



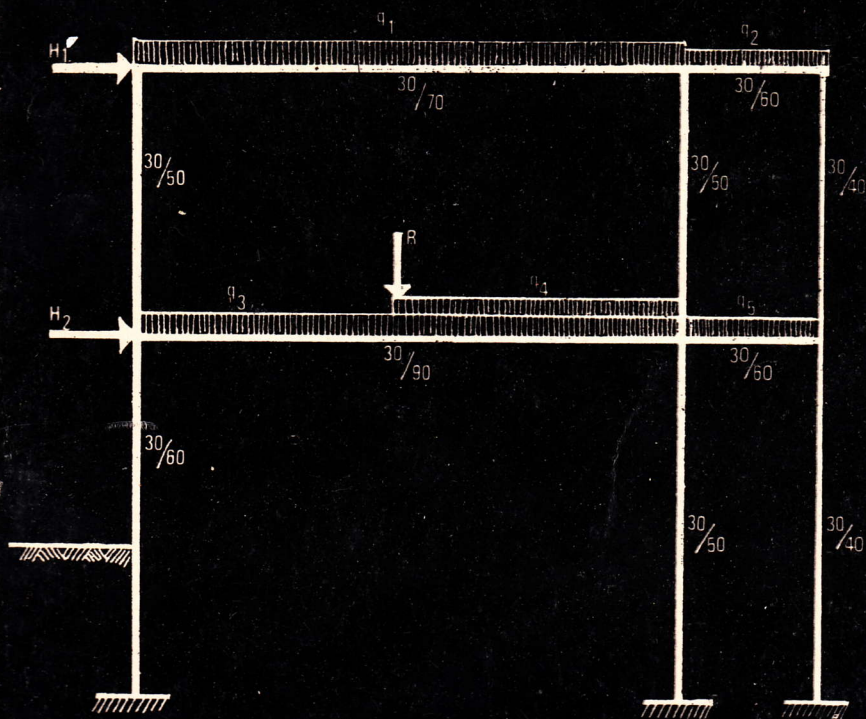
SERI PENYELESAIAN

PORTAL BETON BERTINGKAT

HARSONO L.

Standard : PMI 70 & PBI 71.

NOMOGRAM BETON Prof Ir. Soemono.

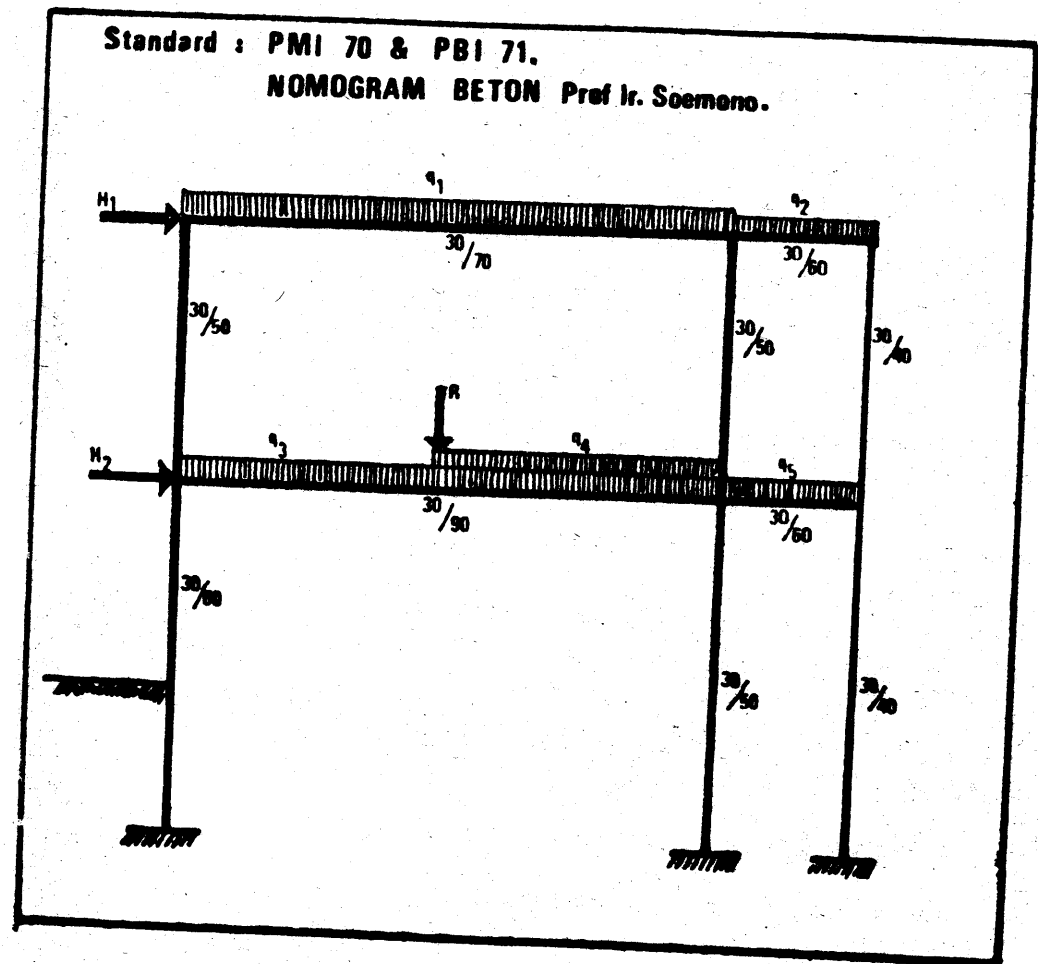


Legh jndoso

SERI PENYELESAIAN

PORTAL BETON BERTINGKAT

HARSONO L.



CIPTA SCIENCE SERIES MENYEDIKAN BUKU-BUKU :

SEKOLAH LANJUTAN : menunjuk-membimbing dan mendorong tiap anak untuk menyelesaikan tiap jenjang pendidikan pada waktunya.

PERGURUAN TINGGI : terbukti melahirkan Sarjana Muda Sarjana Penuh disegala bidang sedini mungkin.

Dengan para penulis berpengalaman bertahun-tahun mengajar dibidangnya.

CETAKAN I : 1986

Film - setting IBM - layout - cetak
oleh : **CIPTA OFFSET**

Dilarang keras mereproduksi dalam bentuk apapun.

Hak cipta C pada pengarang.

KATA PENGANTAR

Buku ini merupakan perbaikan dari edisi lama - yang diterbitkan dengan sistim cetak offset.

Buku ini masih jauh dari sempurna tetapi penulis yakin buku ini dapat sedikit memberikan gambaran dari keseluruhan uraian dalam text book yang ada.

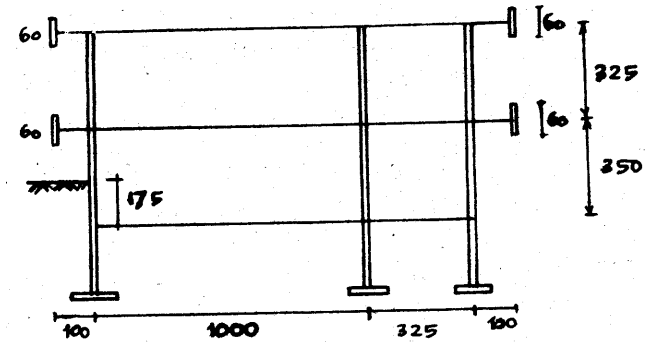
Oleh karena itu kritikan yang membangun dari para ahli sangat diharapkan demi perbaikan isi buku ini khususnya dan kepentingan kita semua pada umumnya.

September, 1986.

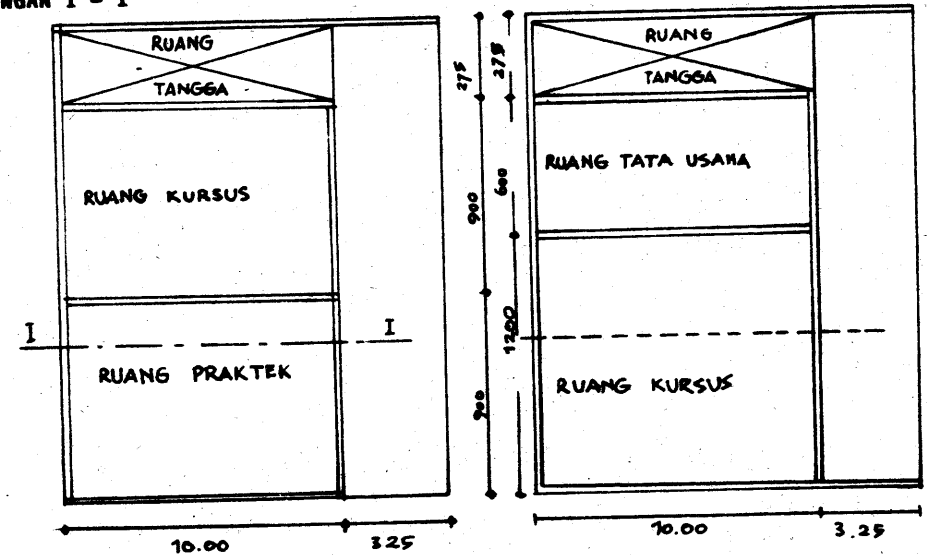
Penyusun

PERENCANAAN PORTAL BERTINGKAT SEDERHANA

Lihat gambar 1



POTONGAN I - I



DENAH LANTAI I

DENAH LANTAI II

Ukuran dalam cm :

a = 325
 b = 325
 c = 350
 d = 1000
 e = 150
 f = 100
 g = 275
 h = 300
 i = 60

$$K = 175 - U_{32}$$

$\sigma_{\text{tanah}} = 1 \text{ kg/cm}$ (tanah cukup baik)
 Tekanan angin diperhitungkan sebagai beban sementara $Q = 50 \text{ kg/m}^2$.

$$\gamma_{\text{tanah}} = 1,7$$

Perhitungan : dengan interaksi metode cross min. 3 jenis portal.

I. DASAR PERHITUNGAN.

1. Mencari " k_c " pada pembebanan tetap.

$$K = 175 \rightarrow \sigma_b = 60 \text{ kg/cm}^2$$

$$U = 32 \rightarrow \sigma_a = 1830 \text{ kg/cm}^2$$

$$n = 24$$

$$P_o = 1850/60 = 30,8333 \rightarrow (p/n)_o = 30,8333/24 = 1,2847$$

$$\frac{n \cdot k}{\sigma_a} = 0,1457 \rightarrow k_o = 0,1457 \cdot 1850/24 = 11,231 \text{ kg/cm}^2$$

2. Mencari k_o pada pembebanan tidak tetap.

$$K = 175 \rightarrow \sigma_b = 100 \text{ kg/cm}^2$$

$$U = 32 \rightarrow \sigma_a = 2650 \text{ kg/cm}^2$$

$$n = 16 \quad P_o = \frac{2650}{100} = 26,50$$

$$(p/n)_o = 26,5/16 = 1,65625$$

$$\left(\frac{n \cdot k}{\sigma_a} \right)_o = 0,7 \rightarrow k_o = 0,1 \cdot 2650/16 = 16,5625 \text{ kg/cm}^2$$

Cara ini untuk pengecekan nanti pada cara 1.

3. Menentukan tegangan geser yang diperkenankan/puntir yang menentukan.

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

$$\tau_b > 14 \rightarrow \text{dimensi dirubah.}$$

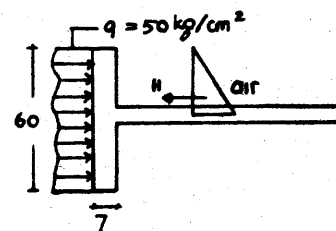
$$5,5 < \tau_b < 14 \rightarrow \text{dengan tegangan geser.}$$

4. Elemen2.

- Berat sendiri dari pasangan b.j = 2,4₂
- Pasir urug tiap 1 cm tebal = 18 kg/cm²
- Plafont + Eternit = 18 kg/cm²
- Penutup lantai (ubin) tiap 1 cm tebal = 24 kg/cm²
- Batu bata $\frac{1}{2}$ bt = 250 kg/cm²
1 bt = 450 kg/cm²
- Muatan tetap atap = 100 kg/cm²
- Muatan untuk pemadam kebakaran = 100 kg
- Muatan bordes (tangga) = 300 kg/cm²
- Muatan lantai = 250 kg/cm².

PERHITUNGAN PLAT.

1. List Plank :



Diperhitungkan terhadap Δ susut dan perubahan suhu.

$$A = 0,25 \% A_{\text{beton.}}$$

$$= 0,25 \% \cdot 10^{-2} \cdot 7 \cdot 60 = 1,05 \text{ cm}^2$$

$$\text{Dipakai } \phi 5/16'' - 12,5 = 3,96 \text{ cm}^2 >$$

$$1,05 \text{ cm}^2$$

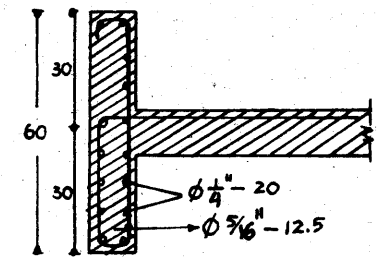
$$v_w = \phi \frac{1}{2}'' - 20 = 1,41 \text{ cm}^2 > 20\% A_t$$

Kontrol terhadap muatan sementara akibat angin.

$$M = \frac{1}{2} \cdot 0 \cdot 0,3^2 = \frac{1}{2} \cdot 0,05 \cdot 0,3^2 = 0,002 \text{ tm}$$

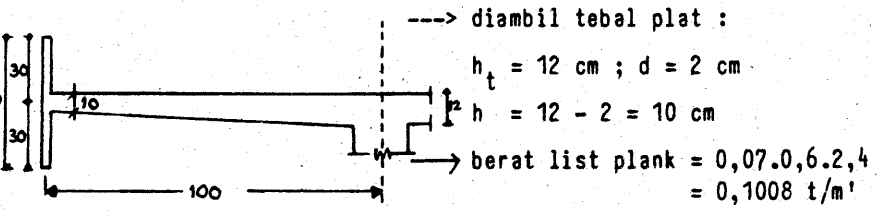
$$k = 225/100 \cdot 3,5^2 = 0,3057 \lll 0K$$

muatan sementara akibat angin.



$M = \frac{1}{2} \cdot 0,5 \cdot 7 \cdot 0,3/3 = 0,025 \text{ tm}$
 $k = 2500/100 \cdot 3,5^2 = 3,4 \text{ kg/cm}^2$
..... OK !
 $\frac{n \cdot k}{\sigma_a} = 24 \cdot 3,4/1850 = 0,044 \rightarrow r_w = 0,05$
 $A = 0,05/24 \cdot 100 \cdot 3,5 = 0,7291 \text{ cm}^2$

2. Flat Luifel. -----> 1 m \perp bidang gambar.



$q_{\text{atap berguna}} = 0,1 \text{ t/m'}$
 $q_{\text{berat sendiri}} = 0,12 \cdot 2,4 = 0,288 \text{ t/m'}$
 $\Sigma q = 0,388 \text{ t/m'}$

$M = 0,1008 \cdot 1 + 0,1 \cdot 1 + \frac{1}{2} \cdot 0,388 \cdot 1^2 = 0,3948 \text{ tm}$

$k = \frac{39480}{100 \cdot 10^2} = 3,948 \text{ kg/cm}^2 < k_0$

$\frac{n \cdot k}{\sigma_a} = \frac{24 \cdot 3,948}{1850} = 0,0512 \rightarrow n_w = 0,057$

$A = 0,057/24 \cdot 100 \cdot 10 = 2,371 \text{ cm}^2$

Dipakai $\phi 3/8^{\text{m}} - 15 = 4,96 \text{ cm}^2 > 2,371 \text{ cm}^2$

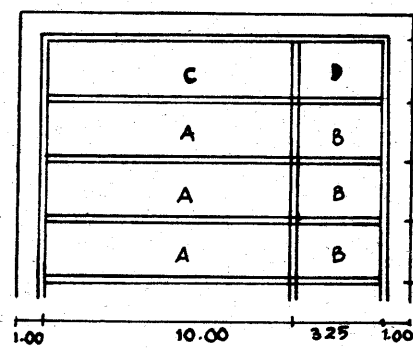
Kontrol terhadap muatan sementara.

$M = \frac{1}{2} \cdot 0,25 \cdot 1^2 + 0,3945 = 0,5108 \text{ tm}$

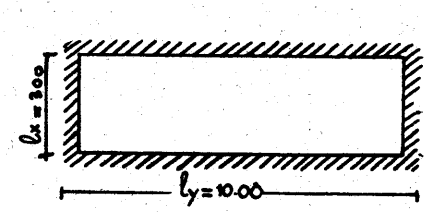
$k = \frac{51980}{100 \cdot 10^2} = 5,198 \text{ kg/cm}^2 < 16,5625 \text{ kg/cm}^2$

$\frac{n \cdot k}{\sigma_a} = \frac{16,5,198}{2650} = 0,031 \rightarrow n_w = 0,05$
 $A = 0,05/16 \cdot 100 \cdot 10 = 3,125 \text{ cm}^2$
Dipakai : $\phi 3/8^{\text{m}} - 15 = 4,98 \text{ cm}^2 > 3,125 \text{ cm}^2$

3. Plat Atap. -----> $t = 12 \text{ cm}$.



Perhitungan Atap A (300.1000)



muatan terbagi rata.
 $q_{\text{berguna}} = 0,1 \text{ t/m'}$
 $q_{\text{berat sendiri}} = 0,12 \cdot 2,4 = 0,288 \text{ t/m'}$
 $q_{\text{pemadam kebakaran}} = 0,1 \text{ t/m'}$
 $q = 0,488 \text{ t/m'}$

$\frac{L_y}{L_x} = \frac{1000}{300} = 3,333 > 2,5$
 $C M L_x = 42$
 $C M L_y = 8$
 $C M t_y = 83$
 $C M t_x = 57$
 $q l_x^2 = 0,488 \cdot 3^2 = 4,392 \text{ tm}$

$M t_x = -0,001 \cdot 4,392 \cdot 83 = -36454 \text{ kg/cm}$

$M t_y = -0,001 \cdot 4,392 \cdot 57 = -25034 \text{ kg/cm}$

$M l_x = 0,001 \cdot 4,392 \cdot 42 = 18446 \text{ kg/cm}$

$M l_y = 0,001 \cdot 4,392 \cdot 8 = 3514 \text{ kg/cm}$

Momen Positif.

Tulangan arah x $\rightarrow M_x = 18446 \text{ kgcm}$.

$$K = \frac{18446}{100 \cdot 10^2} = 1,845 \text{ kg/cm}^2$$

$$\frac{n \cdot k}{\sigma_a} = \frac{24 \cdot 1,845}{1850} = 0,024 \rightarrow nw = 0,05$$

$$A = 0,05/24 \cdot 100 \cdot 10 = 2,08 \text{ cm}^2$$

$$\text{Dipakai } \emptyset 5/16'' - 12,5 = 3,96 \text{ cm}^2 > 2,08 \text{ cm}^2$$

Tulangan Arah y :

$$M_y = 3514 \text{ kgcm} \rightarrow k = \frac{3514}{100 \cdot 9^2} = 0,4338$$

$$\frac{n \cdot k}{\sigma_a} = \frac{24 \cdot 0,4338}{1850} = 0,0036 \rightarrow nw = 0,05$$

$$A = 0,05/24 \cdot 100 \cdot 9 = 1,875 \text{ cm}^2$$

$$\text{Dipakai } \emptyset 5/16'' - 12,5 = 3,96 \text{ cm}^2 > 1,875 \text{ cm}^2$$

Momen Negatif.

Arah x : $M_t = -36454 \text{ kgcm}$

$$K = \frac{36454}{100 \cdot 10^2} = 3,6454 \text{ kg/cm}^2 < k_0$$

$$\frac{n \cdot k}{\sigma_a} = \frac{24 \cdot 3,6454}{1850} = 0,047 \rightarrow nw = 0,0515$$

$$A = 0,0515/24 \cdot 100 \cdot 10 = 2,14 \text{ cm}^2$$

$$\text{Dipakai } \emptyset 5/16'' - 12,5 = 3,96 \text{ cm}^2 > 2,14 \text{ cm}^2$$

$$VW \emptyset 1'' - 20 = 1,58 \text{ cm}^2 > 20\% \cdot A$$

Arah y : $M_t = -25034 \text{ kgcm}$.

$$k = \frac{25034}{100 \cdot 10^2} = 2,5034 \text{ kg/cm}^2 < k_0$$

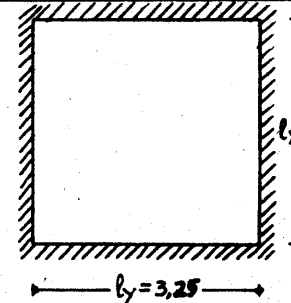
$$\frac{n \cdot k}{\sigma_a} = \frac{24 \cdot 2,5034}{180} = 0,0325 \rightarrow 0,05 = nw$$

$$A = 0,05/24 \cdot 100 \cdot 10 = 2,08 \text{ cm}^2$$

$$\text{Dipakai } \emptyset 5/16'' - 12,5 = 3,96 \text{ cm}^2 > 2,08 \text{ cm}^2$$

$$VW = \emptyset 1'' - 20 = 1,58 \text{ cm}^2 > 20\% \cdot A$$

Perhitungan Atap B (300 x 325).



$$\frac{l_y}{l_x} = \frac{325}{300} = 1,08$$

$$q \cdot l_x^2 = 0,488 \cdot 3^2 = 4,392 \text{ tm}$$

$$M_t = -0,059 \cdot 4,392 = -25913 \text{ kgcm}$$

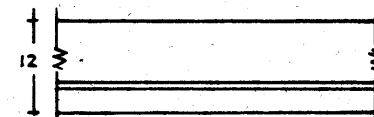
$$M_t = -0,054 \cdot 4,392 = -23717 \text{ kgcm}$$

$$M_x = 0,025 \cdot 4,392 = 1094 \text{ kgcm}$$

$$M_y = 0,021 \cdot 4,392 = 9223 \text{ kgcm}$$

Momen Positif :

Momen arah x \rightarrow



$$M_x = 1094 \text{ kgcm}$$

$$k = \frac{1094}{100 \cdot 10^2} = 0,1094 < k_0$$

$$\frac{n \cdot k}{\sigma_a} = \frac{24 \cdot 0,1094}{1850} = 1,4 \cdot 10^{-3}$$

$$n \cdot w = 0,05$$

$$A = 0,05/24 \cdot 100 \cdot 10 = 2,08 \text{ cm}^2$$

$$\text{Dipakai } \emptyset 5/16'' - 12,5 = 3,96 \text{ cm}^2 > 2,08 \text{ cm}^2$$

Tulangan arah y :

$$Ml_y = 9223 \text{ kgcm} \longrightarrow k = \frac{9223}{100.9^2} = 1,139 \text{ kg/cm}^2 < k_o$$

$$\frac{n.k}{a} = \frac{24.1,139}{1850} = 0,034 \longrightarrow n.w = 0,050$$

$$A = 0,05/24.100.9 = 1,875 \text{ cm}^2.$$

$$\text{Dipakai : } \emptyset 16^{\text{m}} - 12,5 = 3,96 \text{ cm}^2 > 1,875 \text{ cm}^2.$$

