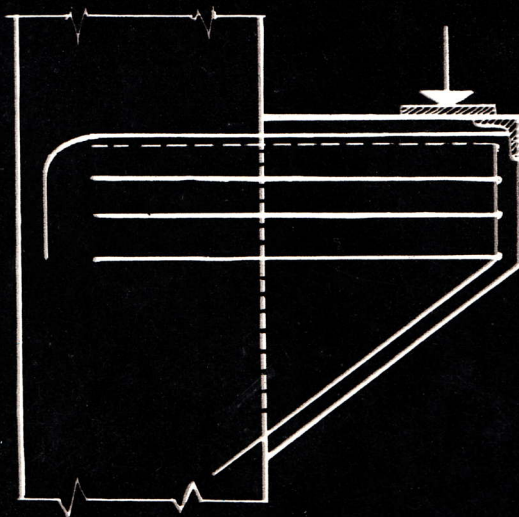


PROFIL BETON BERTULANG



Penyelesaian **“PROFIL BETON BERTULANG”**

Kata Pengantar

Buku ini merupakan hasil revisi dan penyempurnaan dari buku Penyelesaian “PROFIL BETON BERTULANG” terbitan kami sebelumnya yang terbukti banyak peminatnya.

Seluruh materinya berisikan soal-soal serta dilengkapi dengan penyelesaiannya yang sangat praktis dan mudah dipahami tentang profil beton bertulang.

Akhirnya kami berharap semoga buku ini benar-benar dapat membantu para mahasiswa Teknik Sipil dalam mencapai prestasi yang baik.

Hormat kami

Penerbit

■ Mutu beton K₂₂₅

Mutu baja U₂₄

$$\sigma_a = 1400 \text{ kg/cm}^2.$$

$$\phi_0 = \frac{1400}{21 \times 75} = 0,889$$

$$\sigma_{\text{tanah}} = 0,4 \text{ kg/cm}^2.$$
$$\gamma_{\text{tanah}} = 1,8 \text{ t} / \text{m}^2.$$

Jarak antara kolom : 5,0 m.

Penyelesaian Konstruksi :

(1) Balok Kran : (30 x 65)

Keadaan ekstrim bila $P = 10$ t di tengah bentang.

b.s. balok $g = 0,30 \times 0,65 \times 2400 = 468 \text{ kg/m'}$.

$$M_{\max} = \frac{1}{8} \times 468 \times 6,0^2 + \frac{1}{4} \times 10.000 \times 6,0 = 17.106 \text{ kgm.}$$

$N = 2000 \text{ kg (tekan)} \cdot \xrightarrow{\text{max } 8 \text{ } 4} \text{ (lentur \& normal)}$

$$e_0 = \frac{M}{N} = \frac{17106}{2000} = 8,55 \text{ m.} \quad e_0 = 8,57 \text{ m.}$$

$$e_0' = \frac{1}{30} \times 0,70 = 0,02 \text{ m.}$$

$$\frac{e_0}{h_t} = \frac{8,57}{0,65} = 13,18$$

$$c_1 = 1 \quad ; \quad c_2 = 7$$

$$e_1 = 1 \times 7 \times \left(\frac{6,00}{100 \times 0,65} \right)^2 \times 0,65$$

$$= 0,04 \text{ m.}$$

$$e_2 = 0,15 \times 0,65 = 0,10 \text{ m.}$$

$$e_{tot} = 8,57 + 0,04 + 0,10$$
$$= 8,71 \text{ m.}$$

$$e_a = 8,71 + \frac{0,65}{2} - 0,05 = 8,99 \text{ m.}$$

$$M = 2000 \times 8,99 = 17980 \text{ kgm.}$$

$$C_a = \sqrt{\frac{60}{21 \times 17980}} = 2,001 \quad \left. \begin{array}{l} \phi = 1,0 \\ \gamma = 0,844 \end{array} \right\} n\omega = 0,2976 \quad \delta = 0,2$$

$$i = \frac{1}{1 - 0,844 \times \frac{0,60}{8,99}} = 1,06 \rightarrow iA = \frac{0,2976}{21} \times 30 \times 60 = 25,50 \text{ cm}^2$$

$$A_{\min} = \frac{12}{2080} \times 30 \times 60 = 10,38 \text{ cm}^2$$

$$A = \frac{25,50}{1,06} = 24,06 \text{ cm}^2$$

$$A' = 0,2 \times 25,50 = 5,10 \text{ cm}^2$$

$$5\phi 25 = 24,55 \text{ cm}^2$$

$$\rightarrow 3\phi 19 = 5,68 \text{ cm}^2$$

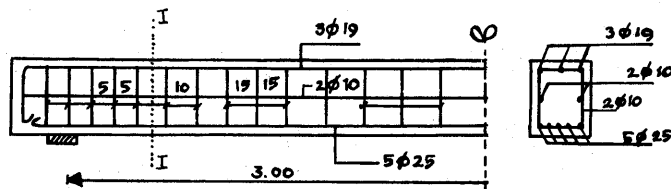
$$D_{\max} = \frac{1}{2} \times 468 \times 6,0 + 10.000 = 11.404 \text{ kg.}$$

$$\tau_b = \frac{8}{7} \times \frac{11404}{30 \times 60} = 7,24 \text{ kg/cm}^2 > \tau_{bt} (= 6,5 \text{ kg/cm}^2)$$

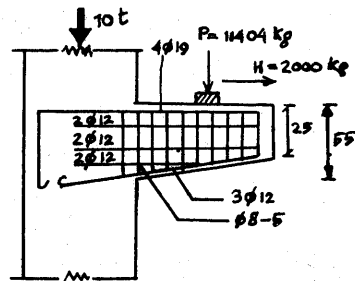
$$\tau_t = 7,24 - 6,5 = 0,74 \text{ kg/cm}^2$$

Sengkang $\phi 8-5$

$$\tau_s = \frac{1,01 \times 11400}{5 \times 30} = 9,42 \text{ kg/cm}^2$$



(2) Konsol Pendek :



$$\frac{a}{h_t} = \frac{50}{55} < 1 \text{ konsol pendek.}$$

$$M = 11404 \times 0,5 = 5702 \text{ kgm}$$

$$H = 2000 \text{ kg.}$$

a/ Tul. pokok :

$$\text{akibat } M = 5702 \text{ kgm.}$$

$$C_a = \sqrt{\frac{50}{21 \times 5702}} = 2,961 \quad \left. \begin{array}{l} \phi = 1,597 \\ n\omega = 0,1328 \end{array} \right\} \delta = 0,2$$

$$A_1 = \frac{0,1328}{21} \times 30 \times 50 = 9,49 \text{ cm}^2$$

akibat H = 2000 kg.

$$A'_1 = 0,2 \times 9,49 = 1,90 \text{ cm}^2$$

$$A_2 = \frac{2000}{1400} = 1,43 \text{ cm}^2$$

$$2\phi 12 = 2,26 \text{ cm}^2$$

$$A_{\text{tot}} = 9,49 + 1,43 = 10,92 \text{ cm}^2 \rightarrow 4\phi 19 = 11,36 \text{ cm}^2$$

$$A_{\min} = 0,03 \times 30 \times 55 \times \frac{225}{2080} = 5,35 \text{ cm}^2$$

b/ Tul. geser :

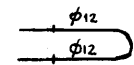
$$A_h = \frac{P}{\sigma_a \mu}$$

$$\mu = 1,4 (\text{monolit})$$

$$A_h = \frac{11.404}{1400 \times 1,4} = 5,82 \text{ cm}^2$$

$$A_{h \min} = 0,5 A$$

$$= 0,5 \times 10,92 = 5,46 \text{ cm}^2$$



$$2 \times 3\phi 12 = 2 \times 3,39 = 6,78 \text{ cm}^2$$

$$D = 11404 \text{ kg.}$$

$$\tau_b = \frac{8}{7} \times \frac{11404}{30 \times 50} = 8,69 \text{ kg/cm}^2 > \tau_{bt} = 6,5 \text{ kg/cm}^2$$

$$< \tau_{bs} = 10 \text{ kg/cm}^2$$

$$\tau_t = 8,69 - 6,5 = 2,19 \text{ kg/cm}^2$$

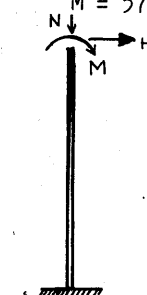
$$\text{Sengkang } \phi 8-5 \rightarrow \tau_s = \frac{1,01 \times 11400}{5 \times 30} = 9,42 \text{ kg/cm}^2 > \tau_t$$

(3) Kolom :

$$N = 10.000 + 11.404 = 21.404 \text{ kg.}; \ell_k = 1,5 \times 4,0 = 6,0 \text{ m}$$

$$H = 2000 \text{ kgm.}$$

$$M = 5702 \text{ kgm}$$



Ditinjau pada dasar kolom :

$$b.2. \text{ kolom : } 0,30 \times 0,70 \times 4,0 \times 2400 = 2016 \text{ kg}$$

$$b.3. \text{ konsol : } \frac{0,25 + 0,55}{2} \times 0,7 \times 0,3 \times 2400 = 202 \text{ kg}$$

$$\text{Akibat beban vertikal} = 21404 \text{ kg}$$

$$\Sigma V = 23622 \text{ kg}$$

$$\Sigma M = 5702 + 2000 \times 4,0 = 13.702 \text{ kgm} + \underbrace{11404 \times 0,35}_{\substack{\text{terhadap tengah} \\ \text{tengah kolom}}} = 17693 \text{ kg}$$

$$e_o = \frac{17693}{23622} = 0,75 \text{ m}$$

$$e' = \frac{1}{30} \times 0,70 = 0,02 \text{ m}$$

$$\left. \begin{array}{l} e_o = 0,75 \text{ m} \\ e' = 0,02 \text{ m} \end{array} \right\} e_o = 0,77 \text{ m}$$

$$\frac{e_o}{h_t} = \frac{0,77}{0,70} = 1,1 ; c_1 = 1 ; c_2 = 7$$

$$e_1 = 1 \times 7 \times \left(\frac{6,0}{100 \times 0,70} \right)^2 \times 0,70 = 0,04 \text{ m}$$

$$e_2 = 0,15 \times 0,70 = 0,11 \text{ m}$$

$$e_{\text{tot}} = 0,92 \text{ m}$$

Dengan grafik column section (Ir. Wiratman)

$$\frac{e_{\text{tot}}}{h_t} = \frac{0,92}{0,70} = 1,31 \dots\dots\dots$$

$$\left. \begin{array}{l} \sigma_o' = \frac{23.622}{30 \times 70} = 11,25 \text{ kg/cm}^2 \\ \sigma_o'/\sigma_b' = \frac{11,25}{75} = 0,15 \dots\dots\dots \end{array} \right\} \begin{array}{l} n_{\text{tot}} = 0,35 \\ \phi = 0,42 \end{array}$$

$$A_{\text{tot}} = \frac{0,35}{21} \times 30 \times 70 = 35,0 \text{ cm}^2 (=1,7\%)$$

$$\frac{1}{2} A_{\text{tot}} = 17,5 \text{ cm}^2 \rightarrow 4\phi 25 = 19,64 \text{ cm}^2$$

Check tegangan :

$$\sigma_a' = 21 \times 75 \times \left(1 - \frac{1+0,8}{2 \times 0,42} \right) = 1200 \text{ kg/cm}^2 < \sigma_a (=1400 \text{ kg/cm}^2)$$

$$\sigma_a = 21 \times 75 \times \left(1 - \frac{1+0,8}{2 \times 0,42} \right) = -1800 \text{ kg/cm}^2 > \sigma_a' (= -1400 \text{ kg/cm}^2)$$

$$\sigma_b' \text{ direduksi menjadi } \sigma_b' = 60 \text{ kg/cm}^2$$

$$\frac{e_{\text{tot}}}{h_t} = 1,31 \dots\dots\dots \left. \begin{array}{l} n_{\text{tot}} = 0,48 \\ \phi = 0,47 \end{array} \right\}$$

$$\frac{\sigma_o'}{\sigma_b'} = \frac{11,25}{60} = 0,19$$

$$\sigma_a' = 21 \times 60 \times \left(1 - \frac{1+0,8}{2 \times 0,47} \right) = 991 \text{ kg/cm}^2$$

$$< \sigma_a' (= 1400 \text{ kg/cm}^2)$$

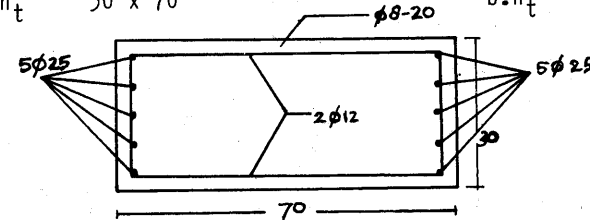
$$\sigma_a = 21 \times 60 \times \left(1 - \frac{1+0,8}{2 \times 0,47} \right) = -1152 \text{ kg/cm}^2$$

$$< \sigma_a (= -1400 \text{ kg/cm}^2)$$

$$A_{\text{tot}} = \frac{48,0}{21} \times 30 \times 30 \times 70 = 48,0 \text{ cm}^2$$

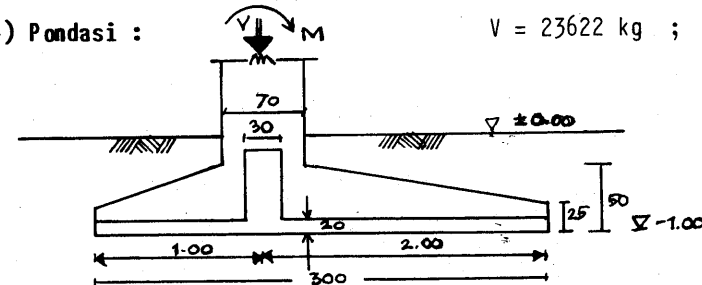
$$2 \times 5\phi 25 = 24,55 \times 2 = 49,1 \text{ cm}^2$$

$$\frac{A_{\text{tot}}}{b \times h_t} = \frac{48,0}{30 \times 70} = 0,02 = 2\% \quad (1\% < \frac{A_{\text{tot}}}{b \cdot h_t} < 6\%) \quad \text{O.K.}$$



(4) Pondasi :

$$V = 23622 \text{ kg} ; M = 17693 \text{ kgm}$$



- Beban vertikal = 23622 kg.
- Berat pelat : $0,20 \times 3,0 \times 5,0 \times 2400 = 7200 \text{ kg}$.
- Berat sloof : $0,30 \times 0,32 \times 5,0 \times 2400 = 1152 \text{ kg}$.
- Berat Rib : $\frac{0,05+0,32}{2} \times 0,30 \times 2,30 \times 2400 = 306 \text{ kg}$.
- Berat tanah : $0,80 \times 3,0 \times 5,0 \times 1800 = 21600 \text{ kg}$.

$$\Sigma V = 53880 \text{ kg}$$

Momen terhadap pusat pondasi :

$$\Sigma M = 17693 - 23622 (1,50 - 1,0) = 5882 \text{ kgm},$$

$$\sigma_v \text{ max} = \frac{53880}{3,0 \times 5,0} + \frac{5882}{\frac{1}{6} \times 5,0 \times 3,0^2} = 3592 + 784 = 4376 \text{ kgm}.$$

$$\sigma_v \min = 3592 - 784 = 2808 \text{ kg/m}^2$$

$$\sigma_{\text{tanah}} = 4376 - 0,80 \times 1800 = 2936 \text{ kg/m}^2 = 0,29 \text{ kg/cm}^2$$

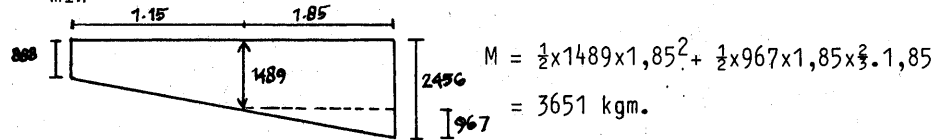
$$< \sigma_t (= 0,3 \text{ kg/cm}^2)$$

a/ Pelat pondasi. (tebal : 20 cm).

$$q_{\text{pelat}} = \frac{53880 - 7200 - 21600}{3,0 \times 5,0} \pm 734 = 1672 \pm 784$$

$$q_{\text{max}} = 1672 + 784 = 2456 \text{ kg/m}^2.$$

$$q_{\text{min}} = 1672 - 784 = 888 \text{ kg/m}^2.$$



$$M = \frac{1}{2} \times 1489 \times 1,85^2 + \frac{1}{2} \times 967 \times 1,85 \times 1,85$$

$$= 3651 \text{ kgm}.$$

$$C_a = \frac{20 - 3}{21 \times 3651} = 2,297$$

$$\frac{1 \times 1400}{\delta} = 0$$

$$\phi = 1,066 > \phi_0$$

$$n_w = 0,2270$$

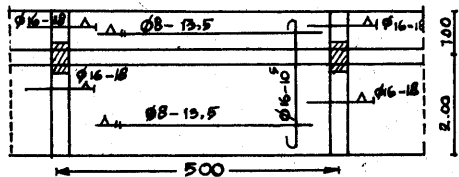
$$A = \frac{0,2270}{21} \times 100 \times 17 = 18,38$$

$$A_{\text{min}} : 0,25\% \times 100 \times 20 = 5,0 \text{ cm}^2$$

$$\phi 16 - 10,5 = 19,15 \text{ cm}^2.$$

$$I.B. = 20\% \times 18,38 = 3,68 \text{ cm}^2$$

$$\phi 8 - 13,5 = 3,72 \text{ cm}^2.$$

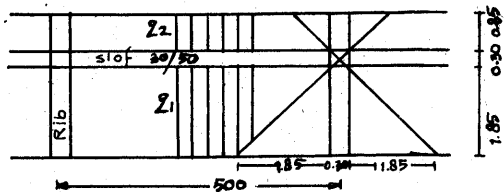


Pada tumpuan rib :

$$A_t = 0,6 \times 18,38 = 11,03 \text{ cm}^2$$

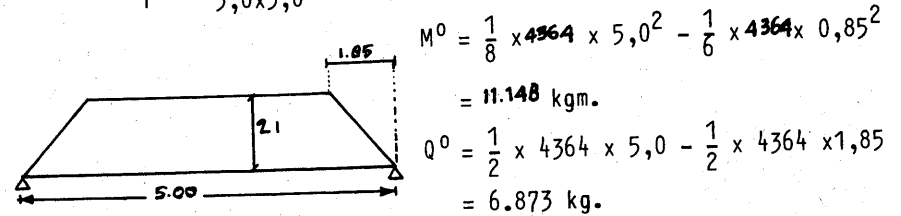
$$\phi 16 - 18 = 11,17 \text{ cm}^2.$$

b/ Sloof & rib :



Sloof : 30 x 50

$$\text{akibat } q_1 : \left(\frac{23622}{5,0 \times 3,0} + 784 \right) \times 1,85 = 4364 \text{ kg/m'}$$



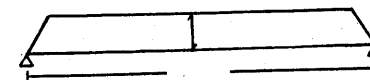
$$M^0 = \frac{1}{8} \times 4364 \times 5,0^2 - \frac{1}{6} \times 4364 \times 0,85^2$$

$$= 11.148 \text{ kgm}.$$

$$Q^0 = \frac{1}{2} \times 4364 \times 5,0 - \frac{1}{2} \times 4364 \times 1,85$$

$$= 6.873 \text{ kg}.$$

$$\text{akibat } q_2 : \left(\frac{23622}{5,0 \times 3,0} - 784 \right) \times 0,85 = 672 \text{ kg/m'}$$



$$M^0 = \frac{1}{8} \times 672 \times 5,0^2 - \frac{1}{6} \times 672 \times 0,85$$

$$= 2019 \text{ kgm}.$$

$$Q^0 = \frac{1}{2} \times 672 \times 5,0 - \frac{1}{2} \times 672 \times 0,85$$

$$= 1.394 \text{ kg}.$$

$$M^0 \text{ total} = 11.148 + 2.019 = 13.167 \text{ kgm}.$$

$$Q^0 \text{ total} = 6.873 + 1.394 = 8.267 \text{ kg}.$$

$$M_{\text{lap.}} = \frac{5}{6} \times 13.167 = 10972 \text{ kgm}.$$

$$Q_{\text{tump.}} = 1,25 \times 8267 = 10334 \text{ kg}.$$

$$M_{\text{tump.}} = -\frac{4}{5} \times 13167 = 10534 \text{ kgm}.$$

$$M_{\text{lap.}} = 10972 \text{ kgm}.$$

$$C_a = \sqrt{\frac{44}{21 \times 10972}} = 1,879$$

$$\frac{0,3 \times 1400}{\delta} = 0,8$$

$$\phi = 1,273 > \phi_0$$

$$n_w = 0,3361 \rightarrow A = \frac{0,3361}{21} \times 30 \times 44$$

$$= 21,13 \text{ cm}^2.$$

$$5\phi 25 = 24,55 \text{ cm}^2.$$

$$A' = 0,8 \times 21,13 = 16,90 \text{ cm}^2. \rightarrow 4\phi 25 = 19,64 \text{ cm}^2.$$

$$M_{\text{tump.}} = 10534 \text{ kgm}.$$

$$Ca = \frac{44}{\sqrt{\frac{21 \times 10534}{0,3 \times 1400}}} = 1,917 \quad \left. \begin{array}{l} \phi = 1,299 > \phi_0 \\ \delta = 0,8 \end{array} \right\} \quad n_w = 0,3186 \rightarrow A = \frac{0,3186}{21} \times 30 \times 44 = 20,03 \text{ cm}^2$$

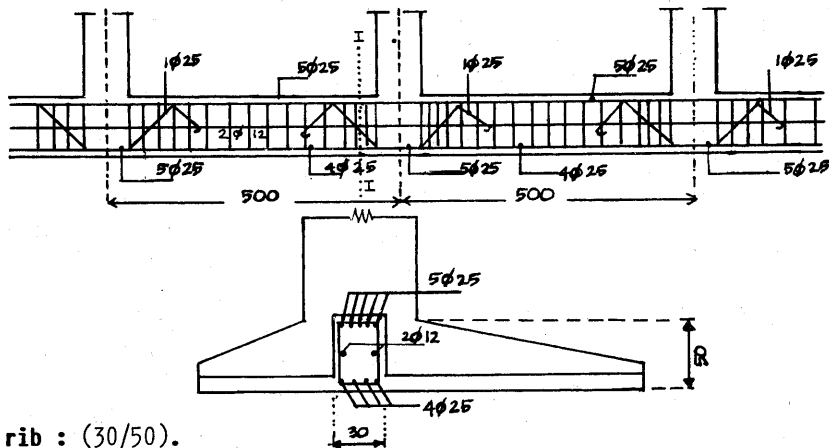
$$A' = 0,8 \times 20,03 = 16,02 \text{ cm}^2$$

$$Q = 10.334 \text{ kg.}$$

$$\tau_b = \frac{8}{7} \times \frac{10334}{30 \times 44} = 8,95 \text{ kg/cm}^2 > \tau_{bt} (= 6,5 \text{ kg/cm}^2) < \tau_{bs} (= 10 \text{ kg/cm}^2)$$

$$\tau_t = 8,95 - 6,5 = 2,45 \text{ kg/cm}^2$$

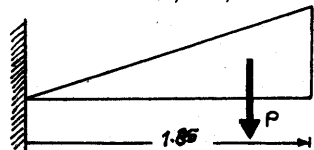
$$\text{Sengkang } \phi 8-5 \quad \tau_s = \frac{1,01 \times 1400}{5 \times 30} = 9,43 \text{ kg/cm}^2 > \tau_t$$



rib : (30/50).

Ditinjau rib yang terpanjang.

$$q = \left(\frac{23622}{3,0 \times 5,0} + 784 \right) \times 2 \times 1,85 = 8728 \text{ kg/m'}$$



$$P = \frac{1}{2} \times 1,85 \times 8728 = 8073 \text{ kg.}$$

$$M = 8073 \times \frac{2}{3} \times 1,85 = 9957 \text{ kgm}$$

$$Ca = \frac{44}{\sqrt{\frac{21 \times 9957}{0,3 \times 1400}}} = 1,972 \quad \left. \begin{array}{l} \phi = 0,980 > \phi_0 \\ \delta = 0,2 \end{array} \right\} \quad n_w = 0,3080 \rightarrow A = \frac{0,3080}{21} \times 30 \times 44 = 19,36 \text{ cm}^2 \rightarrow 4\phi 25 = 19,64 \text{ cm}^2$$

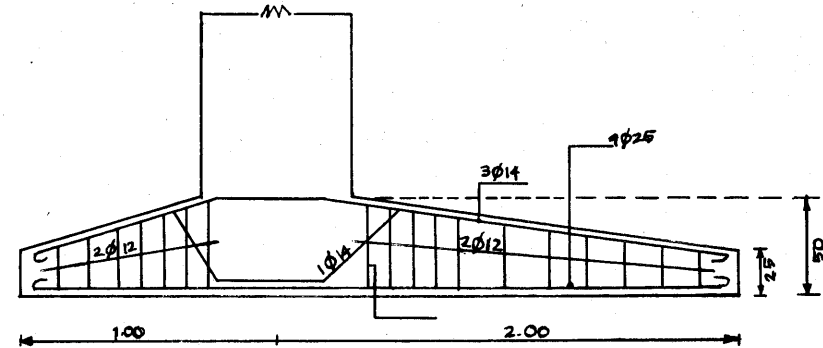
$$A' = 0,2 \times 19,64 = 3,93 \text{ cm}^2 \rightarrow 3\phi 14 = 4,62 \text{ cm}^2$$

$$Q = 8073 \text{ kg.}$$

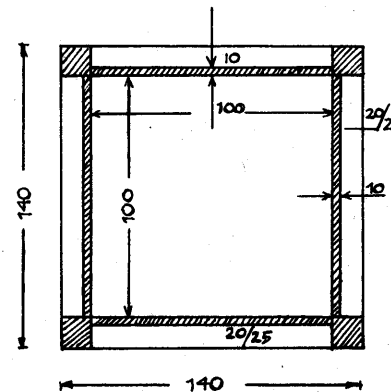
$$\tau_b = \frac{8}{7} \times \frac{8073}{30 \times 44} = 6,99 \text{ kg/cm}^2 > \tau_{bt} (= 6,5 \text{ kg/cm}^2) < \tau_{bs} (= 10 \text{ kg/cm}^2)$$

$$\tau_t = 6,99 - 6,50 = 0,49 \text{ kg/cm}^2$$

$$\text{Sengkang } \phi 8-5 \Rightarrow \tau_s = 9,43 \text{ kg/cm}^2 > \tau_t$$

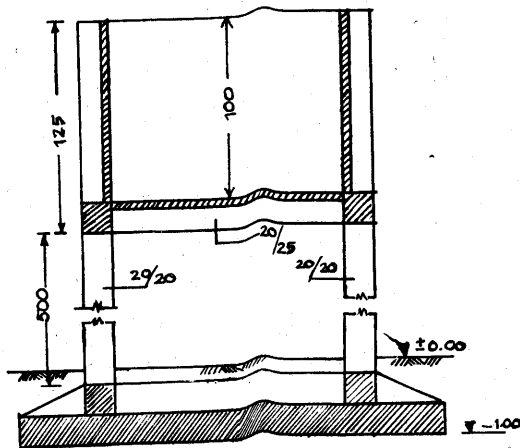


2



Ketentuan :

- Menara air
- Di daerah pantai tekanan angin $W = 60 \text{ kg/m}^2$
- Mutu beton $K_{225} \Rightarrow \sigma_b' = 75 \text{ kg/cm}^2$
 $n_t = 21$
- Mutu baja $U_{24} \Rightarrow \sigma_a = 1400 \text{ kg/cm}^2$
 $\phi_0 = \frac{1400}{21 \times 75} = 0,889$
- $\sigma_{tanah} = 0,4 \text{ kg/cm}^2$



Perhitungan Konstruksi Beton dengan P.B.I. 71 & P.M.S. 70

(1) Pelat dinding bak.

tebal dinding : 10 cm.

a/ Akibat tekanan air penuh ($\gamma_{\text{air}} = 1 \text{ t/m}^3$)
 $a = 0,5 \text{ m}$; $b = 1,0 \text{ m}$.

$$\frac{a}{b} = 0,5 \Rightarrow C_{tx} = 0,0277 ; C_{lx} = 0,0132$$

$$C_{ty} = 0,0325 ; C_{ly} = 0,0104$$

$$M_{tx} = 0,0277 \times 1000 \times 1,0^2 = 27,7 \text{ kgm.}$$

$$M_{lx} = 0,0132 \times 1000 \times 1,0^2 = 13,2 \text{ kgm.}$$

$$p = 1000 \times 1,0 = 1000 \text{ kg/m}^2. \quad M_{ly} = 0,0325 \times 1000 \times 1,0^2 = 32,5 \text{ kgm.}$$

$$M_{ly} = 0,0104 \times 1000 \times 1,0^2 = 10,4 \text{ kgm.}$$

b/ Akibat beban angin $w = 60 \text{ kg/m}^2$.

* Untuk hisap $c = 0,4 \Rightarrow w = 0,4 \times 60 = 24 \text{ kgm}^2$

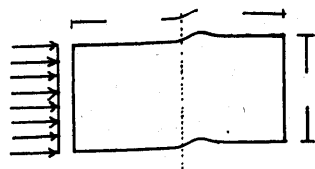
$$a = 0,5 \text{ m} ; b = 1,0 \text{ m.}$$

$$\frac{a}{b} = 0,5 \Rightarrow C_{tx} = 0,0852 ; C_{lx} = 0,0432$$

$$C_{ty} = 0,0534 ; C_{ly} = 0,0135$$

$$M_{tx} = 0,0852 \times 24 \times 1,0^2 = 2,04 \text{ kgm.}$$

$$M_{lx} = 0,0432 \times 24 \times 1,0^2 = 1,04 \text{ kgm.}$$



$$M_{ty} = 0,0534 \times 24 \times 1,0^2 = 1,28 \text{ kgm.}$$

$$M_{ly} = 0,0135 \times 24 \times 1,0^2 = 0,32 \text{ kgm.}$$

* Untuk tekan $C = 0,9 \Rightarrow w = 0,9 \times 60 = 54 \text{ kg/m}^2$.

$$M_{tx} = 0,0852 \times 54 \times 1,0^2 = 4,60 \text{ kgm.}$$

$$M_{lx} = 0,0432 \times 54 \times 1,0^2 = 2,33 \text{ kgm.}$$

$$M_{ty} = 0,0534 \times 54 \times 1,0^2 = 2,88 \text{ kgm.}$$

$$M_{ly} = 0,0135 \times 54 \times 1,0^2 = 0,73 \text{ kgm.}$$

Kombinasi beban :

1. Bak berisi air penuh + hisapan angin.

$$M_{tx} = 27,7 + 2,04 = 29,74 \sim 30 \text{ kgm.}$$

$$M_{lx} = 13,2 + 1,04 = 14,24 \sim 15 \text{ kgm.}$$

$$M_{ty} = 32,5 + 1,28 = 33,78 \sim 34 \text{ kgm.}$$

$$M_{ly} = 10,4 + 0,32 = 10,72 \sim 11 \text{ kgm.}$$

2. Bak kosong + tekanan angin :

$$M_{tx} = 4,60 \sim 5 \text{ kgm.}$$

$$M_{lx} = 2,33 \sim 3 \text{ kgm.}$$

$$M_{ty} = 2,88 \sim 3 \text{ kgm.}$$

$$M_{ly} = 0,73 \sim 1 \text{ kgm.}$$

NOTE : Untuk mengatasi kesalahan pemasangan penulangan, maka penulangan sebelah luar dan sebelah dalam disamakan.

$$M_{lx} = 30 \text{ kgm.} \quad \phi 8-20 = 2,51 \text{ cm}^2.$$

$$Ca = \frac{8}{\sqrt{\frac{21 \times 30}{1 \times 1400}}} = 11,926 \quad \delta = 1$$

$$\phi = 7,0 > \phi_0$$

$$n\omega = 0,919 \times 10^{-2}$$

$$A = \frac{0,919 \times 10^{-2}}{21} \times 100 \times 8 = 0,35 \text{ cm}$$

$$= 0,35 \text{ cm}^2.$$

$$A_{\min} = 0,25\% \times 100 \times 10 = 2,50 \text{ cm}^2$$

$$\phi 8-20 = 2,51 \text{ cm}^2.$$

$$M_{lx} = 15 \text{ kgm} \Rightarrow \underline{\underline{\phi 8-20 = 2,51 \text{ cm}^2}}$$

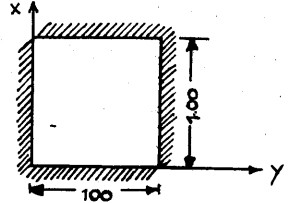
$$M_{ty} = 34 \text{ kgm}$$

$$Ca = \frac{7,5}{\sqrt{\frac{21 \times 34}{1 \times 1400}}} = 10,502 \quad \left. \begin{array}{l} \phi = 6,692 > \phi_0 \\ \delta = 1 \end{array} \right\} n\omega = 0,01006 \Rightarrow A = \frac{0,01006}{21} \times 100 \times 7,5 = 0,036 \text{ cm}^2.$$

$$M_{ly} = 11 \text{ kgm.} \Rightarrow \underline{\underline{\phi 8-20 = 2,51 \text{ cm}^2}} \quad \underline{\underline{\phi 8-20 = 2,51 \text{ cm}^2}}$$

(2) Pelat dasar bak.

tebal pelat = 10 cm.



$$p = 1000 \text{ kg/m}^2$$

$$M_{lx} = M_{tx} = 0,036 \times 1000 \times 1,0^2 = 36 \text{ kgm.}$$

$$M_{ly} = M_{ty} = 0,036 \times 1000 \times 1,0^2 = 36 \text{ kgm.}$$

$$M_{lx} = M_{tx} = 36 \text{ kgm.}$$

$$Ca = \frac{7,5}{\sqrt{\frac{21 \times 36}{1 \times 1400}}} = 10,206 \quad \left. \begin{array}{l} \phi = 6,519 > \phi_0 \\ \delta = 0 \end{array} \right\} n\omega = 0,01020$$

$$A = \frac{0,01020}{21} \times 100 \times 7,5 = 0,36 \text{ cm}^2.$$

$$\underline{\underline{\phi 8-20 = 2,51 \text{ cm}^2}}$$

$$M_{ly} = M_{ty} = 36 \text{ kgm.} \Rightarrow \underline{\underline{\phi 8-20 = 2,51 \text{ cm}^2}}$$

Check terhadap lebar retak :

$$w = \alpha (c_3 \cdot c + c_4 \cdot \frac{d}{\omega_p}) \left(\sigma_a - \frac{c_5}{\omega_p} \right) \cdot 10^{-6} \text{ (cm)}$$

$$\alpha = 1,2; c_3 = 1,50; c_4 = 0,04; c_5 = 7,5; c = 1,50 \text{ cm.}$$

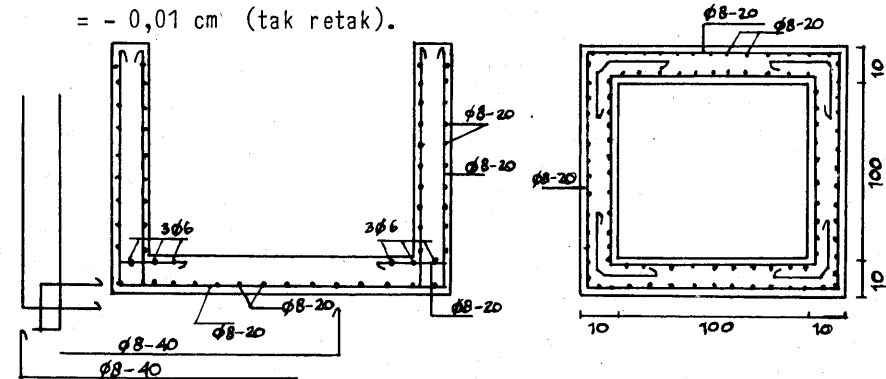
$$d = 0,8 \text{ cm.}$$

$$\omega_p = \frac{2,51}{100 \times 8} = 3,14 \times 10^{-3}$$

$$w = 1,2 \left(1,50 \times 1,50 + 0,04 \times \frac{0,8}{3,14 \times 10^{-3}} \right) \left(1400 - \frac{7,5}{3,14 \times 10^{-6}} \right) \cdot 10^{-6}$$

$$= 12,44 - 988,54$$

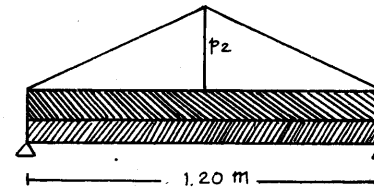
$$= -0,01 \text{ cm (tak retak).}$$



POT. DARI SAMPIR

POT. DARI ATAS

(3) Balok pada bak (20 x 25) :



$$g = 0,20 \times 0,15 \times 2400 = 72 \text{ kg/m'}$$

$$p_1 = 0,10 \times 1,0 \times 2400 = 240 \text{ kg/m'}$$

$$g + p_1 = 312 \text{ kg/m'}$$

$$p_2 = \frac{1,20}{2} \times 1000 = 600 \text{ kg/m'}$$

$$M_{\max} = \frac{1}{8} \times 312 \times 1,2^2 + \frac{1}{12} \times 600 \times 1,2^2 = 128 \text{ kgm.}$$

$$Q_{\max} = \frac{1}{4} \left(600 + \frac{3}{2} \times 312 \right) \times 1,20 = 320 \text{ kgm.}$$

$$M_{\max} = 128 \text{ kgm.}$$

$$Ca = \frac{20}{\sqrt{\frac{21 \times 128}{0,20 \times 1400}}} = 6,455 \quad \left. \begin{array}{l} \phi = 3,878 > \phi_0 \\ \delta = 0,2 \end{array} \right\} n\omega = 0,02715$$

$$A = \frac{0,02715}{21} \times 20 \times 20 = 0,52 \text{ cm}^2$$

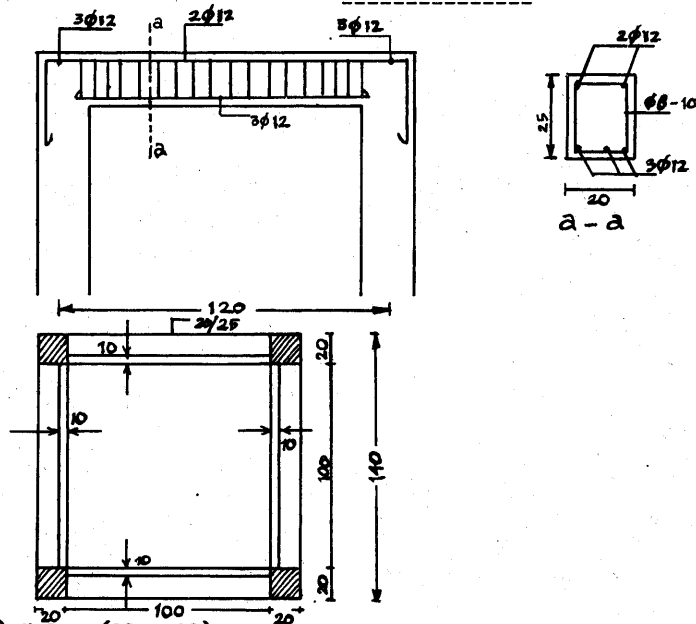
$$A_{\min} = \frac{12}{2080} \times 20 \times 20 = 2,31 \text{ cm}^2 \quad \underline{\underline{3\phi 12 = 3,39 \text{ cm}^2}}$$

$$A' = 0,2 \times 2,31 = 0,46 \text{ cm}^2. \Rightarrow 2\phi 12 = 2,26 \text{ cm}^2.$$

$$Q_{\max} = 320 \text{ kg.}$$

$$\tau_b = \frac{8}{7} \times \frac{320}{20 \times 20} = 0,91 \text{ kg/cm}^2 < \tau_{bt} (= 6,5 \text{ kg/cm}^2)$$

Sengkang $\phi 8-10$.



