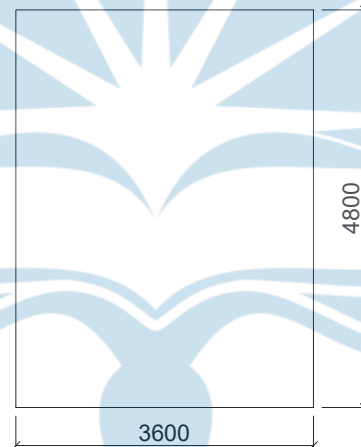


## BAB II

### PRELIMINARY DESIGN

Preliminary design atau yang disebut (desain awal) merupakan tahap awal dalam proses perancangan suatu gedung yang bertujuan untuk menentukan dimensi kolom, balok, dan tebal pelat lantai yang akan menjadi dasar dalam merencanakan Gedung Desain Interior. Berikut merupakan *preliminary design* untuk rancangan bangunan.

#### 2.1 Menentukan Pelat Lantai



Gambar . 1 Ukuran Pelat Lantai Terbesar

$$L_y = 4800 \text{ mm}$$

$$L_x = 3600 \text{ mm}$$

##### a. Identifikasi pelat

Tumpuan satu ujung menerus & dua menerus

$$\frac{L_y}{L_x} = \frac{4800}{3600} = 1,333 < 2$$

Sehingga, menggunakan pelat dua arah

- b. Menentukan tebal pelat dua arah

Sesuai dengan SNI 2847:2019 pasal 8.3.1.2 ketebalan imum pelat dua arah non prategang dengan balok di antara tumpuan pada semua sisinya, berikut adalah desain pada dimensi pelat lantai:

## 2.2 Menentukan Dimensi Balok

Perhitungan tinggi minimum balok didasarkan pada SNI tabel 9.3.1.1 menggunakan kondisi perletakan menerus satu sisi.

- a. Menentukan dimensi minimum balok induk 1

$$h = \frac{1}{18,5} \times L = \frac{1}{18,5} \times 9600 = 518,9189 \text{ mm} \approx 700 \text{ mm}$$

$$b = 0,3 \times h = 0,3 \times 700 = 210 \text{ mm} \approx 350 \text{ mm}$$

maka, dimensi untuk balok induk 1 yaitu 350 x 700 mm

- b. Menentukan dimensi minimum balok induk 2

$$h = \frac{1}{18,5} \times L = \frac{1}{18,5} \times 9000 = 486,4865 \text{ mm} \approx 600 \text{ mm}$$

$$b = 0,3 \times h = 0,3 \times 600 = 180 \text{ mm} \approx 300 \text{ mm}$$

maka, dimensi untuk balok induk 2 yaitu 300 x 600 mm

- c. Menentukan dimensi minimum balok induk 3

$$h = \frac{1}{18,5} \times L = \frac{1}{18,5} \times 7200 = 389,1892 \text{ mm} \approx 550 \text{ mm}$$

$$b = 0,3 \times h = 0,3 \times 550 = 165 \text{ mm} \approx 300 \text{ mm}$$

maka, dimensi untuk balok induk 3 yaitu 300 x 550 mm

- d. Menentukan dimensi minimum balok anak 1

$$h = \frac{1}{18,5} \times L = \frac{1}{18,5} \times 4800 = 259,4595 \text{ mm} \approx 400 \text{ mm}$$

$$b = 0,3 \times h = 0,3 \times 400 = 120 \text{ mm} \approx 250 \text{ mm}$$

maka, dimensi untuk balok anak 1 yaitu 250 x 400 mm

- e. Menentukan dimensi minimum balok anak 2

$$h = \frac{1}{18,5} \times L = \frac{1}{18,5} \times 9600 = 518,9189 \text{ mm} \approx 350 \text{ mm}$$

