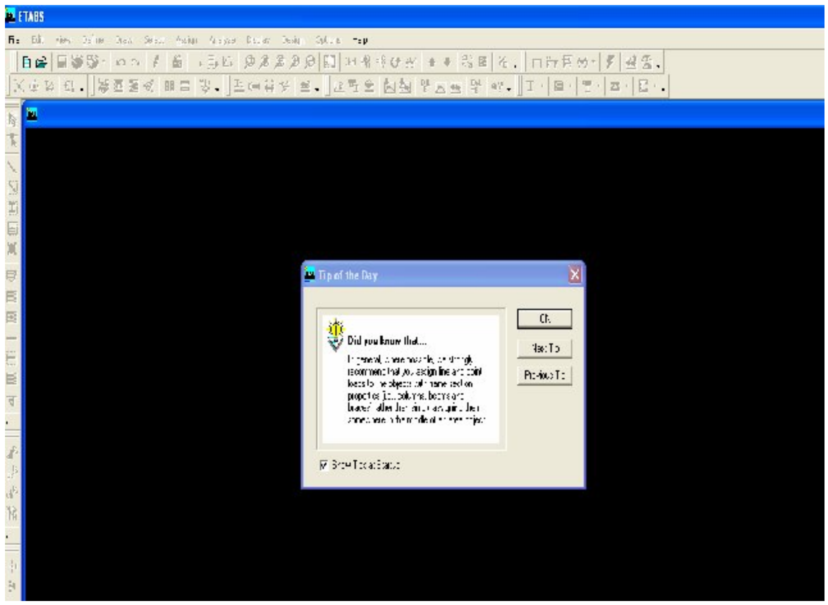
LAMPIRAN I

PEMODELAN GEDUNG

A. Pemodelan Gedung

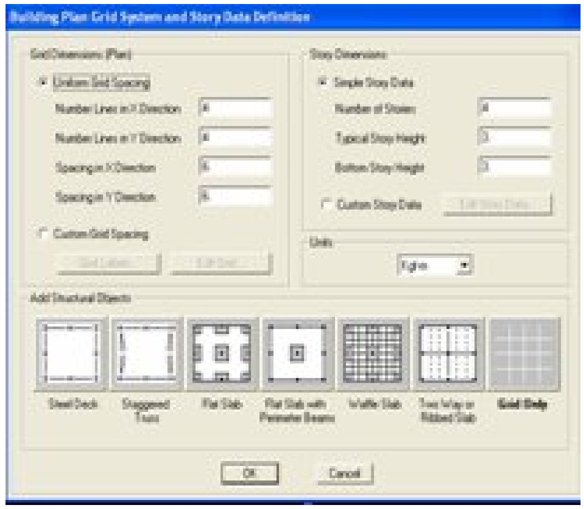
Langkah-langkah dalam pemodelan gedung dengan menggunakan *software* ETABS yaitu:

1. Membuka program dengan mengklik ikon atau diambil dari *start* program.



Gambar L.1.1 Tampilan Awal Program

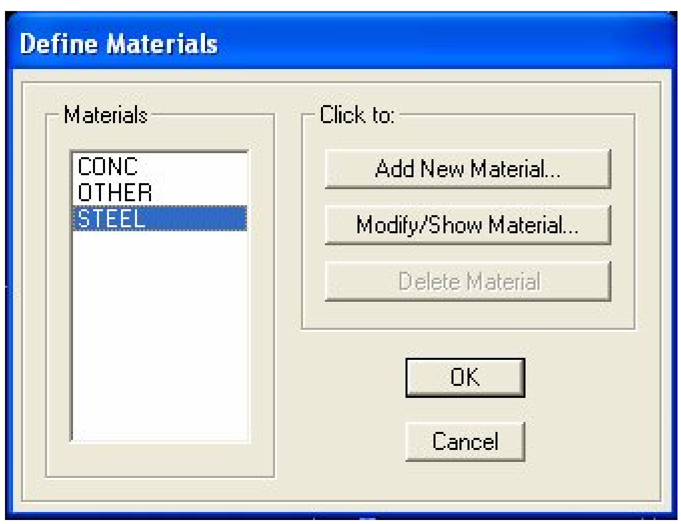
2. Setelah membuka program, langkah awal yaitu merubah satuan di pojok kanan bawah.
3. Kemudian membuat *grid* dan jarak *grid* sesuai dengan model yang akan dibuat dengan cara mengklik *File* – *New Model* – *No* (*new model initialization*) – *Ok* maka akan terlihat tampilan berikut:



Gambar L.1.2 Tampilan Untuk Membuat Jumlah *Grid*, Lantai serta Tinggi Bangunan

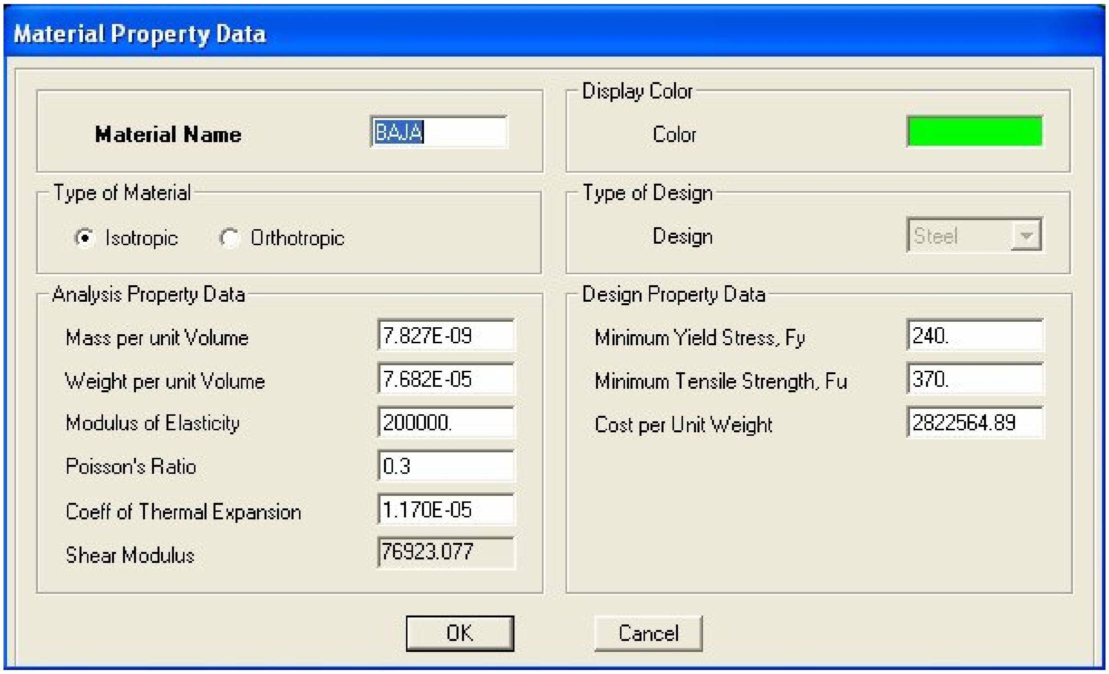
4. Mendefinisikan material dari struktur yang digunakan

   Define – Material properties – conc/steel – Modify/show material - Klik OK



Gambar L.1.3 Definisi Material

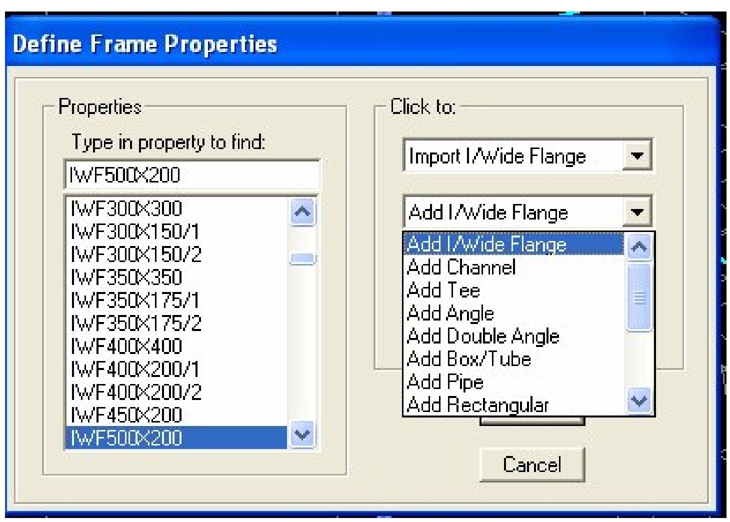
5. Lalu klik pada tulisan *Steel* (Tulisan akan berwarna biru bila di klik) – *Modify Show*, diubah nama material pada kotak *material name,* input data material yang diketahui seperti f_y, f_u, serta modulus elastisitas.



Gambar L.1.4 Input Data Material

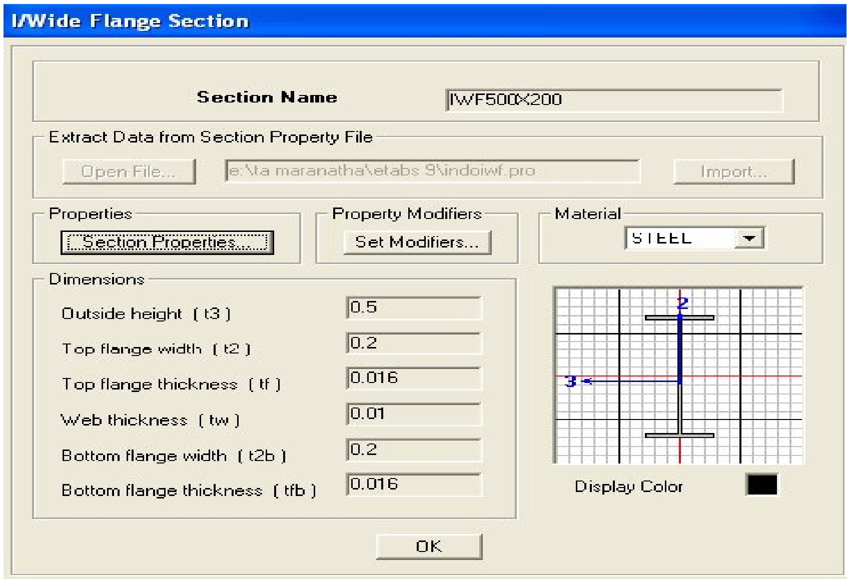
6. Mendefinisikan penampang balok dan kolom bangunan yaitu:

Define – Frame section – Add/ Wide Flange – input data penampang – klik OK



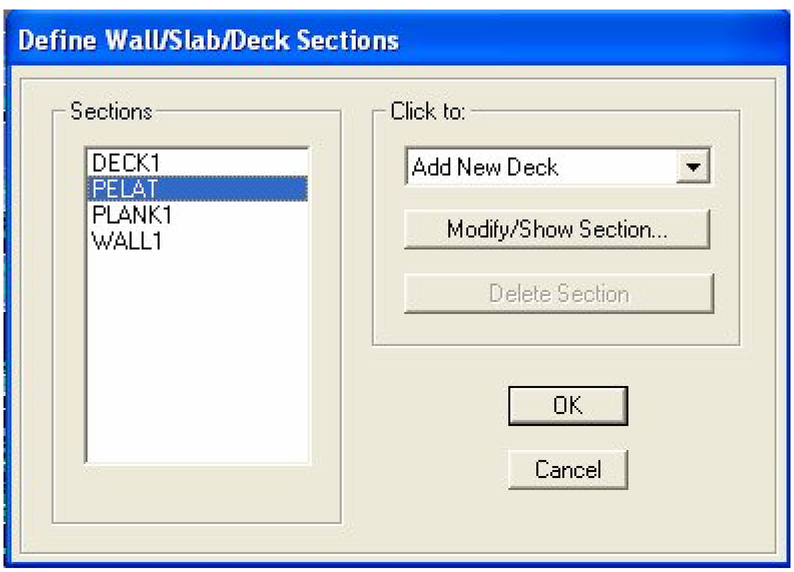
Gambar L.1.5 Definisi Balok, Kolom

Sebelumnya telah dilakukan preliminary desain, dimana hasilnya selengkapnya pada Lampiran 9.



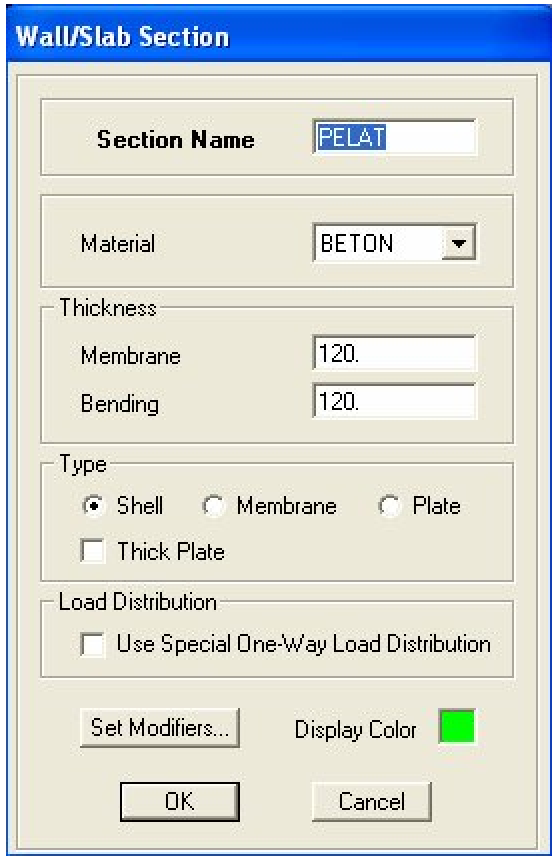
Gambar L.1.6 Input Data Balok, kolom

7. Definisikan pelat dengan cara klik *define – Wall/Slab/Deck section* maka akan telihat tampilan sebagai berikut:



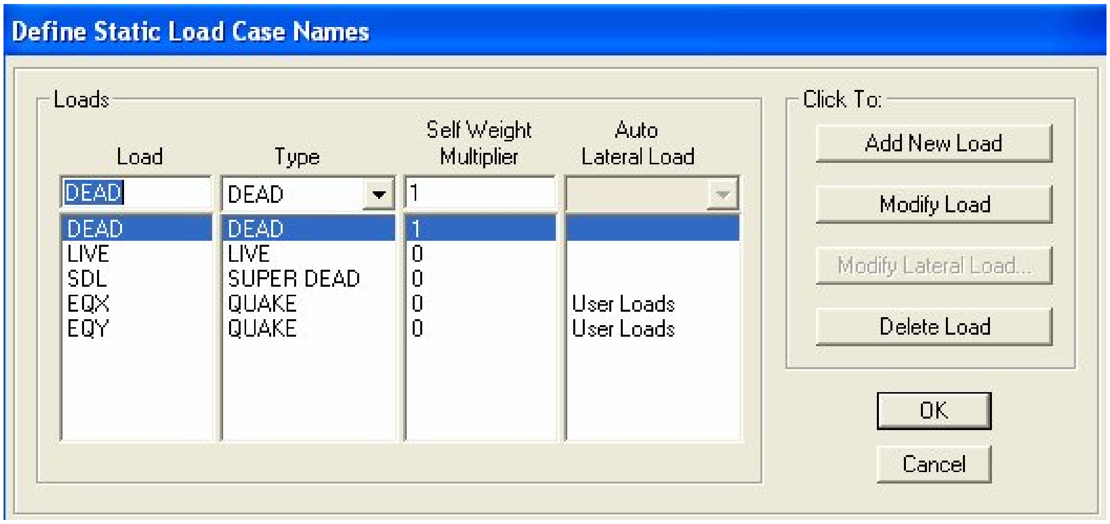
Gambar L.1.7 Definisi Pelat

8. Pilih Slab kemudian klik *Modify/Show Section,* input data pelat kemudian klik OK



Gambar L.1.8 Input Data Pelat

9. Membuat beban yang terjadi dengan cara *Define – Static Load cases* – input jenis pembebanan struktur – klik OK



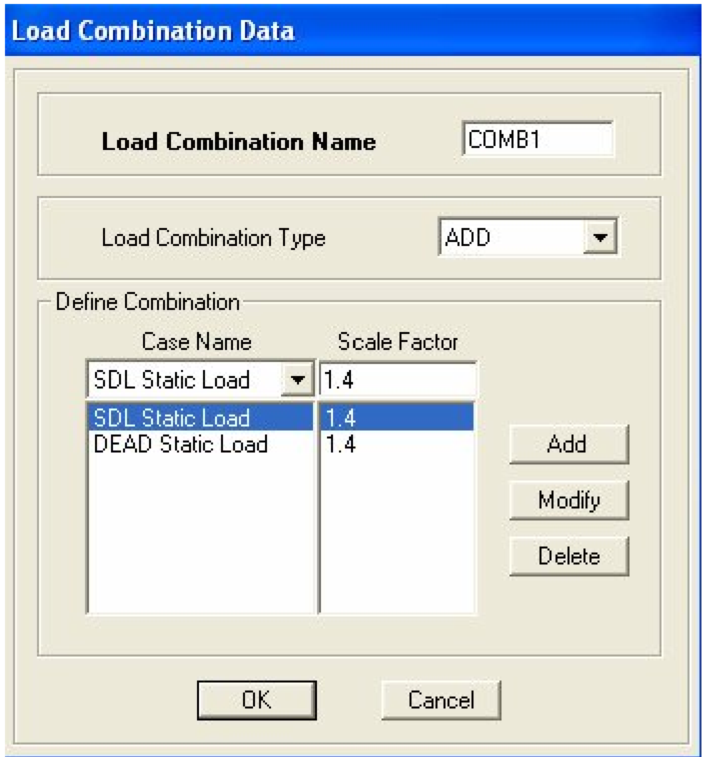
Gambar L.1.9 Membuat Beban

Dalam Tugas Akhir ini, perencanaan beban gempa dihitung menggunakan dua cara yaitu SNI 03-1726-2002 dengan FEMA 450. Oleh karena itu, secara umum gedung akan dianalisis dua kali.

Model pertama adalah beban gempa berdasarkan SNI 03-1726-2002, maka seperti terlihat pada Gambar L.1.9 beban gempa seperti quake, dihitung sesuai dengan rumus-rumus peraturan SNI 03-1726-2002.

Model kedua adalah beban gempa berdasarkan FEMA 450, maka seperti terlihat pada Gambar L.1.9 beban gempa seperti quake, dihitung sesuai dengan rumus-rumus peraturan FEMA 450.

