_c - V_2) \times 11}{\Delta V_u}$$

$$= \frac{(102,680 - 62,436) \times 4500,000}{65,58195}$$

$$= 2761,39$$

Daerah: $\Phi 1/2 V_c$ s/d ΦV_c

$$V_u = 102,68 \text{ kN}$$

Tulangan geser minimum

$$s = \frac{3 A_v f_y}{b} = \frac{3,000 \times 157,080 \times 240,000}{400}$$

$$= 282,743 \text{ mm}$$

$$s \text{ pakai} = 280 \text{ mm}$$

$$\leq d / 2 = 287 \text{ mm} \quad \text{-- OK --}$$

$$\leq 600 \text{ mm} \quad \text{-- OK --}$$

$$x = \frac{(\Phi 1/2 V_c - V_2) \times l_1}{\Delta V_u}$$

$$= \frac{(51,340 - 62,436) \times 4500,000}{65,58195}$$

$$= -761,384$$

Rangkuman hasil perhitungan balok induk dapat di lihat pada tabel berikut ini.

Tabel IV-7 Hasil Perhitungan Balok Induk

| Hasil | M tumpuan kNm | M lapangan kNm | V tumpuan kN | V lapangan kN | Ukuran mm | Panjang m | Lentur | | | Tumpuan | | | Daerah Gaya Geser | | $\Phi 3Vc-\Phi 5Vc$ | | $\Phi Vc-\Phi 3Vc$ | | $\Phi 1/2Vc-\Phi Vc$ | | | | | | |
|------------|---------------|----------------|--------------|---------------|-----------|-----------|--------|-------|------|---------|------------|--------------|-------------------|---------|---------------------|---------|--------------------|---------|----------------------|---|----|----|---|---|----|
| | | | | | | | As' | As | As' | As | As' | As | min | max | s | x | mm | mm | s | x | mm | mm | s | x | mm |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| INDK4 | -370,60 | 121,10 | 149,47 | 62,84 | 400/650 | 9,00 | 2D22 | 10D22 | 2D22 | 10D22 | 10D22 | $\Phi 1/2Vc$ | $\Phi 3Vc$ | P10-140 | - | P10-155 | 2069,32 | P10-285 | - | | | | | | |
| INDK11 | -340,49 | 107,64 | 125,94 | 60,36 | 400/650 | 9,00 | 2D22 | 10D22 | 2D22 | 10D22 | 10D22 | $\Phi 1/2Vc$ | $\Phi 3Vc$ | P10-140 | - | P10-155 | 2904,06 | P10-285 | - | | | | | | |
| INDK18 | -400,03 | 153,10 | 170,95 | 61,09 | 400/650 | 9,00 | 2D22 | 10D22 | 2D22 | 10D22 | 10D22 | $\Phi 1/2Vc$ | $\Phi 3Vc$ | P10-140 | - | P10-155 | 1703,59 | P10-285 | - | | | | | | |
| INDK32 | -350,43 | 101,47 | 124,71 | 59,13 | 400/650 | 9,00 | 2D22 | 10D22 | 2D22 | 10D22 | 10D22 | $\Phi 1/2Vc$ | $\Phi 3Vc$ | P10-140 | - | P10-155 | 2988,53 | P10-285 | - | | | | | | |
| INDK54 | -355,25 | 102,98 | 128,02 | 62,44 | 400/650 | 9,00 | 2D22 | 10D22 | 2D22 | 10D22 | 10D22 | $\Phi 1/2Vc$ | $\Phi 3Vc$ | P10-140 | - | P10-155 | 2761,39 | P10-285 | - | | | | | | |
| INDK78,79 | -389,38 | 205,58 | 171,61 | 45,55 | 400/650 | 9,00 | 2D22 | 10D22 | 2D22 | 10D22 | 0 | $\Phi 3Vc$ | $\Phi 3Vc$ | P10-140 | - | P10-155 | 2039,39 | P10-285 | 206,69 | | | | | | |
| INDK96-100 | -483,15 | 240,81 | 236,15 | 81,34 | 400/650 | 9,00 | 2D22 | 10D22 | 2D22 | 10D22 | 10D22 | $\Phi 1/2Vc$ | $\Phi 5Vc$ | P10-115 | 3008,07 | P10-155 | 620,32 | P10-285 | - | | | | | | |
| INDK1 | -24,46 | 11,35 | 22,44 | 10,86 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | 0 | tidakperlu | - | - | - | P10-155 | - | P10-235 | - | | | | | | |
| INDK5 | -323,52 | 19,06 | 213,26 | 197,42 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | $\Phi 3Vc$ | $\Phi 5Vc$ | $\Phi 5Vc$ | P10-85 | - | P10-155 | - | P10-235 | - | | | | | | |
| INDK12 | -320,60 | 22,31 | 214,41 | 198,57 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | $\Phi 3Vc$ | $\Phi 5Vc$ | $\Phi 5Vc$ | P10-85 | - | P10-155 | - | P10-235 | - | | | | | | |
| INDK19 | -340,97 | 14,57 | 222,60 | 206,76 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | $\Phi 3Vc$ | $\Phi 5Vc$ | $\Phi 5Vc$ | P10-80 | - | P10-155 | - | P10-235 | - | | | | | | |
| INDK33 | -302,67 | 34,12 | 199,86 | 184,02 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | $\Phi 3Vc$ | $\Phi 5Vc$ | $\Phi 5Vc$ | P10-95 | - | P10-155 | - | P10-235 | - | | | | | | |
| INDK56 | -338,38 | 69,96 | 198,53 | 182,69 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | $\Phi 3Vc$ | $\Phi 5Vc$ | $\Phi 5Vc$ | P10-95 | - | P10-155 | - | P10-235 | - | | | | | | |
| INDK80 | -336,28 | 50,68 | 183,57 | 167,73 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | $\Phi 3Vc$ | $\Phi 5Vc$ | $\Phi 5Vc$ | P10-110 | - | P10-155 | - | P10-235 | - | | | | | | |

| Hasil | M tumpuan kNm | M lapangan kNm | V tumpuan kN | V lapangan kN | Ukuran mm | Pan- jang | | Lentur | | Tumpuan | | Daerah Gaya Geser | | Φ3Vc-Φ5Vc | | ΦVc-Φ3Vc | | Φ½Vc-ΦVc | | | | |
|----------|------------------|-------------------|-----------------|------------------|--------------|--------------|------|--------|------|---------|------|----------------------|---------|-----------|---------|----------|---|----------|----|---|---|----|
| | | | | | | m | As' | As | As' | As | As' | As | mm | s | x | mm | s | x | mm | s | x | mm |
| | | | | | | | | | | | | | | | | | | | | | | |
| INDK24 | -143,18 | 17,93 | 121,14 | 95,92 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | ΦVc | Φ3Vc | P10-115 | P10-155 | P10-235 | - | - | - | - | | | |
| INDK25 | -140,69 | 8,36 | 117,49 | 92,26 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | ΦVc | Φ3Vc | P10-115 | P10-155 | P10-235 | - | - | - | - | | | |
| INDK26 | -126,72 | 14,21 | 113,21 | 87,98 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | ΦVc | Φ3Vc | P10-115 | P10-155 | P10-235 | - | - | - | - | | | |
| INDK27 | -240,70 | 61,93 | 160,49 | 135,26 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | ΦVc | Φ5Vc | P10-115 | 960,76 | P10-235 | - | - | - | - | | | |
| INDK6,9 | -562,94 | 400,65 | 270,04 | 219,51 | 450/550 | 6,00 | 2D22 | 10D22 | 4D22 | 13D22 | Φ3Vc | Φ5Vc | P10-60 | P10-140 | P10-235 | - | - | - | - | | | |
| INDK13,1 | -441,72 | 269,94 | -212,82 | -162,29 | 450/550 | 6,00 | 2D22 | 9D22 | 2D22 | 11D22 | ΦVc | Φ5Vc | P10-95 | 539,32 | P10-235 | - | - | - | - | | | |
| INDK20,2 | -446,97 | 264,96 | -212,85 | -162,32 | 450/550 | 6,00 | 2D22 | 9D22 | 2D22 | 11D22 | ΦVc | Φ5Vc | P10-95 | 537,53 | P10-235 | - | - | - | - | | | |
| INDK37,4 | -441,64 | 262,97 | -211,40 | -160,88 | 450/550 | 6,00 | 2D22 | 9D22 | 2D22 | 11D22 | ΦVc | Φ5Vc | P10-95 | 623,15 | P10-235 | - | - | - | - | | | |
| INDK59,7 | -431,53 | 256,51 | 207,46 | 156,93 | 450/550 | 6,00 | 2D22 | 9D22 | 2D22 | 11D22 | ΦVc | Φ5Vc | P10-100 | 857,54 | P10-235 | - | - | - | - | | | |
| INDK84,9 | -538,80 | 395,42 | -271,46 | -230,17 | 450/550 | 6,00 | 2D22 | 10D22 | 4D22 | 13D22 | Φ3Vc | Φ5Vc | P10-60 | P10-140 | P10-235 | - | - | - | - | | | |
| INDK2 | -102,68 | -6,19 | 47,41 | 32,72 | 450/550 | 3,00 | 2D22 | 9D22 | 2D22 | 9D22 | 0 | tidak perlu | - | P10-140 | P10-230 | 1384,53 | - | - | - | | | |
| INDK7,10 | -585,63 | 346,16 | 277,60 | 212,46 | 450/550 | 6,00 | 2D22 | 9D22 | 5D22 | 14D22 | Φ3Vc | Φ5Vc | P10-60 | P10-140 | P10-235 | - | - | - | - | | | |
| INDK14,1 | -454,24 | 252,04 | -226,22 | -161,09 | 450/550 | 6,00 | 2D22 | 9D22 | 2D22 | 11D22 | ΦVc | Φ5Vc | P10-85 | 473,69 | P10-235 | - | - | - | - | | | |
| INDK21,2 | -458,59 | 251,01 | -226,81 | -161,68 | 450/550 | 6,00 | 2D22 | 9D22 | 2D22 | 11D22 | ΦVc | Φ5Vc | P10-85 | 446,52 | P10-235 | - | - | - | - | | | |
| INDK38,4 | -457,52 | 250,48 | -226,69 | -161,55 | 450/550 | 6,00 | 2D22 | 9D22 | 2D22 | 11D22 | ΦVc | Φ5Vc | P10-85 | 452,44 | P10-235 | - | - | - | - | | | |
| INDK60,7 | -447,10 | 239,40 | 221,85 | 156,72 | 450/550 | 6,00 | 2D22 | 9D22 | 2D22 | 11D22 | ΦVc | Φ5Vc | P10-90 | 674,98 | P10-235 | - | - | - | - | | | |

| Hasil | M tumpuan kNm | M lapangan kNm | V tumpuan kN | V lapangan kN | Ukuran mm | Panjang m | Lentur | | Tumpuan | | Daerah Gaya Geser | | | | $\Phi 3V_c - \Phi 5V_c$ | | $\Phi V_c - \Phi 3V_c$ | | $\Phi \frac{1}{2}V_c - \Phi V_c$ | |
|----------|---------------|----------------|--------------|---------------|-----------|-----------|--------|-------|---------|-------|-------------------|-------------|---------|--------|-------------------------|---|------------------------|---|----------------------------------|---|
| | | | | | | | As' | As | As' | As | min | max | s | X | s | X | s | X | s | X |
| INDK85,9 | -526,32 | 388,90 | -272,09 | -235,78 | 450/550 | 6,00 | 2D22 | 10D22 | 4D22 | 13D22 | $\Phi 3V_c$ | $\Phi 5V_c$ | P10-60 | - | P10-140 | - | P10-235 | - | | |
| INDK3 | -82,51 | 4,11 | 40,63 | 26,79 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | 0 | tidak perlu | - | - | P10-155 | - | P10-235 | - | | |
| INDK8 | -320,65 | 55,41 | 113,29 | 85,97 | 400/550 | 6,00 | 2D22 | 8D22 | 2D22 | 8D22 | ΦV_c | $\Phi 3V_c$ | P10-115 | - | P10-155 | - | P10-235 | - | | |
| INDK15 | -182,35 | 24,87 | 79,37 | 52,05 | 400/550 | 6,00 | 2D22 | 8D22 | 2D22 | 8D22 | $\Phi 1/2V_c$ | ΦV_c | - | - | P10-155 | - | P10-235 | - | | |
| INDK22 | -192,21 | 20,32 | 83,97 | 56,65 | 400/550 | 6,00 | 2D22 | 8D22 | 2D22 | 8D22 | $\Phi 1/2V_c$ | ΦV_c | - | - | P10-155 | - | P10-235 | - | | |
| INDK39,4 | -198,37 | 138,67 | -94,72 | 64,45 | 400/550 | 6,00 | 2D22 | 8D22 | 2D22 | 8D22 | $\Phi 1/2V_c$ | $\Phi 3V_c$ | P10-115 | - | P10-155 | - | P10-235 | - | | |
| INDK61,7 | -177,97 | 116,34 | -84,78 | 59,04 | 400/550 | 6,00 | 2D22 | 8D22 | 2D22 | 8D22 | $\Phi 1/2V_c$ | ΦV_c | - | - | P10-155 | - | P10-235 | - | | |
| INDK88 | -263,92 | 62,51 | 109,75 | 82,42 | 400/550 | 6,00 | 2D22 | 8D22 | 2D22 | 8D22 | $\Phi 1/2V_c$ | $\Phi 3V_c$ | P10-115 | - | P10-155 | - | P10-235 | - | | |
| INDK30 | -283,79 | 59,95 | 174,87 | 168,86 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | $\Phi 3V_c$ | $\Phi 5V_c$ | P10-115 | - | P10-155 | - | P10-235 | - | | |
| INDK36,4 | -185,46 | 163,59 | -142,17 | -136,17 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | ΦV_c | $\Phi 3V_c$ | P10-115 | - | P10-155 | - | P10-235 | - | | |
| INDK50 | -177,81 | 13,62 | 140,65 | 124,48 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | ΦV_c | $\Phi 3V_c$ | P10-115 | - | P10-155 | - | P10-235 | - | | |
| INDK62 | -169,25 | 26,35 | 137,25 | 120,61 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | ΦV_c | $\Phi 3V_c$ | P10-115 | - | P10-155 | - | P10-235 | - | | |
| INDK76 | -197,64 | 23,39 | 172,48 | 138,05 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | ΦV_c | $\Phi 5V_c$ | P10-115 | 582,33 | P10-155 | - | P10-235 | - | | |
| INDK86 | -275,07 | 80,47 | 207,49 | 177,92 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | $\Phi 3V_c$ | $\Phi 5V_c$ | P10-90 | - | P10-155 | - | P10-235 | - | | |
| INDK55 | -355,25 | 102,98 | 128,02 | 62,44 | 400/550 | 9,00 | 2D22 | 8D22 | 2D22 | 9D22 | $\Phi 1/2V_c$ | $\Phi 3V_c$ | P10-115 | - | P10-155 | - | P10-235 | - | | |
| INDK58 | -30,54 | 7,47 | 33,72 | 20,06 | 400/550 | 2,50 | 2D22 | 8D22 | 2D22 | 8D22 | 0 | tidak perlu | - | - | P10-155 | - | P10-235 | - | | |

| Hasil | M tumpuan kNm | M lapangan kNm | V tumpuan kN | V lapangan kN | Ukuran mm | Panjang m | Lentur | | Tumpuan | | Daerah Gaya Geser | | Φ3Vc-Φ5Vc | | ΦVc-Φ3Vc | | Φ½Vc-ΦVc | |
|------------------|---------------|----------------|--------------|---------------|-----------|-----------|--------|------|---------|-------|-------------------|------------|-----------|---------|----------|---------|----------|--------|
| | | | | | | | As' | As | As' | As | min | max | s | x | s | x | s | x |
| | | | | | | | mm | mm | mm | mm | mm | mm | mm | mm | mm | mm | mm | mm |
| INDK34 | -526,82 | 3,98 | 194,06 | 149,11 | 400/600 | 6,00 | 2D22 | 7D25 | 3D22 | 9D25 | Φ5Vc | Φ10-125 | 1230,73 | Φ10-155 | - | Φ10-260 | - | |
| INDK51,6 3,82 | -698,98 | 391,32 | -293,55 | -84,89 | 400/600 | 6,00 | 2D22 | 7D25 | 6D22 | 11D25 | Φ½2Vc | Φ10-70 | 1204,70 | Φ10-155 | 126,83 | Φ10-260 | - | |
| INDK35 | -480,97 | 29,47 | 181,68 | 136,73 | 400/550 | 5,95 | 2D25 | 7D25 | 3D25 | 9D25 | ΦVc | Φ10-115 | 984,57 | Φ10-155 | - | Φ10-235 | - | |
| INDK52,6 4,83 | -551,70 | 212,12 | -218,79 | -57,44 | 400/550 | 6,00 | 2D25 | 7D25 | 4D25 | 10D25 | Φ½2Vc | Φ10-95 | 1760,81 | Φ10-155 | 503,56 | Φ10-235 | - | |
| INDK31 | -286,52 | 70,45 | 194,99 | 165,67 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | Φ3Vc | Φ10-105 | - | Φ10-155 | - | Φ10-235 | - | |
| INDK40 | -206,95 | 11,12 | 160,19 | 134,97 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | ΦVc | Φ10-115 | 978,40 | Φ10-155 | - | Φ10-235 | - | |
| INDK53 | -194,76 | 13,54 | 153,24 | 128,02 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | ΦVc | Φ10-115 | 1391,35 | Φ10-155 | - | Φ10-235 | - | |
| INDK65 | -178,57 | 25,63 | 149,78 | 132,21 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | ΦVc | Φ10-115 | - | Φ10-155 | - | Φ10-235 | - | |
| INDK77 | -189,08 | 14,80 | 159,85 | 131,56 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | ΦVc | Φ10-115 | 1052,85 | Φ10-155 | - | Φ10-235 | - | |
| INDK87 | -269,48 | 78,95 | 219,07 | 190,77 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | Φ3Vc | Φ10-85 | - | Φ10-155 | - | Φ10-235 | - | |
| INDK66 | -17,64 | 16,60 | 29,97 | 12,37 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | 0 | tidakperlu | - | Φ10-155 | - | Φ10-235 | - | |
| L a n a i 3 | | | | | | | | | | | | | | | | | | |
| INDK105 | -206,11 | 122,56 | 114,15 | 27,51 | 400/550 | 9,00 | 2D22 | 8D22 | 2D22 | 8D22 | 0 | Φ3Vc | Φ10-115 | - | Φ10-155 | 2940,34 | Φ10-235 | 755,55 |
| INDK112 | -175,38 | 123,10 | 97,27 | 27,44 | 400/550 | 9,00 | 2D22 | 8D22 | 2D22 | 8D22 | 0 | Φ3Vc | Φ10-115 | - | Φ10-155 | 3652,88 | Φ10-235 | 942,41 |
| INDK119 | -234,19 | 175,70 | 150,21 | 29,78 | 400/550 | 9,00 | 2D22 | 8D22 | 2D22 | 8D22 | 0 | Φ3Vc | Φ10-115 | - | Φ10-155 | 2030,47 | Φ10-235 | 458,80 |
| INDK133 | -176,43 | 125,21 | 98,79 | 28,69 | 400/550 | 9,00 | 2D22 | 8D22 | 2D22 | 8D22 | 0 | Φ3Vc | Φ10-115 | - | Φ10-155 | 3558,56 | Φ10-235 | 858,43 |
| INDK156 | -175,49 | 123,37 | 99,02 | 28,36 | 400/550 | 9,00 | 2D22 | 8D22 | 2D22 | 8D22 | 0 | Φ3Vc | Φ10-115 | - | Φ10-155 | 3551,19 | Φ10-235 | 872,49 |