(4) Kolom (20 x 20).

- berat air : $1,0 \times 1,0 \times 1,0 \times 1000 = 1000 \text{ kg.}$
- berat dinding : $4 \times 0,10 \times 1,0 \times 1,0 \times 2400 = 960 \text{ kg.}$
- berat pekat dasar : $0,10 \times 1,0 \times 1,0 \times 2400 = 240 \text{ kg.}$
- berat kolom atas : $4 \times 0,20 \times 0,20 \times 1,0 \times 2400 = 384 \text{ kg.}$
- berat balok : $4 \times 0,20 \times 0,15 \times 1,20 \times 2400 = 346 \text{ kg.}$

$$\Sigma v = 2930 \text{ kg.}$$

Momen akibat beban angin :

$$M = 1,40 \times 1,25 \times 1,3 \times \frac{1,25}{2} = 85,31 \approx 86 \text{ kgm.}$$

Beban vertikal yang dipikul oleh masing-masing kolom :

$$N = \frac{2930}{4} \pm \frac{86}{1,40 \times 2} = 732,5 \pm 30,7$$

$$N_{\max} = 732,5 + 30,7 = 763,2 \approx 765 \text{ kg.}$$

$$N_{\min} = 732,5 - 30,7 = 701,8 \approx 705 \text{ kg.}$$

$$l_k \cdot l_t = 5,0 \text{ m.}$$

$$e_o = 0 \quad \left. \begin{array}{l} e_o = 0,02 \text{ m.} \end{array} \right\}$$

$$e'_o = \frac{1}{30} \times 0,20 = 0,006 \approx 0,02 \text{ m.}$$

$$\frac{e_o}{h_t} = \frac{0,02}{0,20} = 0,10 \Rightarrow c_1 = 1; c_2 = 6,32$$

$$e_1 = 1 \times 6,32 \times \left(\frac{5,0}{100 \times 0,200} \right)^2 \times 0,20 = 0,08 \text{ m.}$$

$$e_2 = 0,15 \times 0,20 = 0,03 \text{ m.}$$

$$e_{\text{tot}} = 0,02 + 0,08 + 0,03 = 0,13 \text{ m.}$$

$$\frac{e_{\text{tot}}}{h_t} = \frac{0,13}{0,20} = 0,65$$

$$\frac{\sigma_a'}{\sigma_b'} = \frac{765}{20 \times 20 \times 75} = 0,03$$

$$\left. \begin{array}{l} \text{tul. min. } (A_{\min}) = 1\% \times 20 \times 20 = 4,0 \text{ cm}^2. \end{array} \right\}$$

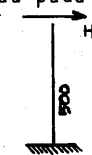
Check tegangan :

$$F_i = F_b + (n-1) A = 20 \times 20 + (21-1) 4,0 = 480 \text{ cm}^2.$$

$$\sigma_b' = \frac{765}{480} = 1,59 \text{ kg/cm}^2 < \sigma_b'.$$

$$\sigma_a' = n \cdot \sigma_b' = 21 \times 1,59 = 33,47 \text{ kg/cm}^2 < \sigma_a$$

Bila ditinjau pada bagian kolom sebelah bawah :



$$H = \frac{1}{4} (1,40 \times 1,25 \times 1,3 \times 60) = 34,13 \approx 35 \text{ kg.}$$

$$M = 35 \times 5 = 175 \text{ kgm.}$$

$$N = 765 + (0,20 \times 0,20 \times 5,0 \times 2400) = 1245 \text{ kg.}$$

$$e_o = \frac{175}{1245} = 0,14 \text{ m.}$$

$$e'_o = 0,02 \text{ m.}$$

$$\left. \begin{array}{l} e_o = 0,14 \text{ m.} \\ e'_o = 0,02 \text{ m.} \end{array} \right\} e_o = 0,16 \text{ m.}$$

$$\frac{e_o}{h_t} = \frac{0,16}{0,20} = 0,8 \Rightarrow c_1 = 1 ; c_2 = 6,98$$

$$e_1 = 1 \times 6,98 \times \left(\frac{5,0}{100 \times 0,20} \right)^2 \times 0,20 = 0,09 \text{ m.}$$

$$e_2 = 0,15 \times 0,20 = 0,03 \text{ m.}$$

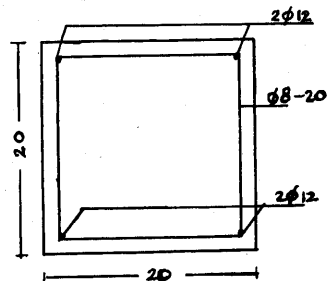
$$e_{tot} = 0,16 + 0,09 + 0,03 = 0,28 \text{ m.}$$

$$\frac{e_{tot}}{h_t} = \frac{0,28}{0,20} = 1,4$$

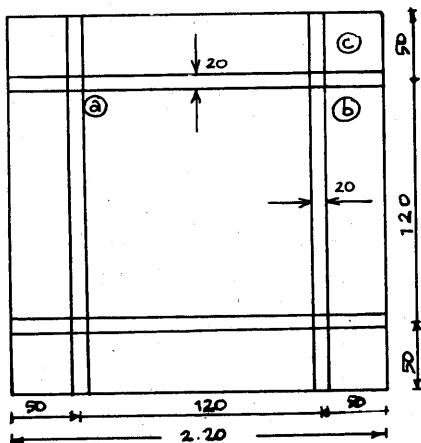
$$\left. \begin{array}{l} \frac{e_{tot}}{h_t} = 1,4 \\ \frac{o'}{b'} = 0,04 \end{array} \right\} \text{ tul. min : } 1 \% \times 20 \times 20 = 4,0 \text{ cm.}$$

$$\frac{o'}{b'} = \frac{1245}{20 \times 20 \times 75} = 0,04$$

$$\underline{\underline{2 \times 2\phi 12 = 4,52 \text{ cm}^2.}}$$



(5) Pondasi :

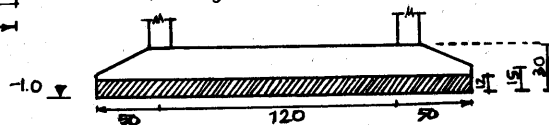


Beban kolom total :

$$2930 + 4(0,20 \times 0,20 \times 5,0 \times 2400) = 4850 \text{ kg.}$$

Momen terhadap pusat pondasi :

$$M = 1,40 \times 1,25 \times 1,3 \times 60 \times \left(\frac{1,25 + 5,0}{2} \right) = 768 \text{ kgm.}$$



Beban vertikal :

- Beban kolom = 4850 kg.
 - Berat pelat : $0,12 \times 2,20 \times 2,20 \times 2400 = 1394 \text{ kg.}$
 - Berat sloof : $4 \times 0,20 \times 0,18 \times 2,20 \times 2400 = 1183 \text{ kg.}$
 - Berat tanah : $0,88 \times 2,20 \times 2,20 \times 1700 = 7240 \text{ kg.}$
- $\Sigma V = 14667 \text{ kg.}$

$$\sigma_v = \frac{14667}{2,20 \times 2,20} + \frac{768}{\frac{1}{6} \times 2,20 \times 2,20^2} = 3030 + 443$$

$$\sigma_v \text{ max} = 3030 + 443 = 3463 \text{ kg/m}^2.$$

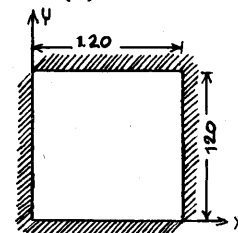
$$\sigma_v \text{ min} = 3130 + 443 = 2597 \text{ kg/m}^2.$$

$$\sigma_t = 3463 - 0,88 \times 1700 = 1967 \text{ kg/m}^2 = 0,2 \text{ kg/cm}^2 < \sigma_t (= 0,4 \frac{\text{kg}}{\text{cm}^2})$$

Pelat pondasi :

$$q_{\text{pelat}} = \frac{14667 - 1394 - 7240}{2,20 \times 2,20} + 443 = 1246 + 433 = 1679 \frac{\text{kg}}{\text{cm}^2}$$

Pelat (a) :



$$\frac{l_y}{l_x} = \frac{1,20}{1,20} = 1$$

$$c_{1x} = c_{tx} = c_{ty} = c_{ly} = 0,036$$

$$M_{1x} = M_{tx} = 0,036 \times 1679 \times 1,20^2 = 87 \text{ kgm.}$$

$$C_a = \frac{9}{\sqrt{\frac{21 \times 87}{1 \times 1400}}} = 7,878 \quad \left. \begin{array}{l} \phi = 4,917 > \phi_o \\ n\omega = 0,01718 \end{array} \right\}$$

$$A = \frac{0,01718}{21} \times 100 \times 9 = 0,74 \text{ cm}^2.$$

$$A \text{ min} : 0,25 \% \times 100 \times 12 = 3,0 \text{ cm}^2 \quad \underline{\underline{\phi 8-16^5 = 3,05 \text{ cm}^2.}}$$

$$\text{I.B. ditumpuan : } \phi 6-25 = 1,13 \text{ cm}^2.$$

$$M_{1y} = M_{ty} = 87 \text{ kgm.} \Rightarrow \underline{\underline{\phi 8-16^5 = 3,05 \text{ cm}^2.}}$$

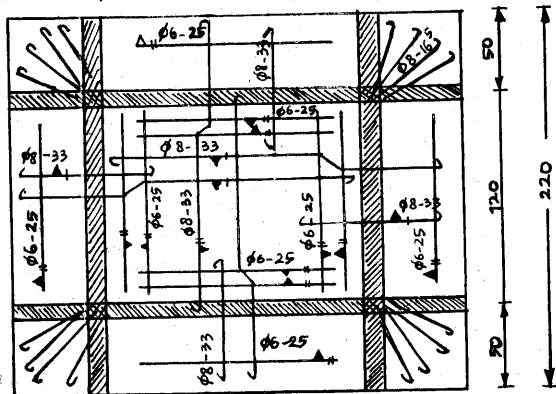
Pelat (b) :

$$M = \frac{1}{2} \times 1679 \times 0,50^2 = 210 \text{ kgm.}$$

$$C_a = \frac{9}{\sqrt{\frac{21 \times 210}{1 \times 1400}}} = 5,070 \quad \left. \begin{array}{l} \phi = 2,968 > \phi_0 \\ n_w = 0,04245 \\ A = \frac{0,04245}{21} \times 100 \times 9 = 1,82 \text{ cm}^2 \\ \phi 8 - 16^5 = 3,05 \text{ cm}^2 \end{array} \right\} \delta = 0$$

Pelat (c) :

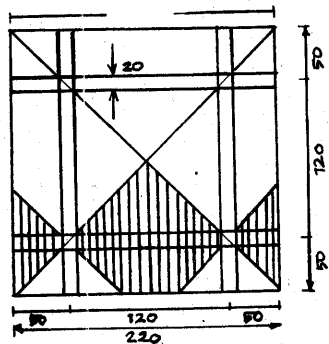
$\phi 8 - 16^5 \Rightarrow$ tul. kipas.



Sloof (20 x 30).

$$q = \frac{4850}{2,20 \times 2,20} + 433 = 1002 + 433 = 1435 \text{ kg/cm}^2.$$

Keadaan a :



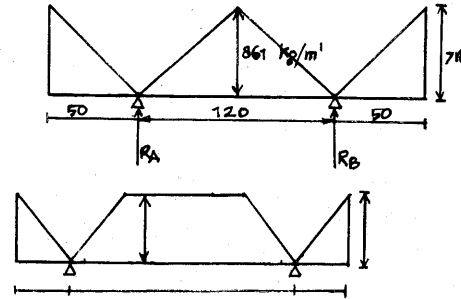
$$M_{\text{overstek}} = \frac{1}{2} \times 0,5 \times 718 \times \frac{2}{3} \times 0,50 = 60 \text{ kgm.}$$

$$Q_{\text{overstek}} = \frac{1}{2} \times 0,5 \times 718 = 180 \text{ kg}$$

$$M_{\text{lap}} = \frac{1}{12} \times 861 \times 1,20^2 - 60 = 180 \text{ kg.}$$

$$Q_{\text{lap}} = \frac{1}{4} \times 861 \times 1,20 = 258 \text{ kg.}$$

Keadaan b :



$$\left. \begin{array}{l} M_{\text{overstek}} = 60 \text{ kgm.} \\ Q_{\text{overstek}} = 180 \text{ kg.} \end{array} \right\}$$

$$M_{\text{lap}} = \frac{1}{8} \times 718 \times 1,20^2 - \frac{1}{6} \times 718 \times 0,5^2 = 100 \text{ kgm} - 60 = 40 \text{ kg.}$$

$$Q_{\text{lap}} = \frac{1}{2} \times 718 \times 1,20 - \frac{1}{2} \times 718 \times 0,5 = 251 \text{ kg.}$$

Kombinasi a & b :

$$M_{\text{overstek}} = 60 \times 2 = 120 \text{ kgm.}$$

$$C_a = \frac{24}{\sqrt{\frac{21 \times 120}{0,2 \times 1400}}} = 8,0 \quad \left. \begin{array}{l} \phi = 5,601 > \phi_0 \\ n_w = 0,01683 \end{array} \right\} \delta = 0,4$$

$$A = \frac{0,01683}{21} \times 20 \times 24 = 0,38 \text{ cm}^2$$

$$A_{\text{min}} = \frac{12}{2080} \times 20 \times 24 = 2,77 \text{ cm}^2 \Rightarrow 3\phi 12 = 3,39 \text{ cm}^2.$$

$$A' : 0,4 \times 2,77 = 1,11 \text{ cm}^2 \Rightarrow 2\phi 12 = 2,26 \text{ cm}^2.$$

$$Q_{\text{overstek}} : 180 \times 2 = 360 \text{ kg.}$$

$$\tau_b = \frac{8}{7} \times \frac{360}{20 \times 24} = 0,86 \text{ kg/cm}^2 < \tau_{bt} (= 6,5 \text{ kg/cm}^2).$$

Senggang $\phi 8 - 10$

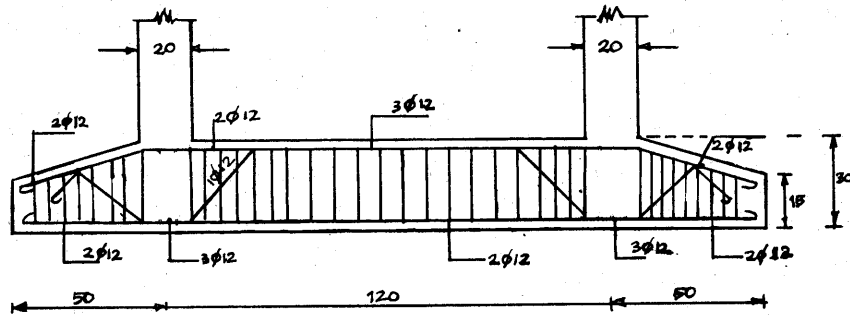
$$M_{\text{lap}} = 44 + 40 = 84 \sim 90 \text{ kgm.}$$

$$\text{Tul. min} \Rightarrow A_{\text{min}} = 2,77 \text{ cm}^2 \Rightarrow 3\phi 12 = 3,39 \text{ cm}^2$$

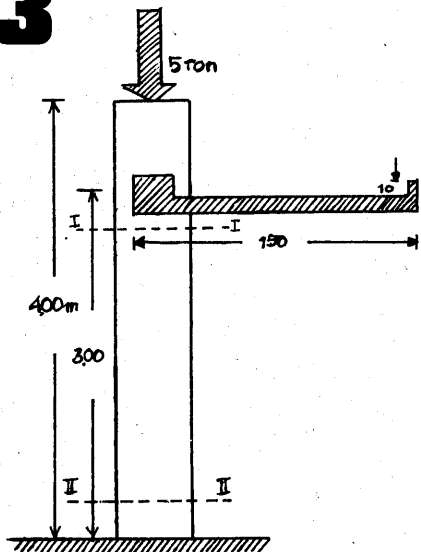
$$Q = 258 + 251 = 509 \text{ kg.} \quad A' \Rightarrow 2\phi 12 = 2,26 \text{ cm}^2$$

$$\tau_b = \frac{8}{7} \times \frac{509}{20 \times 24} = 1,21 \text{ kg/cm}^2 < \tau_{bt} (= 6,5 \text{ kg/cm}^2)$$

Senggang $\phi 8 - 10$.



3



Luifel : $d = 8 \text{ cm}$.
 $p = 100 \text{ kg/m'}$

Mutu beton : $K_{225} \quad b' = 75 \text{ kg/cm}^2$

Mutu baja : $QR_{24} \quad a = 1400 \text{ kg/cm}^2$

Rencanakan : 1) penulangan luifel
 2) penulangan kolom

Beban-Beban :

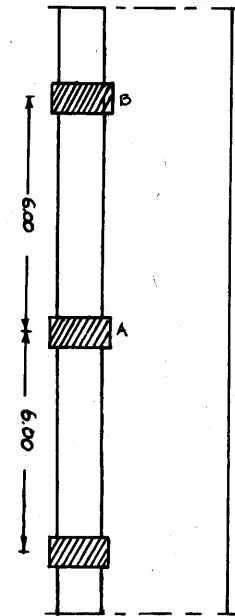
- Berat sendiri pelat = $0,08 \times 1,00$
 (tebal=8cm) $\times 2400 = 192 \text{ kg/m}^2$

- Berat air = $0,10 \times 1,00 \times 1000$
 (P) = 100 kg/m^2

$q = 292 \text{ kg/m}^2$

$M_{\text{pelat maximum}} = \frac{1}{2} q l^2$

$(M_{\text{jepit pelat}}) = \frac{1}{2} \times 292 \times 1,50^2$
 $= 328,5 \text{ kgm/m'}$



$$Ca = \frac{h}{\sqrt{\frac{21 \times 328,5}{1,00 \times 1400}}}$$

$$= \frac{8,00 - 1,5}{2,220} = \frac{6,5}{2,220} = 2,928$$

$$\delta = 0 \Rightarrow nw = 0,1351$$

$$\phi = 1,488 > \phi_0 = 0,889$$

$$A = \frac{0,1351}{21} \times 100 \times 6,5 = 4,182 \text{ cm}^2$$

Dipakai tulangan : $\phi 8 - 12 = 4,19 \text{ cm}^2$
 $> 4,182 \text{ cm}^2$

I.P. = 20% = $20\% \times 4,190 \text{ cm}^2 = 0,838 \text{ cm}^2$

Dipakai tulangan pembagi :

$$\phi 6 - 25 = 1,13 \text{ cm}^2$$

$$> 0,838 \text{ cm}^2$$

Perhitungan balok puntir A-B : 30/40.

$$M_{\text{puntir A-B max}} = M_{\text{jepit}} \times \frac{6,00}{2}$$

$$= 328,5 \times 3,00 = 985,5 \text{ kgm}$$

$$= 98550 \text{ kgcm}$$

Beban-beban balok : 30/40.

- Berat sendiri balok : $0,30 \times 0,40 \times 1,00 \times 2400 = 288 \text{ kg/m'}$

- Beban pelat yang dibebankan kebalok : $292 \times 1,00 \times 1,5 = 438 \text{ kg/m'}$

$$q' = 726 \text{ kg/m'}$$

$$D_{\text{max}} = \frac{1}{2} \times q' \times 6,00 : \frac{1}{2} \times 726 \times 6,00 = 2178 \text{ kg}$$

$$\tau_b = \frac{D_{\text{max}}}{b \times \frac{7}{8} h} = \frac{2178}{2,30 \times \frac{7}{8} \times 0,35} = \frac{2178}{918,75} = 2,371 \text{ kg/cm}^2$$

$$\tau_{b'} = \frac{M_p}{h \cdot b^2}$$

$$\psi = 3 + \frac{2,6}{0,45 + \frac{ht}{b}} = 3 + \frac{2,6}{0,45 + \frac{40}{30}} = 3 + \frac{2,6}{1,7833}$$

$$= 3 + 1,458 = 4,458$$

$$\tau_{b'} = 4,458 \times \frac{98550}{40 \times 30^2} = \frac{439335,9}{36.000} = 12,204 \text{ kg/cm}^2$$

$$\tau_b + \tau_{b'} = 2,371 + 12,204 = 14,575 \text{ kg/cm}^2.$$

$\tau_b = 8 \text{ kg/cm}^2$ (diperlukan tulangan geser lentur puntir)

$\tau_{bm} = 20 \text{ kg/cm}^2$ (ukuran penampang balok memenuhi)

$$b'' = \frac{M_p}{b \cdot f_t} = \frac{98550}{30 \times 25 \times 35} = \frac{98550}{26250} = 3,754 \text{ kg/cm}^2.$$

$$\text{Dipakai beugel : } \emptyset 8 - 10 \Rightarrow \tau_s = \frac{A_s \cdot \sigma_a}{a_s \cdot b} = \frac{1,01 \times 1400}{10 \times 30}$$

$$A_s = 1,01 \text{ cm}^2. \quad = \frac{1414}{300} = 4,7133 \text{ kg/cm}^2$$

$$a_s = 5 \text{ cm.}$$

$$\text{Dipakai tulangan miring : } \emptyset 12 - 30 \Rightarrow A_m = 1,13 \text{ cm}^2$$

$$a_m = 30 \text{ cm.}$$

$$\tau_m = \frac{A_m \cdot \sigma_a \cdot \sqrt{2}}{a_m \cdot b} = \frac{1,13 \times 1400 \cdot \sqrt{2}}{30 \times 30} = \frac{2237,3}{900} = 2,486 \text{ kg/cm}^2.$$

$$\tau_m + \tau_s = 2,486 + 4,7133 = 7,1993 \text{ kg/cm}^2 > \tau_b + \tau_{b''} = 2,371 + 3,754 = 6,125 \text{ cm}^2.$$

$$\tau_m + \tau_s = 7,1993 \text{ kg/cm}^2$$

$$\tau_b + \tau_{b''} = 2,371 + 3,754 = 6,215 \text{ kg/cm}^2.$$

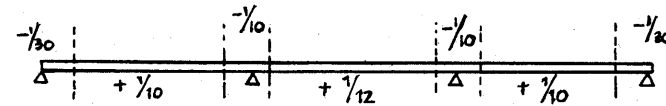
Tulangan puntir memanjang :

$$A_{\min} = \frac{M_p \cdot \psi}{\sigma_a \cdot f_t} = \frac{98550 \times 2 (25 + 35)}{2 \times 1400 \times 25 \times 35}$$

$$= \frac{98550 \times 120}{2450.000} = \frac{11.826.000}{2.450.000} = 4,83 \text{ cm}^2.$$

$$\text{Dipakai tulangan : } 2 \emptyset 19 = 5,68 \text{ cm}^2 > 4,83 \text{ cm}^2.$$

Perhitungan lentur balok A - B :



$$M_{\max (+)} = + \frac{1}{10} \times q_{\text{balok}} \times 6,00^2 = + \frac{1}{10} \times 726 \times 6,00^2 = + 2613,6 \text{ kgm}$$

$$M_{\text{jepit max}} = - \frac{1}{10} \times q_{\text{balok}} \times 6,00^2 = - \frac{1}{10} \times 726 \times 6,00^2 = - 2613,6 \text{ kgm}$$

$$C_a = \frac{10 - 5}{\sqrt{\frac{2613,6 \times 21}{0,30 \times 1400}}} = \frac{35}{11,4315} = 3,062$$

$$\delta = 0,2 \Rightarrow n_w = 0,1234$$

$$\phi = 1,667 > \phi_o = 0,889$$

$$A = \frac{0,1234}{21} \times 30 \times 35 = 6,17 \text{ cm}^2.$$

$$\text{Dipakai tulangan : } 4 \emptyset 16 = 8,04 \text{ cm}^2 > 6,17 \text{ cm}^2$$

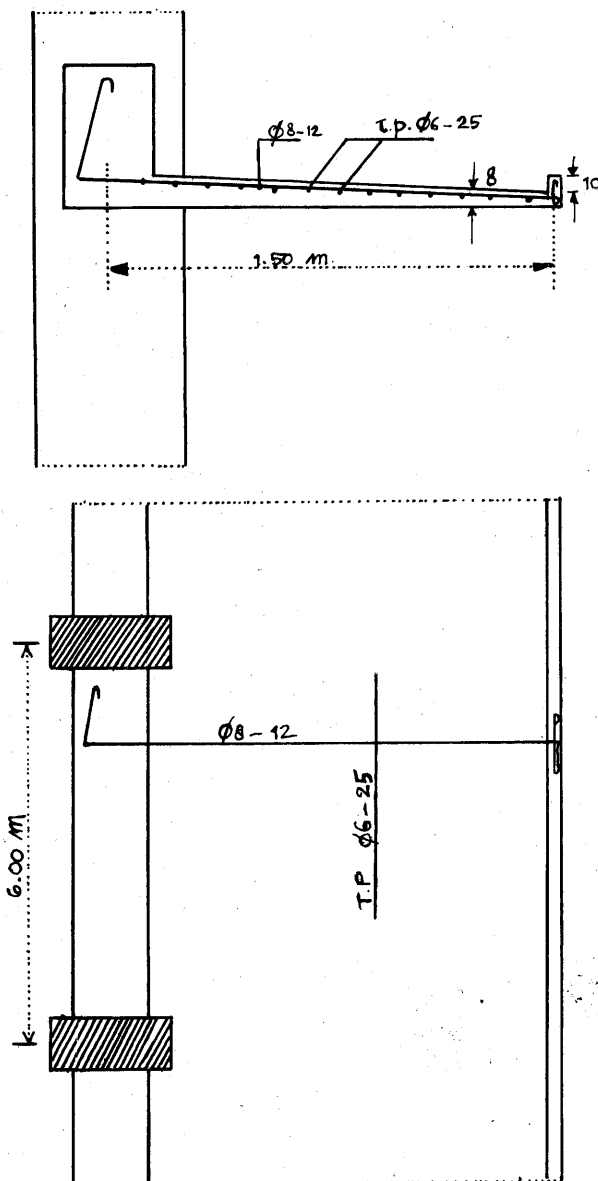
$$A' = 0,2 A = 0,21 \times 6,17 = 1,234 \text{ cm}^2.$$

$$\text{Dipakai tulangan : } 3 \emptyset 12 = 3,39 \text{ cm}^2 > 1,234 \text{ cm}^2.$$

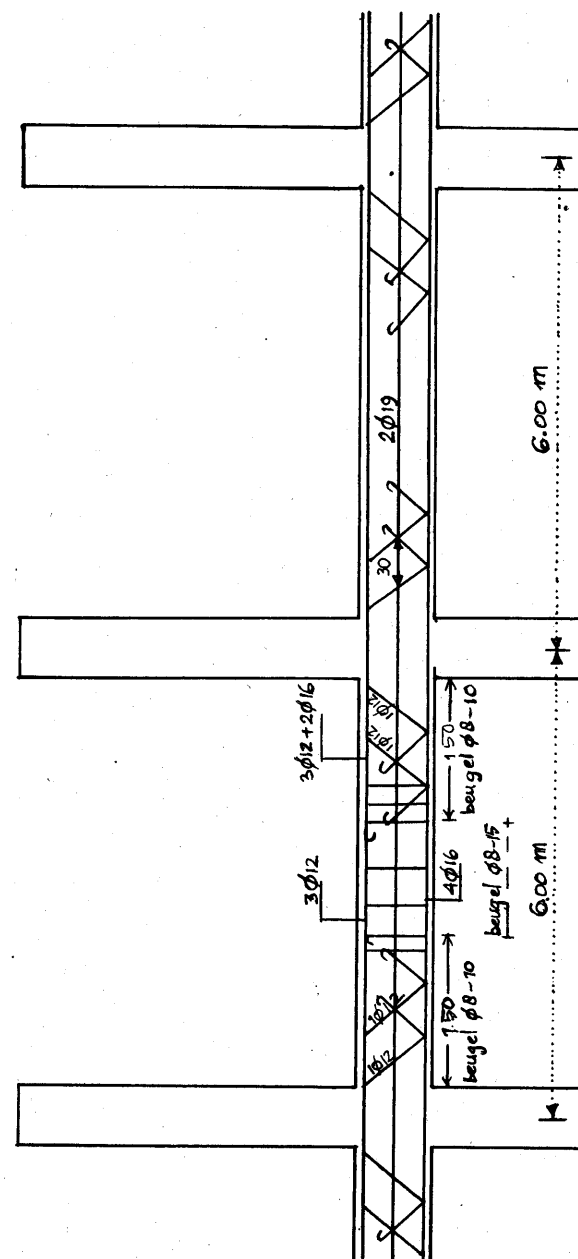
$$\text{Tulangan jepit : } 3 \emptyset 12 + 2 \emptyset 16 = 3,39 + 4,02$$

$$= 7,41 \text{ cm}^2 > 6,17 \text{ cm}^2$$

Tulangan extra : 2 ϕ 16.



PENULANGAN BALOK PUNTIR A-B



Perhitungan Kolom :

Pot I-I : $N_I = 5 \text{ ton} + \text{berat (balok + pelat)} + \text{berat kolom tertinggi } 1,0 \text{ m}$

$$M_I = M_p \times l$$

Pot II-II: $M_{II} = 5 \text{ ton} + \text{berat sendiri kolom} + \text{berat (balok + pelat)}$

$$M_{II} = M_p \times l$$

Pot I-I : lebih berbahaya dari pot II-II, karena excentrisitasnya lebih besar.

