

## BAB III

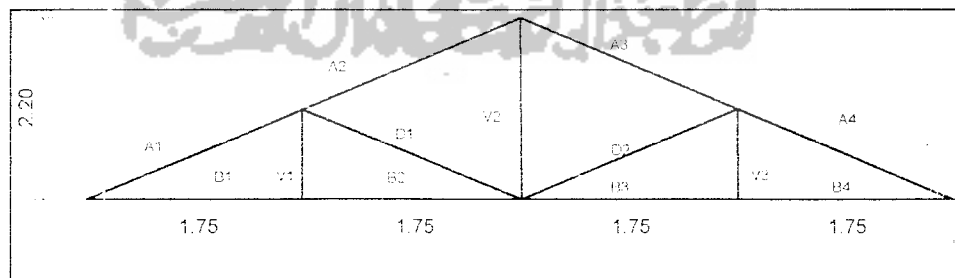
### PERHITUNGAN KONSTRUKSI

#### 3.1 Perhitungan Perencanaan Atap

Hasil perencanaan atap gedung Studio Audiovisual sebagai berikut:

1. Data :

- Gording = 6.76 kg/m
- Eternit dan plafond = 18 kg/m<sup>2</sup>
- Penutup atap = 50 kg/m<sup>2</sup>
- Beban hidup = 20 kg/m<sup>2</sup>
- $f_y = 2400$
- $E = 2,10 \times 10^6$
- $F_u = 3600 \text{ kg/cm}^2$



Gambar 3.1 Rencana kuda-kuda

## 2. Hasil perhitungan perencanaan atap

Tabel 3.1 Hasil perhitungan perencanaan atap

Batang	Panjang (m)	jenis batang	Profil	n baut tiap join
A1	2,067	tekan	2L 50x50x5	2 $\phi$ 1/2'
A2	2,067	tekan	2L 50x50x5	2 $\phi$ 1/2'
A3	2,067	tekan	2L 50x50x5	2 $\phi$ 1/2'
A4	2,067	tekan	2L 50x50x5	2 $\phi$ 1/2'
B1	1,75	tarik	2L 50x50x5	2 $\phi$ 1/2'
B2	1,75	tarik	2L 50x50x5	2 $\phi$ 1/2'
B3	1,75	tarik	2L 50x50x5	2 $\phi$ 1/2'
B4	1,75	tarik	2L 50x50x5	2 $\phi$ 1/2'
D1	2,067	tekan	2L 50x50x5	2 $\phi$ 1/2'
D2	2,067	tekan	2L 50x50x5	2 $\phi$ 1/2'
V1	1,099	tarik	2L 50x50x5	2 $\phi$ 1/2'
V2	2,2	tarik	2L 50x50x5	2 $\phi$ 1/2'
V3	1,099	tarik	2L 50x50x5	2 $\phi$ 1/2'

Perhitungan lengkap perencanaan atap terdapat pada lampiran.

### 3.2 Perencanaan Plat Lantai

Perhitungan plat lantai gedung Studio Audiovisual sebagai berikut:

1. Diketahui:

- a. tebal plat : 0,12 m
- b. tebal pasir : 0,05 m
- c. tebal spesi : 0,03 m
- d. tebal keramik : 0,01 m
- e. bj beton : 24  $\text{kn/m}^3$

- f.  $\gamma_{pasir} : 16 \text{ Kn/m}^3$
  - g.  $\gamma_{spesi} : 24 \text{ Kn/m}^3$
  - h.  $\gamma_{keramik} : 20 \text{ Kn/m}^3$
  - i. beban hidup :  $2,5 \text{ Kn/m}^2$
  - j.  $f_c : 20 \text{ Mpa}$
  - k.  $f_y$  polos ( untuk sengkang, dan pada plat lantai) :  $240 \text{ Mpa}$
  - l.  $f_y$  deform ( tulangan pokok balok dan kolom) :  $400 \text{ Mpa}$
  - m.  $\phi = 0,8$  ( faktor reduksi kekuatan untuk pembebanan lentur tanpa aksial)
2. Perencanaan pembebanan :



Gambar 3.2 Dimensi plat lantai

- a. beban mati(WD)
    - 1) berat pelat =  $t_{pelat} \times \gamma_{beton} = 2,88 \text{ kn/m}^2$
    - 2) berat pasir =  $t_{pasir} \times \gamma_{pasir} = 0,8 \text{ kn/m}^2$
    - 3) berat spesi =  $t_{spesi} \times \gamma_{spesi} = 0,72 \text{ kn/m}^2$
    - 4) berat keramik =  $t_{keramik} \times \gamma_{keramik} = 0,2 \text{ kn/m}^2$
  - b. beban hidup  $W_L = 4 \text{ kn/m}^2$
  - c.  $q_u = 1,2 w_D + 1,6 w_L = 11,92 \text{ kn/m}^2$
3. Perhitungan momen
- $M_u(l_x, t_x, l_y, t_y) = (\pm) 0,001 \cdot q_u \cdot l^2 \cdot x$

Hitung nilai  $I_y/I_x$  untuk mendapatkan faktor perhitungan momen x yang dapat dilihat pada buku *Gideon seri 4 table 14*.

a. momen lapangan arah x

$$\frac{I_y}{I_x} = \frac{4}{3,5} = 1,143 \text{ lihat tabel didapat } 0,001x = 0,034$$

$$\begin{aligned} \text{maka } M_{lx} &= \pm 0,001 \cdot q_u \cdot l^2 \cdot x \\ &= \pm 11,92 \cdot 3,5^2 \cdot 0,034 \\ &= \pm 4,96 \text{ kn-m} \end{aligned}$$

b. momen lapangan arah y

$$\frac{I_y}{I_x} = \frac{4}{3,5} = 1,143 \text{ lihat tabel didapat } 0,001x = 0,022$$

$$\begin{aligned} \text{maka } M_{ly} &= \pm 0,001 \cdot q_u \cdot l^2 \cdot x \\ &= \pm 11,92 \cdot 3,5^2 \cdot 0,022 \\ &= \pm 3,212 \text{ kn-m} \end{aligned}$$

c. momen tumpuan arah x

$$\frac{I_y}{I_x} = \frac{4}{3,5} = 1,143 \text{ lihat tabel didapat } 0,001x = 0,063$$

$$\begin{aligned} \text{maka } M_{tx} &= \pm 0,001 \cdot q_u \cdot l^2 \cdot x \\ &= \pm 11,92 \cdot 3,5^2 \cdot 0,063 \\ &= \pm 9,199 \text{ kn-m} \end{aligned}$$

d. momen tumpuan arah y

$$\frac{I_y}{I_x} = \frac{4}{3,5} = 1,143 \text{ lihat tabel didapat } 0,001x = 0,054$$

$$\begin{aligned} \text{maka } M_{ty} &= \pm 0,001 \cdot q_u \cdot l^2 \cdot x \\ &= \pm 11,92 \cdot 3,5^2 \cdot 0,054 \end{aligned}$$

$$= \pm 7,885 \text{ kn-m}$$

e. perencanaan tulangan

$$d = t \text{ pelat} - p - 0,5 \cdot \phi_b$$

$$= 120 - 20 - 0,5 \cdot 10$$

$$= 95 \text{ mm}$$

$$jd = 0,9 \cdot d$$

$$= 85 \text{ mm}$$

f. menghitung luasan tulangan lapangan atau tumpuan arah x dan y

$$\text{untuk As lx} = \frac{Mu / \phi}{jd \cdot fy}$$

$$= \frac{4,96 / 0,8 \cdot 10^6}{85,5 \cdot 240}$$

$$= 302,144 \text{ mm}^2$$

$$\text{untuk As ly}$$

$$\frac{Mu / \phi}{jd \cdot fy}$$

$$= \frac{3,212 / 0,8 \cdot 10^6}{85,5 \cdot 240}$$

$$= 195,663 \text{ mm}^2$$

$$\text{untuk As tx} = \frac{(Mu / \phi)_{tumpuan}}{(Mu / \phi)_{lapangan}} \cdot Aslx$$

$$= \frac{(9,199 / 0,8)}{(4,96 / 0,8)} \cdot 302,144$$

$$= 560,38 \text{ mm}^2$$

$$\text{untuk As ty} = \frac{(Mu / \phi)_{tumpuan}}{(Mu / \phi)_{lapangan}} \cdot Asly$$

$$= \frac{(7.885/0.8)}{(4.96/0.8)} \cdot 302,144$$

$$= 480,32 \text{ mm}^2$$

g.  $As_{min} = \frac{1,4}{f_y} \cdot b \cdot d$ ,  $b = 1000 \text{ mm}$  (tinjauan per-meter)

$$= \frac{1,4}{240} \cdot 1000 \cdot 95$$

$$= 554,17 \text{ mm}^2$$

h.  $1,33 \cdot As_{lx} = 401,85 \text{ mm}^2$

$1,33 \cdot As_{ly} = 260,23 \text{ mm}^2$

$1,33 \cdot As_{tx} = 745,31 \text{ mm}^2$

$1,33 \cdot As_{ty} = 638,83 \text{ mm}^2$

i. cek nilai  $As > As_{min}$

jika  $As < As_{min}$  dan  $1,33 As > As_{min} \rightarrow As_{min}$  dipakai

jika  $As < As_{min}$  dan  $1,33 As < As_{min} \rightarrow 1,33 As$  dipakai

As pakai  $lx = 401,85 \text{ mm}^2$

As pakai  $ly = 260,23 \text{ mm}^2$

As pakai  $tx = 554,17 \text{ mm}^2$

As pakai  $ty = 554,17 \text{ mm}^2$

j. menghitung  $A\phi = 1/4 \cdot \pi \cdot d^2$

dipakai  $\phi_{tul} = 10 \text{ mm}$

$$A\phi = 78,5 \text{ mm}^2$$

k. menghitung jarak tulangan

$$x = \frac{A\phi \cdot 1000}{As_{pakai}}$$

$$\begin{aligned}x \text{ arah } l_x &= \frac{78,5 \cdot 1000}{401,85} \\ &= 195,35 \text{ mm}\end{aligned}$$

$$\begin{aligned}x \text{ arah } l_y &= \frac{78,5 \cdot 1000}{260,23} \\ &= 301,65 \text{ mm}\end{aligned}$$