$b = 0,3 \times h = 0,3 \times 350 = 105 \text{ mm} \approx 250 \text{ mm}$  maka, dimensi untuk balok anak 2 yaitu  $250 \times 350 \text{ mm}$

f. Cek syarat dimensi penampang balok SRPMK

Balok induk 1

$$L_n > 4d$$

$$9000 > 4 \left( 700 - 10 - \left( \frac{19}{2} \right) - 40 \right)$$

$$9000 > 2562 \rightarrow \text{OK}$$

Balok induk 2

$$L_n > 4d$$

$$8400 > 4 \left( 600 - 10 - \left( \frac{19}{2} \right) - 40 \right)$$

$$9000 \text{ mm} > 2162 \text{ mm} \rightarrow \text{OK}$$

Balok induk 3

$$L_n > 4d$$

$$9000 > 4 \left( 550 - 10 - \left( \frac{19}{2} \right) - 40 \right)$$

$$9000 \text{ mm} > 1962 \text{ mm} \rightarrow \text{OK}$$

Balok anak 1

$$L_n > 4d$$

$$9000 > 4 \left( 550 - 10 - \left( \frac{16}{2} \right) - 40 \right)$$

$$9000 \text{ mm} > 1962 \text{ mm} \rightarrow \text{OK}$$

Balok anak 2

$$L_n > 4d$$

$$9000 > 4 \left( 350 - 10 - \left( \frac{16}{2} \right) - 40 \right)$$

$$9000 \text{ mm} > 1368 \text{ mm} \rightarrow \text{OK}$$

Dari perhitungan di atas dapat disimpulkan bahwa preliminary design

Gedung Departemen Desain Interior di Surabaya, sebagai berikut:

Tabel 2. 1 Rekapitulasi *Preliminary Design*

|               |                |
|---------------|----------------|
| Pelat lantai  | 150 mm         |
| Kolom 1       | 500 x 500 (mm) |
| Kolom 2       | 400 x 400 (mm) |
| Balok Induk 1 | 350 x 700 (mm) |
| Balok Induk 2 | 300 x 600 (mm) |
| Balok Induk 3 | 300 x 550 (mm) |
| Balok Anak 1  | 250 x 400 (mm) |
| Balok Anak 2  | 250 x 350 (mm) |

### 2.2.1 Balok Induk 1 (350 x 700 mm)

Diketahui :

- $h_f$  (asumsi) = 150 mm
- $b_w$  = 350 mm
- $h$  = 700 mm
- $f = h_b = h - h_f = 550$  mm

#### 1) Nilai lebar efektif

Lebar efektif merupakan nilai terkecil dari:

$$b_e = b_w + 2h_b$$

$$b_e = 350 + 2 \times 550$$

$$b_e = 1450 \text{ mm}$$

$$\text{Kontrol : } h_b < 4.h_f$$

$$: 550 \text{ mm} < 600 \text{ mm (OK)}$$

#### 2) Momen inersia balok

$$y_1 = \frac{h_b}{2}$$

$$y_1 = \frac{550}{2}$$

$$y_1 = 275 \text{ mm}$$

$$y_2 = \frac{hf}{2} + hb$$

$$y_2 = \frac{150}{2} + 550$$

$$y_2 = 625 \text{ mm}$$

$$A_1 = hb \times bw$$

$$A_1 = 550 \times 350$$

$$A_1 = 192.500 \text{ mm}^2$$

$$A_2 = be \times hf$$

$$A_2 = 1450 \times 150$$

$$A_2 = 217.500 \text{ mm}^2$$

$$y = \frac{A_1 y_1 + A_2 y_2}{A_1 + A_2}$$

$$y = \frac{192.500 \times 275 + 217.500 \times 625}{192.500 + 217.500}$$

$$y = 460,6707 \text{ mm}$$

$$I_{b1} = \frac{1}{12} bw hb^3 + A_1 (y - y_1)^2 + \frac{1}{12} be hf^3 + A_2 (y_2 - y)^2$$

$$I_{b1} = \frac{1}{12} 350 \times 550^3 + 192.500 (460,6707 - 275)^2 + \frac{1}{12} 1450 \times 150^3 + 217.500 (460,6707 - 625)^2$$

$$I_{b1} = 5.449.291.667 \text{ mm}^4$$

### 3) Momen inersia pelat

$$I_{s1} = \frac{1}{12} Lx hf^3$$

$$I_{s1} = \frac{1}{12} 3000 \times 150^3$$

$$I_{s1} = 843.750.000 \text{ mm}^3$$

### 4) Modulus Elastisitas Beton Balok dan Pelat ( Ecb1 & Ecs1)

$$E = 4700 \sqrt{f_c}$$

$$E_{cb1} = E_{cs1} = 25.742,9602 \text{ MPa}$$

5) Rasio Kekakuan Balok terhadap Pelat ( $\alpha_f$ )

$$\alpha_f = \frac{E_{cb1} \times I_{b1}}{E_{cs1} \times I_{s1}}$$

$$\alpha_f = \frac{25742,9602 \times 5.449.291.667}{25742,9602 \times 843.750.000}$$

$$\alpha_f = 6,4584 > 0,8 \rightarrow \text{OK}$$

### 2.2.2 Balok Induk 2 (300 x 600 mm)

Diketahui :