Momen Negatif.

$$\begin{aligned} \text{Tulangan arah x : } Mt_x = -25913 \text{ kgcm} \longrightarrow k &= \frac{25913}{100.10^2} \\ &= 2,5913 \text{ kg/cm}^2 < k_o \end{aligned}$$

$$\frac{n.k}{a} = \frac{24.2,5913}{1850} = 0,034 \longrightarrow n.w = 0,05$$

$$A = 0,05/24.100.10 = 2,08 \text{ cm}^2.$$

$$\text{Dipakai : } \emptyset 5/16^{\text{m}} - 12,5 = 3,96 \text{ cm}^2 > 2,08 \text{ cm}^2.$$

$$VW : \emptyset 1^{\text{m}} - 20 = 1,58 \text{ cm}^2 > 20\%.A.$$

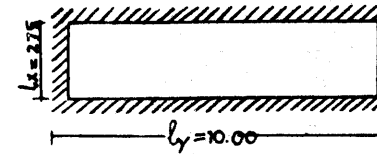
$$\begin{aligned} \text{Tulangan arah y : } Mt_y = -23717 \text{ kgcm} \longrightarrow k &= \frac{23717}{100.10^2} \\ &= 2,3717 \text{ kg/cm}^2 < k_o \end{aligned}$$

$$\frac{n.k}{a} = \frac{24.2,3717}{1850} = 0,031 \longrightarrow n.w = 0,05$$

$$A = 0,05/24.100.10 = 2,08 \text{ cm}^2.$$

$$\text{Dipakai : } \emptyset 5/16 - 12,5 = 3,96 \text{ cm}^2 > 2,08 \text{ cm}^2$$

$$VW : \emptyset 1^{\text{m}} - 20 = 1,58 \text{ cm}^2 > 20\%.A.$$

Plat Atap C (275 x 1000).

$$\frac{l_y}{l_x} = \frac{1000}{275} = 3,6425$$

$$q.l_x^2 = 0,488.2,75^2 = 3,691 \text{ ton.}$$

$$Ml_x = 0,042.3,691 = 15502 \text{ kgcm}$$

$$Ml_y = 0,008.3,691 = 2953 \text{ kgcm}$$

$$Mt_x = -0,083.3,691 = -30635 \text{ kgcm}$$

$$Mt_y = -0,057.3,691 = -21039 \text{ kgcm}$$

Momen Positif.

$$\text{Tulangan arah x} \longrightarrow Ml_x = 15502 \text{ kgcm}$$

$$k = \frac{15502}{100.10^2} = 1,5502 \text{ kg/cm}^2 < k_o$$

$$\frac{n.k}{a} = \frac{24.1,5502}{1850} = 0,02 \longrightarrow n.w = 0,05$$

$$A = 0,05/24.100.10 = 2,08 \text{ cm}^2.$$

$$\text{Dipakai : } \emptyset 5/16^{\text{m}} - 12,5 = 3,96 \text{ cm}^2$$

$$2,08 \text{ cm}^2$$

$$\text{Tulangan arah y} \longrightarrow$$

$$Ml_y = 2953 \text{ kgcm}$$

$$k = \frac{2953}{100.9^2} = 0,365 \text{ kg/cm}^2 < k_o$$

$$\frac{n.k}{a} = \frac{24.0,365}{180} = 0,05 \longrightarrow n.w = 0,05$$

$$A = 0,05/24.100.9 = 1,875 \text{ cm}^2.$$

$$\text{Dipakai : } \emptyset 5/16^{\text{m}} - 12,5 = 3,96 \text{ cm}^2 > 1,875 \text{ cm}^2.$$

Momen Negatif.

Tulangan arah x : -----> $M_t_x = -30635 \text{ kgcm}$

$$k = \frac{30635}{100 \cdot 10^2} = 3,0635 \text{ kg/cm}^2$$

$$\frac{n \cdot k}{\sigma_a} = \frac{24 \cdot 3,0635}{1850} = 0,0397 \text{ ----> } n \cdot w = 0,05$$

$$A = 0,05/24 \cdot 100 \cdot 10 = 2,08 \text{ cm}^2$$

$$\text{Dipakai : } \phi 5/16^{\text{m}} - 12,5 = 3,96 \text{ cm}^2 > 2,08 \text{ cm}^2$$

$$\text{VW } \phi \frac{1}{4}^{\text{m}} - 20 = 1,58 \text{ cm}^2 > 20\% \cdot A.$$

Tulangan arah y : -----> $M_t_y = -21039 \text{ kgcm}$

$$k = \frac{21039}{100 \cdot 10^2} = 2,1039 \text{ kg/cm}^2 < k_0$$

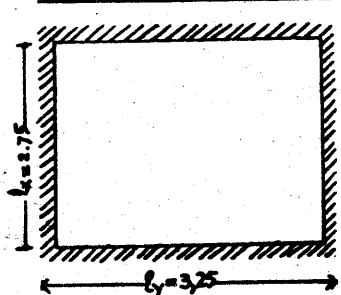
$$\frac{n \cdot k}{\sigma_a} = \frac{24 \cdot 2,1039}{1850} = 0,027 \text{ ----> } n \cdot w = 0,05$$

$$A = 0,05/24 \cdot 100 \cdot 10 = 2,08 \text{ cm}^2$$

$$\text{Dipakai : } \phi 5/16^{\text{m}} - 12,5 = 3,96 \text{ cm}^2 > 2,08 \text{ cm}^2$$

$$\text{VW : } \phi \frac{1}{4}^{\text{m}} - 20 = 1,58 \text{ cm}^2 > 20\% \cdot A.$$

Plat Atap D (275 x 325).



$$\frac{l_y}{l_x} = \frac{325}{275} = 1,2 ; q l_x^2 = 3,691 \text{ ton.}$$

$$M_{l_x} = 0,028 \cdot 3,691 = 10335 \text{ kgcm.}$$

$$M_{l_y} = 0,020 \cdot 3,691 = 7382 \text{ kgcm.}$$

$$M_{t_x} = -0,064 \cdot 3,691 = -23622 \text{ kgcm.}$$

$$M_{t_y} = -0,056 \cdot 3,691 = -20690 \text{ kgcm.}$$

Momen Positif.

Tulangan arah x : $M_{l_x} = 10335 \text{ kgcm}$ ----> $k = \frac{10335}{100 \cdot 9^2} = 1,0335 \text{ kg/cm}^2$

$$\frac{n \cdot k}{\sigma_a} = \frac{24 \cdot 1,0335}{1850} = 0,013 \text{ ----> } n \cdot w = 0,05$$

$$A = 0,05/24 \cdot 100 \cdot 10 = 2,08 \text{ cm}^2$$

$$\text{Dipakai : } \phi 5/16^{\text{m}} - 12,5 = 3,96 \text{ cm}^2 > 2,08 \text{ cm}^2$$

Tulangan arah y : $M_{l_y} = 7382 \text{ kgcm}$ ----> $k = \frac{7382}{100 \cdot 10^2} = 0,7385 \text{ kg/cm}^2 < k_0$

$$\frac{n \cdot k}{\sigma_a} = \frac{24 \cdot 0,7385}{1850} = 0,01 \text{ ----> } n \cdot w = 0,05$$

$$A = 0,05/24 \cdot 100 \cdot 9 = 1,875 \text{ cm}^2$$

$$\text{Dipakai : } \phi 5/16^{\text{m}} - 12,5 = 3,96 \text{ cm}^2 > 1,875 \text{ cm}^2$$

Momen negatif.

Tulangan arah x : $M_{t_x} = -23622 \text{ kgcm}$ ----> $k = \frac{23622}{100 \cdot 10^2} = 2,3622 \text{ kg/cm}^2 < k_0$

$$\frac{n \cdot k}{\sigma_a} = \frac{24 \cdot 2,3622}{1850} = 0,031 \text{ ----> } n \cdot w = 0,05$$

$$A = 0,05/24 \cdot 100 \cdot 10 = 2,08 \text{ cm}^2$$

$$\text{Dipakai : } \phi 5/16^{\text{m}} - 12,5 = 3,96 \text{ cm}^2 > 2,08 \text{ cm}^2$$

$$\text{VW : } \phi \frac{1}{4}^{\text{m}} - 20 = 1,58 \text{ cm}^2 > 20\% \cdot A.$$

Tulangan arah y : $M_{t_y} = -20670 \text{ kgcm}$ ----> $k = 2,0670 \text{ kg/cm}^2$

$$\frac{n \cdot k}{\sigma_a} = 0,03$$

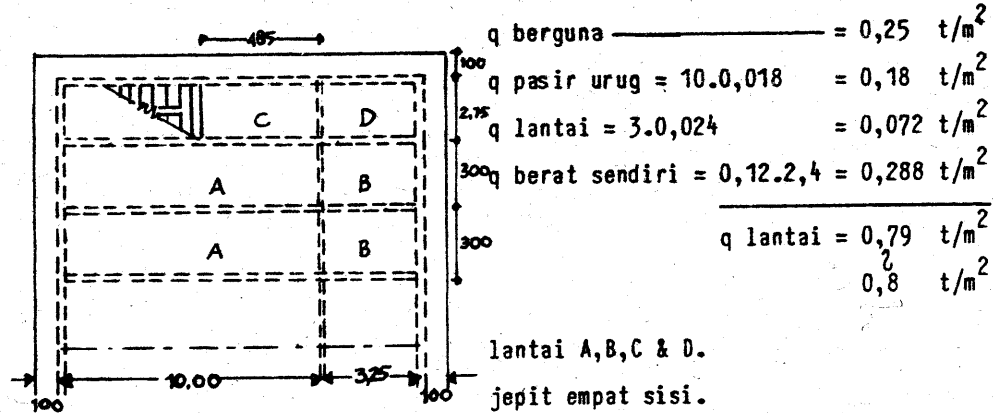
$$n \cdot w = 0,05 ; A = 2,08 \text{ cm}^2$$

$$\text{Dipakai : } \phi 5/16^{\text{m}} - 12,5 = 3,96 \text{ cm}^2 > 2,08 \text{ cm}^2$$

$$\text{VW : } \phi \frac{1}{4}^{\text{m}} - 20 = 1,58 \text{ cm}^2 > 20\% \cdot A.$$

PLAT LANTAI A

Tebal lantai = 12 cm.

**PLAT LANTAI A (300 x 1000).**

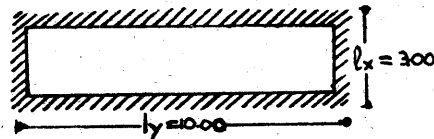
$$\frac{l_y}{l_x} = \frac{1000}{300} = 3,333 > 2,5 \longrightarrow q l_x^2 = 0,8.3^2 = 7,2 \text{ ton.}$$

$$Ml_x = 0,42.7,2 = 30240 \text{ kgcm.}$$

$$Ml_y = 0,008.7,2 = 5760 \text{ kgcm.}$$

$$Mt_x = -0,083.7,2 = -59760 \text{ kgcm.}$$

$$Mt_y = -0,057.7,2 = -41040 \text{ kgcm.}$$

**Momen Positif.**

$$\text{Tulangan arah x : } Ml_x = 30240 \text{ kgcm} \longrightarrow k = \frac{30240}{100.10^2} = 3,0240 \text{ kg/cm}^2 < k_0$$

$$\frac{n.k}{\sigma_a} = \frac{24.3.024}{1850} = 0,04 \longrightarrow nw = 0,05$$

$$A = 0,05/24.100.10 = 2,08 \text{ cm}^2$$

$$\text{Dipakai } \phi 3/8'' - 15 = 4,98 \text{ cm}^2 > 2,08 \text{ cm}^2.$$

$$\text{Tulangan arah y : } Ml_y = 5760 \text{ kgcm} \longrightarrow k = \frac{5760}{100.9^2} = 0,7141 \text{ kg/cm}^2 < k_0$$

$$\frac{n.k}{\sigma_a} = \frac{24.0,7141}{1850} = 0,09 \longrightarrow nw = 0,05$$

$$A = 0,05/24.100.9 = 1,875 \text{ cm}^2.$$

$$\text{Dipakai : } \phi 3/8'' - 15 = 4,98 \text{ cm}^2 > 1,875 \text{ cm}^2.$$

Momen Negatif.

$$\text{Tulangan arah x : } Mt_x = -59760 \text{ kgcm} \longrightarrow k = \frac{59760}{100.10^2} = 5,9760 \text{ kg/cm}^2 < k_0$$

$$\frac{n.k}{\sigma_a} = \frac{24.5,9760}{1850} = 0,078 \longrightarrow nw = 0,088$$

$$A = 0,088/24.100.10 = 3,67 \text{ cm}^2$$

$$\text{Dipakai : } \phi 3/8'' - 15 = 4,98 \text{ cm}^2 > 3,67 \text{ cm}^2$$

$$VW : \phi 5/16'' - 20 = 2,47 \text{ cm}^2 > 20\%.A.$$

$$\text{Tulangan arah y : } Mt_y = -41040 \text{ kgcm} \longrightarrow k = \frac{41040}{100.10^2} = 4,104 \text{ kg/cm}^2 < k_0$$

$$\frac{n.k}{\sigma_a} = \frac{24.4,104}{1850} = 0,053 \longrightarrow nw = 0,059$$

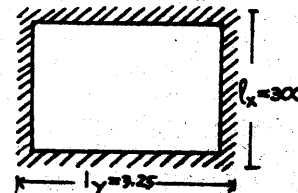
$$A = 0,059/24.100.10 = 2,46 \text{ cm}^2$$

$$\text{Dipakai : } \phi 3/8'' - 15 = 4,98 \text{ cm}^2 > 2,46 \text{ cm}^2$$

$$VW : \phi 5/16'' - 20 = 2,47 \text{ cm}^2 > 20\%.A.$$

PLAT LANTAI B (300 x 325).

$$\frac{l_y}{l_x} = 1,08 ; q.l_x^2 = 7,2 \text{ ton.}$$



$$Ml_x = 0,025.7,2 = 18000 \text{ kgcm.}$$

$$Ml_y = 0,021.7,2 = 15120 \text{ kgcm.}$$

$$Mt_x = -0,059.7,2 = -42480 \text{ kgcm.}$$

$$Mt_y = -0,054.7,2 = -38880 \text{ kgcm.}$$

Momen Positif.

$$\text{Tulangan arah x : } Ml_x = 18000 \text{ kgcm} \rightarrow k = \frac{18000}{100.10^2} = 1,8 \text{ kg/cm}^2.$$

$$\frac{n.k}{\sigma_a} = \frac{24.1,8}{1850} = 0,023 \rightarrow nw = 0,05$$

$$A = 0,05/24.100.10 = 2,08 \text{ cm}^2$$

$$\text{Dipakai : } \emptyset 3/8'' - 15 = 4,98 \text{ cm}^2 > 2,08 \text{ cm}^2.$$

$$\text{Tulangan arah y : } Ml_y = 15120 \text{ kgcm} \rightarrow k = \frac{15120}{100.9^2} = 1,867 \text{ kg/cm}^2 < k_0$$

$$\frac{n.k}{\sigma_a} = \frac{24.1,867}{1850} = 0,024 \rightarrow nw = 0,05$$

$$A = 0,05/24.100.9 = 1,873 \text{ cm}^2.$$

$$\text{Dipakai : } \emptyset 3/8'' - 15 = 4,98 \text{ cm}^2 > 1,875 \text{ cm}^2.$$

Momen Negatif.

$$\text{Tulangan arah x : } Mt_x = 41480 \text{ kgcm} \rightarrow k = \frac{42480}{100.10^2} = 4,2480 \text{ kg/cm}^2 < k_0$$

$$\frac{n.k}{\sigma_a} = \frac{24.4,2480}{1850} = 0,055 \rightarrow nw = 0,051$$

$$A = 0,061/24.100.10 = 2,542 \text{ cm}^2$$

$$\text{Dipakai : } \emptyset 3/8'' - 15 = 4,98 \text{ cm}^2 > 2,542 \text{ cm}^2$$

$$VW : \emptyset 5/16'' - 20 = 2,47 \text{ cm}^2 > 20\% A.$$

$$\text{Tulangan arah y : } Mt_y = 38880 \text{ kgcm} \rightarrow k = \frac{38880}{100.10^2} = 3,888 \text{ kg/cm}^2 < k_0$$

$$\frac{n.k}{\sigma_a} = \frac{24.3,8880}{1850} = 0,053 \rightarrow nw = 0,055$$

$$A = 0,055/24.100.10 = 2,292 \text{ cm}^2$$

$$\text{Dipakai : } \emptyset 3/8'' - 15 = 4,98 \text{ cm}^2 > 2,292 \text{ cm}^2$$

$$VW : \emptyset 5/16'' - 20 = 2,47 \text{ cm}^2 > 20\% A.$$

PLAT LANTAI C (275 x 485).

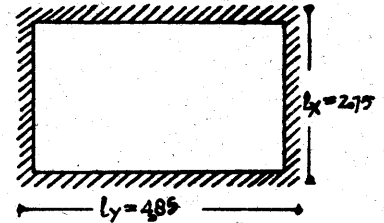
$$\frac{l_y}{l_x} = \frac{485}{275} = 1,8 ; q l_x^2 = 0,8.2,75^2 = 6,05 \text{ ton.}$$

$$Ml_x = 0,040.6,05 = 24200 \text{ kgcm.}$$

$$Ml_y = 0,013.6,05 = 7865 \text{ kgcm.}$$

$$Mt_x = -0,082.6,05 = -49610 \text{ kgcm.}$$

$$Mt_y = -0,057.6,05 = -34485 \text{ kgcm.}$$

Momen Positif.

$$\text{Tulangan arah x : } Ml_x = 24200 \text{ kgcm} \rightarrow k = \frac{24200}{100.10^2} = 2,42 \text{ kg/cm}^2 < k_0$$

$$\frac{n.k}{\sigma_a} = \frac{24.2,42}{1850} = 0,031 \rightarrow nw = 0,05$$

$$A = 0,05/24.100.10 = 2,08 \text{ cm}^2$$

$$\text{Dipakai } \emptyset 3/8'' - 15 = 4,98 \text{ cm}^2 > 2,08 \text{ cm}^2$$

$$\text{Tulangan arah y : } Ml_y = 7865 \text{ kgcm} \rightarrow k = \frac{7865}{100.9^2} = 0,971 \text{ kg/cm}^2 < k_0$$

$$\frac{n.k}{\sigma_a} = \frac{24.0,971}{1850} = 0,126 \rightarrow nw = 0,071$$

$$A = 0,071/24.100.9 = 1,875 \text{ cm}^2$$

$$\text{Dipakai } \emptyset 3/8'' - 15 = 4,98 \text{ cm}^2 > 1,875 \text{ cm}^2.$$

Momen Negatif.

$$\text{Tulangan arah x : } Mt_x = -49610 \text{ kgcm} \rightarrow k = \frac{49610}{100.10^2} = 4,961 \text{ kg/cm}^2 < k_0$$

$$\frac{n.k}{\sigma_a} = \frac{24.4,961}{1850} = 0,064 \rightarrow nw = 0,071$$

$$A = 0,071/24.100.9 = 1,875 \text{ cm}^2.$$

$$\text{Dipakai : } \emptyset 3/8'' - 15 = 4,98 \text{ cm}^2 > 2,96 \text{ cm}^2$$

$$VW : \emptyset 5/16'' - 20 = 2,47 \text{ cm}^2 > 20\% A.$$

Tulangan arah y : $M_{t_y} = -34485 \text{ kgcm} \rightarrow k = \frac{34485}{100.10^2} = 3,4485 \text{ kg/cm}^2 < k_0$

$\frac{n.k}{\sigma_a} = \frac{24.0,971}{1850} = 0,045 \rightarrow nw = 0,05$

$A = 0,05/24.100.10 = 2,08 \text{ cm}^2$

Dipakai : $\emptyset 3/8'' - 15 = 4,98 \text{ cm}^2 > 2,08 \text{ cm}^2$

VW : $\emptyset 5/16'' - 20 = 2,47 \text{ cm}^2 > 20\%.A.$

PLAT LANTAI D (275 x 325).

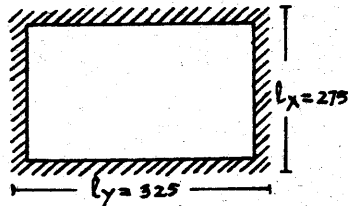
$\frac{l_y}{l_x} = 1,2 ; q.l_x^2 = 6,05 \text{ ton.}$

$M_{l_x} = 0,028.6,05 = 16940 \text{ kgcm.}$

$M_{l_y} = 0,020.6,05 = 12100 \text{ kgcm.}$

$M_{t_x} = -0,064.6,05 = -38720 \text{ kgcm.}$

$M_{t_y} = -0,056.6,05 = -33880 \text{ kgcm.}$



Momen Positif.

Tulangan arah x : $M_{l_x} = 16940 \text{ kgcm} \rightarrow k = \frac{16940}{100.10^2} = 1,694 \text{ kg/cm}^2 < k_0$

$\frac{n.k}{\sigma_a} = \frac{24.1,694}{1850} = 0,022 \rightarrow nw = 0,05$

$A = 0,05/24.100.10 = 2,08 \text{ cm}^2$

Dipakai : $\emptyset 3/8'' - 15 = 4,98 \text{ cm}^2 > 2,08 \text{ cm}^2.$

Tulangan arah y : $M_{l_y} = 12100 \text{ kgcm} \rightarrow k = \frac{12100}{100.9^2} = 1,494 \text{ kg/cm}^2 < k_0$

$\frac{n.k}{\sigma_a} = \frac{24.1,694}{1850} = 0,022 \rightarrow nw = 0,05$

$A = 0,05/24.100.9 = 1,875 \text{ cm}^2$

Dipakai : $\emptyset 3/8'' - 15 = 4,98 \text{ cm}^2 > 1,875 \text{ cm}^2$

Momen Negatif.