Pada pot. I-I .

$$M_I = M_p \times l = 328,5 \times 6,00 = 1971 \text{ kgm}$$

$$N = 5.000 \text{ kg} + 0,30 \times 0,40 \times 1,00 \times 2400 \\ + (\frac{1}{2} \times 726 \times 6,00) \times 2 \quad \text{tinggi luifel} = 1,00 \text{ m.} \\ = 5000 + 288 + 4356 = 9644 \text{ kg.}$$

Perhitungan tulangan kolom : 30/40.

$$M_I = 1971 \text{ kgm.}$$

$$N_I = 9644 \text{ kg.}$$

$$e_{o1} = \frac{M_I}{N_I} = \frac{1971}{9644} = 0,204 \text{ m.}$$

$$e_{o2} = \frac{1}{30} h_t = \frac{1}{30} \times 0,40 = 0,0133 \text{ m} \Rightarrow \text{minimum} = 0,02 \text{ m.}$$

$$e_o = e_{o1} + e_{o2} = 0,204 + 0,02 = 0,224 \text{ m.}$$

$$\frac{e_o}{h_t} = \frac{0,224}{0,40} = 0,56 \Rightarrow c_2 = 6,93$$

$$c_1 = 1 \text{ (penampang persegi).}$$

$$c_1 = c_1 \cdot c_2 \left(\frac{1k}{100 h_t} \right)^2 \cdot h_t = 1 \times 6,93 \times \left(\frac{4,00}{100 \times 0,40} \right)^2 \times 0,40$$

$$= 6,93 \times 0,1^2 \times 0,40 = 0,028 \text{ m.}$$

$$e_2 = 0,15 h_t = 0,15 \times 0,40 = 0,06 \text{ m.}$$

$$e = e_o + e_1 + e_2 = 0,224 + 0,028 + 0,06 = 0,312 \text{ m.}$$

$$e_a = e + \frac{1}{2} h_t - 0,05 = 0,312 + 0,20 - 0,05 = 0,462 \text{ m.}$$

$$N \times e_a = 9644 \times 0,462 = 4455,53 \text{ kgm.}$$

$$C_a = \frac{\frac{40-5}{21 \times 4455,53}}{\sqrt{\frac{0,30 \times 1400}{14,926}}} = \frac{35}{14,926} = 2,345$$

Tulangan Symetris :

$$\delta = 1 - \frac{2 h_t}{8 e_a} = 1 - \frac{2 \times 0,35}{8 \times 0,462} = 1 - \frac{2,45}{3,696} = 1 - 0,663 = 0,34 \approx 0,2$$

$$\delta = 0,2 \Rightarrow \left. \begin{aligned} C_a &= 2,345 \\ n_w &= 0,21184 \\ \phi &= 1,198 > \phi_o = 0,889 \\ \phi' &= 1,535 \\ \psi &= 0,855 \\ e_a &= 0,462 \\ \frac{e_a}{h_t} &= \frac{0,462}{0,35} = 1,32 \end{aligned} \right\} i = 2,84$$

$$iA = \frac{0,21184}{21} \times 30 \times 35 = 10,92 \text{ cm}^2.$$

$$A = \frac{10,92}{21} = 3,85 \text{ cm}^2.$$

$$A' = 5 iA = 0,2 \times 10,92 = 2,18 \text{ cm}^2 \quad A.$$

$$\text{Tulangan min kolom} = 1\% = 0,01 \times 30 \times 40 = 12 \text{ cm}^2.$$

$$A = A' = \frac{1}{2} \times 12 = 6 \text{ cm}^2.$$

$$\text{Dipakai tulangan : } 3 \phi 16 = 6,03 \text{ cm}^2 \approx 6 \text{ cm}^2.$$

Dicheck dengan grafis by Wiratman.

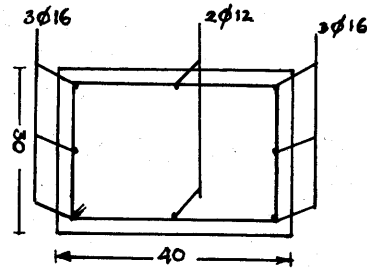
$$\left\{ \begin{aligned} \frac{e}{h_t} &= \frac{0,312}{0,40} = 0,78 \\ \sigma_o' &= \frac{N}{b \times h_t} = \frac{9644}{30 \times 40} = \frac{9644}{1200} = 8,04 \text{ kg/cm}^2 \\ \frac{\sigma_o'}{\sigma_b'} &= \frac{8,04}{75} = 0,1072 \end{aligned} \right.$$

$$n_{w \text{ tot}} = 0,08$$

$$A_{tot} = \frac{0,08}{21} \times 30 \times 40 = 4,57 \text{ cm}^2.$$

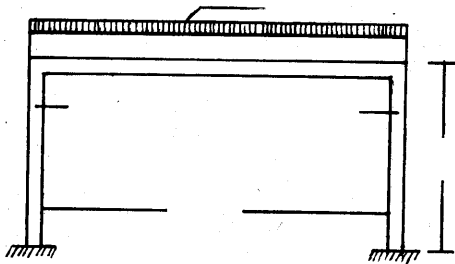
$$\frac{1}{2} A_{tot} = \frac{1}{2} \times 4,57 = 2,286 \text{ cm}^2.$$

Dipakai tulangan minimum : 3 ϕ 16



4

muatan terbagi rata 1 ton/m'



Beban : Mutu K₂₂₅

Baja : Mutu QR₂₄

Peraturan2 : PBI 1971
PBI 1970

Ditanyakan :

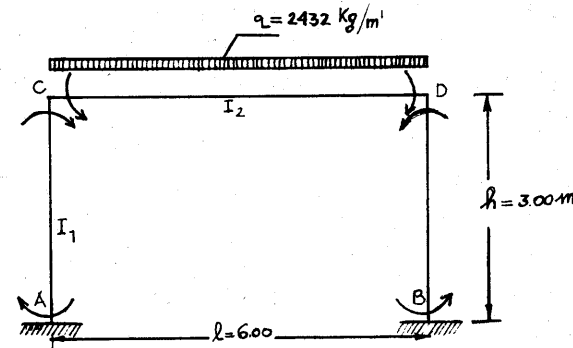
Rencanakan bentuk latei tersebut selengkapnya dan gambar penulangnya.

Muatan-muatan yang bekerja :

- 1) Muatan berguna terbagi rata = 1 ton/m' = 1000 kg/m'
- 2) Beban tembok 1 batu = 500 kg/m² = 500 x 2,00 = 1000 kg/m'
- 3) Berat sendiri balok ukuran 30/60=0,30x0,60x1,00x2400 = 432 kg/m'

$$q = 2432 \text{ kg/m'}$$

Dilihat dibuku tabel Momen dari beton Kalender :



$$M_C = M_D = \frac{q \cdot l^2}{6(k+2)} \quad M_A : M_B = \frac{q \cdot l^2}{12(k+2)}$$

$$k = \frac{I_2}{I_1} \frac{h}{l} = \frac{\frac{1}{12} \times 0,30 \times 0,60^3}{\frac{1}{12} \times 0,30 \times 0,30^3} \times \frac{3,00}{6,00} = \frac{0,216}{0,027} \times \frac{3,00}{6,00}$$

$$= \frac{0,648}{0,612} = 4.$$

$$M_C = M_D = \frac{2432 \times 6,00^2}{6(4+2)} = \frac{87.552}{36} = 2432 \text{ kgm.}$$

$$M_A = M_B = \frac{2432 \times 6,00^2}{12(k+2)} = \frac{87.552}{72} = 1216 \text{ kgm.}$$

Diselesaikan dengan cara Cross :

Momen primair

$$M_{pCD} = -M_{pDC} = \frac{1}{12} q l^2 = \frac{1}{12} \times 2432 \times 6,00^2 = 7296 \text{ kgm.}$$

Faktor Distribusi

$$\mu_{CD} : \mu_{CA} = \frac{4EI_{CD}}{l_{CD}^3} : \frac{4EI_{CA}}{l_{CA}^3} = \frac{\frac{1}{12} \times 0,30 \times 0,60^3}{6,00} : \frac{\frac{1}{12} \times 0,30 \times 0,30^3}{3,00}$$

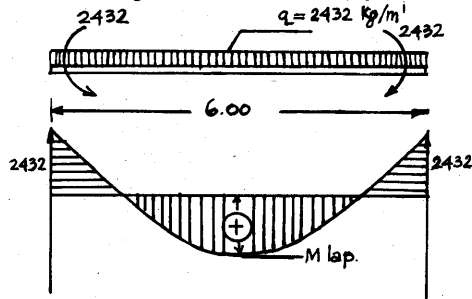
$$= \frac{0,216}{6,00} : \frac{0,027}{3,00}$$

$$= 0,036 : 0,009 = 36 : 9 = 4 \underbrace{: 1}_5$$

$$\left. \begin{array}{l} \mu_{CD} : \frac{4}{5} = 0,800 \\ \mu_{CA} : \frac{1}{5} = 0,200 \end{array} \right\} \Sigma \mu = 1,000$$

Titik	C		D		B	A
Batang	CA	CD	DC	DB	BD	AC
F.D.	0,200	0,800	0,800	0,200	-	-
M _{primair}	-	+7296	-7296	-	-	-
	+1459,2	-5836,8 +2918,4	+5836,8 -2918,4	+1459,2 +729,6		-729,6
	-583,68	-2334,72 +1167,36	+2334,72 -1167,36	+583,68 +291,84		-291,84
	-233,472	-933,888 -466,944	+933,888 -466,944	+233,47 +116,74		-116,74
	- 93,39	-373,55 +186,775	+373,55 -186,775	+ 93,39 + 46,70		- 46,70
	- 37,355	-149,42 + 74,71	+149,42 - 74,71	+ 37,355 + 18,68		- 18,68
	- 14,942	-59,768 +29,884	+59,768 -29,884	+ 14,942 + 7,471		- 7,471
	- 5,977	-23,907 +11,954	+23,907 -11,954	+ 5,977 + 2,988		- 2,988
	- 2,391	- 9,563 + 4,781	+ 9,563 - 4,781	+ 2,391 + 1,195		- 1,195
	- 0,956	- 3,825 + 1,912	+ 3,825 -1,912	+ 0,956 + 0,478		- 0,478
	- 0,382	- 1,530 + 1,530	+ 1,530 - 1,530	+ 0,382 + 0,191		- 0,191
M _{akhir}	-2431,75	+2431,75	-2431,75	+2431,75	+1215,88	-1215,88

Perhitungan Balok C-D 30/60.



$$M_{lap}(+) = \frac{1}{8} q l^2 = 2432$$

$$= \frac{1}{8} \times 2432 \times 6,00^2 = 2432$$

$$= 10.944 - 2432 = 8512 \text{ kgm.}$$

$$C_a = \frac{60-5}{\sqrt{\frac{8512 \times 21}{0,30 \times 1400}}} = \frac{55}{20,630} = 2,666$$

$$\delta = 0,4 \Rightarrow n_w = 0,1667$$

$$\phi = 1,500 > \phi_0 = 0,889$$

$$A = \frac{0,1667}{21} \times 30 \times 55 = 13,10 \text{ cm}^2$$

$$\text{Dipakai tulangan : } 5 \phi 19 = 14,20 \text{ cm}^2 > 13,10 \text{ cm}^2$$

$$A' = 0,4 A = 0,4 \times 13,10 = 5,24 \text{ cm}^2$$

$$\text{Dipakai tulangan : } 3 \phi 16 = 6,03 \text{ cm}^2 > 5,24 \text{ cm}^2$$

$$M_{tulangan} = 2432 \text{ kgm.}$$

$$C_a = \frac{60-5}{\sqrt{\frac{2432 \times 21}{0,30 \times 1400}}} = \frac{55}{11,02724} = 4,988$$

$$\delta = 0,4 \Rightarrow n_w = 0,04529$$

$$\phi = 3,000 > \phi_0 = 0,889$$

$$A = \frac{0,04529}{21} \times 30 \times 55 = 3,56 \text{ cm}^2$$

$$\text{Dipakai tulangan : } 3 \phi 16 = 6,03 \text{ cm}^2 > 3,56 \text{ cm}^2$$

$$A' = 0,4 A = 0,4 \times 3,56 = 1,424 \text{ cm}^2$$

$$\text{Dipakai : } 3 \phi 19 = 8,52 \text{ cm}^2 > 1,424 \text{ cm}^2$$

Perhitungan geser :

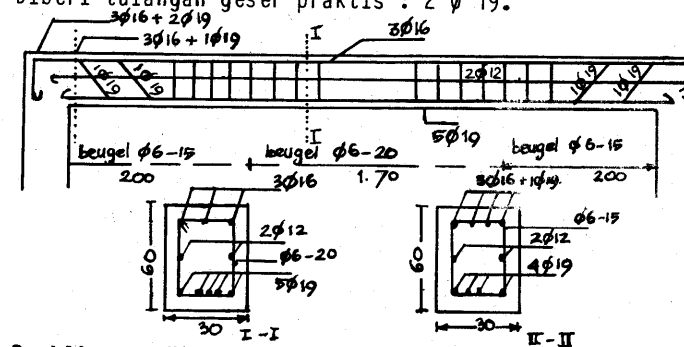
$$D_{max} = \frac{1}{2} q \cdot l_{CD} = \frac{1}{2} \times 2432 \times 6,00 = 7296 \text{ kg.}$$

$$\tau_b = \frac{D_{max}}{b \times \frac{7}{8} h} = \frac{7296}{30 \times \frac{7}{8} \times 55} = \frac{7296}{1443,75} = 5,054 \text{ kg/cm}^2$$

$$< \tau_b = 6,5 \text{ kg/cm}^2$$

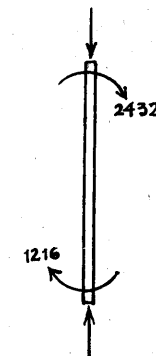
tidak diperlukan tulangan geser.

Diberi tulangan geser praktis : 2 ϕ 19.



Perhitungan Kolom-Kolom : CA dan DB.

$$N_1 = R_{CD} = \frac{1}{2} \times 2432 \times 6,00 = 7296 \text{ kg.}$$



$$N_2 = N_1 + \text{berat sendiri kolom}$$

$$= 7296 + 0,30 \times 0,30 \times 2,40 \times 2400$$

$$= 7296 + 518,4 = 7814 \text{ kg.}$$

$$N_1 = 7296 \text{ kg.}$$

$$M_1 = 2432 \text{ kgm.}$$

$$e_{o_1} = \frac{M_1}{N_1} = \frac{2432}{7296} = 0,333 \text{ m.}$$

$$e_{o_2} = \frac{1}{30} ht = \frac{1}{30} \times 0,30 = 0,010 \text{ m} \rightarrow \text{minimum} = 0,02 \text{ m.}$$

$$e_o = e_{o_1} + e_{o_2} = 0,333 + 0,02 = 0,353 \text{ m.}$$

$$\frac{e_o}{h_t} = \frac{0,353}{0,30} = 1,177 > 1 \quad \left\{ \begin{array}{l} c_2 = 7,00 \text{ (baja lunak)} \\ c_1 = 1 \text{ penampang persegi.} \end{array} \right.$$

$$e_1 = c_1 \cdot c_2 \left(\frac{1}{100} \frac{k}{ht} \right)^2 ht.$$

$$= 1 \times 7,00 \left(\frac{2,40}{100 \times 0,30} \right)^2 \times 0,30$$

$$= 7,00 (0,08)^2 \times 0,30$$

$$= 7,00 \times 0,0064 \times 0,30 = 0,0134 \text{ m.}$$

$$e_2 = 0,15 ht = 0,15 \times 0,30 = 0,045 \text{ m.}$$

$$e = e_o + e_1 + e_2 = 0,353 + 0,0134 + 0,045 = 0,4114 \text{ m.}$$

$$e_a = e + \frac{1}{2} ht - 0,05 = 0,4114 + 0,15 - 0,05 = 0,5114 \text{ m.}$$

$$N \times e_a = 7296 \times 0,5114 = 3731,2 \text{ kgm.}$$

$$Ca = \frac{30-5}{\sqrt{\frac{21 \times 3731,2}{0,30 \times 1400}}} = \frac{25}{13,6587} = 1,8303$$

$$\delta = 1 - \frac{7}{8} \frac{h}{e_a} = 1 - \frac{7}{8} \frac{0,25}{0,5114} = 1 - \frac{1,75}{4,0912} = 1 - 0,4278 = 0,572 \approx 0,6$$

$$Ca = 1,8303$$

$$\delta = 0,6 \Rightarrow \begin{array}{l} nw = 0,3421 \\ \gamma = 0,868 \\ \phi = 1,150 \\ \phi' = 1,466 \end{array}$$

Tegangan-tegangan yang terjadi :

$$\sigma_a = \bar{\sigma}_a = 1400 \text{ kg/cm}^2$$

$$\sigma_{b'} = \frac{\bar{\sigma}_a}{n\phi} = \frac{1400}{21 \times 1,150} = \frac{1400}{24,15} = 57,97 \text{ kg/cm}^2. < 75 \text{ kg/cm}^2.$$

$$\sigma_{a'} = \frac{\bar{\sigma}_a}{n\phi'} = \frac{1400}{21 \times 1,466} = \frac{1400}{30,786} = 45,5 \text{ kg/cm}^2 < 1400 \text{ kg/cm}^2.$$

Tulangan :

$$\frac{e_a}{h} = \frac{0,5114}{0,25} = 2,05 \quad \left. \begin{array}{l} \text{dari tabel didapat :} \\ \gamma = 0,868 \end{array} \right\} i = 1,70$$

$$iA = \frac{nw}{n} \times 30 \times 25$$

$$= \frac{0,3421}{21} \times 30 \times 25 = 12,22 \text{ cm}^2.$$

$$A = \frac{12,22}{1,70} = 7,19 \text{ cm}^2.$$

$$A' = 5 iA = 0,6 \times 12,22 = 7,332 \text{ cm}^2 \text{ A.}$$

$$\text{Dipakai tulangan : } 3 \phi 19 = 8,52 \text{ cm}^2 > 7,19 \text{ cm}^2 > 7,332 \text{ cm}^2.$$

Dicheck dengan grafis by Wiratman.

$$\frac{e}{ht} = \frac{0,4114}{0,30} = 1,37133$$

$$\sigma_o' = \frac{N}{b \cdot ht} = \frac{7296}{30 \times 30} = \frac{7296}{900} = 8,107 \text{ kg/cm}^2.$$

$$\frac{\sigma_o'}{\sigma_b'} = \frac{8,107}{75} = 0,108$$

$$nw_{tot} = 0,20$$

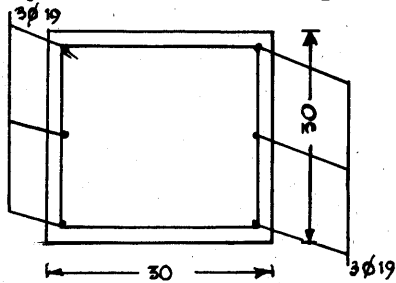
$$A_{tot} : \frac{nw_{tot}}{n} b ht = \frac{0,19}{21} \times 30 \times 30 = 8,14 \text{ cm}^2.$$

$$\frac{1}{2} A_{tot} : \frac{1}{2} \times 8,14 = 4,07 \text{ cm}^2.$$

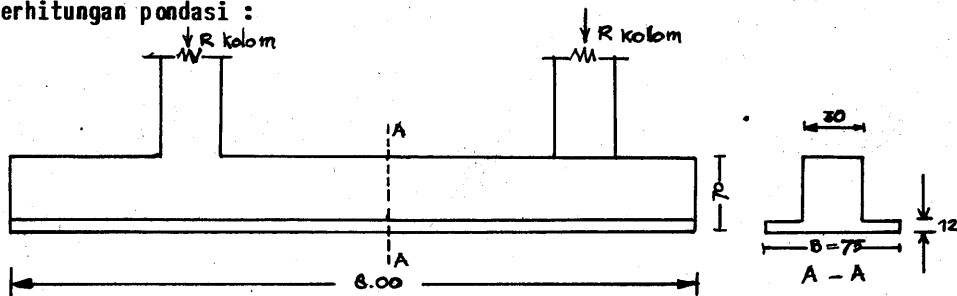
$$\text{Dipakai tulangan : } 3 \phi 19 = 8,52 \text{ cm}^2 > 4,07 \text{ cm}^2.$$

$$\text{Tulangan minimum kolom : } 1\% = 0,01 \times 30 \times 30 = 9 \text{ cm}^2.$$

$$\text{Tulangan minimum } A = A' = \frac{1}{2} \times 9 = 4,5 \text{ cm}^2.$$



Perhitungan pondasi :



$$R_{\text{kolom}} = \frac{1}{2} q l_{CD} + \text{berat sendiri kolom.}$$

$$= \frac{1}{2} \times 2432 \times 6,00 + 0,30 \times 0,30 \times 3,00 \times 2400 = 7296 + 648 = 7944 \text{ kg.}$$

$$\begin{aligned} \text{Berat sendiri pondasi} &= 0,12 \times 0,75 \times 8,00 \times 2400 + 0,30 \times 0,58 \times 8,00 \times 2400 \\ &= 1728 + 3340,8 = 5068,8 \approx 5069 \text{ kg.} \end{aligned}$$

$$\sigma_{\text{tanah}} = \frac{\sum V}{F}$$

$$\sum V = 2 \times 7944 + 5069 = 15888 + 5069 = 20957 \text{ kg.}$$

$$\sigma_{\text{tanah}} = \frac{20.957}{800 \times 75} = \frac{20.957}{60.000} = 0,3493 \text{ kg/cm}^2.$$

$$\text{harus} < \bar{\sigma}_{\text{tanah}} = 0,350 \text{ kg/cm}^2.$$

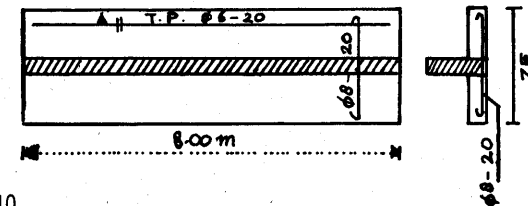
Perhitungan Pelat Pondasi :

$$M_{\text{pelat}} : \frac{1}{2} \sigma_p \left(\frac{B}{2} \right)^2 \text{ untuk pelat tiap lebar } 1 \text{ m'.$$

$$\sigma_p = \frac{20.957 - 1728}{800 \times 75} = \frac{19.229}{60.000} = 0,3205 \text{ kg/cm}^2. = 3205 \text{ kg/m}^2.$$

$$\begin{aligned} M_{\text{pelat}} &: \frac{1}{2} \times 3205 \times \left(\frac{0,75}{2} \right)^2 = \frac{1}{2} \times 3205 \times 0,375^2 \\ &= 225,4 \text{ kgm.} \end{aligned}$$

$$\begin{aligned} Ca &= \frac{12 - 1,5 - 0,4}{\sqrt{\frac{225,4 \times 21}{1,00 \times 1400}}} \\ &= \frac{10,1}{1,839} = 5,492 \end{aligned}$$



$$\delta = 0 \Rightarrow nw : 0,03610$$

$$\phi : 3,255 > \phi_0 = 0,889$$

$$A : \frac{0,03610}{21} \times 100 \times 10,1 = 1,74 \text{ cm}^2$$

$$\text{Dipakai tulangan : } \phi 8 - 20 = 2,51 \text{ cm}^2 > 1,74 \text{ cm}^2$$

$$\text{T.P. : } 20\% A : 0,02 \times 2,51 = 0,05 \text{ cm}^2.$$

$$\text{Dipakai tulangan } \phi 6 - 20 = 1,41 \text{ cm}^2 > 0,05 \text{ cm}^2.$$

Perhitungan Balok Rib : 30/70.

$$\begin{aligned} \sigma_p &= \frac{20.957 - 1728 - 3341}{800 \times 75} = \frac{15.888}{60.000} = 0,265 \text{ kg/cm}^2. \\ &= 2650 \text{ kg/m}^2. \end{aligned}$$

$$q_{\text{balok}} = 2650 \times 0,75 = 1987,5 \text{ kg/m'}$$

$$M_{\text{jepit}} = \frac{1}{2} \times q \times a^2 : \frac{1}{2} \times 1987,5 \times 1,00^2 = 993,75 \text{ kgm.}$$

$$\begin{aligned} M_{\text{lapangan (+)}} &= \frac{1}{8} q l^2 - \frac{1}{2} q a^2 \\ &= \frac{1}{8} \times 1987,5 \times 6,00^2 - \frac{1}{2} \times 1987,5 \times 1,00^2 \\ &= 8943,75 - 993,75 = 7950 \text{ kgm.} \end{aligned}$$

$$M_{\text{lapangan (+)}} = 7950 \text{ kgm.}$$

$$C_a = \frac{70-5}{\sqrt{\frac{7950 \times 21}{0,30 \times 1400}}} = \frac{65}{19,9374} = 3,2602$$

$$\delta = 0,4 \Rightarrow n_w = 0,1068$$

$$\phi = 1,899 > \phi_0 = 0,889$$

$$A = \frac{0,1068}{21} \times 30 \times 65 = 9,92 \text{ cm}^2.$$

$$\text{Dipakai tulangan : } 4 \phi 19 = 11,36 \text{ cm}^2 > 9,92 \text{ cm}^2$$

$$A' = 0,4 A = 0,4 \times 9,92 = 3,97 \text{ cm}^2.$$

$$\text{Dipakai tulangan : } 4 \phi 12 = 4,52 \text{ cm}^2 > 3,97 \text{ cm}^2$$

$$M_{\text{jepit}} = 993,75 \text{ kgm.}$$

$$C_a = \frac{70-5}{\sqrt{\frac{993,75 \times 21}{0,30 \times 1400}}} = \frac{65}{7,049} = 9,2211$$

$$\delta = 0,6 \Rightarrow n_w = 0,0127$$

$$\phi = 5,897 > \phi_0 = 0,889$$

$$A = \frac{0,0127}{21} \times 30 \times 65 = 1,180 \text{ cm}^2.$$

$$\text{Dipakai tulangan : } 4 \phi 12 = 4,52 \text{ cm}^2 > 1,180 \text{ cm}^2.$$

$$A' = 0,6 A = 0,6 \times 1,180 = 0,71 \text{ cm}^2.$$

$$\text{Dipakai tulangan : } 2 \phi 19 = 5,68 \text{ cm}^2 > 0,71 \text{ cm}^2.$$

$$\text{Perhitungan geser : } D_{b1} = q_a = 1987,5 \times 1,00 = 1987,5 \text{ kg.}$$

$$D_{\text{max}} = \frac{1}{2} \times q \times l = \frac{1}{2} \times 1987,5 \times 6,00 = 5962,5 \text{ kg.}$$

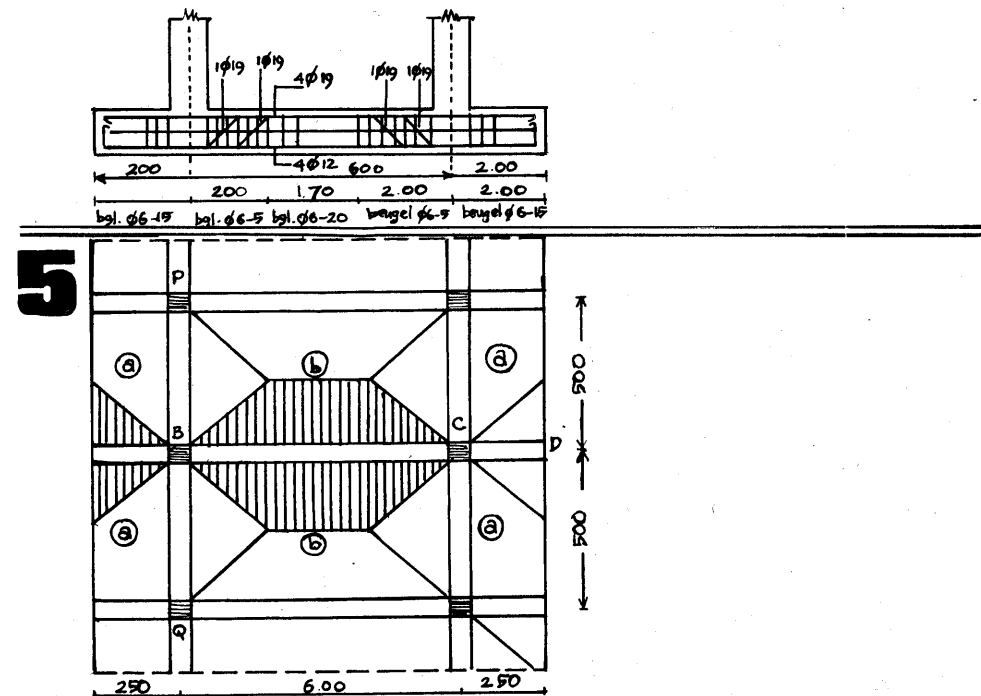
$$(\tau_{br}) = \frac{D_{\text{max}}}{b \times \frac{7}{8} h} = \frac{5962,5}{30 \times \frac{7}{8} \times 65} = \frac{5962,5}{1706,25} = 3,495 \text{ kg/cm}^2.$$

$$b = 3,495 \text{ kg/cm}^2$$

$$< \tau_b = 6,50 \text{ kg/cm}^2.$$

Tidak diperlukan tulangan geser.

Diberi tulangan geser praktis 2 ϕ 19.



Diketahui : mutu beton K_{225}

mutu baja QR_{24}

Tebal plat pondasi = 23 cm.

$P = 20 \text{ ton.}$

$\sigma_{\text{tanah}} (\sigma_{\text{ijin}}) = 0,4 \text{ kg/cm}^2.$

Rencanakan : Pondasi tersebut (pembagian tegangan pada pelat seperti tergambar diatas).

Beban-beban :

- Berat sendiri pelat pondasi (tebal = 23 cm) =
 $0,23 \times 11,00 \times 5,00 \times 2400 = 30.360 \text{ kg.}$
- Berat balok A-B-C-D (30/60) = $0,30 \times 0,60 \times 11,00 \times 2400 = 4.752 \text{ kg.}$
- Berat balok P.B.Q (30/60) = $(0,30 \times 0,60 \times 5,00 \times 2400) \times 2 = 4.320 \text{ kg.}$
- Beban $P = 2 \times 20.000 = 40.000 \text{ kg.}$

$$\Sigma V = 79.432 \text{ kg.}$$

$$\sigma_{\text{tanah}} : \frac{\Sigma V}{F} = \frac{79.432}{1100 \times 500} = \frac{79.432}{550.000} = 0,144 \text{ kg/cm}^2.$$

$$< \bar{\sigma}_{\text{tanah}} = 0,4 \text{ kg/cm}^2.$$

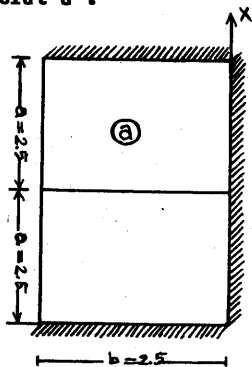
$$\sigma_{\text{tanah}} : 0,144 \text{ kg/cm}^2 = 0,144 \text{ kg} / \frac{1}{10.000} \text{ m}^2$$

$$= 1440 \text{ kg/m}^2.$$

$$q = 1440 \text{ kg/m}^2.$$

Perhitungan pelat pondasi.

Pelat a :



Untuk mencari momen-momen digunakan **Tabel Moody** : Sehingga didapat be - sarnya coefisien-coefisien momen .

$$a/b = \frac{2,5}{2,5} = 1 \quad q = 1440 \text{ kg/cm}^2.$$

Coefisien momen :

$$c_{ix} = -0,2613$$

$$c_x = +0,1008$$

$$c_{iy} = -0,2043$$

$$c_y = +0,0243$$

Momen-momen :

$$M_x \text{ tumpuan} = c_{ix} \times q \times b^2 = -0,261 \times 1440 \times 2,5^2 = -2351,7 \text{ kgm.}$$

$$M_x \text{ lapangan} = c_x \times q \times b^2 = +0,1008 \times 1440 \times 2,5^2 = +907,2 \text{ kgm.}$$

$$M_y \text{ tumpuan} = c_{iy} \times q \times b^2 = -0,2043 \times 1440 \times 2,5^2 = -1838,7 \text{ kgm.}$$

$$M_y \text{ lapangan} = c_y \times q \times b^2 = +0,0243 \times 1440 \times 2,5^2 = +218,7 \text{ kgm.}$$

$$h_t = 23 \text{ cm}$$

$$h = 23 - 2 - 0,6 = 20,4 \text{ cm.}$$

$$M_x \text{ tumpuan} = -2351,7 \text{ kgm.}$$

$$Ca = \frac{20,4}{\sqrt{\frac{2351,7 \times 21}{1,00 \times 1400}}} = \frac{20,4}{5,9393181} = 3,435$$

$$\delta = 0 \Rightarrow nw = 0,0963$$

$$\phi = 1,833 > \phi_o = \frac{1400}{21 \times 75} = \frac{1400}{1575} = 0,889$$

$$A = \frac{0,0963}{21} \times 100 \times 20,4 = 9,355 \text{ cm}^2.$$

Dipakai tulangan :

$$\phi 10-40 + \phi 22-40$$

$$= 1,96 + 9,515 = 11,465 \text{ cm}^2 > 9,355 \text{ cm}^2.$$

$$M_x \text{ lapangan} = +907,2 \text{ kgm.}$$

$$Ca = \frac{20,5}{\sqrt{\frac{907,2 \times 21}{1,00 \times 1400}}} = \frac{20,5}{3,6889} = 5,557$$

$$\delta = 0 \Rightarrow nw = 0,03540$$

$$\phi = 3,292 > \phi_o = 0,889$$

$$A = \frac{0,03540}{21} \times 100 \times 20,4 = 3,44 \text{ cm}^2.$$

$$\text{Dipakai tulangan : } \phi 10-20 = 3,93 \text{ cm}^2 > 3,44 \text{ cm}^2$$

$$M_y \text{ tumpuan} = -1838,7 \text{ kgm.}$$

$$Ca = \frac{23-2-1,0-0,5}{\sqrt{\frac{1838,7 \times 21}{1,00 \times 1400}}} = \frac{19,5}{5,252} = 3,713$$

$$\delta = 0 \Rightarrow nw = 0,08188$$

$$\phi = 2,021 > \phi_o = 0,889$$

$$A = \frac{0,08188}{21} \times 100 \times 19,5 = 7,603 \text{ cm}^2.$$

$$\text{Dipakai tulangan : } \phi 10 - 40 \left. \begin{array}{l} 1,96 + 7,09 \\ + \phi 19-40 \end{array} \right\} = 9,05 \text{ cm}^2 > 7,603 \text{ cm}^2$$

$$M_y \text{ lapangan} = + 218,7 \text{ kgm.}$$

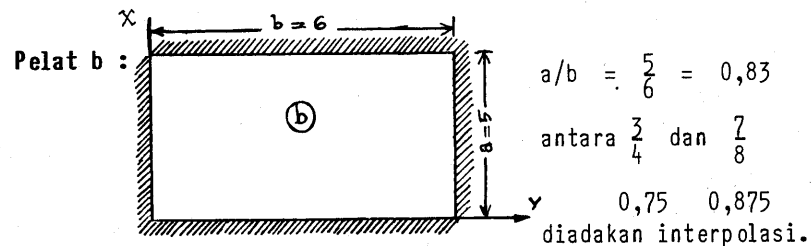
$$C_a = \frac{23 - 2 - 1,0 - 0,5}{\sqrt{\frac{218,7 \times 21}{1,00 \times 1400}}} = \frac{19,5}{1,8112} = 10,766$$

$$\delta = 0 \rightarrow n_w = 0,00908$$

$$\phi = 6,936 > \phi_o = 0,889$$

$$A = \frac{0,00908}{21} \times 100 \times 19,5 = 0,843 \text{ cm}^2.$$

$$\text{Dipakai tulangan : } \phi 10-40 = 1,96 \text{ cm}^2 > 0,843 \text{ cm}^2.$$



$$c_{ix} = -0,0686 + \frac{0,83 - 0,75}{0,875 - 0,75} (0,0686 - 0,0592) =$$

$$-0,0686 + \frac{0,08}{0,125} (0,0094) = -0,0686 + 0,006016 = -0,0626$$

$$c_x = 0,0324 - \frac{0,03}{0,125} \left(\frac{0,0324 - 0,0267}{0,0057} \right) = 0,0324 - 0,003648 = 0,0287$$

$$c_{iy} = -0,0546 + \frac{0,08}{0,125} \left(\frac{0,0546 - 0,0530}{0,0016} \right) = -0,0546 + 0,0010 = -0,0536$$

$$c_y = 0,0191 + \frac{0,08}{0,125} \left(\frac{0,0209 - 0,0191}{0,0018} \right) = 0,0191 + 0,0011 = 0,0202$$

Momen-momen :

$$M_x \text{ tumpuan} = -0,0626 \times \frac{q}{1440} \times 5,00^2 = -2253,6 \text{ kgm.}$$

$$M_x \text{ lapangan} = +0,0287 \times \frac{q}{1440} \times 5,00^2 = +1033,2 \text{ kgm.}$$

$$M_y \text{ tumpuan} = -0,0536 \times \frac{q}{1440} \times 5,00^2 = -1929,6 \text{ kgm.}$$

$$M_y \text{ lapangan} = +0,0202 \times \frac{q}{1440} \times 5,00^2 = +727,2 \text{ kgm.}$$

$$M_x \text{ tumpuan} = -2253,6 \text{ kgm.}$$

$$C_a = \frac{23 - 2 - 0,6}{\sqrt{\frac{2253,6 \times 21}{1,00 \times 1400}}} = \frac{20,4}{5,814112} = 3,5087$$

$$\delta = 0 \quad n_w = 0,0919$$

$$\phi = 1,882 > \phi_o = 0,889$$

$$A = \frac{0,0919}{21} \times 100 \times 20,4 = 8,927 \text{ cm}^2.$$

$$\text{Dipakai tulangan : } \phi 10-38 + \phi 19-38$$

$$= 2,07 + 7,46 = 9,53 \text{ cm}^2 > 8,927 \text{ cm}^2.$$

$$M_x \text{ lapangan} = +1033,2 \text{ kgm.}$$

$$C_a = \frac{23 - 2 - 0,5}{\sqrt{\frac{1033,2 \times 21}{1,00 \times 1400}}} = \frac{20,5}{3,93675} = 5,2073$$

$$\delta = 0 \quad n_w = 0,04051$$

$$\phi = 3,048 > \phi_o = 0,889$$

$$A = \frac{0,04051}{21} \times 100 \times 20,5 = 3,955 \text{ cm}^2.$$

$$\text{Dipakai tulangan : } \phi 10-19 = 4,14 \text{ cm}^2 > 3,955 \text{ cm}^2.$$

$$M_y \text{ tumpuan} = -1929,6 \text{ kgm.}$$

$$C_a = \frac{23 - 2 - 1,0 - 0,5}{\sqrt{\frac{1929,6 \times 21}{1,00 \times 1400}}} = \frac{19,5}{5,37996} = 3,625$$

$$\delta = 0 \quad n_w = 0,08629$$

$$\phi = 1,958 > \phi_o = 0,889$$

$$A = \frac{0,08629}{21} \times 100 \times 19,5 = 8,013 \text{ cm}^2.$$

$$\text{Dipakai tulangan : } \phi 10-40 + \phi 19-40$$

$$= 1,96 + 7,09 = 9,05 \text{ cm}^2 \quad 8,013 \text{ cm}^2$$

$$M_y \text{ lapangan} = +727,2 \text{ kgm}$$

$$Ca = \frac{23 - 2 - 1 - 0,5}{\sqrt{\frac{727,2 \times 21}{1,00 \times 1400}}} = \frac{19,5}{3,3030} = 5,904$$

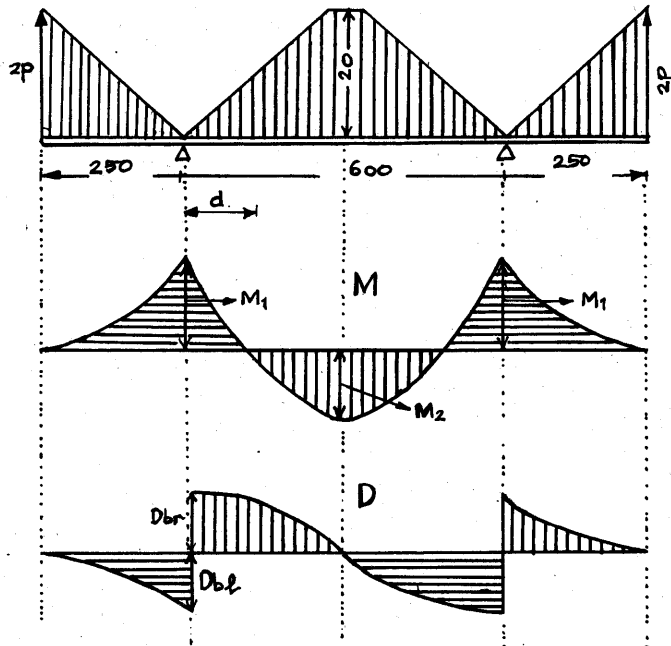
$$\delta = 0 \quad nw = 0,03103$$

$$\phi = 3,545 > \phi_0 = 0,889$$

$$A = \frac{0,03103}{21} \times 100 \times 19,5 = 2,88 \text{ cm}^2.$$

$$\text{Dipakai tulangan : } \phi 10-20 = 3,93 \text{ cm}^2 > 2,88 \text{ cm}^2$$

Perhitungan Balok A-B-C-D : 30/60. (DITAKSIR).