| Hasil | M tumpuan kNm | M lapangan kNm | V tumpuan kN | V lapangan kN | Ukuran mm | Pan-jang m | Lentur | | | Tumpuan | | | Daerah Gaya Geser | | | Φ3Vc-Φ5Vc | | ΦVc-Φ3Vc | | Φ½Vc-ΦVc | | |
|-------------|---------------|----------------|--------------|---------------|-----------|------------|--------|------|------|---------|--------|-------------|-------------------|---------|---------|-----------|---------|----------|---|----------|----|----|
| | | | | | | | As' | As | As | As' | As | As' | min | max | s | X | mm | mm | s | X | mm | mm |
| INDK179,180 | -233,24 | 189,12 | 154,21 | 36,86 | 400/550 | 9,00 | 2D22 | 8D22 | 2D22 | 8D22 | 0 | Φ3Vc | P10-115 | 4392,92 | P10-155 | 1812,30 | P10-235 | 199,42 | | | | |
| INDK208-212 | -302,29 | 220,20 | 211,26 | 37,34 | 400/550 | 9,00 | 2D22 | 8D22 | 2D22 | 8D22 | 0 | Φ5Vc | P10-95 | 2951,64 | P10-155 | 1210,41 | P10-235 | 122,14 | | | | |
| INDK102 | -14,31 | 8,22 | 20,00 | 6,24 | 400/600 | 3,00 | 2D22 | 9D22 | 2D22 | 9D22 | 0 | tidak perlu | - | - | P10-155 | - | P10-260 | - | | | | |
| INDK106 | -139,53 | -9,37 | 90,35 | 74,51 | 400/600 | 3,00 | 2D22 | 9D22 | 2D22 | 9D22 | Φ1/2Vc | ΦVc | - | - | P10-155 | - | P10-260 | - | | | | |
| INDK113 | -146,97 | -5,87 | 95,61 | 79,77 | 400/600 | 3,00 | 2D22 | 9D22 | 2D22 | 9D22 | Φ1/2Vc | ΦVc | - | - | P10-155 | 1315,86 | P10-260 | - | | | | |
| INDK120 | -175,64 | 18,78 | 127,28 | 111,44 | 400/600 | 3,00 | 2D22 | 9D22 | 2D22 | 9D22 | ΦVc | Φ3Vc | P10-130 | - | P10-155 | - | P10-260 | - | | | | |
| INDK134 | -566,41 | 212,76 | 279,00 | 263,16 | 400/600 | 3,00 | 2D22 | 9D22 | 3D22 | 12D22 | Φ3Vc | Φ5Vc | P10-65 | - | P10-155 | - | P10-260 | - | | | | |
| INDK157 | -357,08 | 92,97 | 213,63 | 197,79 | 400/600 | 3,00 | 2D22 | 9D22 | 2D22 | 9D22 | Φ3Vc | Φ5Vc | P10-100 | - | P10-155 | - | P10-260 | - | | | | |
| INDK181 | -215,35 | -6,10 | 117,12 | 101,27 | 400/600 | 3,00 | 2D22 | 9D22 | 2D22 | 9D22 | ΦVc | Φ3Vc | P10-130 | - | P10-155 | - | P10-260 | - | | | | |
| INDK213 | -194,26 | -32,32 | 106,37 | 95,50 | 400/600 | 3,00 | 2D22 | 9D22 | 2D22 | 9D22 | ΦVc | Φ3Vc | P10-130 | - | P10-155 | - | P10-260 | - | | | | |
| INDK151 | -263,63 | 124,03 | 120,52 | 103,51 | 400/600 | 3,00 | 2D20 | 7D25 | 2D20 | 7D25 | ΦVc | Φ3Vc | P10-125 | - | P10-155 | - | P10-255 | - | | | | |
| INDK158 | -591,06 | 70,41 | 230,69 | 197,48 | 400/600 | 5,00 | 2D22 | 7D25 | 4D22 | 10D25 | Φ3Vc | Φ5Vc | P10-90 | - | P10-155 | - | P10-260 | - | | | | |
| INDK182 | -127,02 | 26,21 | 61,39 | 39,56 | 400/600 | 5,00 | 2D22 | 7D25 | 2D22 | 7D25 | 0 | ΦVc | - | - | P10-155 | - | P10-255 | 755,46 | | | | |
| INDK190 | -76,70 | 28,21 | 66,24 | 41,72 | 400/400 | 3,00 | 2D22 | 6D22 | 2D22 | 6D22 | Φ1/2Vc | ΦVc | - | - | P10-155 | 1157,53 | P10-165 | - | | | | |
| INDK191 | -62,85 | 25,67 | 65,30 | 40,78 | 400/400 | 3,00 | 2D22 | 6D22 | 2D22 | 6D22 | Φ1/2Vc | ΦVc | - | - | P10-155 | 1214,89 | P10-165 | - | | | | |
| INDK192 | -58,72 | 17,45 | 65,88 | 41,36 | 400/400 | 3,00 | 2D22 | 6D22 | 2D22 | 6D22 | Φ1/2Vc | ΦVc | - | - | P10-155 | 1179,48 | P10-165 | - | | | | |
| INDK204 | -69,56 | 20,36 | 75,83 | 51,30 | 400/400 | 3,00 | 2D22 | 6D22 | 2D22 | 6D22 | Φ1/2Vc | Φ3Vc | P10-80 | - | P10-155 | 571,23 | P10-165 | - | | | | |

| Hasil | M tumpuan kNm | M lapangan kNm | V tumpuan kN | V lapangan kN | Ukuran mm | Panjang m | Lentur | | Tumpuan | | Daerah Gaya Geser | | $\Phi 3Vc-\Phi 5Vc$ | | $\Phi Vc-\Phi 3Vc$ | | $\Phi 1/2Vc-\Phi Vc$ | | | |
|--------------|---------------|----------------|--------------|---------------|-----------|-----------|--------|------|---------|-------|-------------------|-------------|---------------------|---------|--------------------|---------|----------------------|---------|---|---|
| | | | | | | | As' | As | As' | As | min | max | S | X | S | X | S | X | S | X |
| INDK205 | -85,21 | 38,20 | 66,04 | 41,51 | 400/400 | 3,00 | 2D22 | 6D22 | 2D22 | 6D22 | $\Phi 1/2Vc$ | ΦVc | - | - | P10-155 | 1170,03 | P10-165 | - | - | |
| INDK168-172 | -490,05 | 230,28 | -196,69 | -17,24 | 400/550 | 6,00 | 2D22 | 8D22 | 4D22 | 12D22 | 0 | $\Phi 5Vc$ | P10-105 | 5691,98 | P10-155 | 2841,97 | P10-235 | 1060,72 | - | - |
| INDK173 | -101,04 | -25,59 | 49,67 | 37,86 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | 0 | ΦVc | - | - | P10-155 | - | P10-235 | 471,27 | - | - |
| INDK159 | -28,39 | 3,20 | 29,74 | 17,93 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | 0 | tidak perlu | - | - | P10-155 | - | P10-235 | - | - | - |
| INDK143; 144 | -235,45 | 216,68 | 172,13 | 141,20 | 400/550 | 6,00 | 2D22 | 8D22 | 2D22 | 8D22 | ΦVc | $\Phi 5Vc$ | P10-115 | 991,04 | P10-155 | - | P10-235 | - | - | - |
| INDK145; 146 | -228,11 | 183,87 | -149,91 | -118,97 | 400/550 | 6,00 | 2D22 | 8D22 | 2D22 | 8D22 | ΦVc | $\Phi 3Vc$ | P10-115 | - | P10-155 | - | P10-235 | - | - | - |
| INDK147 | -144,80 | -7,27 | 106,13 | 90,77 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | ΦVc | $\Phi 3Vc$ | P10-115 | - | P10-155 | - | P10-235 | - | - | - |
| INDK124 | -82,35 | 40,94 | 64,93 | 45,03 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | $\Phi 1/2Vc$ | ΦVc | - | - | P10-155 | - | P10-235 | - | - | - |
| INDK125 | -66,62 | 18,96 | 73,16 | 48,63 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | $\Phi 1/2Vc$ | ΦVc | - | - | P10-155 | - | P10-235 | - | - | - |
| INDK126 | -60,08 | 6,15 | 58,57 | 34,04 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | 0 | ΦVc | - | - | P10-155 | - | P10-235 | 490,35 | - | - |
| INDK127 | -61,87 | 14,96 | 62,66 | 38,13 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | 0 | ΦVc | - | - | P10-155 | - | P10-235 | 240,16 | - | - |
| INDK128 | -82,12 | 34,66 | 66,55 | 42,03 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | 0 | ΦVc | - | - | P10-155 | - | P10-235 | 1,85 | - | - |
| INDK110; 107 | -265,29 | 170,53 | 173,77 | 123,25 | 400/550 | 6,00 | 2D22 | 8D22 | 2D22 | 8D22 | ΦVc | $\Phi 5Vc$ | P10-115 | 1672,66 | P10-155 | - | P10-235 | - | - | - |
| INDK114; 117 | -244,32 | 96,67 | -139,45 | -88,92 | 400/550 | 6,00 | 2D22 | 8D22 | 2D22 | 8D22 | ΦVc | $\Phi 3Vc$ | P10-115 | - | P10-155 | - | P10-235 | - | - | - |
| INDK121; 129 | -236,43 | 98,70 | 136,25 | 85,73 | 400/550 | 6,00 | 2D22 | 8D22 | 2D22 | 8D22 | ΦVc | $\Phi 3Vc$ | P10-115 | - | P10-155 | - | P10-235 | - | - | - |

| Hasil | M tumpuan kNm | M lapangan kNm | V tumpuan kN | V lapangan kN | Ukuran mm | Pan- jang m | Lentur | | Tumpuan | | Daerah Gaya Geser | | Φ3Vc-Φ5Vc | | ΦVc-Φ3Vc | | Φ½Vc-ΦVc | |
|-----------------|------------------|-------------------|-----------------|------------------|--------------|-------------------|--------|------|---------|------|----------------------|-------------|-----------|---------|----------|---------|----------|--------|
| | | | | | | | As' | As | As' | As | min | max | s | x | s | x | s | x |
| | | | | | | | mm | mm | mm | mm | mm | mm | mm | mm | mm | mm | mm | mm |
| INDK138; 148 | -250,78 | 151,65 | -158,29 | -107,76 | 400/550 | 6,00 | 2D22 | 8D22 | 2D22 | 8D22 | ΦVc | Φ3Vc | P10-115 | 2591,98 | P10-155 | P10-155 | P10-235 | - |
| INDK160; 174 | -236,01 | 87,49 | 133,23 | 82,71 | 400/550 | 6,00 | 2D22 | 8D22 | 2D22 | 8D22 | Φ1/2Vc | Φ3Vc | P10-115 | - | P10-155 | 83,78 | P10-235 | - |
| INDK185; 206 | -269,59 | 189,61 | -177,11 | -135,82 | 400/550 | 6,00 | 2D22 | 8D22 | 2D22 | 8D22 | ΦVc | Φ5Vc | P10-115 | 1133,27 | P10-155 | - | P10-235 | - |
| INDK103 | -99,20 | -17,69 | 49,26 | 33,72 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | 0 | ΦVc | - | - | P10-155 | - | P10-235 | 751,47 |
| INDK108; 111 | -342,77 | 179,91 | 193,78 | 128,64 | 400/550 | 6,00 | 2D22 | 8D22 | 2D22 | 9D22 | ΦVc | Φ5Vc | P10-105 | 1079,91 | P10-155 | - | P10-235 | - |
| INDK115; 118 | -255,87 | 114,96 | 153,71 | -88,58 | 400/550 | 6,00 | 2D22 | 8D22 | 2D22 | 8D22 | ΦVc | Φ3Vc | P10-115 | 2894,41 | P10-155 | - | P10-235 | - |
| INDK122; 130 | -261,18 | 115,09 | 155,41 | 90,27 | 400/550 | 6,00 | 2D22 | 8D22 | 2D22 | 8D22 | ΦVc | Φ3Vc | P10-115 | 2816,13 | P10-155 | - | P10-235 | - |
| INDK139; 149 | -268,25 | 169,65 | 174,90 | -109,77 | 400/550 | 6,00 | 2D22 | 8D22 | 2D22 | 8D22 | ΦVc | Φ5Vc | P10-115 | 1918,36 | P10-155 | - | P10-235 | - |
| INDK161; 175 | -254,41 | 104,20 | 149,13 | 84,00 | 400/550 | 6,00 | 2D22 | 8D22 | 2D22 | 8D22 | Φ1/2Vc | Φ3Vc | P10-115 | - | P10-155 | 5,57 | P10-235 | - |
| INDK186; 207 | -288,43 | 208,25 | -193,46 | -156,69 | 400/550 | 6,00 | 2D22 | 8D22 | 2D22 | 8D22 | Φ3Vc | Φ5Vc | P10-100 | - | P10-155 | - | P10-235 | - |
| INDK104 | -67,21 | -5,40 | 39,97 | 24,49 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | 0 | tidak perlu | - | - | P10-155 | - | P10-235 | - |
| INDK109 | -238,84 | 41,43 | 90,05 | 62,73 | 400/550 | 6,00 | 2D22 | 8D22 | 2D22 | 8D22 | Φ1/2Vc | Φ3Vc | P10-115 | - | P10-155 | 2349,05 | P10-235 | - |
| INDK116 | -130,99 | 22,89 | 63,42 | 36,10 | 400/550 | 6,00 | 2D22 | 8D22 | 2D22 | 8D22 | 0 | ΦVc | - | - | P10-155 | - | P10-235 | 654,51 |
| INDK123 | -225,88 | 42,16 | 87,03 | 59,71 | 400/550 | 6,00 | 2D22 | 8D22 | 2D22 | 8D22 | Φ1/2Vc | ΦVc | - | - | P10-155 | 2680,76 | P10-235 | - |
| INDK140; 150 | -269,53 | 200,52 | -120,52 | 89,64 | 400/550 | 6,00 | 2D22 | 8D22 | 2D22 | 8D22 | ΦVc | Φ3Vc | P10-115 | - | P10-155 | - | P10-235 | - |

| Hasil | M tumpuan kNm | M lapangan kNm | V tumpuan kN | V lapangan kN | Ukuran mm | Pan- jang m | Lentur | | Tumpuan | | Daerah Gaya Geser | | | $\Phi 3Vc-\Phi 5Vc$ | | $\Phi Vc-\Phi 3Vc$ | | $\Phi 1/2Vc-\Phi Vc$ | |
|---------------------|------------------|-------------------|-----------------|------------------|--------------|-------------------|--------|-------|---------|-------|----------------------|------------|---------|---------------------|---------|--------------------|---------|----------------------|--|
| | | | | | | | As' | As | As' | As | min | max | s | X | s | X | s | X | |
| | | | | | | | mm | mm | mm | mm | mm | mm | mm | mm | mm | mm | mm | mm | |
| INDK162; 176 | -256,31 | 185,38 | -120,13 | -83,06 | 400/550 | 6,00 | 2D22 | 8D22 | 2D22 | 8D22 | $\Phi 1/2Vc$ | $\Phi 3Vc$ | P10-115 | - | P10-155 | 85,85 | P10-235 | - | |
| INDK189 | -241,38 | 34,56 | 105,28 | 77,96 | 400/550 | 6,00 | 2D22 | 8D22 | 2D22 | 8D22 | $\Phi 1/2Vc$ | $\Phi 3Vc$ | P10-115 | - | P10-155 | 676,29 | P10-235 | - | |
| INDK131 | -245,74 | 56,21 | 153,85 | 147,84 | 450/600 | 3,00 | 2D22 | 10D22 | 2D22 | 10D22 | ΦVc | $\Phi 3Vc$ | P10-130 | - | P10-140 | - | P10-260 | - | |
| INDK137; 142 | -187,56 | 135,82 | -132,95 | -126,94 | 450/600 | 3,00 | 2D22 | 10D22 | 2D22 | 10D22 | ΦVc | $\Phi 3Vc$ | P10-130 | - | P10-140 | - | P10-260 | - | |
| INDK152 | -308,08 | 75,24 | 190,35 | 174,65 | 450/600 | 3,00 | 2D22 | 10D22 | 2D22 | 10D22 | ΦVc | $\Phi 3Vc$ | P10-130 | 1362,05 | P10-140 | - | P10-260 | - | |
| INDK163 | -389,50 | 40,73 | 291,67 | 275,96 | 450/600 | 3,00 | 2D22 | 10D22 | 2D22 | 10D22 | $\Phi 3Vc$ | $\Phi 5Vc$ | P10-65 | - | P10-140 | - | P10-260 | - | |
| INDK177 | -296,29 | 69,55 | 252,11 | 218,96 | 450/600 | 3,00 | 2D22 | 10D22 | 2D22 | 10D22 | $\Phi 3Vc$ | $\Phi 5Vc$ | P10-85 | - | P10-140 | - | P10-260 | - | |
| INDK187 | -232,66 | 100,16 | 166,68 | 138,39 | 450/600 | 3,00 | 2D22 | 10D22 | 2D22 | 10D22 | ΦVc | $\Phi 3Vc$ | P10-130 | - | P10-140 | - | P10-260 | - | |
| INDK135 | -338,85 | -13,84 | 126,78 | 86,09 | 400/550 | 5,95 | 2D22 | 8D22 | 2D22 | 9D22 | ΦVc | $\Phi 3Vc$ | P10-115 | - | P10-155 | - | P10-235 | - | |
| INDK153; 164;183 | -462,36 | 345,14 | -249,65 | -53,09 | 400/550 | 12,00 | 2D22 | 9D22 | 3D22 | 11D22 | $\Phi 1/2Vc$ | $\Phi 5Vc$ | P10-70 | 3051,71 | P10-155 | 975,14 | P10-235 | - | |
| INDK136 | -270,88 | 5,57 | 109,41 | 68,73 | 400/550 | 5,95 | 2D22 | 8D22 | 2D22 | 8D22 | $\Phi 1/2Vc$ | $\Phi 3Vc$ | P10-115 | - | P10-155 | 1125,59 | P10-235 | - | |
| INDK154; 165;184 | -348,26 | 194,49 | -167,10 | -23,16 | 400/550 | 6,00 | 2D22 | 8D22 | 2D22 | 9D22 | 0 | $\Phi 5Vc$ | P10-115 | 5374,26 | P10-155 | 2556,63 | P10-235 | 795,61 | |
| INDK132 | -106,65 | 41,00 | 83,73 | 55,43 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | $\Phi 1/2Vc$ | ΦVc | - | - | P10-155 | - | P10-235 | - | |
| INDK141 | -100,08 | 2,93 | 86,77 | 62,25 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | $\Phi 1/2Vc$ | ΦVc | - | - | P10-155 | 1337,81 | P10-235 | - | |
| INDK155 | -84,86 | 10,39 | 74,10 | 49,57 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | $\Phi 1/2Vc$ | ΦVc | - | - | P10-155 | - | P10-235 | - | |
| INDK166 | -80,04 | 26,17 | 77,14 | 61,44 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | $\Phi 1/2Vc$ | ΦVc | - | - | P10-155 | - | P10-235 | - | |