$$\begin{aligned}x \text{ arah } t_x &= \frac{78,5 \cdot 1000}{554,17} \\ &= 141,65 \text{ mm}\end{aligned}$$

$$\begin{aligned}x \text{ arah } t_y &= \frac{78,5 \cdot 1000}{554,17} \\ &= 141,65 \text{ mm}\end{aligned}$$

l. dicoba tulangan :

$$\begin{aligned}\text{arah } l_x : P_{10-190} \text{ As} &= (A\phi \cdot 1000)/x \\ &= (78,5 \cdot 1000)/200 \\ &= 392,50 \text{ mm}^2\end{aligned}$$

$$\begin{aligned}\text{arah } l_y : P_{10-240} \text{ As} &= (A\phi \cdot 1000)/x \\ &= (78,5 \cdot 1000)/240 \\ &= 327,08 \text{ mm}^2\end{aligned}$$

$$\begin{aligned}\text{arah } t_x : P_{10-110} \text{ As} &= (A\phi \cdot 1000)/x \\ &= (78,5 \cdot 1000)/110 \\ &= 713,64 \text{ mm}^2\end{aligned}$$

$$\begin{aligned}\text{arah } t_y : P_{10-150} \text{ As} &= (A\phi \cdot 1000)/x \\ &= (78,5 \cdot 1000)/150 \\ &= 603,85 \text{ mm}^2\end{aligned}$$

m. Kontrol Mn

$$a = \frac{A_s \cdot f_y}{0,85 \cdot f'_{c,b}} \quad M_n = A_s \cdot f_y \cdot (d - a/2) = M_u / \phi$$

$$\text{arah lx } a = \frac{392,5 \cdot 240}{0,85 \cdot 20 \cdot 1000} = 5,54 \text{ mm}$$

$$M_n = 392,5 \cdot 240 \cdot (95 - (5,54/2)) \cdot 10^{-6}$$

$$= 8,68 \text{ kn-m} > 1,33 M_u / \phi = 8,25 \text{ kn-m} \dots \text{aman}$$

$$\text{arah ly } a = \frac{327,08 \cdot 240}{0,85 \cdot 20 \cdot 1000} = 4,61 \text{ mm}$$

$$M_n = 327,08 \cdot 240 \cdot (95 - (4,61/2)) \cdot 10^{-6}$$

$$= 7,27 \text{ kn-m} > 1,33 M_u / \phi = 5,34 \text{ kn-m} \dots \text{aman}$$

$$\text{arah tx } a = \frac{713,64 \cdot 240}{0,85 \cdot 20 \cdot 1000} = 10,07 \text{ mm}$$

$$M_n = 713,64 \cdot 240 \cdot (95 - (10,07/2)) \cdot 10^{-6}$$

$$= 15,41 \text{ kn-m} > 1,33 M_u / \phi = 15,29 \text{ kn-m} \dots \text{aman}$$

$$\text{arah ty } a = \frac{603,85 \cdot 240}{0,85 \cdot 20 \cdot 1000} = 8,52 \text{ mm}$$

$$M_n = 603,85 \cdot 240 \cdot (95 - (8,52/2)) \cdot 10^{-6}$$

$$= 13,15 \text{ kn-m} > 1,33 M_u / \phi = 13,11 \text{ kn-m} \dots \text{aman}$$

Selanjutnya hasil perhitungan plat lantai toko buku, atap dan selasar terdapat pada tabel dengan perhitungan lengkapnya terdapat pada lampiran.



Tabel 3.2 Hasil Perencanaan Plat Lantai studio

Lantai studio 4x3.5 m <sup>2</sup>				
Perhitungan	Mlx	Mly	Mtx	Mty
Mu (Kn m)	4,96468	3,21244	9,19926	7,88508
Mu/φ	6,20585	4,01555	11,499075	9,85635
1,33 Mu/φ	8,253781	5,3406815	15,2937698	13,10895
As (mm <sup>2</sup> )	302,43	195,69	560,38	480,33
1,33 As (mm <sup>2</sup> )	402,23	260,27	745,31	638,84
As min (mm <sup>2</sup> )	554,17	554,17	554,17	554,17
As maks (mm <sup>2</sup> )	3064,17	3064,17	3064,17	3064,17
As perla (mm <sup>2</sup> )	402,23	260,27	554,17	554,17
jrkg tulangan (mm)	195,16	301,61	141,65	141,65
Di pakai tulangan	P <sub>10</sub> - 200	P <sub>10</sub> - 240	P <sub>10</sub> - 110	P <sub>10</sub> - 130
As tersedia (mm)	392,50	327,08	713,64	603,85
λ	5,54	4,62	10,07	8,52
Mn	8,688011	7,2762574	15,4081342	13,14997
Kontrol	Aman	Aman	aman	aman

Tabel 3.3 Hasil Perencanaan Plat Lantai toko buku

Lantai toko buku 4 x 3,5 m <sup>2</sup>				
Perhitungan	Mlx	Mly	Mtx	Mty
Mu (Kn m)	4,96468	3,21244	9,19926	7,88508
Mu/φ	6,20585	4,01555	11,499075	9,85635
1,33. Mu/φ	8,253781	5,3406815	15,2937698	13,10895
As (mm <sup>2</sup> )	302,43	195,69	560,38	480,33
1,33 As (mm <sup>2</sup> )	402,23	260,27	745,31	638,84
As min (mm <sup>2</sup> )	554,17	554,17	554,17	554,17
As maks (mm <sup>2</sup> )	3064,17	3064,17	3064,17	3064,17
As perlu (mm <sup>2</sup> )	402,23	260,27	554,17	554,17
jrak tulangan (mm)	195,16	301,61	141,65	141,65
Di pakai tulangan	P <sub>10</sub> - 200	P <sub>10</sub> - 240	P <sub>10</sub> - 110	P <sub>10</sub> - 130
As tersedia (mm)	392,50	327,08	713,64	603,85
λ	5,54	4,62	10,07	8,52
Min	8,688011	7,2762574	15,4081342	13,14997
Kontrol	aman	aman	aman	aman

Tabel 3.4 Hasil Perencanaan Plat Lantai selasar

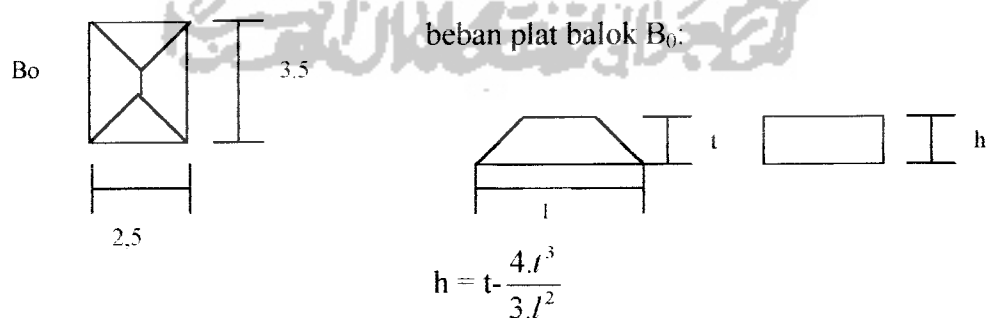
Lantai selasar 2,8 x 4 m <sup>2</sup>				
Perhitungan	Mlx	Mly	Mtx	Mty
Mu (Kn m)	2,59736064	1,68064512	4,81275648	4,12521984
Mu/φ	3,2467008	2,1008064	6,0159456	5,1565248
1,33. Mu/φ	4,3181120	2,7940725	8,0012076	6,8581779
As (mm <sup>2</sup> )	19,78	127,97	366,47	314,12
1.33 As (mm <sup>2</sup> )	263,04	170,2	487,4	417,78
As min (mm <sup>2</sup> )	443,33	443,33	443,33	443,33
As maks (mm <sup>2</sup> )	2451,34	2451,34	2451,34	2451,34
As perlu (mm <sup>2</sup> )	263,04	170,2	443,33	417,78
jrkg tulangan (mm)	191,0	295,17	113,32	120,26
Di pakai tulangan	P <sub>8</sub> - 200	P <sub>8</sub> - 200	P <sub>8</sub> - 100	P <sub>8</sub> - 120
As tersedia (mm)	251,2	251,2	502,4	418,67
A	3,55	3,55	7,09	5,91
Mn	4,47	4,47	8,74	7,34
Kontrol	aman	aman	aman	aman

Tabel 3.5 Hasil Perencanaan Plat Lantai atap

Lantai atap 2,8 x 4 m <sup>2</sup>				
Perhitungan	Mlx	Mly	Mtx	Mty
Mu (Kn m)	1.744	1.128	3.232	2.77
Mu/φ	2.1804	1.4109	4.0402	3.4609
1,33. Mu/φ	2.9000	1.8764	5.3735	4.6059
As (mm <sup>2</sup> )	132,83	85,95	246,12	210,96
1.33 As (mm <sup>2</sup> )	176,66	114,31	327,34	280,57
As min (mm <sup>2</sup> )	443,33	443,33	443,33	443,33
As maks (mm <sup>2</sup> )	2451,34	2451,34	2451,34	2451,34
As perlu (mm <sup>2</sup> )	176,66	114,31	327,34	280,57
jrkg tulangan (mm)	284,39	439,51	153,48	179,1
Di pakai tulangan	P <sub>8</sub> -240	P <sub>8</sub> -240	P <sub>8</sub> -160	P <sub>8</sub> -180
As tersedia (mm)	209,33	209,33	314,0	279,11
a	2,96	2,96	4,43	3,94
Mn	3,74	3,74	5,56	4,96
Kontrol	aman	aman	aman	aman
Tul.susut pakai	P <sub>8</sub> -240	P <sub>8</sub> -240	P <sub>8</sub> -240	P <sub>8</sub> -240

### 3.3 Perencanaan Balok Anak

Perhitungan Balok Anak B<sub>0</sub>



Gambar 3.3 Jenis pembebanan balok anak

## 1. Data :

- a. berat jenis beton  $= 24 \text{ kn/m}^3$
- b. q pelat  $= 11,92 \text{ kn/m}^2$
- c. asumsi ukuran balok  $= 0,25 \times 0,4 \text{ m}^2$
- d. tinggi tembok (lantai 1)  $= 4 \text{ m}$