Beban-beban :

$$\sigma_{\text{tanah}} = \frac{79.432 - 30.360 - 4752}{1100 \times 500} = \frac{44.320}{550.000} = 0,0806 \text{ kg/cm}^2.$$

$$q = 806 \text{ kg/m}^2.$$

$$P = \frac{1}{2} q \cdot l = \frac{1}{2} \times 806 \times 5,00 = 2015 \text{ kg/m'}$$

$$M_1 = \frac{1}{2} \times 2,5 \times 2p \left(\frac{2}{3} \times 2,50 \right) = \frac{2}{3} \times 2,50^2 \times P$$

$$= \frac{2}{3} \times 6,25 \times 2015$$

$$= 8395,83 \text{ kgm.}$$

$$M_2 = \left(\frac{1}{8} 2P \cdot l^2 - \frac{1}{6} 2P d^2 \right) - M_1$$

$$= \left(\frac{1}{8} \times 2 \times 2015 \times 6,00^2 - \frac{1}{6} \times 2 \times 2015 \times 2,50^2 \right) - 8395,83$$

$$= (18.135 - 4197,92) - 8395,83$$

$$= 5541,25 \text{ kgm.}$$

$$D_{B1} = \frac{1}{2} \times 2,50 \times 2P = 2,50 \times P = 2,5 \times 2015 = 5037,5 \text{ kg.}$$

$$D_{Br} = \frac{1}{2} (6+1) \frac{2P}{2} = \frac{1}{2} (6+1) P = \frac{1}{2} 7P = 3,5 P = 3,5 \times 2015 = 7052,5 \text{ kg.}$$

$$M_1 = -8395,83 \text{ kgm (M jepit)}$$

$$Ca = \frac{60-5}{\sqrt{\frac{8395,83 \times 21}{0,30 \times 1400}}} = \frac{55}{20,4888} = 2,6844$$

$$\delta = 0,2$$

$$nw = 0,1602$$

$$\phi = 1,532 > \phi_0 = 0,889$$

$$A = \frac{0,1602}{21} \times 30 \times 55 = 12,587 \text{ cm}^2.$$

$$\text{Dipakai tulangan : } 5 \phi 19 = 14,20 \text{ cm}^2 > 12,587 \text{ cm}^2$$

$$A' = 0,4 A = 0,4 \times 12,587 = 5,035 \text{ cm}^2.$$

$$\text{Dipakai tulangan } 3 \phi 19 = 8,52 \text{ cm}^2 > 5,035 \text{ cm}^2$$

$$M \text{ lapangan } (M_2) = +5541,25 \text{ kgm.}$$

$$Ca = \frac{60-5}{\sqrt{\frac{5541,25 \times 21}{0,30 \times 1400}}} = \frac{55}{16,6425} = 3,3043$$

$$\delta = 0,4$$

$$nw = 0,1068$$

$$\phi = 1,899 > \phi_0 = 0,889$$

$$A = \frac{0,1068}{21} \times 30 \times 55 = 8,392 \text{ cm}^2$$

$$\text{Dipakai tulangan : } 3 \emptyset 19 = 8,52 \text{ cm}^2 > 8,392 \text{ cm}^2$$

$$A' = 0,4 A = 0,4 \times 8,392 = 3,3576 \text{ cm}^2$$

$$\text{Dipakai tulangan : } 2 \emptyset 19 = 5,68 \text{ cm}^2 > 3,357 \text{ cm}^2$$

Perhitungan geser :

$$D_{\max} = D_{br} = 7052,5 \text{ kg.}$$

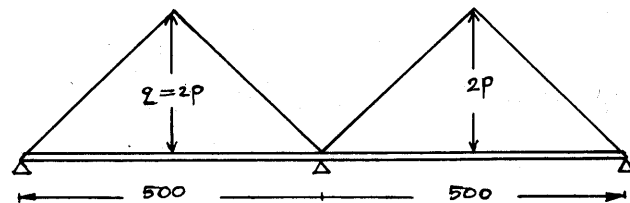
$$\tau_b = \frac{D_{\max}}{b \times \frac{7}{8} h} = \frac{7052,5}{30 \times \frac{7}{8} \times 55} = \frac{7052,5}{1443,75} = 4,885 \text{ kg/cm}^2$$

$$\tau_b = 4,885 \text{ kg/cm}^2 < \tau_b = 6,5 \text{ kg/cm}^2 \Rightarrow K_{225}$$

Tidak diperlukan tulangan geser.

Diberi tulangan geser praktis : $2 \emptyset 19$.

Perhitungan Balok P-B-Q : 30/60.



$$P : \frac{1}{2} q \times l_x = \frac{1}{2} \times q \times 5,00$$

$$\sigma_{\text{tanah}} : \frac{40000}{1100 \times 500} = \frac{40.000}{550.000} = 0,0727 \text{ kg/cm}^2$$

$$q = 727 \text{ kg/m}^2$$

$$P : \frac{1}{2} q \cdot l = \frac{1}{2} \times 727 \times 5,00 = 1817,5 \text{ kg/m}^2$$

$$M_{\max (+)} = \frac{1}{32} q \cdot l^2 = \frac{1}{32} \times 2P \times 5,00^2$$

$$\frac{1}{32} \times 2 \times 1817,5 \times 5,00^2 = +2839,84 \text{ kgm.}$$

$$M_{\text{jepit (-)}} = -\frac{5}{96} q l^2 = -\frac{5}{96} \times 2 \times 1817,5 \times 5,00^2 = -4733,1 \text{ kgm}$$

$$D_{\max} = \frac{1}{4} q \cdot l = \frac{1}{4} \times 2P \times 5,00 = \frac{1}{4} \times 2 \times 1817,5 \times 5,00 = 4543,75 \text{ kg.}$$

$$M_{\max (+)} = +2839,84 \text{ kgm.}$$

$$C_a = \frac{60-5}{\sqrt{\frac{2839,84 \times 21}{0,30 \times 1400}}} = \frac{55}{11,916} = 4,616$$

$$\delta = 0,4 \quad n_w = 0,05248$$

$$\phi = 2,774 > \phi_0 = 0,889$$

$$A = \frac{0,05248}{21} \times 30 \times 55 = 4,123 \text{ cm}^2$$

$$\text{Dipakai tulangan : } 3 \emptyset 16 = 6,03 \text{ cm}^2 > 4,123 \text{ cm}^2$$

$$A' = 0,4 A = 0,4 \times 4,123 = 1,650 \text{ cm}^2$$

$$\text{Dipakai tulangan : } 2 \emptyset 16 = 4,02 \text{ cm}^2 > 1,650 \text{ cm}^2$$

$$M_{\text{jepit (-)}} = -4733,1 \text{ kgm.}$$

$$C_a = \frac{60-5}{\sqrt{\frac{4733,1 \times 21}{0,30 \times 1400}}} = \frac{55}{15,3836} = 3,5753$$

$$\delta = 0,4 \quad n_w = 0,09028$$

$$\phi = 2,077 > \phi_0 = 0,889$$

$$A = \frac{0,09028}{21} \times 30 \times 55 = 7,093 \text{ cm}^2$$

$$\text{Dipakai tulangan : } 4 \emptyset 16 = 8,04 \text{ cm}^2 > 7,093 \text{ cm}^2$$

$$A' = 0,4 A = 0,4 \times 7,093 = 2,84 \text{ cm}^2$$

$$\text{Dipakai tulangan : } 3 \emptyset 16 = 6,03 \text{ cm}^2 > 2,84 \text{ cm}^2$$

Perhitungan Geser :

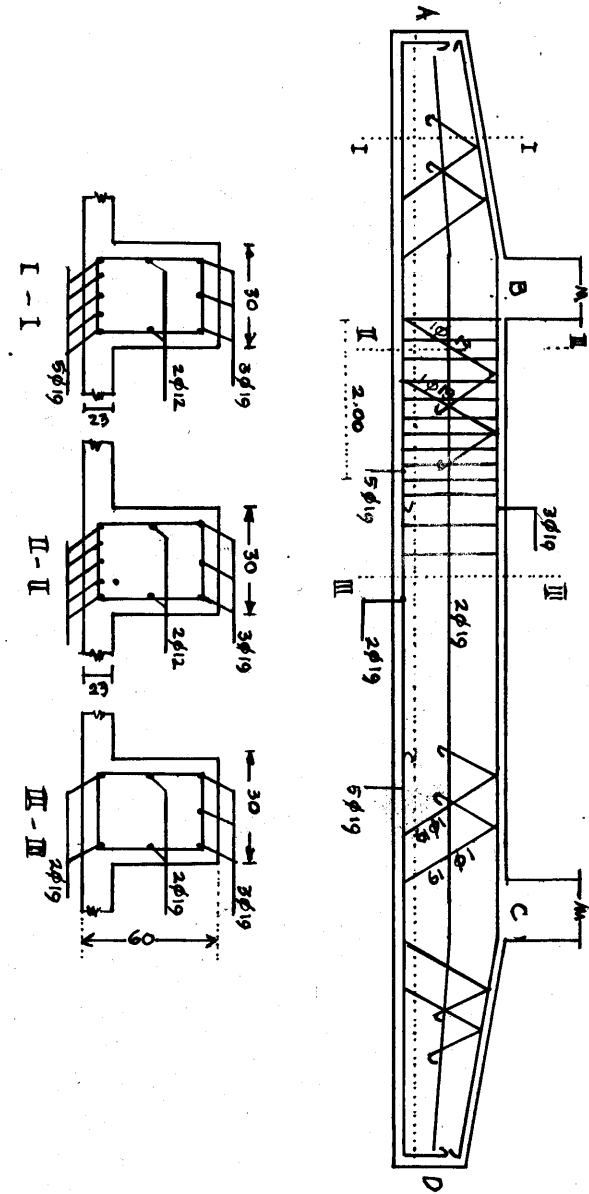
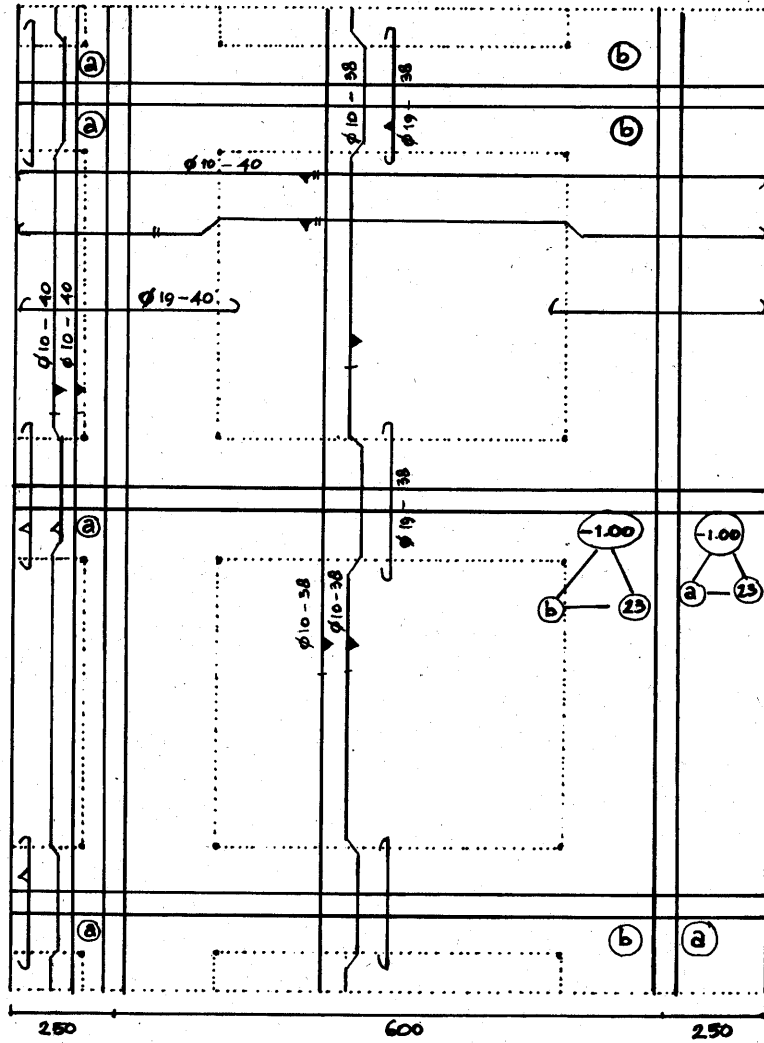
$$D_{\max} = 4543,75 \text{ kg.}$$

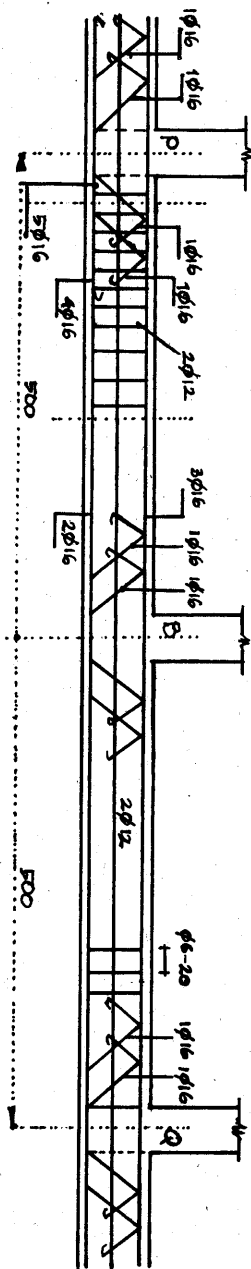
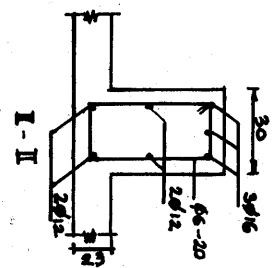
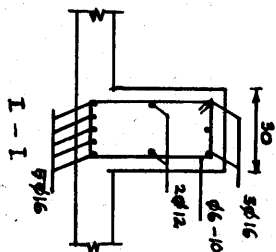
$$\tau_b = \frac{D_{\max}}{6 \times \frac{7}{8} h} = \frac{4043,75}{30 \times \frac{7}{8} \times 55} = \frac{4543,75}{1443,75} = 3,15 \text{ kg/cm}^2$$

$$\tau_b = 3,15 \text{ kg/cm}^2 < \tau_b = 6,5 \text{ kg/cm}^2$$

Tidak diperlukan tulangan geser.

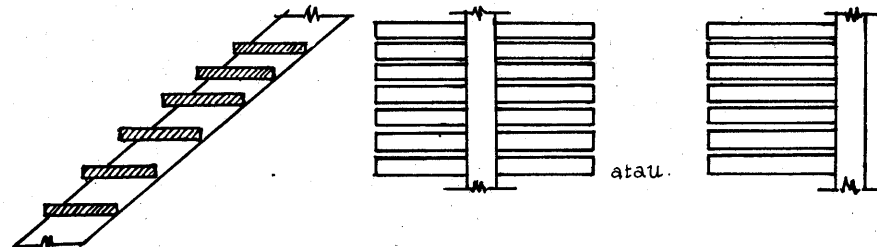
Diberi tulangan geser praktis : $2 \emptyset 16$.





Rencanakan & hitunglah tangga yang terletak disudut sebuah gedung. Lubang tangga ukuran 2,50 x 2,50 tinggi lantai atas + 4.00. Beban hidup direncanakan 200 kg/m². Bentuk tangga yang diminta :

1. balok boleh ditengah
2. balok boleh dipinggir (overstek)



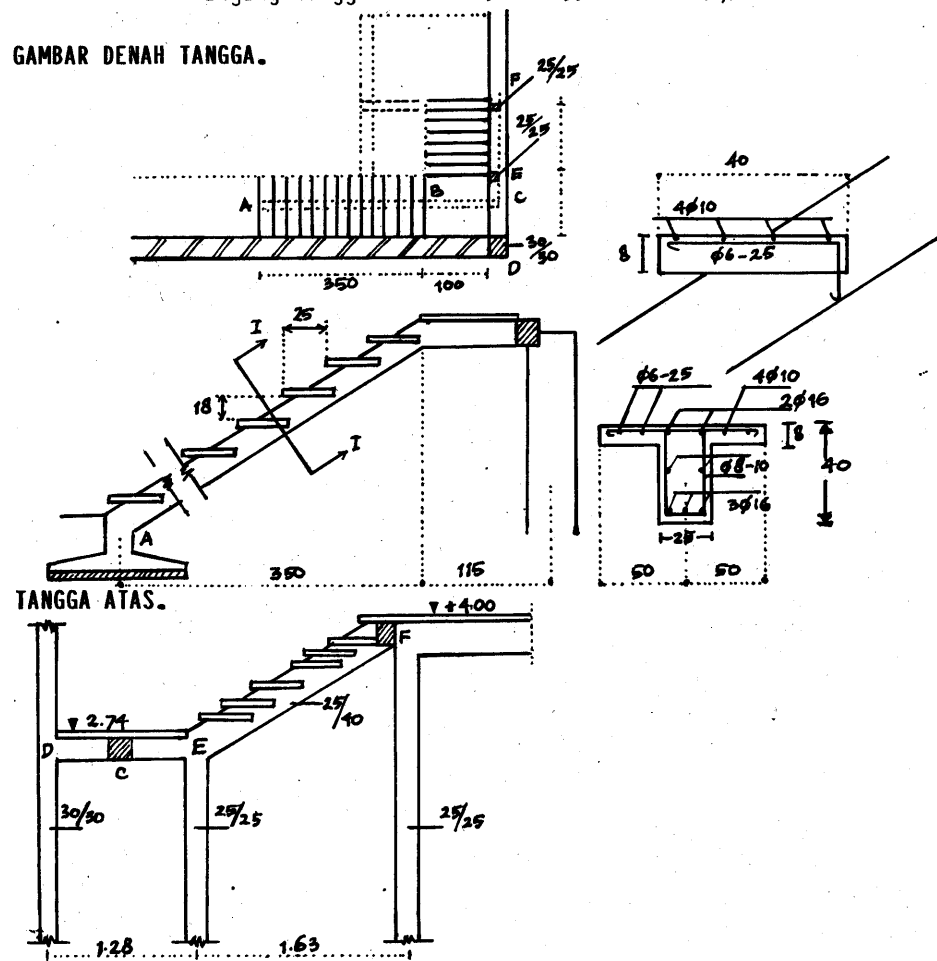
Hitunglah pondasi tangga tersebut ($\tau_{\text{tanah}} = 0,3 \text{ kg/cm}^2$)

Penyelesaian :

Ketentuan : Langkah datar : 25 cm
 Langkah naik : 18 cm
 Lebat tangga : 100 cm

Tangga atas : Peil lantai II : + 4,0
 Banyak langkah datar : $\frac{150}{25} = 6$
 Banyak langkah naik : $6 + 1 = 7$
 Peil bordes : $4,00 - 7 \times 0,18 = + 2,74$
 Tangga bawah: Banyak langkah naik : $15 \Rightarrow 14 \times 0,18 + 1 \times 0,22 = +2,74$
 Peil bordes = + 2,74
 Banyak langkah dasar, $15 - 1 = 14$
 Panjang tangga : $14 \times 25 = 350 \text{ cm} = 3,50 \text{ m}$.

GAMBAR DENAH TANGGA.



TANGGA ATAS.

1. Anak tangga bawah (40 x 100).

tebal : 8 cm.

- berat sendiri : $0,08 \times 2400 = 192 \text{ kg/m}^2$.
- beban hidup : $= 200 \text{ kg/m}^2$.
- tegel + spesi : $= 115 \text{ kg/m}^2$.

$$q = 507 \text{ kg/m}^2$$

$$M = \frac{1}{2} \times 507 \times 0,375^2 = 36 \text{ kgm.}$$

$$C_a = \frac{6}{\sqrt{\frac{24 \times 36}{1 \times 1400}}} = 7,638 \quad \left. \begin{array}{l} \delta = 0 \\ \phi = 4,747 > \phi_0 \\ n_w = 0,01833 \\ A = \frac{0,01833}{24} \times 100 \times 6 \\ = 0,46 \text{ cm}^2 \end{array} \right\}$$

$$A_{\min} 0,25\% \times 100 \times 8 = 2,0 \text{ cm}^2.$$

$$\text{Untuk lebar } 40 \text{ cm} \Rightarrow A = 0,40 \times 2 = 0,80 \text{ cm}^2.$$

$$\Rightarrow 4 \phi 10 = 3,14 \text{ cm}^2.$$

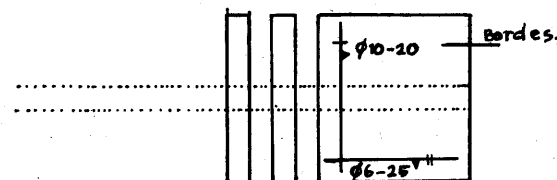
$$\text{T.B. } \phi 6 - 25 = 1,13 \text{ cm}^2.$$

Stek untuk angker $3 \phi 10$.

2. Bordes (1,00 x 1,00).

$$A = 2,0 \text{ cm}^2 \Rightarrow \phi 10 - 20 = 3,93 \text{ cm}^2.$$

$$\text{T.B. } \phi 6 - 25 = 1,13 \text{ cm}^2.$$



3. Tangga Bawah.

$$\cos \alpha = 0,754$$

A.B. :

$$- b.s = 0,25 \times 0,40 \times 2400 \times \frac{1}{0,754} = 318 \text{ kg/m'}$$

$$- \text{beban anak tangga} : 1,0 \times 507 = 507 \text{ kg/m'}$$

$$q_1 = 825 \text{ kg/m'}$$

B.C. :

$$- b.s = 0,25 \times 0,40 \times 2400 = 240 \text{ kg/m'}$$

$$- \text{beban anak tangga} = 507 \text{ kg/m'}$$

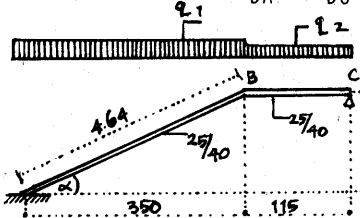
$$q_2 = 747 \text{ kg/m'}$$

$$K_{BA} : K_{BC} = \frac{4EI}{4,64} : \frac{4EI}{1,15} = 1,15 : 4,64$$

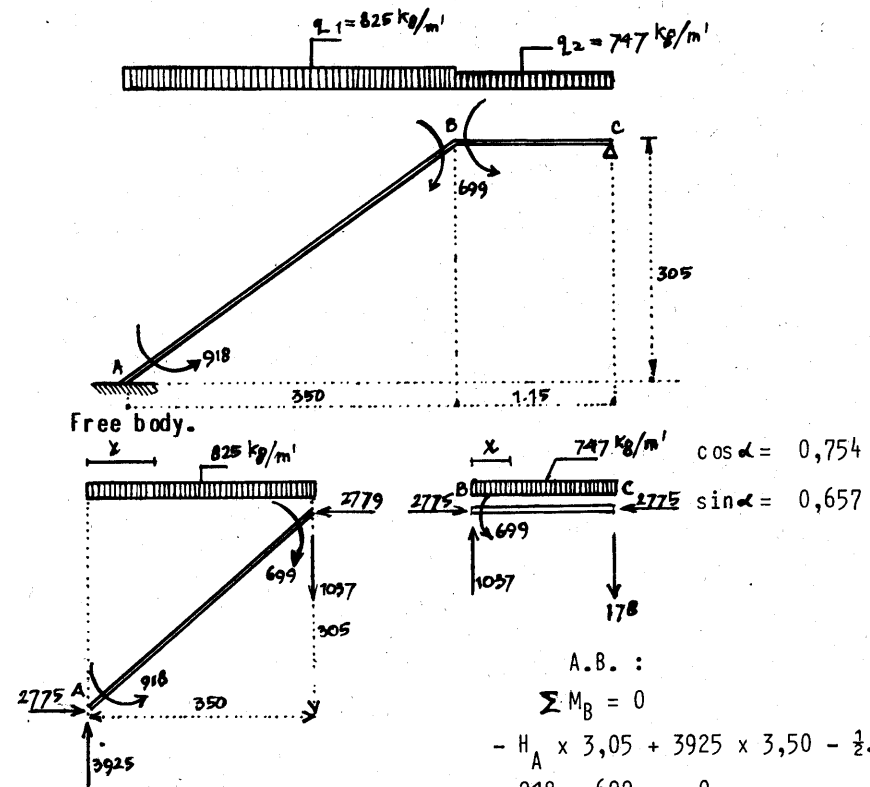
$$\mu_{BA} = 0,199 ; \mu_{BC} = 0,801$$

$$M_{AB} = -M_{BA} = \frac{1}{12} \times 825 \times 3,50^2 = 842 \text{ kgm.}$$

$$M_{BC} = -M_{CB} = \frac{1}{12} \times 747 \times 1,15^2 = 82 \text{ kgm.}$$



A	B		C
AB	BA	BC	CB
-	0,199	0,801	-
842	- 842	82	- 82
-	+ 151	+ 609	+ 82
+ 76	- 8	- 33	
+ 918	- 699	+ 699	-



A.B. :

$$\sum M_B = 0$$

$$- H_A \times 3,05 + 3925 \times 3,50 - \frac{1}{2} \cdot 825 \times 3,50^2$$

$$- 918 + 699 = 0$$

$$H_A = 2775 \text{ kg. } (\rightarrow)$$

$$\text{Check } \sum V = 0 ; 3925 - 178 - 825 \times 3,50 - 747 \times 1,15 = 0,45 \approx 0 \text{ kg.}$$

Bagian A.B.

$$M_x = 3925 \times -2775 \cdot \frac{3,05 \cdot x}{350} - \frac{1}{2} \cdot 825 \cdot x^2 - 918$$

$$= 1506,79 \times -\frac{1}{2} \cdot 825 \cdot x^2 - 918$$

$$\frac{dM_x}{dx} = 0 : 1506,79 - 825 \cdot x = 0 \Rightarrow x = 1,83 \text{ m.}$$

$$M_{\max} = 1506,79(1,83) - \frac{1}{2} \cdot 825 \cdot (1,83)^2 - 918 = 458 \text{ kgm.}$$

Bagian B-C.

$$M_x = 1037 \cdot x - \frac{1}{2} \cdot 747 \cdot x^2 - 699$$

$$\frac{dM_x}{dx} = 0 : 1037 - 747 x = 0 \Rightarrow x = 1,39 \text{ m.} \quad (t'm)$$

BATANG A-B.

$$\begin{aligned} M_A &= -918 \text{ kgm} ; N_A = 2775 \cos \alpha + 3925 \sin \alpha \\ &= 2775 (0,754) + 3925 (0,657) \\ &= 4671 \text{ kg. (tekan).} \end{aligned}$$

$$\begin{aligned} D_A &= -2775 \times 0,657 + 3925 \times 0,754 \\ &= 1136 \text{ kg.} \end{aligned}$$

Ditumpuan :

$$M_A = 918 \text{ kgm} ; N_A = 4671 \text{ kg (tekan)}$$

$$\begin{aligned} e_o &= \frac{M}{N} = \frac{918}{4671} = 0,20 \text{ m.} \\ e_o' &= \frac{1}{30} \times 0,40 = 0,01 \sim 0,02 \\ e_o &= \frac{0,22}{0,40} = 0,55 \Rightarrow c_1 = 1 \\ & \quad c_2 = 6,93 \end{aligned} \quad \left. \begin{array}{l} \\ \\ \end{array} \right\} e_o = 0,22 \text{ m}$$

$$e_1 = 1 \times 6,93 \times \left(\frac{4,64}{100 \times 0,40} \right)^2 \times 0,40 = 0,04 \text{ m.}$$

$$e_2 = 0,15 \times 0,40 = 0,06 \text{ m.}$$

$$e_{tot} = 0,22 + 0,04 + 0,06 = 0,32 \text{ m.}$$

$$e_a = 0,32 + \frac{0,40}{2} - 0,05 = 0,47 \text{ m.}$$

$$N \cdot e_a = 4671 \times 0,47 = 2195 \text{ kgm}$$

$$i = \frac{1}{1 - \frac{h}{e_a}} = \frac{1}{1 - 0,87 \times \frac{0,35}{0,47}} = 2,85$$

$$Ca = \frac{35}{24 \times 2195} = 2,853 \quad \left. \begin{array}{l} \\ \end{array} \right\} \phi = 1,532 > \phi_o = 0,871$$

$$nw = 0,1429$$

$$iA = \frac{0,1429}{24} \times 25 \times 35 = 5,21 \text{ cm}^2.$$

$$A = 1,83 \text{ cm}^2.$$

$$A_{min} = \frac{12}{2080} \times 25 \times 35 = 5,05 \text{ cm}^2 \Rightarrow 3 \phi 16 = 6,03 \text{ cm}^2.$$

$$A' = 0,2 \times 5,21 = 1,04 \text{ cm}^2 \Rightarrow 2 \phi 16 = 4,02 \text{ cm}^2.$$

$$Q_A = 1136 \text{ kg} \Rightarrow \tau_b = \frac{8}{7} \times \frac{1136}{25 \times 35} = 1,48 \text{ kg/cm}^2$$

$$< \tau_{bt} (= 5,5 \text{ kg/cm}^2)$$

$$\text{Sengkang : } \phi 8 - 10$$

Di lapangan :

$$M_{max} = 458 \text{ kgm} ; N = 4671 \text{ kg.} \Rightarrow 3 \phi 16 = 6,03 \text{ cm}^2.$$

Batang B.C. :

$$M_B = 699 \text{ kgm} ; N = 2775 \text{ kg.}$$

$$\begin{aligned} e_o &= \frac{699}{2775} = 0,25 \text{ m.} \\ e_o' &= 0,02 \text{ m} \end{aligned} \quad \left. \begin{array}{l} \\ \end{array} \right\} e_o = 0,27 \text{ m.}$$

$$\frac{e_o}{h_t} = \frac{0,27}{0,40} = 0,68 \quad c_1 = 1 ; c_2 = 6,96$$

$$e_1 = 1 \times 6,96 \times \left(\frac{1,15}{100 \times 0,40} \right)^2 \times 0,40 = 0,02 \text{ m}$$

$$e_2 = 0,06 \text{ m.}$$

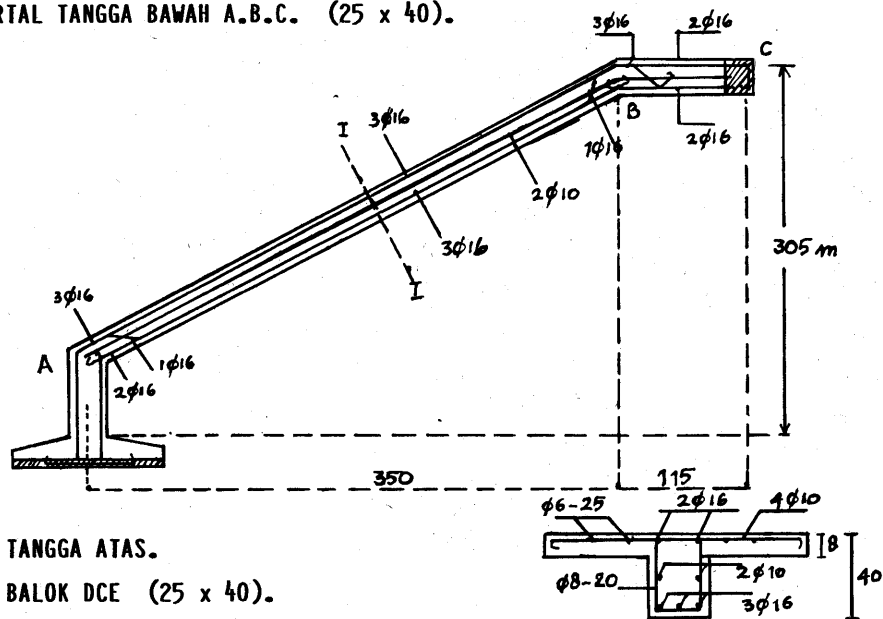
$$e_{tot} = 0,27 + 0,002 + 0,06 = 0,33 \text{ m.}$$

$$e_a = 0,33 + \frac{0,40}{2} - 0,05 = 0,48 \text{ m.}$$

$$N \cdot e_a = 699 \times 0,48 = 335 \text{ kgm.} \Rightarrow 3 \phi 16 = 6,03 \text{ cm}^2.$$

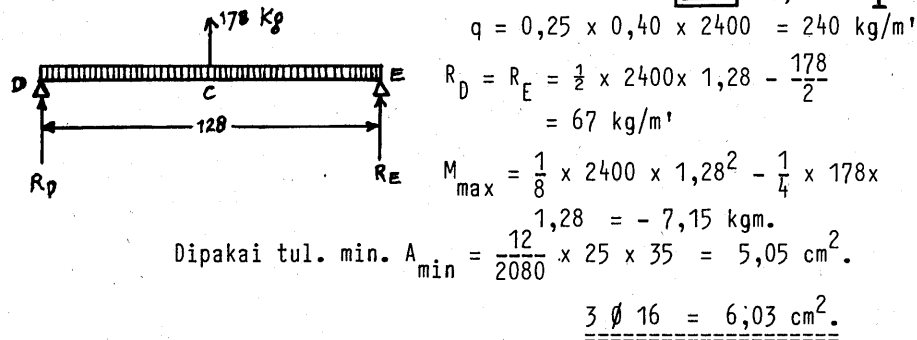
$$Q_o = 178 \text{ kg.} \Rightarrow \text{Sengkang } \phi 8 - 10$$

PORTAL TANGGA BAWAH A.B.C. (25 x 40).