| Hasil | M tumpuan kNm | M lapangan kNm | V tumpuan kN | V lapangan kN | Ukuran mm | Pan- jang m | Lentur | | Tumpuan | | Daerah Gaya Geser | | $\Phi 3Vc-\Phi 5Vc$ | | $\Phi Vc-\Phi 3Vc$ | | $\Phi 1/2Vc-\Phi Vc$ | | |
|-----------------|------------------|-------------------|-----------------|------------------|--------------|-------------------|--------|------|---------|------|----------------------|------------|---------------------|---|--------------------|--------|----------------------|-------|--|
| | | | | | | | As' | As | As | As' | min | max | s | x | s | x | s | x | |
| INDK178 | -108,31 | 20,98 | 97,26 | 68,96 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | $\Phi 1/2Vc$ | $\Phi 3Vc$ | P10-115 | - | P10-155 | 803,65 | P10-235 | - | |
| INDK188 | -81,68 | 46,63 | 102,26 | 73,96 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | $\Phi 1/2Vc$ | $\Phi 3Vc$ | P10-115 | - | P10-155 | 538,70 | P10-235 | - | |
| INDK167 | -13,48 | 14,77 | 25,17 | 9,97 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | 0 | tidakperlu | - | - | P10-155 | - | P10-235 | - | |
| A t a p | | | | | | | | | | | | | | | | | | | |
| INDK193; 195 | 250,70 | 124,63 | 106,15 | 92,80 | 400/550 | 6,00 | 2D22 | 8D22 | 2D22 | 8D22 | ΦVc | $\Phi 3Vc$ | P10-115 | - | P10-155 | - | P10-235 | - | |
| INDK198; 201 | -270,58 | 110,51 | 107,17 | 93,82 | 400/550 | 6,00 | 2D22 | 8D22 | 2D22 | 8D22 | ΦVc | $\Phi 3Vc$ | P10-115 | - | P10-155 | - | P10-235 | - | |
| INDK194 | -58,72 | 17,45 | 65,88 | 41,36 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | 0 | ΦVc | - | - | P10-155 | - | P10-235 | 42,83 | |
| INDK197 | -58,72 | 17,45 | 65,88 | 41,36 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | 0 | ΦVc | - | - | P10-155 | - | P10-235 | 42,83 | |
| INDK200 | -58,72 | 17,45 | 65,88 | 41,36 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | 0 | ΦVc | - | - | P10-155 | - | P10-235 | 42,83 | |
| INDK203 | -58,72 | 17,45 | 65,88 | 41,36 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | 0 | ΦVc | - | - | P10-155 | - | P10-235 | 42,83 | |
| INDK196 | -58,72 | 17,45 | 65,88 | 41,36 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | 0 | ΦVc | - | - | P10-155 | - | P10-235 | 42,83 | |
| INDK199 | -58,72 | 17,45 | 65,88 | 41,36 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | 0 | ΦVc | - | - | P10-155 | - | P10-235 | 42,83 | |
| INDK202 | -58,72 | 17,45 | 65,88 | 41,36 | 400/550 | 3,00 | 2D22 | 8D22 | 2D22 | 8D22 | 0 | ΦVc | - | - | P10-155 | - | P10-235 | 42,83 | |

Sedangkan hasil perhitungan balok induk sebelumnya adalah sebagai berikut.

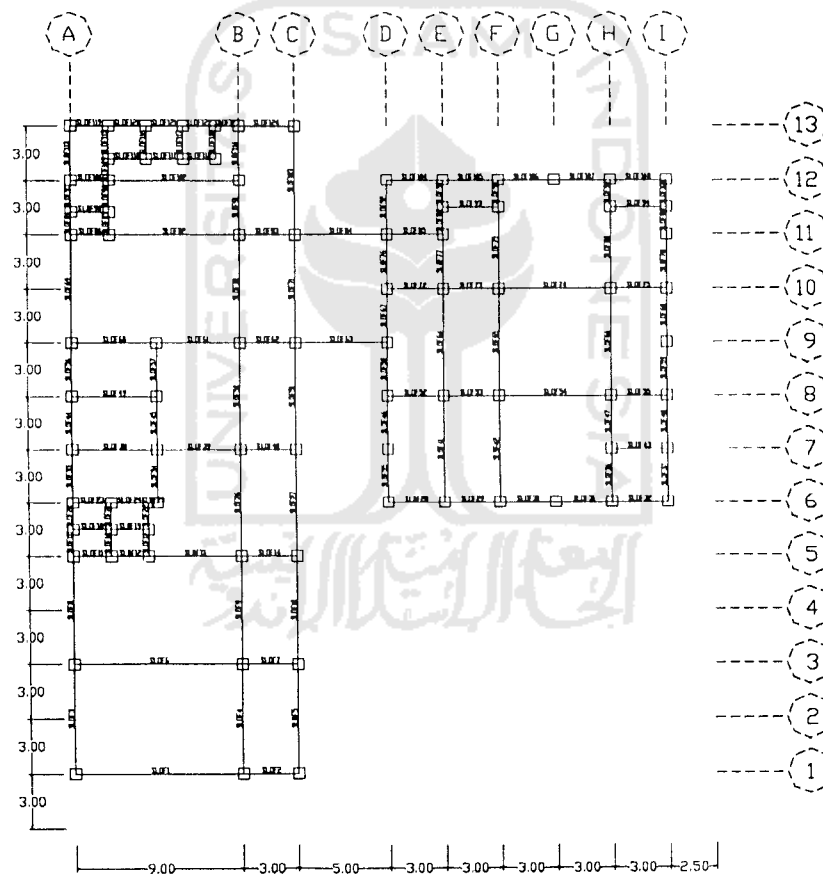
Tabel IV-8 Hasil perhitungan balok induk sebelum perencanaan

| Sebelum Perencanaan Ulang | Ukuran | As | Sengkang |
|------------------------------|---------|-------|----------|
| | mm | | |
| balok lantai | | | |
| b1 | 300/600 | 6D22 | P10-100 |
| b2 | 300/600 | 5D22 | P10-100 |
| b1' | 300/600 | 6D22 | P10-100 |
| b1'' | 300/600 | 4D22 | P10-100 |
| b3 | 300/600 | 5D19 | P10-150 |
| b4 | 300/600 | 6D19 | P10-100 |
| b4' | 300/600 | 6D19 | P10-150 |
| b5 | 250/400 | 6D16 | P8-100 |
| b5' | 250/400 | 8D16 | P8-150 |
| b6 | 300/400 | 6D19 | P10-100 |
| b7 | 300/400 | 7D19 | P10-100 |
| b7' | 300/400 | 4D19 | P10-150 |
| b8 | 300/400 | 3D22 | P10-150 |
| b8' | 300/600 | 5D22 | P10-150 |
| b9 | 150/300 | 2D16 | P8-150 |
| b10 | 200/300 | 2D16 | P8-150 |
| b11 | 400/800 | 10D22 | P10-100 |
| b12 | 150/300 | 3D16 | P8-100 |
| b3' | 300/700 | 11D19 | P10-100 |
| b5'' | 250/600 | 9D16 | P8-100 |

4. 6. Perencanaan Balok Penahan Tembok Dan Balok Ring

Perencanaan balok penahan tembok dan balok ring menggunakan perencanaan balok dengan tulangan sebelah. Gaya-gaya yang dipergunakan untuk merencanakan di ambil dari perhitungan SAP 2000.

Perletakkan dari balok-balok penahan tembok dapat di lihat pada gambar berikut ini.



Gambar IV-15 Letak Balok Penahan Tembok

Adapun langkah-langkah perhitungannya untuk balok penahan tembok dan juga untuk balok ring adalah sebagai berikut ini.

Perencanaan Balok Penahan Tembok

Balok SLOF1

$$M \text{ tumpuan max, } M_{tmp} = -207,614 \text{ kNm}$$

$$M \text{ lapangan max, } M_{lap} = 59,10954 \text{ kNm}$$

$$V1(\text{tump}) = 84,57756 \text{ kNm di: } 0,2 \text{ m}$$

$$V2(\text{lap}) = 31,79934 \text{ kNm di: } 4,5 \text{ m}$$

$$f_c' = 20 \text{ MPa}$$

$$f_y = 400 \text{ MPa}$$

$$\beta_1 = 0,85$$

$$\Phi = 0,8$$

$$E_c = 21019,04 \text{ MPa}$$

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

$$M_u \text{ design} = 207,6141 \text{ kNm}$$

$$M_n \text{ desain} = \frac{M_u}{\Phi} = \frac{207,6141}{0,8}$$

$$= 259,5176 \text{ kNm}$$

$$m = \frac{f_y}{0,85 f_c'} = \frac{400}{0,85 \times 20}$$

$$= 23,52941$$

$$\begin{aligned}\rho_b &= \frac{0,85 \times f_c'}{f_y} \times \beta_1 \times \frac{600}{600 + f_y} \\ &= \frac{0,85 \times 20,000}{400} \times 0,850 \times \frac{600}{600 + 400,000} \\ &= 0,021675\end{aligned}$$

$$\rho_{\max} = 0,75 \times \rho_b = 0,75 \times 0,02168$$

$$= 0,016256$$

$$\rho_{\min} = \frac{1,4}{f_y} = \frac{1,4}{400}$$

$$= 0,0035$$

$$\rho = \rho_{\max}$$

$$= 0,016256$$

$$R_n = \rho \times f_y \times (1 - 0,5 \times \rho \times m)$$

$$= 0,01626 \times 400 \times (1 - 0,5 \times 0,01626 \times 23,529)$$

$$= 5,258897 \text{ MPa}$$

$$bd^2 = \frac{M_n}{R_n} = \frac{259,518 \times 1000000}{5,259}$$

$$= 49348301 \text{ mm}^3$$

$$b \text{ pakai} = 300 \text{ mm} \quad \text{tulangan} = 25 \text{ mm}$$

$$d_{\text{perlu}} = 405,579 \text{ mm} \quad d \text{ pakai} = 1 \text{ d}$$

$$d \text{ tulangan tekan} = 22 \text{ mm} \quad d \text{ pakai} = 405,579 \text{ mm}$$

$$d \text{ tulangan tarik} = 22 \text{ mm} \quad \text{sumsi brs}' = 2$$

$$d \text{ sengkang} = 10 \text{ mm} \quad \text{asumsi brs} = 1$$

$$\text{penutup beton} = 40 \text{ mm}$$

$$ds = pb + d \text{ sengkang} + d \text{ tul}/2$$

$$= 40 + 10 + 22/2$$

$$= 61 \text{ mm}$$

$$d' = pb + d \text{ sengkang} + d \text{ tul}/2 + \text{spasi}$$

$$= 40 + 10 + 22/2 + 25$$

$$= 86 \text{ mm}$$

$$h \text{ perlu} = d \text{ perlu} + ds$$

$$= 405,579 + 61,000$$

$$\approx 500 \text{ mm}$$

$$h \text{ pakai} = 600 \text{ mm}$$

(di sesuaikan dg balok lainnya)

$$d \text{ ada} = h \text{ pakai} - ds = 600 - 61,000$$

$$= 539 \text{ mm}$$

dimensi balok SLOF1 : 300 / 600 (mm)

Tumpuan

$$b = 300 \text{ mm} \quad R_n = 5,258897 \text{ MPa}$$

$$h = 600 \text{ mm} \quad \rho = 0,016256$$

$$d = 539 \text{ mm} \quad M_u = 207,6141 \text{ kNm}$$

$$\Phi = 0,8$$

$$M_u/\phi = \frac{207,6141}{0,8}$$

$$= 259,5176 \text{ kNm}$$

$$bd^2 = 300,000 \times 539,000^2$$

$$= 87156300 \text{ mm}^3$$

$$R_n \text{ baru} = \frac{M_u/\phi}{bd^2} = \frac{259,5176}{87156300}$$

$$= 2,977612 \text{ MPa}$$

$$\rho \text{ baru} = \rho \times R_n \text{ baru} / R_n$$

$$= 0,0163 \times 2,978 / 5,259$$

$$= 0,009204$$

$$A_s' \text{ perlu} = \rho \times b \times d$$

$$= 0,00920 \times 300 \times 539$$

$$= 1488,346 \text{ mm}^2$$

$$d \text{ tulangan} = 22 \text{ mm} \quad \text{tul.akhir} = 4$$

$$\text{jml perlu} = 4 \quad x1 = 11 \text{ mm}$$

$$A_s \text{ ada} = 1520,531 \text{ mm}^2 \quad ds = 61 \text{ mm}$$

$$\text{tul./baris} = 4 \quad \text{jbd} = 37,33333 \text{ mm}$$

$$\text{jml baris} = 1 \text{ --Ok--}$$

$$\text{tulangan} = \mathbf{4D22}$$

Lapangan

$$b = 300 \text{ mm} \quad R_n = 5,258897 \text{ MPa}$$

$$h = 600 \text{ mm} \quad \rho = 0,016256$$

$$d = 539 \text{ mm} \quad \mu = 59,10954 \text{ kNm}$$

$$\Phi = 0,8$$

$$\frac{\mu}{\Phi} = \frac{59,10954}{0,8}$$

$$= 73,88693 \text{ kNm}$$

$$bd^2 = 300,000 \times 539,000^2$$

$$= 87156300 \text{ mm}^3$$

$$R_n \text{ baru} = \frac{\frac{\mu}{\Phi}}{bd^2} = \frac{73,88693}{87156300}$$

$$= 0,847752 \text{ MPa}$$

$$\rho \text{ baru} = \rho \times R_n \text{ baru} / R_n$$

$$= 0,0163 \times 0,848 / 5,259$$

$$= 0,002621$$

$$A_s' \text{ perlu} = \rho \times b \times d$$

$$= 0,00262 \times 300 \times 539$$

$$= 423,745 \text{ mm}^2$$

$$d \text{ tulangan} = 22 \text{ mm} \quad \text{tul.akhir} = 2$$

$$\text{jml perlu} = 2 \quad x1 = 11 \text{ mm}$$

$$\begin{aligned}
 \text{As ada} &= 760,2654 \text{ mm}^2 & \text{ds} &= 61 \text{ mm} \\
 \text{tul./baris} &= 4 & \text{jbd} &= 37,33333 \text{ mm} \\
 \text{jml baris} &= 1 \text{ --Ok--} \\
 \text{tulangan} &= \mathbf{2D22}
 \end{aligned}$$