Tulangan arah x : $M_{t_x} = -38720 \text{ kgcm} \rightarrow k = \frac{38720}{100.10^2} = 3,872 \text{ kg/cm}^2 < k_0$

$\frac{n.k}{\sigma_a} = \frac{24.3,872}{1850} = 0,05 \rightarrow nw = 0,055$

$A = 0,055/24.100.10 = 2,292 \text{ cm}^2$

Dipakai : $\emptyset 3/8'' - 15 = 4,98 \text{ cm}^2 > 2,292 \text{ cm}^2$

VW : $\emptyset 5/16'' - 20 = 2,47 \text{ cm}^2 > 20\%.A.$

Tulangan arah y : $M_{t_y} = -33880 \text{ kgcm} \rightarrow k = \frac{33880}{100.10^2} = 3,388 \text{ kg/cm}^2 < k_0$

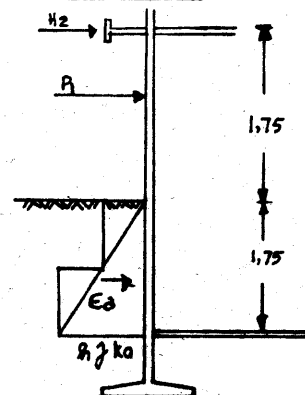
$\frac{n.k}{\sigma_a} = \frac{24.3,388}{1850} = 0,044 \rightarrow nw = 0,05$

$A = 0,05/24.100.10 = 2,08 \text{ cm}^2$

Dipakai : $\emptyset 3/8'' - 15 = 4,98 \text{ cm}^2 > 2,08 \text{ cm}^2.$

VW : $\emptyset 5/16'' - 20 = 2,47 \text{ cm}^2 > 20\%.A.$

PLAT DINDING :



Muatan angin $Q = 50 \text{ kg/m}^2 = 0,05 \text{ t/m}^2$

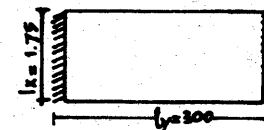
$\gamma \text{ tanah} = 1,7 \text{ t/m}^3.$

$\varphi = 30^\circ \rightarrow K_a = \tan^2(45^\circ - \frac{30^\circ}{2}) = 0,333$

$I_1 = 1,75 \cdot 0,05 = 87,5 \text{ kg/m'}$

$K_a = \frac{1}{2} \cdot h^2 \cdot \gamma \cdot K_a = \frac{1}{2} \cdot 1,75^2 \cdot 1,7 \cdot 0,333 = 867,7 \text{ kg/m'}$

$\frac{l_y}{l_x} = 1,71$



C $M_{l_x} = 68$

C $M_{l_y} = 41$

C $M_{xy} = 112$

$$\text{Untuk } q = h/2 \cdot \gamma \cdot K_a = \frac{1,75 \cdot 1,7 \cdot 0,333}{2} = 0,4953 \text{ t/m}^2 \approx 0,5 \text{ t/m}^2.$$

$$q l x^2 = 0,5 \cdot 1,75^2 = 1,53125 \text{ t}$$

$$M l x = 0,068 \cdot 1,53125 \text{ tm} = 9493,75 \text{ kgcm.}$$

$$M l y = 0,041 \cdot 1,53125 \text{ tm} = 6278,125 \text{ kgcm.}$$

$$M t y = 0,112 \cdot 1,53125 \text{ tm} = 18681,25 \text{ kgcm.}$$

- Arah X :

$$M l x = 9493,75 \rightarrow K = \frac{9493,75}{100 \cdot 10^2} = 0,9454 \rightarrow \frac{n \cdot k}{\sigma_a} = \frac{24 \cdot 0,9494}{1850} = 0,001$$

$$n \cdot w = 0,05 \rightarrow A = \frac{0,05}{24} \cdot 100 \cdot 10 = 2,08 \text{ cm}^2.$$

$$\text{Dipakai : } \phi 5/16'' - 20 = 2,47 \text{ cm}^2 > 2,08 \text{ cm}^2.$$

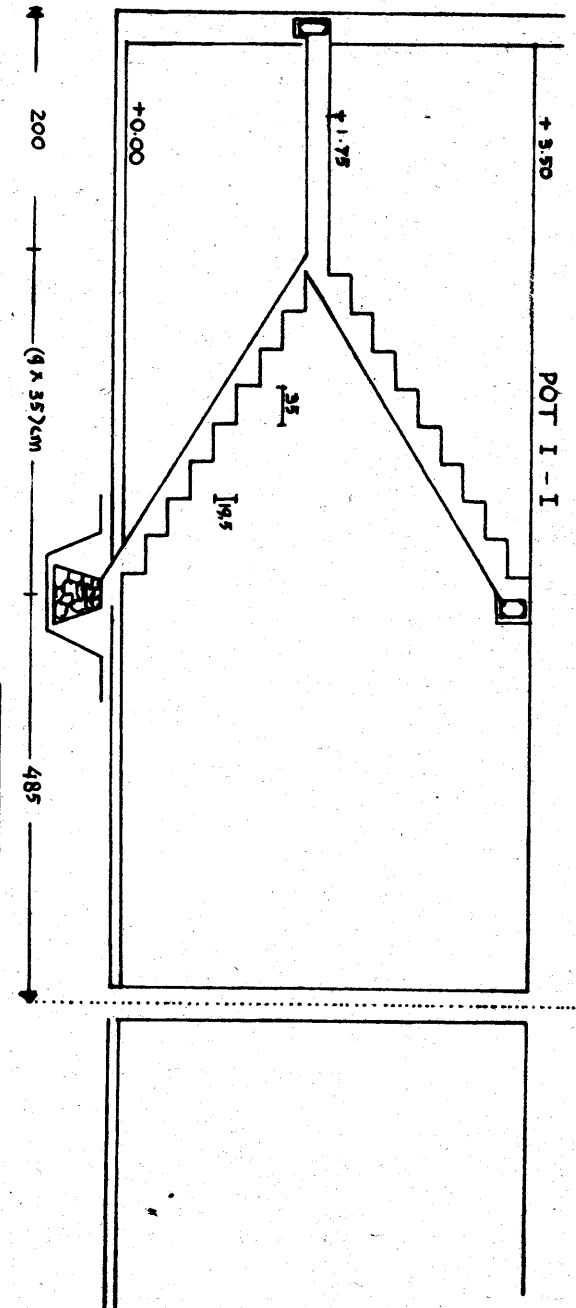
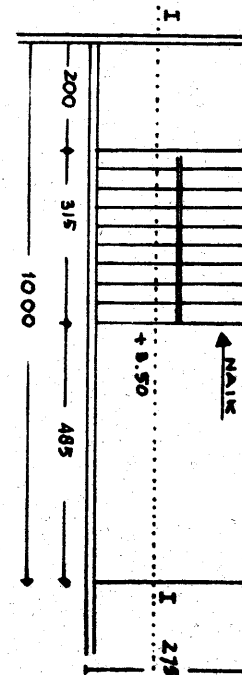
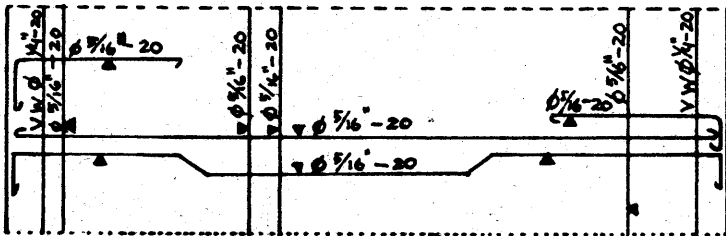
- Arah Y :

$$M l y = 6278,125 \text{ kgcm} \rightarrow K = \frac{6278,125}{100 \cdot 10^2} = 0,6278 \rightarrow \frac{n \cdot k}{\sigma_a} = \frac{24 \cdot 0,6278}{1850} = 0,008$$

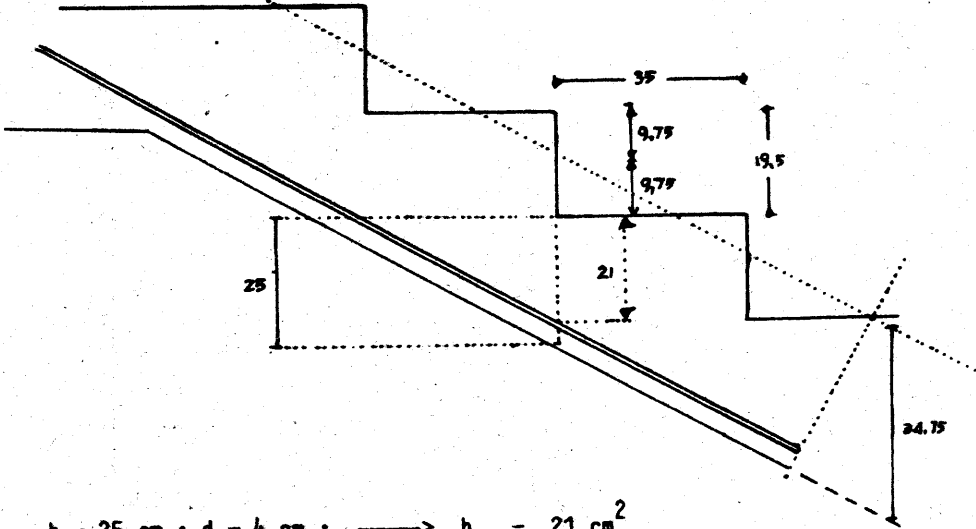
$$n \cdot w = 0,05 \rightarrow A = \frac{0,05}{24} \cdot 100 \cdot 10 = 2,08 \text{ cm}^2$$

$$\text{Dipakai : } \phi 5/16'' - 20 = 2,47 \text{ cm}^2 > 2,08 \text{ cm}^2$$

$$V W : \phi \frac{1}{4}'' - 20 = 1,54 \text{ cm}^2 > 20\% \cdot 2,08 \text{ cm}^2 = 0,416 \text{ cm}^2.$$



PERHITUNGAN TANGGA :



$$h = 25 \text{ cm} ; d = 4 \text{ cm} ; \longrightarrow h_t = 21 \text{ cm}^2$$

$$\begin{aligned} - q \text{ berguna} &= 0,3 \text{ t/m}^2 \\ - q \text{ penutup lantai} &= 3.0,024 = 0,072 \text{ t/m}^2 \\ - q \text{ pasir urug} &= 7.0,018 = 0,126 \text{ t/m}^2 \\ - q \text{ berat sendiri} &= 0,25.2,4 = 0,6 \text{ t/m}^2 \\ \hline q \text{ pelat tangga} &= 1,098 \text{ t/m}^2 \approx 1,1 \text{ t/m}^2 \end{aligned}$$

$$\left. \begin{aligned} q &= 1,1 \text{ t/m}^2 \\ L &= 5,15 \text{ m} \end{aligned} \right\} \begin{aligned} M^+ &= 1/10 \cdot q \cdot l^2 = 1/10 \cdot 1,1 \cdot 5,15^2 = 291748 \text{ kgcm.} \\ K &= \frac{291748}{100 \cdot 21^2} = 6,6156 \text{ kg/cm}^2 < K_o = 11,231 \text{ kg/cm}^2 \end{aligned}$$

$$\frac{n \cdot K}{\sigma_a} = \frac{24 \cdot 6,6156}{1850} = 0,086 \longrightarrow n_w = 0,097$$

$$A = \frac{0,097}{24} \cdot 100 \cdot 21 = 8,4875 \text{ cm}^2.$$

$$\text{Dipakai } \phi \frac{1}{2}'' - 12,5 = 11,40 \text{ cm}^2 > 8,4875 \text{ cm}^2.$$

$$\begin{aligned} VW \phi \frac{1}{2}'' - 20 &= 2,47 \text{ cm}^2 > 20\% \cdot 8,4875 \text{ cm}^2 \\ M^- &= 1/16 \cdot 1,1 \cdot 5,15^2 \text{ tm} = 182342 \text{ kgcm.} \\ K &= \frac{182342}{100 \cdot 21^2} = 4,1347 \text{ kg/cm}^2 < K_o = 11,231 \text{ kg/cm}^2. \end{aligned}$$

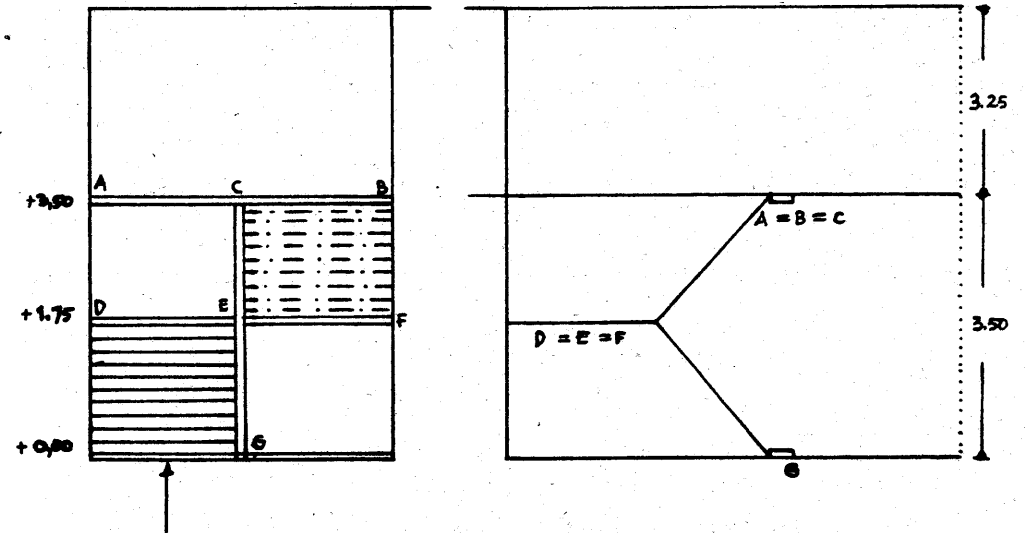
$$\frac{n \cdot K}{\sigma_a} = \frac{24 \cdot 4,1347}{1850} = 0,054 \longrightarrow n_w = 0,06$$

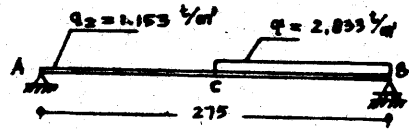
$$A = \frac{0,06}{24} \cdot 100 \cdot 21 = 5,25 \text{ cm}^2.$$

$$\text{Dipakai } \phi \frac{1}{2}'' - 12,5 = 11,40 \text{ cm}^2 > 5,25 \text{ cm}^2$$

$$VW \phi \frac{1}{2}'' - 20 = 2,47 \text{ cm}^2 > 20\% \cdot 5,25 \text{ cm}^2.$$

BALOK TANGGA (35/50).





q_1 = akibat berat tangga + bordes
($l = 5,15$ m)

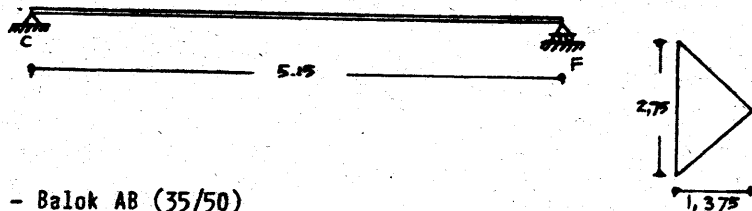
q_2 = akibat berat sendiri + lantai
()

$$q = 1,1 \cdot 1,375 = 1,5125 \text{ t.m'}$$

$$R_C = \frac{1}{2} \cdot 1,5125 \cdot 5,15 = 3,895 \text{ ton.}$$

sepanjang CB :

$$q_1 = 3,895 / 1,375 = 2,833 \text{ t/m'}$$



- Balok AB (35/50)

$$\text{- Berat sendiri balok} = 0,35 \cdot 0,5 \cdot 2,4 = 0,42 \text{ t/m'}$$

$$\text{- Berat lantai} = 2/3 \cdot 1,375 \cdot 0,8 = 0,733 \text{ t/m'}$$

$$q_2 = 1,153 \text{ t/m'}$$

$$R_A = \frac{1,153 \cdot 2,75 \cdot 1,375 + 2,833 \cdot 1,375 / 2}{2,75} = 2,743 \text{ ton.}$$

$$R_B = \frac{1,153 \cdot 3,25 \cdot 1,375 + 2,833 \cdot 1,375 \cdot 2,0625}{2,75} = 4,7 \text{ ton.}$$

M max pada D = 0

$$2,743 \cdot x = 1,153 \cdot 1,375 - 3,9863 \cdot x$$

$$x = 2,5283 / 6,7293 = 0,376 \text{ m.}$$

$$M_{\max} = 2,743 \cdot 1,751 - 1,153 \cdot 1,751^2 / 2 - 2,833 \cdot 0,376 / 2 = 2,83472 \text{ tm.}$$

$$K = \frac{283472}{35 \cdot 45^2} = 3,9997 \text{ kg/cm}^2 < K_o = 11,231 \text{ kg/cm}^2$$

$$\frac{nK}{U_a} = \frac{24 \cdot 3,2397}{1850} = 0,052 \longrightarrow n_w = 0,058$$

$$A = \frac{0,058}{24} \cdot 35 \cdot 45 = 3,806 \text{ cm}^2.$$

$$\text{Dipakai : } 3 \text{ } \phi \text{ } 16 = 8,50 \text{ cm}^2 > 3,806 \text{ cm}^2$$

Kontrol tulangan Puntir dan Lentur :

$$M^- = 1,82342 \text{ tm}$$

$$M_{ta} = \frac{1,82342 \cdot 1,375 \cdot 0,6875}{3,25} = 0,53047 \text{ tm.}$$

$$M_{tb} = \frac{1,375 \cdot 1,82342 \cdot 2,0625}{3,25} = 1,59111 \text{ tm.}$$

$$\text{Momen plat lantai} = 0,057 \cdot 0,8 \cdot 2,75^2 \cdot 2,75 = 0,94834 \text{ tm.}$$

$$\text{Momen untuk puntir} = 1,59111 \text{ tm} - 0,94834 \text{ tm} = 0,64277 \text{ tm} = 64277 \text{ kgcm}$$

$$\psi = 3 \cdot 0 \cdot \frac{2,6}{0,45 + h_t/b} = 3 + \frac{2,6}{0,45 + 60/40} = 4,333$$

$$\tau_b = \tau_{\max} = \psi \cdot \frac{M_t}{b \cdot h_t} = 4,333 \cdot \frac{64277}{35^2 \cdot 50} = 4,55 \text{ kg/cm}^2 < 5,5 \text{ kg/cm}^2$$

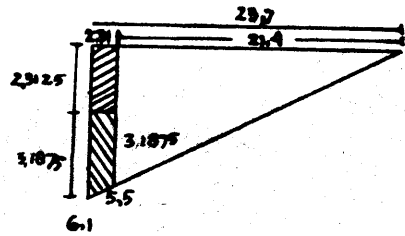
$$D = 4700 \text{ kg.}$$

$$\text{Lentur} \longrightarrow \tau_{b'} = \frac{8 \cdot 4700}{7 \cdot 35 \cdot 45} = 3,41 \text{ kg/cm}^2 < 5,5 \text{ kg/cm}^2$$

$$\tau_b + \tau_{b'} = 4,55 + 3,41 = 7,96 \text{ kg/cm}^2 > 5,5 \text{ kg/cm}^2$$

$$\tau_{b''} = \frac{M_{tu}}{b \cdot F_t} = \frac{64277}{35 \cdot 30 \cdot 40} = 1,53 \text{ kg/cm}^2.$$

$$\tau_{b''} + \tau_b = 1,53 + 4,55 = 6,1 \text{ kg/cm}^2.$$



Dipakai begel $\emptyset 5/16^m \rightarrow A = 0,5 \text{ cm}^2$
 $A_s = 1 \text{ cm}^2$; $a_s = 20 \text{ cm}^2$ (jarak begel)

$$\tau_s = \frac{A_s \cdot a}{a_s \cdot b} = \frac{1,1850}{20 \cdot 40} = 2,315 \text{ kg/cm}^2 > \tau_{bn}$$

$$\tau_m = \frac{A_m \cdot \tau_a (\cos \theta + \sin \theta)}{a_m \cdot b}$$

$$A_m = \frac{m \cdot a_m \cdot b}{a (\cos \theta + \sin \theta)}$$

$$= \frac{(3,7875 + 3,1875) \cdot 23,40}{1850 \cdot \sqrt{2}} = 1,23 \text{ cm}^2$$

Dipakai : $1 \emptyset \frac{1}{2}^m = 2,83 \text{ cm}^2 > 1,23 \text{ cm}^2$.

BALOK BORDES (DE) dicoba ukuran 40/60

| | | |
|---------------------|-------------------------------|------------------------|
| - beban tangga | = $2,8333 \cdot 2$ | = $5,666 \text{ t/m}$ |
| - berat tembok | = $0,15 \cdot 1,75 \cdot 1,8$ | = $0,4725 \text{ t/m}$ |
| - berat plat bordes | = $0,8 \cdot 2$ | = $1,6 \text{ t/m}$ |
| - berat balok (DE) | = $0,4 \cdot 0,6 \cdot 2,4$ | = $0,576 \text{ t/m}$ |
| <hr/> | | |
| q balok DE | | = $8,3145 \text{ t/m}$ |

$$R_E = R_D = \frac{1}{2} \cdot q \cdot l = \frac{1}{2} \cdot 8,3185 \cdot 2,75 = 11,4324 \text{ ton.}$$

$$\rightarrow M_{\max} = 1/8 \cdot q \cdot l^2 = 1/8 \cdot 11,4324 \cdot 2,75^2 = 10,80719 \text{ tm.}$$

$$K = \frac{1080719}{40 \cdot 55} = 8,93 \text{ kg/cm}^2 < K_o = 11,231 \text{ kg/cm}^2$$

$$\frac{nK}{\tau_a} = \frac{24 \cdot 8,93}{1850} = 0,146 \rightarrow m = 0,134$$

$$\lambda = \frac{0,134}{24} \cdot 55,40 = 12,28 \text{ cm}^2$$

$$\text{Dipakai : } 4 \emptyset 7/8^m = 15,48 \text{ cm}^2 > 12,28 \text{ cm}^2$$

$$\rightarrow M_{\min} = 1/16 \cdot 11,4324 \cdot 2,75^2 = 5,40360 \text{ tm.}$$

$$K = \frac{540360}{40 \cdot 55} = 4,466 \text{ kg/cm}^2 < K_o$$

$$\frac{nK}{\tau_a} = \frac{24 \cdot 4,466}{1850} = 0,06 \rightarrow m = 0,067$$

$$\lambda = \frac{0,067}{24} \cdot 40 \cdot 55 = 6,124 \text{ cm}^2$$

$$\text{Dipakai : } 2 \emptyset 7/8^m = 7,74 \text{ cm}^2 > 6,124 \text{ cm}^2$$

Kontrol tulangan Puntir dan Lentur.

$$M^- \text{ plat bordes} = -1/16 \cdot 1,15 \cdot 15 = 1,82342 \text{ tm.}$$

$$\text{Sepanjang } 2,75 \text{ m} \rightarrow 2,75 \cdot 1,82342 = 5,01441 \text{ tm.}$$

$$M_t = \frac{1}{2} \cdot 5,01441 = 2,50720 \text{ tm} = 250720 \text{ kgcm.}$$

$$\psi = 3 + \frac{2,6}{0,45 + h_t/b} = 3 + \frac{2,6}{0,45 + 60/40} = 4,333$$

$$\tau_{b'} = \psi \cdot \frac{2,6}{b^2 \cdot h_t} = 4,333 \cdot \frac{250720}{40^2 \cdot 60} = 11,32 \text{ kg/cm}^2 < 14 \text{ kg/cm}^2$$

LENTUR :

$$R_E = R_D = 11,4324 \rightarrow \tau_b = \frac{8}{7} \cdot \frac{11432,4}{40 \cdot 55} = 5,94 \text{ kg/cm}^2$$

$$\tau_{b'} + \tau_b = (11,32 + 5,94) \text{ kg/cm}^2 = 17,25 \text{ kg/cm}^2 > 14 \text{ kg/cm}^2$$

-----> Ukuran balok bordes di r o b a h.

$$\text{Dipakai ukuran balok} \rightarrow (50/70)$$

$$q \text{ balok bordes } (5,666 + 0,4725 + 1,6 + 0,5 \cdot 0,7 \cdot 2,4) = 8,5783 \text{ t/m}$$

$$R_E = R_D = \frac{1}{2} \cdot 8,5785 \cdot 2,75 = 11,7954 \text{ kg} = 11795,4 \text{ kg}$$

$$\tau_b = \frac{8}{7} \frac{11795,4}{50,65} = 4,15 \text{ kg/cm}^2.$$

$$\text{Lentur} \longrightarrow \tau_b = 4,15 \text{ kg/cm}^2.$$

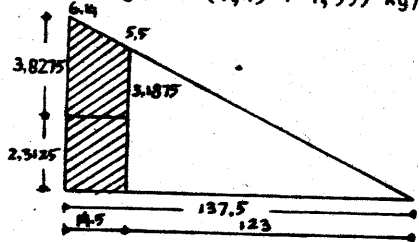
$$\text{Puntir} \longrightarrow \psi = 3 + \frac{2,6}{0,45 + 70/40} = 4,41$$

$$\tau_{b'} = 4,41 \frac{250720}{50,70} = 6,31 \text{ kg/cm}^2$$

$$\tau_b + \tau_{b'} = (4,15 + 6,31) \text{ kg/cm}^2 = 10,46 \text{ kg/cm}^2 < 14 \text{ kg/cm}^2 \text{ OK !}$$

$$\tau_{b''} = \frac{M_t}{b \cdot F_t} = \frac{250720}{50 \cdot 42,60} = 1,99 \text{ kg/cm}^2.$$

$$\tau_b + \tau_{b''} = (4,15 + 1,99) \text{ kg/cm}^2 = 6,14 \text{ kg/cm}^2 > 5,5 \text{ kg/cm}^2$$



Perlu tulangan serong.