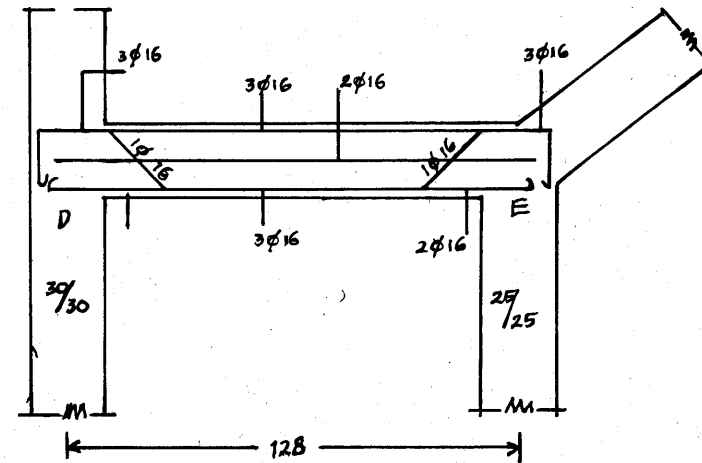
4. TANGGA ATAS.

BALOK DCE (25 x 40).



Untuk menghindari lenturan berubah arah, maka seluruh penampang atas dan bawah diberi tulangan 3 $\phi 16$.

Untuk tul. geser lentur dipakai sengkang $\phi 8 - 10$.



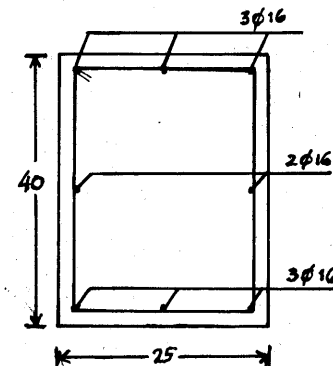
Untuk gaya horizontal $H = 2775 \text{ kg}$, diperhitungkan sbb :

$$M = \frac{1}{2} \times 2775 \times 1,28 = 902 \text{ kgm.}$$

$$C_a = \frac{20}{\sqrt{\frac{24 \times 902}{0,20 \times 1400}}} = 3,217 \quad \left. \begin{array}{l} \phi = 2,125 > \phi_0 \\ nw = 0,03 \end{array} \right\}$$

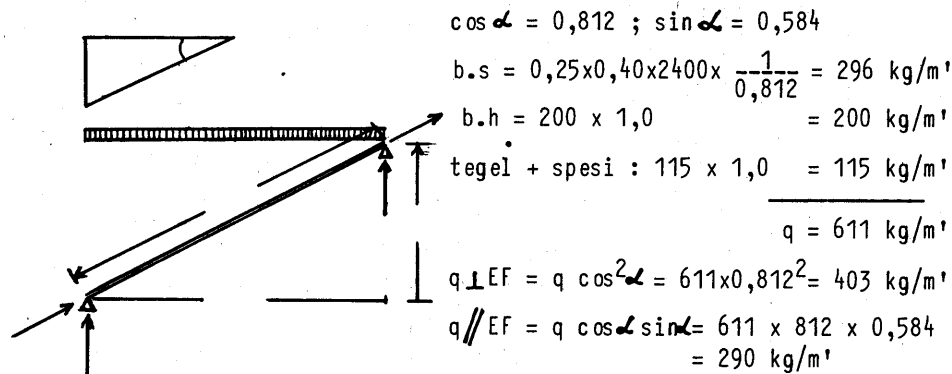
$$A = A' = \frac{0,03}{24} \times 40 \times 20 = 3,71 \text{ cm}^2$$

$$A_{\min} = \frac{12}{2080} \times 40 \times 20 = 4,62 \text{ cm}^2 \Rightarrow 3 \phi 16 = 6,03 \text{ cm}^2$$



BALOK EF (25 x 40).

NOTE : PERHITUNGAN ANAK TANGGA OVERSTEK L = 1,0



$$V_E = V_F = \frac{1}{2} \times 611 \times 1,63 = 498 \text{ kg} (\uparrow)$$

$$N = \frac{1}{2} \times 290 \times 2,01 = 291 \text{ kg.}$$

$$M_{\text{lap}} = \frac{1}{8} \times 403 \times 2,01^2 = 204 \text{ kgm.}$$

$$N = 291 \text{ kg (tekan)}$$

$$e_o = \frac{204}{291} = 0,70 \text{ m} \quad \left. \begin{array}{l} \\ \\ \end{array} \right\} e_o = 0,72 \text{ m.}$$

$$e_o' = \frac{1}{30} \times 0,40 = 0,01 \text{ m} \quad \hookrightarrow 0,02 \text{ m}$$

$$\frac{e_o}{h_t} = \frac{0,72}{0,40} = 1,8 \quad c_1 = 1 ; c_2 = 7$$

$$e_1 = 1 \times 7 \times \left(\frac{2,01}{100 \times 0,4} \right)^2 \times 0,40 = 0,007 \approx 0,01 \text{ m.}$$

$$e_2 = 0,15 \times 0,40 = 0,06 \text{ m.}$$

$$e_{\text{tot}} = 0,72 + 0,01 + 0,06 = 0,79 \text{ m.}$$

$$e_a = 0,79 + \frac{0,40}{2} - 0,05 = 0,94 \text{ m.}$$

$$M = 291 \times 0,94 = 274 \text{ kgm.}$$

$$Ca = \frac{35}{\sqrt{\frac{24 \times 274}{0,25 \times 1400}}} = 8,075 \quad \left. \begin{array}{l} \phi = 5,250 > \phi_o ; \gamma = 0,946 ; \\ \delta = 0,2 \end{array} \right\} 1 = \frac{1}{1 - 0,946 \times \frac{0,35}{0,94}} = 1,54$$

$$n = 0,01546 \rightarrow iA = \frac{0,01546}{24} \times 25 \times 35$$

$$iA = 0,56 \text{ cm}^2$$

$$A = 0,36 \text{ cm}^2$$

$$A_{\text{min}} = \frac{12}{2080} \times 25 \times 35 = 5,05 \text{ cm}^2 \rightarrow 3 \phi 16 = 6,03 \text{ cm}^2$$

$$A' = 0,2 \times 5,05 = 1,01 \text{ cm}^2 \rightarrow 2 \phi 16 = 4,02 \text{ cm}^2$$

$$M_{\text{tump.}} = \frac{1}{3} \times 204 = 68 \text{ kgm} ; N = 291 \text{ kg (tekan)}$$

$$\text{tul. min} \quad A = 5,05 \text{ cm}^2 \rightarrow 3 \phi 16 = 6,03 \text{ cm}^2.$$

$$Q_{\text{tump.}} = \frac{1}{2} \times 403 \times 2,01 = 405 \text{ kg.}$$

$$\tau_b = \frac{8}{7} \times \frac{2,6}{25 \times 35} = 0,53 \text{ kg/cm}^2.$$

$$M_{\text{puntir}} = \left(\frac{1}{2} \times 611 \times 1,0 \right) \times \frac{2,01}{2} = 307 \text{ kgm.}$$

$$\gamma = 3 + \frac{26}{0,45 + \frac{25}{25}} = 4,27$$

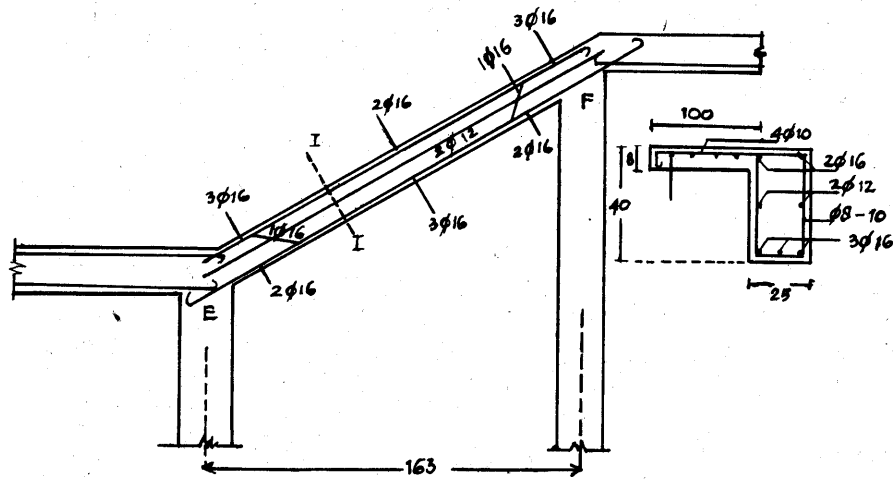
$$\tau_{b'} = 4,27 \times \frac{30700}{25^2 \times 40} = 5,24 \text{ kg/cm}^2.$$

$$\tau_b + \tau_{b'} = 0,53 + 5,24 = 5,77 \text{ kg/cm}^2 < \tau_{bt} (= 7 \text{ kg/cm}^2)$$

Dipakai tul.geser lentur puntir praktis \rightarrow sengkang $\phi 8-10$.

$$\text{Tul. memanjang A} = \frac{30700 (20 + 35)}{1400 \times 20 \times 35} = 1,72 \text{ cm}^2.$$

$$\rightarrow 2 \phi 12 = 2,26 \text{ cm}^2.$$



ANAK TANGGA ATAS (40 x 100).

$$M = \frac{1}{2} \times 611 \times 1,0^2 = 306 \text{ kgm.}$$

$$C_a = \frac{6}{\sqrt{\frac{24 \times 306}{1 \times 1400}}} = 2,620 \quad \left. \begin{array}{l} \phi = 1,283 \\ nw = 0,1707 \\ A = \frac{0,1707}{24} \times 100 \times 6 = 4,27 \text{ cm}^2. \end{array} \right\}$$

Untuk lebar 40 cm $A = 0,40 \times 4,27 = 1,71 \text{ cm}^2.$
 $\Rightarrow 4 \phi 10 = 3,14 \text{ cm}^2.$
 $T.B = 20\% \times 4,27 = 0,85 \text{ cm}^2.$
 $\Rightarrow \phi 6 - 25 = 1,13 \text{ cm}^2.$

KOLOM di E & di F (25 x 25).

$$N_E = 498 + 67 = 565 \text{ kg} \quad \left. \begin{array}{l} N = 3427 \text{ kg} ; l_k = 4,50 \text{ m.} \\ N_F = 498 + 2929 = 3427 \text{ kg} \end{array} \right\}$$

$$e_o = 0, e_d = \frac{1}{30} \times 0,40 = 0,01 \sim 0,02 \text{ m.}$$

$$\frac{e_o}{h_t} = \frac{0,02}{0,25} = 0,08 \Rightarrow c_1 = 1 ; c_2 = 6,14$$

$$e_1 = 1 \times 6,14 \times \left(\frac{4,50}{100 \times 0,25} \right)^2 \times 0,25 = 0,05 \text{ m}$$

$$e_2 = 0,15 \times 0,25 = 0,04 \text{ m.}$$

$$e_{tot} = 0,02 + 0,05 + 0,04 = 0,11 \text{ m.}$$

$$\frac{e_{tot}}{h_t} = \frac{0,11}{0,25} = 0,44 \dots\dots\dots$$

$$\sigma_o' = \frac{3427}{25 \times 25} = 5,48 \text{ kg/cm}^2$$

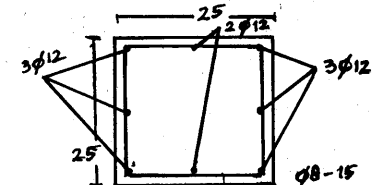
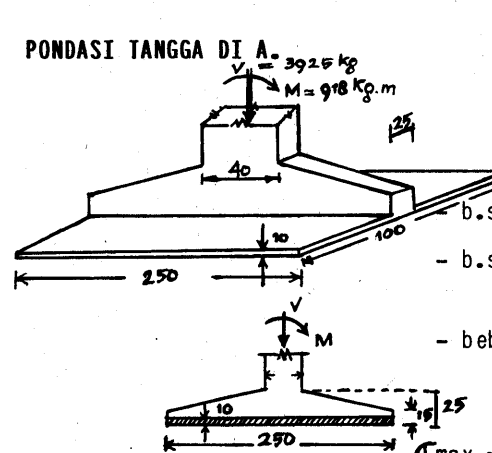
$$n_{tot} = \left. \begin{array}{l} \\ \psi = \end{array} \right\} \text{tul.min}$$

$$\frac{\sigma_o'}{\sigma_b'} = \frac{5,48}{60} = 0,09$$

$$A_{min} : 1\% \times 25 \times 25 = 6,25 \text{ cm}^2$$

$$\frac{1}{2} A_{tot} = 3,13 \text{ cm}^2 \Rightarrow 3 \phi 12 = 3,39 \text{ cm}^2.$$

PONDASI TANGGA DI A.



b.s. pelat : $1,0 \times 2,50 \times 0,10 \times 2400 = 600 \text{ kg}$
 - b.s. rib = $\frac{0,25 + 0,15}{2} \times 2,10 \times 2400 = 252 \text{ kg}$
 - beban vertikal V = 3925 kg

$$\Sigma V = 4777 \text{ kg}$$

$$\sigma_{max} = \frac{4777}{1,0 \times 2,5} + \frac{918 \times 6}{1,0 \times 2,5^2}$$

$$= 1911 + 881 = 27 \text{ kg/m}^2$$

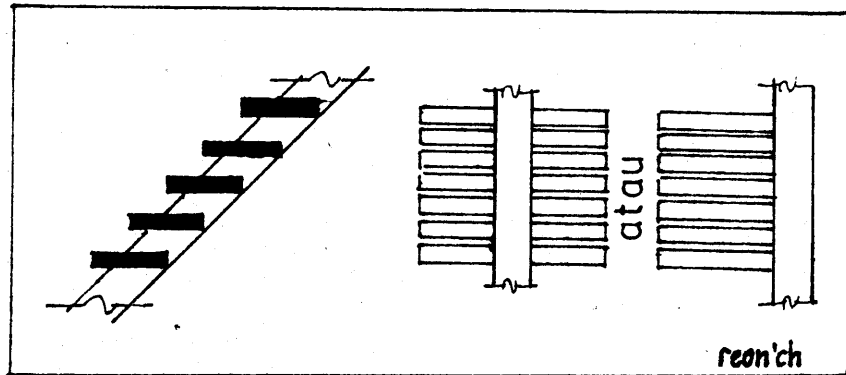
$$= 0,28 \text{ kg/cm}^2 < \sigma_t (0,3 \text{ kg/cm}^2)$$

$$\sigma_{min} = 1911 - 811 = 1030 \text{ kg/cm}^2.$$

SOAL 1 :

Rencanakan & hitunglah tangga yang terletak disudut sebuah gedung. Lubang tangga ukuran 2,50 x 2,50. Tinggi lantai atas + 4,00. Beban hidup direncanakan 200 kg/m².

- Bentuk tangga yang diminta :
1. Balok boleh ditengah
 2. Balok boleh dipinggir (overstek).



Hitunglah pondasi tangga tersebut ($\bar{\sigma}$ tanah = 0,3 kg/cm²).

Penyelesaian :

KETENTUAN :

Langkah datar : 25 cm
Langkah naik : 18 cm
Lebat tangga : 100 cm

Tangga atas :

Peil lantai II : + 4,0

Banyak langkah datar : $\frac{150}{25} = 6$

Banyak langkah naik : $6 + 1 = 7$

Peil bordes : $4,00 - 7 \times 0,18 = + 2,74$

Tangga bawah :

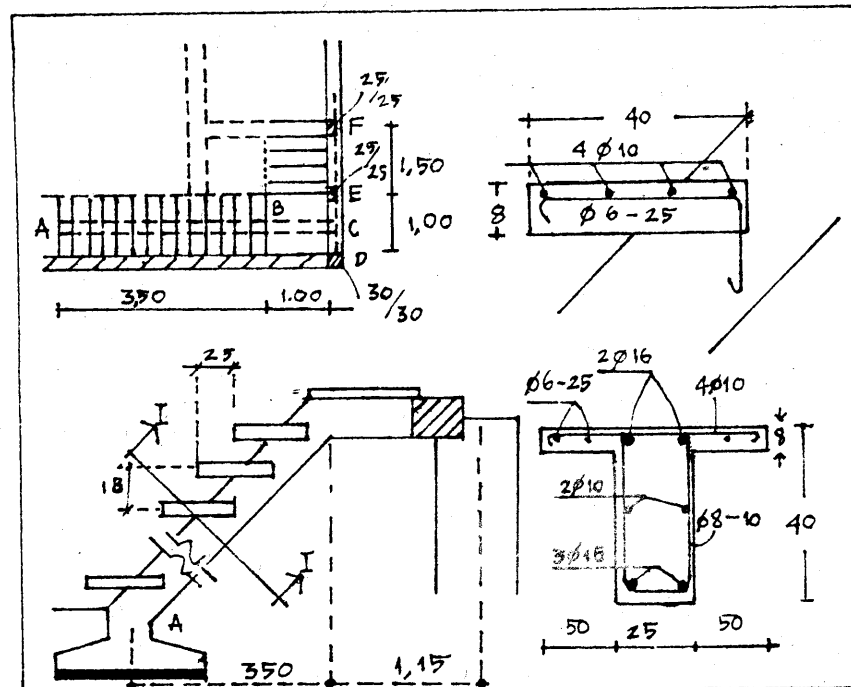
Banyak langkah naik : 15 ----> $14 \times 0,18 + 1 \times 0,22 = + 2,74$

Peil bordes = + 2,74

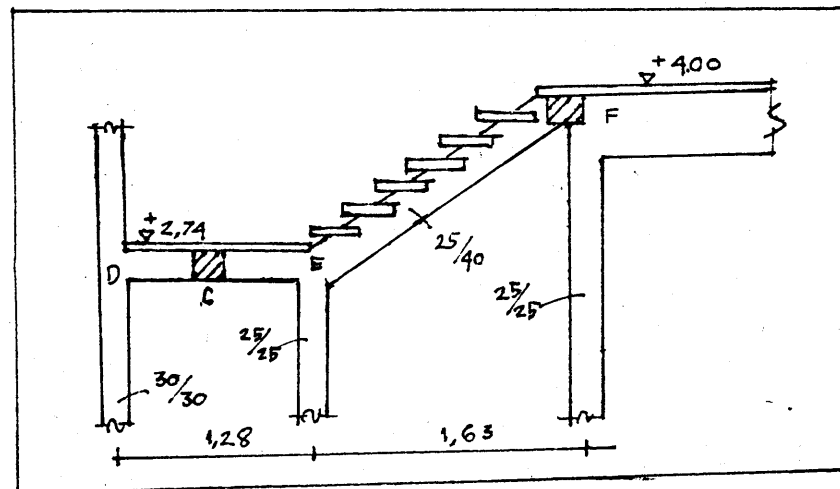
Banyak langkah dasar : $15 - 1 = 14$

Panjang tangga : $14 \times 25 = 350 \text{ cm} = 3,50 \text{ m}$.

GAMBAR DENAH TANGGA.



TANGGA ATAS.



1. Anak tangga bawah (40 x 100)

Tebal : 8 cm

- berat sendiri : $0,08 \times 2400 = 192 \text{ kg/m}^2$
- beban hidup = 200 kg/m^2
- tegel + spesi = 113 kg/m^2

$$q = 507 \text{ kg/m}^2$$

$$M = \frac{1}{2} \times 507 \times 0,375^2 = 36 \text{ kgm.}$$

$$\left. \begin{aligned} C_a &= \frac{6}{\sqrt{\frac{24 \times 36}{1 \times 1400}}} = 7,638 \\ \delta &= 0 \end{aligned} \right\} \begin{aligned} \phi &= 4,747 > \phi_0 \\ n \omega &= 0,01833 \\ A &= \frac{0,01833}{24} \times 100 \times 6 \\ &= 0,46 \text{ cm}^2. \end{aligned}$$

$$A_{\min.} 0,25 \% \times 100 \times 8 = 2,0 \text{ cm}^2.$$

$$\text{Untuk lebar 40 cm} \rightarrow A = 0,40 \times 2 = 0,80 \text{ cm}^2.$$

$$\rightarrow 4 \phi 10 = 3,14 \text{ cm}^2.$$

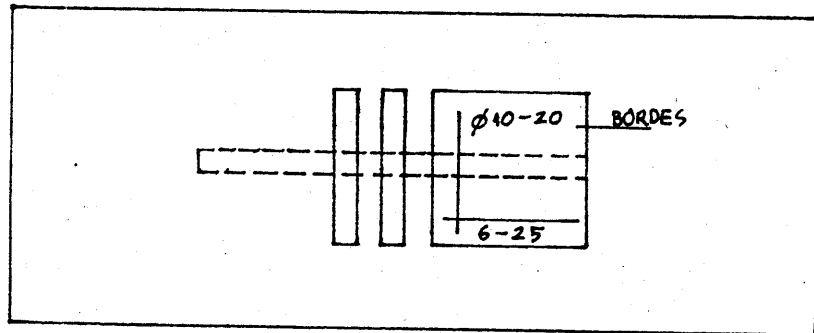
$$T.B. \rightarrow \phi 6 - 25 = 1,13 \text{ cm}^2.$$

$$\text{Stek untuk angker} \rightarrow 3 \phi 10.$$

2. Bordes (1,00 x 1,00).

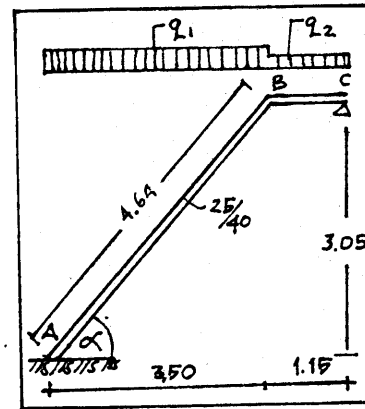
$$A = 2,0 \text{ cm}^2 \rightarrow \phi 10 - 20 = 3,93 \text{ cm}^2.$$

$$T.B. \rightarrow \phi 6 - 25 = 1,13 \text{ cm}^2.$$



3. Tangga bawah.

$$\cos \alpha = 0,754$$



A.B :

$$- b.s = 0,25 \times 0,40 \times 2400 \times \frac{1}{0,754} = 318 \text{ kg/m'}$$

$$- \text{beban anak tangga} : 1,0 \times 507 = 507 \text{ kg/m'}$$

$$q_1 = 825 \text{ kg/m'}$$

B.C. :

$$- b.s = 0,25 \times 0,40 \times 2400 = 240 \text{ kg/m'}$$

$$- \text{beban anak tangga} = 507 \text{ kg/m'}$$

$$q_2 = 747 \text{ kg/m'}$$

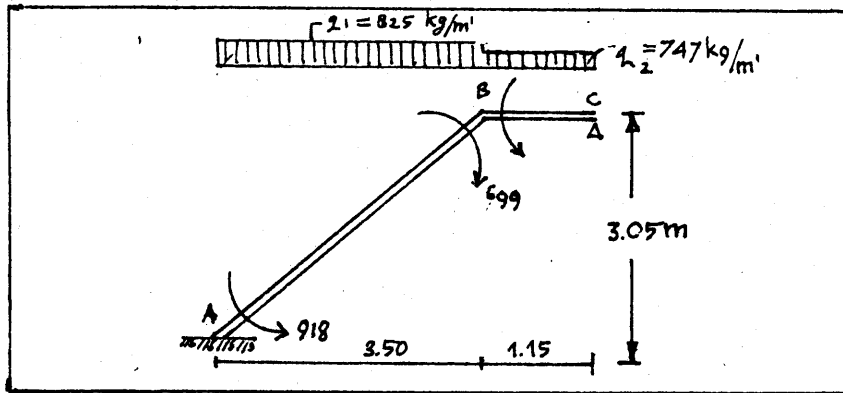
$$K_{BA} : K_{BC} = \frac{4EI}{4,64} : \frac{4EI}{1,15} = 1,15 : 4,64$$

$$\mu_{BA} = 0,199 ; \mu_{BC} = 0,801$$

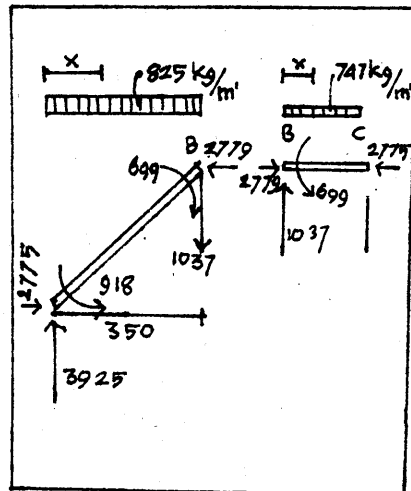
$$M_{AB} = -M_{BA} = \frac{1}{12} \times 825 \times 3,50^2 = 842 \text{ kgm.}$$

$$M_{BC} = -M_{CB} = \frac{1}{12} \times 747 \times 1,15^2 = 82 \text{ kgm.}$$

A	B		C
AB	BA	BC	CB
μ	0,199	0,801	-
842	- 842	82	-82
-	+ 151	+ 609	+82
+76	- 6	+ 41	-
+918	- 699	+ 699	-



Free body:



$$\cos \alpha = 0,754$$

$$\sin \alpha = 0,657$$

A.B.

$$\sum M_B = 0$$

$$- H_A \times 3,05 + 3925 \times 3,50 - \frac{1}{2} \cdot 825 \times 3,50^2$$

$$- 918 + 699 = 0$$

$$H_A = 2775 \text{ kg (---->)}$$

Check $\sum V = 0$; $3925 - 178 - 825 \times 3,50 - 747 \times 1,15$
 $= 0,45 \approx 0 \text{ kg.}$

Bagian A.B.

$$M_x = 3925 \times x - 2775 \times \frac{3,05}{3,50} \times x - \frac{1}{2} \cdot 825 \cdot x^2 - 918$$

$$= 1506,79 \times x - \frac{1}{2} \cdot 825 \cdot x^2 - 918$$

$$\frac{dM_x}{dx} = 0 : 1506,79 - 825 \times x = 0 \text{ ----> } x = 1,83 \text{ m.}$$

$$M_{\max} = 1506,79 (1,83) - \frac{1}{2} \cdot 825 \cdot (1,83)^2 - 918 = 458 \text{ kgm.}$$

BATANG A-B.

$$M_A = -918 \text{ kgm} ; N_A = 2775 \cos \alpha + 3925 \sin \alpha$$

$$= 2775 (0,754) + 3925 (0,657) = 4671 \text{ kg (tekan)}$$

$$D_A = -2775 \times 0,657 + 3925 \times 0,754 = 1136 \text{ kg}$$

Ditumpuan :

$$M_A = 918 \text{ kgm} ; N_A = 4671 \text{ kg (tekan)}$$

$$e_o = \frac{M}{N} = \frac{918}{4671} = 0,20 \text{ m}$$

$$e_o = 0,22 \text{ m}$$

$$e_o' = \frac{1}{30} \times 0,40 = 0,01 \approx 0,02 \text{ m}$$

$$\frac{e_o}{h} = \frac{0,22}{0,40} = 0,55 \text{ ----> } c_1 = 1$$

$$c_2 = 6,93$$

$$e_1 = 1 \times 6,93 \times \left(\frac{4,64}{100} \times \frac{1}{0,40} \right)^2 \times 0,40 = 0,04 \text{ m}$$

$$e_2 = 0,15 \times 0,40 = 0,06 \text{ m}$$

$$e_{\text{tot}} = 0,22 + 0,04 + 0,06 = 0,32 \text{ m}$$

$$e_a = 0,32 + \frac{0,40}{2} - 0,05 = 0,47 \text{ m.}$$

$$N \cdot e_a = 4671 \times 0,47 = 2195 \text{ kgm.}$$

$$i = \frac{1}{1 - \frac{h}{e_a}} = \frac{1}{1 - 0,871 \times \frac{0,35}{0,47}} = 2,85$$

$$C_a = \frac{35}{\sqrt{\frac{24 \times 2195}{0,25 \times 1400}}} = 2,853$$

$$\phi = 1,532 > \phi_o ; \phi = 0,871$$

$$\delta = 0,2$$

$$n\omega = 0,1429 \text{ ----> } iA = \frac{0,1429}{24} \times 25 \times 35$$

$$= 5,21 \text{ cm}^2.$$

$$A = 1,83 \text{ cm}^2.$$

$$A_{\min} : \frac{12}{2080} \times 25 \times 35 = 5,05 \text{ cm}^2 \text{ ----> } 3 \phi 16'' = 6,03 \text{ cm}^2.$$

$$A' = 0,2 \times 5,21 = 1,04 \text{ cm}^2 \text{ ----> } 2 \phi 16 = 4,02 \text{ cm}^2.$$

$$Q_A = 1136 \text{ kg} \rightarrow \tau_b = \frac{8}{7} \times \frac{1136}{25 \times 35} = 1,48 \text{ kg/cm}^2 < \tau_{bt} (=5,5 \text{ kg/cm}^2)$$

Sengkang : $\emptyset 8 - 10$

Dilapangan :

$$M_{\max} = 458 \text{ kgm} ; N = 4671 \text{ kg} \rightarrow \underline{\underline{3 \emptyset 16 = 6,03 \text{ cm}^2}}$$

* Batang B.C.

$$M_B = 699 \text{ kgm} ; N = 2775 \text{ kg}$$

$$\left. \begin{aligned} e_o &= \frac{699}{2775} = 0,25 \text{ m} \\ e_o' &= 0,02 \text{ m} \end{aligned} \right\} e_o = 0,27 \text{ m}$$

$$\frac{e_o}{h_t} = \frac{0,27}{0,40} = 0,68 \quad c_1 = 1 ; c_2 = 6,96$$

$$c_1 = 1 \times 6,96 \times \left(\frac{1,15}{100 \times 0,40} \right)^2 \times 0,40 = 0,002 \text{ m}$$

$$e_2 = 0,06 \text{ m}$$

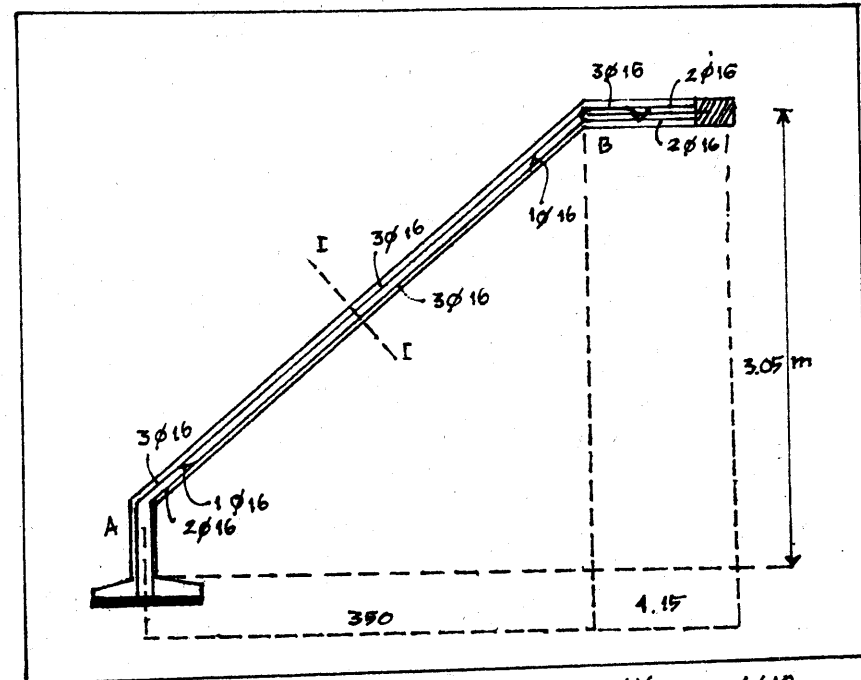
$$e_{\text{tot}} = 0,27 + 0,02 + 0,06 = 0,33 \text{ m}$$

$$e_a = 0,33 + \frac{0,40}{2} - 0,05 = 0,48 \text{ m}$$

$$N \cdot e_a = 699 \times 0,48 = 335 \text{ kgm} \rightarrow \underline{\underline{3 \emptyset 16 = 6,03 \text{ cm}^2}}$$

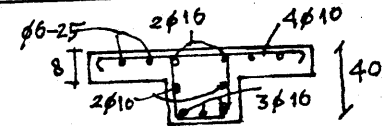
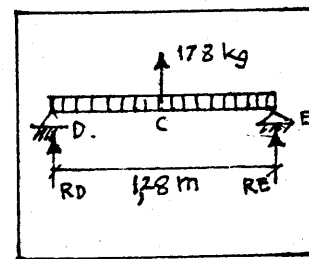
$$Q_o = 178 \text{ kg} \rightarrow \underline{\underline{\text{Sengkang } \emptyset 8 - 10}}$$

PORTAL TANGGA BAWAH A.B.C. (25 x 40).