Perencanaan tulangan geser balok sloof

Dari data sap 2000, gaya geser penampang kritis:

$$\begin{aligned}
 V_1 &= 84,57756 \text{ kNm} & b &= 300 \text{ mm} \\
 \text{pada} & 200 \text{ mm} & h &= 84,57756 \text{ mm} \\
 V_2 &= 31,79934 \text{ kNm} & d &= 405,579 \text{ mm} \\
 \text{pada} & 4500 \text{ mm} \\
 \Phi &= 0,6 \\
 \text{d sengkang} &= 10 \text{ mm} \\
 \text{kaki sengkang} &= 2 \text{ (vertikal)} \\
 F_y &= 240 \text{ MPa} \\
 V_c &= 90,69022 \text{ kN} & \Phi V_c &= 54,41413 \text{ kN} \\
 d/2 &= 202,7895 \text{ mm} & \Phi \frac{1}{2}V_c &= 27,20707 \text{ kN} \\
 d/4 &= 101,3948 \text{ mm} \\
 V_{s1} &= 181,3804 \text{ kN} & \Phi V_{s1} &= 108,8283 \text{ kN} \\
 V_{s2} &= 362,7609 \text{ kN} & \Phi V_{s2} &= 217,6565 \text{ kN} \\
 \Phi(V_c+V_{s1}) &= \Phi 3 V_c = 97,94544 \text{ kN} \\
 \Phi(V_c+V_{s2}) &= \Phi 5 V_c = 163,2424 \text{ kN}
 \end{aligned}$$

$$l_1 = 4300 \text{ mm}$$

$$\Delta V_u = 52,77822 \text{ kN}$$

$$V_u \text{ pada jarak } d = 79,59948 \text{ kN} > \Phi \frac{1}{2} V_c = 27,20707 \text{ -- Ok --}$$

$$\leq \Phi 5 V_c = 163,2424 \text{ -- Ok --}$$

V_u berada pada daerah: $\Phi \frac{1}{2} V_c$ s/d $\Phi 3 V_c$

$$2h = 169,1551 \text{ mm}$$

$$V_u \text{ pada jarak } 2h = 82,50135 \text{ kN}$$

$$A_v = 157,0796 \text{ mm}$$

Daerah: ΦV_c s/d $\Phi 3 V_c$

$$V_u = 97,94544 \text{ kN} \quad x = 1928,193 \text{ mm}$$

$$\Phi V_s = 43,53131 \text{ kN}$$

$$V_s \text{ perlu} = 72552,18 \text{ N}$$

$$s = \frac{A_v \times F_y \times d}{V_s}$$

$$= 210,7444 \text{ mm}$$

$$s \text{ pakai} = 200 \text{ mm} < d / 2 = 202,7895 \text{ -- Ok --}$$

$$< 600 \text{ -- Ok --}$$

Daerah: $\frac{1}{2} \Phi V_c$ s/d ΦV_c

$$V_u = 54,41413 \text{ kN} \quad x = - \text{ mm}$$

$$s = \frac{A_v \times F_y \times d}{V_s}$$

$$= 376,9911 \text{ mm}$$

$$s \text{ pakai} = 200 \text{ mm} < d / 2 = 202,7895 \text{ -- Ok --}$$

$$< 600 \text{ -- Ok --}$$

$$\Phi V_s = 127,4164 \text{ kN}$$

$$V_s \text{ ada} = 212360,7 \text{ N}$$



Hasil perhitungan balok penahan dapat dilihat pada tabel berikut ini.
Tabel IV-9 Hasil perhitungan balok penahan tembok

| Balok P. Tembok | Ukuran | | As' | As | Daerah Gaya geser | | | $\Phi 3Vc-\Phi 5Vc$ | | $\Phi Vc-\Phi 3Vc$ | | $\Phi \frac{1}{2}Vc-\Phi Vc$ | |
|-----------------|---------|--|------|------|-------------------|------------|---------|---------------------|---------|--------------------|---------|------------------------------|-------|
| | mm | | | | min | max | s, mm | x, mm | s, mm | x, mm | s, mm | x, mm | s, mm |
| SLOF1 | 300/600 | | 4D22 | 2D22 | $\Phi 1/2Vc$ | $\Phi 3Vc$ | - | - | P10-200 | 1928 | P10-200 | - | - |
| SLOF6 | 300/600 | | 4D22 | 2D22 | $\Phi 1/2Vc$ | $\Phi 3Vc$ | - | - | P10-200 | 1908 | P10-200 | - | - |
| SLOF11 | 300/600 | | 5D22 | 2D22 | $\Phi 3Vc$ | $\Phi 5Vc$ | P10-110 | - | - | - | - | - | - |
| SLOF12 | 300/600 | | 2D22 | 3D22 | ΦVc | $\Phi 3Vc$ | - | - | P10-155 | - | - | - | - |
| SLOF13 | 300/600 | | 5D22 | 2D22 | ΦVc | $\Phi 3Vc$ | - | - | P10-205 | - | - | - | - |
| SLOF18 | 300/600 | | 2D22 | 2D22 | $\Phi 1/2Vc$ | $\Phi 3Vc$ | - | - | P10-75 | 108 | P10-75 | - | - |
| SLOF19 | 300/600 | | 2D22 | 2D22 | 0 | $\Phi 3Vc$ | - | - | P10-50 | 853 | P10-50 | 260 | - |
| SLOF23 | 300/600 | | 2D22 | 2D22 | ΦVc | $\Phi 5Vc$ | P10-50 | 706 | P10-100 | - | - | - | - |
| SLOF24 | 300/600 | | 2D22 | 2D22 | 0 | ΦVc | - | - | P10-65 | 1070 | P10-65 | 418 | - |
| SLOF25 | 300/600 | | 2D22 | 2D22 | ΦVc | $\Phi 3Vc$ | - | - | P10-40 | - | - | - | - |
| SLOF38 | 300/600 | | 4D22 | 2D22 | ΦVc | $\Phi 5Vc$ | P10-95 | 1149 | P10-195 | - | - | - | - |
| SLOF39 | 300/600 | | 4D22 | 2D22 | ΦVc | $\Phi 3Vc$ | - | - | P10-190 | - | - | - | - |
| SLOF49 | 300/600 | | 2D22 | 2D22 | 0 | $\Phi 3Vc$ | - | - | P10-90 | 978 | P10-90 | 125 | - |

| Balok P. Tembok | Ukuran | | As' | As | Daerah Gaya geser | | Φ3Vc-Φ5Vc | | ΦVc-Φ3Vc | | Φ ^{1/2} Vc-ΦVc | |
|-----------------|---------|------|------|------|---------------------|-------------|-----------|-------|----------|-------|-------------------------|-------|
| | mm | | | | min | max | s, mm | x, mm | s, mm | x, mm | s, mm | x, mm |
| SLOF60 | 300/600 | 3D22 | 2D22 | 2D22 | Φ3Vc | Φ5Vc | P10-80 | - | - | - | - | - |
| SLOF61 | 300/600 | 5D22 | 2D22 | 2D22 | ΦVc | Φ3Vc | - | - | P10-210 | - | - | - |
| SLOF81 | 300/600 | 3D22 | 2D22 | 2D22 | ΦVc | Φ3Vc | - | - | P10-165 | - | - | - |
| SLOF82 | 300/600 | 3D22 | 2D22 | 2D22 | ΦVc | Φ5Vc | P10-70 | 15 | P10-145 | - | - | - |
| SLOF98 | 300/600 | 4D22 | 2D22 | 2D22 | ΦVc | Φ3Vc | - | - | P10-180 | - | - | - |
| SLOF101 | 300/600 | 4D22 | 2D22 | 2D22 | Φ3Vc | Φ5Vc | P10-90 | - | - | - | - | - |
| SLOF102 | 300/600 | 2D22 | 2D22 | 2D22 | ΦVc | Φ5Vc | P10-55 | 741 | P10-115 | - | - | - |
| SLOF110 | 300/600 | 2D22 | 2D22 | 2D22 | 0 | tidak perlu | - | - | - | - | - | - |
| SLOF111 | 300/600 | 2D22 | 2D22 | 2D22 | Φ ^{1/2} Vc | Φ3Vc | - | - | P10-65 | 508 | P10-65 | - |
| SLOF112 | 300/600 | 2D22 | 2D22 | 2D22 | 0 | ΦVc | - | - | P10-70 | 1135 | P10-70 | 434 |
| SLOF119 | 300/600 | 2D22 | 2D22 | 2D22 | ΦVc | Φ3Vc | - | - | P10-120 | - | - | - |
| SLOF120 | 300/600 | 6D22 | 2D22 | 2D22 | Φ3Vc | Φ5Vc | P10-120 | - | - | - | - | - |
| SLOF121 | 300/600 | 2D22 | 2D22 | 3D22 | ΦVc | Φ5Vc | P10-80 | 393 | P10-160 | - | - | - |
| SLOF122 | 300/600 | 2D22 | 2D22 | 3D22 | ΦVc | Φ3Vc | - | - | P10-165 | - | - | - |

| Balok P. Tembok | Ukuran | | As' | As | Daerah Gaya geser | | $\Phi 3Vc-\Phi 5Vc$ | | $\Phi Vc-\Phi 3Vc$ | | $\Phi 1/2Vc-\Phi Vc$ | |
|-----------------|---------|------|------|------|-------------------|------------|---------------------|-------|--------------------|-------|----------------------|-------|
| | mm | | | | min | max | s, mm | x, mm | s, mm | x, mm | s, mm | x, mm |
| SLOF32 | 300/400 | 5D22 | 2D22 | 2D22 | $\Phi 3Vc$ | $\Phi 5Vc$ | P10-80 | - | - | - | - | - |
| SLOF43 | 250/300 | 2D22 | 2D22 | 2D22 | $\Phi 1/2Vc$ | $\Phi 3Vc$ | - | - | P10-95 | 139 | P10-95 | - |
| SLOF52 | 300/450 | 5D22 | 2D22 | 2D22 | ΦVc | $\Phi 3Vc$ | - | - | P10-180 | - | - | - |
| SLOF53 | 300/450 | 5D22 | 2D22 | 2D22 | ΦVc | $\Phi 5Vc$ | P10-95 | 920 | P10-190 | - | - | - |
| SLOF54 | 300/450 | 5D22 | 2D22 | 2D22 | $\Phi 1/2Vc$ | $\Phi 3Vc$ | P10-90 | 3496 | P10-180 | 53 | P10-180 | - |
| SLOF55 | 300/450 | 5D22 | 2D22 | 2D22 | $\Phi 1/2Vc$ | $\Phi 3Vc$ | P10-90 | 3496 | P10-180 | 53 | P10-180 | - |
| SLOF72 | 300/450 | 3D22 | 2D22 | 2D22 | $\Phi 1/2Vc$ | ΦVc | - | - | P10-140 | 2890 | P10-140 | - |
| SLOF73 | 300/450 | 5D22 | 3D22 | 3D22 | ΦVc | $\Phi 5Vc$ | P10-90 | 471 | P10-185 | - | - | - |
| SLOF74 | 300/450 | 5D22 | 2D22 | 2D22 | $\Phi 3Vc$ | $\Phi 5Vc$ | P10-90 | - | - | - | - | - |
| SLOF75 | 300/450 | 3D22 | 2D22 | 2D22 | $\Phi 1/2Vc$ | ΦVc | - | - | P10-140 | 2719 | P10-140 | - |
| SLOF85 | 250/250 | 2D22 | 2D22 | 2D22 | $\Phi 1/2Vc$ | ΦVc | - | - | P10-80 | 9930 | P10-80 | - |
| SLOF93 | 300/450 | 5D22 | 2D22 | 2D22 | $\Phi 3Vc$ | $\Phi 5Vc$ | P10-90 | - | - | - | - | - |
| SLOF94 | 300/450 | 2D22 | 2D22 | 2D22 | $\Phi 1/2Vc$ | $\Phi 3Vc$ | - | - | P10-65 | 776 | P10-65 | - |

| Balok P. Tembok | Ukuran mm | As' | As | Daerah Gaya geser | | Φ3Vc-Φ5Vc | | ΦVc-Φ3Vc | | Φ½Vc-ΦVc | |
|-----------------|--------------|------|------|-------------------|------|-----------|-------|----------|-------|----------|-------|
| | | | | min | max | s, mm | x, mm | s, mm | x, mm | s, mm | x, mm |
| SLOF104 | 300/400 | 4D22 | 2D22 | Φ1/2Vc | Φ3Vc | - | - | P10-145 | 1868 | P10-145 | - |
| SLOF105 | 300/400 | 4D22 | 2D22 | Φ3Vc | Φ5Vc | P10-80 | - | - | - | - | - |
| SLOF106 | 300/400 | 4D22 | 2D22 | Φ3Vc | Φ5Vc | P10-70 | - | - | - | - | - |
| SLOF107 | 300/400 | 4D22 | 2D22 | Φ3Vc | Φ5Vc | P10-70 | - | - | - | - | - |
| SLOF108 | 300/400 | 4D22 | 2D22 | Φ3Vc | Φ5Vc | P10-70 | - | - | - | - | - |
| SLOF3 | 300/500 | 6D22 | 2D22 | ΦVc | Φ3Vc | - | - | P10-205 | - | - | - |
| SLOF8 | 300/500 | 5D22 | 2D22 | ΦVc | Φ3Vc | - | - | P10-205 | - | - | - |
| SLOF15 | 300/500 | 6D22 | 3D22 | Φ3Vc | Φ5Vc | P10-105 | - | - | - | - | - |
| SLOF20 | 300/500 | 2D22 | 3D22 | Φ3Vc | Φ5Vc | P10-65 | - | - | - | - | - |
| SLOF33 | 300/500 | 6D22 | 3D22 | Φ3Vc | Φ5Vc | P10-110 | - | - | - | - | - |
| SLOF44 | 300/500 | 6D22 | 3D22 | ΦVc | Φ5Vc | P10-105 | 452 | P10-210 | - | - | - |
| SLOF56 | 300/500 | 5D22 | 2D22 | Φ3Vc | Φ5Vc | P10-80 | - | - | - | - | - |
| SLOF69 | 300/500 | 4D22 | 2D22 | Φ3Vc | Φ5Vc | P10-80 | - | - | - | - | - |
| SLOF86 | 300/500 | 2D22 | 2D22 | Φ1/2Vc | Φ3Vc | - | - | P10-85 | 540 | P10-85 | - |

| Balok P. Tembok | Ukuran mm | As' | As | Daerah Gaya geser | | | $\Phi 3Vc-\Phi 5Vc$ | | $\Phi Vc-\Phi 3Vc$ | | $\Phi \frac{1}{2}Vc-\Phi Vc$ | |
|-----------------|--------------|------|------|-------------------|------------|---------|---------------------|---------|--------------------|--------|------------------------------|--|
| | | | | min | max | s, mm | x, mm | s, mm | x, mm | s, mm | x, mm | |
| SLOF95 | 300/500 | 2D22 | 2D22 | $\Phi 1/2Vc$ | $\Phi 3Vc$ | - | - | P10-70 | 657 | P10-70 | - | |
| SLOF113 | 300/500 | 2D22 | 2D22 | ΦVc | $\Phi 5Vc$ | P10-20 | 661 | P10-45 | - | - | - | |
| SLOF16 | 300/550 | 2D22 | 2D22 | ΦVc | $\Phi 3Vc$ | - | - | P10-80 | - | - | - | |
| SLOF21 | 300/550 | 2D22 | 2D22 | 0 | ΦVc | - | - | P10-50 | 786 | P10-50 | 123 | |
| SLOF87 | 300/550 | 6D22 | 3D22 | $\Phi 3Vc$ | $\Phi 5Vc$ | P10-105 | - | - | - | - | - | |
| SLOF96 | 300/550 | 3D22 | 2D22 | $\Phi 3Vc$ | $\Phi 5Vc$ | P10-70 | - | - | - | - | - | |
| SLOF109 | 300/550 | 3D22 | 2D22 | $\Phi 3Vc$ | $\Phi 5Vc$ | P10-80 | - | - | - | - | - | |
| SLOF115 | 300/550 | 5D22 | 3D22 | ΦVc | $\Phi 3Vc$ | - | - | P10-205 | - | - | - | |
| SLOF17 | 300/500 | 2D22 | 2D22 | $\Phi 3Vc$ | $\Phi 5Vc$ | P10-50 | - | - | - | - | - | |
| SLOF22 | 300/500 | 2D22 | 2D22 | $\Phi 1/2Vc$ | $\Phi 3Vc$ | - | - | P10-80 | 250 | P10-80 | - | |
| SLOF116 | 300/500 | 2D22 | 2D22 | ΦVc | $\Phi 5Vc$ | P10-45 | 399 | P10-95 | - | - | - | |
| SLOF117 | 300/500 | 2D22 | 2D22 | ΦVc | $\Phi 3Vc$ | - | - | P10-90 | - | - | - | |
| SLOF118 | 300/500 | 2D22 | 2D22 | ΦVc | $\Phi 3Vc$ | - | - | P10-95 | - | - | - | |
| SLOF34 | 300/500 | 2D22 | 2D22 | ΦVc | $\Phi 5Vc$ | P10-55 | 1259 | P10-115 | - | - | - | |

| Balok P. Tembok | Ukuran mm | As' | As | Daerah Gaya geser | | Φ3Vc-Φ5Vc | | ΦVc-Φ3Vc | | Φ½Vc-ΦVc | |
|-----------------|--------------|------|------|-------------------|------|-----------|-------|----------|-------|----------|-------|
| | | | | min | max | s, mm | x, mm | s, mm | x, mm | s, mm | x, mm |
| SLOF45 | 300/500 | 2D22 | 2D22 | ΦVc | Φ5Vc | P10-55 | 1269 | P10-110 | - | - | - |
| SLOF57 | 300/500 | 6D22 | 3D22 | ΦVc | Φ5Vc | P10-100 | 559 | P10-205 | - | - | - |
| SLOF4 | 300/550 | 5D22 | 2D22 | ΦVc | Φ3Vc | - | - | P10-205 | - | - | - |
| SLOF9 | 300/550 | 5D22 | 2D22 | ΦVc | Φ3Vc | - | - | P10-200 | - | - | - |
| SLOF26 | 300/550 | 5D22 | 2D22 | ΦVc | Φ3Vc | - | - | P10-200 | - | - | - |
| SLOF50 | 300/550 | 5D22 | 2D22 | ΦVc | Φ3Vc | - | - | P10-200 | - | - | - |
| SLOF70 | 300/550 | 5D22 | 2D22 | ΦVc | Φ3Vc | - | - | P10-200 | - | - | - |
| SLOF91 | 300/550 | 2D22 | 2D22 | ΦVc | Φ3Vc | - | - | P10-120 | - | - | - |
| SLOF114 | 300/550 | 6D22 | 3D22 | Φ3Vc | Φ5Vc | P10-110 | - | - | - | - | - |
| SLOF5 | 300/400 | 4D22 | 2D22 | Φ1/2Vc | Φ3Vc | - | - | P10-145 | 2148 | P10-145 | - |
| SLOF10 | 300/400 | 4D22 | 2D22 | Φ1/2Vc | ΦVc | - | - | P10-140 | 2750 | P10-140 | - |
| SLOF27 | 300/400 | 4D22 | 2D22 | Φ1/2Vc | ΦVc | - | - | P10-140 | 2731 | P10-140 | - |
| SLOF51 | 300/400 | 4D22 | 2D22 | Φ1/2Vc | ΦVc | - | - | P10-140 | 2732 | P10-140 | - |
| SLOF71 | 300/400 | 7D22 | 2D22 | ΦVc | Φ3Vc | - | - | P10-200 | - | - | - |

| Balok P. Tembok | Ukuran | | As' | As | Daerah Gaya geser | | Φ3Vc-Φ5Vc | | ΦVc-Φ3Vc | | Φ½Vc-ΦVc | |
|-----------------|---------|------|------|------|-------------------|------|-----------|-------|----------|-------|----------|-------|
| | mm | | | | min | max | s, mm | x, mm | s, mm | x, mm | s, mm | x, mm |
| SLOF103 | 300/400 | 3D22 | 2D22 | 2D22 | 0 | Φ3Vc | - | - | P10-125 | 1453 | P10-125 | 276 |
| SLOF35 | 300/500 | 4D22 | 2D22 | 2D22 | Φ3Vc | Φ5Vc | P10-90 | - | - | - | - | - |
| SLOF46 | 300/500 | 4D22 | 2D22 | 2D22 | Φ3Vc | Φ5Vc | P10-80 | - | - | - | - | - |
| SLOF58 | 300/500 | 2D22 | 2D22 | 2D22 | ΦVc | Φ5Vc | P10-50 | 1149 | P10-100 | - | - | - |
| SLOF67 | 300/500 | 4D22 | 2D22 | 2D22 | ΦVc | Φ3Vc | - | - | P10-180 | - | - | - |
| SLOF76 | 300/500 | 5D22 | 2D22 | 2D22 | Φ3Vc | Φ5Vc | P10-95 | - | - | - | - | - |
| SLOF92 | 300/500 | 6D22 | 3D22 | 2D22 | ΦVc | Φ3Vc | - | - | P10-210 | - | - | - |
| SLOF41 | 300/450 | 4D22 | 2D22 | 2D22 | Φ1/2Vc | ΦVc | - | - | P10-150 | 8346 | P10-150 | - |
| SLOF64 | 300/450 | 5D22 | 2D22 | 2D22 | ΦVc | Φ3Vc | - | - | P10-180 | - | - | - |
| SLOF77 | 300/450 | 4D22 | 2D22 | 2D22 | Φ3Vc | Φ5Vc | P10-80 | - | - | - | - | - |
| SLOF88 | 300/450 | 2D22 | 2D22 | 2D22 | ΦVc | Φ3Vc | - | - | P10-50 | - | - | - |
| SLOF97 | 300/450 | 2D22 | 2D22 | 2D22 | Φ1/2Vc | Φ3Vc | - | - | P10-70 | 62 | P10-70 | - |
| SLOF42 | 300/450 | 5D22 | 2D22 | 2D22 | ΦVc | Φ3Vc | - | - | P10-185 | - | - | - |
| SLOF65 | 300/450 | 2D22 | 2D22 | 2D22 | 0 | Φ5Vc | P10-45 | 2737 | P10-95 | 1416 | P10-95 | 591 |