- $h_f$  (asumsi tebal pelat) = 125 mm
- $b_w = 300 \text{ mm}$
- $h = 600 \text{ mm}$
- $f = h_b = h - h_f = 475 \text{ mm}$

1) Nilai lebar efektif

Lebar efektif merupakan nilai terkecil dari:

$$b_e = b_w + 2h_b$$

$$b_e = 300 + 2 \times 475$$

$$b_e = 1250 \text{ mm}$$

$$\text{Kontrol : } h_b < 4.h_f$$

$$: 475 < 500 \text{ (OK)}$$

2) Momen inersia balok

$$y_1 = \frac{h_b}{2}$$

$$y_1 = \frac{475}{2}$$

$$y_1 = 237,5 \text{ mm}$$

$$y_2 = \frac{h_f}{2} + h_b$$

$$y_2 = \frac{125}{2} + 475$$

$$y_2 = 537,5 \text{ mm}$$

$$A_1 = hb \times bw$$

$$A_1 = 475 \times 300$$

$$A_1 = 142.500 \text{ mm}^2$$

$$A_2 = be \times hf$$

$$A_2 = 1250 \times 125$$

$$A_2 = 156.250 \text{ mm}^2$$

$$y = \frac{A_1 y_1 + A_2 y_2}{A_1 + A_2}$$

$$y = \frac{142.500 \times 237,5 + 156.250 \times 537,5}{142.500 + 156.250}$$

$$y = 394,4038 \text{ mm}$$

$$I_{b2} = \frac{1}{12} bw hb^3 + A_1 (y - y_1)^2 + \frac{1}{12} be hf^3 + A_2 (y_2 - y)^2$$

$$I_{b2} = \frac{1}{12} 300 \times 475^3 + 142.500 (394,4038 - 237,5)^2 + \frac{1}{12} 1250 \times 125^3 + 156.250 (537,5 - 394,4038)^2$$

$$I_{b2} = 3.000.575.521 \text{ mm}^4$$

### 3) Momen inersia pelat

$$I_{s2} = \frac{1}{12} Lx hf^3$$

$$I_{s2} = \frac{1}{12} 4500 \times 125^3$$

$$I_{s2} = 732.421.875 \text{ mm}^3$$

### 4) Modulus Elastisitas Beton Balok dan Pelat ( Ecb2 & Ecs2)

$$E = 4700 \sqrt{f_c}$$

$$E_{cb2} = E_{cs2} = 25.742,9602 \text{ MPa}$$

### 5) Rasio Kekakuan Balok terhadap Pelat (af<sub>2</sub>)

$$\alpha f_2 = \frac{E_{cb2} \times I_{b2}}{E_{cs2} \times I_{s2}}$$

$$\alpha f_2 = \frac{25742,9602 \times 3.000.575.521}{25742,9602 \times 732.421.875}$$

$$\alpha f_2 = 4,0968 > 0,8 \rightarrow \text{OK}$$

### 2.2.3 Balok Induk 3 (300 x 550 mm)

Diketahui :

- $h_f$  (asumsi tebal pelat) = 125 mm
- $b_w = 300$  mm
- $h = 550$  mm
- $f = h_b = h - h_f = 425$  mm

1) Nilai lebar efektif

Lebar efektif merupakan nilai terkecil dari:

$$b_e = b_w + 2h_b$$

$$b_e = 300 + 2 \times 425$$

$$b_e = 1150 \text{ mm}$$

$$\text{Kontrol} : h_b < 4 \times h_f$$

$$: 425 < 500 \text{ (OK)}$$

2) Momen inersia balok

$$y_1 = \frac{h_b}{2}$$

$$y_1 = \frac{425}{2}$$

$$y_1 = 212,5 \text{ mm}$$

$$y_2 = \frac{h_f}{2} + h_b$$

$$y_2 = \frac{125}{2} + 425$$

$$y_2 = 487,5 \text{ mm}$$

$$A_1 = h_b \times b_w$$

$$A_1 = 425 \times 300$$

$$A_1 = 127.500 \text{ mm}^2$$

$$A_2 = b e x h f$$

$$A_2 = 1150 \times 125$$

$$A_2 = 143.750 \text{ mm}^2$$

$$y = \frac{A_1 y_1 + A_2 y_2}{A_1 + A_2}$$

$$y = \frac{127.500 \times 212,5 + 143.750 \times 487,5}{127.500 + 143.750}$$

$$y = 358,2373 \text{ mm}$$

$$I_{b3} = \frac{1}{12} b w h b^3 + A_1 (y - y_1)^2 + \frac{1}{12} b e h f^3 + A_2 (y_2 - y)^2$$

$$I_{b3} = \frac{1}{12} 300 \times 425^3 + 127.500 (358,2373 - 212,5)^2 + \frac{1}{12} 1150 \times 125^3 + 143.750 (487,5 - 358,2373)^2$$

$$I_{b3} = 2.203.486.979 \text{ mm}^4$$

3) Momen inersia pelat

$$I_{s3} = \frac{1}{12} L x h f^3$$

$$I_{s3} = \frac{1}{12} 3600 \times 125^3$$

$$I_{s3} = 585.937.500 \text{ mm}^3$$

4) Modulus Elastisitas Beton Balok dan Pelat ( Ecb3 & Ecs3)

$$E = 4700 \sqrt{f_c}$$

$$E_{cb3} = E_{cs3} = 25.742,9602 \text{ MPa}$$

5) Rasio Kekakuan Balok terhadap Pelat (af3)

$$\alpha f_3 = \frac{E_{cb3} \times I_{b3}}{E_{cs3} \times I_{s3}}$$

$$\alpha f_3 = \frac{25742,9602 \times 2.203.486.979}{25742,9602 \times 585.937.500}$$

$$\alpha f_3 = 3,7606 > 0,8 \rightarrow \text{OK}$$

#### 2.2.4 Balok Anak 1 (250 x 400 mm)

Diketahui :

- $h_f$  (asumsi tebal pelat) = 125 mm
- $b_w = 250$  mm
- $h = 400$  mm
- $f = h_b = h - h_f = 275$  mm

##### 1) Nilai lebar efektif

Lebar efektif merupakan nilai terkecil dari:

$$b_e = b_w + 2h_b$$

$$b_e = 250 + 2 \times 275$$

$$b_e = 800 \text{ mm}$$

$$\text{Kontrol} : b_w + 2h_b < b_w + 8 \times h_f$$

$$: 800 < 1250 \text{ (OK)}$$

##### 2) Momen inersia balok

$$y_1 = \frac{h_b}{2}$$

$$y_1 = \frac{275}{2}$$

$$y_1 = 137,5 \text{ mm}$$

$$y_2 = \frac{h_f}{2} + h_b$$

$$y_2 = \frac{125}{2} + 275$$

$$y_2 = 337,5 \text{ mm}$$

$$A_1 = h_b \times b_w$$

$$A_1 = 275 \times 250$$

$$A_1 = 68.750 \text{ mm}^2$$

$$A_2 = b_e \times h_f$$

$$A_2 = 800 \times 125$$

$$A_2 = 100.000 \text{ mm}^2$$

$$y = \frac{A_1 y_1 + A_2 y_2}{A_1 + A_2}$$

$$y = \frac{68.750 \times 137,5 + 100.000 \times 337,5}{68.750 + 100.000}$$

$$y = 256,0185 \text{ mm}$$

$$I_{b4} = \frac{1}{12} b_w h b^3 + A_1 (y - y_1)^2 + \frac{1}{12} b_e h f^3 + A_2 (y_2 - y)^2$$

$$I_{b4} = \frac{1}{12} 250 \times 275^3 + 68.750 (256,0185 - 137,5)^2 + \frac{1}{12} 800 \times 125^3 + 100.000 (337,5 - 256,0185)^2$$

$$I_{b4} = 606.679.687,5 \text{ mm}^4$$

3) Momen inersia pelat

$$I_{s4} = \frac{1}{12} L x h f^3$$

$$I_{s4} = \frac{1}{12} 3600 \times 125^3$$

$$I_{s4} = 585.937.500 \text{ mm}^4$$

4) Modulus Elastisitas Beton Balok dan Pelat ( Ecb4 & Ecs4)