4. TANGGA ATAS.

BALOK DCE (25 x 40).



$$q = 0,25 \times 0,40 \times 2400 = 240 \text{ kg/m'}$$

$$R_D = R_E = \frac{1}{2} \times 2400 \times 1,28 - \frac{178}{2} = 67 \text{ kg}$$

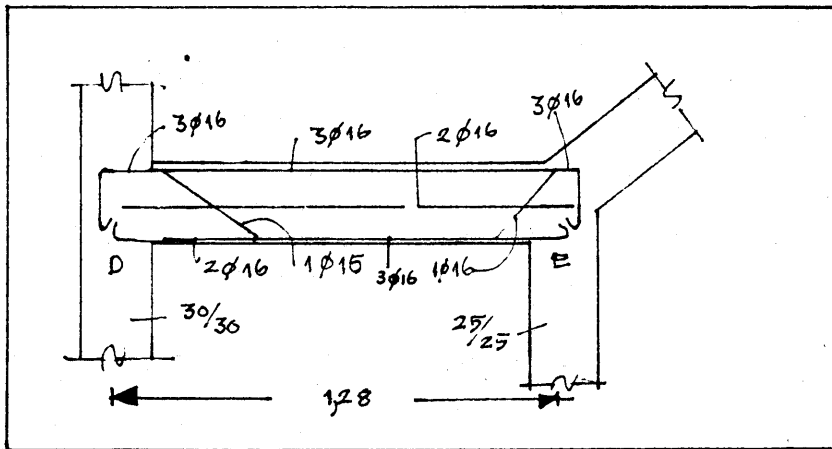
$$M_{\max} = \frac{1}{8} \times 2400 \times 1,28^2 - \frac{1}{4} \times 178 \times 1,28 = -7,15 \text{ kgm}$$

$$\text{Dipakai tul.min. } A_{\min} = \frac{12}{2080} \times 25 \times 35 = 5,05 \text{ cm}^2$$

$$\underline{\underline{3 \emptyset 16 = 6,03 \text{ cm}^2}}$$

Untuk menghindari lenturan berubah arah, maka seluruh penampang atas dan bawah diberi tulangan 3Ø16.

Untuk tul. geser lentur dipakai sengkang $\phi 8 - 10$.



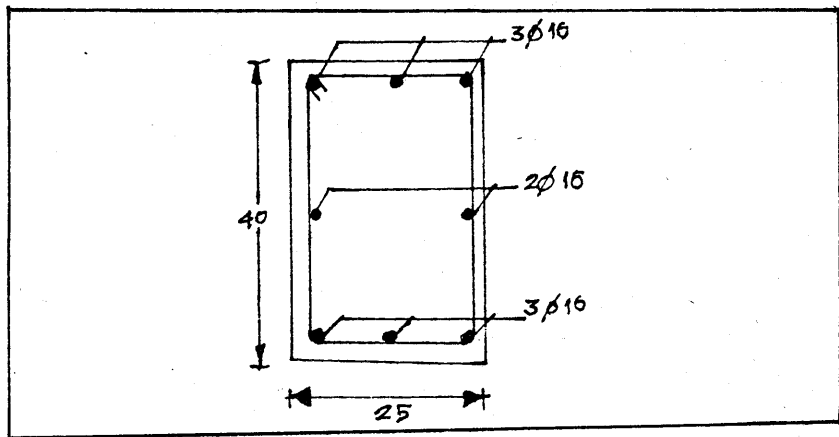
Untuk gaya horizontal $H = 2775 \text{ kg}$, diperhitungkan sbb :

$$M = \frac{1}{4} \times 2775 \times 1,28 = 902 \text{ kgm.}$$

$$C_a = \frac{20}{\sqrt{\frac{24 \times 902}{0,20 \times 1400}}} = 3,217 \quad \left. \begin{array}{l} \phi = 2,125 > \phi_0 \\ \delta = 0,2 \end{array} \right\} n\omega = 0,03$$

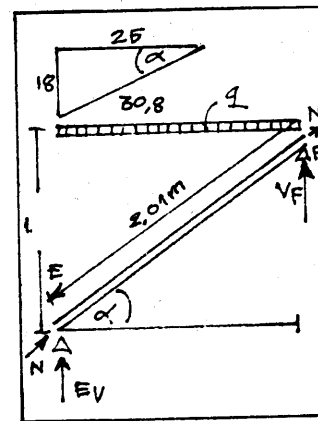
$$A = A' = \frac{0,03}{24} \times 40 \times 20 = 3,71 \text{ cm}^2.$$

$$A_{\min} = \frac{12}{2080} \times 40 \times 20 = 4,62 \text{ cm}^2 \rightarrow 3 \phi 16 = 6,03 \text{ cm}^2.$$



* BALOK EF (25 x 40).

---> NOTE : PERHITUNGAN ANAK TANGGA OVERSTEK $L = 1,0$



$$\cos \alpha = 0,812 ; \sin \alpha = 0,584$$

$$b \cdot s = 0,25 \times 0,40 \times 2400 \times \frac{1}{0,812} = 296 \text{ kg/m'}$$

$$b \cdot h = 200 \times 1,0 = 200 \text{ kg/m'}$$

$$\text{tegel + spesi : } 115 \times 1,0 = 115 \text{ kg/m'}$$

$$q = 611 \text{ kg/m'}$$

$$q \perp EF = q \cos^2 \alpha = 611 \times 0,812^2 = 403 \text{ kg/m'}$$

$$q // EF = q \cos \alpha \sin \alpha = 611 \times 0,812 \times 0,584 = 290 \text{ kg/m'}$$

$$V_E = V_F = \frac{1}{2} \times 611 \times 1,63 = 498 \text{ kg} (\uparrow)$$

$$N = \frac{1}{2} \times 290 \times 2,01 = 291 \text{ kg}$$

$$M_{\text{lap}} = \frac{1}{8} \times 403 \times 2,01^2 = 204 \text{ kgm.}$$

$$N = 291 \text{ kg (tekan).}$$

$$e_o = \frac{204}{291} = 0,70 \text{ m}$$

$$e_o' = \frac{1}{30} \times 0,40 = 0,01 \text{ m} \quad e_o = 0,72 \text{ m}$$

$$\frac{e_o}{h_t} = \frac{0,72}{0,40} = 1,8 \quad c_1' = 1 ; c_2 = 7$$

$$e_1 = 1 \times 7 \times \left(\frac{2,01}{100 \times 0,4} \right)^2 \times 0,40 = 0,007 \approx 0,01 \text{ m.}$$

$$e_2 = 0,15 \times 0,40 = 0,06 \text{ m}$$

$$e_{\text{tot}} = 0,72 + 0,01 + 0,06 = 0,79 \text{ m.}$$

$$e_a = 0,79 + \frac{0,40}{2} - 0,05 = 0,94 \text{ m.}$$

$$M = 291 \times 0,94 = 274 \text{ kgm.}$$

$$C_a = \frac{35}{\sqrt{\frac{24 \times 274}{0,25 \times 1400}}} = 8,075 \quad \phi = 5,250 > \phi_0 ; \phi = 0,946$$

$$S = 0,2 \quad i = \frac{1}{1 - 0,946 \times \frac{0,35}{0,94}} = 1,54$$

$$n = 0,01546 \rightarrow iA = \frac{0,01546}{24} \times 25 \times 35$$

$$iA = 0,56 \text{ cm}^2$$

$$A = 0,36 \text{ cm}^2$$

$$A_{\min} = \frac{12}{2080} \times 25 \times 35 = 5,05 \text{ cm}^2 \rightarrow 3 \phi 16 = 6,03 \text{ cm}^2$$

$$A' = 0,2 \times 5,05 = 1,01 \text{ cm}^2 \rightarrow 2 \phi 16 = 4,02 \text{ cm}^2$$

$$M_{\text{tump.}} = \frac{1}{3} \times 204 = 68 \text{ kgm} ; N = 291 \text{ kg (tekan)}$$

$$\rightarrow \text{tul. min. } A = 5,05 \text{ cm}^2 \rightarrow 3 \phi 16 = 6,03 \text{ cm}^2$$

$$Q_{\text{tump.}} = \frac{1}{2} \times 408 \times 2,01 = 405 \text{ kg.}$$

$$\tau_b = \frac{8}{7} \times \frac{405}{25 \times 35} = 0,53 \text{ kg/cm}^2$$

$$M_{\text{puntir}} = \left(\frac{1}{2} \times 611 \times 1,0 \right) \times \frac{2,01}{2} = 307 \text{ kgm.}$$

$$\phi = 3 + \frac{2,6}{0,45 + \frac{25}{25}} = 4,27$$

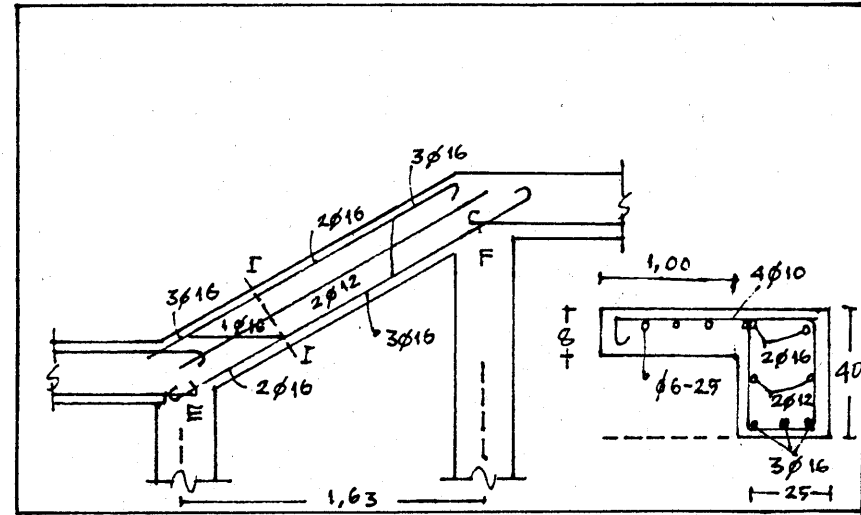
$$\tau_{b'} = 4,27 \times \frac{30700}{25^2 \times 40} = 5,24 \text{ kg/cm}^2$$

$$\tau_b + \tau_{b'} = 0,53 + 5,24 = 5,77 \text{ kg/cm}^2 < \tau_{bt}$$

$$(= 7 \text{ kg/cm}^2).$$

Dipakai tul. geser lentur puntir praktis \rightarrow sengkang $\phi 8 - 10$

$$\text{Tul. memanjang A mem} = \frac{30700 (20 + 35)}{1400 \times 20 \times 35} = 1,72 \text{ cm}^2 \rightarrow 2 \phi 12 = 2,26 \text{ cm}^2$$



* ANAK TANGGA ATAS (40 x 100).

$$M = \frac{1}{2} \times 611 \times 1,0^2 = 306 \text{ kgm.}$$

$$C_a = \frac{6}{\sqrt{\frac{24 \times 306}{1 \times 1400}}} = 2,620 \quad \phi = 1,283$$

$$\delta = 0 \quad n\omega = 0,1707$$

$$A = \frac{0,1707}{24} \times 100 \times 6 = 4,27 \text{ cm}^2$$

$$\text{Untuk lebar 40 cm} \rightarrow A = 0,40 \times 4,27 = 1,71 \text{ cm}^2 \rightarrow$$

$$4 \phi 10 = 3,14 \text{ cm}^2$$

$$\tau_{.B} = 20\% \times 4,27 = 0,85 \text{ cm}^2$$

$$\rightarrow \phi 6 - 25 = 1,13 \text{ cm}^2$$

* KOLOM DI E & DI F (25 x 25).

$$N_E = 498 + 67 = 565 \text{ kg}$$

$$N_F = 498 + 2929 = 3427 \text{ kg}$$

$$N = 3427 \text{ kg} ; l_k = 4,50 \text{ m}$$

$$e_o = 0 ; e_o = \frac{1}{30} \times 0,40 = 0,01 \sim 0,02 \text{ m.}$$

$$\frac{e_o}{h_t} = \frac{0,02}{0,25} = 0,08 \rightarrow c_1 = 1 ; c_2 = 6,14$$

$$e_1 = 1 \times 6,14 \times \left(\frac{4,50}{100 \times 0,25} \right)^2 \times 0,25 = 0,05 \text{ m}$$

$$e_2 = 0,15 \times 0,25 = 0,04 \text{ m}$$

$$e_{\text{tot}} = 0,02 + 0,05 + 0,04 = 0,11 \text{ m}$$

$$\frac{e_{\text{tot}}}{h_t} = \frac{0,11}{0,25} = 0,44 \dots\dots\dots$$

$$\sigma_o' = \frac{3427}{25 \times 25} = 5,48 \text{ kg/cm}^2$$

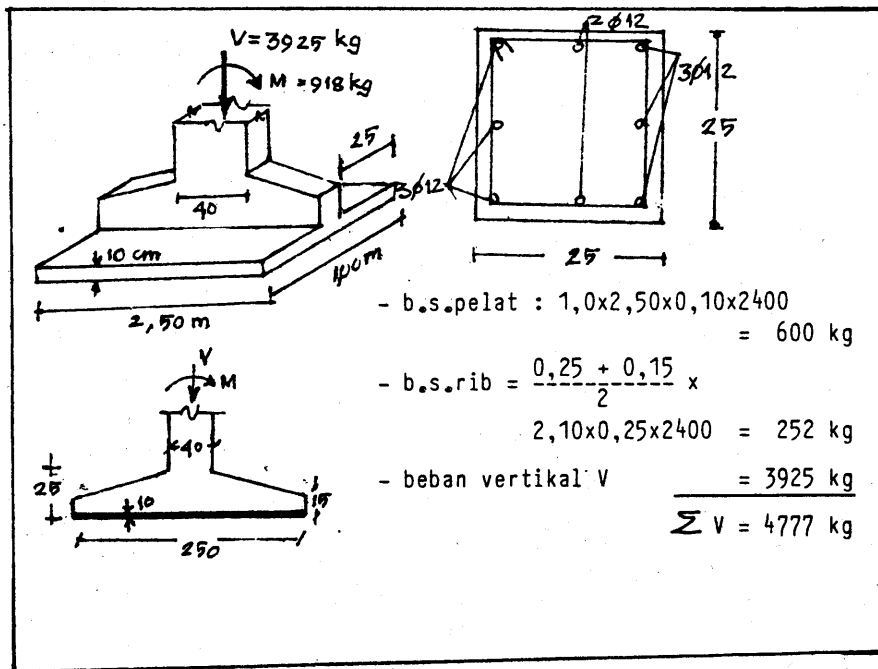
$$n_{\text{tot}} = \left. \begin{array}{l} \\ \varphi = \end{array} \right\} \text{tul.min}$$

$$\frac{\sigma_o'}{\sigma_b'} = \frac{5,48}{60} = 0,09$$

$$A_{\text{min}} : 1\% \times 25 \times 25 = 6,25 \text{ cm}^2.$$

$$\frac{1}{2} A_{\text{tot}} = 3,13 \text{ cm}^2 \rightarrow 3 \varnothing 12 = 3,39 \text{ cm}^2.$$

* PONDASI TANGGA DI A.



$$\begin{aligned} \sigma_{\text{max}} &= \frac{4777}{1,0 \times 2,5} + \frac{918 \times 6}{1,0 \times 2,5^2} \\ &= 1911 + 881 = 2792 \text{ kg/m}^2 \\ &= 0,28 \text{ kg/cm}^2 < \sigma_t (= 0,3 \frac{\text{kg}}{\text{cm}^2}) \end{aligned}$$

$$\sigma_{\text{min}} = 1911 - 811 = 1030 \text{ kg/m}^2$$

Pelat pondasi & tangga.

$$q_{\text{pelat}} = \frac{4777 - 600}{1,0 \times 2,50} + 881 = 2552 \text{ kg/m}^2.$$

$$M = \frac{1}{2} \times 2552 \times 0,375^2 = 179 \text{ kgm.}$$

$$Ca = \frac{7}{\sqrt{\frac{24 \times 179}{4 \times 1400}}} = 4,0 \quad \left. \begin{array}{l} \delta = 0 \\ \varnothing = 2,226 > \varnothing_o \end{array} \right\} n\omega = 0,06964$$

$$A = \frac{0,06964}{24} \times 100 \times 7 = 2,03 \text{ cm}^2$$

$$A_{\text{min}} : 0,25\% \times 100 \times 10 = 2,5 \text{ cm}^2 \quad \varnothing 8 - 20 = 2,51 \text{ cm}^2.$$

$$\text{I.B.} \rightarrow \varnothing 6 - 25 = 1,13 \text{ cm}^2.$$

RIb.

$$q_{\text{rib}} = \frac{3952}{1,0 \times 2,5} + 881 = 2462 \text{ kg/m}^2$$

$$\rightarrow M = \frac{1}{2} \times 2462 \times 1,05^2 = 1357 \text{ kgm.}$$

$$Ca = \frac{19}{\sqrt{\frac{24 \times 1357}{0,25 \times 1400}}} = 1,970 \quad \left. \begin{array}{l} \delta = 0,4 \\ \varnothing = 1,105 > \varnothing_o \end{array} \right\} n\omega = 0,3008$$

$$A = \frac{0,3008}{24} \times 25 \times 19 = 5,95 \text{ cm}^2$$

$$A_{\text{min}} = \frac{12}{2080} \times 25 \times 25 = 3,60 \text{ cm}^2.$$

$$3 \varnothing 16 = 6,03 \text{ cm}^2$$

$$A' = 0,4 \times 5,95 = 2,38 \text{ cm}^2 \rightarrow 2 \varnothing 16 = 4,02 \text{ cm}^2.$$

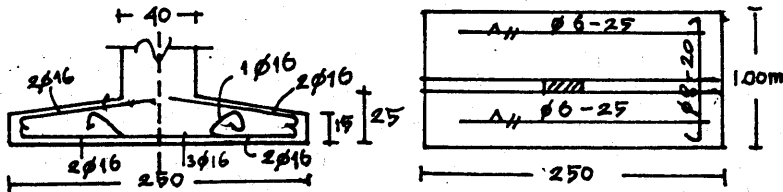
$$\rightarrow Q = 2462 \times 1,05 = 2585 \text{ kg.}$$

$$\tau_b = \frac{8}{7} \times \frac{2585}{25 \times 19} = 6,22 \text{ kg/cm}^2 > \tau_{bt} (= 5,5 \text{ kg/cm}^2).$$

$$< \tau_{bs} (= 9 \text{ kg/cm}^2).$$

$$\tau_t = 6,22 - 5,5 = 0,72 \text{ kg/cm}^2.$$

$$\text{Senggang } \phi 8 - 10 \rightarrow \tau_s = \frac{1,01 \times 1400}{10 \times 25} = 5,66 \text{ kg/cm}^2 > \tau_t$$

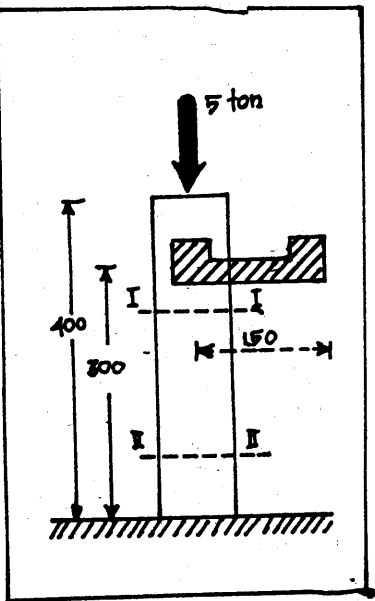


Luifel : d = 8 cm
P = 100 kg/m'

Mutu beton : K₂₂₅ $\sigma_{b'} = 75 \text{ kg/cm}^2$

Mutu baja : QR₂₄ $\sigma_a = 1400 \text{ kg/cm}^2$

Rencanakan : 1. penulangan luifel
2. penulangan kolom



Beban2 :

- Berat sendiri pelat = $0,08 \times 1,00 \times 1,00 \times 2400 = 192 \text{ kg/m}^2$
(tebal 8 cm)
- Berat air = $0,10 \times 1,00 \times 1,00 \times 1000 = 100 \text{ kg/m}^2$
(P)
- $q = 292 \text{ kg/m}^2$

$$M_{\text{pelat maximum}} = \frac{1}{2} q l^2$$

$$(M_{\text{jepit pelat}}) = \frac{1}{2} \times 292 \times 1,50^2$$

$$= 328,5 \text{ kg/m'}$$

$$C_a = \frac{h}{\sqrt{\frac{21 \times 328,5}{1,00 \times 1400}}}$$

$$= \frac{8,00 - 1,5}{2,220} = \frac{6,5}{2,220} = 2,928$$

$$\delta = 0 \rightarrow n_w = 0,1351$$

$$\phi = 1,488 > \phi_0 = 0,889$$

$$A : \frac{0,1351}{21} \times 100 \times 6,5 = 4,182 \text{ cm}^2.$$

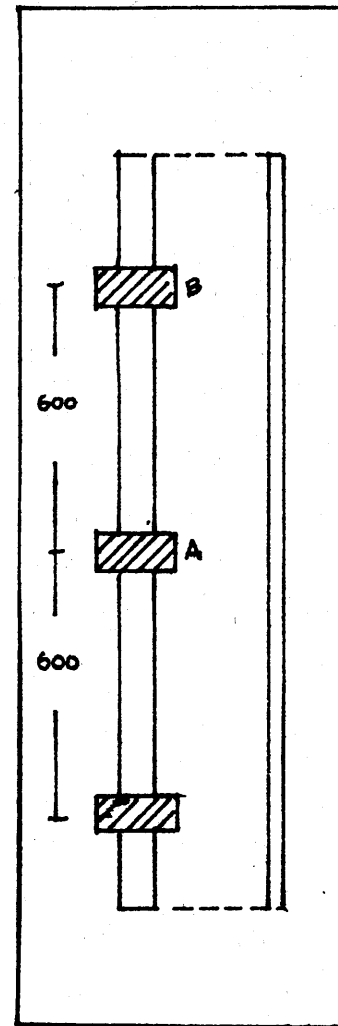
$$\text{Dipakai tulangan : } \phi 8 - 12 = 4,19 \text{ cm}^2$$

$$> 4,182 \text{ cm}^2$$

$$\text{I.P.} = 20\% = 20\% \times 4,190 \text{ cm}^2 = 0,838 \text{ cm}^2$$

Dipakai tulangan pembagi :

$$\phi 6 - 25 : 1,13 \text{ cm}^2 > 0,838 \text{ cm}^2$$



Perhitungan balok puntir A - B : 30/40.

$$M_{\text{puntir A - B max}} = M_{\text{jepit}} \times \frac{6,00}{2}$$

$$= 328,5 \times 3,00 = 985,5 \text{ kgm}$$

$$= 98550 \text{ kg.cm}$$

Beban2 balok : 30/40

- Berat sendiri balok : $0,30 \times 0,40 \times 1,00 \times 2400 = 288 \text{ kg/m'}$

- Beban pelat yang dibebankan ke balok = $292 \times 1,00 \times 1,50 = 438 \text{ kg/m'}$

$$q' = 726 \text{ kg/m'}$$

$$D_{\text{max}} = \frac{1}{2} \times q' \times 6,00 : \frac{1}{2} \times 726 \times 6,00 = 2178 \text{ kg.}$$

$$\tau_b = \frac{D_{\text{max}}}{b \times \frac{778}{h}} = \frac{2178}{2,30 \times \frac{778}{0,35}} = \frac{2178}{918,75} = 2,371 \text{ kg/cm}^2.$$

$$\tau_{b'} = \gamma \frac{M_p}{h t_b^2}$$

$$= 3 + \frac{2,6}{0,45 + \frac{h t}{b}} = 3 + \frac{2,6}{0,45 + \frac{40}{30}} = 3 + \frac{2,6}{1,7833}$$

$$= 3 + 1,458 = 4,458$$

$$\tau_{b'} = 4,458 \times \frac{98550}{40 \times 30^2} = \frac{439335,9}{36.000} = 12,204 \text{ kg/cm}^2.$$

$$\tau_b + \tau_{b'} = 2,371 + 12,204 = 14,575 \text{ kg/cm}^2$$

$$> \tau_b = 8 \text{ kg/cm}^2 \text{ (diperlukan tulangan geser lentur-puntir)}$$

$$< \tau_{bm} = 20 \text{ kg/cm}^2 \text{ (ukuran penampang balok memenuhi).}$$

$$\tau_{b''} = \frac{M_p}{b \cdot F_t} = \frac{98550}{30 \times 25 \times 35} = \frac{98550}{26250} = 3,754 \text{ kg/cm}^2.$$

Dipakai beugel : $\emptyset 8 - 10 \rightarrow \tau_s = \frac{A_s \cdot \sigma_a}{a_s \cdot b} = \frac{1,01 \times 1400}{10 \times 30}$

$$A_s = 1,01 \text{ cm}^2$$

$$a_s = 5 \text{ cm}$$

$$= \frac{1414}{300} = 4,7133 \text{ kg/cm}^2.$$

Dipakai tulangan miring : $\emptyset 12 - 30 \rightarrow A_m = 1,13 \text{ cm}^2$
 $a_m = 30 \text{ cm}.$

$$\tau_m = \frac{A_m \sigma_a \sqrt{2}}{a_m b} = \frac{1,13 \times 1400 \sqrt{2}}{30 \times 30} = \frac{2237,3}{900} = 2,486 \text{ kg/cm}^2.$$

$$\tau_m + \tau_s = 2,486 + 4,7133 = 7,1993 \text{ kg/cm}^2 > \tau_b + \tau_{b''}$$

$$= 2,371 + 3,754$$

$$= 6,125 \text{ cm}^2.$$

$$\tau_m + \tau_s = 7,1993 \text{ kg/cm}^2$$

$$> \tau_b + \tau_{b''} = 2,371 + 3,754 = 6,125 \text{ kg/cm}^2.$$

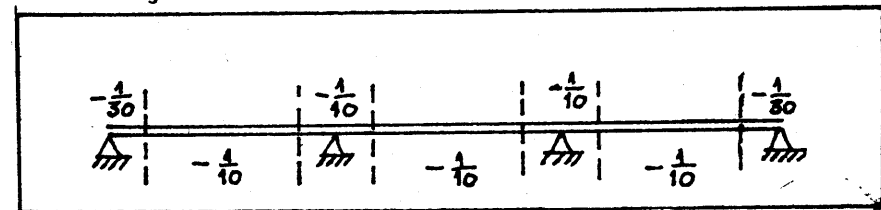
Tulangan puntir memanjang :

$$A_{\text{min}} = \frac{M_p \cdot U_t}{2 \cdot \sigma_a \cdot F_t} = \frac{98550 \times 2 (25 + 35)}{2 \times 1400 \times 25 \times 35}$$

$$= \frac{28550 \times 120}{2 \cdot 450.000} = \frac{11.826.000}{2.450.000} = 4,83 \text{ cm}^2.$$

Dipakai tulangan : $2 \emptyset 19 = 5,68 \text{ cm}^2 > 4,83 \text{ cm}^2.$

*** Perhitungan lentur balok A - B :**



$$M_{\text{max}(+)} = + \frac{1}{10} \times q_{\text{balok}} \times 6,00^2 = + \frac{1}{10} \times 726 \times 6,00^2$$

$$= + 2613,6 \text{ kgm.}$$

$$M_{\text{jepit max}} = - \frac{1}{10} \times q_{\text{balok}} \times 6,00^2 = - \frac{1}{10} \times 726 \times 6,00^2$$

$$= - 2613,6 \text{ lgm.}$$

$$C_a = \frac{40 - 5}{\sqrt{\frac{2613,6 \times 21}{0,30 \times 1400}}} = \frac{35}{11,4315} = 3,062$$

$$\delta = 0,2 \rightarrow n_w = 0,1234$$

$$\phi = 1,667 > \phi_0 = 0,889$$

$$A = \frac{0,1234}{21} \times 30 \times 35 = 6,17 \text{ cm}^2$$

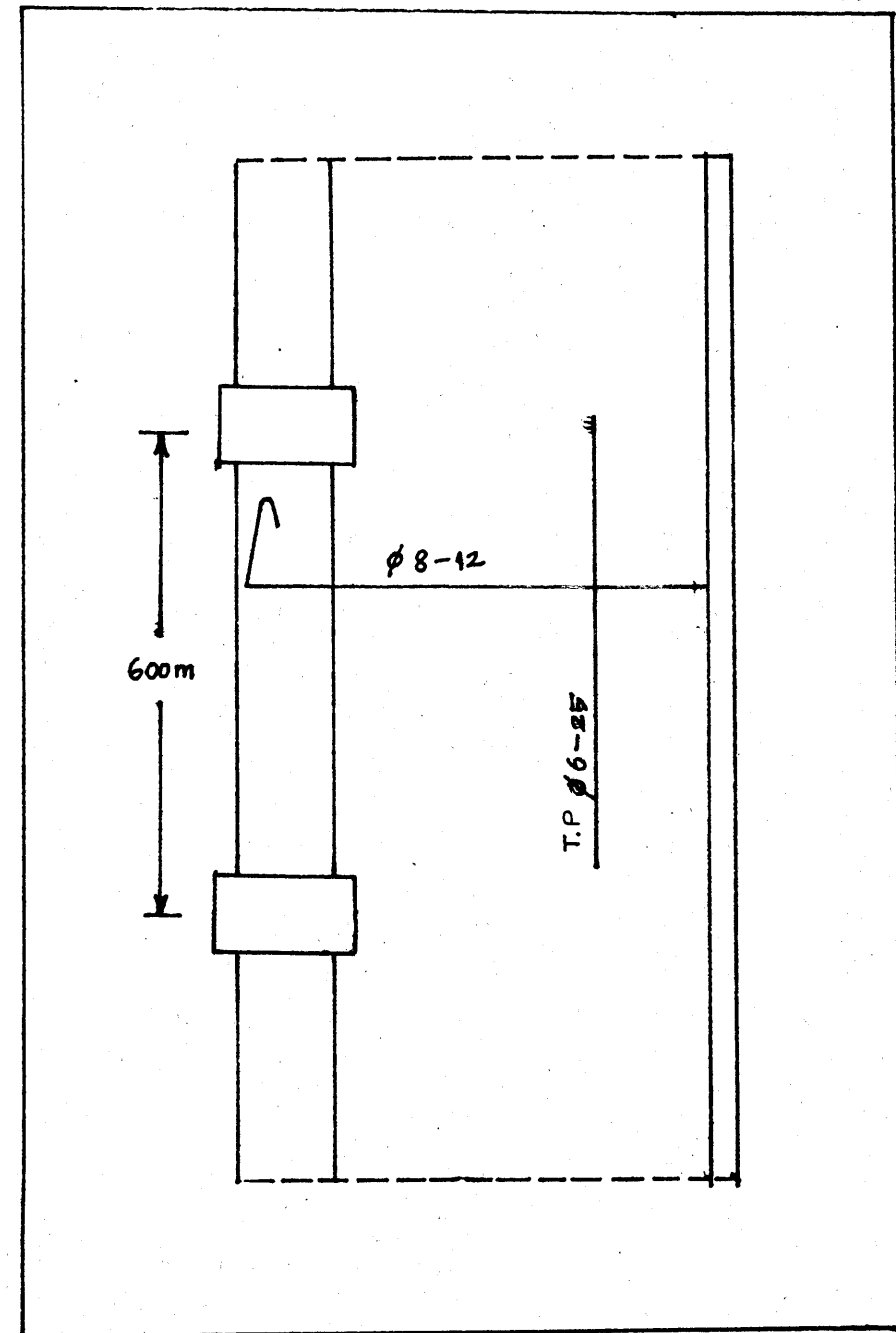
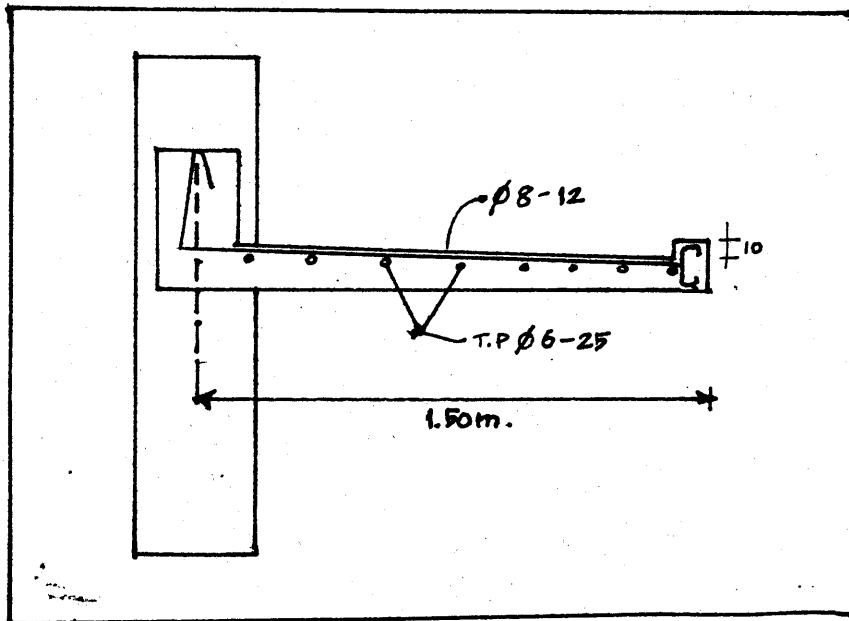
$$\text{Dipakai tulangan : } \underline{\underline{4 \phi 16}} = 8,04 \text{ cm}^2 > 6,17 \text{ cm}^2$$

$$A' = 0,2 A = 0,21 \times 6,17 = 1,234 \text{ cm}^2$$

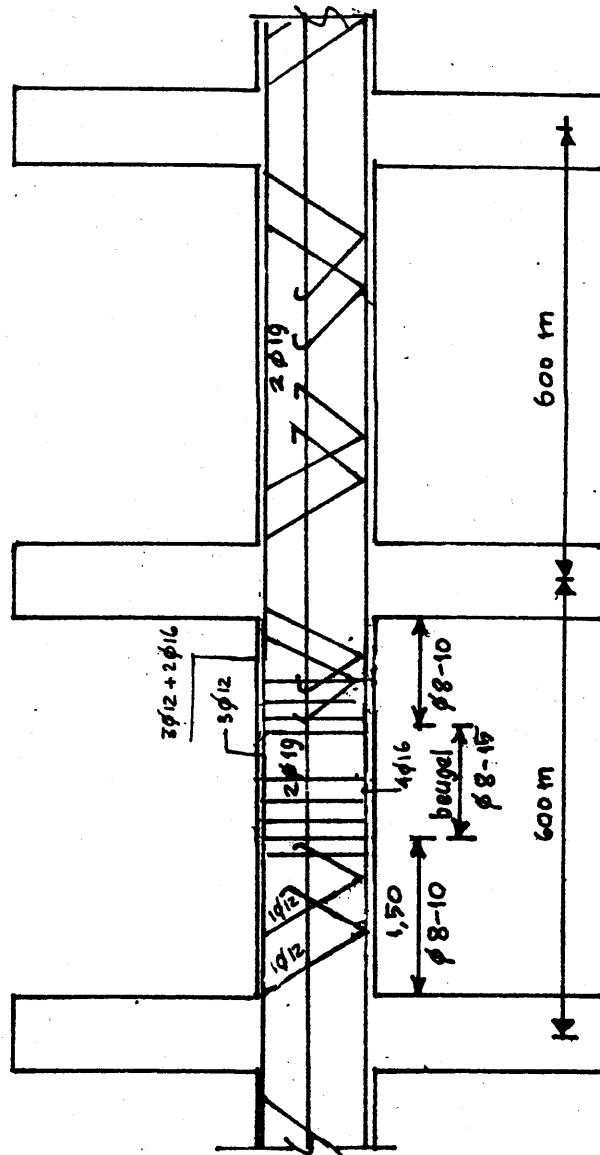
$$\text{Dipakai tulangan : } \underline{\underline{3 \phi 12}} = 3,39 \text{ cm}^2 > 1,234 \text{ cm}^2$$

$$\begin{aligned} \text{Tulangan jepit : } 3 \phi 12 + 2 \phi 16 &= 3,39 + 4,02 \\ &= \underline{\underline{7,41 \text{ cm}^2}} > 6,17 \text{ cm}^2 \end{aligned}$$

$$\text{Tulangan extra : } \underline{\underline{2 \phi 16}}$$



PENULANGAN BALOK PUNTIR A-B.