Dipakai begel 5/16" - 20

$$A = 0,5 \text{ cm}^2 ; a_s = 20 \text{ cm} ; A_s = 1 \text{ cm}^2$$

$$\tau_s = \frac{1,1850}{20 \cdot 40} = 2,3125 \text{ kg/cm}^2.$$

$$x = 137,5 - \frac{5,5}{6,14} \cdot 137,5 = 14,5 \text{ cm}.$$

$$A_m = \frac{\frac{1}{2} \cdot (3,8275 + 3,1875) \cdot 14 \cdot 5,50}{1850 \sqrt{2}} = 0,97 \text{ cm}^2$$

$$\text{Dipakai : } 1 \text{ } \emptyset 7/8'' = 3,87 \text{ cm}^2 > 0,972 \text{ cm}^2$$

$$R_E = R_D = \frac{1}{2} \cdot 2,75 \cdot 8,57585 = 11,7954 \text{ cm}^2$$

$$-M_{\max} = 1/11 \cdot 8,57585 \cdot 2,75^2 = 589590 \text{ kgcm}.$$

$$K = \frac{589590}{65^2 \cdot 50} = 2,79 \text{ kg/cm}^2 < K_o$$

$$\frac{nK}{U a} = \frac{24 \cdot 2,79}{1850} = 0,036 \longrightarrow n_v = 0,05$$

$$A = \frac{0,05}{24} \cdot 65 \cdot 50 = 6,77 \text{ cm}^2$$

$$\text{Dipakai : } 2 \text{ } \emptyset 7/8'' = 7,74 \text{ cm}^2 > 6,77 \text{ cm}^2$$

$$-M_{\min} = 1/16 \cdot 8,57585 \cdot 2,75^2 = 405343 \text{ kgcm}.$$

$$K = \frac{405343}{65^2 \cdot 50} = 1,92 \text{ kg/cm}^2 < K_o$$

$$\frac{n \cdot K}{U a} = \frac{24 \cdot 1,92}{1850} = 0,025 \longrightarrow n_v = 0,05$$

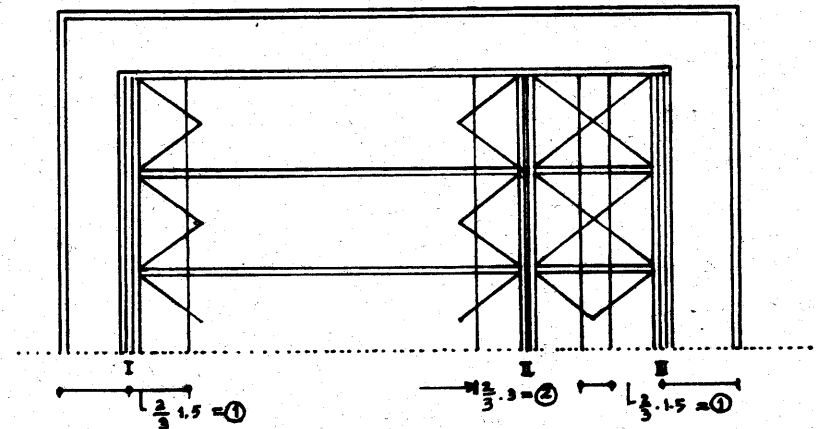
$$A = \frac{0,05}{24} \cdot 65 \cdot 50 = 6,77 \text{ cm}^2$$

$$\text{Dipakai : } 2 \text{ } \emptyset 7/8'' = 7,74 \text{ cm}^2 > 6,77 \text{ cm}^2$$

$$\text{Begel : } \emptyset 5/16'' - 20$$

III. PERHITUNGAN BALOK MEMANJANG.

1. Balok Memanjang Atap :



Perhitungan balok I = balok III, ukuran 25/40.

$$q \text{ plat atap} = 0,488 \text{ t/m}^2$$

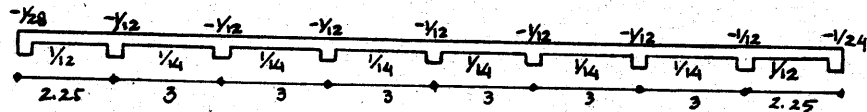
$$q \text{ liat plank} = 0,07 \cdot 2,4 = 0,168 \text{ t/m}^2$$

$$\text{- berat plat atap} = 2 \cdot 0,488 = 0,975 \text{ t/m}$$

$$\text{- berat list plank} = 0,6 \cdot 0,168 = 0,101 \text{ t/m}$$

$$\text{- berat balok sendiri} = 0,25 \cdot 0,28 \cdot 2,4 = 0,168 \text{ t/m}$$

$$q_{\text{balok}} = 1,244 \text{ t/m} \approx 1,25 \text{ t/m}$$



$$M_{\text{neg}} = -1/24 \cdot q \cdot l^2 = -1/24 \cdot 1,25 \cdot 3^2 = -0,47 \text{ tm} = 47000 \text{ kg cm.}$$

$$K = \frac{47000}{25 \cdot 35^2} = 1,53 \rightarrow \frac{nK}{\sigma_a} = \frac{24 \cdot 1,53}{1850} = 0,0199 \rightarrow n_w = 0,05$$

$$A = \frac{0,05}{24} \cdot 25 \cdot 35 = 1,823 \text{ cm}^2$$

$$\text{Dipakai : } 3 \text{ } \emptyset \text{ } 3/8^{\text{m}} = 2,13 \text{ cm}^2 > 1,823 \text{ cm}^2$$

$$M_{\text{pos}} = 1/12 \cdot q \cdot l^2 = 1/12 \cdot 1,25 \cdot 3^2 = 0,9375 \text{ tm} = 93750 \text{ kgcm.}$$

$$K = \frac{93750}{25 \cdot 35^2} = 3,06 \rightarrow \frac{nK}{\sigma_a} = \frac{24 \cdot 3,06}{1850} = 0,04 \rightarrow n_w = 0,05$$

$$A = \frac{0,05}{24} \cdot 25 \cdot 35 = 1,823 \text{ cm}^2$$

$$\text{Dipakai : } 3 \text{ } \emptyset \text{ } 3/8^{\text{m}} = 2,13 \text{ cm}^2 > 1,823 \text{ cm}^2$$

$$M_{\text{neg}} = 1/12 \cdot q \cdot l^2 = 1/12 \cdot 1,25 \cdot 3^2 = 0,9375 \text{ tm} = 93750 \text{ kgcm}$$

$$\text{Dipakai : } 3 \text{ } \emptyset \text{ } 3/8^{\text{m}} = 2,13 \text{ cm}^2 > 1,823 \text{ cm}^2$$

$$M_{\text{pos}} = 1/14 \cdot q \cdot l^2 = 1/14 \cdot 1,25 \cdot 3^2 = 0,80357 \text{ tm} = 80357 \text{ kgcm.}$$

$$K = \frac{80357}{25 \cdot 35^2} = 2,62 \rightarrow \frac{nK}{\sigma_a} = \frac{24 \cdot 2,62}{1850} = 0,034 \rightarrow n_w = 0,05$$

$$A = \frac{0,05}{24} = 1,823 \text{ cm}^2$$

$$\text{Dipakai : } 3 \text{ } \emptyset \text{ } 3/8^{\text{m}} = 2,13 \text{ cm}^2 > 1,823 \text{ cm}^2$$

Kontrol terhadap tulangan serong :

$$D = \frac{1}{2} \cdot q \cdot l = \frac{1}{2} \cdot 1,25 \cdot 3 = 1,875 \text{ ton} = 1875 \text{ kg}$$

$$\tau = \frac{8}{7} \cdot \frac{1875}{25 \cdot 35} = 2,4490 \text{ kg/cm}^2 < 5,5 \text{ kg/cm}^2$$

Tidak perlu tulangan serong.

Perhitungan balok II :

$$\text{Ukuran } 25/40 \cdot h_t = 40 \text{ cm ; } d = 5 \text{ cm ; } h = 35 \text{ cm}$$

$$\text{- berat plat atap} = 2 \cdot 0,488 = 0,975 \text{ t/m}$$

$$\text{- berat balok sendiri} = 0,25 \cdot 0,28 \cdot 2,4 = 0,168 \text{ t/m}$$

$$q_{\text{balok}} = 1,143 \text{ t/m} \approx 1,15 \text{ t/m}$$

M negatif :

$$M = -1/24 \cdot q \cdot l^2 = -1/24 \cdot 1,15 \cdot 5^2 = -0,45125 \text{ tm} = 45125 \text{ kgcm.}$$

$$K = \frac{45125}{25 \cdot 35^2} = 1,408 \rightarrow \frac{nK}{\sigma_a} = \frac{24 \cdot 1,408}{1850} = 0,04 \rightarrow n_w = 0,05$$

$$A = \frac{0,05}{24} \cdot 25 \cdot 35 = 1,823 \text{ cm}^2$$

$$\text{Dipakai : } 3 \text{ } \emptyset \text{ } 3/8^{\text{m}} = 2,13 \text{ cm}^2 > 1,823 \text{ cm}^2$$

$$M = -1/12 \cdot q \cdot l^2 = -1/12 \cdot 1,15 \cdot 3^2 = -86250 \text{ kgcm.}$$

$$K = \frac{86250}{25 \cdot 35^2} = 2,82 \rightarrow \frac{nK}{\sigma_a} = \frac{24 \cdot 2,82}{1850} = 0,04 \rightarrow n_w = 0,05$$

$$A = 1,823 \text{ cm}^2 \rightarrow \text{Dipakai : } 3 \text{ } \emptyset \text{ } 3/8^{\text{m}} = 2,13 \text{ cm}^2 > 1,823 \text{ cm}^2$$

M positif :

$$M = 1/12 \cdot q \cdot l^2 = 1/12 \cdot 1,15 \cdot 3^2 = 73929 \text{ kg cm.}$$

$$A = 1,823 \text{ cm}^2 \rightarrow \text{Dipakai :}$$

$$M = 1/14 \cdot q \cdot l^2 = 1/14 \cdot 1,15 \cdot 3^2 = 73929 \text{ kg cm.}$$

$$K = \frac{73929}{25 \cdot 35^2} = 2,414 \rightarrow \frac{nK}{\sigma_a} = \frac{24 \cdot 2,414}{1850} = 0,031 \rightarrow n_w = 0,05$$

$$A = 1,823 \text{ cm}^2$$

$$\text{Dipakai : } 3 \text{ } \emptyset \text{ } 3/8'' = 2,13 \text{ cm}^2 > 1,823 \text{ cm}^2.$$

Kontrol terhadap tulangan serong :

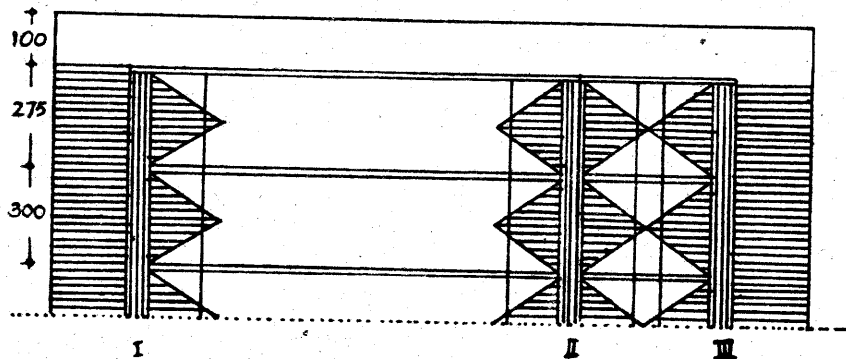
$$D = \frac{1}{2} \cdot q \cdot l = \frac{1}{2} \cdot 1,15 \cdot 3 = 1,725 \text{ ton} = 1725 \text{ kg}$$

$$= \frac{8}{7} \cdot \frac{1725}{25 \cdot 35} = 2,2531 \text{ kg/cm}^2 < 5,5 \text{ kg/cm}^2$$

Tidak perlu tulangan serong.

Diambil penulangan balok I = II = III.

Karena luas penampangnya sama, maka susunan penulangan balok memanjang atap type I, II, III dibuat sama.

2. BALOK PEMANJANG LANTAI.Perhitungan balok lantai I = III

$$q \text{ plat lantai} = 0,8 \text{ t/m}^2$$

$$\text{Ukuran balok } 25/50 ; h_t = 50 \text{ cm} ; d = 5 \text{ cm} ; h = 45 \text{ cm}$$

$$\text{- berat plas lantai} = 2,0,8 = 1,6 \text{ t/m}$$

$$\text{- berat list plank} = 0,07 \cdot 0,6 \cdot 2,4 = 0,1008 \text{ t/m}$$

$$\text{- berat balok sendiri} = 0,25 \cdot 0,25 \cdot 2,4 = 0,2280 \text{ t/m}$$

$$\text{- berat pasangan bata } (\frac{1}{2} \text{ bt}) = 0,15 \cdot 2,85 \cdot 0,25 = 0,1069 \text{ t/m}$$

$$q_{\text{balok}} = 2,0357 \text{ t/m} \approx 2,04 \text{ t/m}$$

M negatif :

$$M = 1/24 \cdot q \cdot l^2 = -1/24 \cdot 2,04 \cdot 3^2 = -0,765 \text{ tm} = 76500 \text{ kg cm}$$

$$K = \frac{76500}{24 \cdot 45^2} = 1,511 \rightarrow \frac{nK}{\sigma_a} = 0,0196 \rightarrow n_w = 0,05$$

$$A = \frac{0,05}{24} \cdot 25 \cdot 45 = 2,344 \text{ cm}^2$$

$$\text{Dipakai : } 4 \text{ } \emptyset \text{ } 3/8'' = 2,85 \text{ cm}^2 > 2,344 \text{ cm}^2$$

$$M = -1/12 \cdot q \cdot l^2 = -1/12 \cdot 2,04 \cdot 3^2 = -1,53 \text{ tm} = -153000 \text{ kg cm}$$

$$K = \frac{153000}{25 \cdot 45^2} = 3,15 \rightarrow \frac{nK}{\sigma_a} = 0,041 \rightarrow n_w = 0,05$$

$$A = 2,344 \text{ cm}^2 \rightarrow \text{Dipakai : } 4 \text{ } \emptyset \text{ } 3/8'' = 2,85 \text{ cm}^2 > 2,344 \text{ cm}^2.$$

M positif :

$$M = 1/12 \cdot q \cdot l^2 = 153000 \text{ kg cm.}$$

$$A = 2,344 \text{ cm}^2 \rightarrow \text{Dipakai : } 4 \text{ } \emptyset \text{ } 3/8'' = 2,85 \text{ cm}^2 > 2,344 \text{ cm}^2$$

$$M = 1/14 \cdot q \cdot l^2 = 1/14 \cdot 2,04 \cdot 3^2 = 1,31143 \text{ tm} = 131143 \text{ kg cm.}$$

$$K = \frac{131143}{25 \cdot 45^2} = 2,6 \rightarrow \frac{nK}{\sigma_a} = 0,034 \rightarrow n_w = 0,05$$

$$A = 2,344 \text{ cm}^2 \text{ ----> Dipakai : } 4 \text{ } \emptyset \text{ } 3/8'' = 2,85 \text{ cm}^2 > 2,344 \text{ cm}^2.$$

Kontrol terhadap tulangan serong.

$$D = \frac{1}{2} \cdot q \cdot l = \frac{1}{2} \cdot 2,04 \cdot 3 = 3,06 \text{ ton} = 3060 \text{ kg}$$

$$= \frac{8}{7} \cdot \frac{3060}{25 \cdot 45} = 3,1085 \text{ kg/cm}^2 \quad 5,5 \text{ kg/cm}^2$$

Tidak perlu tulangan serong.

Perhitungan balok lantai II :

$$\text{Ukuran balok } 25/50 ; M_t = 50 \text{ cm} ; h = 5 \text{ cm} ; h = 45 \text{ cm}^2$$

$$\text{- berat plat lantai} = 2,08 \text{ ----} = 1,6 \text{ t/m}$$

$$\text{- berat balok sendiri} = 0,25 \cdot 0,38 \cdot 2,4 \text{ ----} = 0,1069 \text{ t/m}$$

$$\text{- berat pasangan bata} (\frac{1}{2} \text{ bt}) = 0,15 \cdot 2,85 \cdot 0,25 = 0,228 \text{ t/m}$$

$$q_{\text{balok}} = 1,9349 \text{ t/m} \approx 2,00 \text{ t/m}$$

M negatif :

$$M = -1/24 \cdot q \cdot l^2 = -1/24 \cdot 2,3^2 = -75000 \text{ kg cm.}$$

$$K = \frac{75000}{25 \cdot 45^2} = 1,5 \text{ ----> } \frac{nK}{\sigma_a} = 0,012 \text{ ----> } n_w = 0,05$$

$$A = \frac{0,05}{24} \cdot 25 \cdot 45 = 2,344 \text{ cm}^2$$

$$\text{Dipakai : } 4 \text{ } \emptyset \text{ } 3/8'' = 2,85 \text{ cm}^2 > 2,344 \text{ cm}^2$$

$$M = -1/12 \cdot q \cdot l^2 = -1/12 \cdot 2,3^2 = -150000 \text{ kg cm.}$$

$$K = \frac{150000}{25 \cdot 45^2} = 3,09 \text{ ----> } \frac{nK}{\sigma_a} = 0,04 \text{ ----> } n_w = 0,05$$

$$A = 2,344 \text{ cm}^2 \text{ ----> Dipakai : } 4 \text{ } \emptyset \text{ } 3/8'' = 2,85 \text{ cm}^2 > 2,344 \text{ cm}^2$$

M positif :

$$M = 1/12 \cdot q \cdot l^2 = 150000 \text{ kg cm.}$$

$$A = 2,344 \text{ cm}^2$$

$$\text{Dipakai : } 4 \text{ } \emptyset \text{ } 3/8'' = 2,85 \text{ cm}^2 > 2,344 \text{ cm}^2$$

$$M = 1/14 \cdot q \cdot l^2 = 1/14 \cdot 2,3^2 \text{ tm} = 128572 \text{ kg cm.}$$

$$K = \frac{128572}{25 \cdot 45^2} = 2,54 \text{ ----> } \frac{nK}{\sigma_a} = 0,033 \text{ ----> } n_w = 0,05$$

$$A = 2,344 \text{ cm}^2 \text{ ----> Dipakai : } 4 \text{ } \emptyset \text{ } 3/8'' = 2,85 \text{ cm}^2 > 2,344 \text{ cm}^2.$$

Kontrol terhadap tulangan serong :

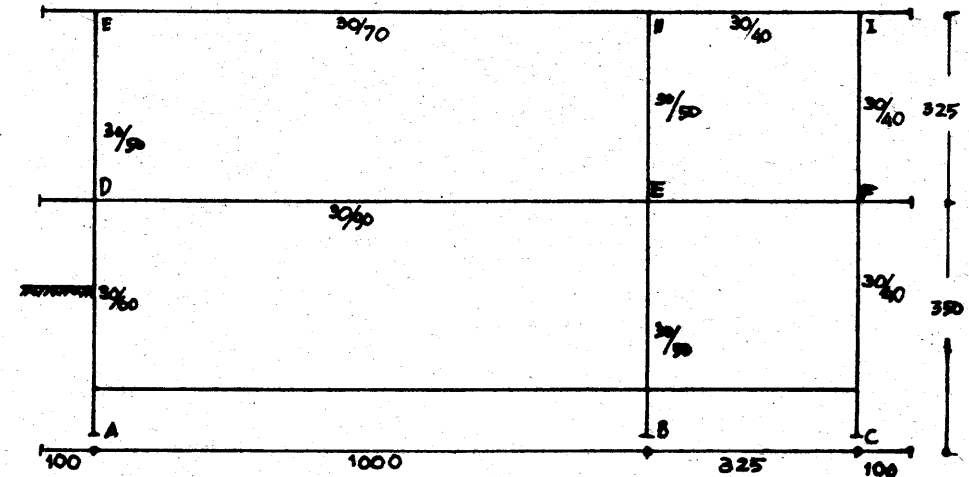
$$D = \frac{1}{2} \cdot q \cdot l = \frac{1}{2} \cdot 2,3 \text{ ton} = 3000 \text{ kg}$$

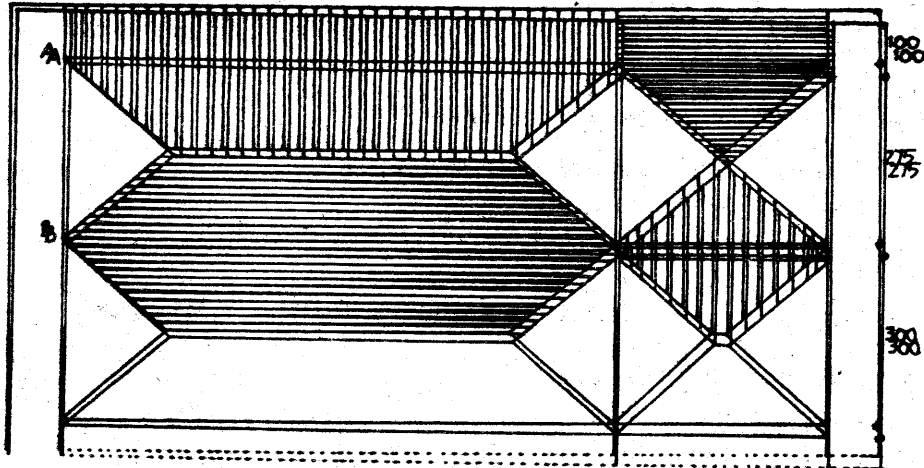
$$= \frac{8}{7} \cdot \frac{3000}{25 \cdot 45} = 3,05 \text{ kg/cm}^2 = 5,5 \text{ kg/cm}^2$$

Tidak perlu tulangan serong.