10. Definisikan kombinasi beban yang ada dengan cara *Define – Load combinations – input kombinasi – Klik Ok*



Gambar L.1.10 Kombinasi Beban

Dalam Tugas Akhir ini, kombinasi yang digunakan ada 18, yang terdiri dari:

a. Comb 1 (1,4.(SDL+DL)

b. Comb 2 (1,2.(SDL+DL) + 1,6.(LL))

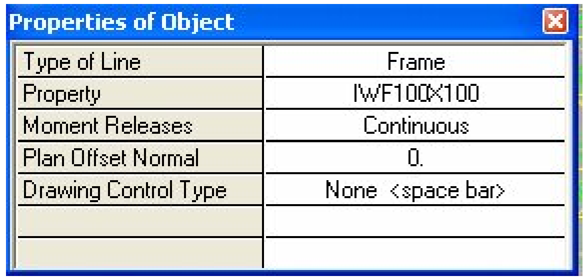
c. Comb 3 (1,2.(SDL+DL)+0,5(LL) ± EQx ± 0,3.EQy

d. Comb 4 (1,2(SDL+DL)+0,5(LL) ± 0,3.EQx ± EQy

e. Comb 5 (0,9(SDL+DL) ± EQx ± 0,3.EQy

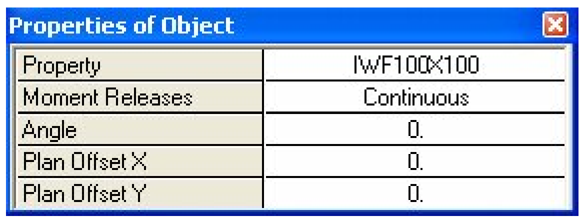
f. Comb 6 (0,9(SDL+DL) ± 0,3.EQx ± EQy

11. Penggambaran balok IWF ke grid dengan cara *Draw – Draw Lines objects – Draw Line – gambar balok dari joint ke joint.*



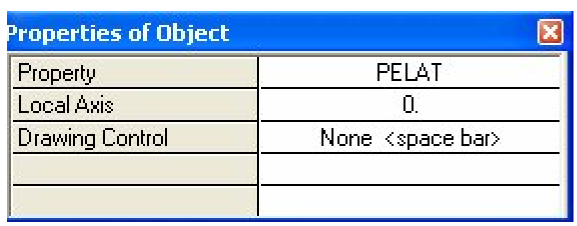
Gambar L.1.11 Menggambar Balok

12. Gambar kolom dengan cara *Draw – Draw Lines objects – create columns – gambar kolom pada tiap joint – klik OK.*



Gambar L.1.12 Menggambar Kolom

13. Penggambaran pelat dengan cara *Draw – Draw Area Objects – Draw Areas – Input properties object sesuai dengan properties pelat – Klik joint terluar.*



Gambar L.1.13 Menggambar Pelat

14. Tentukan *restraint* pada tumpuan : *Select plan level base – select semua joint – assign – joint/point – Restaint.*

Gambar L.1.14 *Restraint* Tumpuan

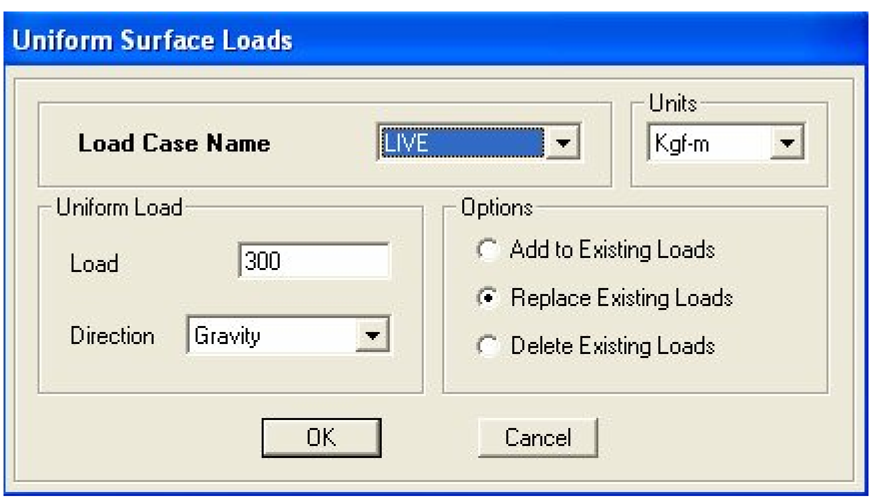
B. Pemodelan Beban Gravitasi

Beban gravitasi yang diperhitungkan adalah :

- Beban Mati (DL) dihitung sendiri oleh program ETABS
- Beban Mati Tambahan (SDL) = 112 kg/m^2
- Bebah Hidup = 300 kg/m^2

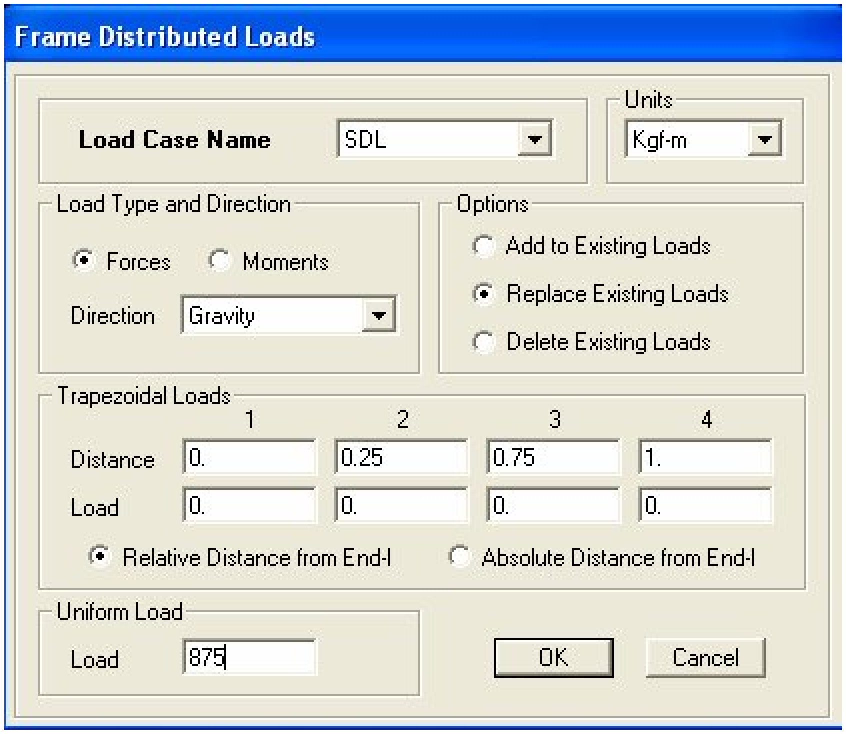
Adapun langkah- langkah memasukkan data beban ke dalam ETABS yaitu :

1. Beban pada pelat dengan cara : *Select pelat – Assign – Shell/ Area Load – Uniform* – pilih jenis beban yang akan digunakan.



Gambar L.1.15 Membuat Beban pada Pelat

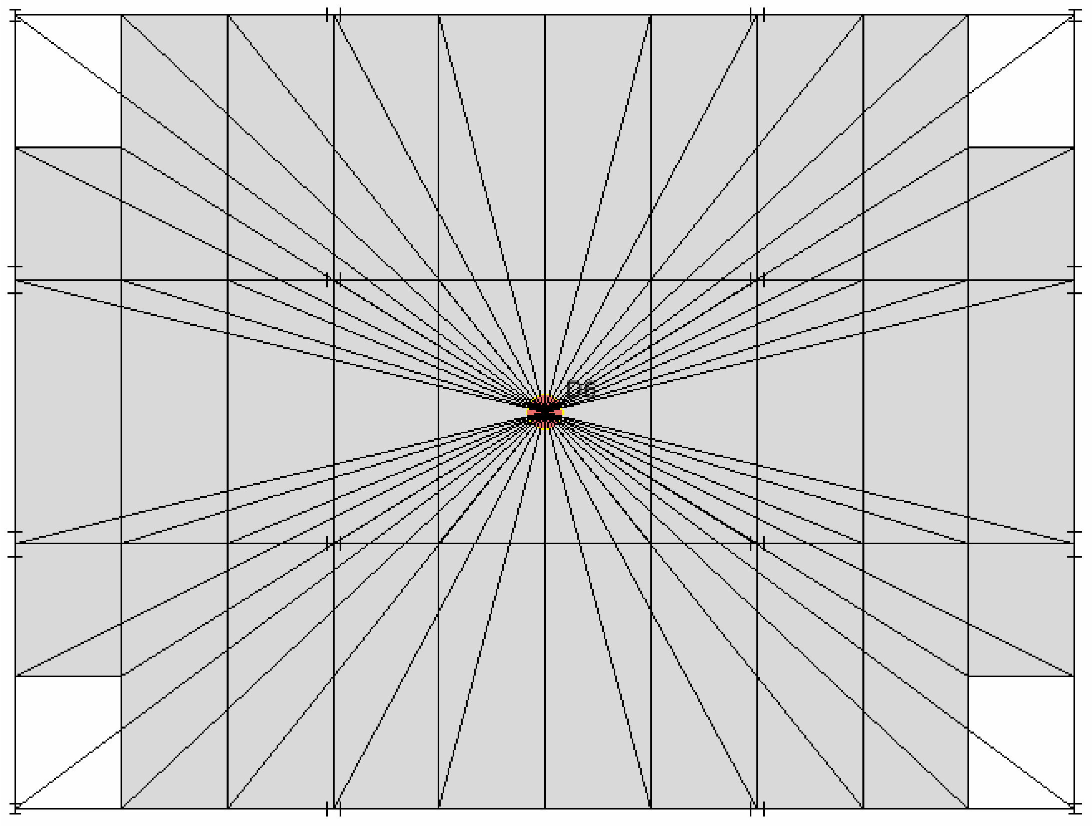
2. Beban pada balok dengan cara: *Select* balok yang menerima beban dinding – *Assign – Frame/ line load – Distributed* – Pilih jenis beban yang akan digunakan – Klik OK.



Gambar L.1.16 Membuat Beban pada Balok

C. Pusat Massa

Dalam Tugas Akhir ini, lantai dimodelkan sebagai lantai diagfragma rigid. Artinya massa dipusatkan pada satu titik.



Gambar L.1.17 Pusat Massa (Tipikal)

LAMPIRAN II

NILAI PERIODE GETAR

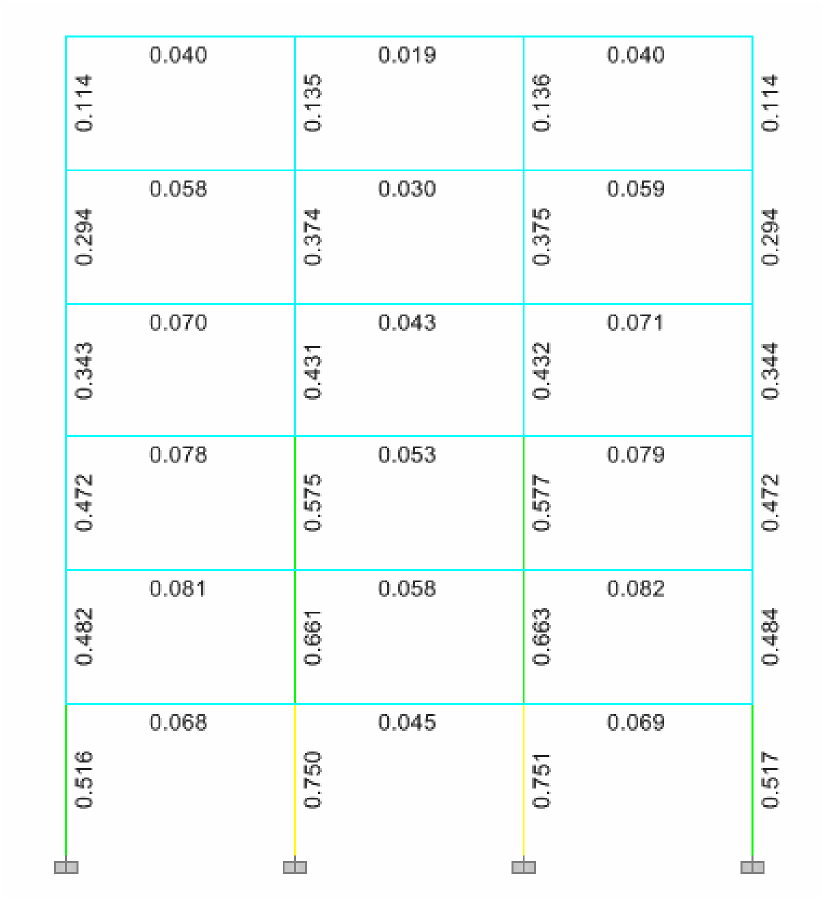
Nilai Periode Getar

Mode	Period	UX	UY	UZ	SumUX	SumUY	SumUZ	RX	RY	RZ	SumRX	SumRY	SumRZ
1	1.071123	0.0003	81.7143	0	0.0003	81.7143	0	99.5709	0.0004	0.0638	99.5709	0.0004	0.0638
2	0.981274	79.6819	0.0003	0	79.6822	81.7146	0	0.0003	99.6976	0.0005	99.5712	99.698	0.0643
3	0.834068	0.0005	0.0677	0	79.6826	81.7823	0	0.0798	0.0006	80.2177	99.6511	99.6986	80.282
4	0.34946	0.0001	10.9812	0	79.6827	92.7635	0	0.1053	0	0.0075	99.7563	99.6986	80.2895
5	0.329379	12.6302	0	0	92.3129	92.7636	0	0	0.0005	0	99.7563	99.699	80.2896
6	0.271697	0	0.0063	0	92.3129	92.7699	0	0.0001	0	11.8792	99.7564	99.699	92.1687
7	0.191944	0	4.3038	0	92.313	97.0737	0	0.2219	0	0.0024	99.9783	99.699	92.1712
8	0.18584	4.9335	0	0	97.2465	97.0737	0	0	0.2878	0	99.9783	99.9868	92.1712
9	0.148318	0	0.002	0	97.2465	97.0757	0	0.0001	0	4.6868	99.9784	99.9868	96.858
10	0.126056	0	1.7857	0	97.2465	98.8614	0	0.0007	0	0.0002	99.9791	99.9868	96.8581
11	0.123557	1.7736	0	0	99.0201	98.8614	0	0	0.0001	0	99.9791	99.9869	96.8581
12	0.095855	0	0	0	99.0201	98.8615	0	0	0	1.9581	99.9791	99.9869	98.8162

LAMPIRAN III

PEMBAHASAN RASIO P/M

Pembahasan Rasio P-M



Gambar L.3.1 Balok dan Kolom yang Ditinjau

A. Pembahasan Rasio P-M Gedung yang Didesain Berdasarkan SNI 1726-2002

Desain Balok

Elevation-B (B17) Story 2

Karakteristik Profil :

WF = 300.150.6,5.9 (BJ37)

d = 300 mm	bf = 150 mm
tw = 6,5 mm	tf = 9 mm
L = 6000 mm	Ag = $4,678.10^3 mm^2$
Ix = $7,21.1010^7 mm^4$	Iy = $5,08.10^6 mm^4$
r_x =124 mm	r_y =32,9 mm

$S_x = 4{,}81.10^5 mm^3$ $S_y = 6{,}77.10^4 mm^3$

$r_c = 13mm$

$h' = d - 2.t_f - 2.r_c$ $h' = 256mm$

$A_w = \left(d - 2.t_f\right).t_w$ $A_w = 1833mm^2$

$Z_x = b.t_f.\left(d - t_f\right) + \frac{1}{4} t_w.\left(d - 2.t_f\right)^2$ $Z_x = 5{,}22.10^5 mm^3$

$Z_y = \frac{1}{2}.t_f.b^2 + \frac{1}{4}.(d - 2.t_f).t_w^2$ $Z_y = 1{,}04.10^5 mm^3$

Data Material:

Modulus Elastisitas:

$E_s = 200000MPa$

Tegangan Leleh sayap dan Badan:

$f_y = 240MPa$

Tegangan Sisa:

$f_r = 70MPa$ (rolled beam)

Faktor reduksi

$\phi = 0{,}9$ $\phi_c = 0{,}85$ $\phi_b = 0{,}9$

Faktor modifikasi Tegangan Leleh:

$R_y = 1{,}5$ jika $f_y \leq 250MPa$

$R_y = 1{,}3$ jika $f_y \leq 290MPa$

Maka $R_y = 1{,}5$

Besaran penampang yang perlu dihitung:

$f_L = f_y - f_r$ $f_r = 70MPa$ $G = 0{,}8.10^5 MPa$

$f_L = 170MPa$

$J = \left(\frac{1}{3}\right).\left[\left(2.b_f.t_f^{\ 3}\right) + \left[\left(d - 2.t_f\right).t_w^{\ 3}\right]\right]$ $J = 98714{,}75mm^4$

$$I_w = \left[\left(\frac{1}{2}\right).(d\text{-}t_f)\right]^2 \qquad I_w = 21170{,}25 mm^2$$

Momen Leleh: $M_y = S_x . f_y$ $\qquad M_y = 115{,}44.10^6 Nmm$

Momen Plastis: $M_p = Z_x . f_y$ $\qquad M_p = 125{,}3x10^6 Nmm$

Momen Batas Tekuk: $M_r = (f_y - f_r).S_x$ $\qquad M_r = 81{,}77.10^6 Nmm$ (karena tegangan leleh flens dan badan sama)

Gaya aksial Leleh: $P_y = A_g . f_y$ $\qquad P_y = 1{,}123.10^6 N$

Periksa Kekompakan Penampang:

Harus memenuhi syarat kekompakan penampang pada Tabel 15.7-1 (SNI 03-1729-2002)

Pada Pelat sayap:

$$\lambda_f = \frac{b_f}{2.t_f} \qquad \lambda_f = 8{,}333$$

$$\lambda_p = \frac{170}{\sqrt{f_y}} \qquad \lambda_{ps} = 10{,}97$$

Kesimpulan: Penampang kompak

Pada Pelat badan:

$$\lambda_w = \frac{h'}{t_w} \qquad \lambda_w = 39{,}38$$

$$\lambda_p = \frac{1680}{\sqrt{f_y}} \qquad \lambda_p = 108{,}54$$

Kesimpulan: Penampang kompak ($\lambda_w < \lambda_p$)

1. Menghitung Kapasitas Momen Balok B-13

1.a Kondisi batas tekuk lokal

Momen Nominal Tekuk lokal (berdasarkan Tabel 7.5-1)

Pada pelat sayap:

$$\lambda_{pf} = \frac{170}{\sqrt{F_y}} \qquad \lambda_{pf} = 10,97$$

$$\lambda_{rf} = \frac{370}{\sqrt{f_y - f_r}} \qquad \lambda_{rf} = 28,38$$

$$\lambda_f = 8,333$$

Momen Nominal Tekuk Lokal pada pelat sayap: (M_{nFLB})

$$M_{nFLB} = M_p \text{ jika } \lambda_f \leq \lambda_{pf}$$

$$M_{nFLB} = M_p - \frac{(\lambda_f - \lambda_{pf})}{(\lambda_{rf} - \lambda_{pf})}.(M_p - M_r) \text{ jika } \lambda_{pf} < \lambda_f < \lambda_{rf}$$

$$M_{nFLB} = \left(\frac{\lambda_{rf}}{\lambda_f}\right)^2 .M_r \text{ jika } \lambda_f \geq \lambda_{rf}$$

$$M_{nFLB} = M_p = 125,3x10^6 Nmm$$

$$\phi M_{nFLB} = 112752000 Nmm$$

Pada pelat badan:

$$\lambda_{pw} = \left[\frac{1680}{\sqrt{f_y}}\right] \qquad \lambda_{pw} = 108,44$$

$$\lambda_{rw} = \left[\frac{2550}{\sqrt{f_y}}\right] \qquad \lambda_{rw} = 164,61$$

$$\lambda_w = 39,38$$

Momen Nominal Tekuk Lokal pada pelat badan:

$$M_{nWLB} = M_p \text{ jika } \lambda_w \leq \lambda_{pw}$$

$$M_{nWLB} = M_p - \frac{(\lambda_w - \lambda_{pw})}{(\lambda_{rw} - \lambda_{pw})}.(M_p - M_r) \text{ jika } \lambda_{pw} < \lambda_w < \lambda_{rw}$$

$$M_{nWLB} = \left(\frac{\lambda_{rw}}{\lambda_w}\right)^2 .M_r \text{ jika} \lambda_w \geq \lambda_{rw}$$

$$M_{nWLB} = M_p = 125{,}3x10^6 Nmm$$

$$\phi M_{nWLB} = 112752000 Nmm$$

1.b Kondisi batas tekuk lateral

Panjang tak bertumpu:

$$L_b = 6000mm$$

Batas-batas jarak pengekang lateral:

$$I_w = \frac{1}{4}.h^2.I_y = \frac{1}{4}.\left(300^2\right).5{,}08.10^6 = 1{,}143.10^{11}$$

$$L_p = 1{,}76.r_y.\sqrt{\frac{E}{F_y}} = 1{,}76.32{,}9.\sqrt{\frac{200000}{240}} = 1671{,}54mm$$

$$X_1 = \frac{\pi}{S}\sqrt{\frac{E.G.J.A}{2}} = \frac{\pi}{4{,}81.10^5}.\sqrt{\frac{200000.80000.98714{,}75.4{,}678.10^3}{2}} = 12553{,}68MPa$$

$$X_2 = 4.\left(\frac{S}{G.J}\right)^2.\frac{I_w}{I_Y} = 4.\left(\frac{4{,}81.10^5}{80000.98714{,}75}\right)^2.\frac{1{,}143.10^{11}}{5{,}08.10^6} = 3{,}34.10^{-4} mm^4/N^2$$

$$L_r = r_y.\left(\frac{X_1}{F_L}\right).\sqrt{1+\sqrt{1+X_2.F_L{}^2}}$$

$$L_r = 32{,}9.\left(\frac{12553{,}68}{170}\right).\sqrt{1+\sqrt{1+3{,}34.10^{-4}.170^2}} = 7929{,}5mm$$

Maka,

$L_b = 6000mm$ $\quad$ $L_p = 1671{,}54mm$ $\quad$ $L_r = 7929{,}5mm$

Keterangan: “Bentang pendek” jika $L_b \leq L_p$

“ Bentang menengah jika $L_p < L_b < L_r$

“ Bentang panjang jika $L_b \geq L_r$

Kesimpulan: bentang menengah

Momen Nominal Tekuk Lateral (M_{nLTB})

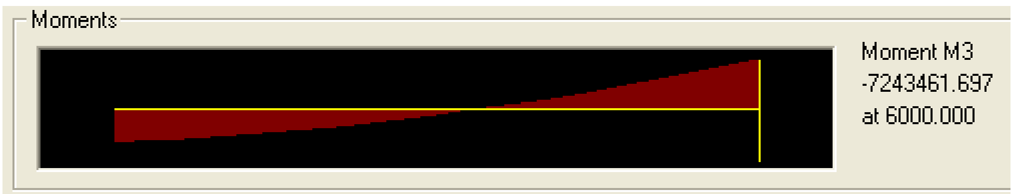
Momen Plastis

$$M_p = 125{,}3x10^6 Nmm$$

Momen Batas Tekuk

$$M_r = S.(f_y - f_r) = 81770000 Nmm$$

Menghitung nilai C_b :



Gambar L.3.2 Momen Maksimum

Data Momen yang didapat dari ETABS untuk menghitung nilai C_b:

Momen di ¼ bentang (M_a) = 3140308,957 Nmm

Momen di ½ bentang (M_b) = 654605,411 Nmm

Momen di ¾ bentang (M_c) = 2817192,817 Nmm

Momen maksimum = 7243461,697 Nmm

$$C_b = \frac{12{,}5.M_{maks}}{2{,}5.M_{maks} + 3.M_A + 4.M_B + 3.M_c} \leq 2{,}3$$

$$C_b = \frac{12{,}5.7243461{,}697}{2{,}5.7243461{,}697 + 3.3140308{,}957 + 4.654605{,}411 + 3.2817192{,}817} \leq 2{,}3$$

$$C_b = 2{,}24 \leq 2{,}3$$

Menghitung Momen kritis:

$$C_w = \frac{\left[I_y.\left(d - t_f\right)^2\right]}{4} \qquad C_w = 1{,}075x10^{-7} m^6$$

$$A_1 = E_s.I_y.G.J = 8{,}02x10^{21} \qquad A_2 = \left(\frac{\pi.E_s}{L}\right)^2.I_y.C_w = 3{,}04x10^{28}$$

$$M_{cr} = C_b.\frac{\pi}{L}.\sqrt{A_1 + A_2} \qquad M_{cr} = 2{,}045x10^{11} Nmm$$

Momen Nominal Tekuk Lateral pada sumbu-x: (M_{nLTBx})

$M_{nLTBx} = M_p$ jika $L_b \leq L_p$

$$M_{nLTBx} = C_b.\left[M_r + \left(M_{p1} - M_r\right)\left(\frac{L_r - L}{L_r - L_p}\right)\right] \text{jika } L_p < L_b < L_r$$

$M_{nLTBx} = \min M_{cr}, M_{p1}$ jika $L_b \geq L_r$

Jadi $M_{nLTBx} = 114672264{,}4$ Nmm

$\phi M_{nLTBx} = 104247513{,}15$ Nmm

Momen nominal Tekuk Lateral pada sumbu-y:(M_{nLTBy})

Momen plastis pada sumbu –y:

$M_{py} = \min\ (Z_y.F_y, 1{,}5S_y.F_y)$

$M_{py} = 24372000$ Nmm

$\phi M_{nLTBy} = 21934800$Nmm

1.c Menghitung Momen Nominal (M_n)

Momen nominal pada sumbu-x: (M_{nx})

$M_{nx} = \min\ (M_{nFLB}, M_{nWLB}, M_{nLTBx}, M_p)$

$M_{nx} = 114672264{,}4$ Nmm

Momen Nominal pada sumbu-y: (M_{ny})

$M_{ny} = M_{nLTBy}$

$M_{ny} = 24372000$ Nmm

Maka besarnya kapasitas momen adalah sebagai berikut:

Kapasitas momen pada sumbu-x: (M_{nx})

$\phi M_{nx} = 104247513{,}15$ Nmm

Kapasitas momen pada sumbu-y: (M_{ny})

ϕM_{ny} = 21934800 Nmm

2. Menghitung kapasitas Tarik Balok B-17

Kuat tarik nominal: (P_{nt})

$P_{nt} = A_g . f_y$ $\quad\quad$ $P_{nt} = 1122720 N$

Maka besarnya kapasitas tarik adalah sebagai berikut: (ϕP_{nt})

$\phi P_{nt} = 1010448 N$

3. Menghitung Kapasitas Tekan Balok B-17

3.a Hitung tegangan kritis: F_{crl}

Besaran penampang yang perlu dihitung:

$k_c = 1$ (beban aksial tidak ada)

$L_k = k_c . L$ $\quad\quad$ $L_k = 6000mm$

$r = \min (r_x, r_y)$ $\quad\quad$ $r = 32,9mm$

$\lambda_c = \frac{L_k}{\pi . r} . \sqrt{\frac{f_y}{E_s}}$ $\quad\quad$ $\lambda_c = 2,01$

$$F_{cr1} = \left[\left(0,658.\lambda_c^2\right).F_y\right] jika \lambda_c \leq 1,5$$

$$F_{cr1} = \left[\left(\frac{0,877}{\lambda_c^2}\right).F_y\right] jika \lambda_c > 1,5$$

$F_{cr1} = 52,10 MPa$

3.b Hitung Tegangan kritis dengan memperhitungkan tekuk puntir lentur:

Besaran penampang yang perlu dihitung:

$$C_w = \frac{\left[I_y.(d-2.t_f)^2\right]}{4}$$

$C_w = 1,075x10^{11}$

Tegangan Tekuk elastik puntir lentur:(Fe)

$$F_e = \left[\frac{\pi^2 . E_s . C_w}{\left(K.L_k \right)^2} + G.J \right] \frac{1}{I_x + I_y} \qquad F_e = 178,69 MPa$$

$$\lambda_e = \sqrt{\frac{f_y}{F_e}} \qquad \lambda_e = 1,159$$

Maka besarnya Tegangan kritis dengan memperhitungkan tekuk puntir lentur:

$$f_{cr2} = \left[\left(0,658^{\lambda_e^2} \right) . f_y \right] jika \lambda_c \leq 1,5 \qquad f_{cr1} = \left[\left(\frac{0,877}{\lambda_e^2} \right) . f_y \right] jika \lambda_c > 1,5$$

$$F_{cr1} = 156,69 MPa$$

Besarnya Kuat tekan nominal adalah:

$$F_{cr} = 156,69 MPa$$

$$P_{nc} = A_g . F_{cr} \qquad P_{nc} = 732995,82 N$$

Sehingga besarnya kapasitas tekan balok adalah:

$$\phi P_{nc} = 659696,238 N$$

4. Menghitung Kapasitas Gaya Geser Balok B-13

4.a Gaya Geser Nominal pada sumbu-x:

Besaran penampang yang perlu dihitung:

$$A_{w1} = d.t_w \qquad A_{w1} = 1950 \text{ mm}^2$$

a = 6000 mm

$$k_n = 5 + \left[\frac{5}{\left(\frac{a}{h'} \right)^2} \right] \qquad k_n = 5,009$$

Maka besarnya gaya geser nominal pada sumbu-x:

$$\lambda_w = \frac{h'}{t_w} \qquad \lambda_w = 39,385$$

$$V_{nx} = (0{,}6.F_y.A_{w1})\, jika\, \lambda_w \le \left(1{,}10.\sqrt{\frac{k_n.E_s}{F_y}}\right)$$

$$V_{nx} = 0{,}6.F_y.A_{w1}.1{,}10.\sqrt{\frac{k_n.E_s}{F_y}}.\frac{1}{\lambda_w}\, jika \left(1{,}10.\sqrt{\frac{k_n.E_s}{F_y}}\right) \le \lambda_w < 1{,}37.\sqrt{\frac{k_n.E_s}{F_y}}$$

$$V_{nx} = \frac{0{,}9.A_{w1}.k_n.E_s}{(\lambda_w)^2}\, jika\, \lambda_w \ge 1{,}37.\sqrt{\frac{k_n.E_s}{F_y}}$$

$$V_{nx} = 280800\,N$$

4.b Gaya geser Nominal pada sumbu-y:

Besaran penampang yang perlu dihitung:

$$A_{w2} = \left(\frac{5}{3}.b_f.t_f\right) \qquad A_{w2} = 2250\,mm^2$$

Maka besarnya gaya geser nominal pada sumbu-y:

$$V_{ny} = 0{,}6.F_y.A_{w2} \qquad V_{ny} = 324000\ N$$

Maka besarnya kapasitas gaya geser adalah sebagai berikut:

Kapasitas gaya geser pada sumbu-x:

$$\phi V_{nx} = 252720\,N$$

Kapasitas gaya geser pada sumbu-y:

$$\phi V_{ny} = 291600\,N$$

Selanjutnya, akan dihitung rasio tegangan akibat gaya geser yang bekerja:

Rasio tegangan pada sumbu-x:

$$\frac{V_{ux}}{\phi V_{nx}} = 0{,}000$$ **Hasil Output ETABS: Rasio= 0,000**

Rasio tegangan pada sumbu-y:

$$\frac{V_{uy}}{\phi V_{ny}} = 0{,}012$$ **Hasil Output ETABS: Rasio= 0,011**

5. Menghitung Faktor Modifikasi Momen (Cm)

$C_m = 1$ ujung-ujung batang yang bisa bertranslasi

6.Menghitung Faktor Amplikasi Momen (δ_b)

Data yang diperlukan:

$$P_{cr} = \frac{A_g . F_y}{\lambda_c^2} \qquad\qquad P_{cr} = 277894{,}1115 \text{ N}$$

Maka faktor Amplikasi momen adalah sebagai berikut:

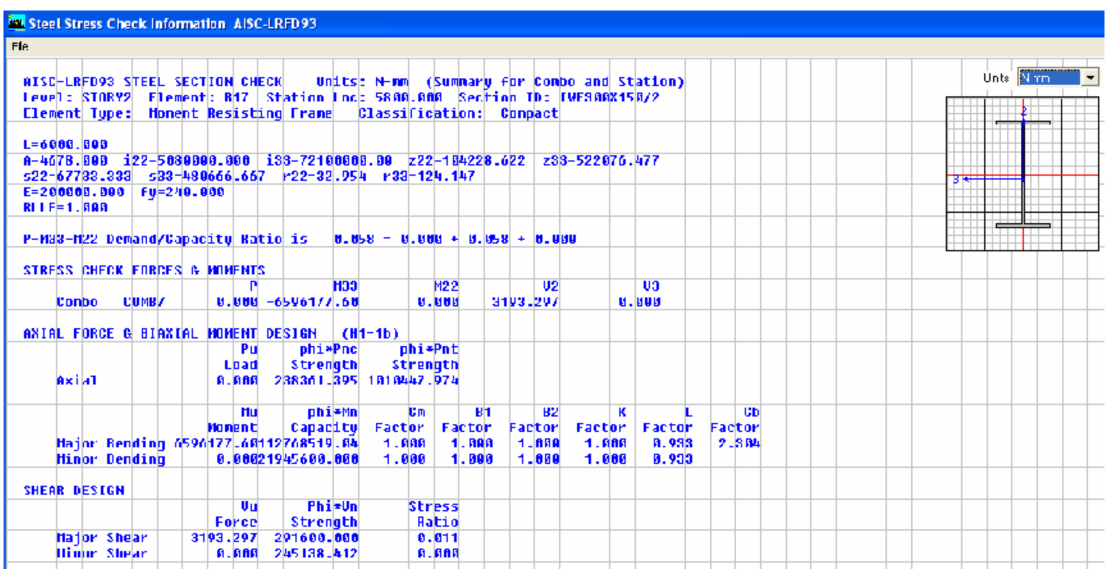
$$\delta_{b1} = \frac{C_m}{1 - \left(\frac{P_u}{P_{cr}}\right)} \qquad\qquad \delta_{b1} = 1{,}02$$

Dari hasil kombinasi pembebanan dan kapasitas balok yang didapat diatas, maka dapat dihitung persamaan interaksi akibat gaya aksial dan momen sebagai berikut:

$$\text{Rasio} = \left[\frac{P_u}{\phi P_{nt}} + \frac{8}{9}.\left(\frac{M_{ux}}{\phi_b . M_{nx}} + \frac{M_{uy}}{\phi_b . M_{ny}}\right)\right] \text{jika } \frac{P_u}{\phi P_{nt}} \geq 0{,}2$$

$$\left[\frac{P_u}{2.\phi P_{nt}} + \left(\frac{M_{ux}}{\phi_b . M_{nx}} + \frac{M_{uy}}{\phi_b . M_{ny}}\right)\right] \text{jika } \frac{P_u}{\phi P_{nt}} < 0{,}2$$

Maka rasio = 0,062 **Hasil Output ETABS: Rasio= 0,058**



Gambar L.3.3 Nilai Output Balok yang Didesain Berdasarkan SNI 03-1726-2002

Desain Kolom

Karakteristik Profil:

WF = 400.400.13.21 (BJ37)

$d = 400$ mm	$b_f = 400$ mm
$t_w = 13$ mm	$t_f = 21$ mm
$L = 3500$ mm	$Ag = 21870\ mm^2$
$I_x = 6{,}66.10^8 mm^4$	$I_y = 2{,}24.10^8 mm^4$
$r_x = 175$ mm	$r_y = 101$ mm
$S_x = 33{,}3.10^5 mm^3$	$S_y = 11{,}2.10^5 mm^3$
$r_c = 22$ mm	
$h' = d - 2.t_f - 2.r_c$	$h' = 314$ mm
$A_w = \left(d - 2.t_f\right).t_w$	$A_w = 4654\ mm^2$
$Z_x = b.t_f.\left(d - t_f\right) + \frac{1}{4} t_w.\left(d - 2.t_f\right)^2$	$Z_x = 3{,}66.10^6 mm^3$
$Z_y = \frac{1}{2}.t_f.b^2 + \frac{1}{4}.(d - 2.t_f).t_w^2$	$Z_y = 1{,}69.10^6 mm^3$

Data Material:

Modulus Elastisitas:

$E_s = 200000 MPa$

Tegangan Leleh Flens dan Badan:

$f_y = 240 MPa$

Tegangan Sisa:

$f_r = 70 MPa$ (rolled beam)

Faktor reduksi

$\phi = 0{,}9$ $\phi_c = 0{,}85$ $\phi_b = 0{,}9$

Faktor modifikasi Tegangan Leleh:

$R_y = 1,5$ jika $f_y \leq 250MPa$

$R_y = 1,3$ jika $f_y \leq 290MPa$

Maka $R_y = 1,5$

Besaran penampang yang perlu dihitung:

$f_L = f_y - f_r$ $\quad$ $f_r = 70MPa$ $\quad$ $G = 0,8.10^5 MPa$

$f_L = 170MPa$

$J = \left(\frac{1}{3}\right).\left[\left(2.b_f.t_f^{\,3}\right) + \left[\left(d - 2.t_f\right).t_w^{\,3}\right]\right]$ $\quad$ $J = 3256126\ mm^4$

$I_w = \left[\left(\frac{1}{2}\right).\left(d - t_f\right)\right]^2$ $\quad$ $I_w = 35910,25\ mm^2$

Momen Leleh: $\quad$ $M_y = S_x.f_y$ $\quad$ $M_y = 799,2.10^6\ Nmm$

Momen Plastis: $\quad$ $M_p = Z_x.f_y$ $\quad$ $M_p = 878,4.10^6\ Nmm$

Momen Batas Tekuk: $M_r = (f_y - f_r).S_x$ $\quad$ $M_r = 566,1.10^6\ Nmm$ (karena tegangan leleh flens dan badan sama)

Gaya aksial Leleh: $P_y = A_g.f_y$ $\quad$ $P_y = 5,25.10^6 N$

Periksa Kekompakan Penampang:

Harus memenuhi syarat kekompakan penampang pada Tabel 15.7-1 (SNI 03-1729-2002)

Pada Pelat sayap:

$\lambda_f = \frac{b_f}{2.t_f}$ $\quad$ $\lambda_f = 9,5$

$\lambda_p = \frac{170}{\sqrt{f_y}}$ $\quad$ $\lambda_{ps} = 10,97$

$$\lambda_f < \lambda_{ps}$$

Kesimpulan: penampang kompak

Pada Pelat badan:

$$\lambda_w = \frac{h'}{t_w} \qquad \lambda_w = 24{,}9$$

$$\lambda_p = \frac{1680}{\sqrt{f_y}} \qquad \lambda_p = 108{,}54$$

Kesimpulan: Penampang kompak ($\lambda_w < \lambda_p$)

1. Menghitung Kapasitas Momen Kolom C-7 (Lantai 2)

1.a Kondisi batas tekuk lokal

Momen Nominal Tekuk lokal (berdasarkan Tabel 7.5-1)

Pada pelat sayap:

$$\lambda_{pf} = \frac{170}{\sqrt{F_y}} \qquad \lambda_{pf} = 10{,}97$$

$$\lambda_{rf} = \frac{370}{\sqrt{F_y - F_r}} \qquad \lambda_{rf} = 28{,}38$$

$$\lambda_f = 9{,}5$$

Momen Nominal Tekuk Lokal pada pelat sayap: (M_{nFLB})

$$M_{nFLB} = M_p \text{ jika } \lambda_f \leq \lambda_{pf}$$

$$M_{nFLB} = M_p - \frac{(\lambda_f - \lambda_{pf})}{(\lambda_{rf} - \lambda_{pf})}.(M_p - M_r) \text{jika} \lambda_{pf} < \lambda_f < \lambda_{rf}$$

$$M_{nFLB} = \left(\frac{\lambda_{rf}}{\lambda_f}\right)^2 .M_r \text{jika} \lambda_f \geq \lambda_{rf}$$

$$M_{nFLB} = M_p = 878{,}4.10^6 \text{ Nmm}$$

$$\phi M_{nFLB} = 790560000 \text{Nmm}$$

Pada pelat badan:

$$\lambda_{pw} = \left[\frac{1680}{\sqrt{f_y}} - \left[1 - \frac{2,75.N_u}{\phi_b.N_y}\right]\right] \text{jika} \frac{N_u}{\phi_b.N_y} \leq 0,125$$

$$\lambda_{pw} = \max\left[\frac{500}{\sqrt{F_y}}.\left(2,33-\frac{N_u}{\phi_b.N_y}\right)\right],\left(\frac{665}{\sqrt{f_y}}\right) \text{jika} \frac{N_u}{\phi_b.N_y} \geq 0,125$$

$\lambda_{pw} = 42,93$

$$\lambda_{rw} = \frac{2550}{\sqrt{F_y}}.\left[1-0,74\left(\frac{N_u}{\phi_b.N_y}\right)\right]$$

$\lambda_{rw} = 87,26$ $\lambda_w = 24,9$

Momen Nominal Tekuk Lokal pada pelat badan:

$M_{nWLB} = M_p$ jika $\lambda_w \leq \lambda_{pw}$

$$M_{nWLB} = M_p - \frac{(\lambda_w - \lambda_{pw})}{(\lambda_{rw} - \lambda_{pw})}.(M_p - M_r) \text{ jika } \lambda_{pw} < \lambda_w < \lambda_{rw}$$

$$M_{nWLB} = \left(\frac{\lambda_{rw}}{\lambda_w}\right)^2.M_r \text{ jika } \lambda_w \geq \lambda_{rw}$$

$M_{nWLB} = M_p = 878,4.10^6$ Nmm

$\phi M_{nWLB} = 790560000$Nmm

1.b Kondisi batas tekuk lateral

Panjang tak bertumpu:

$L_b = 3500$mm

Batas-batas jarak pengekang lateral:

$$I_w = \frac{1}{4}.h^2.I_y = \frac{1}{4}.(400^2).2,24.10^8 = 8,96.10^{12}$$

$$L_p = 1,76.r_y.\sqrt{\frac{E}{f_y}} = 1,76.101.\sqrt{\frac{200000}{240}} = 5131,49 \text{ mm}$$

$$X_1 = \frac{\pi}{S}\sqrt{\frac{E.G.J.A}{2}} = \frac{\pi}{33,3.10^5}.\sqrt{\frac{200000.80000.3256126.21870}{2}} = 22517,78 \text{ MPa}$$

$$X_2 = 4.\left(\frac{S}{G.J}\right)^2.\frac{I_w}{I_Y} = 4.\left(\frac{33,3.10^5}{80000.3256126}\right)^2.\frac{8,96.10^{12}}{2,24.10^8} = 2,61.10^{-5}\text{mm}^4/\text{N}^2$$

$$L_r = r_y.\left(\frac{X_1}{F_L}\right).\sqrt{1+\sqrt{1+X_2.F_L{}^2}}$$

$$L_r = 101.\left(\frac{22517,78}{170}\right).\sqrt{1+\sqrt{1+2,61.10^{-5}.170^2}} = 18930,14 \text{ mm}$$

Maka,

$L_b = 3500\text{mm}$ $L_p = 5131,49$ mm $L_r = 18930,14$ mm

Keterangan: " Bentang pendek" jika $L_b \le L_p$

" Bentang menengah jika $L_p < L_b < L_r$

" Bentang panjang jika $L_b \ge L_r$

Kesimpulan: bentang pendek

Momen Nominal Tekuk Lateral (M_{nLTB})

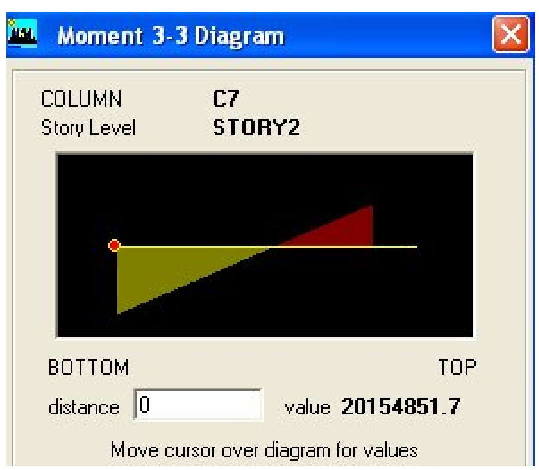
Momen Plastis

$M_p = 878,4.10^6$ Nmm

Momen Batas Tekuk

$M_r = S.(f_y - f_r) = 566,1.10^6$ Nmm

Menghitung nilai C_b :



Gambar L.3.4 Momen pada Kolom

Data Momen yang didapat dari ETABS untuk menghitung nilai cb:

Momen di ¼ bentang (M_a) = 10512168,1 Nmm

Momen di ½ bentang (M_b) = 869484,48 Nmm

Momen di ¾ bentang (M_c) = 8773199 Nmm

Momen maksimum = 20154851,7 Nmm

$$C_b = \frac{12{,}5.M_{maks}}{2{,}5.M_{maks} + 3.M_A + 4.M_B + 3.M_c} \leq 2{,}3$$

$$C_b = \frac{12{,}5.20154851{,}7}{2{,}5.20154851{,}7 + 3.10512168{,}1 + 4.869484{,}48 + 3.8773199} \leq 2{,}3$$

$$C_b = 2{,}25 \leq 2{,}3$$

Menghitung Momen kritis:

$$C_w = \frac{\left[I_y.\left(d\text{-}t_f\right)^2 \right]}{4}$$

$$C_w = 8{,}04.10^{12}$$

$$A_1 = E_s.I_y.G.J = 1{,}17.10^{25}$$

$$A_2 = \left(\frac{\pi.E_s}{L}\right)^2.I_y.C_w = 5{,}8.10^{25}$$

$$M_{cr} = C_b.\frac{\pi}{L}.\sqrt{A_1 + A_2}$$

$$M_{cr} = 1{,}69x10^{10} \text{ Nmm}$$

Momen Nominal Tekuk Lateral pada sumbu-x: (M_{nLTBx})

$$M_{nLTBx} = M_p \text{ jika } L_b \leq L_p$$

$$M_{nLTBx} = C_b.\left[M_r + \left(M_{p1} - M_r\right)\left(\frac{L_r - L}{L_r - L_p}\right)\right] \text{jika } L_p < L_b < L_r$$

$$M_{nLTBx} = \min M_{cr}, M_{p1} \text{ jika } L_b \geq L_r$$

Jadi $M_{nLTBx} = M_p = 878{,}4x10^6$ Nmm

ϕM_{nLTBx} = 790560000 Nmm

Momen nominal Tekuk Lateral pada sumbu-y:(M_{nLTBy})

Momen plastis pada sumbu –y:

M_{py} =min(Z_y.F_y,1,5S_y.F_y)

M_{py} = 403200000 Nmm

ϕM_{nLTBy} =362880000 Nmm

1.c Menghitung Momen Nominal (M_n)

Momen nominal pada sumbu-x: (M_{nx})

M_{nx} =min(M_{nFLB},M_{nWLB},M_{nLTBx},M_p)

M_{nx} = 878,4x10^6Nmm

Momen Nominal pada sumbu-y: (M_{ny})

M_{ny} =M_{nLTBy}

M_{ny} = 403200000 Nmm

Maka besarnya kapasitas momen adalah sebagai berikut:

Kapasitas momen pada sumbu-x: (M_{nx})

ϕM_{nx} = 790560000 Nmm

Kapasitas momen pada sumbu-y: (M_{ny})

ϕM_{ny} =362880000 Nmm

2. Menghitung kapasitas Tarik Kolom C-7 (Lantai 2)

Kuat tarik nominal: (P_{nt})

P_{nt} =A_g.f_y

P_{nt} =5,25x10^6N

Maka besarnya kapasitas tarik adalah sebagai berikut: (ϕP_{nt})

ϕP_{nt} = 4723920 N

3. Menghitung Kapasitas Tekan Kolom C-7 (Lantai 2)

3.a Hitung tegangan kritis: F_{crl}

Besaran penampang yang perlu dihitung:

Faktor panjang efektif k_c, ditentukan dengan menggunakan faktor G:

$G_A = 1,0$ (jepit)

$$G_B = \frac{\Sigma(\frac{I}{L})_A}{\Sigma(\frac{I}{L})_B} = \frac{\left(\frac{66600}{350}\right)+\left(\frac{66600}{350}\right)}{\left(\frac{7210}{600}\right)+\left(\frac{7210}{600}\right)} = 15,8$$

$k_c = 2$

$L_k = k_c.L$ $\quad\quad$ $L_k = 7000$ mm

$r = \min(r_x, r_y)$ $\quad\quad$ $r = 101$mm

$\lambda_c = \frac{L_k}{\pi.r}.\sqrt{\frac{f_y}{E_s}}$ $\quad\quad$ $\lambda_c = 0,76$

$$F_{cr1} = \left[\left(0,658^{\lambda_c^2}\right).f_y\right] \text{jika} \lambda_c \le 1,5$$

$$F_{cr1} = \left[\left(\frac{0,877}{\lambda_c^2}\right).f_y\right] \text{jika} \lambda_c > 1,5$$

$F_{cr1} = 195,71$ MPa

3.b Hitung Tegangan kritis dengan memperhitungkan tekuk puntir lentur:

Besaran penampang yang perlu dihitung:

$C_w = \frac{\left[I_y.(d\text{-}t_f)^2\right]}{4}$ $\quad\quad$ $C_w = 8,04x10^{12}$

Tegangan Tekuk elastik puntir lentur:(Fe)

$$F_e = \left[\frac{\pi^2.E_s.C_w}{(K_z.L_k)^2} + G.J\right]\frac{1}{I_x + I_y}$$

$F_e = 1748,34$ MPa

$$\lambda_e = \sqrt{\frac{f_y}{F_e}} \qquad \lambda_e = 0{,}37$$

Maka besarnya Tegangan kritis dengan memperhitungkan tekuk puntir lentur:

$$F_{cr2} = \left[\left(0{,}658^{\lambda_e^2}\right).f_y\right] \text{jika} \lambda_c \leq 1{,}5$$

$$F_{cr2} = \left[\left(\frac{0{,}877}{\lambda_e^2}\right).f_y\right] \text{jika} \lambda_c > 1{,}5$$

$$F_{cr2} = 226{,}63 \text{ MPa}$$

Besarnya Kuat tekan nominal adalah:

$$F_{cr} = \min(F_{cr1}, F_{cr2})$$

$$F_{cr} = 195{,}71 \text{ MPa}$$

$$P_{nc} = A_g.F_{cr} \qquad P_{nc} = 4280114{,}486 \text{ N}$$

Sehingga besarnya kapasitas tekan kolom adalah:

$$\phi P_{nc} = 3852103{,}04 \text{ N}$$

4. Menghitung Faktor Modifikasi Momen (Cm)

$M_1 =$ 12905778 Nmm (momen ujung terkecil)

$M_2 =$ 20154851,7 Nmm (momen ujung terbesar)

Kurvatur = 2 (*double curvature*)

$$\beta_m = \frac{\min(M_1, M_2)}{\max(M_1, M_2)} \text{ jika kurvatur} > 2$$

$$\beta_m = \left(-\frac{\min(M_1, M_2)}{\max(M_1, M_2)}\right) \text{ jika kurvatur} < 1$$

$$C_m = 0{,}6 - 0{,}4.\beta_m$$

$$C_m = 0{,}34$$

5.Menghitung Faktor Amplikasi Momen (δ_b)

Data yang diperlukan:

$N_u = 2445642{,}9N$

$\lambda_{cx} = \frac{L_k}{\pi . r_x} . \sqrt{\frac{F_y}{E_s}}$ $\lambda_{cx} = 0{,}44$

$\lambda_{cy} = \frac{L_k}{\pi . r_y} . \sqrt{\frac{F_y}{E_s}}$ $\lambda_{cy} = 0{,}76$

$N_{crx} = \frac{A_g . F_y}{\lambda_{cx}^2}$ $N_{crx} = 108446281\ N$

$N_{cry} = \frac{A_g . F_y}{\lambda_{cy}^2}$ $N_{cry} = 36349030{,}47\ N$

Maka faktor Amplikasi momen adalah sebagai berikut:

$\delta_{b1x} = \frac{C_m}{1 - \left(\frac{N_u}{N_{crx}} \right)}$ $\delta_{b1x} = 0{,}35$

$\delta_{b1x} = \max(\delta_{b1x}, 1)$ $\delta_{b1x} = 1{,}00$

$\delta_{b1y} = \frac{C_m}{1 - \left(\frac{N_u}{N_{cry}} \right)}$ $\delta_{b1y} = 0{,}36$

$\delta_{b1y} = \max(\delta_{b1y}, 1)$ $\delta_{b1y} = 1{,}00$

6. Menghitung Kapasitas Gaya Geser Kolom C-7 (Lantai 2)

6.a Gaya Geser Nominal pada sumbu-x:

Besaran penampang yang perlu dihitung:

$A_{w1} = d.t_w$ $A_{w1} = 5200 mm^2$

a = 3500 mm

$$k_n = 5 + \left[\frac{5}{\left(\frac{a}{h'} \right)^2} \right] \qquad k_n = 5{,}04$$

Maka besarnya gaya geser nominal pada sumbu-x:

$$\lambda_w = \frac{h'}{t_w} \qquad \lambda_w = 24{,}15$$

$$V_{nx} = (0{,}6.f_y.A_{w1}) \text{jika} \lambda_w \leq \left(1{,}10.\sqrt{\frac{k_n.E_s}{f_y}} \right)$$

$$V_{nx} = 0{,}6.F_y.A_{w1}.1{,}10.\sqrt{\frac{k_n.E_s}{F_y}}.\frac{1}{\lambda_w} \text{ jika} \left(1{,}10.\sqrt{\frac{k_n.E_s}{F_y}} \right) \leq \lambda_w < 1{,}37.\sqrt{\frac{k_n.E_s}{F_y}}$$

$$V_{nx} = \frac{0{,}9.A_{w1}.k_n.E_s}{(\lambda_w)^2} \text{ jika} \lambda_w \geq 1{,}37.\sqrt{\frac{k_n.E_s}{F_y}}$$

$V_{nx} = 748800$ N

6.b Gaya geser Nominal pada sumbu-y:

Besaran penampang yang perlu dihitung:

$$A_{w2} = \left(\frac{5}{3}.b_f.t_f \right) \qquad A_{w2} = 1400 mm^2$$

Maka besarnya gaya geser nominal pada sumbu-y:

$$V_{ny} = 0{,}6.f_y.A_{w2} \qquad V_{ny} = 2016000 \text{ N}$$

Maka besarnya kapasitas gaya geser adalah sebagai berikut:

Kapasitas gaya geser pada sumbu-x:

$\phi V_{nx} = 673920$ N

Kapasitas gaya geser pada sumbu-y:

$\phi V_{ny} = 1814400$N

Selanjutnya, akan dihitung rasio tegangan akibat gaya geser yang bekerja:

Rasio tegangan pada sumbu-x:

V_{ux} didapat dari nilai maksimum kombinasi = 640,96 N

$$\frac{V_{ux}}{\phi V_{nx}} = \frac{640,96}{673920} = 0,001$$ **Hasil Output ETABS: Rasio= 0,001**

Rasio tegangan pada sumbu-y:

V_{uy} didapat dari nilai maksimum kombinasi = 11020,21 N

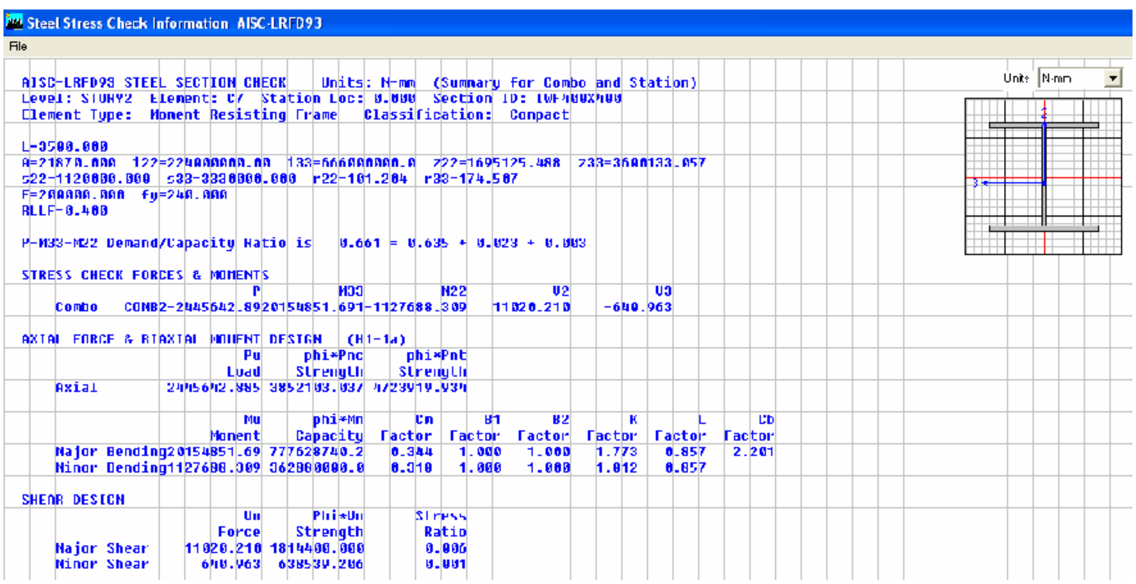
$$\frac{V_{uy}}{\phi V_{ny}} = \frac{11020,21}{1814400} = 0,006$$ **Hasil Output ETABS: Rasio= 0,006**

Dari hasil kombinasi pembebanan dan kapasitas kolom yang didapat diatas, maka dapat dihitung persamaan interaksi akibat gaya aksial dan momen sebagai berikut:

$$\text{Rasio} = \left[\frac{N_u}{\phi N_{nt}} + \frac{8}{9}.\left(\frac{M_{ux}}{\phi_b.M_{nx}} + \frac{M_{uy}}{\phi_b.M_{ny}}\right)\right] \text{jika } \frac{N_u}{\phi N_{nt}} > 0,2$$

$$\left[\frac{N_u}{2.\phi N_{nt}} + \left(\frac{M_{ux}}{\phi_b.M_{nx}} + \frac{M_{uy}}{\phi_b.M_{ny}}\right)\right] \text{jika } \frac{N_u}{\phi N_{nt}} < 0,2$$

Maka rasio = 0,660 **Hasil Output ETABS: Rasio= 0,661**



Gambar L.3.5 Nilai Output Kolom yang Didesain Berdasarkan SNI 1726-2002

B. Pembahasan Rasio P-M Gedung yang Didesain Berdasarkan FEMA 450

Desain Balok

Elevation-B (B17) Story 2

Karakteristik Profil :

WF = 300.150.6,5.9 (BJ37)

d = 300 mm	bf = 150 mm
tw = 6,5 mm	tf = 9 mm
L = 6000 mm	Ag = $4,678.10^3 mm^2$
Ix = $7,21.1010^7 mm^4$	Iy = $5,08.10^6 mm^4$
$r_x = 124$ mm	$r_y = 32,9$ mm
$S_x = 4,81.10^5 mm^3$	$S_y = 6,77.10^4 mm^3$
$r_c = 13mm$	
$h' = d - 2.t_f - 2.r_c$	h' = 256mm
$A_w = (d - 2.t_f).t_w$	$A_w = 1833 mm^2$
$Z_x = b.t_f.(d - t_f) + \frac{1}{4} t_w.(d - 2.t_f)^2$	$Z_x = 5,22.10^5 mm^3$
$Z_y = \frac{1}{2}.t_f.b^2 + \frac{1}{4}.(d - 2.t_f).t_w^2$	$Z_y = 1,04.10^5 mm^3$

Data Material:

Modulus Elastisitas :

$E_s = 200000 MPa$

Tegangan Leleh Flens dan Badan:

$f_y = 240 MPa$

Tegangan Sisa:

$f_r = 70 MPa$ (rolled beam)

Faktor reduksi

$\phi = 0,9$ $\phi_c = 0,85$ $\phi_b = 0,9$

Faktor modifikasi Tegangan Leleh:

$R_y = 1,5$ jika $f_y \leq 250 \text{MPa}$

$R_y = 1,3$ jika $f_y \leq 290 \text{MPa}$

Maka $R_y = 1,5$

Besaran penampang yang perlu dihitung:

$f_L = f_y - f_r$ $\quad$ $f_r = 70 \text{MPa}$ $\quad$ $G = 0,8.10^5 \text{MPa}$

$f_L = 170 \text{MPa}$

$J = \left(\frac{1}{3}\right).\left[\left(2.b_f.t_f^3\right) + \left[\left(d-2.t_f\right).t_w^3\right]\right]$ $\quad$ $J = 98714,75 \text{mm}^4$

$I_w = \left[\left(\frac{1}{2}\right).\left(d-t_f\right)\right]^2$ $\quad$ $I_w = 21170,25 \text{mm}^2$

Momen Leleh: $M_y = S_x.f_y$ $\quad$ $M_y = 115,44.10^6 \text{Nmm}$

Momen Plastis: $M_p = Z_x.f_y$ $\quad$ $M_p = 125,3 \times 10^6 \text{Nmm}$

Momen Batas Tekuk: $M_r = (f_y - f_r).S_x$ $\quad$ $M_r = 81,77.10^6 \text{Nmm}$ (karena tegangan leleh flens dan badan sama)

Gaya aksial Leleh: $P_y = A_g.f_y$ $\quad$ $P_y = 1,123.10^6 \text{N}$

Periksa Kekompakan Penampang:

Harus memenuhi syarat kekompakan penampang pada Tabel 15.7-1 (SNI 03-1729-2002)

Pada Pelat sayap:

$\lambda_f = \frac{b_f}{2.t_f}$ $\quad$ $\lambda_f = 8,333$

$\lambda_p = \frac{170}{\sqrt{f_y}}$ $\quad$ $\lambda_{ps} = 10,97$

Kesimpulan: Penampang kompak

Pada Pelat badan:

$$\lambda_w = \frac{h'}{t_w} \qquad \lambda_w = 39{,}38$$

$$\lambda_p = \frac{1680}{\sqrt{f_y}} \qquad \lambda_p = 108{,}54$$

Kesimpulan: Penampang kompak ($\lambda_w < \lambda_p$)

1. Menghitung Kapasitas Momen Balok B-13

1.a Kondisi batas tekuk lokal

Momen Nominal Tekuk lokal (berdasarkan Tabel 7.5-1)

Pada pelat sayap:

$$\lambda_{pf} = \frac{170}{\sqrt{F_y}} \qquad \lambda_{pf} = 10{,}97$$

$$\lambda_{rf} = \frac{370}{\sqrt{f_y - f_r}} \qquad \lambda_{rf} = 28{,}38$$

$$\lambda_f = 8{,}333$$

Momen Nominal Tekuk Lokal pada pelat sayap: (M_{nFLB})

$$M_{nFLB} = M_p \text{ jika } \lambda_f \le \lambda_{pf}$$

$$M_{nFLB} = M_p - \frac{(\lambda_f - \lambda_{pf})}{(\lambda_{rf} - \lambda_{pf})}.(M_p - M_r) \text{ jika } \lambda_{pf} < \lambda_f < \lambda_{rf}$$

$$M_{nFLB} = \left(\frac{\lambda_{rf}}{\lambda_f}\right)^2 .M_r \text{ jika } \lambda_f \ge \lambda_{rf}$$

$$M_{nFLB} = M_p = 125{,}3x10^6 Nmm$$

$$\phi M_{nFLB} = 112752000 Nmm$$

Pada pelat badan:

$$\lambda_{pw} = \left[\frac{1680}{\sqrt{f_y}}\right] \qquad \lambda_{pw} = 108,44$$

$$\lambda_{rw} = \left[\frac{2550}{\sqrt{f_y}}\right] \qquad \lambda_{rw} = 164,61$$

$$\lambda_w = 39,38$$

Momen Nominal Tekuk Lokal pada pelat badan:

$$M_{nWLB} = M_p \text{ jika } \lambda_w \leq \lambda_{pw}$$

$$M_{nWLB} = M_p - \frac{(\lambda_w - \lambda_{pw})}{(\lambda_{rw} - \lambda_{pw})}.(M_p - M_r) \text{ jika } \lambda_{pw} < \lambda_w < \lambda_{rw}$$

$$M_{nWLB} = \left(\frac{\lambda_{rw}}{\lambda_w}\right)^2.M_r \text{ jika } \lambda_w \geq \lambda_{rw}$$

$$M_{nWLB} = M_p = 125,3x10^6 Nmm$$

$$\phi M_{nWLB} = 112752000 Nmm$$

1.b Kondisi batas tekuk lateral

Panjang tak bertumpu:

$$L_b = 6000mm$$

Batas-batas jarak pengekang lateral:

$$I_w = \frac{1}{4}.h^2.I_y = \frac{1}{4}.(300^2).5,08.10^6 = 1,143.10^{11}$$

$$L_p = 1,76.r_y.\sqrt{\frac{E}{F_y}} = 1,76.32,9.\sqrt{\frac{200000}{240}} = 1671,54mm$$

$$X_1 = \frac{\pi}{S}\sqrt{\frac{E.G.J.A}{2}} = \frac{\pi}{4,81.10^5}.\sqrt{\frac{200000.80000.98714,75.4,678.10^3}{2}} = 12553,68MPa$$

$$X_2 = 4.\left(\frac{S}{G.J}\right)^2.\frac{I_w}{I_Y} = 4.\left(\frac{4,81.10^5}{80000.98714,75}\right)^2.\frac{1,143.10^{11}}{5,08.10^6} = 3,34.10^{-4} mm^4/N^2$$

$$L_r = r_y . \left(\frac{X_1}{F_L}\right) . \sqrt{1+\sqrt{1+X_2 . F_L^{\ 2}}}$$

$$L_r = 32{,}9 . \left(\frac{12553{,}68}{170}\right) . \sqrt{1+\sqrt{1+3{,}34.10^{-4} . 170^2}} = 7929{,}5 mm$$

Maka,

$L_b = 6000mm$ $L_p = 1671{,}54mm$ $L_r = 7929{,}5mm$

Keterangan: "Bentang pendek" jika $L_b \le L_p$

" Bentang menengah jika $L_p < L_b < L_r$

" Bentang panjang jika $L_b \ge L_r$

Kesimpulan: bentang menengah

Momen Nominal Tekuk Lateral (M_{nLTB})