$$E = 4700 \sqrt{f_c}$$

$$E_{cb4} = E_{cs4} = 25.742,9602 \text{ MPa}$$

5) Rasio Kekakuan Balok terhadap Pelat (af4)

$$\alpha f_4 = \frac{E_{cb4} \cdot I_{b4}}{E_{cs4} \cdot I_{s4}}$$

$$\alpha f_4 = \frac{25742,9602 \times 606.679.687,5}{25742,9602 \times 585.937.500}$$

$$\alpha f_4 = 1,0354 > 0,8 \rightarrow \text{OK}$$

## 2.2.5 Balok Anak 2 (250 x 350 mm)

Diketahui :

- hf (asumsi tebal pelat) = 125 mm

- $b_w = 250 \text{ mm}$
- $h = 350 \text{ mm}$
- $f = h_b = h - h_f = 225 \text{ mm}$

1) Nilai lebar efektif

Lebar efektif merupakan nilai terkecil dari:

$$b_e = b_w + 2h_b$$

$$b_e = 250 + 2 \times 225$$

$$b_e = 700 \text{ mm}$$

$$\begin{aligned} \text{Kontrol} & : b_w + 2h_b < b_w + 8h_f \\ & : 700 < 1250 \text{ (OK)} \end{aligned}$$

2) Momen inersia balok

$$y_1 = \frac{h_b}{2}$$

$$y_1 = \frac{225}{2}$$

$$y_1 = 112,5 \text{ mm}$$

$$y_2 = \frac{h_f}{2} + h_b$$

$$y_2 = \frac{125}{2} + 225$$

$$y_2 = 287,5 \text{ mm}$$

$$A_1 = h_b \times b_w$$

$$A_1 = 225 \times 250$$

$$A_1 = 56.250 \text{ mm}^2$$

$$A_2 = b_e \times h_f$$

$$A_2 = 700 \times 125$$

$$A_2 = 87.500 \text{ mm}^2$$

$$y = \frac{A_1 y_1 + A_2 y_2}{A_1 + A_2}$$

$$y = \frac{56.250 \times 112,5 + 87.500 \times 287,5}{56.250 + 87.500}$$

$$y = 219,0217 \text{ mm}$$

$$I_{b5} = \frac{1}{12} bw hb^3 + A_1 (y - y_1)^2 + \frac{1}{12} be hf^3 + A_2 (y_2 - y)^2$$

$$I_{b5} = \frac{1}{12} 250 \times 225^3 + 56.250 (219,0217 - 112,5)^2 + \frac{1}{12} 700 \times 125^3 + 87.500 (287,5 - 219,0217)^2$$

$$I_{b5} = 382.721.354,2 \text{ mm}^4$$

### 3) Momen inersia pelat

$$I_{s5} = \frac{1}{12} Lx hf^3$$

$$I_{s5} = \frac{1}{12} 1500 \times 125^3$$

$$I_{s5} = 244.140.625 \text{ mm}^3$$

### 4) Modulus Elastisitas Beton Balok dan Pelat ( Ecb5 & Ecs5)

$$E = 4700 \sqrt{f_c}$$

$$E_{cb5} = E_{cs5} = 25.742,960 \text{ MPa}$$

### 5) Rasio Kekakuan Balok terhadap Pelat (af5)

$$\alpha f_5 = \frac{E_{cb5} \times I_{b5}}{E_{cs5} \times I_{s5}}$$

$$\alpha f_5 = \frac{25742,9602 \times 382.721.354,2}{25742,9602 \times 244.140.625}$$

$$\alpha f_5 = 1,5676 > 0,8 \rightarrow \text{OK}$$

Rata-rata rasio kekakuan pelat

$$\alpha_{fm} = \frac{\sum \alpha f_m}{n} = \frac{\alpha f_1 + \alpha f_2 + \alpha f_3 + \alpha f_4 + \alpha f_5}{n}$$

$$\alpha_{fm} = \frac{16,9188}{5}$$

$$\alpha_{fm} = 3,3838 (\alpha_{fm} > 2)$$

H minimum

$$\beta = \frac{Ln1}{Ln2}$$

$$\beta = \frac{4800}{3600}$$

$$\beta = 1,333$$

$$h_{min} = \frac{\ln(0,8 + \frac{Fy}{1.400})}{36 + 9\beta}$$

$$h_{min} = \frac{4800(0,8 + \frac{420}{1.400})}{36 + 9 \times 1,333}$$

$$h_{min} = 110 \text{ mm}$$

### 2.3 Menentukan Dimensi Kolom

Diketahui :