## 2. Penyelesaian:

## a. pembebanan

$$1) \text{ beban pelat} = (1) \cdot l_1 \cdot q_{\text{pelat}}$$

$$= 1 \cdot (1,25 - \frac{4 \cdot 1,25^3}{3 \cdot 3,5^2}) \cdot 11,92$$

$$= 12,37 \text{ kn/m}$$

$$2) \text{ berat balok} = b_{\text{balok}} \cdot (h_{\text{balok}} - t_{\text{pelat}}) \cdot b_j \cdot 1,2$$

$$= 0,25 \cdot (0,4 - 0,12) \cdot 24 \cdot 1,2$$

$$= 2,02 \text{ kn/m}$$

$$3) \text{ beban tembok} = \text{berat}_{\text{tembok}} \cdot (t_{\text{tembok}} - h_{\text{balok}}) \cdot 1,2$$

$$= 2,5 \cdot (4 - 0,4) \cdot 1,2$$

$$= 10,8 \text{ kn/m}$$

## b. Momen Mu

lihat faktor momen, Gideon dapatkan  $M_u$ , dan  $M_u \phi$ , dengan  $\phi = 0,8$

$$\frac{1/24}{\triangle 1/11} \quad \frac{1/9}{\triangle 1/11} \quad \frac{1/24}{\triangle}$$

Gambar 3.4 Pembagian faktor momen

$$M_u = (1/24) \cdot q_u \cdot l^2$$

$$= (1/24) \cdot 25,18 \cdot 3,5^2$$

$$= 12,85 \text{ kn-m}$$



$$Mu/\phi = 16,07 \text{ kn-m}$$

$$\begin{aligned} Mu &= (1/11).qu.l^2 \\ &= (1/11).25,18.3,5^2 \\ &= 28,04 \text{ kn-m} \end{aligned}$$

$$Mu/\phi = 35,05 \text{ kn-m}$$

$$\begin{aligned} Mu &= (1/9).qu.l^2 \\ &= (1/9).25,18.3,5^2 \\ &= 34,28 \text{ kn-m} \end{aligned}$$

$$Mu/\phi = 42,84 \text{ kn-m}$$

c. penulangan balok

data:

- 1)  $f'_c = 20 \text{ Mpa}$
- 2)  $f_y \text{ ulir} = 390 \text{ Mpa}$
- 3)  $\phi \text{ tul pokok} = 20 \text{ mm}$
- 4)  $\phi \text{ tul sengkang, max } 20 \text{ mm} = 10 \text{ mm}$
- 5)  $\beta_1 = 0,85$  untuk  $f'_c \leq 30 \text{ Mpa}$   
 untuk  $f'_c > 30 \text{ Mpa}$   $\beta_1 = 0,85 - 0,008.(f'_c - 30) \geq 0,65$

d. perhitungan:

$$\begin{aligned} \rho_b &= \frac{0,85.f'_c.\beta_1}{f_y} \left( \frac{600}{600 + f_y} \right) \\ &= \frac{0,85.20.0,85}{390} \left( \frac{600}{600 + 390} \right) \\ &= 0,022 \end{aligned}$$

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

$$= 0,75 \cdot 0,22$$

$$= 0,165$$

$$\rho_{\min} = 1,4/f_y$$

$$= 1,4/390$$

$$= 0,00359$$

diambil  $\rho = 0,5$ ,  $\rho_{\max} = 0,0084$

$$m = \frac{f_y}{0,85 \cdot f'_c}$$

$$= \frac{390}{0,85 \cdot 20}$$

$$= 22,941$$

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

$$= 0,0084 \cdot 390 \cdot (1 - 0,5 \cdot 0,0084 \cdot 22,941)$$

$$= 2,9669$$

$$b \cdot d^2 = \frac{M_u / \phi}{R_n}$$

$$= \frac{42,84}{2,9669} \cdot 10^6$$

$$= 14439423 \text{ mm}^3$$

perkiraan  $d_{\text{perlu}}$  :

diambil  $b = 200 \text{ mm}$  ;  $d_{\text{perlu}} = 269 \text{ mm}$

coba ukuran balok :

$b = 200 \text{ mm}$  ;  $d = 400 \text{ mm}$

$$\begin{aligned}
 \text{hitung } d_{\text{pakai}} &= h_{\text{balok}} - p_b - \phi_{\text{sejangkang}} - 0,5 \cdot \phi_{\text{tul pelat}} \\
 &= 400 - 40 - 10 - 0,5 \cdot 20 \\
 &= 340 \text{ mm}
 \end{aligned}$$

cek  $d_{\text{pakai}} > d_{\text{perlu}}$  dipakai tulangan sebelah, jika  $d_{\text{pakai}} < d_{\text{perlu}}$  dipakai tulangan rangkap.

Karena  $d_{\text{pakai}} > d_{\text{perlu}}$ , dipakai tulangan sebelah

tulangan sebelah

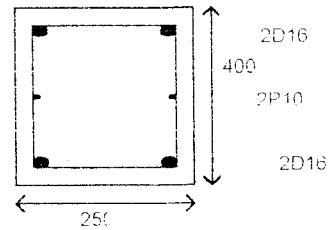
$$\begin{aligned}
 Rn_{\text{baru}} &= \frac{Mu / \phi}{b \cdot d^2} \\
 &= \frac{42,84}{200 \cdot 340^2} \cdot 10^6 \\
 &= 1,8529 \\
 \rho_{\text{baru}} &= \frac{Rn_{\text{baru}}}{Rn} \cdot \rho \\
 &= \frac{1,8529}{2,9669} \cdot 0,0084 \\
 &= 0,0052591 \\
 A_{\text{Sbaru}} &= \rho_{\text{baru}} \cdot b \cdot d \\
 &= 0,0052591 \cdot 200 \cdot 340 \\
 &= 357,619 \text{ mm}^2
 \end{aligned}$$

ambil jumlah  $\phi_{\text{tul}}$  dan hitung  $A_{\text{S tul}} = n \cdot A \phi \geq A_{\text{S}}$

diambil tul 2 $\phi$ 16 :  $A_{\text{S tul}} = 401,92 \text{ mm}^2 > A_{\text{S}} = 357,619 \text{ mm}^2$  ... aman

periksa jarak tulangan :





Gambar 3.5 Penampang balok

$$x = b_{\text{balok}} - 2 \cdot (\text{jarak luar ke tulangan sengkang} + \phi_{\text{tul sengkang}})$$

$$200 - 2 \cdot (25 + 10)$$

$$130 \text{ mm}$$

jarak antar tulangan:

$$\text{jrk} = (x - (n \cdot \phi_{\text{tul}})) / 2, \text{ dengan } n = \text{jumlah tulangan}$$

$$= (130 - (2 \cdot 16)) / 2$$

$$= 49 \text{ mm}$$

Periksa untuk  $M_u / \phi = 35,05 \text{ kn-m}$

$$R_{\text{baru}} = \frac{M_u / \phi}{b \cdot d^2}$$

$$R_{\text{baru}} = \frac{35,05 \cdot 10^6}{200 \cdot 340^2}$$

$$= 1,516$$

$$\rho = \frac{M_u / \phi}{M_u / \phi_{\text{max}}} \cdot \rho$$

$$= \frac{35,05}{42,84} \cdot 0,0084 = 0,00687$$

$$A_{S_{\text{min}}} = \rho_{\text{min}} \cdot b \cdot d$$

$$= 0,00359 \cdot 200 \cdot 340$$

$$= 244,12 \text{ mm}^2$$

$$\begin{aligned}
 A_s &= \frac{Mu/\phi}{Mu/\phi_{max}} \cdot A_s \\
 &= \frac{35,05}{42,84} \cdot 357,619 \\
 &= 292,6 \text{ mm}^2 > A_s \text{ min}
 \end{aligned}$$

Kontrol tulangan:

dipakai tulangan: 2 $\phi$ 16,  $A_{s_{tul}} = 401,92 \text{ mm}^2 > A_{s_{pakai}} = 292,6$  .....aman

$$Mu/\phi = 16,066632 \text{ kn-m}$$

$$\begin{aligned}
 A_s &= \frac{Mu/\phi}{Mu/\phi_{max}} \cdot A_{s_{min}} \\
 &= \frac{16,0666}{42,84} \cdot 357,619 \\
 &= 134,12 < A_{s_{min}} = 244,12 \text{ mm}^2, \text{ maka dipakai } A_s \text{ min} = 244,12 \text{ mm}^2
 \end{aligned}$$

dipakai tulangan: 2 $\phi$ 16,  $A_{s_{tul}} = 401,92 \text{ mm}^2 > A_{s_{pakai}} = 244,12$  .....aman

Tabel 3.6 Perencanaan balok anak

Perhitungan	Balok Ba0	Balok Ba1	Balok Ba2	Balok Ba3
Mu/ $\phi$ (Kn/m)	67,204585	71,8	51,03	67,2
tulangan	3D16	3D16	2D16	3D16
Mu/ $\phi$ (Kn/m)	61,1	65,27	23,39	61,1
tulangan	3D16	3D16	2D16	2D16
Mu/ $\phi$ (Kn/m)	67,204585	71,8	51,03	67,2
tulangan	3D16	3D16	2D16	3D16
Mu/ $\phi$ (Kn/m)	61,095077	65,27	23,39	61,1
tulangan	3D16	3D16	2D16	3D16

### 3.4. Perencanaan Balok Induk

#### 1. Data :

- a.  $f_y = 400 \text{ mpa}$
- b.  $f_c' = 20 \text{ mpa}$
- c. penutup beton ( $P_b$ ) = 40 mm
- d. diameter tul.utama = 22 mm
- e. diameter tul.tekan = 22 mm
- f. diameter sengkang = 10 mm
- g.  $b = 300 \text{ mm} = 0,3 \text{ m}$
- h.  $h = 500 \text{ mm} = 0,5 \text{ m}$
- i.  $\phi = 0,8$
- j.  $\text{Beta} = 0,85$
- k.  $d' = 40 + 10 + (22/2) = 61 \text{ mm} = 0,061 \text{ m}$
- l.  $d = 500 - 61 = 439 \text{ mm} = 0,439 \text{ m}$
- m.  $d'/d = 0,138952164$
- n.  $p_b = 0,021675$
- o.  $p_{\text{mak}} = 0,01625625$
- p.  $p_{\text{min}} = 0,0035$