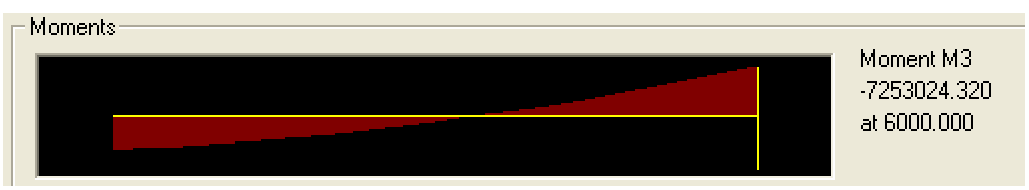
Momen Plastis

$M_p = 125{,}3x10^6 Nmm$

Momen Batas Tekuk

$M_r = S.(f_y - f_r) = 81770000 Nmm$

Menghitung nilai c_b :



Gambar L.3.6 Momen Maksimum

Data Momen yang didapat dari ETABS untuk menghitung nilai cb:

Momen di ¼ bentang (M_a) = 3145095,258 Nmm

Momen di ½ bentang (M_b) = 654608,737 Nmm

Momen di ¾ bentang (M_c) = 2821972,465 Nmm

Momen maksimum = 7253024,32 Nmm

$$C_b = \frac{12,5.M_{maks}}{2,5.M_{maks}+3.M_A+4.M_B+3.M_c} \leq 2,3$$

$$C_b = \frac{12,5.7253024,32}{2,5.7253024,32+3.3145095,258+4.654608,737+3.2821972,465} \leq 2,3$$

$$C_b = 2,24 \leq 2,3$$

Menghitung Momen kritis:

$$C_w = \frac{\left[I_y.\left(d-t_f\right)^2\right]}{4} \qquad C_w = 1,075x10^{-7}m^6$$

$$A_1 = E_s.I_y.G.J = 8,02x10^{21} \qquad A_2 = \left(\frac{\pi.E_s}{L}\right)^2.I_y.C_w = 3,04x10^{28}$$

$$M_{cr} = C_b.\frac{\pi}{L}.\sqrt{A_1+A_2} \qquad M_{cr} = 2,045x10^{11}Nmm$$

Momen Nominal Tekuk Lateral pada sumbu-x: (M_{nLTBx})

$$M_{nLTBx} = M_p \text{ jika } L_b \leq L_p$$

$$M_{nLTBx} = C_b.\left[M_r+\left(M_{p1}-M_r\right)\left(\frac{L_r-L}{L_r-L_p}\right)\right] \text{jika } L_p < L_b < L_r$$

$$M_{nLTBx} = \min M_{cr}, M_{p1} \text{ jika } L_b \geq L_r$$

Jadi $M_{nLTBx} = 114672264,4$ Nmm

$\phi M_{nLTBx} = 104247513,15$ Nmm

Momen nominal Tekuk Lateral pada sumbu-y:(M_{nLTBy})

Momen plastis pada sumbu –y:

$M_{py} = \min\ (Z_y.F_y, 1,5S_y.F_y)$

$M_{py} = 24372000$ Nmm

$\phi M_{nLTBy} = 21934800 Nmm$

1.c Menghitung Momen Nominal (M_n)

Momen nominal pada sumbu-x: (M_{nx})

$M_{nx} = \min (M_{nFLB}, M_{nWLB}, M_{nLTBx}, M_p)$

$M_{nx} = 114672264{,}4$ Nmm

Momen Nominal pada sumbu-y: (M_{ny})

$M_{ny} = M_{nLTBy}$

$M_{ny} = 24372000$ Nmm

Maka besarnya kapasitas momen adalah sebagai berikut:

Kapasitas momen pada sumbu-x: (M_{nx})

$\phi M_{nx} = 104247513{,}15$ Nmm

Kapasitas momen pada sumbu-y: (M_{ny})

$\phi M_{ny} = 21934800$ Nmm

2. Menghitung kapasitas Tarik Balok B-17

Kuat tarik nominal: (P_{nt})

$P_{nt} = A_g . F_y$ $\qquad$ $P_{nt} = 1122720N$

Maka besarnya kapasitas tarik adalah sebagai berikut: (ϕP_{nt})

$\phi P_{nt} = 1010448N$

3. Menghitung Kapasitas Tekan Balok B-17

3.a Hitung tegangan kritis: F_{crl}

Besaran penampang yang perlu dihitung:

$k_c = 1$ (beban aksial tidak ada)

$L_k = k_c . L$ $\qquad$ $L_k = 6000mm$

$r = \min (r_x, r_y)$ $\qquad$ $r = 32{,}9mm$

$\lambda_c = \frac{L_k}{\pi.r}.\sqrt{\frac{f_y}{E_s}}$ λ_c=2,01

$F_{cr1} = \left[\left(0{,}658.\lambda_c^2\right).F_y\right] \text{jika} \lambda_c \leq 1,5$ $F_{cr1} = \left[\left(\frac{0{,}877}{\lambda_c^2}\right).F_y\right] \text{jika} \lambda_c > 1,5$

F_{cr1}=52,10MPa

3.b Hitung Tegangan kritis dengan memperhitungkan tekuk puntir lentur:

Besaran penampang yang perlu dihitung:

$$C_w = \frac{\left[I_y.(d\text{-}2.t_f)^2\right]}{4}$$

C_w=1,075x10^{11}

Tegangan Tekuk elastik puntir lentur:(Fe)

$F_e = \left[\frac{\pi^2.E_s.C_w}{\left(K.L_k\right)^2} + G.J\right]\frac{1}{I_x + I_y}$ F_e=178,69MPa

$\lambda_e = \sqrt{\frac{f_y}{F_e}}$ λ_e=1,159

Maka besarnya Tegangan kritis dengan memperhitungkan tekuk puntir lentur:

$f_{cr2} = \left[\left(0{,}658^{\lambda_e^2}\right).f_y\right] \text{jika} \lambda_c \leq 1,5$ $f_{cr1} = \left[\left(\frac{0{,}877}{\lambda_e^2}\right).f_y\right] \text{jika} \lambda_c > 1,5$

F_{cr1}=156,69MPa

Besarnya Kuat tekan nominal adalah:

F_{cr}=156,69MPa

$P_{nc} = A_g.F_{cr}$ P_{nc}=732995,82N

Sehingga besarnya kapasitas tekan balok adalah:

ϕP_{nc}=659696,238N

4. Menghitung Kapasitas Gaya Geser Balok B-13

4.a Gaya Geser Nominal pada sumbu-x:

Besaran penampang yang perlu dihitung:

$A_{w1} = d.t_w$ $\qquad A_{w1} = 1950 \text{ mm}^2$

a = 6000 mm

$$k_n = 5 + \left[\frac{5}{\left(\frac{a}{h'}\right)^2} \right] \qquad k_n = 5{,}009$$

Maka besarnya gaya geser nominal pada sumbu-x:

$$\lambda_w = \frac{h'}{t_w} \qquad \lambda_w = 39{,}385$$

$$V_{nx} = (0{,}6.F_y.A_{w1}) \text{ jika } \lambda_w \leq \left(1{,}10.\sqrt{\frac{k_n.E_s}{F_y}} \right)$$

$$V_{nx} = 0{,}6.F_y.A_{w1}.1{,}10.\sqrt{\frac{k_n.E_s}{F_y}}.\frac{1}{\lambda_w} \text{ jika } \left(1{,}10.\sqrt{\frac{k_n.E_s}{F_y}} \right) \leq \lambda_w < 1{,}37.\sqrt{\frac{k_n.E_s}{F_y}}$$

$$V_{nx} = \frac{0{,}9.A_{w1}.k_n.E_s}{(\lambda_w)^2} \text{ jika } \lambda_w \geq 1{,}37.\sqrt{\frac{k_n.E_s}{F_y}}$$

$V_{nx} = 280800 \text{N}$

4.b Gaya geser Nominal pada sumbu-y:

Besaran penampang yang perlu dihitung:

$$A_{w2} = \left(\frac{5}{3}.b_f.t_f \right) \qquad A_{w2} = 2250 \text{mm}^2$$

Maka besarnya gaya geser nominal pada sumbu-y:

$V_{ny} = 0{,}6.F_y.A_{w2}$ $\qquad V_{ny} = 324000 \text{ N}$

Maka besarnya kapasitas gaya geser adalah sebagai berikut:

Kapasitas gaya geser pada sumbu-x:

$\phi V_{nx} = 252720 \text{N}$

Kapasitas gaya geser pada sumbu-y:

ϕV_{ny} =291600N

Selanjutnya, akan dihitung rasio tegangan akibat gaya geser yang bekerja:

Rasio tegangan pada sumbu-x:

$\frac{V_{ux}}{\phi V_{nx}} = 0{,}000$ **Hasil Output ETABS: Rasio= 0,000**

Rasio tegangan pada sumbu-y:

$\frac{V_{uy}}{\phi V_{ny}} = 0{,}012$ **Hasil Output ETABS: Rasio= 0,011**

5. Menghitung Faktor Modifikasi Momen (C_m)

$C_m = 1$ ujung-ujung batang yang bisa bertranslasi

6.Menghitung Faktor Amplikasi Momen (δ_b)

Data yang diperlukan:

$P_{cr} = \frac{A_g . F_y}{\lambda_c^2}$ $P_{cr} = 277894{,}1115$ N

Maka faktor Amplikasi momen adalah sebgai berikut:

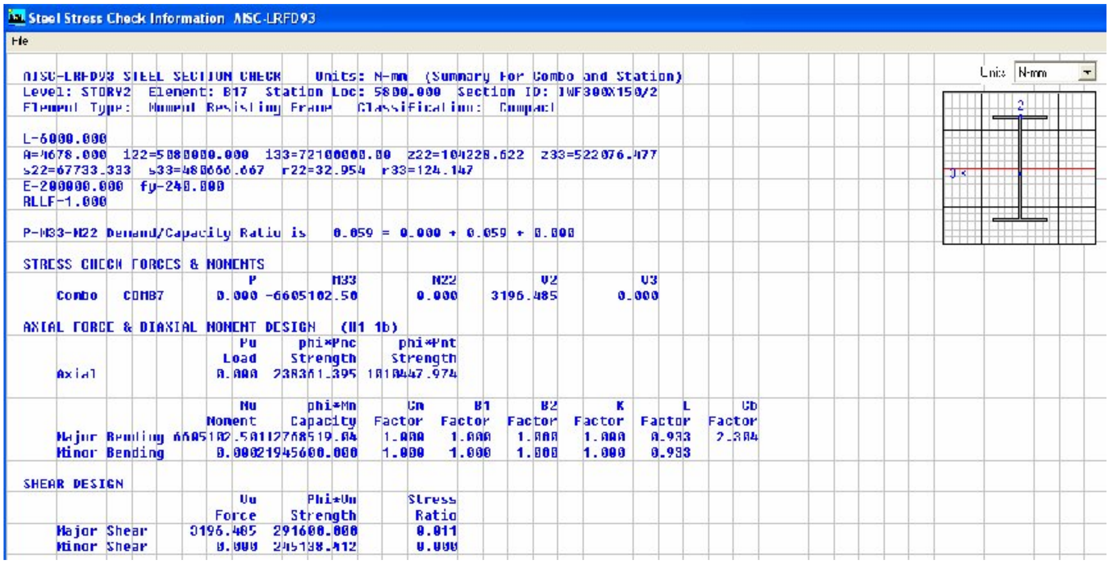
$\delta_{b1} = \frac{C_m}{1 - \left(\frac{P_u}{P_{cr}}\right)}$ $\delta_{b1} = 1{,}02$

Dari hasil kombinasi pembebanan dan kapasitas balok yang didapat diatas, maka dapat dihitung persamaan interaksi akibat gaya aksial dan momen sebagai berikut:

$$\text{Rasio} = \left[\frac{P_u}{\phi P_{nt}} + \frac{8}{9}.\left(\frac{M_{ux}}{\phi_b . M_{nx}} + \frac{M_{uy}}{\phi_b . M_{ny}}\right)\right] \text{jika } \frac{P_u}{\phi P_{nt}} \geq 0{,}2$$

$$\left[\frac{P_u}{2.\phi P_{nt}} + \left(\frac{M_{ux}}{\phi_b . M_{nx}} + \frac{M_{uy}}{\phi_b . M_{ny}}\right)\right] \text{jika } \frac{P_u}{\phi P_{nt}} < 0{,}2$$

Maka rasio = 0,062 **Hasil Output ETABS: Rasio= 0,059**



Gambar L.3.7 Nilai Output Balok yang Didesain Berdasarkan FEMA 450

Desain Kolom

Karakteristik Profil:

WF = 400.400.13.21 (BJ37)

$d = 400$ mm | $b_f = 400$ mm

$t_w = 13$ mm | $t_f = 21$ mm

$L = 3500$ mm | $Ag = 21870\ mm^2$

$I_x = 6{,}66.10^8 mm^4$ | $I_y = 2{,}24.10^8 mm^4$

$r_x = 175$ mm | $r_y = 101$ mm

$S_x = 33{,}3.10^5 mm^3$ | $S_y = 11{,}2.10^5 mm^3$

$r_c = 22$ mm

$h' = d - 2.t_f - 2.r_c$ | $h' = 314$ mm

$A_w = (d - 2.t_f).t_w$ | $A_w = 4654\ mm^2$

$Z_x = b.t_f.(d - t_f) + \frac{1}{4} t_w.(d - 2.t_f)^2$ | $Z_x = 3{,}66.10^6 mm^3$

$Z_y = \frac{1}{2}.t_f.b^2 + \frac{1}{4}.(d - 2.t_f).t_w^2$ | $Z_y = 1{,}69.10^6 mm^3$

Data Material:

Modulus Elastisitas:

E_s=200000MPa

Tegangan Leleh Flens dan Badan:

f_y=240MPa

Tegangan Sisa:

f_r=70MPa (*rolled beam*)

Faktor reduksi

$\phi = 0,9$ $\phi_c = 0,85$ $\phi_b = 0,9$

Faktor modifikasi Tegangan Leleh:

$R_y = 1,5$ jika $F_y \leq 250$MPa

$R_y = 1,3$ jika $F_y \leq 290$MPa

Maka R_y=1,5

Besaran penampang yang perlu dihitung:

$f_L = f_y - f_r$ f_r=70MPa G=0,8.10^{5}MPa

f_L=170MPa

$J=\left(\frac{1}{3}\right).\left[\left(2.b_f.t_f^{\,3}\right)+\left[\left(d\text{-}2.t_f\right).t_w^{\,3}\right]\right]$ J= 3256126 mm^4

$I_w=\left[\left(\frac{1}{2}\right).\left(d\text{-}t_f\right)\right]^2$ I_w= 35910,25 mm^2

Momen Leleh: $M_y=S_x.f_y$ M_y=799,2.10^6 Nmm

Momen Plastis: $M_p=Z_x.f_y$ M_p=878,4.10^6 Nmm

Momen Batas Tekuk: $M_r=(f_y\text{-}f_r).S_x$ M_r= 566,1.10^6 Nmm (karena tegangan leleh sayap dan badan sama)

Gaya aksial Leleh: $P_y=A_g.f_y$ P_y= 5,25.10^{6}N

Periksa Kekompakan Penampang:

Harus memenuhi syarat kekompakan penampang pada Tabel 15.7-1 (SNI 03-1729-2002)

Pada Pelat sayap:

$$\lambda_f = \frac{b_f}{2.t_f} \qquad \lambda_f = 9{,}5$$

$$\lambda_p = \frac{170}{\sqrt{f_y}} \qquad \lambda_{ps} = 10{,}97$$

$$\lambda_f < \lambda_{ps}$$

Kesimpulan: penampang kompak

Pada Pelat badan:

$$\lambda_w = \frac{h'}{t_w} \qquad \lambda_w = 24{,}9$$

$$\lambda_p = \frac{1680}{\sqrt{f_y}} \qquad \lambda_p = 108{,}54$$

Kesimpulan: Penampang kompak ($\lambda_w < \lambda_p$)

1. Menghitung Kapasitas Momen Kolom C-7 (Lantai 2)

1.a Kondisi batas tekuk lokal

Momen Nominal Tekuk lokal (berdasarkan Tabel 7.5-1)

Pada pelat sayap:

$$\lambda_{pf} = \frac{170}{\sqrt{F_y}} \qquad \lambda_{pf} = 10{,}97$$

$$\lambda_{rf} = \frac{370}{\sqrt{F_y - F_r}} \qquad \lambda_{rf} = 28{,}38$$

$$\lambda_f = 9{,}5$$

Momen Nominal Tekuk Lokal pada pelat sayap: (M_{nFLB})

$M_{nFLB} = M_p$ jika $\lambda_f \leq \lambda_{pf}$

$$M_{nFLB} = M_p - \frac{(\lambda_f - \lambda_{pf})}{(\lambda_{rf} - \lambda_{pf})}.(M_p - M_r) \text{jika} \lambda_{pf} < \lambda_f < \lambda_{rf}$$

$$M_{nFLB} = \left(\frac{\lambda_{rf}}{\lambda_f}\right)^2 .M_r \text{jika} \lambda_f \geq \lambda_{rf}$$

$$M_{nFLB} = M_p = 878,4.10^6 \text{ Nmm}$$

$$\phi M_{nFLB} = 790560000 \text{Nmm}$$

Pada pelat badan:

$$\lambda_{pw} = \left[\frac{1680}{\sqrt{f_y}} - \left[1 - \frac{2,75.N_u}{\phi_b.N_y}\right]\right] \text{ jika } \frac{N_u}{\phi_b.N_y} \leq 0,125$$

$$\lambda_{pw} = \max\left[\frac{500}{\sqrt{f_y}}.\left(2,33 - \frac{N_u}{\phi_b.N_y}\right)\right],\left(\frac{665}{\sqrt{F_y}}\right) \text{jika} \frac{N_u}{\phi_b.N_y} \geq 0,125$$

$$\lambda_{pw} = 42,93$$

$$\lambda_{rw} = \frac{2550}{\sqrt{F_y}}.\left[1 - 0,74\left(\frac{N_u}{\phi_b.N_y}\right)\right]$$

$$\lambda_{rw} = 87,26$$

$$\lambda_w = 24,9$$

Momen Nominal Tekuk Lokal pada pelat badan:

$$M_{nWLB} = M_p \text{jika} \lambda_w \leq \lambda_{pw}$$

$$M_{nWLB} = M_p - \frac{(\lambda_w - \lambda_{pw})}{(\lambda_{rw} - \lambda_{pw})}.(M_p - M_r) \text{jika} \lambda_{pw} < \lambda_w < \lambda_{rw}$$

$$M_{nWLB} = \left(\frac{\lambda_{rw}}{\lambda_w}\right)^2 .M_r \text{jika} \lambda_w \geq \lambda_{rw}$$

$$M_{nWLB} = M_p = 878,4.10^6 \text{ Nmm}$$

$$\phi M_{nWLB} = 790560000 \text{Nmm}$$

1.b Kondisi batas tekuk lateral

Panjang tak bertumpu:

L_b=3500mm

Batas-batas jarak pengekang lateral:

$$I_w = \frac{1}{4}.h^2.I_y = \frac{1}{4}.\left(400^2\right).2{,}24.10^8 = 8{,}96.10^{12}$$

$$L_p = 1{,}76.r_y.\sqrt{\frac{E}{f_y}} = 1{,}76.101.\sqrt{\frac{200000}{240}} = 5131{,}49 \text{ mm}$$

$$X_1 = \frac{\pi}{S}\sqrt{\frac{E.G.J.A}{2}} = \frac{\pi}{33{,}3.10^5}.\sqrt{\frac{200000.80000.3256126.21870}{2}} = 22517{,}78 \text{ MPa}$$

$$X_2 = 4.\left(\frac{S}{G.J}\right)^2.\frac{I_w}{I_Y} = 4.\left(\frac{33{,}3.10^5}{80000.3256126}\right)^2.\frac{8{,}96.10^{12}}{2{,}24.10^8} = 2{,}61.10^{-5}\text{mm}^4/\text{N}^2$$

$$L_r = r_y.\left(\frac{X_1}{F_L}\right).\sqrt{1+\sqrt{1+X_2.F_L{}^2}}$$

$$L_r = 101.\left(\frac{22517{,}78}{170}\right).\sqrt{1+\sqrt{1+2{,}61.10^{-5}.170^2}} = 18930{,}14 \text{ mm}$$

Maka,

L_b=3500mm $\qquad$ L_p= 5131,49 mm $\qquad$ L_r= 18930,14 mm

Keterangan: “ Bentang pendek” jika $L_b \le L_p$

“ Bentang menengah jika $L_p < L_b < L_r$

“ Bentang panjang jika $L_b \ge L_r$

Kesimpulan: bentang pendek

Momen Nominal Tekuk Lateral (M_{nLTB})