Dimensi asumsi kolom : 400 mm x 600 mm

$f'_c$  : 30 Mpa

Perhitungan dimensi kolom menggunakan cara tributary area dengan perhitungan sebagai berikut :

a. Menghitung beban mati

- DL pelat  $= 4,3 \times 2,475 \times 0,13 \times 4 \times 24$   
 $= 132,818 \text{ kN}$
- DL balok induk X+  $= 2,15 \times 0,3 \times 0,6 \times 4 \times 24$   
 $= 37,152 \text{ kN}$
- DL balok induk X-  $= 2,15 \times 0,3 \times 0,6 \times 4 \times 24$   
 $= 37,152 \text{ kN}$
- DL balok induk Y+  $= 1,225 \times 0,3 \times 0,55 \times 4 \times 24$   
 $= 19,404 \text{ kN}$
- DL balok induk Y-  $= 1,25 \times 0,3 \times 0,55 \times 4 \times 24$   
 $= 19,8 \text{ kN}$
- DL dinding X  $= 8,3 \times 0,15 \times 3 \times 4 \times 5,51$   
 $= 82,3194 \text{ kN}$
- DL dinding Y  $= 4,65 \times 0,15 \times 3,05 \times 4 \times 5,51$   
 $= 46,8873 \text{ kN}$

- DL kolom  $= 3,6 \times 0,4 \times 0,6 \times 4 \times 24$   
 $= 82,944 \text{ kN}$
- Total beban mati (DL)  $= 132,8184 + 37,152 + 37,152 + 19,404 + 19,8$   
 $+ 82,3194 + 46,8873 + 82,944$   
 $= 458,4771 \text{ kN}$

b. Menghitung beban SIDL

- Pasir 4 cm  $: 6,775 \times 1 \times 0,6 = 4,065 \text{ kN}$
- Spesi 2 cm  $: 6,775 \times 1 \times 0,48 = 3,252 \text{ kN}$
- Penutup lantai  $: 6,775 \times 3 \times 0,236 = 4,7967 \text{ kN}$
- Partisi  $: 6,775 \times 2 \times 1 = 13,55 \text{ kN}$
- Waterproofing  $: 6,775 \times 1 \times 0,05 = 0,3388 \text{ kN}$
- Plafon, ME, dll  $: 6,775 \times 4 \times 0,24 = 6,504 \text{ kN}$
- Total beban SIDL  $: 4,065 + 3,252 + 4,7967 + 13,55 + 0,3388 + 6,504$   
 $: 32,5065 \text{ kN}$

c. Menghitung beban hidup

- LL ruang pribadi dan koridor  $= 6,775 \times 4 \times 1,92 = 52,032 \text{ kN}$
- LL atap  $= 6,775 \times 1 \times 0,96 = 6,504 \text{ kN}$
- Total beban hidup (LL)  $= 52,032 + 6,504 = 58,536 \text{ kN}$

d. Beban total (Pu)

$$\begin{aligned} \text{DL} + \text{SIDL} + \text{LL} &= 458,4771 + 32,5065 + 58,536 \\ &= 549,52 \text{ kN} \end{aligned}$$

e. Mengecek syarat dimensi kolom

- Luasan yang diperlukan (Ag)  $= \frac{Pu}{0,35 \times f'c}$   
 $= \frac{549519,595}{0,35 \times 30} = 54139,8616 \text{ mm}^2$
- Sisi kolom minimum  $= \sqrt{54139,8616} = 232,6797 \text{ mm}$
- Jika digunakan dimensi 500 mm x 500 mm  
Luasan kolom  $= 250000 \text{ mm}^2$

Luasan kolom > luasan yang diperlukan, sehingga penggunaan dimensi kolom 500 mm x 500 mm diperbolehkan.

- Jika digunakan dimensi 400 x 400 mm

Luasan kolom = 160000 mm<sup>2</sup>

Luasan kolom > luasan yang diperlukan, sehingga penggunaan dimensi kolom 400 mm x 400 mm diperbolehkan.