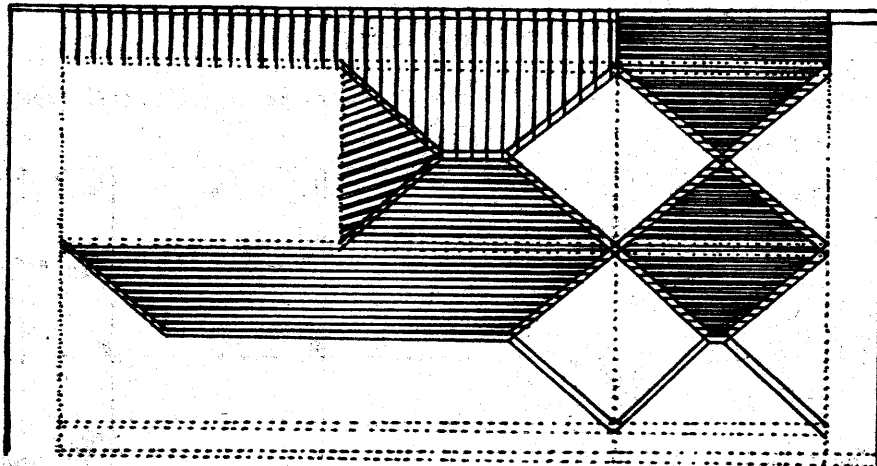
Karena luasnya sama, maka susunan penulangan balok memanjang lantai type

I = II = III dibuat sama.



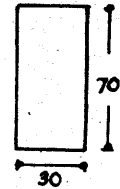
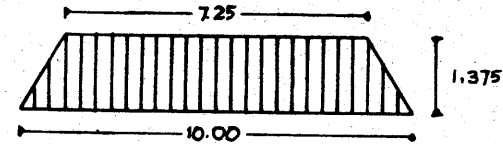


DENAH ATAS



DENAH LANTAI

MUATAN UNTUK PORTAL A.



BALOK EN (30/70) :

$$R_A = \frac{10.00 + 7.25}{2} \cdot 1.375 \cdot \frac{1}{2} = 5.92$$

$$1. M_{\max} = 5.935 - 1.375 \cdot 2.4 \cdot 0.8 - 3.625^2 / 2 \cdot 1.375 = 16.759 \text{ ton.}$$

$$2. M = 1/8 \cdot h \cdot l^2 = 1/8 \cdot h \cdot 10^2 = 12.5 \cdot h$$

$$16.759 = 12.5 \cdot h \rightarrow h = 1.341 \text{ m}$$

x. Berat plafond eternit

$$= 0.018 \text{ t/m.}$$

$$\text{berat sendiri balok} = 0.3 \cdot 0.7 \cdot 2.4$$

$$= 0.504 \text{ t/m.}$$

$$\text{berat luifel} = 0.388 \cdot 1.$$

$$= 0.388 \text{ t/m.}$$

$$\text{berat atap} = 0.488 \cdot 1.568$$

$$= 0.765 \text{ t/m.}$$

$$\text{berat list plank} = 0.07 \cdot 0.6 \cdot 2.4$$

$$= 0.101 \text{ t/m.}$$

$$\text{berat pemadam kebakaran}$$

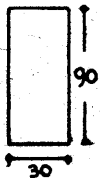
$$= 0.1 \text{ t/m.}$$

$$\underline{1.876 \text{ t/m.}}$$

BALOK HI (30/40).

| | |
|-----------------------------------|-------------------|
| X. berat plafond dan eternit | = 0,018 t/m. |
| berat sendiri balok = 0,3.0,4.2,4 | = 0,288 t/m. |
| berat atap = 2/3.0,488.1,625 | = -0,529 t/m. |
| berat luifel = 0,388.1 | = -0,388 t/m. |
| berat list plank = 0,07.0,6.2,4 | = 0,101 t/m. |
| berat pemadam kebakaran | = 0,1 t/m. |
| | <u>1,407 t/m.</u> |

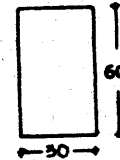
BALOK DE (30/90).



| | |
|--|-------------------|
| berat plafond & eternit | = 0,018 t/m. |
| berat tembok $\frac{1}{2}$ bt = 0,15(3,25-0,7) | = 0,689 t/m. |
| berat sendiri balok = 0,3.0,9.2,4 | = 0,648 t/m. |
| berat lantai = 0,8.1,568 | = 0 t/m. |
| berat luifel = | = 0,388 t/m. |
| berat pemadam kebakaran | = 0,1 t/m. |
| | <u>1,843 t/m.</u> |

$R_A = R_B = \frac{1,6 + 4,86}{2} \cdot 1,625 = 2,62 \text{ ton}$
 $M_x = 2,62 \cdot 2,425 - \frac{1,625^2}{2} \cdot 1,342 - \frac{0,8^2}{2} \cdot 1,625 = 4,321 \text{ ton}$
 $M = \frac{1}{8} \cdot h \cdot 4,85$
 $h = \frac{8 \cdot 4,321}{4,85} = 1,47 \text{ m}$
 $Q \text{ berat lantai} = 1,47 \cdot 0,8 = 1,176 \text{ t/m.}$

BALOK EF.



| | |
|--------------------------------------|--------------|
| berat lantai = 2/3.1,625.0,8 | = 0,867 t/m. |
| berat luifel | = 0,388 t/m. |
| berat plafond + eternit | = 0,018 t/m. |
| berat balok sendiri = 0,3.0,6.2,4 | = 0,432 t/m. |
| berat tembok = 0,15.(3,25 - 0,4) 2,4 | = 1,026 t/m. |
| list plank | = 0,101 t/m. |
| berat pemadam kebakaran | = 0,100 t/m. |

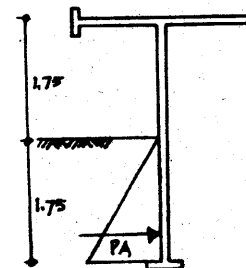
AKIBAT ANGIN.

W angin = 0,90.50 = 45 kg/m².

$H_1' = \frac{1}{2} \cdot 3,25 \cdot \frac{1}{2} \cdot 3,25 \cdot 45 = 118,83 = 119 \text{ kg}$

$H_2' = \frac{1}{2} \cdot 3,25 \cdot \frac{1}{2} \cdot (3,25 + 1,750) \cdot 45 = 182,81 = 183 \text{ kg.}$

AKIBAT TANAH.



$K_a = \tan^2 (45 - \frac{1}{2}) = 0,33$

$\gamma \text{ tanah} = 1,7$

$P_A = \frac{1}{2} \cdot 3,25 \cdot \frac{1}{2} \cdot h^2 \cdot \gamma \cdot K_a$

$= \frac{1}{2} \cdot 3,25 \cdot \frac{1}{2} \cdot 1,75^2 \cdot 1,7 \cdot 0,33 = 1,396 \text{ ton.}$

$P' \cdot 3,5 = P_A \cdot 1,75/3$

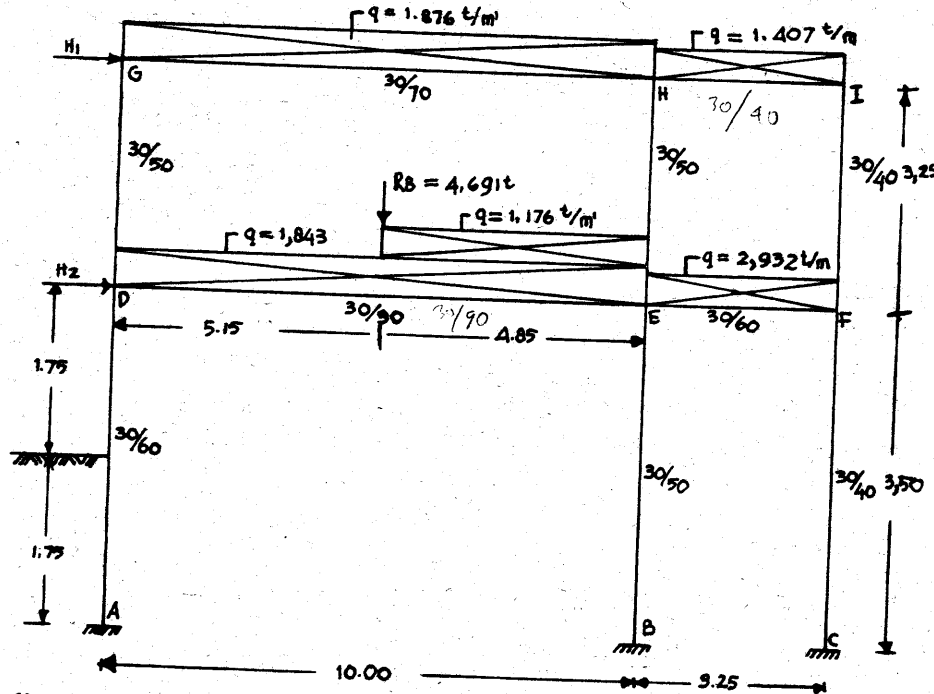
$P' = \frac{1,393 \cdot 1,75/3}{3,5}$

$= 232,67 \text{ kg} = 233 \text{ kg.}$

GAYA2 HORIZONTAL YANG BEKERJA.

$$H_1 = H_1' = 119 \text{ kg}$$

$$H_2 = H_2' + P' = 183 + 232,67 = 415,67 \text{ kg.}$$



Menghitung Inertia batang.

$$\begin{aligned} I_{GH} &= 1/12 \cdot 30 \cdot 70^3 = 857500 \text{ cm}^4 \\ I_{HI} &= 1/12 \cdot 30 \cdot 40^3 = I_{FC} = I_{FI} = 160000 \text{ cm}^4 \\ I_{DE} &= 1/12 \cdot 30 \cdot 90^3 = 1822500 \text{ cm}^4 \\ I_{EF} &= I_{EB} = I_{AD} = 1/12 \cdot 30 \cdot 60^3 = 540000 \text{ cm}^4 \\ I_{GD} &= I_{HE} = 1/12 \cdot 30 \cdot 50^3 = 312500 \text{ cm}^4 \end{aligned}$$

ANGKA STIFFNESS

$$\begin{aligned} K_{gh} &= 857500/1000 = 857,5 \\ K_{hi} &= 160000/325 = 492,31 \\ K_{fc} &= 160000/350 = 457,14 \\ K_{fi} &= 160000/325 = 492,31 \\ K_{de} &= 1822500/1000 = 1822,5 \\ K_{de} &= 1822500/1000 = 1822,5 \end{aligned}$$

$$\begin{aligned} K_{ef} &= 540000/325 = 1661,54 \\ K_{eb} &= 540000/350 = 1542,86 \\ K_{gd} &= 540000/350 = 1542,86 \\ K_{gd} &= 540000/350 = 1542,86 \\ K_{he} &= 312500/325 = 961,54 \\ K_{he} &= 312500/325 = 961,54 \\ K_{gd} &= 312500/325 = 961,54 \\ K_{gd} &= 312500/325 = 961,54 \end{aligned}$$

FAKTOR DISTRIBUSI

$$\begin{aligned} G : GH &= 0,471 \\ GD &= 0,529 \\ H : HG &= 0,371 \\ HE &= 0,416 \\ HI &= 0,213 \end{aligned}$$

$$\begin{aligned} D : DE &= 0,222 \\ DE &= 0,421 \\ DA &= 0,357 \\ E : ED &= 0,304 \\ EB &= 0,258 \\ EF &= 0,277 \\ EH &= 0,161 \end{aligned}$$

$$\begin{aligned} F : FE &= 0,636 \\ FI &= 0,189 \\ FC &= 0,175 \\ I : IH &= 0,5 \\ IF &= 0,5 \end{aligned}$$

MOMEN MOMEN PRIMER UNTUK BATANG DATAR:

$$M_{GH} = 1/12 \cdot 1,876 \cdot 10^2 = \pm 15,633 \text{ tm.}$$

$$M_{HG} = -15,633 \text{ tm.}$$

$$M_{HI} = 1/12 \cdot 1,843 \cdot 3,25^2 = 1,238 \text{ tm.}$$

$$M_{IH} = -1,238 \text{ tm.}$$

$$\begin{aligned} M_{De} &= 1/12 \cdot 1,843 \cdot 10^2 + 1,176/10 \cdot (1/3 \cdot 10 \cdot x^2 - \frac{1}{2} \cdot x^4) \cdot \frac{1}{10} \\ &= \frac{1,691 \cdot 5 \cdot 15 \cdot 1,852}{10^2} \end{aligned}$$

$$= 15,358 + 2,845 + 6,716 = 24,919 \text{ tm.}$$

$$M_{ED} = -\left(\frac{1}{12} \cdot 1,843 \cdot 10^2 + 1,176/10^2 \cdot \left(\frac{1}{3} \cdot 10 \cdot x^2 - \frac{1}{2} \cdot x^4\right)\right) \cdot \frac{10}{5,15} + \frac{4,691 \cdot 4,85 \cdot 5,15^2}{10^2}$$

$$= -15,358 - (83,333 - 279,442) \cdot 1,176/10^2 + 7,131$$

$$= -29,003 \text{ tm.}$$

$$M_{EF} = 1/12 \cdot 2,932 \cdot 3,25^2 = 2,581 \text{ tm.}$$

$$M_{FE} = -2,581 \text{ tm.}$$

UNTUK BEBAN SEMENTARA (ANGIN),

1. Titik G bergeser kekanan sebesar δ

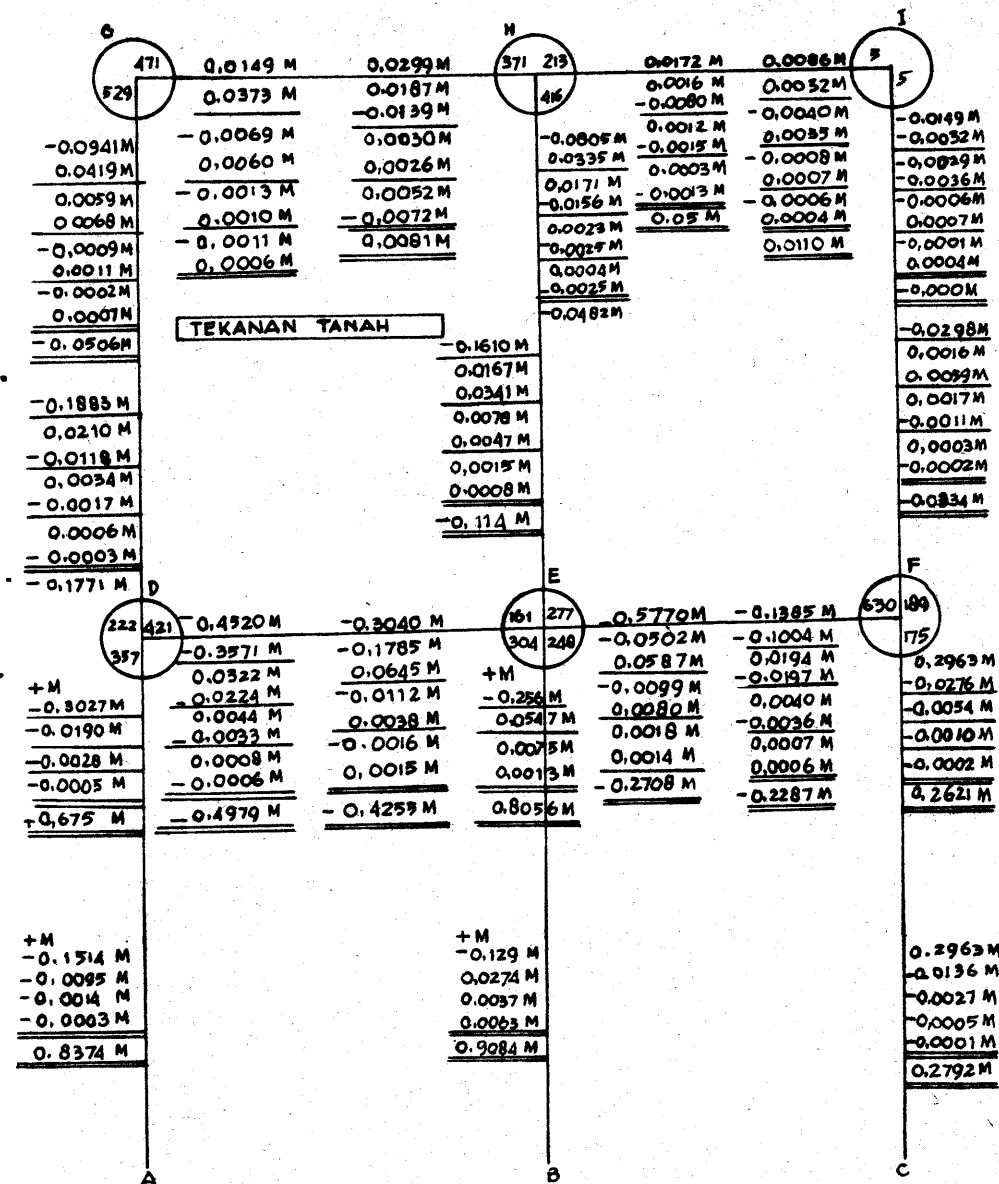
$$M_{GD} = M_{DE} = M_{HE} = M_{EH} = -386,75 \text{ kgm.}$$

$$M_{IF} = M_{FI} = -198,016 \text{ kgm.}$$

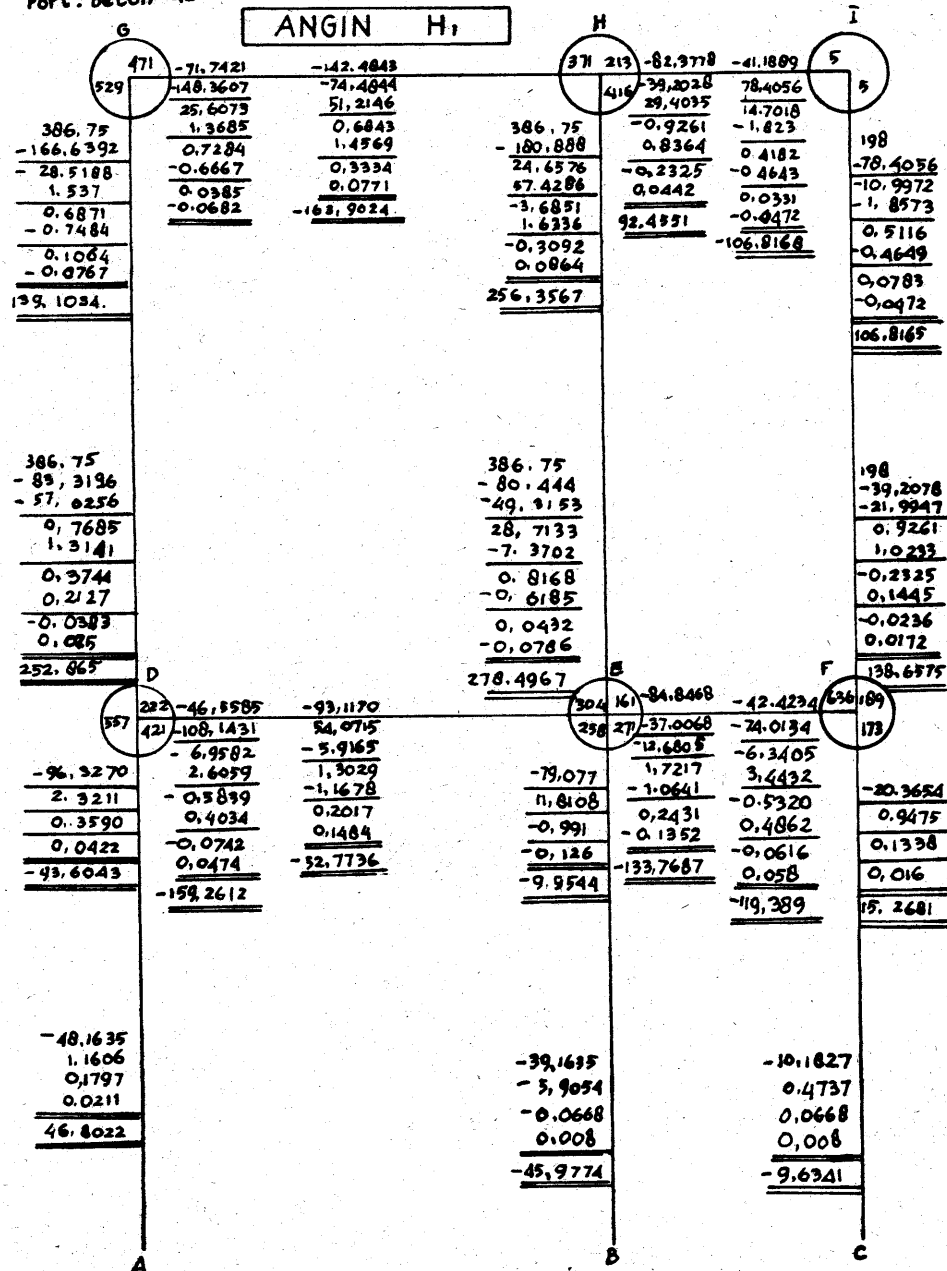
$$M_{DA} = M_{AD} = \frac{6EI}{3,5^2} = \frac{6 \cdot 1,728 \cdot 914,667}{3,5^2} = 774,144 \text{ kgm.}$$

$$M_{DB} = M_{BD} = M_{EB} = M_{BE}$$

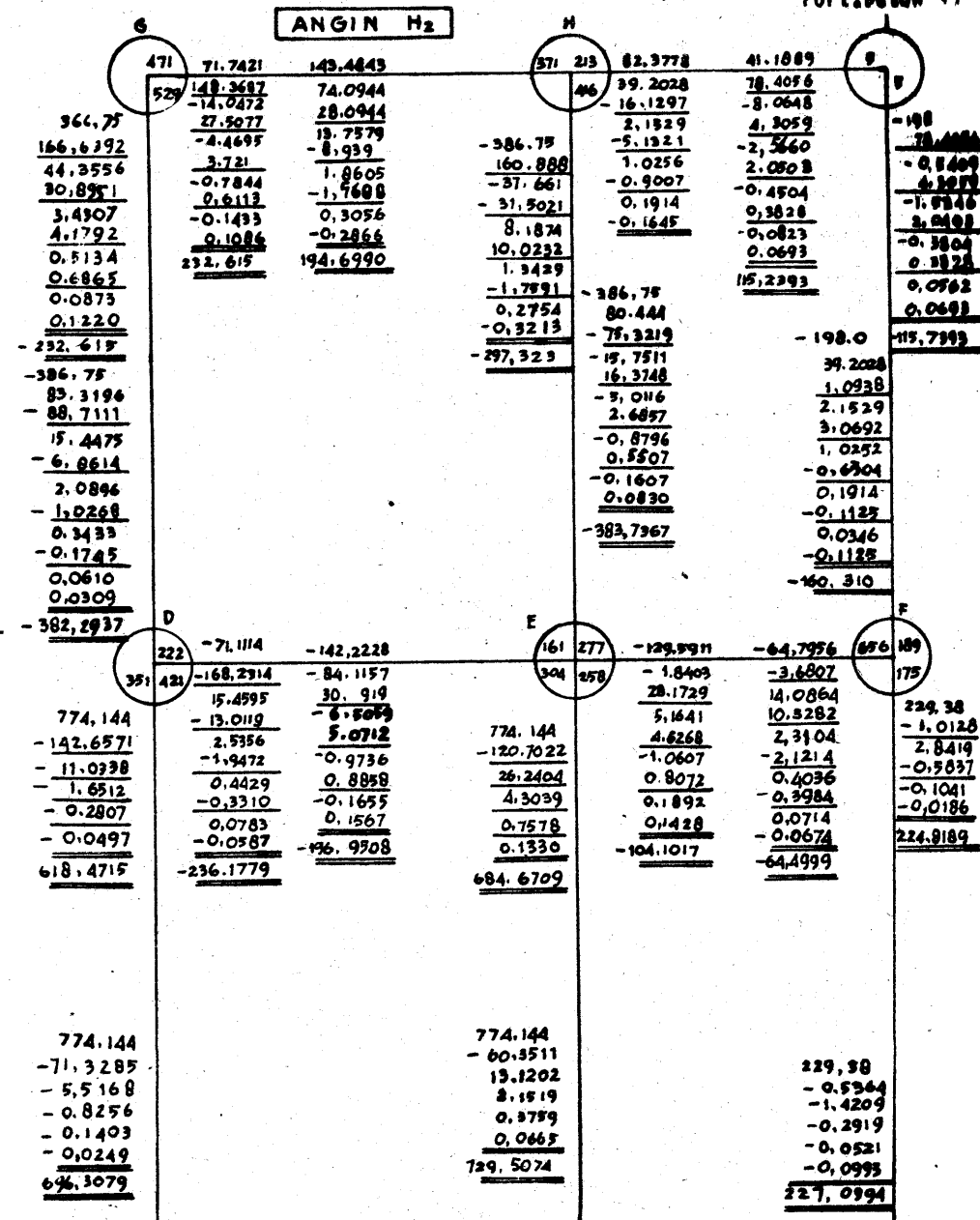
$$M_{IF} = M_{FI} = \frac{6 \cdot 0,512 \cdot EI \cdot \delta}{3,5^2} = \frac{6 \cdot 0,512 \cdot 914,667}{3,5^2} = 229,376 \text{ kgm.}$$