| Balok P. Tembok | Ukuran mm | As' | As | Daerah Gaya geser | | | Φ3Vc-Φ5Vc | | ΦVc-Φ3Vc | | Φ½Vc-ΦVc | |
|-----------------|--------------|------|------|-------------------|------|--------|-----------|---------|----------|-------|----------|--|
| | | | | min | max | s, mm | x, mm | s, mm | x, mm | s, mm | x, mm | |
| SLOF79 | 300/450 | 4D22 | 2D22 | Φ3Vc | Φ5Vc | P10-80 | - | - | - | - | - | |
| SLOF98 | 300/450 | 5D22 | 2D22 | ΦVc | Φ3Vc | - | - | P10-180 | - | - | - | |
| SLOF36 | 300/500 | 5D22 | 3D22 | ΦVc | Φ3Vc | - | - | P10-195 | - | - | - | |
| SLOF47 | 300/500 | 5D22 | 3D22 | ΦVc | Φ3Vc | - | - | P10-200 | - | - | - | |
| SLOF66 | 300/500 | 4D22 | 2D22 | ΦVc | Φ3Vc | - | - | P10-175 | - | - | - | |
| SLOF80 | 300/500 | 4D22 | 2D22 | ΦVc | Φ3Vc | - | - | P10-165 | - | - | - | |
| SLOF99 | 300/500 | 4D22 | 3D22 | ΦVc | Φ3Vc | - | - | P10-180 | - | - | - | |
| SLOF37 | 300/450 | 5D22 | 2D22 | Φ3Vc | Φ5Vc | P10-90 | - | - | - | - | - | |
| SLOF48 | 300/450 | 4D22 | 2D22 | Φ3Vc | Φ5Vc | P10-80 | - | - | - | - | - | |
| SLOF59 | 300/450 | 4D22 | 2D22 | Φ3Vc | Φ5Vc | P10-80 | - | - | - | - | - | |
| SLOF68 | 300/450 | 4D22 | 2D22 | Φ3Vc | Φ5Vc | P10-80 | - | - | - | - | - | |
| SLOF78 | 300/450 | 2D22 | 2D22 | ΦVc | Φ5Vc | P10-55 | 1115 | P10-115 | - | - | - | |
| SLOF89 | 300/450 | 2D22 | 2D22 | ΦVc | Φ3Vc | - | - | P10-115 | - | - | - | |
| SLOF100 | 300/450 | 5D22 | 3D22 | ΦVc | Φ3Vc | - | - | P10-180 | - | - | - | |

Sedangkan hasil perhitungan sebelumnya adalah sebagai berikut.

Tabel IV-10 Hasil perhitungan balok penahan tembok

| Sebelum Perencanaan Ulang | Ukuran | As | Sengkang |
|---------------------------|---------|------|----------|
| | mm | | |
| balok sloof | | | |
| S1 | 200/400 | 6D16 | P8-150 |
| S2 | 200/350 | 4D16 | P8-150 |
| S3 | 200/300 | 2D16 | P8-150 |



Rangkuman hasil perhitungan balok ring dapat dilihat pada tabel berikut ini.

Tabel IV-11 Hasil perhitungan balok ring

| Balok Ring | Ukuran | | As' | As | Daerah Gaya geser | | $\Phi 3Vc-\Phi 5Vc$ | | $\Phi Vc-\Phi 3Vc$ | | $\Phi 1/2Vc-\Phi Vc$ | |
|------------|---------|--|------|------|-------------------|------------|---------------------|-------|--------------------|-------|----------------------|-------|
| | mm | | | | min | max | s, mm | x, mm | s, mm | x, mm | s, mm | x, mm |
| RING3 | 250/250 | | 2D22 | 2D22 | 0 | ΦVc | - | - | P10-65 | 4736 | P10-65 | 1730 |
| RING5 | 250/250 | | 2D22 | 2D22 | 0 | ΦVc | - | - | P10-60 | 4269 | P10-60 | 1553 |
| RING7 | 250/250 | | 2D22 | 2D22 | 0 | ΦVc | - | - | P10-55 | 4124 | P10-55 | 1586 |
| RING9 | 250/250 | | 2D22 | 2D22 | 0 | ΦVc | - | - | P10-60 | 4283 | P10-60 | 1681 |
| RING11 | 250/250 | | 2D22 | 2D22 | 0 | ΦVc | - | - | P10-60 | 4191 | P10-60 | 1405 |
| RING13 | 250/250 | | 2D22 | 2D22 | 0 | ΦVc | - | - | P10-65 | 4941 | P10-65 | 1805 |
| RING4 | 250/350 | | 5D22 | 2D22 | $\Phi 1/2Vc$ | $\Phi 3Vc$ | P10-85 | 13741 | P10-175 | 829 | P10-175 | - |
| RING6 | 250/350 | | 4D22 | 2D22 | $\Phi 1/2Vc$ | $\Phi 3Vc$ | P10-75 | 13829 | P10-150 | 2617 | P10-150 | - |
| RING8 | 250/300 | | 3D22 | 2D22 | 0 | ΦVc | - | - | P10-120 | 7470 | P10-120 | 1933 |
| RING10 | 250/300 | | 3D22 | 2D22 | $\Phi 1/2Vc$ | ΦVc | - | - | P10-115 | 4648 | P10-115 | - |
| RING12 | 250/300 | | 3D22 | 2D22 | $\Phi 1/2Vc$ | ΦVc | - | - | P10-125 | 4759 | P10-125 | - |

| Balok Ring | Ukuran mm | As' | As | Daerah Gaya geser | | | | $\Phi 3Vc-\Phi 5Vc$ | | $\Phi Vc-\Phi 3Vc$ | | $\Phi 1/2Vc-\Phi Vc$ | |
|------------|--------------|------|------|-------------------|------------|---------|-------|---------------------|-------|--------------------|-------|----------------------|-------|
| | | | | min | max | s, mm | x, mm | s, mm | x, mm | s, mm | x, mm | s, mm | x, mm |
| RING14 | 250/350 | 5D22 | 2D22 | $\Phi 1/2Vc$ | ΦVc | - | - | P10-170 | 6149 | P10-170 | - | - | - |
| RING1 | 250/250 | 2D22 | 2D22 | 0 | ΦVc | - | - | P10-75 | 5277 | P10-75 | - | - | 2268 |
| RING2 | 250/250 | 2D22 | 2D22 | $\Phi 1/2Vc$ | ΦVc | - | - | P10-60 | 1915 | P10-60 | - | - | - |
| RING15 | 250/250 | 2D22 | 2D22 | 0 | ΦVc | - | - | P10-85 | 6125 | P10-85 | - | - | 2430 |
| RING16 | 250/250 | 2D22 | 2D22 | ΦVc | $\Phi 3Vc$ | P10-30 | 4345 | P10-65 | - | P10-65 | - | - | - |
| RING22 | 250/450 | 6D22 | 2D22 | $\Phi 3Vc$ | $\Phi 5Vc$ | P10-110 | - | P10-220 | - | P10-220 | - | - | - |
| RING24 | 250/400 | 5D22 | 2D22 | $\Phi 3Vc$ | $\Phi 5Vc$ | P10-95 | - | P10-190 | - | P10-190 | - | - | - |
| RING26 | 250/300 | 4D22 | 3D22 | 0 | ΦVc | - | - | P10-130 | 6217 | P10-130 | - | - | 279 |
| RING28 | 250/400 | 5D22 | 2D22 | $\Phi 3Vc$ | $\Phi 5Vc$ | P10-95 | - | P10-195 | - | P10-195 | - | - | - |
| RING30 | 250/300 | 4D22 | 3D22 | $\Phi 1/2Vc$ | ΦVc | - | - | P10-135 | 5859 | P10-135 | - | - | - |
| RING32 | 250/450 | 6D22 | 2D22 | $\Phi 3Vc$ | $\Phi 5Vc$ | P10-115 | - | P10-230 | - | P10-230 | - | - | - |
| RING23 | 250/250 | 2D22 | 2D22 | $\Phi 1/2Vc$ | ΦVc | - | - | P10-40 | 1832 | P10-40 | - | - | - |
| RING25 | 250/250 | 2D22 | 2D22 | $\Phi 1/2Vc$ | ΦVc | - | - | P10-50 | 2349 | P10-50 | - | - | - |

| Balok Ring | Ukuran | | As' | As | Daerah Gaya geser | | $\Phi 3Vc-\Phi 5Vc$ | | $\Phi Vc-\Phi 3Vc$ | | $\Phi 1/2Vc-\Phi Vc$ | |
|------------|---------|--|------|------|-------------------|-----------|---------------------|-------|--------------------|-------|----------------------|-------|
| | mm | | | | min | max | s, mm | x, mm | s, mm | x, mm | s, mm | x, mm |
| RING27 | 250/250 | | 2D22 | 2D22 | $\Phi 1/2Vc$ | ΦVc | - | - | P10-55 | 2659 | P10-55 | - |
| RING29 | 250/250 | | 2D22 | 2D22 | $\Phi 1/2Vc$ | ΦVc | - | - | P10-45 | 1704 | P10-45 | - |
| RING31 | 250/250 | | 2D22 | 2D22 | $\Phi 1/2Vc$ | ΦVc | - | - | P10-55 | 2127 | P10-55 | - |
| RING33 | 250/250 | | 2D22 | 2D22 | 0 | ΦVc | - | - | P10-50 | 2870 | P10-50 | 501 |
| RING17 | 250/250 | | 2D22 | 2D22 | $\Phi 1/2Vc$ | ΦVc | - | - | P10-90 | 2368 | P10-90 | - |
| RING18 | 250/250 | | 2D22 | 2D22 | $\Phi 1/2Vc$ | ΦVc | - | - | P10-45 | 1524 | P10-45 | - |
| RING19 | 250/250 | | 2D22 | 2D22 | 0 | ΦVc | - | - | P10-40 | 2503 | P10-40 | 618 |
| RING20 | 250/250 | | 2D22 | 2D22 | 0 | ΦVc | - | - | P10-45 | 2261 | P10-45 | 202 |
| RING21 | 250/250 | | 2D22 | 2D22 | 0 | ΦVc | - | - | P10-40 | 2389 | P10-40 | 370 |
| RING34 | 250/250 | | 2D22 | 2D22 | $\Phi 1/2Vc$ | ΦVc | - | - | P10-80 | 1755 | P10-80 | - |
| RING35 | 250/250 | | 2D22 | 2D22 | $\Phi 1/2Vc$ | ΦVc | - | - | P10-50 | 2197 | P10-50 | - |
| RING36 | 250/250 | | 2D22 | 2D22 | $\Phi 1/2Vc$ | ΦVc | - | - | P10-40 | 1912 | P10-40 | - |
| RING37 | 250/250 | | 2D22 | 2D22 | $\Phi 1/2Vc$ | ΦVc | - | - | P10-40 | 1612 | P10-40 | - |

| Balok Ring | Ukuran | | As' | As | Daerah Gaya geser | | | | $\Phi 3V_c - \Phi 5V_c$ | | $\Phi V_c - \Phi 3V_c$ | | $\Phi \frac{1}{2}V_c - \Phi V_c$ | |
|------------|---------|--|------|------|-------------------|------------|-------|-------|-------------------------|-------|------------------------|-------|----------------------------------|-------|
| | mm | | | | min | max | s, mm | x, mm | s, mm | x, mm | s, mm | x, mm | s, mm | x, mm |
| RING38 | 250/250 | | 2D22 | 2D22 | $\Phi 1/2V_c$ | ΦV_c | - | - | P10-50 | 1848 | P10-50 | 1848 | P10-50 | - |



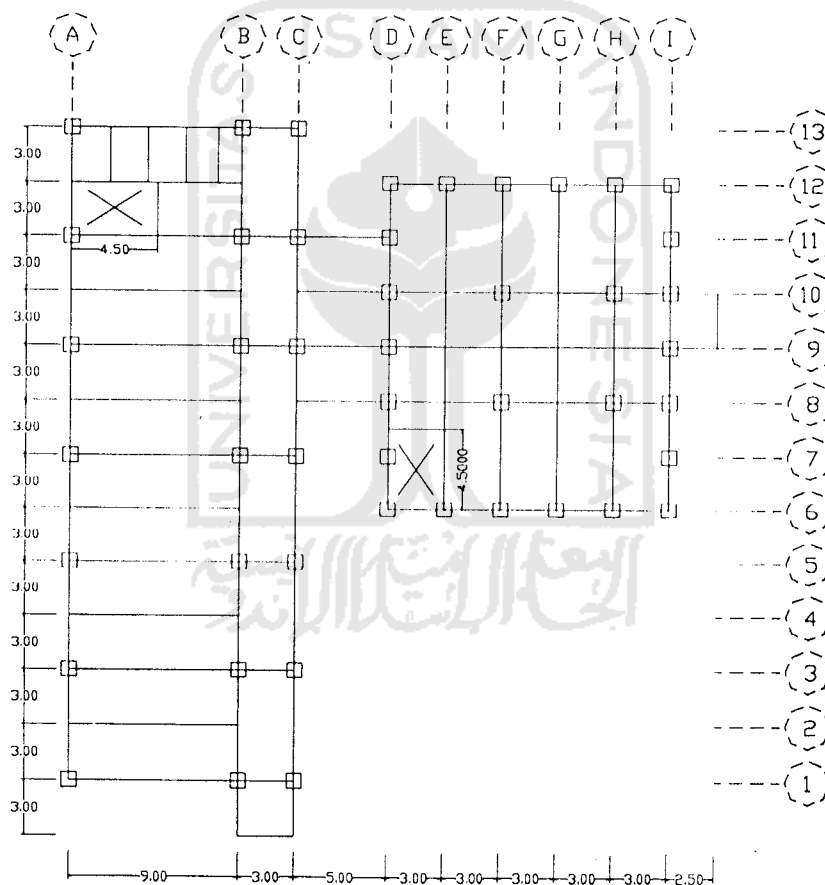
Sedangkan hasil perhitungan balok ring sebelumnya adalah sebagai berikut.

Tabel IV-12 Hasil perhitungan balok ring

| Sebelum Perencanaan Ulang | Ukuran | As | Sengkang |
|------------------------------|---------|------|----------|
| | mm | | |
| R1 | 250/400 | 3D16 | P8-150 |
| R1' | 250/400 | 6D16 | P8-150 |
| R2 | 150/300 | 2D16 | P8-150 |
| R3 | 250/400 | 3D16 | P8-150 |
| R4 | 250/400 | 3D16 | P8-150 |
| R7 | 150/400 | 4D16 | P8-150 |
| R5 | 200/400 | 3D16 | P8-150 |
| R6 | 200/300 | 3D16 | P8-150 |

4. 7. Perencanaan Kolom

Kolom direncanakan sebagai kolom persegi. Perencanaan menggunakan hasil-hasil yang di peroleh dari analisis struktur, seperti halnya momen dan gaya geser. Tulangan yang dipakai adalah persentase tulangan yang di peroleh dari diagram interaksi kolom dengan menggunakan gaya aksial, momen arah x, dan momen arah y. Sedangkan letak kolom dapat dilihat dari gambar berikut ini.



Gambar IV-16 Perletakan kolom

Untuk merencanakan kolom digunakan beberapa langkah perhitungan. Berikut ini adalah contoh perhitungan salah satu kolom.