Perhitungan Kolom :

Pot I - I : $N_I = 5 \text{ ton} + \text{berat (balok + pelat)} + \text{berat kolom - tertinggi } 1,00\text{m}$

$$M_I = M_p \times 1$$

Pot II - II : $M_{II} = 5 \text{ ton} + \text{berat sendiri kolom} + \text{berat (balok + pelat)}$

$$M_{II} = M_p \times 1$$

Pot I - I lebih berbahaya dari pot II - II, karena excentrisitasnya lebih besar.

Pada pot I - I.

$$M_I = M_p \times 1 = 328,5 \times 6,00 = 1972 \text{ kgm.}$$

$$N = 5.000 \text{ kg} + 0,30 \times 0,40 \times 1,00 \times 2400 + \left(\frac{1}{2} \times 726 \times 6,00\right) \times 2$$

tinggi luifal = 1,00 m

$$= 5000 + 288 + 4356 = 9644 \text{ kg.}$$

Perhitungan tulangan kolom : 30/40.

$$M_I = 1971 \text{ kgm}$$

$$N_I = 9644 \text{ kg}$$

$$e_{o1} = \frac{M_I}{N_I} = \frac{1971}{9644} = 0,204 \text{ m.}$$

$$e_{o2} = \frac{1}{30} h_t = \frac{1}{30} \times 0,40 = 0,0133 \text{ m} \rightarrow \text{minimum} = 0,02 \text{ m}$$

$$e_o = e_{o1} + e_{o2} = 0,204 + 0,02 = 0,224 \text{ m}$$

$$\frac{e_o}{h_t} = \frac{0,224}{0,40} = 0,56 \rightarrow c_2 = 6,93$$

$$c_1 = 1 \text{ (penampang persegi)}$$

$$c_1 = c_1 \cdot c_2 \left(\frac{1K}{100 h_t} \right)^2 \cdot h_t = 1 \times 6,93 \times \left(\frac{4,00}{100 \times 0,40} \right)^2 \times 0,40$$

$$= 6,93 \times 0,1^2 \times 0,40 = 0,028 \text{ m.}$$

$$e_2 = 0,15 h_t = 0,15 \times 0,40 = 0,06 \text{ m}$$

$$e = e_0 + e_1 + e_2 = 0,224 + 0,028 + 0,06 = 0,312 \text{ m}$$

$$e_a = e + \frac{1}{2} h_t - 0,05 = 0,312 + 0,20 - 0,05 = 0,462 \text{ m}$$

$$N \times e_a = 9644 \times 0,462 = 4455,53 \text{ kgm.}$$

$$C_a = \frac{40 - 5}{\sqrt{\frac{21 \times 4455,53}{0,30 \times 1400}}} = \frac{35}{14,926} = 2,345$$

Tulangan Simetris :

$$= 1 - \frac{7}{8} \frac{h}{e_a} = 1 - \frac{7}{8} \frac{0,35}{0,462} = 1 - \frac{2,45}{3,696} = 1 - 0,663 = 0,34 \approx 0,2$$

$$\delta = 0,2 \rightarrow C_a = 2,345$$

$$n_w = 0,2184$$

$$\phi = 1,198 > \phi_0 = 0,889$$

$$\phi = 1,535$$

$$\phi = 0,855$$

$$e_a = 0,462$$

$$\frac{e_a}{h} = \frac{0,462}{0,35} = 1,32$$

$$i = 2,84$$

$$iA = \frac{0,2184}{21} \times 30 \times 35 = 10,92 \text{ cm}^2.$$

$$A = \frac{10,92}{21} = 3,85 \text{ cm}^2.$$

$$A' = 5 iA = 0,2 \times 10,92 = 2,18 \text{ cm}^2.$$

$$\text{Tulangan min kolom} = 1\% = 0,01 \times 30 \times 40 = 12 \text{ cm}^2$$

$$A : A' : \frac{1}{2} \times 12 = 6 \text{ cm}^2$$

$$\text{Dipakai tulangan : } 3 \phi 16 = 6,03 \text{ cm}^2 \approx 6 \text{ cm}^2.$$

Dicheck dengan grafis by Wiratman.

$$\frac{e}{h_t} = \frac{0,312}{0,40} = 0,78$$

$$\sigma_{o'} = \frac{N}{b \times h_t} = \frac{9644}{30 \times 40} = \frac{9644}{1200} = 8,04 \text{ kg/cm}^2.$$

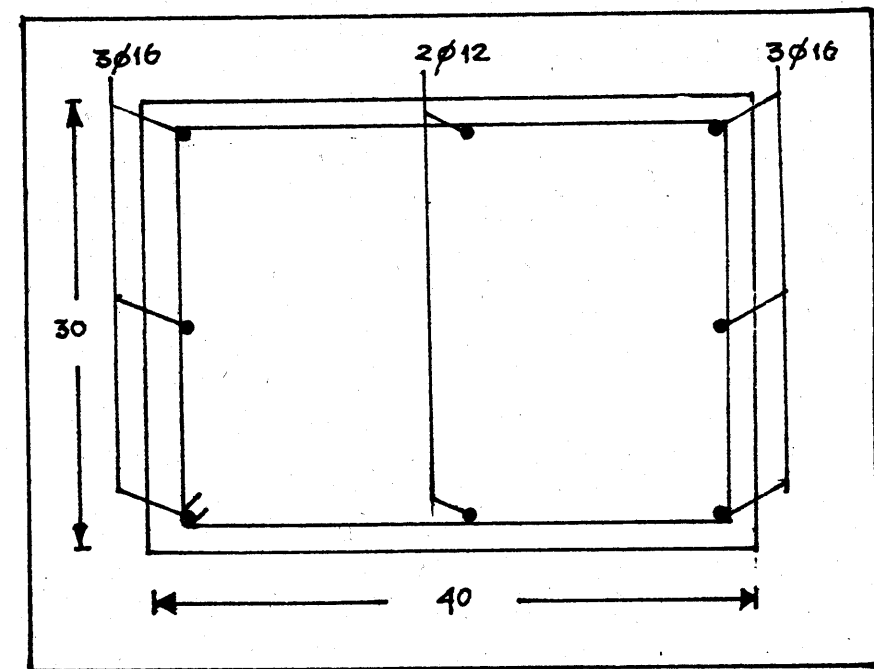
$$\frac{\sigma_{o'}}{\sigma_{b1}} = \frac{8,04}{75} = 0,1072$$

$$n_w \text{ tot} = 0,08$$

$$A_{\text{tot}} = \frac{0,08}{21} \times 30 \times 40 = 4,57 \text{ cm}^2.$$

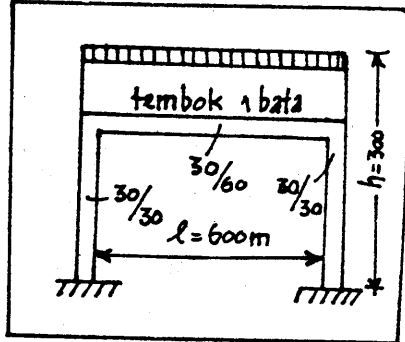
$$\frac{1}{2} A_{\text{tot}} = \frac{1}{2} \times 4,57 = 2,286 \text{ cm}^2.$$

Dipakai tulangan minimum : 3 ϕ 16.



SOAL 3 :

Muatan terbagi rata 1 ton/m'.



Beban : Mutu K₂₂₅

Baja : Mutu QR₂₄

Peraturan2 : P.B.I. 1971
P.B.I. 1970

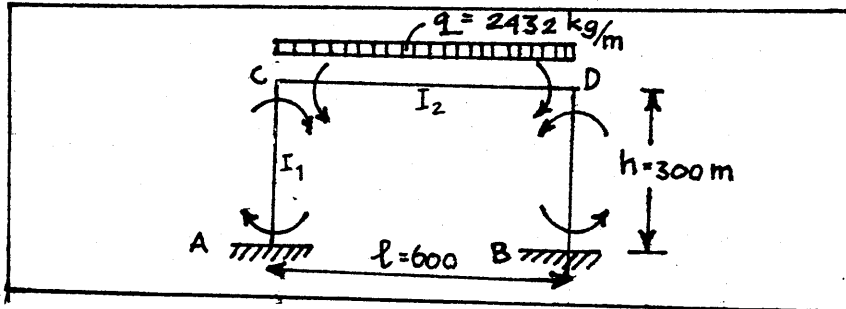
Ditanyakan :

Rencanakan bentuk lantai tsb se-
lengkap2nya dan gambar penulang-
annya.

Muatan2 yang bekerja :

1. Muatan berguna terbagi rata = 1 ton/m' = 1000 kg/m'
2. Beban tembok 1 batu = 500 kg/m² = 500 x 2,00 = 1000 kg/m'
3. Berat sendiri balok ukuran 30/60 = 0,30x0,60x1,00x
2400 = 432 kg/m'
q = 2432 kg/m'

Dilihat dibuku tabel Momen dari beton Kalender :



$$M_C = M_D = \frac{q \cdot l^2}{6(k+2)}$$

$$M_A : M_B = \frac{q \cdot l^2}{12(k+2)}$$

$$k = \frac{I_2}{I_1} \frac{h}{l} = \frac{\frac{1}{12} \times 0,30 \times 0,60^3}{\frac{1}{12} \times 0,30 \times 0,30^3} \times \frac{3,00}{6,00} : \frac{0,216}{0,027} \times \frac{3,00}{6,00}$$

$$= \frac{0,648}{0,162} = 4.$$

$$M_C = M_D = \frac{2432 \times 6,00^2}{6(4+2)} = \frac{87552}{36} = 2432 \text{ kgm.}$$

$$M_A = M_B = \frac{2432 \times 6,00^2}{12(k+2)} = \frac{87552}{72} = 1216 \text{ kgm.}$$

Diselesaikan dengan cara Cross :

Momen primair.

$$M_{pCD} = -M_{pDC} = \frac{1}{12} q l^2 = \frac{1}{12} \times 2432 \times 6,00^2 = 7296 \text{ kgm.}$$

Faktor Distribusi.

$$\mu_{CD} : \mu_{CA} = \frac{4EI_{CD}}{l_{CD}^3} : \frac{4EI_{CA}}{l_{CA}^3}$$

$$= \frac{1/12 \times 0,30 \times 0,60^3}{6,00} : \frac{1/12 \times 0,30 \times 0,30^3}{3,00}$$

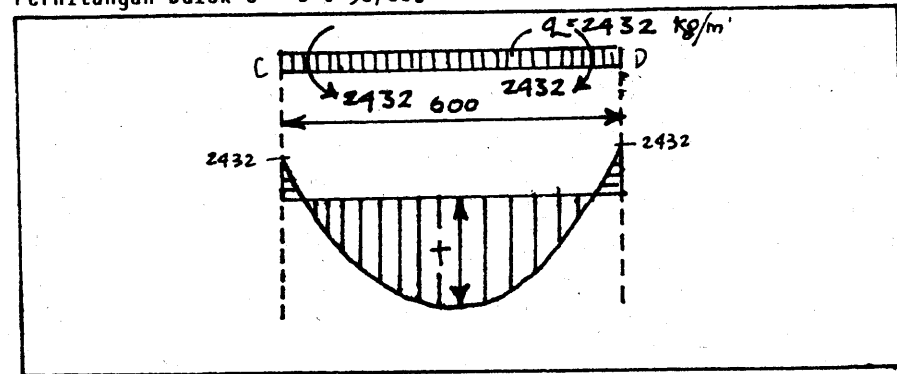
$$= \frac{0,216}{6,00} : \frac{0,027}{3,00}$$

$$= 0,036 : 0,009 = 36 : 9 = \frac{4}{5} : 1$$

$$\left. \begin{array}{l} \mu_{CD} : \frac{4}{5} = 0,800 \\ \mu_{CA} : \frac{1}{5} = 0,200 \end{array} \right\} \Sigma \mu = 1,000$$

TITIK	C		D		B	A
BATANG	CA	CD	DC	DB	BD	AC
F.D.	0,200	0,800	0,800	0,200	-	-
M _{prima}	-	+7296	-7296	-	-	-
	+1459,2	-5836,8	+5836,8	+1459,2		
		+2918,4	-2918,4	+729,6	-729,6	
	-583,68	-2334,72	+2334,72	+583,68		
		+1167,36	-1167,36	+291,84	-291,84	
	-233,472	-933,888	+933,888	+233,472		
		-466,944	-466,944	+116,74	-116,74	
	- 93,39	-373,55	+373,55	+ 93,39		
		+186,775	-186,775	+ 46,70	- 46,70	
	- 37,355	-149,42	+149,42	+37,355		
		+ 74,71	- 74,71	+ 18,68	- 18,68	
	- 14,942	- 59,768	+ 59,768	+14,942		
		+ 29,884	- 29,884	+ 7,471	- 7,471	
	- 5,977	- 23,907	+ 23,907	+ 5,977		
		+ 11,954	- 11,954	+ 2,988	- 2,988	
	- 2,391	- 9,563	+ 9,563	+ 2,391		
		+ 4,781	- 4,781	+ 1,195	- 1,195	
	- 0,956	- 3,825	+ 3,825	+ 0,956		
		+ 1,912	- 1,912	+ 0,478	0,478	
	- 0,382	- 1,530	+ 1,530	+ 0,382		
				+ 0,191	- 0,191	
M _{akhir}	-2431,75	+2431,75	-2431,75	+2431,75	+1215,88	-1215,88

Perhitungan Balok C - D : 30/60.



$$\begin{aligned}
 M_{lap} (+) &= \frac{1}{8} q l^2 = 2432 \\
 &= \frac{1}{8} 2432 \times 6,00^2 - 2432 \\
 &= 10.944 - 2432 = \underline{\underline{8512 \text{ kgm.}}}
 \end{aligned}$$

$$Ca = \frac{60 - 5}{\sqrt{\frac{8512 \times 21}{0,30 \times 1400}}} = \frac{55}{20,630} = 2,666$$

$$\delta = 0,4 \rightarrow nw = 0,1667$$

$$\phi = 1,500 > \phi_0 = 0,889$$

$$A = \frac{0,1667}{21} \times 30 \times 55 = 13,10 \text{ cm}^2$$

$$\text{Didapat tulangan : } \underline{\underline{5 \phi 19}} = 14,20 \text{ cm}^2 > 13,10 \text{ cm}^2$$

$$A' = 0,4 A = 0,4 \times 13,10 = 5,24 \text{ cm}^2$$

$$\text{Dipakai tulangan : } \underline{\underline{3 \phi 16}} = 6,03 \text{ cm}^2 > 5,24 \text{ cm}^2$$

$$M_{tulangan} = 2432 \text{ kgm.}$$

$$Ca = \frac{60 - 5}{\sqrt{\frac{2432 \times 21}{0,30 \times 1400}}} = \frac{55}{11,02724} = 4,988$$

$$\delta = 0,4 \rightarrow nw = 0,04529$$

$$\phi = 3,000 > \phi_0 = 0,889$$

$$A = \frac{0,04529}{21} \times 30 \times 55 = 3,56 \text{ cm}^2$$

$$\text{Dipakai tulangan : } 3 \phi 16 = 6,03 \text{ cm}^2 > 3,56 \text{ cm}^2$$

$$A' = 0,4 A = 0,4 \times 3,56 = 1,424 \text{ cm}^2$$

$$\text{Dipakai tulangan : } 3 \phi 19 = 8,52 \text{ cm}^2 > 1,424 \text{ cm}^2$$

Perhitungan geser :

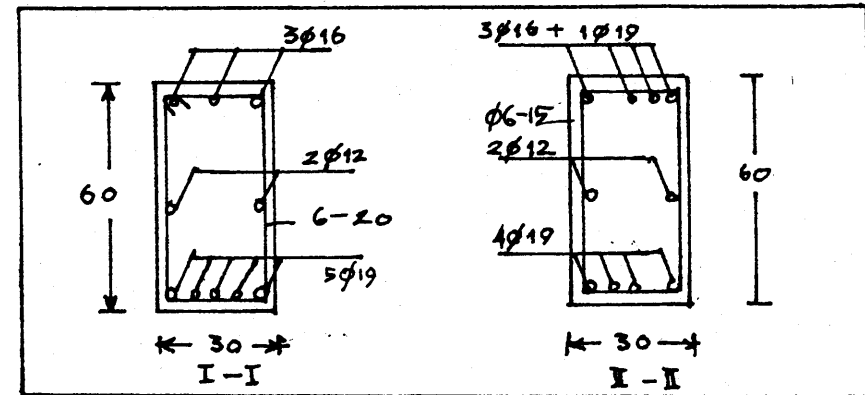
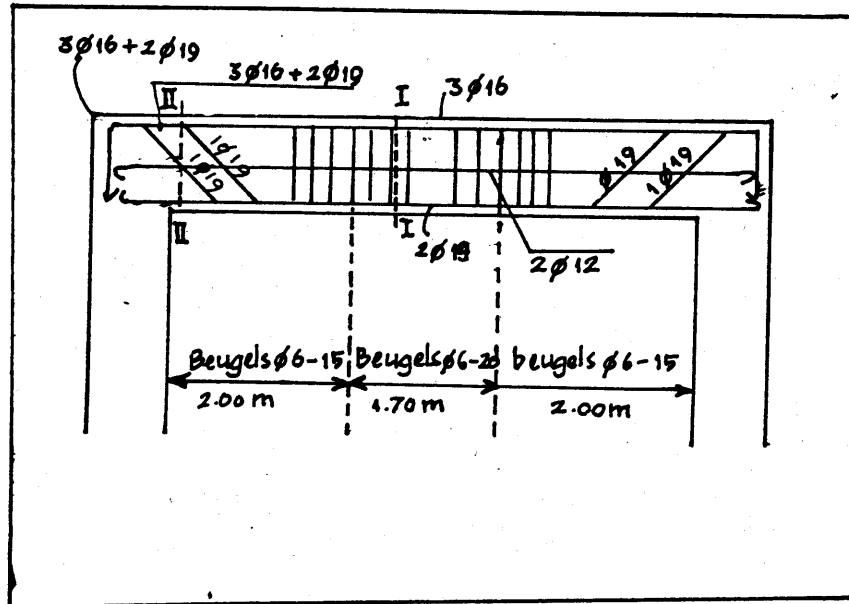
$$D_{\max} = \frac{1}{2} q_{CD} = \frac{1}{2} \times 2432 \times 6,00 = 7296 \text{ kg.}$$

$$\tau_b = \frac{D_{\max}}{b \times \frac{7}{8} h} = \frac{7296}{30 \times \frac{7}{8} \times 55} = \frac{7296}{1443,75} = 5,054 \text{ kg/cm}^2$$

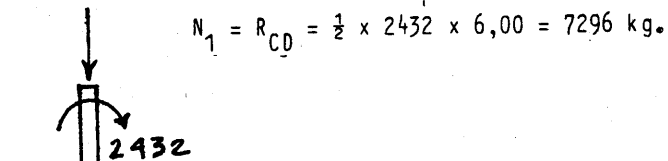
$$< \bar{\tau}_b = 6,5 \text{ kg/cm}^2$$

Tidak diperlukan tulangan geser.

Diberi tulangan geser praktis : 2 $\phi 19$.



Perhitungan Kolom2 : CA dan DB.



$$N_1 = R_{CD} = \frac{1}{2} \times 2432 \times 6,00 = 7296 \text{ kg.}$$

$$\begin{aligned} N_2 &= N_1 + \text{berat sendiri kolom} = 7296 + 0,30 \times 0,30 \times 2,40 \times 2400 \\ &= 7296 + 518,4 \\ &= 7814,4 \text{ kg} \end{aligned}$$

$$N_1 = 7296 \text{ kg}$$

$$M_1 = 2432 \text{ kgm}$$

$$e_{o1} = \frac{M_1}{N_1} = \frac{2432}{7296} = 0,333 \text{ m}$$

$$e_{o2} = \frac{1}{30} h_t = \frac{1}{30} \times 0,30 = 0,010 \text{ m} \rightarrow \text{minimum} = 0,02 \text{ m}$$

$$e_o = e_{o1} + e_{o2} = 0,333 + 0,02 = 0,353 \text{ m}$$

$$\frac{e_o}{h_t} = \frac{0,353}{0,30} = 1,177 > 1 \quad \left\{ \begin{array}{l} c_2 = 7,00 \text{ (baja lunak)} \\ c_1 = 1 \text{ penampang persegi} \end{array} \right.$$

$$e_1 = c_1 \cdot c_2 \left(\frac{l_k}{100 h_t} \right)^2 h_t$$

$$= 1 \times 7,00 \left(\frac{2,40}{100 \times 0,30} \right)^2 \times 0,30$$

$$= 7,00 (0,08)^2 \times 0,30$$

$$= 7,00 \times 0,0064 \times 0,30 = 0,0134 \text{ m}$$

$$e_2 = 0,15 h_t = 0,15 \times 0,30 = 0,045 \text{ m}$$

$$e = e_0 + e_1 + e_2 = 0,352 + 0,0134 + 0,045 = 0,4114 \text{ m}$$

$$e_a = e + \frac{1}{2} h_t - 0,05 = 0,4114 + 0,15 - 0,05 = 0,5114 \text{ m}$$

$$N \times e_a = 7296 \times 0,5114 = 3731,2 \text{ kgm.}$$

$$C_a = \frac{30 - 5}{\sqrt{\frac{21 \times 3731,2}{0,30 \times 1400}}} = \frac{25}{13,6587} = 1,8303$$

$$\delta = 1 - \frac{7}{8} \frac{h}{e_a} = 1 - \frac{7}{8} \frac{0,25}{0,5114} = 1 - \frac{1,75}{4,0912} = 1 - 0,4278 = 0,572 \approx 0,6$$

$$C_a = 1,8303$$

$$\delta = 0,6 \longrightarrow \begin{aligned} n_w &= 0,3421 \\ \eta &= 0,868 \\ \phi &= 1,150 \\ \phi' &= 1,466 \end{aligned}$$

Tegangan2 yang terjadi :

$$\sigma_a = \bar{\sigma}_a = 1400 \text{ kg/cm}^2.$$

$$\sigma_{b'} = \frac{\bar{\sigma}_a}{n\phi} = \frac{1400}{21 \times 1,150} = \frac{1400}{24,15} = 57,97 \text{ kg/cm}^2 < 75 \text{ kg/cm}^2.$$

$$\sigma_{a'} = \frac{\bar{\sigma}_s}{n\phi'} = \frac{1400}{21 \times 1,466} = \frac{1400}{30,786} = 45,5 \text{ kg/cm}^2 < 1400 \text{ kg/cm}^2$$

Tulangan :

$$\frac{e_a}{h} = \frac{0,5114}{0,25} = 2,05 \quad \left. \begin{array}{l} \text{dari tabel didapat :} \\ i = 1,70 \end{array} \right\}$$

$$\eta = 0,868$$

$$iA = \frac{n_w}{n} \times 30 \times 25$$

$$= \frac{0,3421}{21} \times 30 \times 25 = 12,22 \text{ cm}^2.$$

$$A = \frac{12,22}{1,70} = 7,19 \text{ cm}^2.$$

$$A' = 5 iA = 0,6 \times 12,22 = 7,332 \text{ cm}^2.$$

$$\text{Dipakai tulangan : } 3 \phi 19 = 8,52 \text{ cm}^2 > 7,19 \text{ cm}^2 \\ > 7,332 \text{ cm}^2$$

Dicheck dengan grafis by Wiratman.

$$\frac{e}{h_t} = \frac{0,4114}{0,30} = 1,37133$$

$$\sigma_o' = \frac{N}{b \cdot h_t} = \frac{7296}{30 \times 30} = \frac{7296}{900} = 8,107 \text{ kg/cm}^2.$$

$$\frac{\sigma_o!}{\sigma_b'} = \frac{8,107}{75} = 0,108$$

$$n_{w_{tot}} = 0,20$$

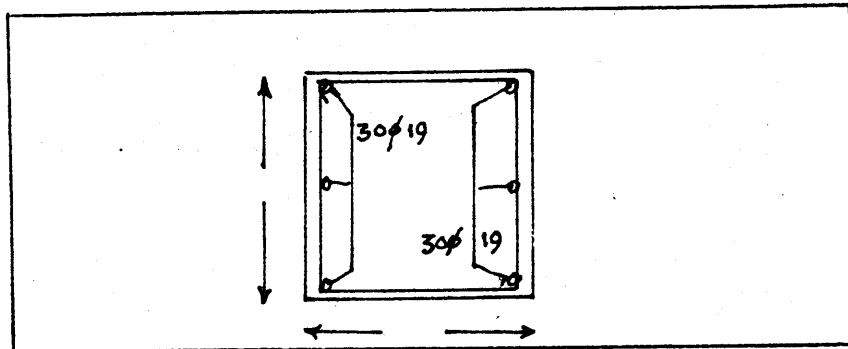
$$A_{tot} = \frac{n_{w_{tot}}}{n} b h_t = \frac{0,19}{21} \times 30 \times 30 = 8,14 \text{ cm}^2.$$

$$\frac{1}{2} A_{tot} : \frac{1}{2} \times 8,14 = 4,07 \text{ cm}^2.$$

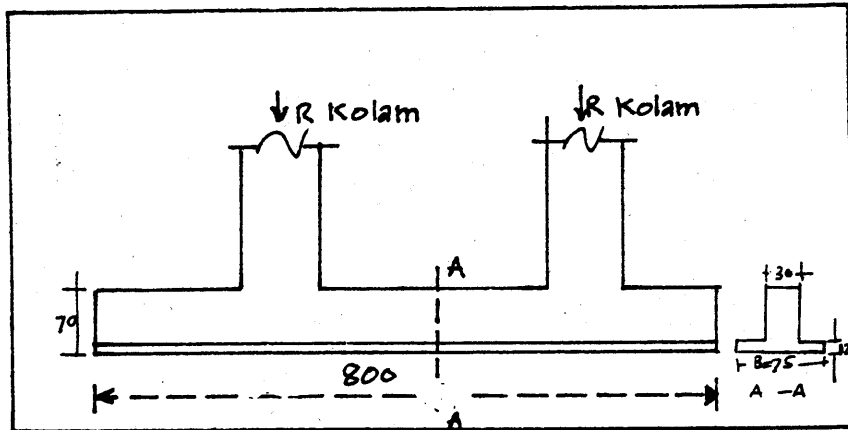
$$\text{Dipakai tulangan : } 3 \phi 19 = 8,52 \text{ cm}^2 > 4,07 \text{ cm}^2$$

$$\text{Tulangan minimum kolom : } 1\% = 0,01 \times 30 \times 30 \\ = 9 \text{ cm}^2.$$

$$\text{Tul. minimum } A = A' = \frac{1}{2} \times 9 = 4,5 \text{ cm}^2$$



Perhitungan pondasi :



$$\begin{aligned} R_{\text{kolom}} &= \frac{1}{2} q \cdot l_{\text{CD}} + \text{berat sendiri kolom} \\ &= \frac{1}{2} \times 2432 \times 6,00 + 0,30 \times 0,30 \times 3,00 \times 2400 \\ &= 7296 + 648 = 7944 \text{ kg.} \end{aligned}$$

$$\begin{aligned} \text{Berat sendiri pondasi} &= 0,12 \times 0,75 \times 8,00 \times 2400 + 0,30 \times 0,58 \times 8,00 \times 2400 \\ &= 1728 + 3340,8 = 5068,8 \approx 5069 \text{ kg.} \end{aligned}$$

$$\sigma_{\text{tanah}} = \frac{\sum V}{F}$$

$$\sum V = 2 \times 7944 + 5069 = 15888 + 5069 = 20957 \text{ kg.}$$

$$\begin{aligned} \sigma_{\text{tanah}} &= \frac{20.957}{800 \times 75} = \frac{20.957}{60.000} = 0,3493 \text{ kg/cm}^2 \\ &\text{harus} < \sigma_{\text{tanah}} = 0,350 \text{ kg/cm}^2 \end{aligned}$$

Perhitungan Pelat Pondasi.

$$M_{\text{pelat}} : \frac{1}{2} \sigma_p \cdot \left(\frac{8}{2} \right)^2 \rightarrow \text{untuk pelat tiap lebar } 1 \text{ m'}$$

$$\sigma_p = \frac{20.957 - 1728}{800 \times 75} = \frac{19.229}{60.000} = 0,3205 \text{ kg/cm}^2 = 3205 \text{ kg/m}^2.$$

$$\begin{aligned} M_{\text{pelat}} &: \frac{1}{2} \times 3205 \times \left(\frac{0,75}{2} \right)^2 = \frac{1}{2} \times 3205 \times 0,375^2 \\ &= 225,4 \text{ kgm.} \end{aligned}$$

$$C_a = \frac{12 - 1,5 - 0,4}{\sqrt{\frac{225,4 \times 21}{1,00 \times 1400}}}$$

$$= \frac{10,1}{1,839} = 5,492$$

$$\delta = 0 \rightarrow n_w = 0,03610$$

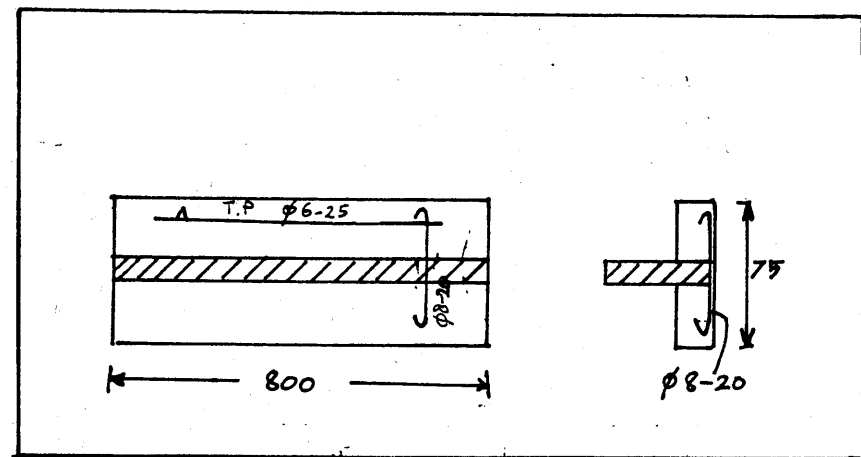
$$\phi = 3,255 > \phi_0 = 0,889$$

$$A = \frac{0,03610}{21} \times 100 \times 10,1 = 1,74 \text{ cm}^2$$

$$\begin{aligned} \text{Dipakai tulangan : } \phi 8 - 20 &= 2,51 \text{ cm}^2 \\ &> 1,74 \text{ cm}^2 \end{aligned}$$

$$\text{I.P.} = 20 \% A : 0,02 \times 2,51 = 0,05 \text{ cm}^2$$

$$\text{Dipakai tulangan : } \phi 6 - 20 = 1,41 \text{ cm}^2 > 0,05 \text{ cm}^2$$



Perhitungan Balok Rib : 30/70.

$$\sigma_p = \frac{20.957 - 1728 - 3341}{800 \times 75} = \frac{15.888}{60.000} = 0,265 \text{ kg/cm}^2 = 2650 \text{ kg/m}^2$$

$$q_{\text{balok}} = 2650 \times 0,75 = 1987,5 \text{ kg/m'}$$

$$M_{\text{jepit}} = \frac{1}{2} \times q \times a^2 = \frac{1}{2} \times 1987,5 \times 1,00^2 = 993,75 \text{ kgm.}$$

$$\begin{aligned} M_{\text{lapangan (+)}} &= \frac{1}{8} q l^2 - \frac{1}{2} q a^2 \\ &= \frac{1}{8} \times 1987,5 \times 6,00^2 - \frac{1}{2} \times 1987,5 \times 1,00^2 \\ &= 8943,75 - 993,75 = 7950 \text{ kgm.} \end{aligned}$$

$$M_{\text{lapangan (+)}} = 7950 \text{ kgm.}$$

$$C_a = \frac{70 - 5}{\sqrt{\frac{7950 \times 21}{0,30 \times 1400}}} = \frac{65}{19,9374} = 3,2602$$

$$\delta = 0,4 \rightarrow n_w = 0,1068$$

$$\phi = 1,899 > \phi_0 = 0,889$$

$$A = \frac{0,1068}{21} \times 30 \times 65 = 9,92 \text{ cm}^2$$

$$\text{Dipakai tulangan : } 4 \phi 19 = 11,36 \text{ cm}^2 > 9,92 \text{ cm}^2$$

$$A' = 0,4 A = 0,4 \times 9,92 = 3,97 \text{ cm}^2$$

$$\text{Dipakai tulangan : } 4 \phi 12 = 4,52 \text{ cm}^2 > 3,97 \text{ cm}^2$$

$$M_{\text{jepit}} = 993,75 \text{ kgm.}$$

$$C_a = \frac{70 - 5}{\sqrt{\frac{993,75 \times 21}{0,30 \times 1400}}} = \frac{65}{7,049} = 9,2211$$

$$\delta = 0,6 \rightarrow n_w = 0,0127$$

$$\phi = 5,897 > \phi_0 = 0,889$$

$$A = \frac{0,0127}{21} \times 30 \times 65 = 1,180 \text{ cm}^2$$

$$\text{Dipakai tulangan : } 4 \phi 12 = 4,52 \text{ cm}^2 > 1,180 \text{ cm}^2$$

$$A' = 0,6 A = 0,6 \times 1,180 = 0,71 \text{ cm}^2$$

$$\text{Dipakai tulangan : } 2 \phi 19 = 5,68 \text{ cm}^2 > 0,71 \text{ cm}^2$$

$$\text{Perhitungan geser : } D_{bl} = q a = 1987,5 \times 1,00 = 1987,5 \text{ kg}$$

$$D_{\text{max}} = \frac{1}{2} \times q \times l = \frac{1}{2} \times 1987,5 \times 6,00 = 5962,5 \text{ kg}$$

$$(= D_{br})$$

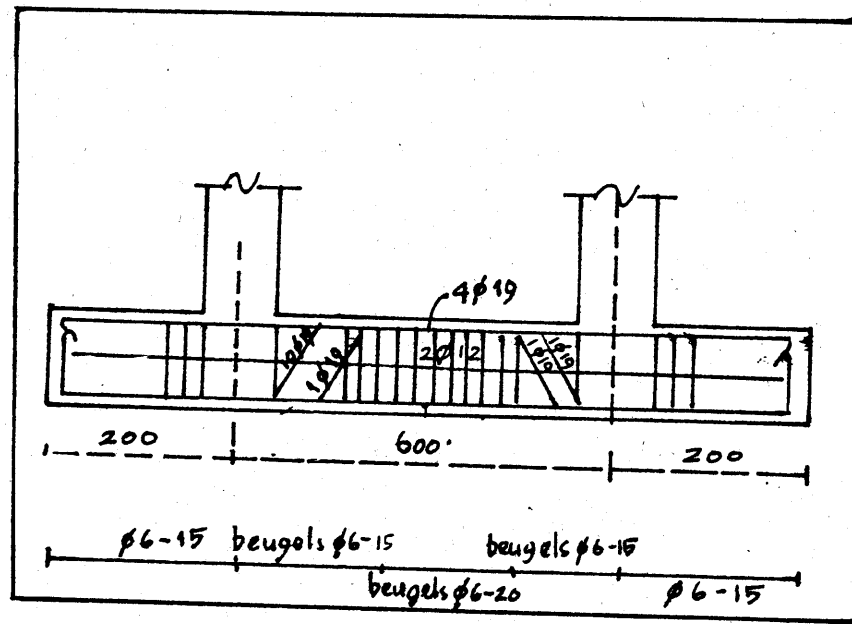
$$\tau_b = \frac{D_{\text{max}}}{b \times \frac{778}{n}} = \frac{5962,5}{30 \times \frac{778}{65}} = \frac{5962,5}{1706,25} = 3,495 \text{ kg/cm}^2$$

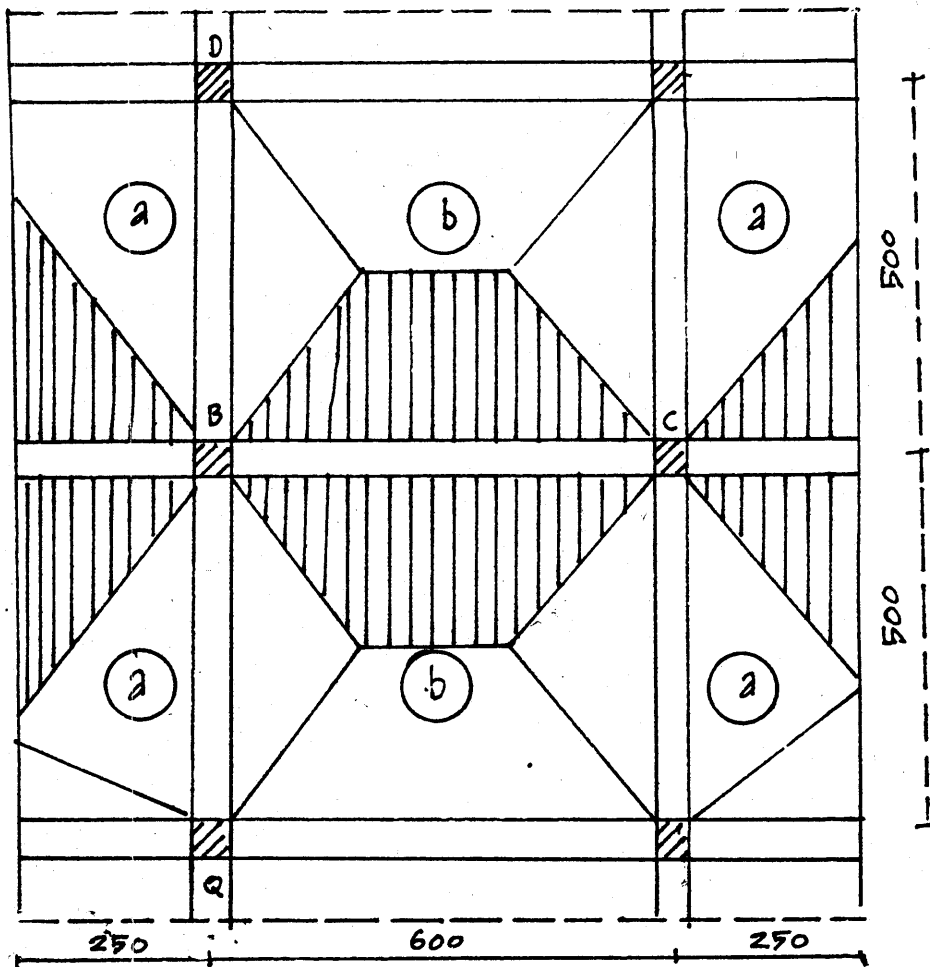
$$b = 3,495 \text{ kg/cm}^2$$

$$< \tau_b = 6,50 \text{ kg/cm}^2$$

Tidak diperlukan tulangan geser.