Port. Beton 42



Port. Beton 41



MUATAN VERTIKAL

| | | | | | | |
|------------|------------|------------|------------|-----------|-----------|------------|
| 471 | 156.33 | 156.33 | 371 | 219 | 1238 | -1238 |
| 529 | 2670.2725 | 5540.545 | 416 | 3066.135 | 1533.0675 | -1425.938 |
| -9682.4321 | -8620.8424 | 4310.4207 | -73.7669 | 532.1265 | 147.5398 | -55.7540 |
| 2623.9068 | 443.4247 | 926.8495 | -52.5773 | 105.1547 | 55.8526 | -105.1547 |
| 1142.8062 | 1417.5879 | 508.794 | -76.8017 | 88.4008 | 72.1367 | 72.1367 |
| -141.7835 | -159.9752 | -307.9503 | -36.0634 | 33.3105 | 16.6593 | -14.1414 |
| 156.4364 | 139.3023 | 69.6592 | -7.0791 | -14.154 | 3.1449 | -2.0865 |
| 19.3039 | -29.0099 | -58.0198 | 6.2897 | 1.3079 | 0.5959 | 2.6157 |
| 30.8480 | 27.4658 | 13.7329 | -0.0719 | 0.2349 | 0.4598 | 0.4591 |
| -3.5898 | -5.4777 | -10.9553 | -0.1984 | 0.0947 | 0.061 | 0.0672 |
| 4.7703 | 4.2472 | 2.1336 | 4536.9312 | 289.0493 | -289.0454 | -73.7660 |
| -0.60 | 0.9333 | 1.8667 | 2994.16 | 3771.8822 | 111.7952 | 54.1947 |
| 0.841 | 0.7222 | 0.8611 | 579.6353 | 747.6514 | -11.7052 | 36.0634 |
| 0.1037 | -0.1649 | 0.3298 | 172.6914 | 141.5459 | -23.7995 | 7.0797 |
| 0.1421 | 0.1265 | 13460.4853 | -32.6286 | 17.4409 | -4.173 | 1.3073 |
| 11145.7468 | 11145.7467 | 8923.5359 | -6.1421 | 3.20 | -0.8645 | 0.2879 |
| -4841.2156 | -5247.8172 | 571.448 | -1.0466 | 0.5546 | 0.1344 | 0.0405 |
| 571.448 | 283.866 | 78.2282 | -0.1849 | 0.0978 | 0.0236 | -332.8093 |
| 38.6078 | 15.424 | 7.0796 | 2.3851 | -1.20 | 0.4056 | -0.2073 |
| 2.3851 | -1.20 | 0.4056 | -0.2073 | 0.0710 | -0.0365 | 9751.7679 |
| -0.2073 | 0.0710 | -0.0365 | 9751.7679 | 24919 | 3361.0317 | -9951.9416 |
| 24919 | 3361.0317 | -9951.9416 | 705.8807 | 6.0423 | -1.1380 | 1.0567 |
| 705.8807 | 6.0423 | -1.1380 | 1.0567 | -0.1966 | 0.1847 | 25527.1021 |
| 1.0567 | -0.1966 | 0.1847 | 25527.1021 | 3.6212 | -2.2761 | 0.5283 |
| 3.6212 | -2.2761 | 0.5283 | 0.5283 | -0.3932 | 0.5283 | -0.0668 |
| 0.5283 | -0.3932 | 0.5283 | -0.0668 | 4098.5297 | 228.0032 | 31.0427 |
| 4098.5297 | 228.0032 | 31.0427 | 5.6929 | 0.9651 | 0.0667 | 0.0122 |
| 5.6929 | 0.9651 | 0.0667 | 0.0122 | 4485.4278 | 3719.529 | 3022.1914 |
| 4485.4278 | 3719.529 | 3022.1914 | 599.0698 | 81.2026 | 13.9744 | 2.5640 |
| 599.0698 | 81.2026 | 13.9744 | 2.5640 | 0.4484 | 0.0784 | 3719.529 |
| 2.5640 | 0.4484 | 0.0784 | 3719.529 | 51.624 | 51.7154 | 10.784 |
| 51.624 | 51.7154 | 10.784 | 1.9119 | 0.3953 | 0.0622 | 0.0109 |
| 1.9119 | 0.3953 | 0.0622 | 0.0109 | 16.4837 | | |

2. Titik G bergeser kekanan sebesar δ

$$M_{CD} = M_{DE} = M_{HE} = M_{EH} = -306,75 = 119,3,25 = 386,75 \text{ kgm.}$$

$$\frac{6EI}{3,25^2} = 386,75 \rightarrow EI \delta = 680,841$$

$$M_{IF} = M_{FI} = \frac{6EI \delta}{3,25^2} = \frac{6 \cdot 0,512 \cdot EI \delta}{3,25^2} = \frac{6 \cdot 0,512 \cdot 680,841}{3,25^2} = 198,016 \text{ kgm.}$$

AKIBAT GAYA HORIZONTAL H, MAKA D GOYANG KEKANAN SEBESAR δ Momen primer pada tiang2 karena δ kekanan :

$$M_{DA} = M_{AD} = +6 \cdot EI \delta / 3,5^2 = 0,4898 EI \delta = +M$$

$$M_{BE} = M_{EB} = +6 \cdot EI \delta / 3,5^2 = 0,4898 EI \delta = +M$$

$$M_{FC} = M_{CF} = +6 \cdot 0,2963 EI \delta / 3,5^2 = +2963 M.$$

MOMEN AKIBAT GAYA HORIZONTAL (TEKANAN TANAH).

$$\Sigma H = 0$$

$$233 = \frac{0,675 M + 0,8374 M + 0,8055 M + 0,9084 M + 0,262 + 0,2792 M}{3,5}$$

$$= \frac{3,7676 M}{3,5}$$

$$M = \frac{233 \cdot 3,5}{3,7676} = 216,45$$

$$M_{GH} = +0,0505 \cdot 216,45 = 10,9307 \text{ kgm.}$$

$$M_{GD} = +0,0505 \cdot 216,45 = -10,9307 \text{ kgm.}$$

$$M_{HD} = +0,0381 \cdot 216,45 = +8,2467 \text{ kgm.}$$

$$M_{HE} = -0,0482 \cdot 216,45 = +10,4329 \text{ kgm.}$$

$$M_{HI} = +0,0100 \cdot 216,45 = +2,1645 \text{ kgm.}$$

$$M_{IH} = +0,0100 \cdot 216,45 = +2,3810 \text{ kgm.}$$

$$\begin{aligned}
 M_{IF} &= - 0,0110 \cdot 216,45 = - 2,3810 \text{ kgm.} \\
 M_{DG} &= - 0,1771 \cdot 216,45 = - 38,3330 \text{ kgm.} \\
 M_{DE} &= - 0,4979 \cdot 216,45 = - 107,7705 \text{ kgm.} \\
 M_{DA} &= + 0,6750 \cdot 216,45 = + 146,2038 \text{ kgm.} \\
 M_{EB} &= - 0,4255 \cdot 216,45 = - 92,0995 \text{ kgm.} \\
 M_{EH} &= - 0,1140 \cdot 216,45 = - 24,6753 \text{ kgm.} \\
 M_{EF} &= - 0,2708 \cdot 216,45 = - 58,6580 \text{ kgm.} \\
 M_{EE} &= + 0,8055 \cdot 216,45 = + 174,3505 \text{ kgm.} \\
 M_{FE} &= - 0,2287 \cdot 216,45 = - 49,5021 \text{ kgm.} \\
 M_{FI} &= - 0,0334 \cdot 216,45 = - 7,2292 \text{ kgm.} \\
 M_{FC} &= + 0,2621 \cdot 216,45 = + 56,7315 \text{ kgm.} \\
 M_{AD} &= + 0,8374 \cdot 216,45 = + 181,2552 \text{ kgm.} \\
 M_{BE} &= + 0,9084 \cdot 216,45 = + 191,6232 \text{ kgm.} \\
 M_{CF} &= + 0,2792 \cdot 216,45 = + 60,4328 \text{ kgm.}
 \end{aligned}$$

MOMEN GABUNGAN ANTARA GAYA2 VERTIKAL & GAYA TETAP HORIZONTAL.

$$\begin{aligned}
 M_{GH} &= + 10,9307 + 11145,7467 = + 11156,6774 \text{ kgm.} \\
 M_{GD} &= - 10,9307 - 11145,7467 = - 11156,6774 \text{ kgm.} \\
 M_{HD} &= + 8,2467 - 13460,4853 = - 13452,2386 \text{ kgm.} \\
 M_{HE} &= - 10,4329 + 8923,5359 = + 8913,1030 \text{ kgm.} \\
 M_{HI} &= + 2,1645 + 4536,9312 = + 4538,7957 \text{ kgm.} \\
 M_{IH} &= + 2,381 + 298,0453 = + 291,4263 \text{ kgm.} \\
 M_{IF} &= - 2,3810 - 298,0453 = - 291,4263 \text{ kgm.} \\
 M_{DG} &= - 38,3333 - 9751,96790 = - 9790,1012 \text{ kgm.} \\
 M_{DE} &= - 107,7705 + 18722,6244 = + 18614,8539 \text{ kgm.} \\
 M_{DA} &= + 146,1038 - 8970,8555 = - 8824,7517 \text{ kgm.}
 \end{aligned}$$

$$\begin{aligned}
 M_{ED} &= - 92,0995 - 25527,1021 = - 25619,2016 \text{ kgm.} \\
 M_{EH} &= - 24,6753 + 7443,4195 = + 7418,7442 \text{ kgm.} \\
 M_{EF} &= - 58,6580 + 10144,5990 = + 10085,9410 \text{ kgm.} \\
 M_{EB} &= + 174,3515 + 7439,0579 = + 7613,4084 \text{ kgm.} \\
 M_{FE} &= - 49,5021 + 565,7768 = + 516,2747 \text{ kgm.} \\
 M_{EB} &= + 7,2292 - 332,8093 = - 340,0387 \text{ kgm.} \\
 M_{EC} &= 56,7315 - 232,9677 = - 176,2362 \text{ kgm.} \\
 M_{AD} &= + 181,2552 - 4485,4278 = - 4304,1726 \text{ kgm.} \\
 M_{BE} &= + 196,6232 + 3719,5290 = + 3916,1522 \text{ kgm.} \\
 M_{CF} &= + 60,4328 - 116,4839 = + 56,0511 \text{ kgm.}
 \end{aligned}$$

GAYA HORIZONTAL AKIBAT GAYA2 VERTIKAL.

$$\begin{aligned}
 H_1 &= \frac{- 11145,7468 - 9751,7679 + 8923,5359 + 7943,419 + 289,0454 + 332,8093}{3,25} \\
 &= - 1428,4352 \text{ kg (} \leftarrow \text{)}
 \end{aligned}$$

$$\begin{aligned}
 H_2 &= \frac{- 8970,8555 - 4485,4274 + 7439,0579 + 3719,529 - 232,9677 - 116,8439 - H_1}{3,25} \\
 &= - 756,4307 - (- 1428,4352) = 672,005 \text{ (} \rightarrow \text{)}
 \end{aligned}$$

GAYA2 HORIZONTAL (H₁ & H₂) AKIBAT GAYA ANGIN.

Akibat titik G bergeser kekanan sebesar 8 m.

$$\begin{aligned}
 H_1 &= \frac{193,1034 + 252,8654 + 256,3567 + 278,4967 + 106,8165 + 138,0575}{3,25} \\
 &= + 377,322 \text{ kgm (} \rightarrow \text{)} \\
 H_2 &= \frac{- 93,6043 - 46,8022 - 91,9544 - 45,9774 - 19,2681 - 9,6341}{3,5} - H_1 \\
 &= - 87,783 - 377,322 = - 289,539 \text{ kg (} \leftarrow \text{)}
 \end{aligned}$$

AKIBAT TITIK D BERGESER KEKANAN SEBESAR 8 m.

$$H_1 = \frac{-232,615 - 382,2937 - 297,323 - 383,7367 - 115,239 - 160,319}{3,25}$$

$$= -483,5466 \text{ kg } (<---)$$

$$H_2 = \frac{618,4715 + 696,3079 + 684,6709 + 729,5074 + 224,099}{3,25} - H_1$$

$$= 908,82 + 483,5466 = +1392,3683 \text{ kg } (---->)$$

$$C_1(H_1) + C_2(H_2) + (H_1) = 128$$

$$C_1 \cdot 377,322 + (-483,5466) C_2 - 1428,4352 = 119$$

$$377,539 \cdot C_1 - 483,5466 \cdot C_2 = 1547,4352 \dots\dots\dots (1)$$

$$C_1(H_2) + C_2(H_2) + H_2 = 415,67$$

$$-289,539 \cdot C_1 + 1392,3683 C_2 = 256,335$$

$$\frac{1330,9626 \cdot C_2 = 1213,384}{+} \text{ -----> } C_2 = 0,9117$$

$$C_1 = \frac{1547,4352 + 483,5466 \cdot (0,9117)}{377,322} = 5,269$$

MOMEN PORTAL UNTUK BEBAN SEMENTARA.

$$M_{GH} = 0,9117 \cdot (-193,103) + 5,269 \cdot (232,615) + 11145,7416 = 12195,3440 \text{ kgm}$$

$$M_{GD} = 0,9117 \cdot (193,103) + 5,269 \cdot (-232,615) - 11145,7476 = -12195,3651 \text{ kgm}$$

$$M_{HG} = 0,9117 \cdot (-163,9024) + 5,269 \cdot (194,699) - 13460,4853 = -12584,0451 \text{ kgm}$$

$$M_{HE} = 0,9117 \cdot (256,3567) + 5,269 \cdot (-297,323) + 8923,5359 = 7590,6614 \text{ kgm}$$

$$M_{HI} = 0,9117 \cdot (-92,4550) + 5,269 \cdot (102,6231) + 1536,9312 = 4993,3010 \text{ kgm}$$

$$M_{IH} = 0,9117 \cdot (-106,8168) + 5,269 \cdot (115,2393) + 289,0453 = 798,8563 \text{ kgm}$$

$$M_{IF} = 0,9117 \cdot (106,8168) + 5,269 \cdot (-115,2393) - 289,0453 = -798,8563 \text{ kgm}$$

$$M_{DG} = 0,9117 \cdot (252,8654) + 5,269 \cdot (-382,2937) - 9751,7679 = -11535,5360 \text{ kgm}$$

$$M_{DE} = 0,9117 \cdot (-159,2612) + 5,269 \cdot (-236,1779) + 18722,6244 = 17333,0040 \text{ kgm}$$

$$M_{DA} = 0,9117 \cdot (-93,6043) + 5,269 \cdot (618,4715) - 8970,8555 = -5797,4682 \text{ kgm}$$

$$M_{KD} = 0,9117 \cdot (-52,7736) + 5,269 \cdot (-196,9508) - 25527,1021 = -26612,9495 \text{ kgm}$$

$$M_{KH} = 0,9117 \cdot (278,4967) + 5,269 \cdot (-383,7367) + 7943,4195 = 6175,4163 \text{ kgm}$$

$$M_{KF} = 0,9117 \cdot (-133,7687) + 5,269 \cdot (-104,1017) + 10144,5990 = 9474,1302 \text{ kgm}$$

$$M_{KB} = 0,9117 \cdot (-91,9544) + 5,269 \cdot (684,6709) + 7439,0579 = 10962,7816 \text{ kgm}$$

$$M_{FE} = 0,9117 \cdot (-119,3890) + 5,269 \cdot (-64,4999) + 565,7768 = 117,0799 \text{ kgm}$$

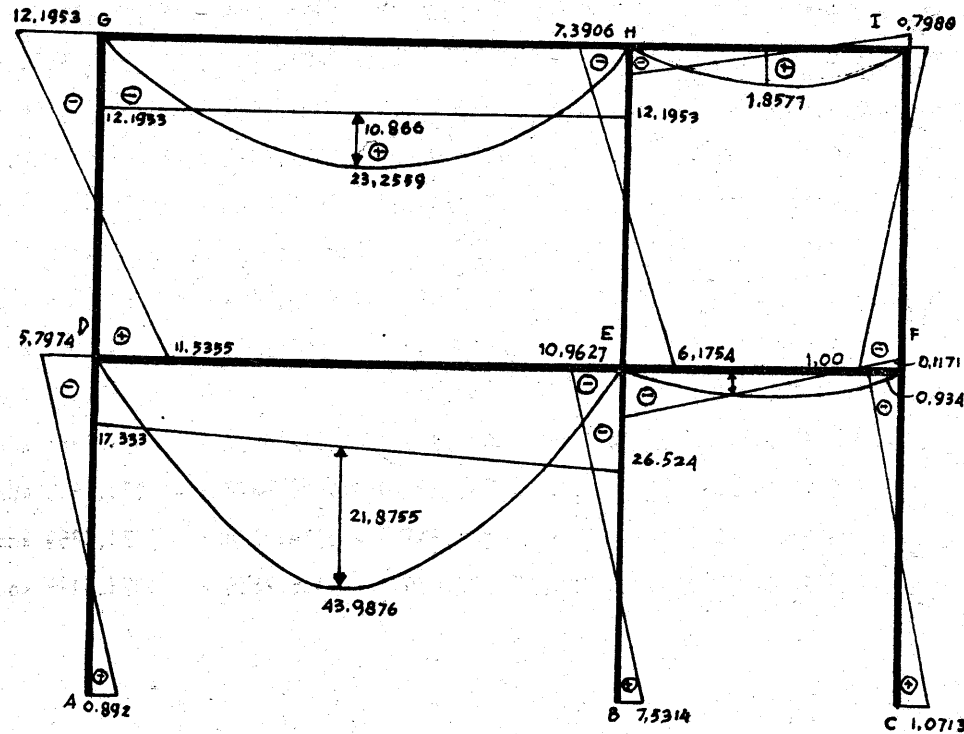
$$M_{FI} = 0,9117 \cdot (138,6575) + 5,269 \cdot (-160,3290) - 332,8093 = -1051,1687 \text{ kgm}$$

$$M_{FC} = 0,9117 \cdot (-19,2681) + 5,269 \cdot (224,8189) - 232,9677 = 934,0363 \text{ kgm}$$

$$M_{AD} = 0,9117 \cdot (-46,8022) + 5,269 \cdot (696,3079) - 4485,4278 = -859,2510 \text{ kgm}$$

$$M_{BE} = 0,9117 \cdot (-45,9774) + 5,269 \cdot (729,5075) + 3719,5290 = 7521,3859 \text{ kgm}$$

$$M_{CF} = 0,9117 \cdot (-9,6341) + 5,269 \cdot (227,0994) - 116,4839 = 1071,3194 \text{ kgm}$$



$$G_V = \frac{12,1953 - 12,584}{10} + \frac{1}{2} \cdot 1,876 \cdot 10 = 9,3411 \text{ ton.}$$