#### 2. Perhitungan balok portal D lantai 2 elemen 21

##### a. Momen Tumpuan

$$M_u = 137,1 \text{ Knm}$$

$$R_n = \frac{M_u}{b \cdot d^2}$$

$$= \frac{137,1}{0,3 \cdot 0,439^2}$$

$$= 2371,1$$

dari data  $f_y$ ,  $f_c'$ ,  $R_n$ ,  $d'/d$  lihat tabel Gideon 5.3.b didapat  $\rho = 0,008 > \rho$

min = 0,0035, maka dipakai  $\rho = 0,008$

$$A_s = \rho \cdot b \cdot d$$

$$= 0,008 \cdot 300 \cdot 439$$

$$= 1053,6 \text{ mm}^2$$

dipakai tulangan 3D22  $A_s \text{ tul} = 1139,82 \text{ mm}^2$

$$A_s' = 0,5 \cdot A_s$$

$$= 526,8 \text{ mm}^2 \text{ dipakai 2D22}$$

#### b. Momen Lapangan

$$M_u = 11,4 \text{ Knm}$$

$$R_n = \frac{M_u}{b \cdot d^2}$$

$$= \frac{11,4}{0,3 \cdot 0,439^2}$$

$$= 197,9$$

dari data  $f_y$ ,  $f_c'$ ,  $R_n$ ,  $d'/d$  lihat tabel Gideon 5.3.b didapat  $\rho = 0,0007 < \rho$

min = 0,0035, maka dipakai  $\rho = 0,0035$

$$A_s = \rho \cdot b \cdot d$$

$$= 0,0035 \cdot 300 \cdot 439$$

$$= 460,95 \text{ mm}^2$$

dipakai tulangan 2D22  $A_s \text{ tul} = 759,88 \text{ mm}^2$

$$A_s' = 0,5 \cdot A_s = 230,48 \text{ mm}^2 \text{ dipakai 2D22}$$

#### c. Tulangan & Momen Nominal Aktual

Jumlah tulangan terpasang  $A_s = 3D22 = 1139,82 \text{ mm}^2$  (tulangan atas) dan  
 $A_s' = 2D22 = 759,88 \text{ mm}^2$

$$a = \frac{(A_s - A_s') \cdot f_y}{0,85 \cdot f'_c \cdot b}$$

$$= \frac{(1139,82 - 759,88) \cdot 400}{0,85 \cdot 20 \cdot 300}$$

$$= 29,8 \text{ mm}$$

$$M_{\text{nak}} = (0,85 \cdot f'_c \cdot a \cdot b \cdot (d - (a/2))) + (A_s' \cdot f_y \cdot (d - d'))$$

$$= (0,85 \cdot 20 \cdot 10^3 \cdot 29,8 \cdot 10^3 \cdot 0,3 \cdot (0,439 - (29,8 \cdot 10^{-3} / 2))) + (759,88 \cdot 10^6 \cdot 400 \cdot 10^3 \cdot (0,439 - 0,061))$$

$$= 179,35 \text{ Knm}$$

$$MR = 0,8 \cdot M_{\text{nak}}$$

$$= 143,48 \text{ Knm}$$

$$M_{\text{kap}} = 1,25 \cdot M_{\text{nak}}$$

$$= 224,19 \text{ Knm}$$

$$f_s' = 600 \cdot \left( 1 - \frac{0,85 \cdot f'_c \cdot \beta_1 \cdot d'}{(\rho - \rho') \cdot f_y \cdot d} \right)$$

$$= 600 \cdot \left( 1 - \frac{0,85 \cdot 20 \cdot 0,85 \cdot 61}{((1139,82 / 300) - (759,88 / 300)) \cdot 400 \cdot 439} \right)$$

$$= 446 \text{ Mpa} > f_y = 400 \text{ Mpa, maka dipakai } f_y = 400 \text{ Mpa}$$

sehingga dengan cara yang sama didapat:

$$M_{\text{nak}}' = 179,35 \text{ Knm}$$

$$M_{\text{kap}} = 224,18 \text{ Knm}$$

## d. Perencanaan Gaya Geser

$$VD = +13,33 \text{ Kn (ujung kiri)}$$

$$-13,38 \text{ Kn (ujung kanan)}$$

$$VL = +7,83 \text{ Kn (ujung kiri)}$$

$$-7,85 \text{ Kn (ujung kanan)}$$

$$VE_{\text{kiri}} = -75,18 \text{ Kn (ujung kiri)}$$

$$-81,9 \text{ Kn (ujung kanan)}$$

$$VE_{\text{kanan}} = 81,74 \text{ Kn (ujung kiri)}$$

$$= 75,02 \text{ Kn (ujung kanan)}$$

$$M_{\text{kap},b} = 224,18 \text{ Knm}$$

$$M_{\text{kap}',b} = 224,18 \text{ Knm}$$

$$Vu_{1,b} = 0,7 \cdot \phi_c \cdot \left[ \frac{M_{\text{kap},b} + M_{\text{kap}',b}}{l_n} \right] + 1,05 \cdot F_g \cdot V_g - VD + VL$$

$$= 0,7 \cdot 1,25 \cdot \left[ \frac{224,18 + 224,18}{2,5} \right] + 1,05 \cdot (13,33 + 7,83)$$

$$= 179,15 \text{ Kn}$$

$$Vu_{2b,\text{kiri}} = 1,05 \cdot (VD + VL + 4/K \cdot VE)$$

$$= 1,05 \cdot (13,33 + 7,83 + 4/1 \cdot -75,18)$$

$$= -293,52 \text{ Kn}$$

$$Vu_{2b,\text{kanan}} = 1,05 \cdot (VD + VL + 4/K \cdot VE)$$

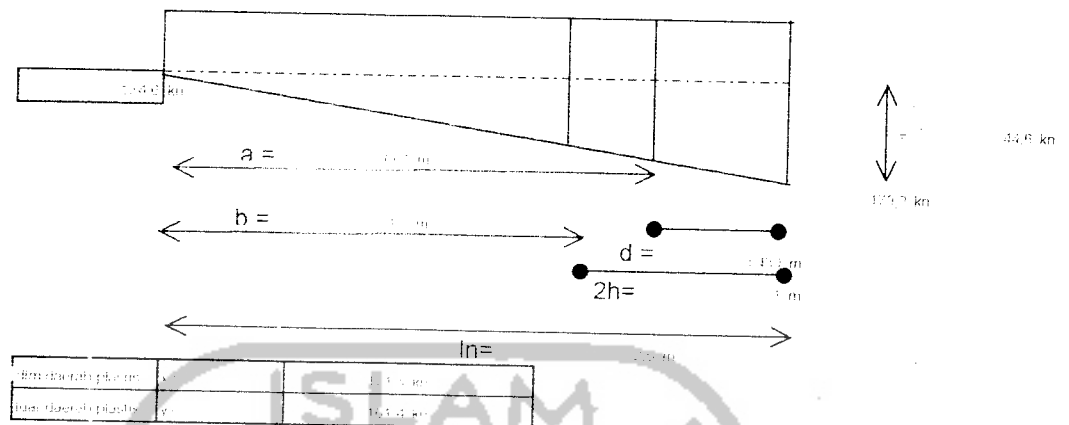
$$= 1,05 \cdot (13,33 + 7,83 + 4/1 \cdot 81,74)$$

$$= 365,51 \text{ Kn}$$

$V_u$  pilih adalah nilai terkecil negatif atau positif antara  $Vu_1$ ,  $Vu_{2b,\text{kiri}}$ ,

$Vu_{2b,\text{kanan}}$ , sehingga didapat  $V_u$  pilih = 179,2 Kn. Dari hitungan diagram

segitiga diperoleh  $V_{ub}$  didaerah plastis diperoleh 171,4 Kn.



Gambar 3.6 diagram segitiga tegangan geser

$$V_c = 0$$

$$V_{s \text{ min}} = 1/3 \cdot b \cdot d$$

$$= 1/3 \cdot 300 \cdot 439 \cdot 10^{-3}$$

$$= 43,9$$

$$V_s = V_{ub}/0,6$$

$$= 171,4/0,6$$

$$= 285,7 \text{ Kn}$$

$$S \geq 2 \cdot A_v \cdot f_y \cdot d / V_s$$

$$= 2 \cdot 0,25 \cdot \pi \cdot 10^2 \cdot 240 \cdot 439 / 285,7 \cdot 10^3$$

$$= 59,7 < d/4 = 439/4 = 109,75. \text{ maka dipakai } S = 59,7 \text{ mm}$$

dipakai 2P10-100

periksa :

$$V_{u,b}/\phi \leq V_c + V_s$$

$$171,4/0,8 \leq 0 + 285,7$$

$$214,25 < 285,7 \dots\dots\text{OK}$$

$V_{ub}$  di luar daerah plastis diperoleh: 161,4 Kn

$$\begin{aligned} V_c &= (\sqrt{f'_c/6})b.d \\ &= (\sqrt{20/6})300.439.10^{-3} \\ &= 240,45 \end{aligned}$$

$$\begin{aligned} V_s \text{ min} &= 1/3.b.d \\ &= 1/3.300.439.10^{-3} \\ &= 43,9 \end{aligned}$$

$$\begin{aligned} V_s &= V_{ub}/0,6 - V_c \\ &= 161,4/0,6 - 240,45 \\ &= 28,5 \text{ Kn} \end{aligned}$$

$$\begin{aligned} S &= 2.A_v.f_y.d/V_s \\ &= 2.0,25.\pi.10^2.240.439/376,8.10^3 \\ &= 376,8 > d/2 = 439/2 = 219,5 \text{ maka dipakai } S = 219,5 \text{ mm} \end{aligned}$$

dipakai 2P10-100

periksa :

$$V_u.b/\phi < V_c + V_s$$

$$161,4/0,8 < 240,45 + 28,5$$

$$201,75 < 268,95 \dots\dots\text{OK}$$



Hasil perhitungan balok induk portal terdapat pada tabel berikut :