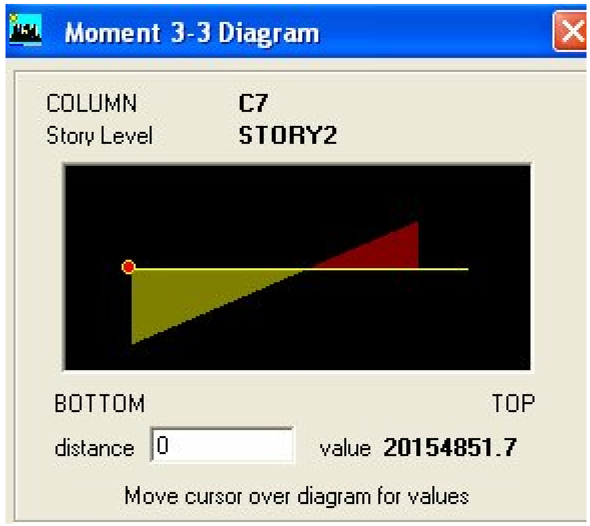
Momen Plastis

M_p=878,4.10^6 Nmm

Momen Batas Tekuk

M_r=S.(f_y-f_r)= 566,1.10^6 Nmm

Menghitung nilai C_b :



Gambar L.3.8 Momen pada Kolom

Data Momen yang didapat dari ETABS untuk menghitung nilai C_b:

Momen di ¼ bentang (M_a) = 10512168,1 Nmm

Momen di ½ bentang (M_b) = 869484,48 Nmm

Momen di ¾ bentang (M_c) = 8773199 Nmm

Momen maksimum = 20154851,7 Nmm

$$C_b = \frac{12,5.M_{maks}}{2,5.M_{maks} + 3.M_A + 4.M_B + 3.M_c} \leq 2,3$$

$$C_b = \frac{12,5.20154851,7}{2,5.20154851,7 + 3.10512168,1 + 4.869484,48 + 3.8773199} \leq 2,3$$

$$C_b = 2,25 \leq 2,3$$

Menghitung Momen kritis:

$$C_w = \frac{\left[I_y.(d\text{-}t_f)^2\right]}{4}$$

$$C_w = 8,04.10^{12}$$

$$A_1 = E_s.I_y.G.J = 1,17.10^{25}$$

$$A_2 = \left(\frac{\pi.E_s}{L}\right)^2.I_y.C_w = 5,8.10^{25}$$

$$M_{cr} = C_b . \frac{\pi}{L} . \sqrt{A_1 + A_2}$$

$$M_{cr} = 1{,}69x10^{10} \text{ Nmm}$$

Momen Nominal Tekuk Lateral pada sumbu-x: (M_{nLTBx})

$$M_{nLTBx} = M_p \text{ jika } L_b \leq L_p$$

$$M_{nLTBx} = C_b . \left[M_r + \left(M_{p1} - M_r \right) \left(\frac{L_r - L}{L_r - L_p} \right) \right] \text{jika } L_p < L_b < L_r$$

$$M_{nLTBx} = \text{min} M_{cr}, M_{p1} \text{ jika } L_b \geq L_r$$

Jadi $M_{nLTBx} = M_p = 878{,}4x10^6 \text{Nmm}$

$$\phi M_{nLTBx} = 790560000 \text{ Nmm}$$

Momen nominal Tekuk Lateral pada sumbu-y:(M_{nLTBy})

Momen plastis pada sumbu –y:

$$M_{py} = \min(Z_y . F_y , 1{,}5 S_y . F_y)$$

$$M_{py} = 403200000 \text{ Nmm}$$

$$\phi M_{nLTBy} = 362880000 \text{ Nmm}$$

1.c Menghitung Momen Nominal (M_n)

Momen nominal pada sumbu-x: (M_{nx})

$$M_{nx} = \min(M_{nFLB}, M_{nWLB}, M_{nLTBx}, M_p)$$

$$M_{nx} = 878{,}4x10^6 \text{Nmm}$$

Momen Nominal pada sumbu-y: (M_{ny})

$$M_{ny} = M_{nLTBy}$$

$$M_{ny} = 403200000 \text{ Nmm}$$

Maka besarnya kapasitas momen adalah sebagai berikut:

Kapasitas momen pada sumbu-x: (M_{nx})

$\phi M_{nx} = 790560000$ Nmm

Kapasitas momen pada sumbu-y: (M_{ny})

$\phi M_{ny} = 362880000$ Nmm

2. Menghitung kapasitas Tarik Kolom C-7 (Lantai 2)

Kuat tarik nominal: (P_{nt})

$P_{nt} = A_g . f_y$

$P_{nt} = 5,25 x 10^6 N$

Maka besarnya kapasitas tarik adalah sebagai berikut: (ϕP_{nt})

$\phi P_{nt} = 4723920$ N

3. Menghitung Kapasitas Tekan Kolom C-7 (Lantai 2)

3.a Hitung tegangan kritis: F_{crl}

Besaran penampang yang perlu dihitung:

Faktor panjang efektif k_c, ditentukan dengan menggunakan faktor G:

$G_A = 1,0$ (jepit)

$$G_B = \frac{\Sigma(\frac{I}{L})_A}{\Sigma(\frac{I}{L})_B} = \frac{\left(\frac{66600}{350}\right) + \left(\frac{66600}{350}\right)}{\left(\frac{7210}{600}\right) + \left(\frac{7210}{600}\right)} = 15,8$$

$k_c = 2$

$L_k = k_c . L$ $L_k = 7000$ mm

$r = \min(r_x, r_y)$ $r = 101$mm

$\lambda_c = \frac{L_k}{\pi . r} . \sqrt{\frac{f_y}{E_s}}$ $\lambda_c = 0,76$

$$F_{cr1}=\left[\left(0,658^{\lambda_c^2}\right).f_y\right] jika \lambda_c \leq 1,5$$

$$F_{cr1}=\left[\left(\frac{0,877}{\lambda_c^2}\right).f_y\right] jika \lambda_c > 1,5$$

F_{cr1}= 195,71 MPa

3.b Hitung Tegangan kritis dengan memperhitungkan tekuk puntir lentur:

Besaran penampang yang perlu dihitung:

$$C_w=\frac{\left[I_y.\left(d\text{-}t_f\right)^2\right]}{4} \qquad C_w=8,04x10^{12}$$

Tegangan Tekuk elastik puntir lentur:(F_e)

$$F_e=\left[\frac{\pi^2.E_s.C_w}{\left(K_z.L_k\right)^2}+G.J\right]\frac{1}{I_x+I_y}$$

F_e= 1748,34 MPa

$$\lambda_e=\sqrt{\frac{f_y}{F_e}} \qquad \lambda_e=0,37$$

Maka besarnya tegangan kritis dengan memperhitungkan tekuk puntir lentur:

$$F_{cr2}=\left[\left(0,658^{\lambda_e^2}\right).f_y\right] jika \lambda_c \leq 1,5$$

$$F_{cr2}=\left[\left(\frac{0,877}{\lambda_e^2}\right).f_y\right] jika \lambda_c > 1,5$$

F_{cr2}=226,63 MPa

Besarnya kuat tekan nominal adalah:

F_{cr}=min(F_{cr1},F_{cr2})

F_{cr}=195,71 MPa

$P_{nc}=A_g.F_{cr}$ $\qquad$ P_{nc}=4280114,486 N

Sehingga besarnya kapasitas tekan kolom adalah:

ϕP_{nc}=3852103,04 N

4. Menghitung Faktor Modifikasi Momen (C_m)

$M_1 = 12905778$ Nmm (momen ujung terkecil)

$M_2 = 20154851,7$ Nmm (momen ujung terbesar)

Kurvatur = 2 (*double curvature*)

$$\beta_m = \frac{\min(M_1,M_2)}{\max(M_1,M_2)} \quad \text{jika kurvatur} > 2$$

$$\beta_m = \left(-\frac{\min(M_1,M_2)}{\max(M_1,M_2)} \right) \text{jika kurvatur} < 1$$

$$C_m = 0,6 - 0,4.\beta_m$$

$$C_m = 0,34$$

5.Menghitung Faktor Amplikasi Momen (δ_b)

Data yang diperlukan:

$N_u = 2445642,9$N

$$\lambda_{cx} = \frac{L_k}{\pi.r_x}.\sqrt{\frac{F_y}{E_s}} \qquad \lambda_{cx} = 0,44$$

$$\lambda_{cy} = \frac{L_k}{\pi.r_y}.\sqrt{\frac{F_y}{E_s}} \qquad \lambda_{cy} = 0,76$$

$$N_{crx} = \frac{A_g.F_y}{\lambda_{cx}^2} \qquad N_{crx} = 108446281 \text{ N}$$

$$N_{cry} = \frac{A_g.F_y}{\lambda_{cy}^2} \qquad N_{cry} = 36349030,47 \text{ N}$$

Maka faktor Amplikasi momen adalah sebgai berikut:

$$\delta_{b1x} = \frac{C_m}{1-\left(\frac{N_u}{N_{crx}}\right)} \qquad \delta_{b1x} = 0,35$$

$$\delta_{b1x} = \max(\delta_{b1x},1) \qquad \delta_{b1x} = 1,00$$

$$\delta_{b1y} = \frac{C_m}{1-\left(\frac{N_u}{N_{cry}}\right)} \qquad \delta_{b1y} = 0,36$$

$$\delta_{b1y} = \max(\delta_{b1y},1) \qquad \delta_{b1y} = 1,00$$

6. Menghitung Kapasitas Gaya Geser Kolom C-7 (Lantai 2)

6.a Gaya Geser Nominal pada sumbu-x:

Besaran penampang yang perlu dihitung:

$$A_{w1} = d.t_w \qquad A_{w1} = 5200 mm^2$$

a = 3500 mm

$$k_n = 5 + \left[\frac{5}{\left(\frac{a}{h'}\right)^2}\right] \qquad k_n = 5,04$$

Maka besarnya gaya geser nominal pada sumbu-x:

$$\lambda_w = \frac{h'}{t_w} \qquad \lambda_w = 24,15$$

$$V_{nx} = (0,6.f_y.A_{w1}) \text{jika} \lambda_w \leq \left(1,10.\sqrt{\frac{k_n.E_s}{f_y}}\right)$$

$$V_{nx} = 0,6.F_y.A_{w1}.1,10.\sqrt{\frac{k_n.E_s}{F_y}}.\frac{1}{\lambda_w} \text{ jika } \left(1,10.\sqrt{\frac{k_n.E_s}{F_y}}\right) \leq \lambda_w < 1,37.\sqrt{\frac{k_n.E_s}{F_y}}$$

$$V_{nx} = \frac{0,9.A_{w1}.k_n.E_s}{(\lambda_w)^2} \text{ jika} \lambda_w \geq 1,37.\sqrt{\frac{k_n.E_s}{F_y}}$$

V_{nx} = 748800 N

6.b Gaya geser Nominal pada sumbu-y:

Besaran penampang yang perlu dihitung:

$$A_{w2} = \left(\frac{5}{3}.b_f.t_f\right) \qquad A_{w2} = 1400 mm^2$$

Maka besarnya gaya geser nominal pada sumbu-y:

$V_{ny} = 0{,}6.f_y.A_{w2}$ $V_{ny} = 2016000$ N

Maka besarnya kapasitas gaya geser adalah sebagai berikut:

Kapasitas gaya geser pada sumbu-x:

$\phi V_{nx} = 673920$ N

Kapasitas gaya geser pada sumbu-y:

$\phi V_{ny} = 1814400$N

Selanjutnya, akan dihitung rasio tegangan akibat gaya geser yang bekerja:

Rasio tegangan pada sumbu-x:

V_{ux} didapat dari nilai maksimum kombinasi = 640,96 N

$$\frac{V_{ux}}{\phi V_{nx}} = \frac{640{,}96}{673920} = 0{,}001$$ **Hasil Output ETABS: Rasio= 0,001**

Rasio tegangan pada sumbu-y:

V_{uy} didapat dari nilai maksimum kombinasi = 11020,21 N

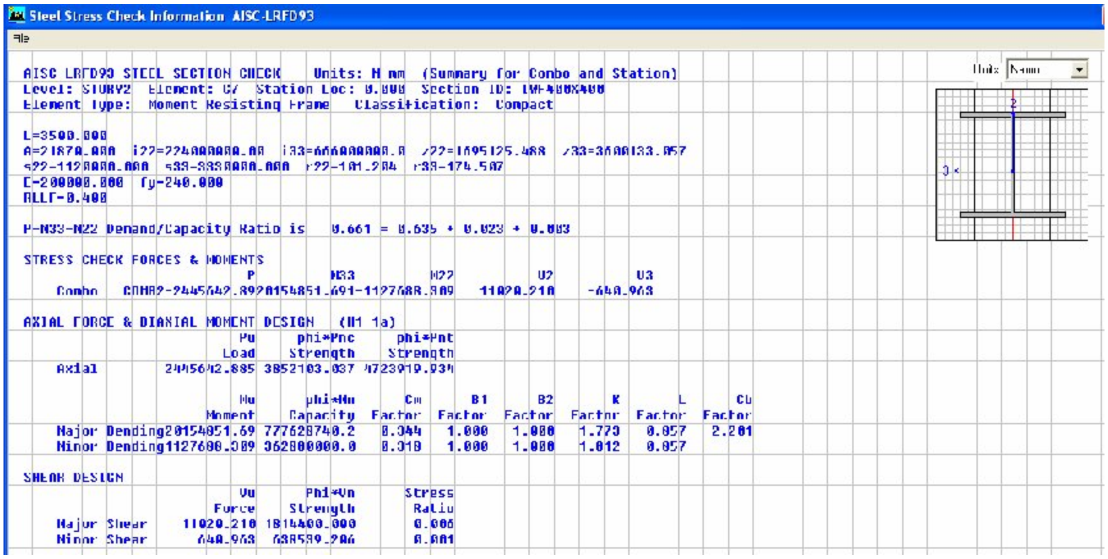
$$\frac{V_{uy}}{\phi V_{ny}} = \frac{11020{,}21}{1814400} = 0{,}006$$ **Hasil Output ETABS: Rasio= 0,006**

Dari hasil kombinasi pembebanan dan kapasitas kolom yang didapat diatas, maka dapat dihitung persamaan interaksi akibat gaya aksial dan momen sebagai berikut:

$$\text{Rasio} = \left[\frac{N_u}{\phi N_{nt}} + \frac{8}{9}.\left(\frac{M_{ux}}{\phi_b.M_{nx}} + \frac{M_{uy}}{\phi_b.M_{ny}}\right)\right] \text{jika } \frac{N_u}{\phi N_{nt}} > 0{,}2$$

$$\left[\frac{N_u}{2.\phi N_{nt}} + \left(\frac{M_{ux}}{\phi_b.M_{nx}} + \frac{M_{uy}}{\phi_b.M_{ny}}\right)\right] \text{jika } \frac{N_u}{\phi N_{nt}} < 0{,}2$$

Maka rasio = 0,660 **Hasil Output ETABS: Rasio= 0,661**

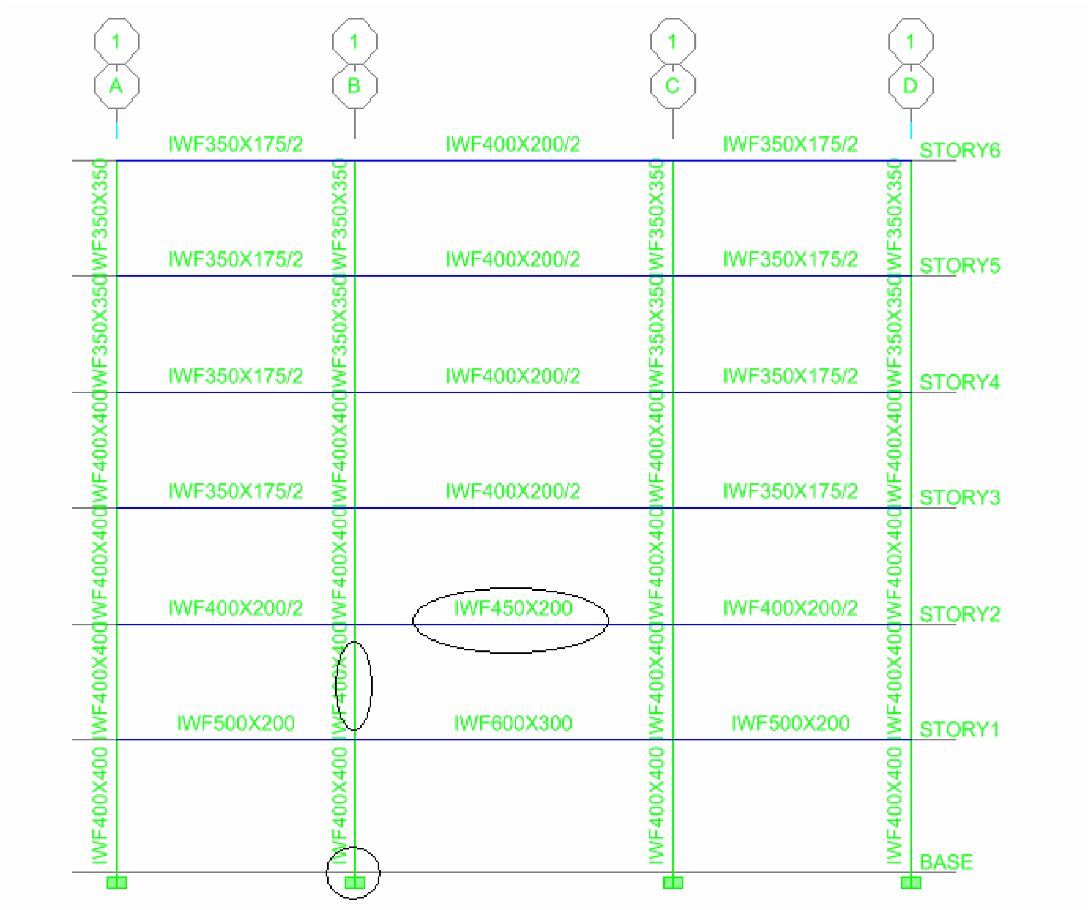


Gambar L.3.9 Nilai Output Kolom yang Didesain Berdasarkan FEMA 450

LAMPIRAN IV

DESAIN SAMBUNGAN

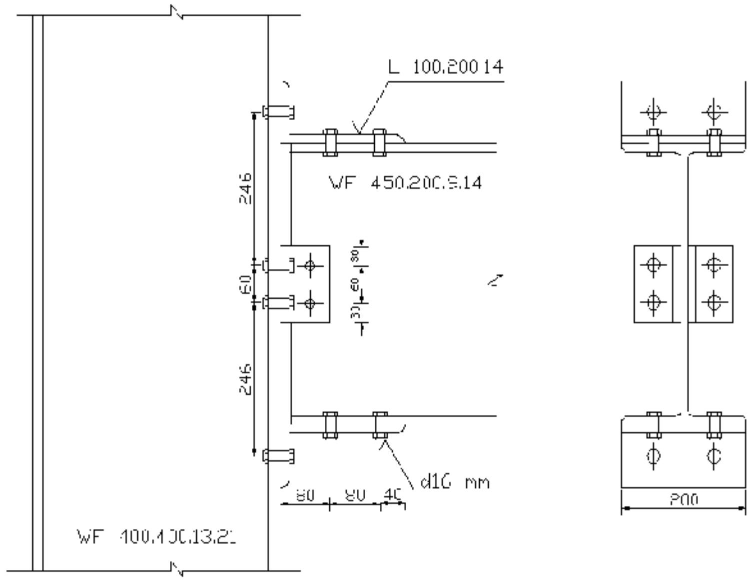
L.4 Desain Sambungan



Gambar L.4.1 Desain Sambungan

L.4.1 Elemen Struktur Gedung yang Didesain Berdasarkan SNI 03-1726-2002

A. Desain dan Detailing Sambungan Balok – Kolom



Gambar L.4.2 Detail Sambungan Balok-Kolom

Didapat dari data ETABS: M_u = 7501,054 kgm = 75010540 Nmm

V_u= 4295,91 kg = 42959,1 N

Balok 450.200.9.14

Kolom 400.400.13.21

Menghitung tahanan nominal baut:

Geser

$$\phi R_n = \phi . r_1 . f_u^b . Ab.m = 0,75.0,5.825.(0,25.\pi.16^2).1 = 62203,53 \text{ N}$$

Tumpu

Badan balok : ϕR_n =2,4.d_b.t_p.f_u = 0,75.2,4.16. 9.370 = 95904 N

Sayap balok : ϕR_n =2,4.d_b.t_p.fu = 0,75 . 2,4.16.14.370 = 358041,6 N

Tarik

$$\phi R_n = 0,75.0,75\ .f_u^b.Ab = 0,75.0,75.825\ .201,062 = 93305,302 \text{ N}$$

Perhitungan siku penyambung atas dan bawah

Dicoba dua buah baut arah sayap kolom pada masing-masing profil siku, sehingga :

$$d = \frac{M}{2T} = \frac{75010540}{2.93305,302} = 401,96 \approx 550 \text{ mm}$$

Jarak baut terhadap sayap atas balok = ½* (550 – 450) = 50 mm. Gunakan profil siku 100.200.14, sehingga :

$$a = 50 - t_{siku} - r_{siku} = 50 - 14 - 15 = 21 \text{ mm}$$

dengan d = 550 mm, maka gaya yang bekerja pada profil siku adalah :

$$T = \frac{M}{d} = \frac{75010540}{550} = 136382,8 \text{ N}$$

Gaya ini menimbulkan momen pada profil siku sebesar :

$$M = 0,5.\ T.\ a = 0,5.136382,8\ .21 = 1432019,4 \text{ N}$$

Kapasitas nominal penampang persegi adalah :

$$\phi M_n = 0,9\left(\frac{bxd^2}{4}\right).f_y$$

Sehingga diperoleh : $b = \frac{4x1432019,4}{0,9x240x14^2} = 135,3$ mm

Gunakan profil siku 100.200.14 dengan panjang 200 mm pada arah sayap balok.