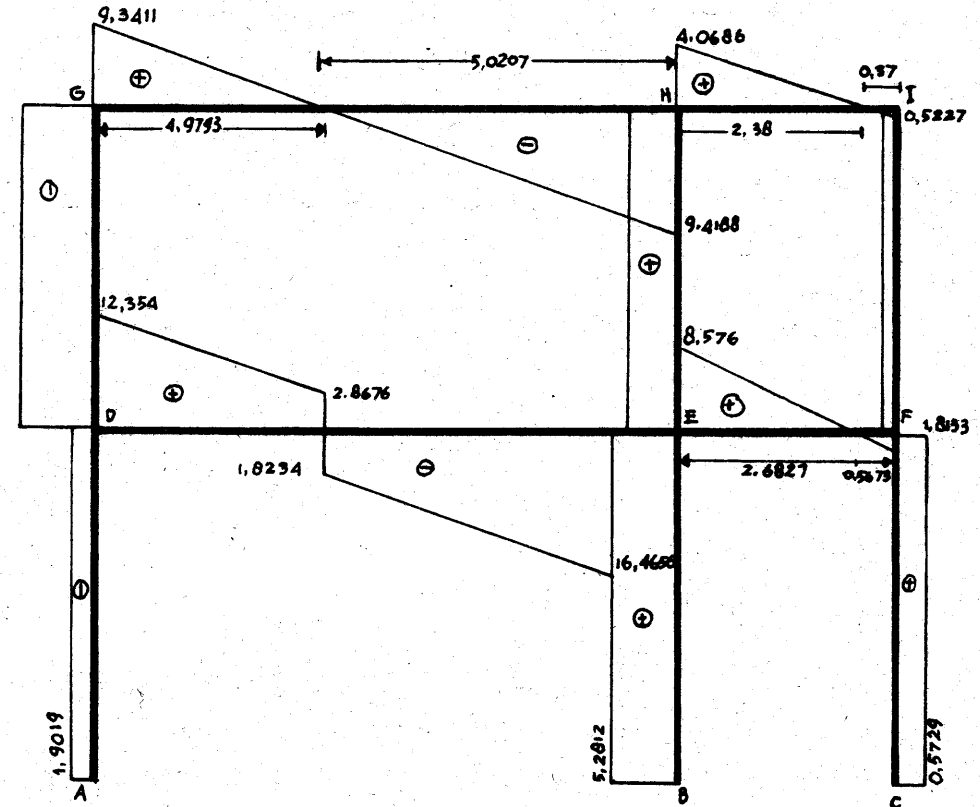
$$K_V = \frac{1}{2} \cdot 1,876 \cdot 10 + \frac{12,584 - 12,1953}{10} + \frac{1}{2} \cdot 1,407 \cdot 3,25 + \frac{4,9933 + 0,7988}{3,25} = 13,4874$$

$$I_V = \frac{1}{2} \cdot 1,407 \cdot 3,25 + \frac{(-0,7988 - 4,933)}{3,25} = 0,5227 \text{ ton.}$$

$$D_V = 13,287 + \frac{17,333 - 26,6129}{10} = 12,359 \text{ ton.}$$

$$E_V = 16,396 + \frac{26,6129 - 17,333}{10} + \frac{1}{2} \cdot 2,938 \cdot 3,25 + \frac{9,4741 + 0,1171}{3,25} = 25,0396 \text{ ton.}$$

$$F_V = \frac{1}{2} \cdot 2,932 \cdot 3,25 + \frac{(-0,1171 - 9,4741)}{3,25} = 1,8133 \text{ ton.}$$



$$D_H = \frac{-11,5355 - 12,1953}{3,25} = -7,3018 \text{ t (} \rightarrow \text{)}$$

$$E_H = \frac{7,5906 + 6,1754}{3,25} = 4,2357 \text{ t (} \leftarrow \text{)}$$

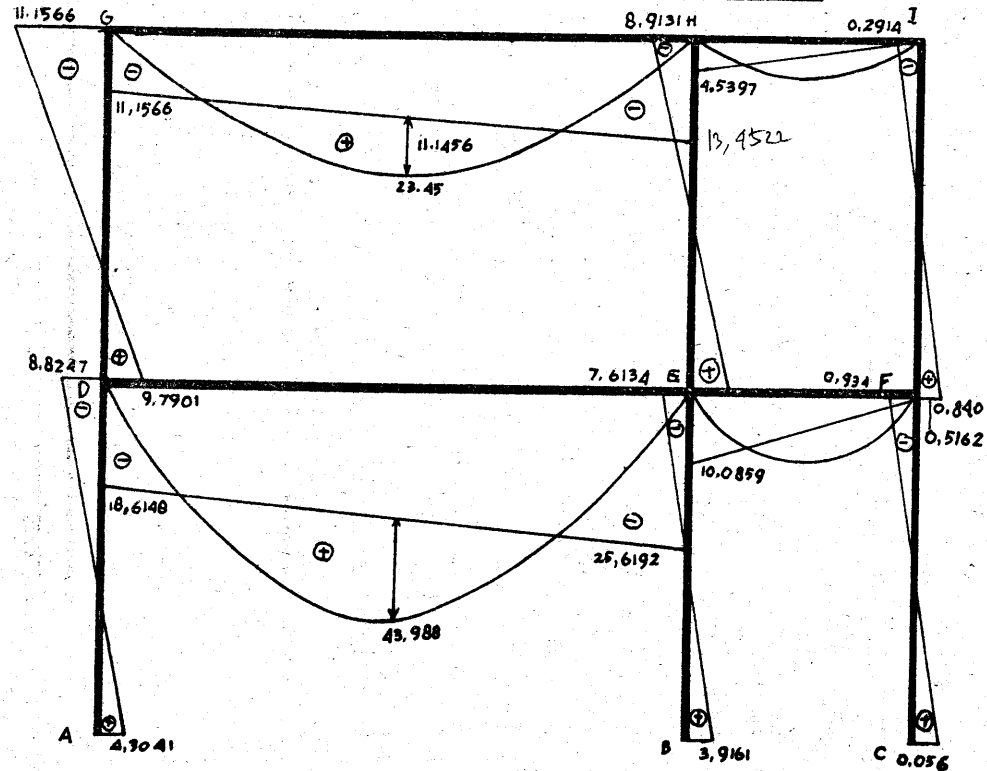
$$F_H = \frac{-0,7988 - 1,0511}{3,25} = -0,5692 \text{ t (} \rightarrow \text{)}$$

$$A_H = \frac{-0,8592 - 5,7974}{3,50} = -1,9019 \text{ t (} \rightarrow \text{)}$$

$$B_H = \frac{10,9267 + 7,5214}{3,50} = 5,2812 \text{ t (} \leftarrow \text{)}$$

$$C_H = \frac{0,934 + 1,0713}{3,50} = 0,57 \text{ t (} \leftarrow \text{)}$$

MOMEN GABUNGAN ANTARA GAYA2 VERTIKAL DAN GAYA TETAP HORIZONTAL.



$$G_V = \frac{1}{2} \cdot 1,876 \cdot 10 + \frac{11,1566 - 13,4522}{10} = 9,1504 \text{ ton.}$$

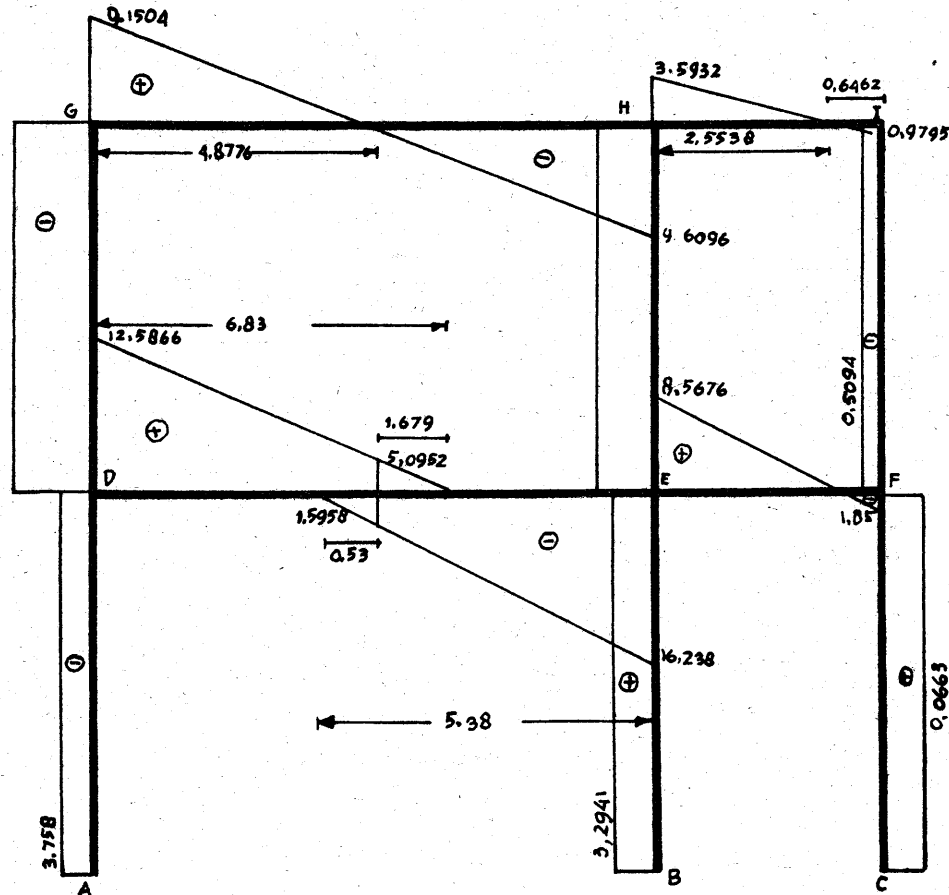
$$H_V = \frac{1}{2} \cdot 1,876 \cdot 10 + \frac{13,4522 - 11,1566}{10} = \frac{1}{2} \cdot 1,407 \cdot 3,25 + \frac{4,5387 - 0,2914}{3,25} = 13,2028 \text{ ton.}$$

$$I_V = \frac{1}{2} \cdot 1,407 \cdot 3,25 + \frac{0,2914 - 4,5387}{3,25} = 0,9795 \text{ ton.}$$

$$D_V = 13,287 + \frac{18,6148 - 25,6192}{10} = 12,5866 \text{ ton.}$$

$$E_V = 16,396 + \frac{25,6192 - 18,6148}{10} + \frac{1}{2} \cdot 2,932 \cdot 3,25 + \frac{10,0859 - 0,5162}{3,25} = 24,8055 \text{ ton.}$$

$$F_V = \frac{1}{2} \cdot 2,932 \cdot 3,25 + \frac{0,5162 - 10,0859}{3,25} = 1,82 \text{ ton.}$$



$$D_H = \frac{-11,1566 - 9,7901}{3,25} = -6,4451 \text{ ton (} \rightarrow \text{)}$$

$$E_H = \frac{8,9131 + 7,4187}{3,25} = 5,0252 \text{ ton (} \leftarrow \text{)}$$

$$F_H = \frac{-0,2914 - 0,34}{3,25} = -0,1943 \text{ ton (} \rightarrow \text{)}$$

$$A_H = \frac{-4,3041 - 8,8247}{3,50} = -3,7511 \text{ ton (} \rightarrow \text{)}$$

$$B_H = \frac{7,6134 + 3,9161}{3,50} = 3,2941 \text{ ton (} \leftarrow \text{)}$$

$$C_H = \frac{0,1762 + 0,056}{3,50} = 0,0663 \text{ ton (} \leftarrow \text{)}$$

PERHITUNGAN BALOK.

Untuk pembebanan tetap : beton K₁₇₅ $\rightarrow \bar{\sigma} b' = 66 \text{ kg/cm}^2$
 baja U₃₂ $\rightarrow \bar{\sigma} a = 1850 \text{ kg/cm}^2$
 $n = 24$
 $K_o = 11,231 \text{ kg/cm}^2$
 $P_o = 30,833$
 $(p/n)_o = 1,285 \quad \tau = 5 \text{ kg/cm}^2$

Untuk pembebanan sementara :

beton K₁₇₅ $\rightarrow \bar{\sigma} b' = 100 \text{ kg/cm}^2$
 baja U₃₂ $\rightarrow \bar{\sigma} a = 2650 \text{ kg/cm}^2$
 $n = 16$
 $K_o = 16,5625 \text{ kg/cm}^2$
 $P_o = 26,5$
 $(p/n)_o = 1,6563$
 $\tau_s = 9 \text{ kg/cm}^2$

BALOK GN.

$$M^+ = 1114560 \text{ kg cm.}$$

$$K = \frac{1114560}{30.63^2} = 9,36 < K_o = 11,231 \text{ kg/cm}^2$$

$$\frac{n \cdot k}{\bar{\sigma} a} = \frac{24 \cdot 9,36}{1850} = 0,1214 \rightarrow m = 0,141$$

$$A = 0,141/24 \cdot 30 \cdot 63 = 11,10375 \text{ cm}^2$$

$$\text{Dipakai} = 3 \text{ } \varnothing \text{ } 7/8'' = 11,61 > 11,104 \text{ cm}^2.$$

Kontrol terhadap muatan sementara.

$$M^+ = 10,8662 \text{ tm} \longrightarrow k = \frac{1086620}{30,63^2} = 9,126$$

$$\frac{n \cdot k}{\sigma \cdot a} = \frac{16 \cdot 9,126}{2650} = 0,083 \longrightarrow n_w = 0,094$$

$$A_2 = 0,094/16 \cdot 30 \cdot 63 = 7,4025 \text{ cm}^2 < A = 11,10375 \text{ cm}^2$$

Dipakai $A = 11,10375 \text{ cm}^2$ (pada perhitungan tetap)

$$M^- \text{ kiri} = 11,1566 \text{ tm} \longrightarrow k = \frac{1115660}{30,63^2} = 9,37 < k_0$$

$$\frac{n \cdot k}{\sigma \cdot a} = \frac{24 \cdot 9,37}{1850} = 0,122 \longrightarrow n_w = 0,141$$

$$A = 0,141/24 \cdot 30 \cdot 63 = 11,10375 \text{ cm}^2$$

$$\text{Dipakai} = 3 \text{ } \varnothing \text{ } 7/8'' = 11,61 > 11,10375 \text{ cm}^2$$

Kontrol terhadap SF.

$$M^- \text{ kiri} = 9150,4 \text{ kg}$$

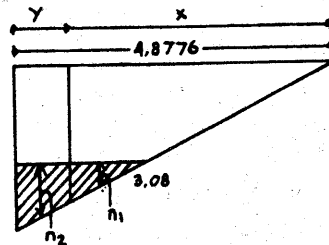
$$\tau = 8/7 \cdot \frac{9150,4}{30,63} = 5,53 \text{ kg/cm}^2 > 5 \text{ kg/cm}^2$$

$$x = 5/5 \cdot 53 \cdot 4,8776 = 4,41 \text{ m.}$$

$$y = 4,8776 - 4,41 = 0,4676 = 46,76 \text{ cm}$$

Dipakai begel $\varnothing 8 \text{ mm} - 20 \text{ cm}$

$$\left. \begin{array}{l} A_s = 2,05 = 1 \text{ cm}^2 \\ a_s = 20 \text{ cm} \end{array} \right\} \tau_s = \frac{A_s}{a_s \cdot b} = \frac{1 \cdot 1850}{20 \cdot 30} = 3,08 \text{ kg/cm}^2.$$



$$\text{Tulangan miring} = T_m = \frac{A_m \sigma_a (\cos \psi + \sin \varphi)}{a_m \cdot b}$$

$$\left. \begin{array}{l} n_1 = 5 - 3,08 = 1,92 \\ P_2 = 5,53 - 3,08 = 2,45 \end{array} \right\} \begin{array}{l} \sigma_a (\cos \varphi + \sin \varphi) \\ 1850 (\frac{1}{2} V_2 + \frac{1}{2} V_2) = 1850 V_2 \end{array}$$

$$a_m = (1,92 + 2,45) \cdot 0,467/2 = 1,0204 \text{ m} = 102,04 \text{ cm.}$$

$$b = 30 \text{ cm}$$

$$A_m = \frac{102,04 \cdot 30}{1850 \sqrt{2}} = 1,17 \text{ cm}^2$$

$$\text{Dipakai} \longrightarrow = 1 \text{ } \varnothing \text{ } 7/8'' = 3,87 \text{ cm}^2 > 1,17 \text{ cm}^2.$$

Kontrol beban sementara.

$$M^- \text{ kiri} = 1219530 \text{ kg cm} \longrightarrow k = \frac{1219530}{30,63^2} = 10,242 < k_0$$

$$\frac{n \cdot k}{\sigma \cdot a} = \frac{16 \cdot 10,242}{2650} = 0,062 \longrightarrow n_w = 0,069$$

$$A^- = 0,069/16 \cdot 30 \cdot 63 = 5,434 \text{ cm}^2 < 11,10375 \text{ cm}^2.$$

Kontrol terhadap tulangan serong.

$$D \text{ kiri} = 9341,1 \text{ kg} \longrightarrow \tau = 8/7 \cdot \frac{9341,1}{30,63} = 5,65 < \tau_s = 9 \text{ kg/cm}^2$$

tanpa tulangan serong.

$$M^- \text{ kanan} = 1345220 \text{ kg cm} \quad d = 5 : h = 65$$

$$k = \frac{1345220}{30,63^2} = 10,613 < k_0$$

$$\frac{n \cdot k}{\sigma \cdot a} = \frac{24 \cdot 10,613}{1850} = 0,138 \longrightarrow n_w = 0,161$$

$$A = 0,161/24 \cdot 30 \cdot 63 = 13,08 \text{ cm}^2$$

$$\text{Dipakai} : 4 \text{ } \varnothing \text{ } 7/8'' = 15,48 \text{ cm}^2 > 13,08 \text{ cm}^2$$

Kontrol terhadap SF.

$$D = 9689,6 \text{ kg} \rightarrow \tau = \frac{8/7 \cdot 9689,6}{30,65} = 5,68 > 5 \text{ kg/cm}^2$$

Dipakai begel 8 mm - 20 cm

$$\tau_s = 3,08 \text{ kg/cm}^2$$

$$x = 5/5,58 \cdot 5,0252 = 4,424 \text{ m}$$

$$y = 5,0252 - 4,424 = 60 \text{ cm}$$

$$A_m = \frac{\frac{(1,92 + 2,60)}{2} \cdot 60 \cdot 30}{1850V2} = 1,555 \text{ cm}^2$$

$$\text{Dipakai : } 1 \text{ } \phi \text{ } 7/8'' = 3,87 \text{ cm}^2 > 1,555 \text{ cm}^2$$

Kontrol terhadap beban sementara.

$$M^- \text{ kanan} = 12,584 \text{ tm} \rightarrow k = \frac{1258400}{30,65^2} = 9,928 < k_0$$

$$\frac{n \cdot k}{\sigma_a} = \frac{16 \cdot 9,928}{2650} = 0,06 \rightarrow nw = 0,067$$

$$A = 0,067/16 \cdot 30 \cdot 65 = 8,166 \text{ cm}^2 < 13,08 \text{ cm}^2$$

Check terhadap SF.

$$D = 9418,8 \text{ kg} \rightarrow \tau = \frac{8/7 \cdot 9418,8}{30 \cdot 65} = 5,52 < 9 \text{ kg/cm}^2$$

(tanpa tulangan serong)

BALOK HI.

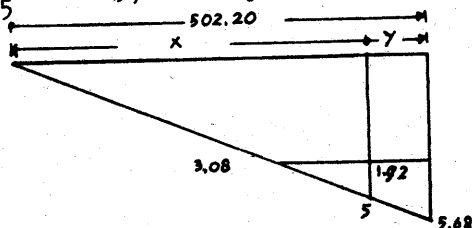
$$M^+ = 1,201 \text{ tm} = 120100 \text{ kgcm}$$

$$k = \frac{120100}{30,35^2} = 3,268 \text{ kg/cm}^2 < k_0$$

$$\frac{n \cdot k}{\sigma_a} = \frac{24 \cdot 3,268}{1850} = 0,042 \rightarrow nw = 0,05$$

$$A = 0,05/24 \cdot 30 \cdot 35 = 2,1875 \text{ cm}^2$$

$$\text{Dipakai : } 2 \text{ } \phi \text{ } 1/2'' = 2,53 \text{ cm}^2 > 2,1875 \text{ cm}^2$$



Kontrol beban sementara.

$$M^+ = 0,88 \text{ tm} = 88000 \text{ kg cm}$$

$$k = \frac{88000}{30,35^2} = 2,395 \text{ kg/cm}^2 < k'_0 \cdot \frac{n \cdot k}{a} = \frac{16 \cdot 2,395}{2650} = 0,014 \rightarrow nw = 0,05$$

$$A = 0,05/16 \cdot 30 \cdot 35 = 3,28 \text{ cm}^2 > 2,1875 \text{ cm}^2$$

$$\text{Dipakai : } 3 \text{ } \phi \text{ } 1/2'' = 3,8 \text{ cm}^2 > 3,28 \text{ cm}^2 \text{ (yang dipakai)}$$

Beban tetap :

$$M^- \text{ kiri} = 453870 \text{ kgcm} \rightarrow k = \frac{453870}{30,35^2} = 12,35 \text{ kg/cm}^2 > 11,231 \text{ kg/cm}^2$$

$$\frac{k}{\sigma_a} = \frac{12,35}{60} = 0,206$$

} nw = 0,265

$$p/n = 0,97$$

$$A = 0,265/24 \cdot 30 \cdot 35 = 11,594 \text{ cm}^2$$

$$\text{Dipakai : } 4 \text{ } \phi \text{ } 7/8'' = 15,48 \text{ cm}^2 > 11,594 \text{ cm}^2$$

Kontrol terhadap SF.

$$D = 3543,2 \text{ kg} \rightarrow \tau = \frac{8/7 \cdot 3543,2}{30 \cdot 35} = 3,857 < 5 \text{ kg/cm}^2$$

(tidak perlu tulangan serong)

$$M^- \text{ kanan} = 29140 \text{ kgcm} \rightarrow k = \frac{29140}{30,35^2} = 0,793 < k_0$$

$$\frac{n \cdot k}{\sigma_a} = \frac{24 \cdot 0,793}{1850} = 0,01 \rightarrow nw = 0,05$$

$$A = 0,05/24 \cdot 30 \cdot 35 = 2,1875 \text{ cm}^2$$

$$\text{Dipakai : } 2 \text{ } \phi \text{ } 1/2'' = 2,53 \text{ cm}^2 > 2,1875 \text{ cm}^2$$

Kontrol terhadap SF.

$D = 979,5 \text{ kg} \longrightarrow \tau = \frac{8/7 \cdot 979,5}{30 \cdot 35} = 1,1 \text{ kg/cm}^2 < 5 \text{ kg/cm}^2$
(tidak perlu tulangan serong)

Beban sementara.

$M^- = 499330 \text{ kgcm} \longrightarrow k = \frac{499330}{30 \cdot 35^2} = 13,59 \text{ kg/cm}^2 < k'_0 = 16,5625 \text{ kg/cm}^2$

$\frac{n \cdot k}{\sigma_a} = \frac{16 \cdot 13,59}{2650} = 0,082 \longrightarrow nw = 0,092$

$A = 0,092/16 \cdot 30 \cdot 35 = 6,0375 \text{ cm}^2 < 11,594 \text{ cm}^2$
dipakai tulangan pada perhitungan beban tetap.

Kontrol terhadap SF.

$D = 4068,6 \text{ kg} \longrightarrow \tau = \frac{8/7 \cdot 4086,6}{30 \cdot 35} = 4,45 < 9 \text{ kg/cm}^2$

$M^+ \text{ kanan} = 0,7988 \text{ tm} \longrightarrow k = \frac{79880}{30 \cdot 35^2} = 2,174 \text{ kg/cm}^2 < k'_0$

$\frac{n \cdot k}{\sigma_a} = \frac{16 \cdot 2,174}{2650} = 0,013 \longrightarrow nw = 0,05$

$A = 0,05/16 \cdot 30 \cdot 35 = 3,28 \text{ cm}^2 > 2,1875 \text{ cm}^2$
Dipakai : 2 \emptyset 7/8" = 7,74 cm² > 3,28 cm² (yang dipakai dalam konst.)

Kontrol terhadap SF.

$D = 522,7 \text{ kg} \quad \tau = \frac{8/7 \cdot 522,7}{30 \cdot 35} = 0,569 \text{ kg/cm}^2 < 9 \text{ kg/cm}^2$
(tanpa tulangan serong)

BALOK DE.

$D = 7 \text{ cm} ; h = 83 \text{ cm}$

$M^+ = 2176600 \text{ kg cm} \longrightarrow k = \frac{2176600}{30 \cdot 35^2} = 10,83 \text{ kg/cm}^2 < k'_0$

$\frac{n \cdot k}{\sigma_a} = \frac{24 \cdot 10,83}{1850} = 0,137 \longrightarrow nw = 0,16$

$A = 0,16/24 \cdot 30 \cdot 83 = 16,6 \text{ cm}^2$

Dipakai : 5 \emptyset 7/8" = 19,35 cm² > 16,6 cm²

$M^- \text{ kiri} = 1861480 \text{ kg cm} \longrightarrow k = \frac{1861480}{30 \cdot 83^2} = 9,01 \text{ kg/cm}^2 < k_0$

$\frac{n \cdot k}{\sigma_a} = \frac{24 \cdot 9,01}{1850} = 0,117 \longrightarrow nw = 0,135$

$A = 0,135/24 \cdot 30 \cdot 83 = 14,01 \text{ cm}^2$

Dipakai : 4 \emptyset 7/8" = 15,48 cm² > 14,01 cm².

Kontrol terhadap SF.