Tabel 3.7 Hasil perencanaan balok induk portal A

Perencanaan Balok Induk Portal A							
Lantai/ elemen	Ukuran balok (mm)	tulangan tumpuan		tulangan lapangan		tulangan geser	
		n atas	n bawah	n atas	n bawah	plastis	Luar plastis
sloop/16	300/500	2D22	2D22	2D22	2D22	P10-90	P10-210
/17	300/500	2D22	2D22	2D22	2D22	P10-100	P10-210
lt. 1/18	300/500	3D22	2D22	2D22	2D22	2P10-100	P10-210
/19-20	300/500	3D22	2D22	2D22	2D22	P10-80	P10-210
lt. 2/21	300/500	3D22	2D22	2D22	2D22	P10-100	P10-210
/22-23	300/500	3D22	2D22	2D22	2D22	2P10-120	P10-210
lt. 3/24	300/500	2D22	2D22	2D22	2D22	P10-100	P10-210
/25-26	300/500	3D22	2D22	2D22	2D22	P10-100	P10-210
Atap/27	300/500	2D22	2D22	2D22	2D22	P10-100	P10-210
/28-29	300/500	2D22	2D22	2D22	2D22	P10-100	P10-210

Tabel 3.8 Hasil perencanaan balok induk portal B

Perencanaan Balok Induk Portal B							
Lantai/ Elemen	Ukuran balok (mm)	tulangan tumpuan		tulangan lapangan		tulangan geser	
		n atas	n bawah	n atas	n bawah	plastis	Luar plastis
Sloop/16	300/500	2D22	2D22	2D22	2D22	P10-95	P10-210
/17	300/500	2D22	2D22	2D22	2D22	P10-100	P10-210
lt. 1/18	300/500	4D22	2D22	2D22	2D22	2P10-80	P10-210
/19-20	300/500	4D22	2D22	2D22	2D22	P10-100	P10-210
lt. 2/21	300/500	4D22	2D22	2D22	2D22	2P10-80	P10-210
/22-23	300/500	4D22	2D22	2D22	2D22	P10-100	P10-210
lt. 3/24	300/500	3D22	2D22	2D22	2D22	2P10-100	P10-210
/25-26	300/500	4D22	2D22	2D22	2D22	P10-70	P10-210
atap/27	300/500	2D22	2D22	2D22	2D22	P10-100	P10-210
/28-29	300/500	2D22	2D22	2D22	2D22	P10-100	P10-210
atap/33	300/500	2D22	2D22	2D22	2D22	P10-100	P10-210
/34-35	300/500	2D22	2D22	2D22	2D22	P10-100	P10-210

Tab

Tabel 3.9 Hasil perencanaan balok induk portal D

Perencanaan Balok Induk Portal D								
Lantai/ Elemen	Ukuran balok (mm)	tulangan tumpuan		tulangan lapangan		tulangan geser		
		n atas	n bawah	n atas	n bawah	Plastis	Luar plastis	
sloof	/16	300/500	2D22	2D22	2D22	2D22	P10-90	P10-210
	/17	300/500	2D22	2D22	2D22	2D22	P10-100	P10-210
lt.	1/18	300/500	3D22	2D22	2D22	2D22	2P10-100	P10-210
/1	/19-20	300/500	4D22	2D22	2D22	2D22	P10-100	P10-210
lt.	2/21	300/500	3D22	2D22	2D22	2D22	2P10-100	P10-210
/1	/22-23	300/500	4D22	2D22	2D22	2D22	P10-100	P10-210
ata	lt. 3/24	300/500	3D22	2D22	2D22	2D22	2P10-100	P10-210
/2	/25-26	300/500	4D22	2D22	2D22	2D22	P10-100	P10-210
Tab	atap/27	300/500	2D22	2D22	2D22	2D22	P10-100	P10-210
	/28-29	300/500	2D22	2D22	2D22	2D22	P10-100	P10-210

Tabel 3.10 Hasil perencanaan balok induk portal H

Perencanaan Balok Induk Portal H								
Lantai/ Elemen	Ukuran Balok (mm)	tulangan tumpuan		Tulangan lapangan		tulangan geser		
		n atas	n bawah	n atas	n bawah	Plastis	Luar plastis	
sloof	/16	300/500	2D22	2D22	2D22	2D22	P10-100	P10-210
/4	/17	300/500	2D22	2D22	2D22	2D22	P10-100	P10-210
lt.	Lt. 1/18	300/500	3D22	2D22	2D22	2D22	2P10-100	P10-210
/5	/19-21	300/500	4D22	2D22	2D22	2D22	P10-100	P10-210
lt.	Lt. 2/22	300/500	3D22	2D22	2D22	2D22	2P10-100	P10-210
/6	/23-24	300/500	4D22	2D22	2D22	2D22	P10-100	P10-210
ata	lt. 3/25	300/500	2D22	2D22	2D22	2D22	P10-90	P10-210
/	/26-27	300/500	3D22	2D22	2D22	2D22	P10-100	P10-210
/7	atap/28	300/500	2D22	2D22	2D22	2D22	P10-100	P10-210
/7	/29-30	300/500	2D22	2D22	2D22	2D22	P10-100	P10-210

Tabel 3.13 Hasil perencanaan balok induk portal 2

Perencanaan Balok Induk Portal 2							
Lantai/ Elemen	Ukuran balok (mm)	tulangan tumpuan		tulangan lapangan		tulangan geser	
		n atas	n bawah	n atas	n bawah	plastis	nonplastis
sloop/45	200/350	2D19	2D19	2D19	2D19	P10-70	P10-145
/46-49	200/350	2D19	2D19	2D19	2D19	P10-70	P10-145
lt. 1/50	200/350	2D19	2D19	2D19	2D19	P10-70	P10-145
/51-57	200/350	3D19	2D19	2D19	2D19	P10-70	P10-145
lt. 2/58	200/350	2D19	2D19	2D19	2D19	P10-70	P10-145
/59-65	200/350	3D19	2D19	2D19	2D19	P10-70	P10-145
lt. 3/66	200/350	2D19	2D19	2D19	2D19	P10-70	P10-145
/67-73	200/350	3D19	2D19	2D19	2D19	P10-70	P10-145
atap/74	200/350	2D19	2D19	2D19	2D19	P10-70	P10-145
/75	200/350	2D19	2D19	2D19	2D19	P10-70	P10-145
/76-81	200/350	2D19	2D19	2D19	2D19	P10-70	P10-145

### 3.5. Perencanaan Kolom

Perencanaan kolom 2D portal D

1. Data:

a. Ukuran kolom :

$$b = 400 \text{ mm} = 0,4 \text{ m}$$

$$h = 600 \text{ mm} = 0,6 \text{ m}$$

b. Ukuran balok :

$$b = 300 \text{ mm} = 0,3 \text{ m}$$

$$h = 500 \text{ mm} = 0,5 \text{ m}$$

c.  $r = 0,3 \cdot h = 0,18 \text{ m}$

d.  $f_c = 20 \text{ mpa}$

- e.  $f_y \text{ deform} = 400 \text{ mpa}$
- f.  $f_y \text{ polos} = 240 \text{ mpa}$
- g.  $E_c = E_g = 4700 \cdot \sqrt{f_c} = 21019,04 \text{ mpa} = 21019039,0 \text{ kn/m}^2$
- h.  $I_c \text{ ( Inersia kolom )} = 0,0072 \text{ m}^4$
- i.  $I_g \text{ ( Inersia balok )} = 0,003125 \text{ m}^4$
- j. tinggi kolom :
- k.  $h \text{ pondasi} = 2 \text{ m}$
- l. panjang balok :
- m.  $l_{b1} = 2,8 \text{ m}$
- n.  $l_{b1}' \text{ (bentang bersih balok )} = l_{b1} - b \text{ kolom} = 2,4 \text{ m}$
- o.  $l_{b2} = 7 \text{ m}$
- p.  $l_{b2}' = 6,6 \text{ m}$
- q.  $c_m = 1 \text{ (unbraced frame)}$
- r.  $\phi = 0,65$
- s.  $\phi_0 = 1,25$
- t.  $d' = 50 \text{ mm}$
- u.  $d = h - d' = 550 \text{ mm}$

2. Perencanaan kolom tengah portal D elemen 5

a. Data momen.

$$M_{D \text{ atas}} = -34,03 \text{ Knm}$$

$$M_{D \text{ bawah}} = 24,03 \text{ Knm}$$

$$M_{E \text{ atas}} = -9,17 \text{ Knm}$$

$$M_{E \text{ bawah}} = 3,9 \text{ Knm}$$

$$M_{F \text{ atas}} = -58,02 \text{ Knm}$$

$$M_{I \text{ bawah}} = 156,87 \text{ Knm}$$

$$\begin{aligned} \text{(atas)} \quad 1,2 M_D + 1,6 M_I &= 1,2 \cdot (-34,03) + 1,6 \cdot (-9,17) \\ &= -55,51 \text{ Knm} \end{aligned}$$

$$\begin{aligned} \text{(bawah)} \quad 1,2 M_D + 1,6 M_I &= 1,2 \cdot 24,03 + 1,6 \cdot 3,9 \\ &= 35,08 \text{ Knm} \end{aligned}$$

$$\begin{aligned} \text{(atas)} \quad 1,05 \cdot (M_D + M_{I_r}) &= 1,05 \cdot (-34,03 + -9,17 \cdot 0,6) \\ M_b &= -41,51 \text{ Knm} \end{aligned}$$

$$\begin{aligned} \text{(bawah)} \quad 1,05 \cdot (M_D + M_{I_r}) &= 1,05 \cdot (24,03 + 3,9 \cdot 0,6) \\ M_b &= 27,69 \text{ Knm} \end{aligned}$$

$$\text{(atas)} \quad 1,05 M_{I_l} = 1,05 \cdot (-58,02)$$

$$M_s = -60,921 \text{ Knm}$$

$$\text{(bawah)} \quad 1,05 M_{I_l} = 1,05 \cdot 156,87$$

$$M_s = 164,71 \text{ Knm}$$

$$\begin{aligned} \text{(atas)} \quad M_b + M_s &= -41,51 + -60,92 \\ &= -102,43 \text{ Knm} \end{aligned}$$