Perencanaan Tulangan Kolom

Hasil SAP Kolom K1

FRAME

| LOC | P | V2 | V3 | T | M2 | M3 |
|-----|---|----|----|---|----|----|
|-----|---|----|----|---|----|----|

ULTKLM MAX

| | | | | | | |
|-----|--------|--------|--------|------|---------|---------|
| 0 | 610,31 | 473,03 | 601,16 | 2,75 | 1747,87 | 1343,68 |
| 1,4 | 615,85 | 473,03 | 601,16 | 2,75 | 906,24 | 689,8 |
| 2,8 | 621,38 | 473,03 | 601,16 | 2,75 | 105,12 | 196,76 |

ULTKLM MIN

| | | | | | | |
|-----|----------|---------|---------|-------|----------|----------|
| 0 | -1722,62 | -500,49 | -613,18 | -2,75 | -1763,94 | -1362,89 |
| 1,4 | -1717,08 | -500,49 | -613,18 | -2,75 | -905,48 | -670,57 |
| 2,8 | -1711,55 | -500,49 | -613,18 | -2,75 | -87,53 | -139,09 |

$$P_u = 1722,619 \text{ kN}$$

$$M_u x = 1763,938 \text{ kNm}$$

$$M_u y = 1362,891 \text{ kNm}$$

$$V_u = 613,1828 \text{ kN}$$

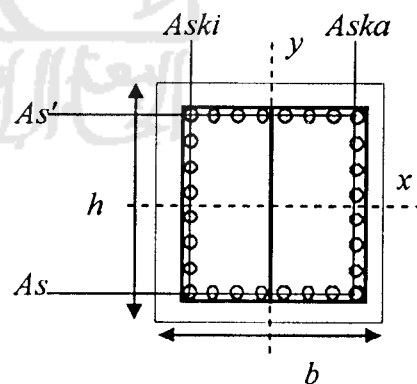
$$L = 2,8 \text{ m}$$

$$f_y = 400 \text{ MPa}$$

$$f_c' = 20 \text{ MPa}$$

$$d' = 60 \text{ mm}$$

$$b = 750 \text{ mm}$$



$$h = 750 \text{ mm}$$

$$d = 690 \text{ mm}$$

$$\Phi = 0,65$$

$$P_u/\Phi = 1722,619 / 0,65 = 2650,183 \text{ kN}$$

$$M_{ux}/\Phi = 1763,938 / 0,65 = 2713,751 \text{ kNm}$$

$$M_{uy}/\Phi = 1362,891 / 0,65 = 2096,755 \text{ kNm}$$

$$\beta_1 = 0,85$$

Arah x

$$P_n \text{ desain} = 2650,183 \text{ kN}$$

$$M \text{ desain} = 2713,751 \text{ kNm}$$

$$e = \frac{M_u/\Phi}{P_u/\Phi} = \frac{2713,751}{2650,183}$$

$$= 1,023986 \text{ m}$$

dari grafik P_u & M_n :

$$\%A_{st} = 2,80\%$$

$$A_{st} = \%A_{st} \times b \times h = 2,800\% \times 750 \times 750$$

$$= 15750 \text{ mm}^2$$

$$D. \text{ tul} = 36 \text{ mm}$$

$$\text{jml. perlu} = 16$$

$$\text{jml. pakai} = 16$$

$$\text{pakai} = 16 \text{ } \emptyset 36$$

$$A_{st} = n \times \frac{1}{4} \times \pi \times D^2 = 16 \times \frac{1}{4} \times \pi \times 36^2$$

$$= 16286,02 \text{ mm}^2$$

$$A_s = A_s' = \frac{1}{2} A_{st} = \frac{1}{2} \times 16286,016$$

$$= 8143,008 \text{ mm}^2$$

$$x_b = \frac{600 d}{600 + f_y} = \frac{600 \times 690,000}{600 + 400,000}$$

$$= 414 \text{ mm}$$

$$a_b = x_b \beta_1 = 414,000 \times 0,850$$

$$= 351,9 \text{ mm}$$

$$f_s' = \frac{x_b - d'}{x_b} \times 600 = \frac{414 - 60}{414} \times 600$$

$$= 513,0435 \text{ Mpa}$$

$$> f_y = 400 \text{ MPa}$$

$$\text{maka } f_s' = 400 \text{ Mpa}$$

$$P_{nb} = \beta_1 \times f_c' \times b \times d + A_s \times f_y - A_s' \times f_s'$$

$$= 0,85 \times 20,000 \times 750,000 \times 351,900 + 8143,008 \times 400,000$$

$$- 8143,008 \times 400,000$$

$$= 4486725 \text{ N} \qquad = 4486,725 \text{ kN}$$

$$M_{nb} = 0,85 f_c' b a (h/2 - a/2) + A_s' (f_s' - 0,85 f_c') (h/2 - d') + A_s f_y (d - h/2)$$

$$= 0,85 \times 20,000 \times 750,000 \times 351,900 \times (750,000/2 - 351,900/2)$$

$$+ 8143,008 \times (400,000 - 0,85 \times 20,000) \times (750,000/2 - 60,000)$$

$$+ 8143,008 \times 400,000 \times (690,000 - 750,000/2)$$

$$= 2901,515 \text{ kNm}$$

$$e_b = 0,646689 \text{ m}$$

$$e < e_b: \text{Patah Desak}$$

Patah Desak

$$e = 1023,986 \text{ mm}$$

$$P_n = \frac{A_s \cdot f_y}{\left(\frac{e}{d-d'} + 0,5\right)} + \frac{b \cdot h \cdot f_c'}{\left(3 \cdot h \cdot \frac{e}{d^2} + 1,18\right)}$$

$$P_n = \frac{8143,008 \cdot 400}{\left(\frac{1023,986}{690 - 60} + 0,5\right)} + \frac{750 \cdot 750 \cdot 20}{\left(3 \cdot 750 \cdot \frac{1023,986}{690^2} + 1,18\right)}$$

$$= 3401534 \text{ N} \qquad = 3401,534 \text{ kN}$$

$$> P_n \text{ desain} = 2650,183 \text{ kN} \quad \text{--Ok--}$$

Arah y

$$P_n \text{ desain} = 2650,183 \text{ kN}$$

$$M \text{ desain} = 2096,755 \text{ kNm}$$

$$e = \frac{M_u / \phi}{P_u / \phi} = \frac{2096,755}{2650,183}$$

$$= 0,791174 \text{ m}$$

dari grafik Pu & Mn:

$$\%Ast = 2,80\%$$

$$Ast = \%Ast \times b \times h = 2,800\% \times 750 \times 750$$

$$= 15750 \text{ mm}^2$$

$$D. \text{ tul} = 36 \text{ mm}$$

$$\text{jml. perlu} = 16$$

$$\text{jml. pakai} = 16$$

$$\text{pakai} = 16 \text{ } \emptyset 36$$

$$Ast = n \times \frac{1}{4} \times \pi \times D^2 = 16 \times \frac{1}{4} \times \pi \times 36^2$$

$$= 16286,02 \text{ mm}^2$$

$$Aski = Aska = \frac{1}{2} Ast = \frac{1}{2} \times 16286,016$$

$$= 8143,008 \text{ mm}^2$$

$$x_b = \frac{600 d}{600 + f_y} = \frac{600 \times 690,000}{600 + 400,000}$$

$$= 414 \text{ mm}$$

$$a_b = x_b \beta_1 = 414,000 \times 0,850$$

$$= 351,9 \text{ mm}$$

$$f_s' = \frac{x_b - d'}{x_b} \times 600 = \frac{414 - 60}{414} \times 600$$

$$= 513,0435 \text{ Mpa} > f_y =$$

$$\text{maka } f_s' = 400 \text{ Mpa}$$

$$\begin{aligned}
 P_{nb} &= \beta_1 \times f_c' \times b \times d + A_s \times f_y - A_s' \times f_s' \\
 &= 0,85 \times 20,000 \times 750,000 \times 351,900 + 8143,008 \times 400,000 \\
 &\quad - 8143,008 \times 400,000 \\
 &= 4486725 \text{ N} \qquad \qquad \qquad = 4486,725 \text{ kN}
 \end{aligned}$$

$$\begin{aligned}
 M_{nb} &= 0,85 f_c' b a (h/2 - a/2) + A_s' (f_s' - 0,85 f_c') (h/2 - d') + A_s f_y (d - h/2) \\
 &= 0,85 \times 20,000 \times 750,000 \times 351,900 \times (750,000/2 - 351,900/2) \\
 &= 8143,008 \times (400,000 - 0,85 \times 20,000) \times (750,000/2 - 60,000) \\
 &\quad + 8143,008 \times 400,000 \times (690,000 - 750,000/2) \\
 &= 2901,515 \text{ kNm}
 \end{aligned}$$

$$e_b = 0,646689 \text{ m} \qquad e < e_b: \text{Patah Desak}$$

Patah Desak

$$e = 791,1738 \text{ mm}$$

$$P_n = \frac{A_s \cdot f_y}{\left(\frac{e}{d-d'} + 0,5\right)} + \frac{b \cdot h \cdot f_c'}{\left(3 \cdot h \cdot \frac{e}{d^2} + 1,18\right)}$$

$$\begin{aligned}
 P_n &= \frac{8143,008 \cdot 400}{\left(\frac{791,174}{690 - 60} + 0,5\right)} \\
 &\quad + \frac{750 \cdot 750 \cdot 20}{\left(3 \cdot 750 \cdot \frac{791,174}{690^2} + 1,18\right)} \\
 &= 4142125 \text{ N} \qquad \qquad \qquad = 4142,125 \text{ kN}
 \end{aligned}$$

$$> P_n \text{ design} = 2650,183 \text{ kN} \qquad \text{--Ok--}$$

Perencanaan tulangan geser kolom

$$V_u = 613,1828 \text{ kNm}$$

$$L = 2800 \text{ mm}$$

$$b = 750 \text{ mm}$$

$$h = 750 \text{ mm}$$

$$d = 690 \text{ mm}$$

$$\Phi = 0,6$$

$$d \text{ sengkang} = 10 \text{ mm}$$

$$\text{kaki sengkang} = 3 \text{ (vertikal)}$$

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

$$V_c = 1/6 \sqrt{f_c'} b d = 1/6 \sqrt{20,000} \times 750,000 \times 690,000$$

$$= 385721,7 \text{ N}$$

$$= 385,7217 \text{ kN}$$

$$d/2 = 345 \text{ mm}$$

$$d/4 = 172,5 \text{ mm}$$

$$V_{s1} = 2 \times V_c = 2 \times 385,722$$

$$= 771,4435 \text{ kN}$$

$$V_{s2} = 4 \times V_c = 4 \times 385,722$$

$$= 1542,887 \text{ kN}$$

$$\Phi V_c = 0,600 \times 385,722 = 231,433 \text{ kN}$$

$$\Phi \frac{1}{2} V_c = 0,600 \times 192,861 = 115,7165 \text{ kN}$$

$$\Phi V_{s1} = 0,600 \times 771,443 = 462,8661 \text{ kN}$$

$$\Phi V_{s2} = 0,600 \times 1542,887 = 925,7321 \text{ kN}$$

$$\Phi(V_c + V_{s1}) = \Phi 3V_c = 0,600 \times (385,722 + 771,443) = 416,5795 \text{ kN}$$

$$\Phi(V_c + V_{s2}) = \Phi 5V_c = 0,600 \times (385,722 + 1542,887) = 694,2991 \text{ kN}$$

$$l_1 = 2800 \text{ mm}$$

$$V_u = 613,1828 \text{ kN} > \Phi \frac{1}{2} V_c = \text{-Ok-}$$

$$\leq \Phi 5V_c = \text{-Ok-}$$

V_u berada pd daerah: $\Phi 3 V_c$ s/d $\Phi 5 V_c$

$$A_v = k \times \frac{1}{4} \times \pi \times D \text{ sengkang}^2 = 3,000 \times \frac{1}{4} \times \pi \times 10,000^2$$

$$= 235,6194 \text{ mm}$$

Daerah: $\Phi 3V_c$ s/d $\Phi 5V_c$

$$V_u = 613,1828 \text{ kN}$$

$$\Phi V_s = V_u - \Phi V_c$$

$$= 381,7498 \text{ kN}$$

$$= 381749,8 \text{ N}$$

$$V_s \text{ perlu} = \frac{\Phi V_s}{\Phi} = \frac{381749,8}{0,6}$$

$$= 636249,6 \text{ N}$$

$$s = \frac{235,619 \times 240,000 \times 690,000}{636249,607}$$

$$= 61,3259 \text{ mm}$$

$$s \text{ pakai} = 60 \text{ mm} \leq d / 4 \quad \text{-Ok-}$$

$$\leq 300 \quad \text{-Ok-}$$

Hasil perhitungan kolom sebelum perencanaan ulang adalah sebagai berikut ini.

Tabel IV-13 Hasil perhitungan kolom sebelum perencanaan ulang

| Sebelum Perencanaan Ulang | Ukuran | As | Sengkang | Letak |
|---------------------------|---------|-------|----------|---|
| | mm | | | |
| k1 | 400/400 | 16D22 | P10-100 | A3,A5,A7,A9,A11, B1,B3,B5,B7,B9,B11, F8,F10, H8,H10 |
| k2 | 400/400 | 12D22 | P10-100 | A1,A13,B13 |
| k3 | 300/300 | 12D22 | P10-100 | C1,C3,C5,C7,C9,C11, D6-D12,E6,E12, F6,F12, G6,G12, H6,H12, I6-I12 |

Rangkuman hasil perhitungan kolom adalah sebagai berikut ini.

Tabel IV-14 Hasil perhitungan kolom

Hasil Perhitungan Kolom Pondasi

| Elemen | Letak | Ukuran, m | As+As' | Aska+Aski | Daerah Vu | | S _{pakai} , mm |
|--------|-------|-----------|--------|-----------|-------------|-------------|-------------------------|
| | | | | | Φ Vc | Φ 5 Vc | |
| K1 | A1 | 750 / 750 | 16 Ø36 | 12 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 60 |
| K2 | B1 | 800 / 800 | 12 Ø36 | 12 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 50 |
| K3 | C1 | 750 / 750 | 6 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 185 |
| K4 | A3 | 850 / 850 | 16 Ø36 | 10 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 55 |
| K5 | B3 | 850 / 850 | 14 Ø36 | 12 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 55 |
| K6 | C3 | 750 / 750 | 6 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 185 |
| K7 | A5 | 850 / 850 | 16 Ø36 | 10 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 50 |
| K8 | B5 | 850 / 850 | 14 Ø36 | 10 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 55 |
| K9 | C5 | 750 / 750 | 6 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 190 |
| K10 | D6 | 750 / 750 | 6 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 345 |
| K11 | E6 | 750 / 750 | 6 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 230 |
| K12 | F6 | 750 / 750 | 6 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 280 |

| Elemen | Letak | Ukuran, m | As+As' | Aska+Aski | Daerah Vu | | Spakai, mm |
|--------|-------|-------------|--------|-----------|-----------|--------|------------|
| | | | | | | | |
| K13 | G6 | 750 / 750 | 6 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 270 |
| K14 | H6 | 750 / 750 | 6 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 240 |
| K15 | I6 | 750 / 750 | 6 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 345 |
| K16 | A7 | 850 / 850 | 16 Ø36 | 10 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 55 |
| K17 | B7 | 850 / 850 | 14 Ø36 | 10 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 60 |
| K18 | C7 | 1000 / 1000 | 10 Ø36 | 10 Ø36 | Φ 1/2 Vc | Φ Vc | P10- 165 |
| K19 | D7 | 750 / 750 | 10 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 135 |
| K20 | I7 | 750 / 750 | 10 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 145 |
| K21 | D8 | 750 / 750 | 8 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 130 |
| K22 | F8 | 850 / 850 | 14 Ø36 | 10 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 70 |
| K23 | H8 | 850 / 850 | 12 Ø36 | 10 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 70 |
| K24 | I8 | 750 / 750 | 6 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 170 |
| K25 | A9 | 850 / 850 | 16 Ø36 | 12 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 55 |
| K26 | B9 | 850 / 850 | 14 Ø36 | 12 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 60 |
| K27 | C9 | 1150 / 1150 | 14 Ø36 | 14 Ø36 | Φ 1/2 Vc | Φ Vc | P10- 145 |
| K28 | D9 | 1150 / 1150 | 14 Ø36 | 14 Ø36 | Φ 1/2 Vc | Φ Vc | P10- 145 |
| K29 | I9 | 750 / 750 | 6 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 160 |
| K30 | D10 | 1100 / 1100 | 12 Ø36 | 12 Ø36 | Φ 1/2 Vc | Φ Vc | P10- 150 |
| K31 | F10 | 1000 / 1000 | 14 Ø36 | 10 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 40 |
| K32 | H10 | 950 / 950 | 18 Ø36 | 16 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 40 |
| K33 | I10 | 750 / 750 | 6 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 165 |
| K34 | A11 | 850 / 850 | 16 Ø36 | 8 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 55 |
| K35 | B11 | 850 / 850 | 14 Ø36 | 16 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 60 |
| K36 | C11 | 850 / 850 | 8 Ø36 | 8 Ø36 | Φ Vc | Φ 3 Vc | P10- 395 |
| K37 | D11 | 750 / 750 | 8 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 130 |
| K38 | I11 | 750 / 750 | 8 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 150 |

| Elemen | Letak | Ukuran, m | As+As' | Aska+Aski | Daerah Vu | | Spakai, mm |
|-------------------------------|-------|-----------|--------|-----------|-----------|--------|------------|
| | | | | | | | |
| K39 | D12 | 750 / 750 | 6 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 345 |
| K40 | E12 | 750 / 750 | 6 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 230 |
| K41 | F12 | 750 / 750 | 6 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 265 |
| K42 | G12 | 750 / 750 | 6 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 285 |
| K43 | H12 | 750 / 750 | 6 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 240 |
| K44 | I12 | 750 / 750 | 6 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 345 |
| K45 | A13 | 850 / 850 | 12 Ø36 | 8 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 75 |
| K46 | B13 | 850 / 850 | 12 Ø36 | 12 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 55 |
| K47 | C13 | 750 / 750 | 6 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 200 |
| Hasil Perhitungan Kolom Lt. 1 | | | | | | | |
| K48 | A1 | 700 / 700 | 14 Ø36 | 10 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 55 |
| K49 | B1 | 800 / 800 | 12 Ø36 | 12 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 50 |
| K50 | C1 | 700 / 700 | 6 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 185 |
| K51 | A3 | 850 / 850 | 16 Ø36 | 8 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 50 |
| K52 | B3 | 850 / 850 | 14 Ø36 | 14 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 50 |
| K53 | C3 | 700 / 700 | 6 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 140 |
| K54 | A5 | 850 / 850 | 16 Ø36 | 10 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 50 |
| K55 | B5 | 850 / 850 | 14 Ø36 | 12 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 50 |
| K56 | C5 | 700 / 700 | 6 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 150 |
| K57 | D6 | 700 / 700 | 6 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 185 |
| K58 | E6 | 700 / 700 | 6 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 160 |
| K59 | F6 | 700 / 700 | 6 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 180 |
| K60 | G6 | 700 / 700 | 6 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 175 |
| K61 | H6 | 700 / 700 | 6 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 165 |
| K62 | I6 | 700 / 700 | 6 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 160 |
| K63 | A7 | 850 / 850 | 16 Ø36 | 8 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 50 |