$D = 12586,6 \text{ kg} \longrightarrow \tau = \frac{8/7 \cdot 12586,6}{30 \cdot 83} = 5,78 \text{ kg/cm}^2 > 5 \text{ kg/cm}^2$
(perlu tulangan serong)

$x = 5/5,78 \cdot 683 = 590,8 \text{ cm}$

$y = 683 - 590,8 = 92,2 \text{ cm}$

Dipakai beugel \emptyset 8 mm - 20 cm

$s = 3,08 \text{ kg/cm}^2$

$A_m = \frac{\frac{(2,7 + 1,92)}{2} \cdot 92,2 \cdot 30}{1850 \cdot \sqrt{2}} = 2,44 \text{ cm}^2$

Dipakai : 1 \emptyset 7/8" = 3,67 cm² > 2,44 cm².

$M^- \text{ kanan} = 2561920 \text{ kg cm} \longrightarrow k = 12,4 \text{ kg/cm}^2 > k_0$

Tulangan rangkap :

$\left. \begin{aligned} \frac{n \cdot k}{\sigma_a} &= \frac{24 \cdot 12,4}{1850} = 0,161 \\ d/h &= 7/83 = 0,08 \\ P_o/n &= 30,833/24 = 1,285 \end{aligned} \right\} \begin{aligned} nw' &= 0,03 \\ nw &= 0,185 \end{aligned}$

$$A = 0,185/24.30.83 = 19,194 \text{ cm}^2 \text{ --- dipakai } 5 \text{ } \phi 1^{\prime\prime} = 19,35 \text{ cm}^2 > 19,194$$

$$A' = 0,03/24.30.83 = 3,1125 \text{ cm}^2 \text{ --- dipakai } 1 \text{ } \phi \frac{7}{8}^{\prime\prime} = 3,87 \text{ cm}^2 > 3,1125$$

Kontrol terhadap SF.

$$D = 16238 \text{ kg} \text{ --- } \tau = \frac{8/7.16238}{30.83} = 7,45 \text{ kg/cm}^2 > 5 \text{ kg/cm}^2$$

(perlu tulangan serong)

$$x = 5/5,45.5,38 = 361 \text{ cm}$$

$$y = 538 - 361 = 177 \text{ cm}$$

Dipakai beugel $\phi 8 \text{ mm} - 20 \text{ cm}$

$$A_m = \frac{\frac{(1,92 + 4,37)}{2} \cdot 177.30}{1850V2} = 6,38 \text{ cm}^2$$

$$\text{Dipakai } 2 \text{ } \phi 7/8^{\prime\prime} = 7,74 \text{ cm}^2 > 6,38 \text{ cm}^2.$$

BEDAN SEMENTARA.

$$M^+ = 2187550 \text{ kg cm} \text{ --- } k = \frac{2187550}{30.83^2} = 10,585 \text{ kg/cm}^2 < k_0$$

$$\frac{n.k}{\sigma_a} = \frac{16.10585}{2650} = 0,064 \text{ --- } nw = 0,071$$

$$A = 0,071/16.30.83 = 11,05 \text{ cm}^2 < 16,6 \text{ cm}^2 \text{ (tak dipakai)}$$

$$M^- \text{ kiri} = 1733300 \text{ kg cm} \text{ --- } k = 8,39 \text{ kg/cm}^2 < k_0$$

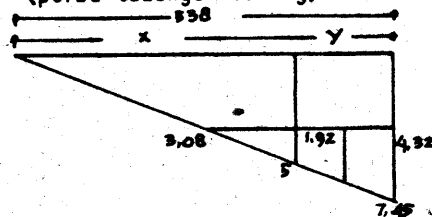
$$\frac{n.k}{\sigma_a} = \frac{16.8,39}{2650} = 0,051 \text{ --- } nw = 0,056$$

$$A = 0,071/16.30.83 = 8,715 \text{ cm}^2 < 14 \text{ cm}^2 \text{ (tak dipakai)}$$

Kontrol terhadap SF.

$$D = 12359 \text{ kg} \text{ --- } \tau = \frac{8/7.12359}{30.83} = 5,67 \text{ kg/cm}^2 < 9 \text{ kg/cm}^2$$

(tak perlu tulangan serong)



$$M^- \text{ kanan} = 2661290 \text{ kg cm} \text{ --- } k = 12,877 \text{ kg/cm}^2 < k_0$$

$$\frac{n.k}{\sigma_a} = 0,078 \text{ --- } nw = 0,086$$

$$A = 0,088/16.30.83 = 13,695 \text{ cm}^2 < 19,194 \text{ cm}^2 \text{ (tak perlu dipakai)}$$

Kontrol terhadap SF.

$$D = 16465,6 \text{ kg} \text{ --- } \tau = \frac{6/7.16456,6}{30.83} = 7,55 \text{ kg/cm} < 9 \text{ kg/cm}^2.$$

(tak perlu tulangan serong)

BALOK EF (30/60).

$$d = 5 \text{ cm} ; h = 55 \text{ cm}$$

Muatan tetap.

$$M^+ = 0,05 \text{ tm} = 500 \text{ kg cm} \text{ --- } k = 0,0136 \text{ kg/cm}^2 < k_0$$

$$\frac{n.k}{\sigma_a} = 0,002 \text{ --- } nw = \text{kecil sekali}$$

$$M^- = 10,0859 \text{ tm} \text{ --- } k = \frac{100859}{30.55^2} = 11,11 \text{ kg/cm}^2 < k_0$$

$$\frac{n.k}{\sigma_a} = 0,144 \text{ --- } nw = 0,131$$

$$A = 0,131/24.30.55 = 9,01 \text{ cm}^2 \text{ ---}$$

$$\text{Dipakai : } 2 \text{ } \phi 7/8^{\prime\prime} = 10,27 \text{ cm}^2 > 9,01 \text{ cm}^2$$

Kontrol terhadap SF.

$$D = 8567,6 \text{ kg} \text{ --- } \tau = \frac{8/7.8576,6}{30.55} = 5,94 \text{ kg/cm}^2 > 5 \text{ kg/cm}^2$$

(perlu tulangan serong).

$$x = 5/5,94 \cdot 268,1 = 226 \text{ cm}$$

$$y = 268,1 - 226 = 42,1 \text{ cm}$$

Dipakai beugel $\phi 8 \text{ mm} - 20 \text{ cm}$.

$$A_m = \frac{(2,86 + 1,92) \cdot 42 \cdot 1,30}{1850 \sqrt{2}} = 1,154 \text{ cm}^2$$

Dipakai 1 $\phi 7/8^{\text{m}} = 3,87 \text{ cm}^2 > 1,154 \text{ cm}^2$.

$$M^- \text{ kanan} = 51620 \text{ kg cm} \longrightarrow k = 0,57 \text{ kg/cm}^2 < k_0$$

$$\frac{n \cdot k}{\sigma_a} = 0,007 \longrightarrow n_w = \text{kecil sekali}$$

Dipakai tulangan susut saja = 2 $\phi \frac{1}{2}^{\text{m}} = 2,53 \text{ cm}^2$.

Kontrol terhadap SF.

$$D = 1920 \text{ kg} \longrightarrow \tau = \frac{8/7 \cdot 1920}{30 \cdot 55} = 1,26 \text{ kg/cm}^2 < 5 \text{ kg/cm}^2$$

(tidak perlu tulangan serong)

MUATAN SEMENTARA.

$$M^+ = 65500 \text{ kg cm} \longrightarrow k = \frac{65500}{30 \cdot 55^2} = 0,72 \text{ kg/cm}^2 < k'_0$$

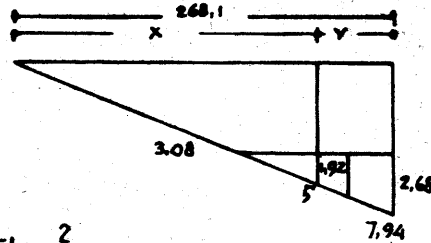
$$\frac{n \cdot k}{\sigma_a} = 0,007 \longrightarrow n_w = \text{kecil sekali}$$

tidak dipakai.

$$M^- \text{ kiri} = 047410 \text{ kg cm} \longrightarrow k = 10,14 \text{ kg/cm}^2 < k'_0$$

$$\frac{n \cdot k}{\sigma_a} = \frac{16 \cdot 10,44}{2650} = 0,063 \longrightarrow n_w = 0,07$$

$$A = 0,07/16 \cdot 30 \cdot 55 = 7,219 \text{ cm}^2 < 9,01 \text{ cm}^2 \text{ (tidak dipakai)}$$



Kontrol terhadap SF.

$$D = 8574 \text{ kg} \longrightarrow \tau = \frac{8/7 \cdot 8574}{30 \cdot 55} = 5,94 \text{ kg/cm}^2 < 9 \text{ kg/cm}^2$$

(tak perlu tulangan serong)

$$M^+ = \text{kanan} = 11710 \text{ kg cm} < 65500 \text{ kg cm}$$

Untuk tulangan dipakai tulangan susut saja : 2 $\phi \frac{1}{2}^{\text{m}} = 2,53 \text{ cm}^2$.

Kolom 6D : (30/50)

$$\text{berat kolom} = 0,3 \cdot 0,5 \cdot 3,25 \cdot 2,4 = 1,17 \text{ ton}$$

$$\text{berat balok tepi atap (I)} = \frac{1}{2} \cdot 2,75 \cdot 1,244 = 1,7105 \text{ ton}$$

$$G_V = 9,1504 \text{ ton}$$

$$\Sigma P = 12,0309 \text{ ton}$$

$$M = 11,1508 \text{ ton.}$$

$$e_0 = M/P = 11,1568/12,0309 = 93 \text{ cm}$$

$$e'_0 = 1/30 \cdot 50 = 1,67 = 2 \text{ cm}$$

$$e_2 = 0,15 \cdot 50 = 7,5 \text{ cm}$$

$$e_1 = 1 ; e_0/h_t - 93750 = 1,86 ; e_2 = 7$$

$$e_1 = 1,7 \cdot \left(\frac{325}{100 \cdot 50} \right)^2 \cdot 50 = 1,42 \text{ cm}$$

$$e = 104,00 \text{ cm}$$

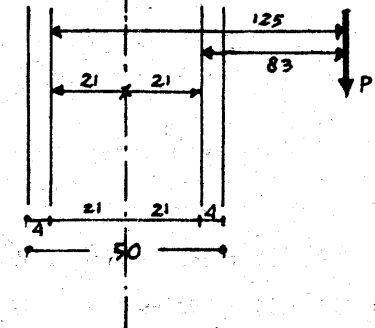
$$C_d = 104,00 - 21 = 83,00 \text{ cm}$$

$$C_t = 104,00 + 21 = 125,00 \text{ cm}$$

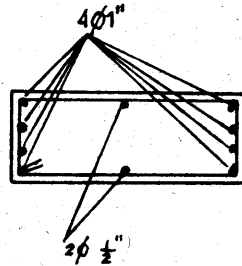
$$M_d = 12,0309 \cdot 83 = 998565 \text{ kg cm}$$

$$K_d = \frac{998565}{30 \cdot 46^2} = 15,73 \text{ kg/cm}^2 > k_0$$

$$K_t = \frac{1503863}{30 \cdot 46^2} = 23,69 \text{ kg/cm}^2 > k_0$$



$$\left. \begin{aligned} k_d / \sigma_{b'} &= 15,73/60 = 0,262 \\ k_t / \sigma_{b'} &= 23,69/60 = 0,39 \\ d'/h &= 4/46 = 0,087 \\ p/n &= 1,285 \end{aligned} \right\} \begin{aligned} nw &= 0,25 \\ nw' &= 0,275 \end{aligned}$$



$$\text{Dipakai } A' = A = 0,275/24 \cdot 30 \cdot 46 = 15,825 \text{ cm}^2$$

$$\text{Dipakai } 4 \phi 1'' = 20,27 \text{ cm}^2 > 15,825 \text{ cm}^2$$

$$\text{Check : } \frac{19,35}{30,50} \times 100 \% = 1,29 \% > 1 \% \text{ f beton.}$$

Untuk tulangan susut dipakai $2 \phi \frac{1}{2}''$.

Kontrol terhadap beban sementara.

$$\begin{aligned} - \text{berat kolom} &= 1,17 \text{ ton.} \\ - \text{berat balok atap (I)} &= 1,7105 \text{ ton.} \\ - \text{D balok} &= 9,3411 \text{ ton.} \end{aligned}$$

$$P = 12,2216 \text{ ton.}$$

$$M = 12,1953 \text{ tm}$$

$$e_0 = P/M = 12,2216/12,1953 = 100 \text{ cm}$$

$$e'_0 = 1/30 \cdot 50 = 2 \text{ cm}$$

$$e_2 = 0,15 \cdot 50 = 7,5 \text{ cm}$$

$$e_0/h_t = 100/50 = 2 ; C_2 = 7 ; C_1 = 1$$

$$e_1 = 1.7 \left(\frac{325}{100 \cdot 50} \right)^2 \cdot 50 = 1,48 \text{ cm}$$

$$e = 110,98 \text{ cm} = 111 \text{ cm}$$

$$C_t = 111 + 21 = 132 \text{ cm} ; M_t = 12,2216 \cdot 132 = 1613 \text{ kg cm}$$

$$C_d = 111 - 21 = 90 \text{ cm} ; M_d = 12,2216 \cdot 90 = 1100000 \text{ kg cm}$$

$$k_t = \frac{1813250}{30 \cdot 46^2} = 25,414 \text{ kg/cm}^2 > k_0$$

$$k_d = 17,33 \text{ kg/cm}^2 > k_0$$

$$\left. \begin{aligned} k_t / \sigma_{b'} &= 0,354 \\ k_d / \sigma_{b'} &= 0,173 \\ d'/h &= 0,087 \\ p/n &= 1,6563 \end{aligned} \right\} \begin{aligned} nw &= 0,1197 \\ nw' &= 0,138 \end{aligned}$$

dipakai tulangan pada perhitungan tetap.

KOLOM HE. (30/50).

$$- \text{berat kolom} = 0,3 \cdot 0,5 \cdot 3,25 \cdot 2,4 = 1,1700 \text{ ton}$$

$$- \text{berat balok atap (II)} = 0,5 \cdot 2,75 \cdot 1,143 = 1,5720 \text{ ton}$$

$$- H_v = 13,2028 \text{ ton}$$

$$P = 15,9444 \text{ ton}$$

$$m = 8,9131 \text{ tm}$$

$$e_0 = 8,9131/15,9444 = 56 \text{ cm}$$

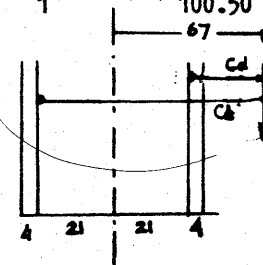
$$e'_0 = 1/30 \cdot 50 = 2 \text{ cm}$$

$$e_2 = 0,15 \cdot 50 = 7,5 \text{ cm}$$

$$C_1 = 1 ; C_2 = 7 ; e_0/h_t = 56/50 = 1,12$$

$$e_1 = 1.7 \left(\frac{325}{100 \cdot 50} \right)^2 \cdot 50 = 1,48 \text{ cm}$$

$$e = 66,98 \text{ cm} = 67 \text{ cm}$$



$$\begin{aligned}
 C_t &= 67 + 21 = 88 \text{ cm} ; M_t = 15,9444 \cdot 88 = 1403107 \text{ kg cm} \\
 C_d &= 67 - 21 = 46 \text{ cm} ; M_d = 15,9444 \cdot 46 = 733442 \text{ kg cm} \\
 k_t &= 22,103 \text{ kg/cm}^2 \\
 k_d &= 11,554 \text{ kg/cm}^2
 \end{aligned}$$

$$\left. \begin{aligned}
 k_t / \sigma_{b'} &= 0,368 \\
 k_d / \sigma_{b'} &= 0,193 \\
 p/n &= 1,285 \\
 d'/h &= 0,087
 \end{aligned} \right\} \begin{aligned}
 nw &= 0,18 \\
 nw' &= 0,27 \\
 A &= A' = 0,27/24 \cdot 30 \cdot 46 = 15,585 \text{ cm}^2
 \end{aligned}$$

Dipakai $4 \phi 1'' = 20,27 \text{ cm}^2 > 15,525 \text{ cm}^2$.

Kontrol terhadap muatan sementara.

$$\begin{aligned}
 - \text{berat kolom} &= 1,1700 \text{ ton} \\
 - \text{berat balok atap (I)} &= 1,7105 \text{ ton} \\
 - H_v &= 13,4874 \text{ ton} \\
 \hline
 P &= 16,3679 \text{ ton}
 \end{aligned}$$

$$\begin{aligned}
 M &= 7,5906 \text{ tm} \\
 e_o &= 7,5906/16,3679 = 46,40 \text{ cm} \\
 e'_o &= 1/30 \cdot 50 = 2 \text{ cm} \\
 e_2 &= 0,15 \cdot 50 = 7,5 \text{ cm} \\
 C_1 &= 1 ; C_2 = 6,993 ; e_o/h_t = 46,4/50 = 0,928 \\
 e_1 &= 1,6,993 \left(\frac{325}{100 \cdot 50} \right)^2 \cdot 50 = 1,48 \text{ cm} \\
 \hline
 e &= 57,4 \text{ cm}
 \end{aligned}$$

$$C_t = 57,4 + 21 = 78,4 \text{ cm} ; M_t = 16,3679 \cdot 78,4 = 283243 \text{ kg cm}.$$

$$C_d = 57,4 - 21 = 36,4 \text{ cm} ; M_d = 16,3679 \cdot 36,4 = 595792 \text{ kg cm}.$$

$$k_t = \frac{1283243}{30 \cdot 46^2} = 20,215 \text{ kg/cm}^2 > k_o$$

$$k_d = \frac{595792}{30 \cdot 45^2} = 9,39 \text{ kg/cm}^2 < k_o$$

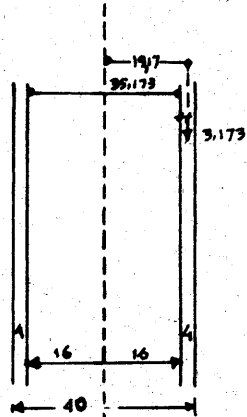
$$\left. \begin{aligned}
 k_t / \sigma_{b'} &= 20,215/100 = 0,202 \\
 k_d / \sigma_{b'} &= 9,39/100 = 0,094 \\
 p/n &= 1,6563 \\
 d'/h &= 0,087
 \end{aligned} \right\} \begin{aligned}
 nw &= 0,064 \\
 nw' &= 0,058 \\
 A &= A' = 0,064/16 \cdot 30 \cdot 46 \\
 &= 5,52 \text{ cm}^2 < 15,525 \text{ cm}^2
 \end{aligned}$$

Dipakai perhit.tul.muatan tetap.

KOLOM IF (30/40)

$$\begin{aligned}
 - \text{teras kolom} &= 0,3 \cdot 0,4 \cdot 3,25 \cdot 2,4 = 0,936 \text{ ton} \\
 - \text{berat balok tepi atap (III)} &= 0,5 \cdot 2,75 \cdot 1,244 = 1,7105 \text{ ton} \\
 - I_v &= 0,9795 \text{ ton} \\
 \hline
 P &= 3,626 \text{ ton}
 \end{aligned}$$

$$\begin{aligned}
 M &= 0,34 \text{ tm} \\
 e_o &= 0,34/3,626 = 9,4 \text{ cm} \\
 e'_o &= 1/30 \cdot 40 = 2 \text{ cm} \\
 e_2 &= 0,15 \cdot 40 = 6 \text{ cm} \\
 C_1 &= 1 ; e_o/h_t = 9,4/40 = 0,235 ; C_2 = 0,716 \\
 e_1 &= 1,6,815 \left(\frac{325}{100 \cdot 40} \right)^2 \cdot 40 = 1,733 \text{ cm} \\
 \hline
 e &= 19,173 \text{ cm}
 \end{aligned}$$



$$C_t = 16 + 19,173 = 35,173 \text{ cm}$$

$$C_d = 19,173 - 16 = 3,173 \text{ cm}$$

$$M_t = 0,35,173 \cdot 3,636 = 1,2754 \text{ cm}$$

$$M_d = 0,03173 \cdot 3,636 = 0,1151 \text{ cm}$$

$$k_t = \frac{127540}{30.36^2} = 3,28 \text{ kg/cm}^2 < k_o$$

$$k_d = \frac{11510}{30.36^2} = 0,296 \text{ kg/cm}^2 < k_o$$

$$k_t / \nabla b' = 3,28/60 = 0,055$$

$$k_d / \nabla b' = 0,296/60 = 0,005$$

$$p/n = 1,285$$

$$d'/h = 4/36 = 0,11$$

nw = kecil sekali

nw' = kecil sekali

luas tul.kolom diambil $1\% F_t < A < 3\% F_t$

$$A = 15 \text{ cm}^2 ; 1\% F_t < 15 \text{ cm}^2 < 3\% F_t$$

$$\text{Dipakai tulangan } 2 \text{ } \emptyset 7/8'' = 7,74 \text{ cm}^2 = A = A'$$

$$A + A' = 15,48 \text{ cm}^2 > 15 \text{ cm}^2$$

Kontrol terhadap beban sementara.

$$\text{- berat kolom} = 0,936 \text{ t\ddot{o}n}$$

$$\text{- berat balok tepi atap (III)} = 1,7105 \text{ ton}$$

$$\text{- } I_v = 0,5227 \text{ ton}$$

$$P = 3,1692 \text{ ton}$$

$$e = 1,052 \text{ tm}$$

$$e_o = 1,052/3,1692 = 33 \text{ cm}$$

$$e'_o = 1/30.40 = 2 \text{ cm}$$

$$e_2 = 0,15.40 = 6 \text{ cm}$$

$$C_1 = 1 ; C_2 = 6,9825 ; e_o/h_t = 33/40 = 0,825$$

$$e_1 = 1.6,9825 \left(\frac{325}{100.40} \right)^2 \cdot 40 = 1,84 \text{ cm}$$

$$e = 42,84 \text{ cm} = 43 \text{ cm}$$

$$C_t = 43 + 16 = 59 \text{ cm} ; M_t = 3,1692 \cdot 0,59 = 1,86983 \text{ tm} ; k_t = 4,8 \text{ kg/cm}^2 < k_o$$

$$C_d = 43 - 16 = 27 \text{ cm} ; M_d = 3,1692 \cdot 0,27 = 0,85568 \text{ tm} ; k_d = 2,2 \text{ kg/cm}^2 < k_o$$

$$k_t / \alpha b' = 0,048$$

$$k_d / \alpha b' = 2,2/60 = 0,022$$

$$p/n = 1,6563$$

$$d'/h = 0,11$$

nw = nw' = kecil sekali

A dipakai pada perhitungan tetap.

KOLOM DA (30/60).

$$\text{- berat muatan bordes} = 11,4324 \text{ ton}$$

$$\text{- berat kolom GD} = 12,0309 \text{ ton}$$

$$\text{- berat kolom DA} = 0,3.0,6.3,5.2,4 = 1,5120 \text{ ton}$$

$$\text{- berat kolom tepi lantai (I)} = 0,5.2,75.2,04 = 12,5866 \text{ ton}$$

$$P = 40,3669 \text{ ton}$$