$$\begin{aligned} \text{(bawah)} \quad M_b + M_s &= 27,69 + 164,71 \\ &= 192,4 \text{ Knm} \end{aligned}$$

$$\begin{aligned} \text{(atas)} \quad 1,05 \cdot (M_D + M_I + (4/1) \cdot M_{I_l}) &= 1,05 \cdot (-34,03 + -9,17 + 4 \cdot (-58,02)) \\ &= -289,044 \text{ Knm} \end{aligned}$$

$$\begin{aligned} \text{(bawah)} \quad 1,05 \cdot (M_D + M_I + (4/1) \cdot M_{I_l}) &= 1,05 \cdot (24,03 + 3,9 + 4 \cdot 156,87) \\ &= 688,18 \text{ Knm} \end{aligned}$$

b. Data gaya axial:

$$P_{D \text{ atas}} = -305,54 \text{ Kn}$$

$$P_{D \text{ bawah}} = -330,88 \text{ Kn}$$

$$P_{F, \text{atas}} = -122,91 \text{ Kn}$$

$$P_{F, \text{bawah}} = -122,91 \text{ Kn}$$

$$P_{F, \text{atas}} = -331,22 \text{ Kn}$$

$$P_{F, \text{bawah}} = -331,22 \text{ Kn}$$

$$\begin{aligned} \text{(atas)} \quad 1,2 P_D + 1,6 P_F &= 1,2 \cdot -305,54 + 1,6 \cdot -122,91 \\ &= -563,31 \text{ Kn} \end{aligned}$$

$$\begin{aligned} \text{(bawah)} \quad 1,2 P_D + 1,6 P_F &= 1,2 \cdot -330,88 + 1,6 \cdot -122,91 \\ &= -593,72 \text{ Kn} \end{aligned}$$

$$\text{(atas)} \quad 1,05 \cdot (P_D + P_{F, \text{atas}}) = 1,05 \cdot (-305,54 + -122,91 \cdot 0,6)$$

$$P_b = -398,25 \text{ Kn}$$

$$\text{(bawah)} \quad 1,05 \cdot (P_D + P_{F, \text{atas}}) = 1,05 \cdot (-330,88 + -122,91 \cdot 0,6)$$

$$P_b = -424,86 \text{ Kn}$$

$$\text{(atas)} \quad 1,05 P_F = 1,05 \cdot -331,22$$

$$P_s = -347,78 \text{ Kn}$$

$$\text{(bawah)} \quad 1,05 P_F = 1,05 \cdot -331,22$$

$$P_s = -347,78 \text{ Kn}$$

$$\begin{aligned} \text{(atas)} \quad P_b + P_s &= -398,25 + -347,78 \\ &= -746,03 \text{ Kn} \end{aligned}$$

$$\begin{aligned} \text{(bawah)} \quad M_b + M_s &= -424,86 + -347,78 \\ &= -772,64 \text{ Kn} \end{aligned}$$

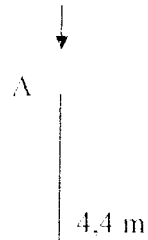
$$\text{(atas)} \quad P_u \text{ pakai} = -563,31 \text{ Kn}$$

$$\text{(bawah)} \quad P_u \text{ pakai} = -593,72 \text{ Kn}$$

$$\begin{aligned} \text{(atas)} \quad 1,05 \cdot (P_D + P_F) &= 1,05 \cdot (-305,54 + -122,91) \\ &= -449,87 \text{ Kn} \end{aligned}$$

$$\begin{aligned} \text{(bawah)} \quad 1,05 \cdot (P_D + P_L) &= 1,05 \cdot (-330,88 + -122,91) \\ &= -476,48 \text{ Kn} \end{aligned}$$

c. Perhitungan Momen Rencana ( $M_e$ )



Gambar 3.7 elemen kolom

$$M_A = -102,4 \text{ Knm}$$

$$M_B = 192,4 \text{ Knm}$$

$$P_{DA} = -305,54 \text{ Kn}$$

$$P_{DB} = -330,88 \text{ Kn}$$

$$P_{uA} = -746,03 \text{ Kn}$$

$$P_{uB} = -772,64 \text{ Kn}$$

$$\begin{aligned} e &= M/P_u \\ &= 192,4/746,03 \end{aligned}$$

$$= 0,258 \text{ m}$$

$$e_{min} = (1,5 + 0,03 \cdot h) \text{ cm}$$

$$= (1,5 + 0,03 \cdot 60) \text{ cm}$$

$$= 3,3 \text{ cm}$$

$$= 0,033 \text{ m} < 0,342 \text{ m, maka dipakai } e = 0,342 \text{ m}$$



$$\Psi_A = \Psi_B = \frac{\sum \left( \frac{E_c \cdot I_c}{L_c} \right)}{\sum \left( \frac{E_g \cdot I_g}{L_g} \right)}$$

$$\Psi_A = \frac{\sum \left( \frac{21019039,0,0072}{4,4} \right) + \left( \frac{21019039,0,0072}{4,0} \right)}{\sum \left( \frac{21019039,0,003125}{2,8} \right) + \left( \frac{21019039,0,003125}{7} \right)}$$

$$= 2,20$$

$$\Psi_B = \frac{\sum \left( \frac{21019039,0,0072}{4,4} \right) + \left( \frac{21019039,0,0072}{2,0} \right)}{\sum \left( \frac{21019039,0,003125}{2,8} \right) + \left( \frac{21019039,0,003125}{7} \right)}$$

$$= 3,35$$

lihat nomogram unbranched frames, didapat  $k = 1,75$

$$\frac{k \cdot l}{r} = \frac{1,75 \cdot 4,4}{0,18}$$

$= 42,78 > 22$  dan  $< 100$ , maka termasuk kolom panjang, dipakai

konsep perbesaran momen.

$$EI = \frac{(E_c \cdot I_g / 2,5)}{(1 + \beta \cdot I)}$$

$$= \frac{(21019039,0,003125 / 2,5)}{\left( 1 + \frac{305,54}{746,03} \right)}$$

$$= 18639,9$$

$$P_c = \frac{\pi^2 \cdot EI}{(k \cdot l)^2}$$

$$= \frac{\pi^2 \cdot 18639,9}{(1,75 \cdot 4,4)^2}$$

$$= 3099,71$$

$$\delta_b = \frac{C_m}{1 - \left( \frac{P_u}{\phi \cdot P_c} \right)} \geq 1$$

$$= \frac{1}{1 - \left( \frac{746,03}{0,65 \cdot 3099,7} \right)} \geq 1$$

$$= 1,59$$

$$\delta_s = \frac{1}{1 - \left( \frac{\sum P_u}{\phi \cdot \sum P_c} \right)} \geq 1$$

$$= \frac{1}{1 - \left( \frac{506,43 + 746,03 + 492,18}{0,65 \cdot 2580,29 + 0,65 \cdot 3099,7 + 0,65 \cdot 1056,67} \right)} \geq 1$$

$$= -6,25 < 1 \dots \text{diambil } \delta_s = 1$$

$$M_c = \delta_b \cdot M_b + \delta_s \cdot M_s$$

$$= 1,59 \cdot -41,5 + 1 \cdot -60,9$$

$$= -126,88 \text{ Knm}$$

#### d. Penulangan Kolom

Kolom tengah basement elemen 5

$$h_k = 4,4 \text{ m}$$

$$h_k' = 4,4 - h_{\text{balok}}$$

$$= 4,4 - 0,5$$

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

Rv -1

$$M_{\text{kap(kiri)}} = 224,18 \text{ Knm}$$

$$M_{\text{kap(kanan)}} = 299,09 \text{ Knm}$$

$$\begin{aligned} Nu,k1 &= 0,7.Rv.\phi0.(Mkap_{k1m} + Mkap_{k1mm})/hk + 1,05.Ng \\ &= 0,7.1.1,25.(224,18 + 299,09)/4,4 + 1,05.449,87 \\ &= 553,93 \text{ Kn} \end{aligned}$$

$$\begin{aligned} Nu,k2 &= 1,05.Ng + 1,05.Pp.4/K \\ &= 449,87 + 1,05.331.22,4/1 \\ &= 1841,00 \text{ Kn} \end{aligned}$$

dipakai Nu,k minimum, yaitu Nu,k1 = 553,93 Kn

$$M \text{ mak} = -102,4 \text{ Knm (atas)}$$

$$M \text{ mak} = 192,4 \text{ Knm (bawah)}$$

$$\begin{aligned} \alpha &= \frac{M_{atas}}{M_{atas} + M_{bawah}} \\ &= \frac{102,4}{102,4 + 192,4} \\ &= 0,35 \end{aligned}$$

$$\omega d = 1$$

$$\begin{aligned} Mu,k1 &= \frac{hk}{hk'} . \alpha \times 1,0,8 . \left( \frac{l_{ki}}{l'_{ki}} . Mkap_{ki} + \frac{l_{ka}}{l_{ka}'} . Mkap_{ka} \right) \\ &= \frac{4,4}{3,9} . 1,0,8 . \left( \frac{2,8}{2,4} . 224,18 + \frac{7}{6,6} . 229,09 \right) \\ &= 158,8 \text{ Knm} \end{aligned}$$

$$Mu,k2 = 289,04 \text{ Knm}$$

$$Mu,k \text{ pakai} = 158,8 \text{ Knm}$$

e. Penulangan:

$$Mc = 126,8 \text{ Knm}$$

$$Mu,k = 158,8 \text{ Knm}$$

$$Mu \text{ terpakai} = 158,8$$

$$Mu/\phi = 158,8/0,65$$

$$= 244,31 \text{ Kmm}$$

$$Nu/\phi = 553,93/0,65$$

$$= 852,2 \text{ Kn}$$

$$e = 244,31/852,2$$

$$= 0,29 \text{ m}$$

lihat grafik Mu, Pn didapat 1%, Ast = 1% b.h

$$= 1\% \cdot 400.600$$

$$= 2400 \text{ mm}^2$$

$$As \text{ perlu} = Ast/2$$

$$= 2400/2$$

$$= 1200 \text{ mm}^2$$

dipakai 4D22 As tul = 1519,76 mm<sup>2</sup> > As perlu..... OK

runtuh tarik:

$$\rho = \frac{Astul}{b \cdot d}$$

$$= \frac{1519,76}{400 \cdot 550}$$

$$= 0,0069$$

$$Pn = 0,85 \cdot f'c \cdot b \cdot d \cdot \left[ \left( \frac{(h-2 \cdot e)}{(2 \cdot d)} \right) + \sqrt{\left( \left( \frac{(h-2 \cdot e)}{(2 \cdot d)} \right)^2 + 2 \cdot \left( \frac{fy}{(0,85 \cdot f'c)} \right) \cdot \rho \cdot \left( 1 - \left( \frac{d}{d'} \right) \right) \right)} \right]$$

$$= 2125,83 \text{ Kn} > Nu/\phi$$

$$\begin{aligned}
 \text{jarak tulangan} &= 2 \cdot p_b + n/2 \cdot \phi + 2 \cdot \phi_{\text{sengkaung}} + ((n/2)-1) \cdot 25 < b \\
 &= 2 \cdot 40 + 4/2 \cdot 22 + 2 \cdot 10 + ((4/2)-1) \cdot 25 < 400 \\
 &= 169 \text{ mm} < 400 \text{ mm} \dots \dots \dots \text{OK}
 \end{aligned}$$