| Elemen | Letak | Ukuran, m | As+As' | Aska+Aski | Daerah Vu | | Spakai, mm |
|--------|-------|-------------|-------------------|-------------------|---------------|-------------|------------|
| | | | | | Φ 3 Vc | Φ 5 Vc | |
| K64 | B7 | 850 / 850 | 14 \emptyset 36 | 12 \emptyset 36 | Φ 3 Vc | Φ 5 Vc | P10- 50 |
| K65 | C7 | 1000 / 1000 | 10 \emptyset 36 | 10 \emptyset 36 | Φ 1/2 Vc | Φ Vc | P10- 165 |
| K66 | D7 | 700 / 700 | 10 \emptyset 36 | 6 \emptyset 36 | Φ 3 Vc | Φ 5 Vc | P10- 95 |
| K67 | I7 | 700 / 700 | 10 \emptyset 36 | 6 \emptyset 36 | Φ 3 Vc | Φ 5 Vc | P10- 90 |
| K68 | D8 | 700 / 700 | 10 \emptyset 36 | 6 \emptyset 36 | Φ 3 Vc | Φ 5 Vc | P10- 95 |
| K69 | F8 | 850 / 850 | 14 \emptyset 36 | 10 \emptyset 36 | Φ 3 Vc | Φ 5 Vc | P10- 45 |
| K70 | H8 | 850 / 850 | 14 \emptyset 36 | 12 \emptyset 36 | Φ 3 Vc | Φ 5 Vc | P10- 50 |
| K71 | I8 | 700 / 700 | 10 \emptyset 36 | 6 \emptyset 36 | Φ 3 Vc | Φ 5 Vc | P10- 95 |
| K72 | A9 | 850 / 850 | 16 \emptyset 36 | 8 \emptyset 36 | Φ 3 Vc | Φ 5 Vc | P10- 50 |
| K73 | B9 | 850 / 850 | 14 \emptyset 36 | 12 \emptyset 36 | Φ 3 Vc | Φ 5 Vc | P10- 50 |
| K74 | C9 | 1150 / 1150 | 14 \emptyset 36 | 14 \emptyset 36 | Φ 1/2 Vc | Φ Vc | P10- 145 |
| K75 | D9 | 1150 / 1150 | 14 \emptyset 36 | 14 \emptyset 36 | Φ 1/2 Vc | Φ Vc | P10- 145 |
| K76 | I9 | 700 / 700 | 10 \emptyset 36 | 6 \emptyset 36 | Φ 3 Vc | Φ 5 Vc | P10- 90 |
| K77 | D10 | 1100 / 1100 | 12 \emptyset 36 | 12 \emptyset 36 | Φ 1/2 Vc | Φ Vc | P10- 150 |
| K78 | I10 | 700 / 700 | 6 \emptyset 36 | 6 \emptyset 36 | Φ 3 Vc | Φ 5 Vc | P10- 90 |
| K79 | A11 | 850 / 850 | 16 \emptyset 36 | 8 \emptyset 36 | Φ 3 Vc | Φ 5 Vc | P10- 50 |
| K80 | B11 | 850 / 850 | 16 \emptyset 36 | 12 \emptyset 36 | Φ 3 Vc | Φ 5 Vc | P10- 45 |
| K81 | C11 | 850 / 850 | 8 \emptyset 36 | 8 \emptyset 36 | Φ Vc | Φ 3 Vc | P10- 395 |
| K82 | D11 | 700 / 700 | 10 \emptyset 36 | 6 \emptyset 36 | Φ 3 Vc | Φ 5 Vc | P10- 95 |
| K83 | I11 | 700 / 700 | 6 \emptyset 36 | 6 \emptyset 36 | Φ 3 Vc | Φ 5 Vc | P10- 90 |
| K84 | D12 | 700 / 700 | 6 \emptyset 36 | 6 \emptyset 36 | Φ Vc | Φ 3 Vc | P10- 185 |
| K85 | E12 | 700 / 700 | 6 \emptyset 36 | 8 \emptyset 36 | Φ Vc | Φ 3 Vc | P10- 145 |
| K86 | F12 | 700 / 700 | 6 \emptyset 36 | 8 \emptyset 36 | Φ Vc | Φ 3 Vc | P10- 155 |
| K87 | G12 | 700 / 700 | 6 \emptyset 36 | 8 \emptyset 36 | Φ Vc | Φ 3 Vc | P10- 160 |
| K88 | H12 | 700 / 700 | 6 \emptyset 36 | 8 \emptyset 36 | Φ Vc | Φ 3 Vc | P10- 145 |
| K89 | I12 | 700 / 700 | 6 \emptyset 36 | 6 \emptyset 36 | Φ Vc | Φ 3 Vc | P10- 165 |

| Elemen | Letak | Ukuran, m | As+As' | Aska+Aski | Daerah Vu | | S _{pakai} , mm |
|-------------------------------|-------|-------------|--------|-----------|-----------|--------|-------------------------|
| | | | | | | | |
| K90 | A13 | 850 / 850 | 12 Ø36 | 8 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 80 |
| K91 | B13 | 850 / 850 | 12 Ø36 | 14 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 50 |
| K92 | C13 | 700 / 700 | 6 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 155 |
| Hasil Perhitungan Kolom Lt. 2 | | | | | | | |
| K93 | A1 | 600 / 600 | 12 Ø36 | 8 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 75 |
| K94 | B1 | 600 / 600 | 10 Ø36 | 10 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 65 |
| K95 | C1 | 600 / 600 | 6 Ø36 | 4 Ø36 | Φ Vc | Φ 3 Vc | P10- 270 |
| K96 | A3 | 700 / 700 | 14 Ø36 | 8 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 55 |
| K97 | B3 | 700 / 700 | 14 Ø36 | 10 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 55 |
| K98 | C3 | 600 / 600 | 8 Ø36 | 4 Ø36 | Φ Vc | Φ 3 Vc | P10- 180 |
| K99 | A5 | 700 / 700 | 14 Ø36 | 8 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 60 |
| K100 | B5 | 700 / 700 | 12 Ø36 | 10 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 55 |
| K101 | C5 | 600 / 600 | 6 Ø36 | 4 Ø36 | Φ Vc | Φ 3 Vc | P10- 205 |
| K102 | D6 | 600 / 600 | 4 Ø36 | 4 Ø36 | Φ Vc | Φ 3 Vc | P10- 270 |
| K103 | E6 | 600 / 600 | 4 Ø36 | 4 Ø36 | Φ Vc | Φ 3 Vc | P10- 270 |
| K104 | F6 | 600 / 600 | 4 Ø36 | 4 Ø36 | Φ Vc | Φ 3 Vc | P10- 270 |
| K105 | G6 | 600 / 600 | 4 Ø36 | 4 Ø36 | Φ Vc | Φ 3 Vc | P10- 270 |
| K106 | H6 | 600 / 600 | 4 Ø36 | 4 Ø36 | Φ Vc | Φ 3 Vc | P10- 235 |
| K107 | I6 | 600 / 600 | 6 Ø36 | 4 Ø36 | Φ Vc | Φ 3 Vc | P10- 220 |
| K107 | A7 | 600 / 600 | 6 Ø36 | 4 Ø36 | Φ Vc | Φ 3 Vc | P10- 220 |
| K109 | B7 | 700 / 700 | 10 Ø36 | 8 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 55 |
| K110 | C7 | 1000 / 1000 | 10 Ø36 | 10 Ø36 | Φ 1/2 Vc | Φ Vc | P10- 165 |
| K111 | D7 | 600 / 600 | 4 Ø36 | 4 Ø36 | Φ Vc | Φ 3 Vc | P10- 165 |
| K112 | I7 | 600 / 600 | 6 Ø36 | 4 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 135 |
| K113 | D8 | 600 / 600 | 6 Ø36 | 4 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 135 |
| K114 | F8 | 750 / 750 | 14 Ø36 | 10 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 55 |

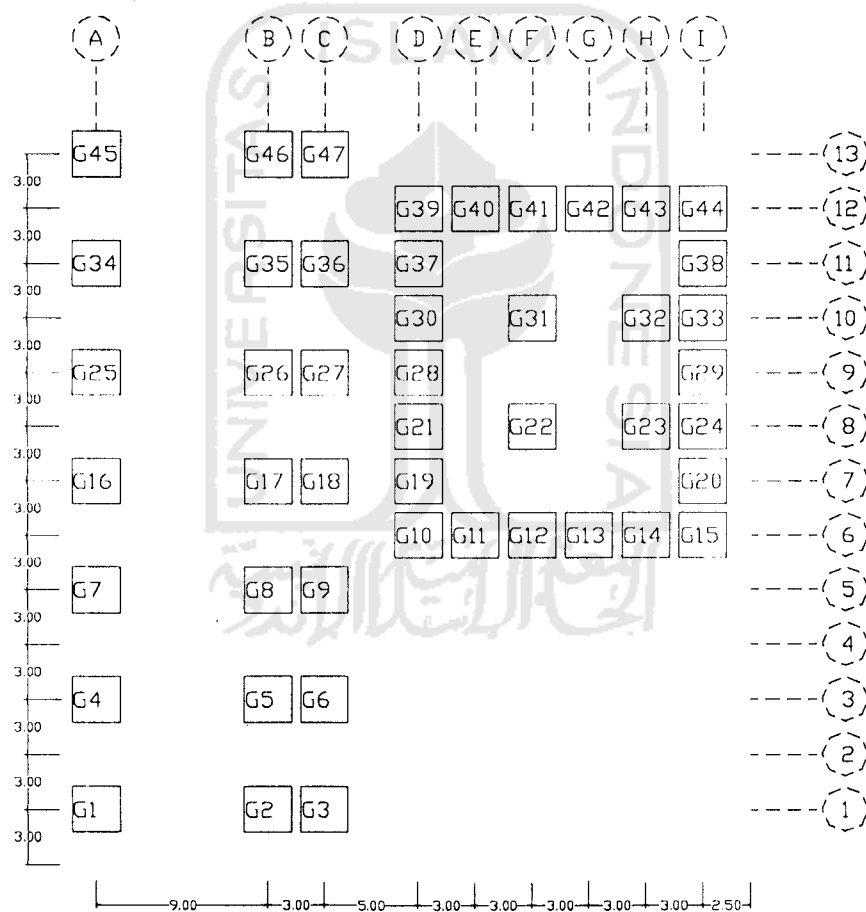
| Elemen | Letak | Ukuran, m | As+As' | Aska+Aski | Daerah Vu | | S _{pakai} , mm |
|-------------------------------|-------|-------------|--------|-----------|----------------------------|--------|-------------------------|
| | | | | | | | |
| K115 | H8 | 750 / 750 | 14 Ø36 | 10 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 60 |
| K116 | I8 | 600 / 600 | 6 Ø36 | 4 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 135 |
| K117 | A9 | 700 / 700 | 14 Ø36 | 8 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 60 |
| K118 | B9 | 700 / 700 | 12 Ø36 | 10 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 60 |
| K119 | C9 | 1150 / 1150 | 14 Ø36 | 14 Ø36 | tidak perlu tulangan geser | | |
| K120 | D9 | 1150 / 1150 | 14 Ø36 | 14 Ø36 | tidak perlu tulangan geser | | |
| K121 | I9 | 600 / 600 | 6 Ø36 | 4 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 135 |
| K122 | D10 | 1100 / 1100 | 12 Ø36 | 12 Ø36 | tidak perlu tulangan geser | | |
| K123 | I10 | 600 / 600 | 6 Ø36 | 4 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 135 |
| K124 | A11 | 700 / 700 | 14 Ø36 | 10 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 55 |
| K125 | B11 | 750 / 750 | 6 Ø36 | 6 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 60 |
| K126 | C11 | 850 / 850 | 8 Ø36 | 8 Ø36 | Φ 1/2 Vc | Φ Vc | P10- 195 |
| K127 | D11 | 600 / 600 | 4 Ø36 | 4 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 135 |
| K128 | I11 | 600 / 600 | 6 Ø36 | 4 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 135 |
| K129 | D12 | 600 / 600 | 4 Ø36 | 4 Ø36 | Φ Vc | Φ 3 Vc | P10- 270 |
| K130 | E12 | 600 / 600 | 4 Ø36 | 4 Ø36 | Φ Vc | Φ 3 Vc | P10- 270 |
| K131 | F12 | 600 / 600 | 4 Ø36 | 4 Ø36 | Φ Vc | Φ 3 Vc | P10- 270 |
| K132 | G12 | 600 / 600 | 4 Ø36 | 4 Ø36 | Φ Vc | Φ 3 Vc | P10- 270 |
| K133 | H12 | 600 / 600 | 4 Ø36 | 4 Ø36 | Φ Vc | Φ 3 Vc | P10- 270 |
| K134 | I12 | 600 / 600 | 6 Ø36 | 4 Ø36 | Φ Vc | Φ 3 Vc | P10- 230 |
| K135 | A13 | 600 / 600 | 12 Ø36 | 4 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 70 |
| K136 | B13 | 700 / 700 | 10 Ø36 | 10 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 85 |
| K137 | C13 | 600 / 600 | 6 Ø36 | 6 Ø36 | Φ Vc | Φ 3 Vc | P10- 270 |
| Hasil Perhitungan Kolom Lt. 3 | | | | | | | |
| K138 | A1 | 1000 / 1000 | 12 Ø36 | 28 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 40 |
| K139 | B1 | 1150 / 1150 | 14 Ø36 | 16 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 45 |

| Elemen | Letak | Ukuran, m | As+As' | Aska+Aski | Daerah Vu | | Spakai, mm |
|--------|-------|-------------|--------|-----------|----------------------------|-------------|------------|
| | | | | | Φ 3 Vc | Φ 5 Vc | |
| K140 | C1 | 1150 / 1150 | 16 Ø36 | 16 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 45 |
| K141 | A3 | 1100 / 1100 | 18 Ø36 | 12 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 50 |
| K142 | B3 | 850 / 850 | 16 Ø36 | 8 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 50 |
| K143 | C3 | 600 / 600 | 4 Ø36 | 4 Ø36 | tidak perlu tulangan geser | | |
| K144 | A5 | 600 / 600 | 6 Ø36 | 4 Ø36 | Φ 1/2 Vc | Φ Vc | P10- 270 |
| K145 | B5 | 600 / 600 | 6 Ø36 | 4 Ø36 | Φ Vc | Φ 3 Vc | P10- 270 |
| K146 | C5 | 600 / 600 | 4 Ø36 | 4 Ø36 | tidak perlu tulangan geser | | |
| K147 | D6 | 600 / 600 | 12 Ø36 | 4 Ø36 | Φ Vc | Φ 3 Vc | P10- 220 |
| K148 | E6 | 600 / 600 | 4 Ø36 | 4 Ø36 | tidak perlu tulangan geser | | |
| K149 | F6 | 600 / 600 | 10 Ø36 | 4 Ø36 | Φ Vc | Φ 3 Vc | P10- 270 |
| K150 | G6 | 600 / 600 | 4 Ø36 | 4 Ø36 | tidak perlu tulangan geser | | |
| K151 | H6 | 600 / 600 | 4 Ø36 | 4 Ø36 | tidak perlu tulangan geser | | |
| K152 | I6 | 600 / 600 | 4 Ø36 | 4 Ø36 | tidak perlu tulangan geser | | |
| K153 | A7 | 600 / 600 | 4 Ø36 | 4 Ø36 | tidak perlu tulangan geser | | |
| K154 | B7 | 600 / 600 | 6 Ø36 | 4 Ø36 | Φ 1/2 Vc | Φ Vc | P10- 270 |
| K155 | C7 | 600 / 600 | 6 Ø36 | 4 Ø36 | Φ Vc | Φ 3 Vc | P10- 270 |
| K156 | D7 | 600 / 600 | 12 Ø36 | 4 Ø36 | Φ Vc | Φ 3 Vc | P10- 155 |
| K157 | I7 | 600 / 600 | 4 Ø36 | 4 Ø36 | tidak perlu tulangan geser | | |
| K158 | D8 | 600 / 600 | 4 Ø36 | 4 Ø36 | tidak perlu tulangan geser | | |
| K159 | I8 | 600 / 600 | 4 Ø36 | 4 Ø36 | tidak perlu tulangan geser | | |
| K160 | A9 | 600 / 600 | 4 Ø36 | 4 Ø36 | tidak perlu tulangan geser | | |
| K161 | B9 | 600 / 600 | 4 Ø36 | 4 Ø36 | tidak perlu tulangan geser | | |
| K162 | C9 | 600 / 600 | 16 Ø36 | 4 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 105 |
| K163 | D9 | 600 / 600 | 4 Ø36 | 4 Ø36 | tidak perlu tulangan geser | | |
| K164 | I9 | 600 / 600 | 14 Ø36 | 14 Ø36 | Φ 3 Vc | Φ 5 Vc | P10- 115 |
| K165 | D10 | 600 / 600 | 4 Ø36 | 4 Ø36 | tidak perlu tulangan geser | | |

| Elemen | Letak | Ukuran, m | As+As' | Aska+Aski | Daerah Vu | S_{pakai} , mm |
|--------|-------|-----------|--------|-----------|----------------------------|------------------|
| K166 | I10 | 600 / 600 | 4 Ø36 | 4 Ø36 | tidak perlu tulangan geser | |
| K167 | A11 | 600 / 600 | 4 Ø36 | 4 Ø36 | tidak perlu tulangan geser | |
| K168 | B11 | 600 / 600 | 16 Ø36 | 4 Ø36 | Φ 3 Vc | Φ 5 Vc P10- 105 |
| K169 | C11 | 600 / 600 | 4 Ø36 | 4 Ø36 | tidak perlu tulangan geser | |
| K170 | D11 | 600 / 600 | 12 Ø36 | 4 Ø36 | Φ 3 Vc | Φ 5 Vc P10- 135 |
| K171 | I11 | 600 / 600 | 6 Ø36 | 4 Ø36 | Φ 1/2 Vc | Φ Vc P10- 270 |
| K172 | D12 | 600 / 600 | 4 Ø36 | 4 Ø36 | tidak perlu tulangan geser | |
| K173 | E12 | 600 / 600 | 4 Ø36 | 4 Ø36 | tidak perlu tulangan geser | |
| K174 | F12 | 600 / 600 | 4 Ø36 | 4 Ø36 | tidak perlu tulangan geser | |
| K175 | G12 | 600 / 600 | 4 Ø36 | 4 Ø36 | tidak perlu tulangan geser | |
| K176 | H12 | 600 / 600 | 6 Ø36 | 6 Ø36 | Φ 3 Vc | Φ 5 Vc P10- 80 |
| K177 | I12 | 600 / 600 | 6 Ø36 | 4 Ø36 | Φ 3 Vc | Φ 5 Vc P10- 95 |
| K178 | A13 | 600 / 600 | 8 Ø36 | 4 Ø36 | Φ 3 Vc | Φ 5 Vc P10- 95 |
| K179 | B13 | 850 / 850 | 12 Ø36 | 8 Ø36 | Φ 3 Vc | Φ 5 Vc P10- 50 |
| K180 | C13 | 850 / 850 | 12 Ø36 | 8 Ø36 | Φ 3 Vc | Φ 5 Vc P10- 45 |

4. 8. Perencanaan Pondasi

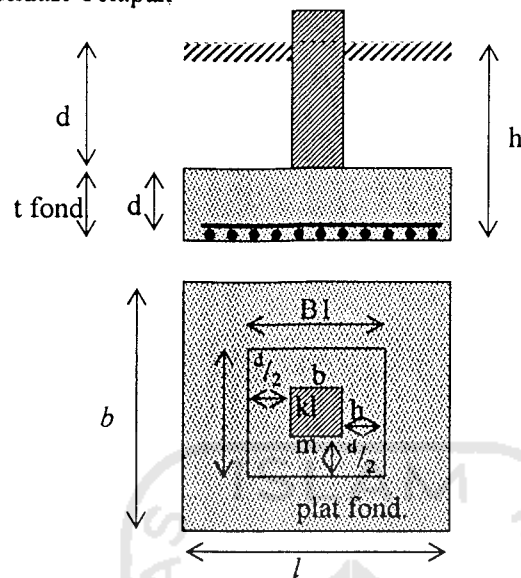
Pondasi direncanakan sebagai pondasi telapak dengan gaya-gaya yang dipergunakan diambil dari perhitungan SAP 2000. Gaya-gaya yang diambil adalah reaksi dari model struktur. Data-data tanah juga dipergunakan untuk memperoleh tegangan ijin. Letak dari pondasi dapat di lihat pada gambar berikut ini.