Diberi tulangan geser praktis 2 ϕ 19.





Diketahui : mutu beton K_{225}
 mutu baja QR_{24}
 tebal plat pondasi = 23 cm
 $P = 20$ ton
 $\bar{\sigma}_{\text{tanah}} (\sigma_{\text{ijin}}) = 0,4 \text{ kg/cm}^2$.

Rencanakan : Pondasi tersebut (pembagian tegangan pada pelat seperti pada gambar diatas).

Beban2 :

- Berat sendiri pelat pondasi (tabel = 23 cm)
 $0,23 \times 11,00 \times 5,00 \times 2400 = 30.360 \text{ kg}$
 - Berat balok A - B - C - D (30/60)
 $0,30 \times 0,60 \times 11,00 \times 2400 = 4.752 \text{ kg}$
 - Berat balok P.B.0 (30/60)
 $(0,30 \times 0,60 \times 5,00 \times 2400) \times 2 = 4.320 \text{ kg}$
 - Beban $P = 2 \times 20.000 = 40.000 \text{ kg}$
-
- $\Sigma V = 79.432 \text{ kg}$

$$\sigma_{\text{tanah}} : \frac{\Sigma V}{F} = \frac{79.432}{1100 \times 500} = \frac{79.432}{550.000} = 0,144 \text{ kg/cm}^2$$

$$< \bar{\sigma}_{\text{tanah}} = 0,4 \text{ kg/cm}^2$$

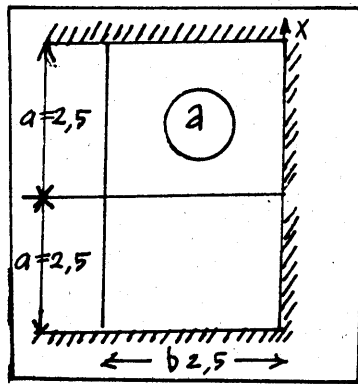
$$\sigma_{\text{tanah}} : 0,144 \text{ kg/cm}^2 = 0,144 \text{ kg} / \frac{1}{10.000} \text{ m}^2$$

$$= \underline{\underline{1440 \text{ kg/m}^2}}$$

$$\underline{\underline{q = 1440 \text{ kg/m}^2}}$$

Perhitungan pelat pondasi :

Pelat a :



Untuk mencari momen digunakan :
Tabel Moody sehingga didapat besarnya koefisien2 momen.

$$a/b = \frac{2,5}{2,5} = 1 ; q = 1440 \text{ kg/cm}^2.$$

Koefisien momen :

$$c_{ix} = -0,2613$$

$$c_x = +0,1008$$

$$c_{iy} = -0,2043$$

$$c_y = +0,0243$$

Momen2 :

$$M_x \text{ tumpuan} = c_{ix} \times q \times b^2 = -0,2613 \times 1440 \times 2,5^2 = -2351,7 \text{ kgm}$$

$$M_x \text{ lapangan} = c_x \times q \times b^2 = +0,1008 \times 1440 \times 2,5^2 = +907,2 \text{ kgm}$$

$$M_y \text{ tumpuan} = c_{iy} \times q \times b^2 = -0,2043 \times 1440 \times 2,5^2 = -1838,7 \text{ kgm}$$

$$M_x \text{ lapangan} = c_y \times q \times b^2 = +0,0243 \times 1440 \times 2,5^2 = +218,7 \text{ kgm}$$

$$h_t = 23 \text{ cm}$$

$$h = 23 - 2 - 0,6 = 20,4 \text{ cm}$$

$$M_x \text{ tumpuan} = -2351,7 \text{ kgm.}$$

$$Ca = \frac{20,4}{\sqrt{\frac{2351,7 \times 21}{1,00 \times 1400}}} = \frac{20,4}{5,9393181} = 3,435$$

$$\delta = 0 \text{ ----> } nw = 0,0963$$

$$\phi = 1,833 > \phi_0 = \frac{1400}{21 \times 75} = \frac{1400}{1575} = 0,889$$

$$A = \frac{0,0963}{21} \times 100 \times 20,4 = 9,355 \text{ cm}^2.$$

$$\text{Dipakai tulangan : ----> } \phi 10 - 40 + \phi 22 - 40 \\ = 1,96 + 9,515 = 11,465 \text{ cm}^2 > 9,355 \text{ cm}^2.$$

$$- M_x \text{ lapangan} = +907,2 \text{ kgm.}$$

$$Ca = \frac{20,5}{\sqrt{\frac{907,2 \times 21}{1,00 \times 1400}}} = \frac{20,5}{3,6889} = 5,557$$

$$\delta = 0 \text{ ----> } nw = 0,03540$$

$$\phi = 3,292 > \phi_0 = 0,889$$

$$A = \frac{0,03540}{21} \times 100 \times 20,4 = 3,44 \text{ cm}^2.$$

$$\text{Dipakai tulangan : } \phi 10 - 20 = 3,93 \text{ cm}^2 \\ > 3,44 \text{ cm}^2$$

$$- M_y \text{ tumpuan} = -1838,7 \text{ kgm.}$$

$$Ca = \frac{23 - 2 - 1,0 - 0,5}{\sqrt{\frac{1838,7 \times 21}{1,00 \times 1400}}} = \frac{19,5}{5,252} = 3,713$$

$$\delta = 0 \text{ ----> } nw = 0,08188$$

$$\phi = 2,021 > \phi_0 = 0,889$$

$$A = \frac{0,08188}{21} \times 100 \times 19,5 = 7,603 \text{ cm}^2.$$

$$\text{Dipakai tulangan : } \phi 10 - 40 \} 1,96 + 7,09 \\ \phi 19 - 40 \} \\ = 9,05 \text{ cm}^2 \\ > 7,603 \text{ cm}^2$$

$$- M_y \text{ lapangan} = +218,7 \text{ kgm.}$$

$$Ca = \frac{23 - 2 - 1,0 - 0,5}{\sqrt{\frac{218,7 \times 21}{1,00 \times 1400}}} = \frac{19,5}{1,8112} = 10,766$$

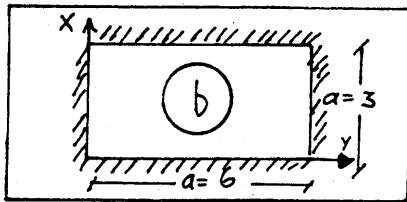
$$\delta = 0 \text{ ----> } nw = 0,00908$$

$$\phi = 6,936 > \phi_0 = 0,889$$

$$A = \frac{0,00908}{21} \times 100 \times 19,5 = 0,843 \text{ cm}^2.$$

$$\text{Dipakai : } \phi 10 - 40 = 1,96 \text{ cm}^2 > 0,843 \text{ cm}^2.$$

Pelat b :



$$a/b = \frac{5}{6} = 0,83$$

antara $\frac{3}{4}$ dan $\frac{7}{8}$

0,75 0,875

Diadakan interpolasi.

$$c_{ix} = -0,0686 + \frac{0,83 - 0,75}{0,875 - 0,75} (0,0686 - 0,0592)$$

$$= -0,0686 + \frac{0,08}{0,125} (0,0094) = -0,0686 + 0,006016 = -0,0626$$

$$e_x = 0,0324 - \frac{0,03}{0,125} (0,0324 - 0,0267) = 0,0324 - 0,003648 = 0,0287$$

$$c_{iy} = -0,0546 + \frac{0,08}{0,125} (0,0546 - 0,0530) = -0,0546 + 0,0010 = -0,0536$$

$$c_{y.} = 0,0191 + \frac{0,08}{0,125} (0,0209 - 0,0191) = 0,0191 + 0,0011 = 0,0202$$

Momen2 :

$$M_x \text{ tumpuan} = -0,0626 \times 1440 \times 5,00^2 = -2253,6 \text{ kgm.}$$

$$M_x \text{ lapangan} = +0,0287 \times 1440 \times 5,00^2 = +1033,2 \text{ kgm.}$$

$$M_y \text{ tumpuan} = -0,0536 \times 1440 \times 5,00^2 = -1929,6 \text{ kgm.}$$

$$M_y \text{ lapangan} = +0,0202 \times 1440 \times 5,00^2 = +727,2 \text{ kgm.}$$

- Mx tumpuan = -2253,6 kgm

$$C_a = \frac{23 - 2 - 0,6}{\sqrt{\frac{2253,6 \times 21}{1,00 \times 1400}}} = \frac{20,4}{5,81412} = 3,5087$$

$$\delta = 0 \text{ ----> } n_w = 0,0919$$

$$\phi = 1,882 > \phi_0 = 0,889$$

$$A = \frac{0,0919}{21} \times 100 \times 20,4 = 8,927 \text{ cm}^2.$$

$$\text{Dipakai tulangan : } \frac{\phi 10 - 38}{21} + \frac{\phi 19 - 38}{21} = 2,07 + 7,46 = 9,53 \text{ cm}^2 > 8,927 \text{ cm}^2.$$

- Mx lapangan = +1033,2 kgm.

$$C_a = \frac{23 - 2 - 0,5}{\sqrt{\frac{1033,2 \times 21}{1,00 \times 1400}}} = \frac{20,5}{3,93675} = 5,2073$$

$$\delta = 0 \text{ ----> } n_w = 0,04051$$

$$\phi = 3,048 > \phi_0 = 0,889$$

$$A = \frac{0,04051}{21} \times 100 \times 20,5 = 3,955 \text{ cm}^2.$$

$$\text{Dipakai tulangan : } \phi 10 - 19 = 4,14 \text{ cm}^2 > 3,955 \text{ cm}^2.$$

- My tumpuan = -1929,6 kgm.

$$C_a = \frac{23 - 2 - 1,0 - 0,5}{\sqrt{\frac{1929,6 \times 21}{1,00 \times 1400}}} = \frac{19,5}{5,37996} = 3,625$$

$$\delta = 0 \text{ ----> } n_w = 0,08629$$

$$\phi = 1,958 > \phi_0 = 0,889$$

$$A = \frac{0,08629}{21} \times 100 \times 19,5 = 8,013 \text{ cm}^2.$$

$$\text{Dipakai tulangan : } \frac{\phi 10 - 40}{21} + \frac{\phi 19 - 40}{21} = 1,96 + 7,09 = 9,05 \text{ cm}^2 > 8,013 \text{ cm}^2.$$

- My lapangan = + 727,2 kgm.

$$C_a = \frac{23 - 2 - 1 - 0,5}{\sqrt{\frac{727,2 \times 21}{1,00 \times 1400}}} = \frac{19,5}{3,3030} = 5,904$$

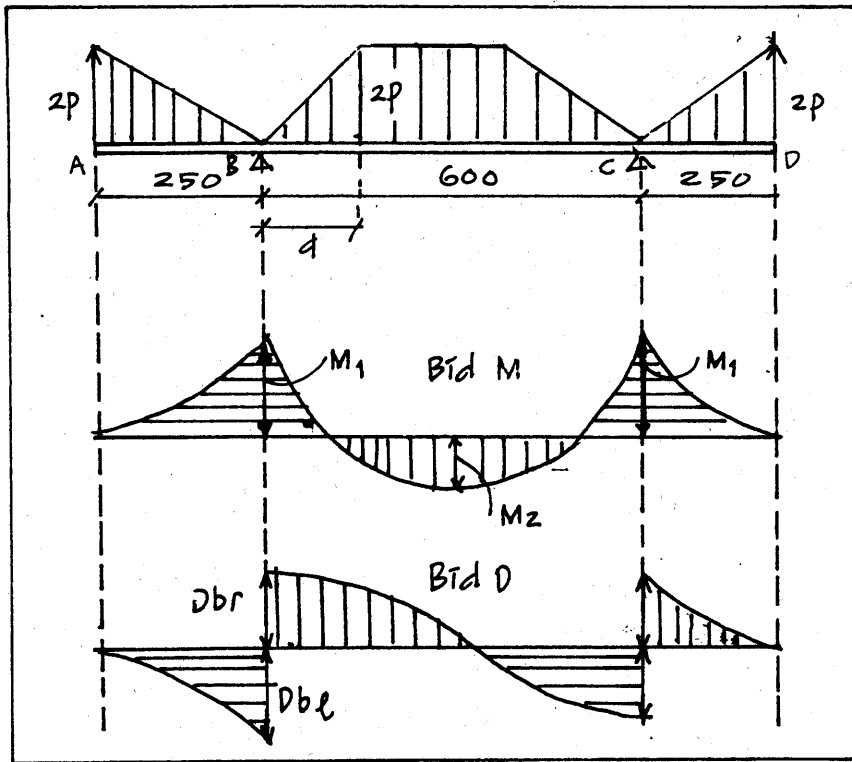
$$\delta = 0 \rightarrow nw = 0,03103$$

$$\phi = 3,545 > \phi_0 = 0,889$$

$$A = \frac{0,03103}{21} \times 100 \times 19,5 = 2,88 \text{ cm}^2.$$

$$\text{Dipakai tulangan : } \frac{\phi 10 - 20}{\text{=====}} = 3,93 \text{ cm}^2 > 2,88 \text{ cm}^2.$$

Perhitungan Balok A-B-C-D : 30/60 (taksir)



Beban2 :

$$\sigma_{\text{tanah}} = \frac{79.432 - 30.360 - 4752}{1100 \times 500} = \frac{44.320}{550.000} = 0,0806 \text{ kg/cm}^2.$$

$$q = 806 \text{ kg/m}^2.$$

$$P = \frac{1}{2} q \cdot l = \frac{1}{2} \times 806 \times 5,00 = 2015 \text{ kg/m'}$$

$$\begin{aligned} M_1 &= \frac{1}{2} \times 2,5 \times 2p \left(\frac{2}{3} \times 2,50 \right) = \frac{2}{3} \times 2,50^2 \times P \\ &= \frac{2}{3} \times 6,25 \times 2015 \\ &= 8395,83 \text{ kgm.} \end{aligned}$$

$$\begin{aligned} M_2 &= \left(\frac{1}{8} 2P \cdot l^2 - \frac{1}{6} 2P d^2 \right) - M_1 \\ &= \left(\frac{1}{8} \times 2 \times 2015 \times 6,00^2 - \frac{1}{6} \times 2 \times 2015 \times 2,50^2 \right) - 8395,83 \\ &= (18.135 - 4197,92) - 8395,83 \\ &= 5541,25 \text{ kgm.} \end{aligned}$$

$$D_{Bl} = \frac{1}{2} \times 2,50 \times 2P = 2,50 \times P = 2,5 \times 2015 = 5037,5 \text{ kg}$$

$$\begin{aligned} D_{Br} &= \frac{1}{2} (6 + 1) \frac{2P}{2} = \frac{1}{2} (6 + 1) P = \frac{1}{2} 7P = 3,5 P = 3,5 \times 2015 \\ &= 7052,5 \text{ kg.} \end{aligned}$$

$$- M_1 = - 8395,83 \text{ kgm (M jepit).}$$

$$C_a = \frac{60 - 5}{\sqrt{\frac{8395,83 \times 21}{0,30 \times 1400}}} = \frac{55}{20,4888} = 2,6844$$

$$\delta = 0,4 \rightarrow nw = 0,1602$$

$$\phi = 1,532 > \phi_0 = 0,889$$

$$A = \frac{0,1602}{21} \times 30 \times 55 = 12,587 \text{ cm}^2.$$

$$\text{Dipakai tulangan : } \frac{5 \phi 19}{\text{=====}} = 14,20 \text{ cm}^2 > 12,587 \text{ cm}^2$$

$$A' = 0,4 A = 0,4 \times 12,587 = 5,035 \text{ cm}^2.$$

$$\text{Dipakai tulangan : } \underline{\underline{3 \text{ } \emptyset 19}} = 8,52 \text{ cm}^2 > 5,035 \text{ cm}^2.$$

$$- M \text{ lapangan } (M_2) = + 5541,25 \text{ kgm.}$$

$$C_a = \frac{60 - 5}{\sqrt{\frac{5541,25 \times 21}{0,30 \times 1400}}} = \frac{55}{16,6452} = 3,3043$$

$$\delta = 0,4 \text{ ----> } n_w = 0,1068$$

$$\emptyset = 1,899 > \emptyset_0 = 0,889$$

$$A = \frac{0,1068}{21} \times 30 \times 55 = 8,392 \text{ cm}^2.$$

$$\text{Dipakai tulangan : } \underline{\underline{3 \text{ } \emptyset 19}} = 8,52 \text{ cm}^2 > 8,392 \text{ cm}^2.$$

$$A' = 0,4 A = 0,4 \times 8,392 = 3,3576 \text{ cm}^2.$$

$$\text{Dipakai tulangan : } \underline{\underline{2 \text{ } \emptyset 19}} = 5,68 \text{ cm}^2 > 3,357 \text{ cm}^2.$$

Perhitungan geser :

$$M_{\max} = D_{br} = 7052,5 \text{ kg}$$

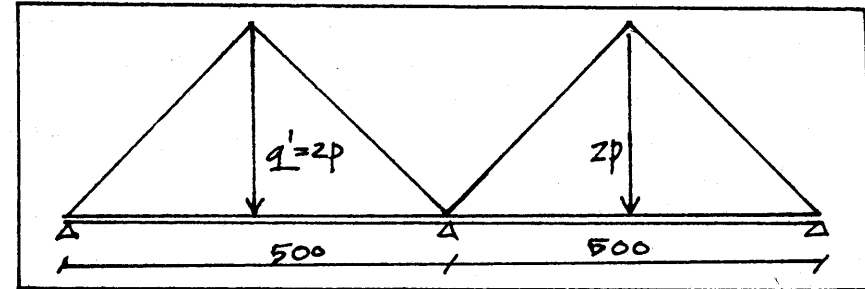
$$\tau_b = \frac{D_{\max}}{b \times \frac{7}{8} h} = \frac{7052,5}{30 \times \frac{7}{8} \times 55} = \frac{7052,5}{1443,75} = 4,885 \text{ kg/cm}^2.$$

$$\tau_b = 4,885 \text{ kg/cm}^2 < \tau_b = 6,5 \text{ kg/cm}^2 \text{ ----> } K_{225}$$

Tidak diperlukan tulangan geser.

Diberi tulangan geser praktis : 2 \text{ } \emptyset 19.

Perhitungan Balok P-8-0 : 30/60.



$$P : \frac{1}{2} q \times l_x = \frac{1}{2} \times q \times 5,00$$

$$\sigma_{\text{tanah}} = \frac{40.000}{1100 \times 500} = \frac{40.000}{550.000} = 0,0727 \text{ kg/cm}^2$$

$$q = 727 \text{ kg/m}^2.$$

$$P : \frac{1}{2} q \cdot l = \frac{1}{2} \times 727 \times 5,00 = 1817,5 \text{ kg.m'}$$

$$M_{\max (+)} = \frac{1}{32} q' l^2 = \frac{1}{32} \times 2P \times 5,00^2$$

$$\frac{1}{32} \times 2 \times 1817,5 \times 5,00^2 = + 2839,84 \text{ kgm.}$$

$$M_{\text{jepit } (-)} = - \frac{5}{96} q^2 = - \frac{5}{96} \times 2 \times 1817,5 \times 5,00^2 = -4733,1 \text{ kgm.}$$

$$D_{\max} = \frac{1}{4} q' l = \frac{1}{4} \times 2P \times 5,00 = \frac{1}{4} \times 2 \times 1817,5 \times 5,00$$

$$= 4543,75 \text{ kg.}$$

$$M_{\max (+)} = + 2839,84 \text{ kgm.}$$

$$C_a = \frac{60 - 5}{\sqrt{\frac{2839,84 \times 21}{0,30 \times 1400}}} = \frac{55}{11,916} = 4,616$$

$$\delta = 0,4 \text{ ----> } n_w = 0,05248$$

$$\emptyset = 2,774 > \emptyset_0 = 0,889$$

$$A = \frac{0,05248}{21} \times 30 \times 55 = 4,123 \text{ cm}^2.$$

Dipakai tulangan : $\underline{\underline{3 \text{ } \phi 16}} = 6,03 \text{ cm}^2 > 4,123 \text{ cm}^2$.

$$A' = 0,4 A = 0,4 \times 4,123 = 1,650 \text{ cm}^2$$

Dipakai tulangan : $\underline{\underline{2 \text{ } \phi 16}} = 4,02 \text{ cm}^2 > 1,650 \text{ cm}^2$.

M jepit (-) = - 4733,1 kgm.

$$C_a = \frac{60 - 5}{\sqrt{\frac{4733,1 \times 21}{0,30 \times 1400}}} = \frac{55}{15,3836} = 3,5753$$

$$\delta = 0,4 \text{ ----> } n_w = 0,09028$$

$$\phi = 2,077 > \phi_0 = 0,889$$

$$A = \frac{0,09028}{21} \times 30 \times 55 = 7,093 \text{ cm}^2$$

Dipakai tulangan : $4 \text{ } \phi 16 = 8,04 \text{ cm}^2$
 $> 7,093 \text{ cm}^2$

$$A' = 0,4 A = 0,4 \times 7,093 = 2,84 \text{ cm}^2$$

Dipakai tulangan : $3 \text{ } \phi 16 = 6,03 \text{ cm}^2$
 $> 2,84 \text{ cm}^2$

Perhitungan geser :

$$D_{\max} = 4543,75 \text{ kg}$$

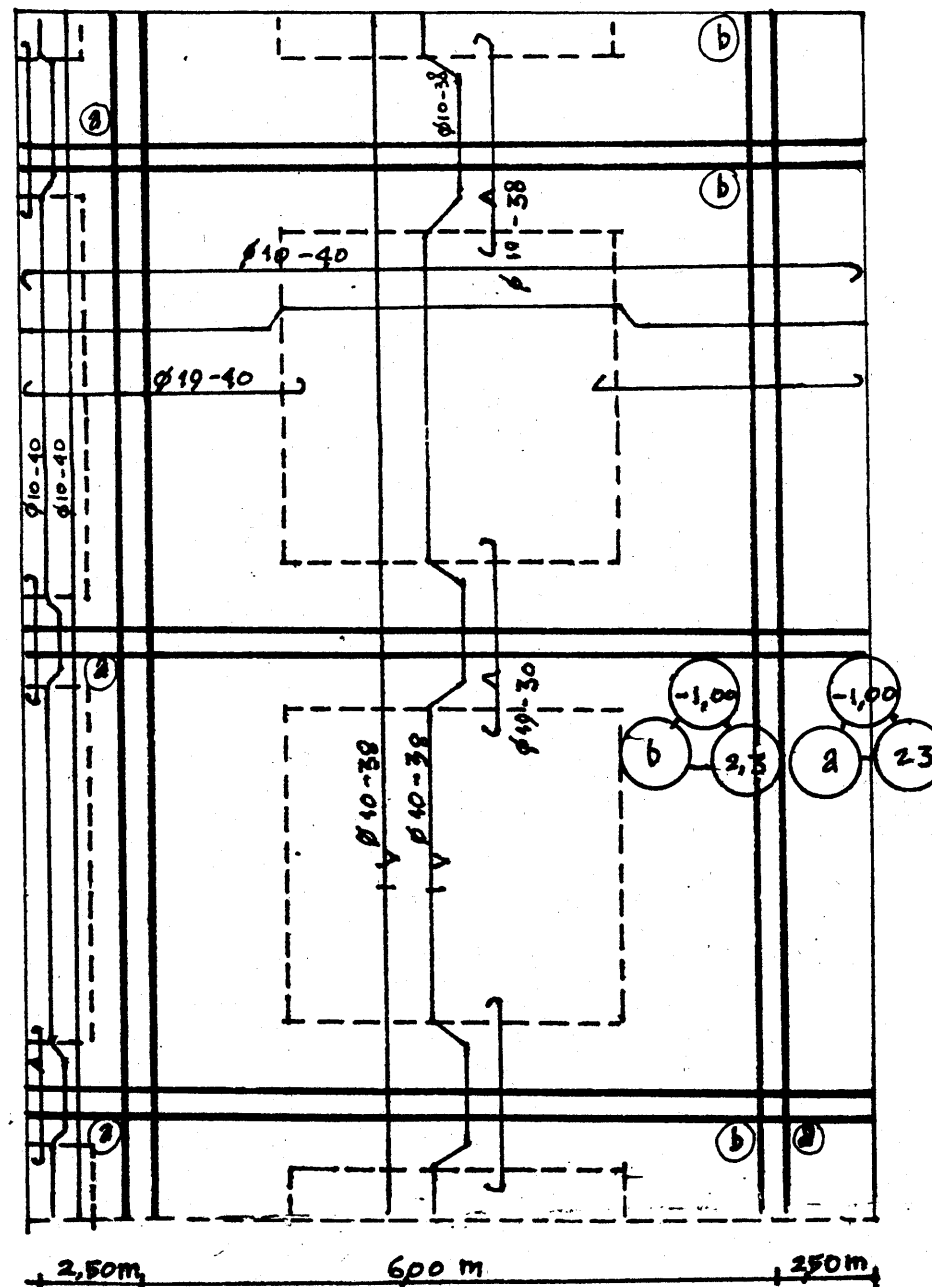
$$\tau_b = \frac{D_{\max}}{b \times \frac{778}{h}} = \frac{4543,75}{30 \times \frac{778}{55}} = \frac{4543,75}{1443,75} = 3,15 \text{ kg/cm}^2$$

$$\tau_b = 3,15 \text{ kg/cm}^2 < \bar{\tau}_b = 6,5 \text{ kg/cm}^2$$

Tidak diperlukan tulangan geser.

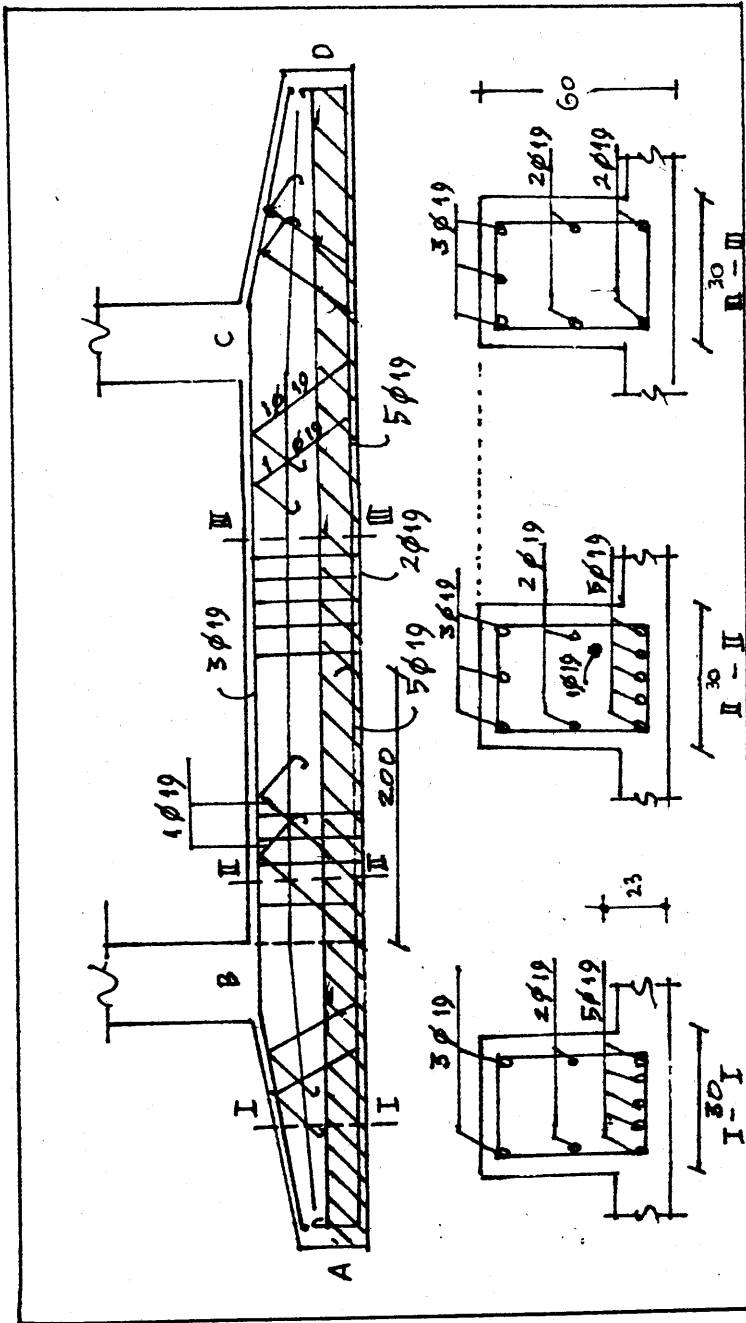
Diberi tulangan geser praktis : $2 \text{ } \phi 16$.

PENULANGAN PELAT PONDASI



PENULANGAN BALOK RIB PONDASI 30/60

A-B-C-D

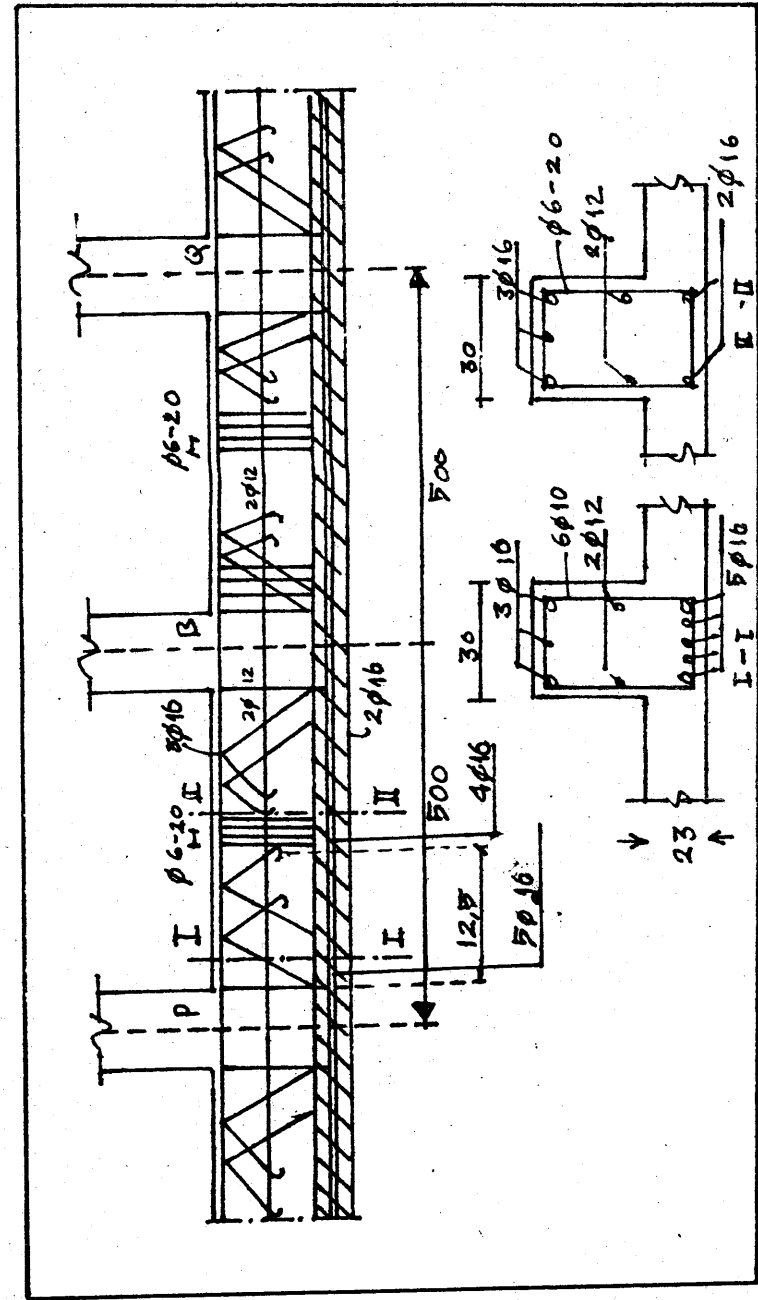


P. B. B.

P. B. B.

PENULANGAN BALOK RIB PONDASI 30/60

P - B - Q



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