#### f. Penulangan Geser

$$\begin{aligned}
 V_u &= (M_{u,k \text{ atas}} + u_{k \text{ bawah}}) / h_k \\
 &= (158,8 + 298,3) / 3,9 \\
 &= 117,2 \text{ Kn}
 \end{aligned}$$

$$\begin{aligned}
 0,5 \cdot \phi \cdot V_c &= (1 + (N_u / b \cdot h)) \cdot \sqrt{f_c} / 6 \cdot b \cdot d \cdot 0,5 \cdot \phi \\
 &= (1 + (553,93 / (400 \cdot 600))) \cdot (\sqrt{20} / 6) \cdot 400 \cdot 550 \cdot 0,5 \cdot 0,6 \\
 &= 113,84 < V_{u,k} \text{ perlu tulangan geser minimum.}
 \end{aligned}$$

Dipakai tulangan geser  $d = 10 \text{ mm}$ ,  $A_v = 157 \text{ mm}^2$ .

$$\begin{aligned}
 S &= A_v \cdot f_y \cdot 3 / b \\
 &= 157 \cdot 240 \cdot 3 / 400 \\
 &= 282,6 \text{ mm}
 \end{aligned}$$

dicoba  $S = 250 \text{ mm}$

$$\begin{aligned}
 V_s &= A_v \cdot f_y \cdot d / S \\
 &= 157 \cdot 240 \cdot 550 / 250 \cdot 10^{-3} \\
 &= 82,89 \text{ Kn}
 \end{aligned}$$

$$\begin{aligned}
 \sqrt{f_c} / 3 \cdot b \cdot d &= \sqrt{20} / 3 \cdot 400 \cdot 550 \cdot 10^{-3} \\
 &= 327,96 \text{ Kn} > V_s \dots \dots \text{OK, maka dipakai tulangan geser } \phi 10\text{-}250
 \end{aligned}$$

Perhitungan kolom portal terdapat pada tabel berikut:

Tabel 3.13 Perhitungan kolom portal A

PORTAL A						
Posisi kolom	Lantai/ elemen	tinggi kolom (m)	ukuran kolom(mm)	Perencanaan tulangan		
				lentur	geser	
tengah	base /5	4,4	400/600	11D22	Ø10-250	
		4,4	400/600	11D22		
	lt. 1/8	4	400/600	4D22	Ø10-250	
		4	400/600	4D22		
	lt. 2/11	4	400/600	6D22	Ø10-250	
		4	400/600	6D22		
	lt. 3/14	5	400/600	4D22	Ø10-250	
		5	400/600	4D22		
	Tepi kiri	base /4	4,4	400/600	12D22	Ø10-250
			4,4	400/600	12D22	
lt. 1/7		4	400/600	4D22	Ø10-250	
		4	400/600	4D22		
lt. 2/10		4	400/600	4D22	Ø10-250	
		4	400/600	4D22		
lt. 3/13		3,2	400/600	4D22	Ø10-250	
		3,2	400/600	4D22		
tepi kanan		base /6	4,4	400/600	10D22	Ø10-250
			4,4	400/600	10D22	
	lt. 1/9	4	400/600	4D22	Ø10-250	
		4	400/600	4D22		
	lt. 2/12	4	400/600	4D22	Ø10-250	
		4	400/600	4D22		
	lt. 3/15	5	400/600	4D22	Ø10-250	
		5	400/600	4D22		

Tabel 3.14 Perhitungan kolom portal D

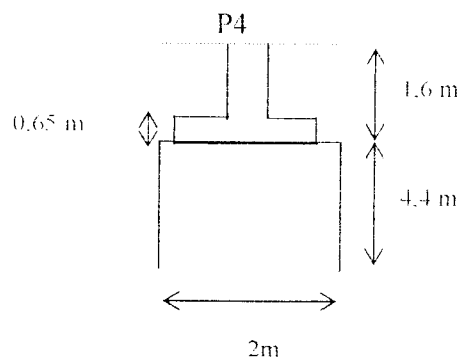
Posisi Kolom	Lantai/ elemen	tinggi kolom(m)	ukuran kolom(mm)	Perencanaan tulangan		
				lentur	geser	
Tengah	base /5	4,4	400/600	4D22	Ø10-250	
		4,4	400/600	4D22		
	lt. 1/8	4	400/600	6D22	Ø10-250	
		4	400/600	8D22		
	lt. 2/11	4	400/600	8D22	Ø10-250	
		4	400/600	4D22		
	lt. 3/14	5	400/600	4D22	Ø10-250	
		5	400/600	4D22		
	Tepi kiri	base /4	4,4	400/600	4D22	Ø10-250
			4,4	400/600	4D22	
lt. 1/7		4	400/600	5D22	Ø10-250	
		4	400/600	5D22		
lt. 2/10		4	400/600	4D22	Ø10-250	
		4	400/600	4D22		
lt. 3/13		5	400/600	4D22	Ø10-250	
		5	400/600	4D22		
tepi kanan		base /6	4,4	400/600	4D22	Ø10-250
			4,4	400/600	4D22	
	lt. 1/9	4	400/600	8D22	Ø10-250	
		4	400/600	8D22		
	lt. 2/12	4	400/600	4D22	Ø10-250	
		4	400/600	4D22		
	lt. 3/15	5	400/600	4D22	Ø10-250	
		5	400/600	4D22		

Tabel 3.15 Perhitungan kolom portal H

Posisi Kolom	Lantai/ elemen	tinggi Kolom(m)	ukuran Kolom(mm)	Perencanaan tulangan	
				lentur	Geser
tengah	lt. 1/5	4	400/600	4D22	Ø10-250
		4	400/600	4D22	
	lt. 2/8	4	400/600	4D22	Ø10-250
		4	400/600	4D22	
	lt. 3/11	3,2	400/600	5D22	Ø10-250
		3,2	400/600	5D22	
Tepi kiri	lt. 1/4	4	400/600	4D22	Ø10-250
		4	400/600	4D22	
	lt. 2/7	4	400/600	4D22	Ø10-250
		4	400/600	4D22	
	lt. 3/10	3,2	400/600	4D22	Ø10-250
		3,2	400/600	4D22	
tepi kanan	lt. 1/6	4	400/600	4D22	Ø10-250
		4	400/600	4D22	
	lt. 2/9	4	400/600	4D22	Ø10-250
		4	400/600	4D22	
	lt. 3/12	3,2	400/600	4D22	Ø10-250
		3,2	400/600	4D22	



### 3.6 Perencanaan Pondasi



Gambar 3.8 Perencanaan pondasi P4

1. Data : P4

a.  $\sigma$  tanah = 200 Kn/m<sup>2</sup>

b. h tnlh keras = 1.6 m

c.  $f_c'$  = 20 Mpa

d.  $f_y$  = 400 Mpa

e.  $\gamma$  tanah = 15,9 Kn/m<sup>3</sup>

f.  $\gamma$  beton = 24 Kn/m<sup>3</sup>

g. P = 216,9 Kn

2. Perencanaan pondasi sumuran

Bj beton siklop = 23 Kn/m<sup>3</sup>

$\phi$  coba = 2 m

h pondasi sumuran = 4,4 m

$$\begin{aligned} P \text{ pondasi sumuran} &= 0,25 \pi \cdot d^2 \cdot h \cdot \gamma \\ &= 0,25 \cdot \pi \cdot 2^2 \cdot 4,4 \cdot 23 \\ &= 317,77 \text{ Kn} \end{aligned}$$

P total = P + P<sub>sumuran</sub>

= 219,9 + 317,77

$$= 534,67 \text{ Kn}$$

$$A \text{ perlu} = \frac{P_u}{\sigma_{\text{tanah}}}$$

$$= \frac{534,67}{200}$$

$$= 2,67 \text{ mm}^2$$

$$\text{diameter sumuran perlu} = \sqrt{\frac{A}{0,25 \cdot \pi}}$$

$$= \sqrt{\frac{2,67}{0,25 \cdot 3,14}}$$

$$= 1,84 \text{ m}$$

dipakai diameter sumuran = 2 m

σijin sumuran diambil = 700 Kn/m<sup>2</sup>

3. Perencanaan pondasi telapak:

Asumsi tebal pondasi = 0,4 m

Ukuran kolom :

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

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

Perhitungan:

Daya dukung netto :

$$q = h_1 \cdot \gamma_1 + h_2 \cdot \gamma_2$$

$$1,2 \cdot 15,9 + 0,4 \cdot 24$$

$$= 28,68 \text{ Kn/m}^2$$

$$q \text{ netto} = \sigma_{\text{sumuran}} - q$$

$$= 750 - 28,68$$

$$= 721.32 \text{ Kn/m}^2$$

Dimensi pondasi bujur sangkar :

$$\begin{aligned} A \text{ perlu} &= \frac{P_u}{q_{neto}} \\ &= \frac{534.67}{721.32} \\ &= 0.74 \text{ m}^2 \end{aligned}$$

$$b = \sqrt{A}$$

$$= \sqrt{0.74}$$

$$= 0.86 \text{ m}$$

dicoba  $b = 1 \text{ m}$ ,  $A = 1 \text{ m}^2$

$$\sigma = p_u = \frac{P_u}{A}$$

$$= \frac{216.9/1.2}{1}$$

$$= 260.3 \text{ Kn/m}^2$$

Perencanaan tebal pondasi telapak (syarat kuat geser) :

asumsi tebal pondasi = 400 mm

tebal selimut beton = 70 mm

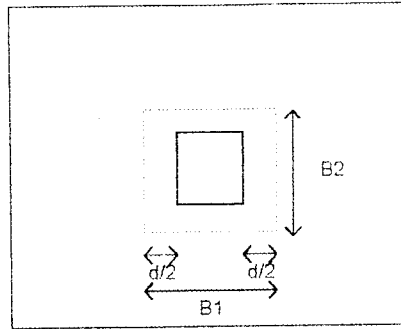
$\phi$  tulangan = 19 mm

$$d = t \text{ pondasi} - t \text{ beton} - \phi \text{ tulangan}$$

$$= 400 - 70 - 19$$

$$= 311 \text{ mm}$$

Perhitungan geser beton untuk 2 arah



Gambar 3.9 Penampang kritis dan permukaan geser beton 2 arah

$$\begin{aligned} B1 &= b_{kolom} + d/2.2 \\ &= 400 + 311/2.2 \\ &= 711 \text{ mm} \end{aligned}$$

$$\begin{aligned} B2 &= h_{kolom} + d/2.2 \\ &= 600 + 311/2.2 \\ &= 911 \text{ mm} \end{aligned}$$

$$\begin{aligned} b_o &= 2.B1 + 2.B2 \\ &= 2.711 + 2.911 \\ &= 3244 \text{ mm} \end{aligned}$$

$$\begin{aligned} V_u &= \rho_u \left( b_{pakai}^2 - (B1.B2) \right) \\ &= 260.3 \cdot (1^2 - (711 \cdot 911 \cdot 10^{-6})) \\ &= 91.69 \text{ Kn} \end{aligned}$$

$$\beta_c = 1.5$$

$$\begin{aligned} V_c &= \left( 1 + \frac{2}{\beta_c} \right) \cdot (2 \cdot \sqrt{f_c'}) \cdot b_o \cdot d \\ &= \left( 1 + \frac{2}{1.5} \right) \cdot (2 \cdot \sqrt{20 \cdot 10^3}) \cdot 3244 \cdot 10^{-3} \cdot 311 \cdot 10^{-3} \end{aligned}$$

$$= 665,83 \text{ Kn}$$

tetapi nilai tersebut tidak boleh lebih besar dari nilai:

$$V_c' = (4 \cdot \sqrt{f_c'}) \cdot b_0 \cdot d$$

$$= (4 \cdot \sqrt{(20 \cdot 10^3)}) \cdot 3244 \cdot 10^{-3} \cdot 311 \cdot 10^{-3}$$

$$= 570,71 \text{ Kn. sehingga dipakai } V_c = 570,71 \text{ Kn}$$

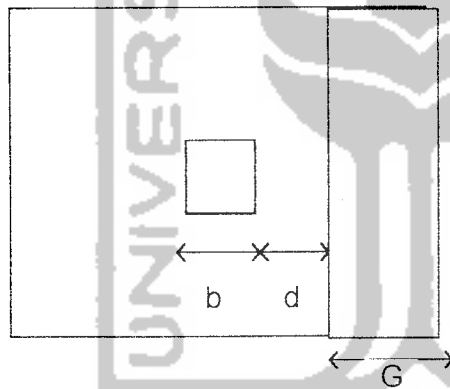
$$\phi V_n = 0,6 \cdot 570,71$$

$$= 342,43 \text{ Kn}$$

periksa :  $V_u < \phi V_n$

$$91,69 \text{ Kn} < 342,42 \text{ Kn}$$

Perhitungan geser beton untuk 1 arah



Gambar 3.10 Penampang kritis dan permukaan geser beton satu arah

$$G = b_{\text{pakai}}/2 - d - b_{\text{kolom}}$$

$$= 1,10^3/2 - 311 - 400$$

$$= -11 \text{ mm}$$

$$V_u = p_u \cdot b \cdot G$$

$$= 260,3 \cdot 1,1 \cdot 10^{-3}$$

$$= -2,86 \text{ Kn}$$

$$V_c = \left( \frac{1}{6} \sqrt{f_c'} \right) b w . d$$

$$= \left( \frac{1}{6} \sqrt{20 \cdot 10^3} \right) 1.311 \cdot 10^{-3}$$

$$= 7,33 \text{ Kn}$$

$$\phi V_c = 0,6 \cdot 7,33$$

$$= 4,39 \text{ Kn}$$

$$\text{periksa : } V_u < \phi V_c$$

$$-2,86 < 4,39 \text{ Kn} \dots\dots\dots \text{OK}$$

Perencanaan tulangan untuk arah X & Y

$$L = (b_{\text{pakai}} - b) / 2$$

$$= (1 - 400 \cdot 10^{-3}) / 2$$

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

$$M_u = 0,5 \cdot p_u \cdot L \cdot b_{\text{pakai}}$$

$$= 0,5 \cdot 216 \cdot 9 \cdot 0,3^2 \cdot 1$$

$$= 9,76 \text{ Knm}$$

$$M_u / \phi = 9,76 / 0,8$$

$$= 12,2 \text{ Kn}$$

$$A_s = \frac{M_u / \phi}{\gamma_d \cdot f_y}$$

$$= \frac{12,2 \cdot 10^6}{0,9 \cdot 311 \cdot 400}$$

$$= 108,97 \text{ mm}^2$$

$$As_{min} = \frac{1,4}{f_y} \cdot b \cdot d, \quad b = 1000 \text{ mm (tinjauan per-meter)}$$

$$= \frac{1,4}{400} \cdot 1000 \cdot 311$$

$$= 1088,5 \text{ mm}^2$$

$$1,33 \cdot As = 144,93 \text{ mm}^2$$

$$As_{pakai} = 144,93 \text{ mm}^2$$

$$\text{Jarak tulangan} = x \frac{A\phi \cdot 1000}{As_{pakai}}$$

$$= \frac{0,25 \cdot 3,14 \cdot 19^2 \cdot 1000}{144,93}$$

$$= 1173,14 \text{ mm}$$

di ambil jarak tulangan = 250 mm

dipakai tulangan D19-250

$$As_{tersedia} = \frac{A\phi \cdot 1000}{\text{jaraktulangan}}$$

$$= \frac{0,25 \cdot 3,14 \cdot 19^2 \cdot 1000}{250}$$

$$= 1133,54 \text{ mm}^2$$

$$a = \frac{As \cdot f_y}{0,85 \cdot f'_c \cdot b}$$

$$= \frac{1133,54 \cdot 400}{0,85 \cdot 20 \cdot 1000}$$

$$= 26,67 \text{ mm}$$

$$M_n = As \cdot f_y \cdot (d - a/2) > 1,33 M_u / \phi$$

$$= 1133,54 \cdot 400 \cdot (311 - 26,67/2) > 1,33 M_u / \phi$$

$$= 134,966 \text{ Knm} > 16,2268 \text{ Knm}$$

Tinjauan terhadap beban sementara dengan lebar pondasi 1m

$$M = 1,3 \text{ Knm}$$

$$P = 216,9 \text{ Kn}$$

$$e = \frac{M}{P}$$

$$= \frac{1,3}{216,9} = 0,006 \text{ m}$$

$$\sigma_{\text{terjadi}} = \frac{P}{By \cdot (By - 2 \cdot e)}$$

$$= \frac{219,9}{1 \cdot (1 - 2 \cdot 0,006)}$$

$$= 219,351 \text{ Kn/m}^2 < 1,5 \cdot \sigma_{\text{ijin}} = 1,5 \cdot 200 = 300 \text{ Kn/m}^2 \dots \text{aman}$$

Perencanaan tulangan susut:

$$As_{\text{tul susut}} = 0,002 \cdot b \cdot d$$

$$= 0,002 \cdot 1000 \cdot 311$$

$$= 622 \text{ mm}^2$$

$$\text{Jarak tulangan susut} = \frac{A \phi \cdot 1000}{As_{\text{tul susut}}}$$

$$= \frac{0,25 \cdot 3,14 \cdot 10^2 \cdot 1000}{622}$$

$$= 126,206 \text{ mm}$$

dipakai tulangan susut P10-120

$$\sqrt{(A_2/A_1)} = \sqrt{((1 \cdot 1000^2)/(400 \cdot 600))}$$

$$= 2,0412 > 2, \text{ maka dipakai } 2$$

$$\text{Kuat tumpuan pondasi} = \phi \cdot 0,85 \cdot f_c' \cdot A_1 \cdot \sqrt{A_1/A_2}$$



$$= 0,7 \cdot 0,85 \cdot 20.400.600 \cdot 10^{-3} \cdot 2$$

$$= 5712 \text{ Kn}$$

Kuat tumpuan kolom =  $\phi \cdot 0,85 \cdot f_c' \cdot A_1$

$$= 0,7 \cdot 0,85 \cdot 20.400.600 \cdot 10^{-3}$$

$$= 2856 \text{ Kn}$$

periksa :  $P_u < \text{kuat tumpuan pondasi} < \text{kuat tumpuan kolom}$

$$: 216,9 < 5712 < 2856 \text{ Kn} \dots\dots\dots \text{OK}$$

Tabel 3.16 Perencanaan pondasi:

Pondasi	dimensi	Tulangan arah X dan Y	Tulangan susut
telapak P1	1,8x1,8 m	D19-180	P10-50
telapak P2	1,8x1,8 m	D19-170	P10-50
telapak P3	1,6x1,6 m	D19-250	P10-60
telapak P4	1x1 m	D19-250	P10-120
telapak P5	1x1 m	D19-250	P10-90
telapak P6	1x1 m	D19-250	P10-120
sumuran P4	D 2m	-	-
sumuran P5	D 2m	-	-
sumuran P6	D 2m	-	-