Gambar IV-17 Letak Titik Pondasi

Berikut ini adalah contoh perhitungan pondasi dan rangkuman hasilnya, sedangkan hitung pondasi lainnya dapat di lihat pada lampiran.

Perencanaan Pondasi Telapak



Data : G1

$$\begin{aligned} \sigma_{\text{tanah}} : 95 \text{ kg/cm}^2 &= 9,3163 \text{ MPa} \\ &= 9316,3 \text{ kN/m}^2 \end{aligned}$$

h tnh keras : 3 m

 $f_c : 20 \text{ MPa}$ $f_y : 400 \text{ MPa}$

$$B_j \text{ tnh} : 1,69 \text{ g/cm}^3 = 16,57321 \text{ kN/m}^3$$

 $B_j \text{ btn} : 24 \text{ kN/m}^3$

tebal pondasi : 0,65 m

 $P_u : 847,7698 \text{ kN}$ $M_{ux} : 447,0112 \text{ kNm}$ $M_{uy} : 347,9272 \text{ kNm}$

Ukuran kolom :

 $b_{klm} : 750 \text{ mm}$ $h_{klm} : 750 \text{ mm}$

Daya dukung netto :

$$\begin{aligned} df &= h - t_{pondasi} &&= 3-0,65 \\ &= 2,35 \text{ m} \end{aligned}$$

$$\begin{aligned} q &= (b_j \text{ tnh} \times df) + (b_j \text{ btn} \times t_{bl}) \\ &= 16,573 \times 2,35 + 24 \times 0,65 \\ &= 54,54704 \text{ kN/m}^2 \end{aligned}$$

$$\begin{aligned} \sigma_{\text{netto}} &= \sigma_{\text{tanah}} - q &&= 9,3163 \times 1000 - 54,5470373157895 \\ &= 9261,753 \text{ kN/m}^2 \end{aligned}$$

$$SF = 1,5$$

$$\begin{aligned} \sigma_{\text{ijin}} &= SF \times \sigma_{\text{tanah}} = 1,5 \times 9316,3 \\ &= 13974,45 \text{ kN/m}^2 \end{aligned}$$

Dimensi pondasi bjr. sangkar :

$$A_{f_{\text{perlu}}} = \frac{P_u}{\sigma_{\text{netto}}} = \frac{847,7698}{9261,753} = 0,091534 \text{ m}^2$$

$$\begin{aligned} b &= \sqrt{A} = \sqrt{0,092} \\ &= 0,302547 \text{ m} \end{aligned}$$

$$\approx 0,35 \text{ m}$$

$$b : 3,55 \text{ m} \quad \frac{1}{6} b = 0,591667 \text{ m}$$

$$l : 3,55 \text{ m} \quad \frac{1}{6} l = 0,591667 \text{ m}$$

$$A_{f_{\text{pakai}}} = 3,55 \times 3,55 = 12,6025 \text{ m}^2$$

$$\begin{aligned} \sigma &= q_s = P_u \div A_{\text{pakai}} &&= 847,7698 \div 12,6025 \\ &= 67,26997 \text{ kN/m}^2 \end{aligned}$$

Perenc t_{bl} pond telapak syarat kuat geser :

asumsi tebal pondasi / d : 550 mm

tebal selimut beton / pb : 70 mm

Ø tul : 22 mm

$$d = d - pb - \text{Øtul} = 550 - 70 - 22$$

$$= 458 \text{ mm}$$

$$e_x = M_{ux} + P u = 447,011 + 847,770$$

$$= 0,527279 \text{ m}$$

$$e_y = M_{uy} + P u = 347,927 + 847,770$$

$$= 0,410403 \text{ m}$$

$$I_x = \frac{1}{12} \times b_x \times b_y^3 = \frac{1}{12} \times 3,55 \times 3,55^3$$

$$= 13,23525 \text{ m}^4$$

$$I_y = \frac{1}{12} \times b_x^3 \times b_y = \frac{1}{12} \times 3,55^3 \times 3,55$$

$$= 13,23525 \text{ m}^4$$

$$x_{\max} = 0,5 \times b_x = 0,5 \times 3,550$$

$$= 1,775 \text{ m}$$

$$y_{\max} = 0,5 \times b_y = 0,5 \times 3,550$$

$$= 1,775 \text{ m}$$

$$x_{\min} = -0,5 \times b_x = -0,5 \times 3,550$$

$$= -1,775 \text{ m}$$

$$y_{\min} = -0,5 \times b_y = -0,5 \times 3,550$$

$$= -1,775 \text{ m}$$

$$\sigma_{\max} = \frac{P}{A} + \frac{M_x \times y_{\max}}{I_x} + \frac{M_y \times x_{\max}}{I_y} + q < \sigma_{ijin}$$

$$= 228,4274 \text{ kN/m}^2 < \sigma_{ijin} \quad \text{--Ok--}$$

$$\begin{aligned}\sigma_{\min} &= \frac{P}{A} + \frac{Mx \times y_{\min}}{I_x} + \frac{My \times x_{\min}}{I_y} + q > 0 \\ &= 15,20658 \text{ kN/m}^2 > 0 \quad \text{--Ok--}\end{aligned}$$

1. Perhitungan geser beton untuk 2 arah

$$\phi_{\text{lentur}} = 0,7$$

$$\phi_{\text{geser}} = 0,6$$

$$\begin{aligned}B1_{\text{kritis}} &= b + (d \div 2) \times 2 &= 750 + (458 \div 2) \times 2 \\ &= 1208 \text{ mm}\end{aligned}$$

$$\begin{aligned}B2_{\text{kritis}} &= h + (d \div 2) \times 2 &= 750 + (458 \div 2) \times 2 \\ &= 1208 \text{ mm}\end{aligned}$$

$$\begin{aligned}\text{keliling kritis } b_o &= 2 \times B1 + 2 \times B2 &= 2 \times 1208 + 2 \times 1208 \\ &= 4832 \text{ mm}\end{aligned}$$

$$\begin{aligned}V_u \text{ pada bid kritis} &= q_s (A_f - (B1 \times B2)) \\ &= 67,270 \times (12,6025 - ((1208 \div 1000) \times (1208 \div 1000))) \\ &= 749,6052 \text{ kN}\end{aligned}$$

$$\begin{aligned}\beta_c &= b_{klm} \div h_{klm} &= 750 \div 750 \\ &= 1\end{aligned}$$

$$\begin{aligned}V_c &= \left(2 + \frac{4}{\beta_c}\right) \times (\sqrt{f_c'}) \times b_o \times d \\ &= \left(2 + \frac{4}{1}\right) \times (\sqrt{20 \times 1000}) \times \frac{4832}{1000} \times \frac{458}{1000} \\ &= 1877,84 \text{ kN}\end{aligned}$$

$$\begin{aligned}V_c' &= 4\sqrt{f_c'} \times (b_o \times d) \\ &= 4\sqrt{(20 \times 1000)} \times (4832 \div 1000) \times (458 \div 1000) \\ &= 1251,894 \text{ kN}\end{aligned}$$

$$V_c \text{ pakai} = 1251,894 \text{ kN}$$

$$\begin{aligned}\Phi V_n &= 0,6 \times V_c \\ &= 0,6 \times 1251,894 \\ &= 751,1361 \text{ kN}\end{aligned}$$

check : $V_u < \Phi V_n$ --Ok--

2. Perhitungan geser beton untuk 1 arah

$$\begin{aligned}l_{\text{kritis}} &= (b_{\text{pakai}} - b_{\text{klm}}) \div 2 - d &= (((3,55 \times 1000) - 750) \div 2) - 458 \\ &= 942 \text{ mm}\end{aligned}$$

$$\begin{aligned}V_u &= \sigma \times b_{\text{pakai}} \times l_{\text{kritis}} &= 67,270 \times 3,55 \times (942 \div 1000) \\ &= 224,9575 \text{ kN}\end{aligned}$$

$$\begin{aligned}V_c &= (1/6) \times \sqrt{f_c} \times b_{\text{pakai}} \times d \\ &= (1/6) \times \sqrt{20 \times 1000} \times 3,55 \times (458 \div 1000) \\ &= 38,32283 \text{ kN}\end{aligned}$$

$$\begin{aligned}\Phi V_c &= 0,6 \times 2949,391 \\ &= 1769,635 \text{ kN}\end{aligned}$$

check : $V_u < \Phi V_c$ Ok

Perenc. Tulangan Utk Arah X & Y

$$\text{lengan mmn arah pj.} = (l - b_{\text{klm}}) \div 2 = (3,55 - (750 \div 1000)) \div 2$$

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

$$\begin{aligned}M_u &= 0,5 \times P_u \times l^2 \times b_{\text{pakai}} &= 0,5 \times 847,7698 \times 1,4^2 \times 3,55 \\ &= 2949,391 \text{ kNm}\end{aligned}$$

$$\beta_1 = 0,85$$

$$\begin{aligned}m &= f_y \div (0,85 \times f_c) &= 400 \div (0,85 \times 20) \\ &= 23,52941\end{aligned}$$

$$\begin{aligned}
 R_n &= M_u \div (0,85 \times f_c' \times b_y \times d^2) \\
 &= (2949,391) \div (0,85 \times 3,55 \times (458 \div 1000)^2) \\
 &= 4,659659 \text{ MPa}
 \end{aligned}$$

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

$$\rho = \frac{1}{23,52941} \times \left(1 - \sqrt{1 - \frac{2 \times 23,52941 \times 4,659659}{400}} \right)$$

$$= 0,013933$$

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

$$= \frac{0,85 \times 20}{400} \times 0,85 \times \left(\frac{600}{600 + 400} \right)$$

$$= 0,021675$$

$$\rho_{\max} = 0,75 \times \rho_b = 0,75 \times 0,02168$$

$$= 0,016256$$

$$\rho_{\min} = 1,4 \div f_y = 1,4 \div 400$$

$$= 0,0035$$

$$\rho_{\text{pakai}} = 0,013933 \text{ (}\rho \text{ perlu)}$$

$$\text{As perlu /sat lebar} = \rho_{\text{pakai}} \times d = 0,01393 \times 10^3 \times 458$$

$$= 6381,322 \text{ mm}^2$$

Jumlah tulangan sejajar arah lebar melintang hanya selebar pondasi

$$= 17 \text{ (=P22-200)}$$

$$\text{As tulangan} = 6458,98 \text{ mm}^2$$

check : $A_s \text{ tul} > A_s \text{ perlu}$ Ok

$$\begin{aligned} A_{s1} &= 2A_s \div (\beta + 1) &&= 2 \times 6381,322 \div (1+1) \\ &= 6458,98 \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} \text{sisas } A_s \text{ di tepi} &= A_s - A_{s1} &&= 6458,98 - 6458,98 \\ &= 0 \text{ mm}^2 \end{aligned}$$

$$\sqrt{A_2/A_1} = 4,733333$$

$$\sqrt{A_2/A_1} \text{ pakai } < 2 = 2$$

$$\begin{aligned} \text{Kuat tumpuan klm} &= \phi 0,85 f_c' b_{klm} h_{klm} &&= 0,7 \times 0,85 \times 20 \times (750 \times 750) \\ &= 6693,75 \text{ kN} \end{aligned}$$

check : $P_u < \text{kuat tumpuan kolom}$ --Ok--

$$\begin{aligned} \text{Kuat tumpuan fond.} &= \phi 0,85 f_c' b_{klm} h_{klm} \sqrt{A_2/A_1} \\ &= 0,7 \times 0,85 \times 20 \times (750 \times 750) \times \sqrt{A_2/A_1} \\ &= 13387,5 \text{ kN} \end{aligned}$$

check : $P_u < \text{kuat tumpuan fond.}$ --Ok--

Rangkuman hasil perhitungan pondasi dapat dilihat pada tabel berikut ini.

Tabel IV-15 Hasil perhitungan pondasi

| Titik Pondasi | b (m) | l (m) | σ max (kN/m ²) | tebal pondasi / d (mm) | As perlu /sat lebar (mm ²) | Ø tul(mm) | Jml tul. |
|---------------|-------|-------|-----------------------------------|------------------------|--|-----------|----------|
| G1 | 3,55 | 3,55 | 227,68475 | 550 | 6381,322 | 22 | 17 |
| G2 | 3,25 | 3,25 | 315,34562 | 630 | 5464,84 | 22 | 15 |
| G3 | 2,2 | 2,2 | 362,31969 | 440 | 1557,927 | 22 | 5 |
| G4 | 3,5 | 3,5 | 246,45223 | 560 | 6184,744 | 22 | 17 |
| G5 | 3,35 | 3,35 | 299,73536 | 620 | 5827,949 | 22 | 16 |
| G6 | 2,4 | 2,4 | 295,57611 | 420 | 1923,034 | 22 | 6 |
| G7 | 3,45 | 3,45 | 270,55627 | 590 | 6158,201 | 22 | 17 |
| G8 | 3,3 | 3,3 | 312,19753 | 620 | 5647,049 | 22 | 15 |
| G9 | 2,4 | 2,4 | 297,62949 | 430 | 1908,875 | 22 | 6 |
| G10 | 2,3 | 2,3 | 295,54755 | 400 | 1671,068 | 22 | 5 |
| G11 | 2,75 | 2,75 | 188,09489 | 340 | 2528,295 | 22 | 7 |
| G12 | 2,75 | 2,75 | 190,00629 | 340 | 2570,933 | 22 | 7 |
| G13 | 2,75 | 2,75 | 166,06241 | 300 | 2409,94 | 22 | 7 |
| G14 | 2,6 | 2,6 | 227,49738 | 380 | 2247,281 | 22 | 6 |
| G15 | 2,3 | 2,3 | 290,68281 | 390 | 1669,341 | 22 | 5 |
| G16 | 3,45 | 3,45 | 258,49788 | 570 | 6003,158 | 22 | 16 |
| G17 | 3,3 | 3,3 | 297,09405 | 600 | 5531,177 | 22 | 15 |
| G18 | 2,3 | 2,3 | 305,66553 | 340 | 1532,954 | 22 | 5 |
| G19 | 3 | 3 | 141,09099 | 280 | 2743,529 | 22 | 8 |
| G20 | 2,85 | 2,85 | 167,15377 | 310 | 2787,354 | 22 | 8 |
| G21 | 2,65 | 2,65 | 219,93908 | 370 | 2393,506 | 22 | 7 |
| G22 | 2,65 | 2,65 | 539,5364 | 670 | 3464,753 | 22 | 10 |
| G23 | 3,2 | 3,2 | 318,18422 | 610 | 5078,13 | 22 | 14 |
| G24 | 2,45 | 2,45 | 276,94166 | 410 | 2009,336 | 22 | 6 |
| G25 | 3,55 | 3,55 | 238,10029 | 550 | 6382,763 | 22 | 17 |
| G26 | 3,4 | 3,4 | 281,91401 | 600 | 5936,005 | 22 | 16 |

| Titik Pondasi | b (m) | l (m) | σ max (kN/m ²) | tebal pondasi / d (mm) | As perlu /sat lebar (mm ²) | Ø tul(mm) | Jml tul. |
|---------------|-------|-------|-----------------------------------|------------------------|--|-----------|----------|
| G27 | 2,5 | 2,5 | 275,72748 | 320 | 1895,707 | 22 | 5 |
| G28 | 2,15 | 2,15 | 405,78909 | 330 | 1211,862 | 22 | 4 |
| G29 | 2,45 | 2,45 | 240,5953 | 370 | 1886,247 | 22 | 5 |
| G30 | 2,05 | 2,05 | 465,73787 | 340 | 1125,012 | 22 | 3 |
| G31 | 5,25 | 5,25 | 99,149875 | 340 | 3753,91 | 22 | 10 |
| G32 | 5,2 | 5,2 | 100,18975 | 350 | 3819,389 | 22 | 11 |
| G33 | 2,3 | 2,3 | 330,7677 | 430 | 1766,901 | 22 | 5 |
| G34 | 3,2 | 3,2 | 316,14689 | 600 | 5161,349 | 22 | 14 |
| G35 | 3,05 | 3,05 | 350,85417 | 620 | 4523,717 | 22 | 12 |
| G36 | 2,6 | 2,6 | 202,37666 | 320 | 2148,426 | 22 | 6 |
| G37 | 2,55 | 2,55 | 228,61872 | 370 | 2133,85 | 22 | 6 |
| G38 | 2,7 | 2,7 | 188,50027 | 330 | 2441,656 | 22 | 7 |
| G39 | 2,2 | 2,2 | 332,11593 | 410 | 1505,354 | 22 | 4 |
| G40 | 2,5 | 2,5 | 251,13466 | 390 | 2047,986 | 22 | 6 |
| G41 | 2,25 | 2,25 | 336,44784 | 430 | 1619,978 | 22 | 5 |
| G42 | 2,25 | 2,25 | 300,94426 | 390 | 1585,997 | 22 | 5 |
| G43 | 2,45 | 2,45 | 262,61503 | 400 | 1952,161 | 22 | 6 |
| G44 | 2,3 | 2,3 | 295,304 | 400 | 1686,116 | 22 | 5 |
| G45 | 3,4 | 3,4 | 274,93802 | 590 | 5904,383 | 22 | 16 |
| G46 | 3,25 | 3,25 | 329,1923 | 640 | 5427,726 | 22 | 15 |
| G47 | 2,45 | 2,45 | 258,70261 | 390 | 1956,466 | 22 | 6 |

Hasil perhitungan pondasi sebelum perencanaan ulang adalah sebagai berikut ini.

Tabel IV-16 Hasil perhitungan pondasi sebelum perencanaan ulang

| Sebelum perencanaan | b (m): | l (m): | Tulangan | Letak |
|---------------------|--------|--------|----------|--|
| F1 | 2,75 | 2,75 | D16-100 | G4-5;G7-8;G16-17;G25-26;G34-35;G22-23;G31-32 |
| F2 | 2 | 2 | D16-150 | G3;G6;G9;G18;G47 |
| F3 | 2,5 | 2,5 | D16-125 | G1-2;G10-15;G19-20;G21;G24;G27-29;G30;G33;G36-46 |