Perhitungan sambungan pada sayap balok

Gaya geser pada sayap balok adalah = $\frac{75010540}{450} = 166690,09$ N

Baut penyambung adalah baut dengan satu bidang geser, sehingga:

$$n = \frac{166690,09}{62203,53} = 2,67 \approx 4 \text{ buah baut}$$

Perhitungan sambungan pada badan balok

Tahanan dua bidang geser (124407,0691 N) lebih besar dari pada tahanan tumpu (95904 N) sehingga baut ditentukan oleh tahanan tumpu.

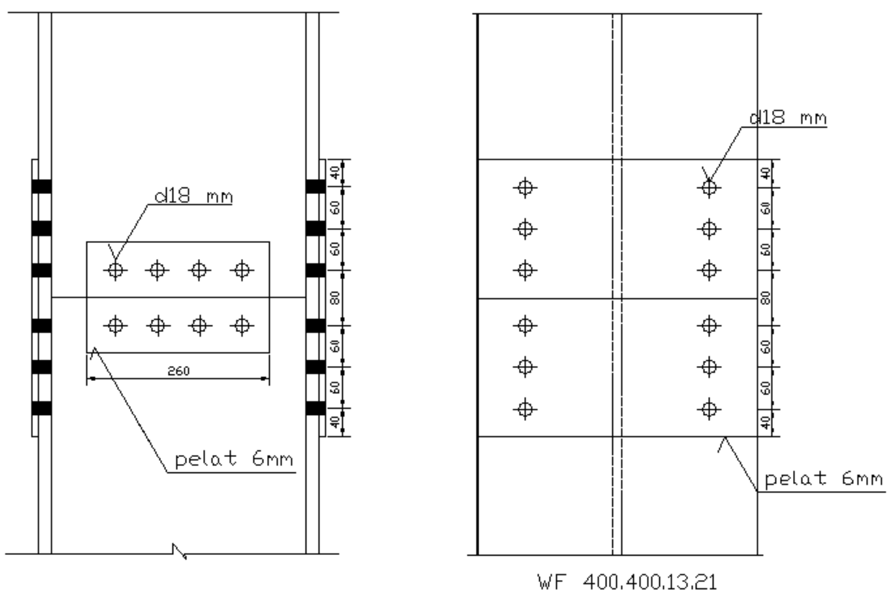
$$n = \frac{42959,1}{95904} = 0,447 \approx 2 \text{ buah baut}$$

Sambungan badan balok dengan sayap kolom

Baut yang menghubungkan balok dengan sayap kolom adalah sambungan dengan satu bidang geser ($\phi R_n = 62203,53$ N), sehingga:

$$n = \frac{42959,1}{62203,53} = 0,69 \approx 2 \text{ buah baut}$$

B. Desain dan Detailing Sambungan Kolom – Kolom



Gambar L.4.3 Detail Sambungan Kolom-Kolom

Didapat dari data ETABS: M_u = 4345,71 kgm = 43457100 Nmm

V_u = 2031,21 kg = 20312,1 N

N_u = 127187,84 kg = 1271878,4 N

Kolom 400.400.13.21

1. Plat Penyambung Badan

Menggunakan tipe tumpu, tanpa ulir pada bidang geser f_u^b = 825 Mpa f_u = 370 MPa

An = [260- 4(16+2)] .6.2 = 2256 mm^2

SNI 03-1729-2002 TCPSBUBG Hal 110 Pasal 13.5.4 (las pengisi)

$\phi R_n = \phi.(0,6.f_u).An$ = 0,75.(0,6.370).2256 =375624 N $\geq V_u$ = 20312,1 N (OK)

2. Plat Penyambung Sayap

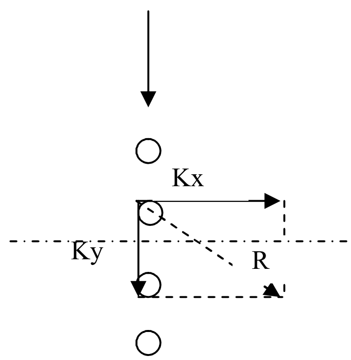
$$P = \frac{c.N_u}{2} + \frac{M_u}{h'} = \frac{0{,}5.1271878{,}4}{2} + \frac{43457100}{(400\text{-}2.21)} = 439358{,}15 \text{ N}$$

An = [398-2.(16+2)] .6 = 2172 mm^2

ϕ.Ag.f_y =0,9.21870.240 = 4723920 N $\geq$ P = 439358,15 N (OK)

ϕ.An.f_u =0,75.2172.370=602730 N $\geq$ P = 439358,15 N (OK)

3. Baut Penyambung Badan



Σx^2 = $(30^2 .2)+(90^2. 2)$ = 18000 mm^2

= 18000 mm^2

Akibat Momen:

$$K_x = \frac{M.y}{\Sigma x^2 + \Sigma y^2} = \frac{43457100.0}{18000} = 0 \text{ N}$$

$$K_y = \frac{M.x}{\Sigma x^2 + \Sigma y^2} = \frac{43457100.30}{18000} = 72428{,}5 \text{ N}$$

Akibat Lintang:

$$K_{x'} = \frac{Vu}{n} = \frac{20312{,}1}{4} = 5078{,}025 \text{ N}$$

$$R = \sqrt{(K_x + K_{x'})^2 + (K_y)^2} = \sqrt{(0 + 5078{,}025)^2 + (72428{,}5)^2} = 72606{,}29 \text{ N}$$

SNI 03-1729-2002 TCPSBUBG Hal 100 Pasal 13.2.2.3 (Baut tipe tumpu memikul geser dan tarik)

Kekuatan sebuah baut:

$\phi V_n = \phi . r_1 . f_u^b .Ab.m$ =0,75.0,5.825.(0,25. π .16^2).2= 124407,07 N

ϕR_n =2,4.d_b.t_p.f_u = 0,75.2,4.16.9. 370 = 95904 N (ambil nilai terkecil)

ϕR_n = 95904 N $\geq$ R = 72606,29 N (OK)

4. Baut Penyambung Sayap

Tiap baut memikul gaya : $\frac{P}{n} = \frac{439358,15}{6} = 73226,36\,N$

Catatan: n = dilihat tiap segmen

SNI 03-1729-2002 TCPSBUBG Hal 101 Pasal 13.2.2.4 (Kuat tumpu)

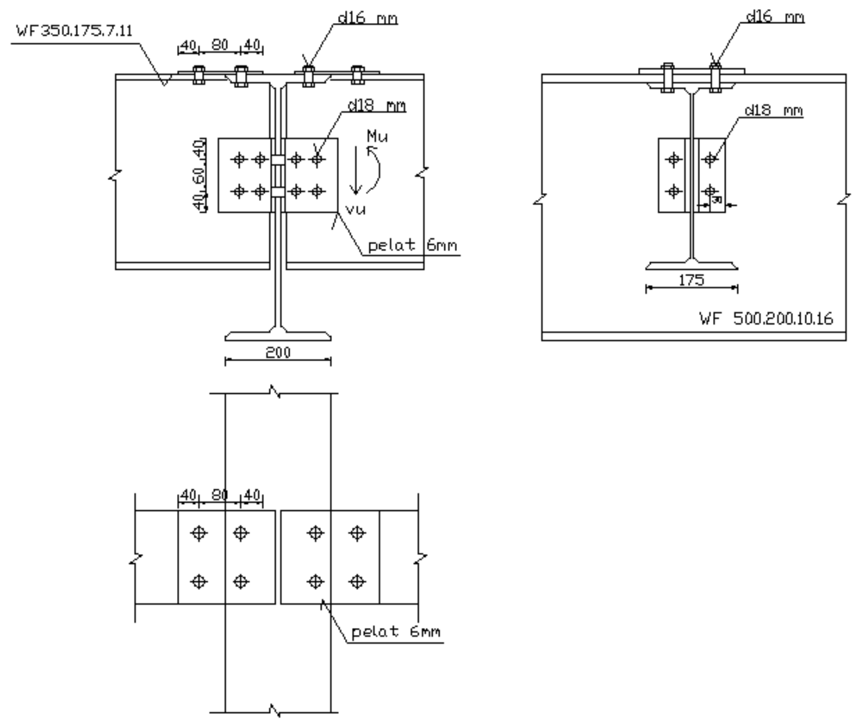
Kekuatan sebuah baut:

$\phi V_n = \phi . r_1 . f_u^b .Ab.m$ =0,75.0,5.825.(0,25. π .16^2).2=124407,07 N

ϕR_n =2,4.d_b.t_p.f_u = 0,75.2,4.16.9. 370 = 95904 N (ambil nilai terkecil)

ϕR_n = 95904 N $\geq \frac{P}{n}$ = 73226,36 N (OK)

C. Desain dan Detailing Sambungan Balok Induk – Balok Anak



Gambar L.4.4 Detail Sambungan Balok Induk-Balok Anak

Didapat dari data ETABS: M_u = 267,087 kgm = 2670870 Nmm

V_u = 178,06 kg = 1780,6 N

Balok Induk 500.200.10.16

Balok Anak 350.175.7.11

1. Plat Penyambung Badan

Menggunakan tipe tumpu, tanpa ulir pada bidang geser f_u^b = 825 Mpa; f_u = 370 MPa

An = [140- 4.(16+2)].6.2 = 816 mm^2

<u>SNI 03-1729-2002 TCPSBUBG Hal 110 Pasal 13.5.4</u>

$\phi R_n = \phi.(0,6.f_u).An$ = 0,75.(0,6.370).816 = 135864 N $\geq$ V_u = 1780,6 N (Baut kuat)

2. Plat Penyambung Sayap

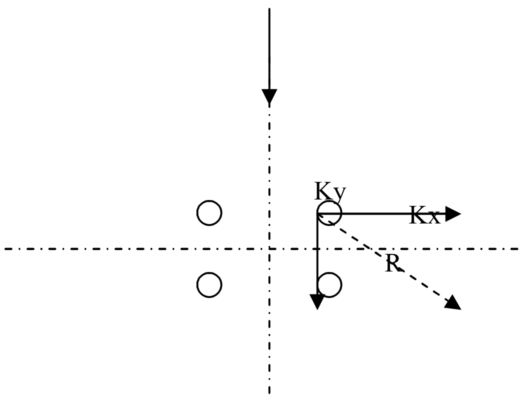
$$T_u = \frac{M_u}{h'} = \frac{2670870}{(350\text{-}2.11)} = 8142{,}89 \text{ N}$$

An = [160-2.(16+2)] .6 = 744 mm^2

ϕ.Ag.f_y =0,9.(160.6).240=207360 N $\geq$ T_u = 8142,89 N (OK)

ϕ.An.f_u =0,75.744.370=206460 N $\geq$ T_u = 8142,89 N (OK)

3. Baut Penyambung Badan



Σx^2 = (40^2.4) = 6400 mm^2

Σy^2 = (30^2 . 4) = 3600 mm^2

= 10000 mm^2

Akibat Momen:

$$K_x = \frac{M.y}{\Sigma x^2 + \Sigma y^2} = \frac{2670870.30}{10000} = 8012{,}61 \text{ N}$$

$$K_y = \frac{M.x}{\Sigma x^2 + \Sigma y^2} = \frac{2670870.40}{10000} = 10683{,}48 \text{ N}$$

Akibat Lintang:

$$K_{y'} = \frac{V_u}{n} = \frac{1780{,}6}{4} = 445{,}15 \text{ N}$$

$$R = \sqrt{Kx^2 + (Ky + Ky')^2} = \sqrt{(8012{,}61)^2 + (10683{,}48 + 445{,}15)^2} = 13713{,}07 \text{ N}$$

Kekuatan sebuah baut:

SNI 03-1729-2002 TCPSBUBG Hal 100 Pasal 13.2.2.3

$\phi V_n = \phi . r_1 . f_u^b . Ab.m = 0,75.0,5.825.(0,25.\pi.16^2).2 = 124407,07$ N

$\phi R_n = 2,4.d_b.t_p.f_u = 0,75.2,4.16.6.\ 370 = 63936$ N (ambil nilai terkecil)

$\phi R_n = 63936$ N $\geq$ R = 13713,07 N (OK)

4. Baut Penyambung Sayap

Tiap baut memikul gaya : $\dfrac{T_u}{n} = \dfrac{8142,89}{4} = 2035,7225\,\text{N}$

Catatan: n = dilihat tiap segmen

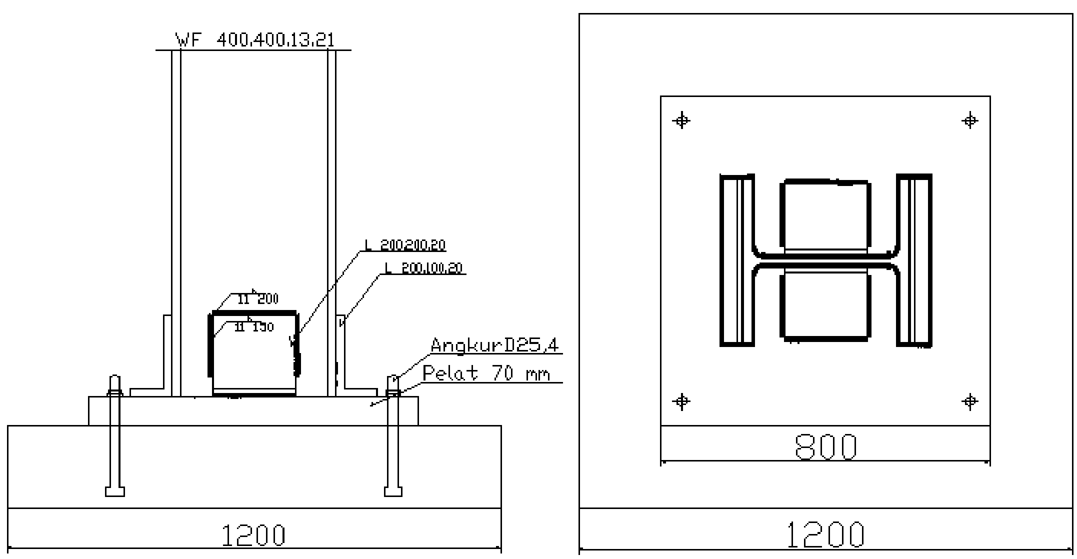
Kekuatan sebuah baut:

$\phi V_n = \phi . r_1 . f_u^b . Ab.m = 0,75.0,5.825.(0,25.\pi.16^2).2 = 124407,07$ N

$\phi R_n = 2,4.d_b.t_p.f_u = 0,75.2,4.16.6.370 = 63936$ N (ambil nilai terkecil)

$\phi R_n = 63936$ N $\geq \dfrac{Tu}{n} = 2035,7225$ N (OK)

D. Desain dan Detailing Sambungan Kolom–Perletakan



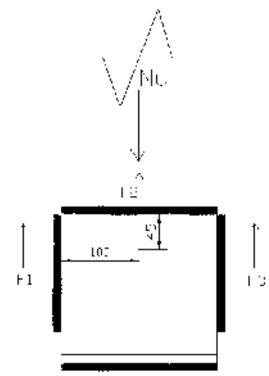
Gambar L.4.5 Detail Sambungan Kolom-Perletakan

Didapat dari data ETABS: M_u = 5367,851 kgm = 53678510 Nmm

V_u = 2205,02 kg = 22050,2 N

N_u = 154901,13 kg = 1549011,3 N

Kolom 400.400.13.21



Las pada pengaku badan kolom

Persyaratan ukuran las:

Maksimum = t_p – 1,6 = 20-1,6 = 18,4 mm

Minimum = 6 mm

Dicoba ukuran las 10 mm

$$\phi R_{nw} = \phi.t_e.0,60.f_{uw} = 0,75.(0,707.10).0,60.490 = 1558,935 \text{ N/mm}$$

$$\max\ \phi R_{nw} = \phi.t.0,60.f_u = 0,75.20.0,6.370 = 3330 \text{ N/mm}$$

Menentukan panjang las

$$F_2 = \phi.R_{nw}.L_{w2} = 1558,935.\ 200 = 311787 \text{ N}$$

$$F_1 = F_3 = \frac{774505,65\text{-}311787}{2} = 231359,325 \text{ N}$$

$$L_{w1} = \frac{F_1}{\phi R_{nw}} = \frac{231359,325}{1558,935} = 148,41 \approx 150 \text{ mm}$$

Letak titik berat kelompok las:

$$\bar{x} = \frac{2.150.75}{(2.150).+200} = 45 \text{ mm}$$

Panjang las, L_w =(2.150)+200= 500 mm

$$I_p = \frac{1}{12}.200^3 + (150.100^2.2) + 2.\frac{1}{12}.150^3 + (2.150.30^2) + 200.45^2$$

$$I_p = 4704166,67 \text{ mm}^3$$

komponen gaya pada las akibat geser langsung:

$$R_v = \frac{V_u}{L_w} = \frac{22050,2}{500} = 44,1004 \text{ N/mm}$$

komponen gaya akibat momen tehadap titik berat las:

$$R_x = \frac{M.y}{I_p} = \frac{53678510.45}{4704166,67} = 1198,14 \text{ N/mm}$$

$$R_y = \frac{M.x}{I_p} = \frac{53678510.100}{4704166,67} = 1141,08 \text{ N/mm}$$

Resultan gaya, R

$$R = \sqrt{1198,14^2 + (1141,08 + 44,10)^2} = 1685,29 \text{ N/mm}$$

Tahanan oleh las, $\phi.R_{nw} = 0,75.t_e.0,60.f_{uw}$ =0,75.(0,707.a).0,60.490 = 155,894 a

Untuk mendapatkan ukuran las, samakan $\phi.R_{nw}$ dengan R_u:

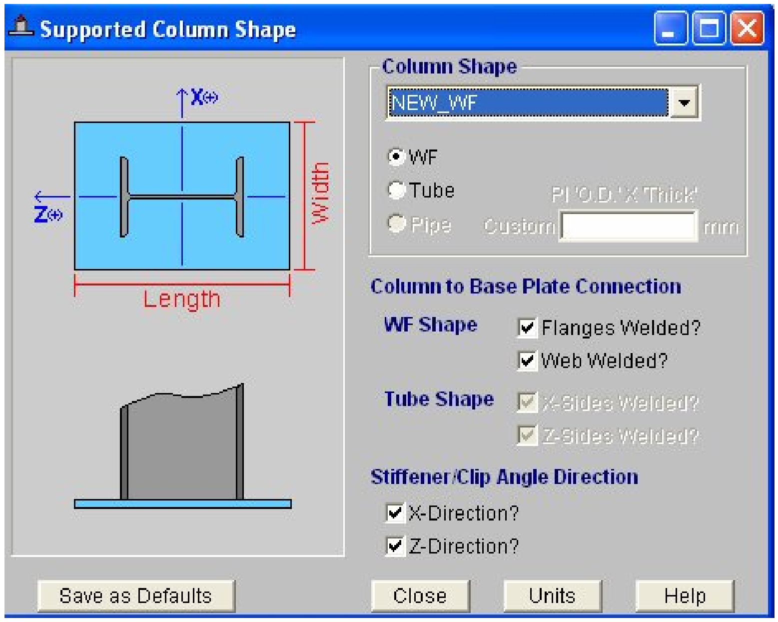
155,894.a = 1685,29

a = 10,81 mm $\approx$ 11 mm

Digunakan ukuran las 11 mm

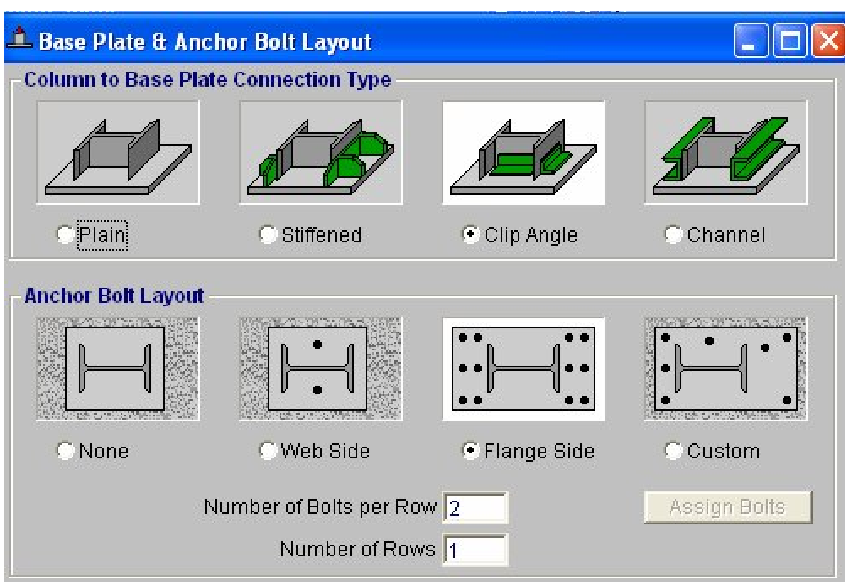
Desain sambungan kolom-perletakan menggunakan bantuan program *RISABase Plate.* Adapun langkah-langkah dalam mendesain adalah:

1. Definisikan jenis kolom yang akan ditinjau.



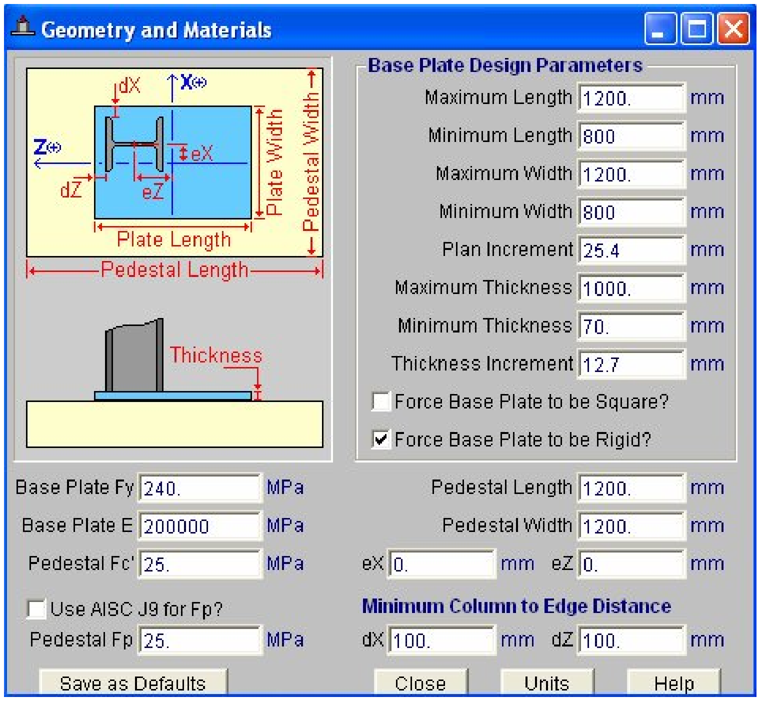
Gambar L.4.6 Definisi kolom

2. Tentukan koneksi pengikat antara kolom dengan plat landas serta letak angkur baut.



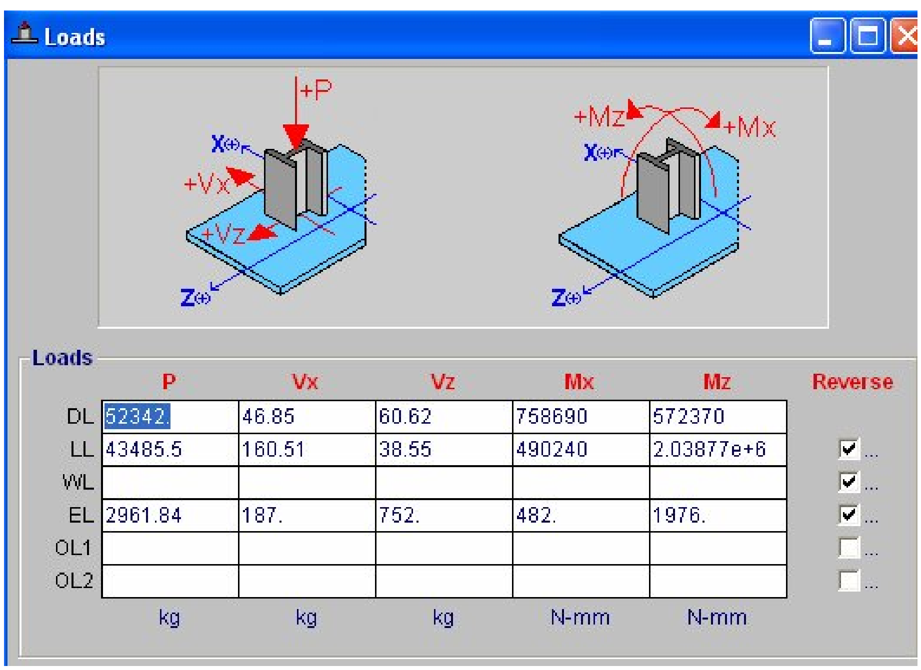
Gambar L.4.7 Jenis koneksi dan letak angkur

3. Tentukan parameter dari plat landas yang akan digunakan.



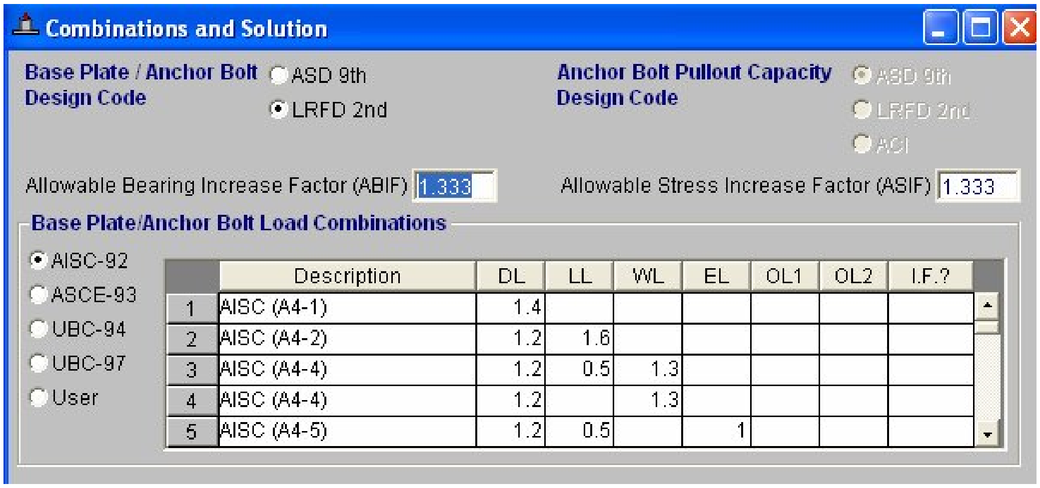
Gambar L.4.8 Parameter plat landas

4. Masukkan nilai beban yang bekerja, seperti beban mati, beban hidup, dan beban gempa.



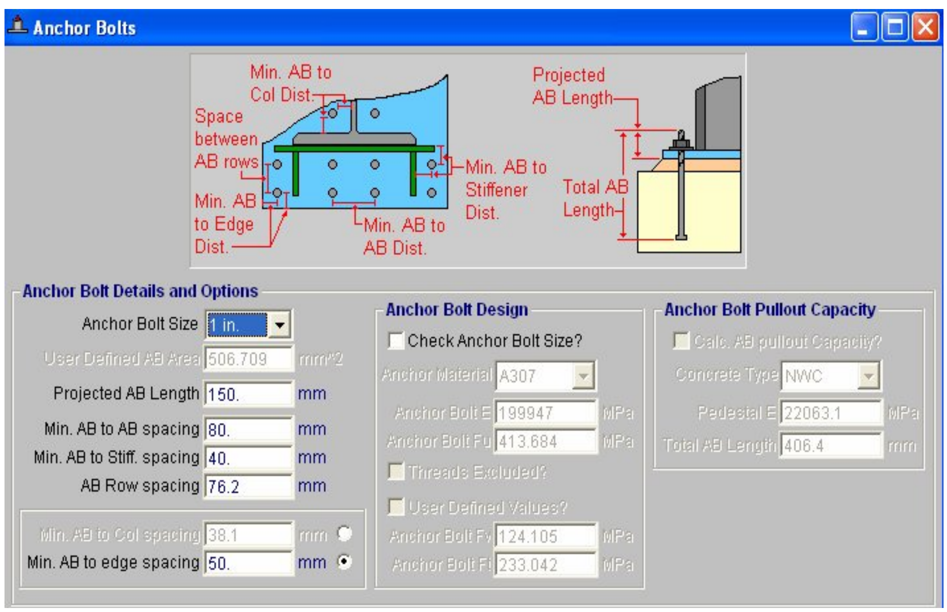
Gambar L.4.9 Beban yang bekerja

5. Tentukan jenis kombinasi pembebanan yang akan dipakai.



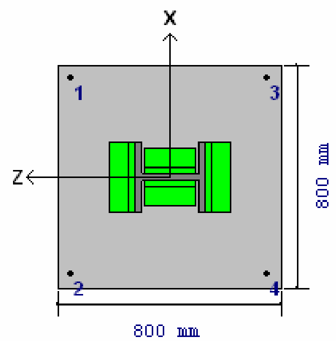
Gambar L.4.10 Kombinasi yang digunakan

6. Tentukan jenis angkur, panjang angkur, serta jarak antar angkur.



Gambar L.4.11 Jenis angkur

Company : **RISA Technologies**		July 28, 2009
Designer :		
Job Number :	**AISC ASD 9th Base Plate Example 12, pg 3 - 108**	Checked By:_____



Bolt	X (mm)	Z (mm)
1	350.	350.
2	-350.	350.
3	350.	-350.
4	-350.	-350.

Geometry and Materials

Length	**800. mm**	Column Shape	**NEW_WF**	Anchor Bolt Diameter	**25.4 mm**
Width	**800. mm**	Column eX	**0. mm**	Anchor Bolt Material	**A307**
Thickness	**70. mm**	Column eZ	**0. mm**	Anchor Bolt Fu	**413.684 MPa**
Base Plate Fy	**240. MPa**	Column to Edge Min (X)	**100. mm**	Anchor Bolt E	**199947 MPa**
Base Plate E	**200000 MPa**	Column to Edge Min (Z)	**100. mm**	AB Projected Length	**150 mm**
Bearing Fp	**15. MPa**	**WF Flanges welded**		AB to AB Min Spacing	**80 mm**
Bearing Fc'	**25. MPa**	**WF Web welded**		AB to Stiffner Min Spacing	**40 mm**
Pedestal Length	**1200 mm**	**Clip Angle Base Plate Connection**		AB to Column Min Spacing	**38.1 mm**
Pedestal Width	**1200 mm**	**Vx Shear Lug NOT present**		AB to Edge Min Spacing	**50 mm**
Analyze Base Plate as Rigid		**Vz Shear Lug NOT present**		AB Row Min Spacing	**76.2 mm**
Fp is User Defined				**Priority is AB to Edge Spacing**	
AISC LRFD 2nd				**Include Threads for AB Design**	
				AB Fv, Ft are User Defined	

Loads

	P (kg)	Vx (kg)	Vz (kg)	Mx (N-mm)	Mz (N-mm)	Reverse
DL	52342.	46.85	60.62	758690	572370	Yes
LL	43485.5	160.51	38.55	490240	2.03877e+6	Yes
EL	2957.02	187.02	751.37	1.97324e+7	4.81397e+6	Yes

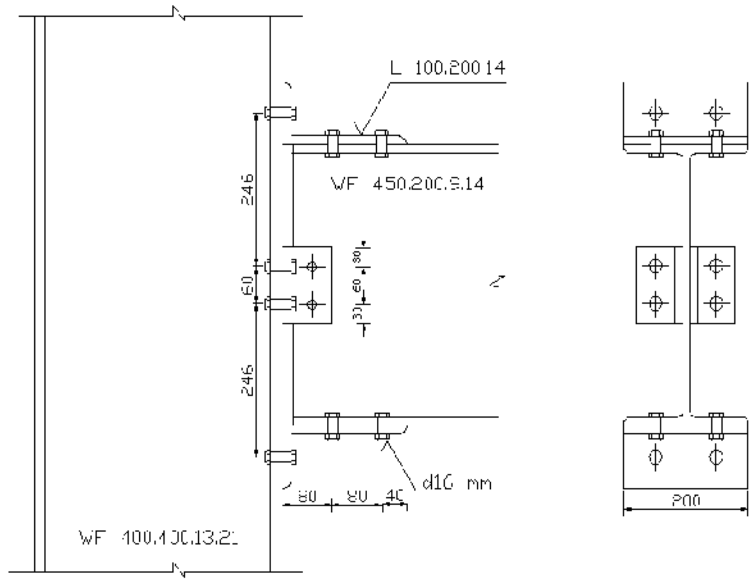
Base Plate Stress and Bearing Result

		Base Plate Stress (MPa)			Bearing Pressure (MPa)		
Description	Load Sets	Allowable	ASIF	U.C.	Allowable	ABIF	U.C.
AISC (A4-1)	1.4DL	216.	1.	.415	15.	1.	.076
AISC (A4-2)	1.2DL+1.6LL	216.	1.	.757	15.	1.	.139
AISC (A4-2)	1.2DL-1.6LL	216.	1.	0.	15.	1.	0.
AISC (A4-4)	1.2DL+.5LL+1.3WL	216.	1.	.481	15.	1.	.088
AISC (A4-4)	1.2DL-.5LL+1.3WL	216.	1.	.232	15.	1.	.042
AISC (A4-4)	1.2DL+.5LL-1.3WL	216.	1.	.481	15.	1.	.088
AISC (A4-4)	1.2DL-.5LL-1.3WL	216.	1.	.232	15.	1.	.042
AISC (A4-4)	1.2DL+1.3WL	216.	1.	.355	15.	1.	.065
AISC (A4-4)	1.2DL-1.3WL	216.	1.	.355	15.	1.	.065
AISC (A4-5)	1.2DL+.5LL+1EL	216.	1.	.56	15.	1.	.11
AISC (A4-5)	1.2DL-.5LL+1EL	216.	1.	.309	15.	1.	.064
AISC (A4-5)	1.2DL+.5LL-1EL	216.	1.	.509	15.	1.	.1
AISC (A4-5)	1.2DL-.5LL-1EL	216.	1.	.275	15.	1.	.057
AISC (A4-5)	1.2DL+1EL	216.	1.	.434	15.	1.	.087
AISC (A4-5)	1.2DL-1EL	216.	1.	.392	15.	1.	.079
AISC (A4-6)(W)	.9DL+1.3WL	216.	1.	.267	15.	1.	.049
AISC (A4-6)(W)	.9DL-1.3WL	216.	1.	.267	15.	1.	.049
AISC (A4-6)(E)	.9DL+1EL	216.	1.	.345	15.	1.	.071
AISC (A4-6)(E)	.9DL-1EL	216.	1.	.306	15.	1.	.063

Gambar L.4.12 Output Program *RISABase Plate*

L.4.2 Elemen Struktur Gedung yang Didesain Berdasarkan FEMA 450

A. Sambungan Kolom dengan Balok



Gambar L.4.12 Detail Sambungan Balok-Kolom

Didapat dari data ETABS: M_u = 7502,864 kgm = 75028640 Nmm

V_u = 4296,26 kg = 42962,6 N

Balok 450.200.9.14

Kolom 400.400.13.21

Menghitung tahanan nominal baut:

Geser

$$\phi R_n = \phi . r_1 . f_u^b . Ab . m = 0{,}75.0{,}5.825.(0{,}25.\pi.16^2).1 = 62203{,}53 \text{ N}$$

Tumpu

Badan balok : $\phi R_n = 2{,}4.d_b.t_p.f_u = 0{,}75.2{,}4.16.\ 9.370 = 95904$ N

Sayap balok : $\phi R_n = 2{,}4.d_b.t_p.f_u = 0{,}75\ .\ 2{,}4.16.14.370 = 358041{,}6$ N

Tarik

$$\phi R_n = 0{,}75.0{,}75\ .f_u^b.Ab = 0{,}75.0{,}75.825\ .201{,}062 = 93305{,}302 \text{ N}$$

Perhitungan siku penyambung atas dan bawah

Dicoba dua buah baut arah sayap kolom pada masing-masing profil siku, sehingga :

$$d = \frac{M}{2T} = \frac{75028640}{2.93305,302} = 402,05 \approx 550 \text{ mm}$$

Jarak baut terhadap sayap atas balok = ½.(550 – 450) = 50 mm. Gunakan profil siku 100.200.14, sehingga:

$$a = 50 - t_{siku} - r_{siku} = 50 - 14 - 15 = 21 \text{ mm}$$

dengan d = 550 mm, maka gaya yang bekerja pada profil siku adalah :

$$T = \frac{M}{d} = \frac{75028640}{550} = 136415,71 \text{ N}$$

Gaya ini menimbulkan momen pada profil siku sebesar :

$$M = 0,5.\ T.\ a = 0,5.136415,71.21 = 1432364,95 \text{ N}$$

Kapasitas nominal penampang persegi adalah :

$$\phi M_n = 0,9\left(\frac{bxd^2}{4}\right).f_y$$

Sehingga diperoleh : $b = \dfrac{4x1432364,95}{0,9x240x14^2} = 135,3$ mm

Gunakan profil siku 100.200.14 dengan panjang 200 mm pada arah sayap balok.

Perhitungan sambungan pada sayap balok

Gaya geser pada sayap balok adalah = $\dfrac{75028640}{450} = 166730,31$ N

Baut penyambung adalah baut dengan satu bidang geser, sehingga :

$$n = \frac{166730,31}{62203,53} = 2,68 \approx 4 \text{ buah baut}$$

Perhitungan sambungan pada badan balok

Tahanan dua bidang geser (124407,0691 N) lebih besar dari pada tahanan tumpu (69264 N) sehingga baut ditentukan oleh tahanan tumpu.

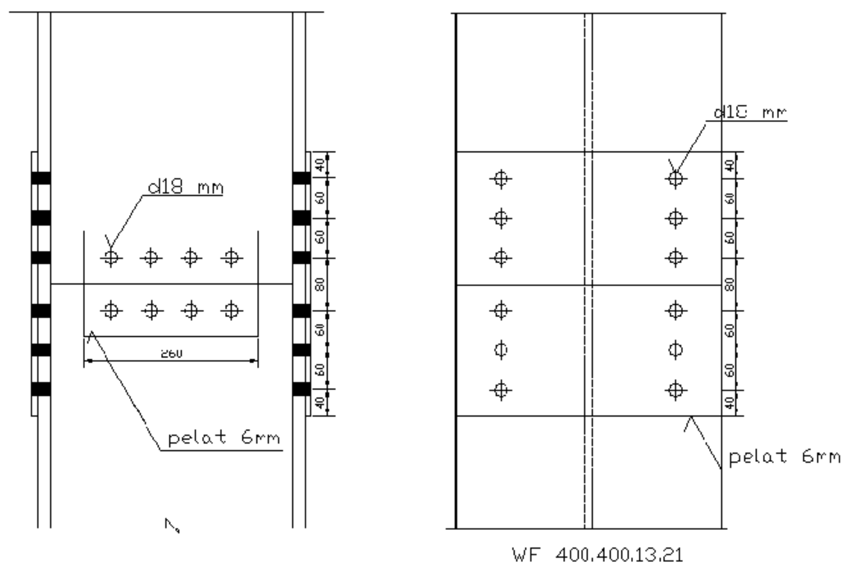
$$n = \frac{42962,6}{95904} = 0,45 \approx 2 \text{ buah baut}$$

Sambungan badan balok dengan sayap kolom

Baut yang menghubungkan balok dengan sayap kolom adalah sambungan dengan satu bidang geser ($\phi R_n = 62203,53$ N), sehingga:

$$n = \frac{42962,6}{62203,53} = 0,69 \approx 2 \text{ buah baut}$$

B. Sambungan Kolom dengan Kolom



Gambar L.4.13 Detail Sambungan Kolom-Kolom

Didapat dari data ETABS: M_u = 4349,10 kgm = 43491000 Nmm

V_u = 2032,75 kg = 20327,5 N

N_u = 127188,86 kg = 1271888,6 N

Kolom 400.400.13.21

1. Plat Penyambung Badan

Menggunakan tipe tumpu, tanpa ulir pada bidang geser f_u^b = 825 Mpa fu = 370 MPa

An = [260- 4(16+2)] .6.2 = 2256 mm^2

<u>SNI 03-1729-2002 TCPSBUBG Hal 110 Pasal 13.5.4 (Las Pengisi)</u>

$\phi R_n = \phi.(0,6.f_u).An = 0,75.(0,6.370).2256 = 375624 \text{ N} \geq V_u = 20327,5$ N (OK)

2. Plat Penyambung Sayap

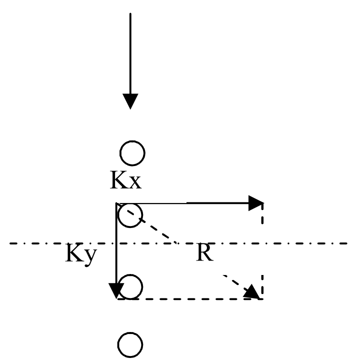
$$P = \frac{c.N_u}{2} + \frac{M_u}{h'} = \frac{0{,}5.1271888{,}6}{2} + \frac{43491000}{(400\text{-}2.21)} = 439455{,}39\text{ N}$$

An = [398-2.(16+2)] .6 = 2172 mm^2

ϕ.Ag.f_y =0,9.21870.240 = 4723920 N $\geq$ P = 439455,39 N (OK)

ϕ.An.f_u =0,75.2172.370=602730 N $\geq$ P = 439455,39 N (OK)

3. Baut Penyambung Badan



Σx^2 = (30^2 .2)+(90^2. 2) = 18000 mm^2

= 18000 mm^2

Akibat Momen:

$$Kx = \frac{M.y}{\Sigma x^2 + \Sigma y^2} = \frac{43491000.0}{18000} = 0\text{ N}$$

$$Ky = \frac{M.x}{\Sigma x^2 + \Sigma y^2} = \frac{43491000\ .30}{18000} = 72485\text{ N}$$

Akibat Lintang:

$$Kx' = \frac{Vu}{n} = \frac{20327{,}5}{4} = 5081{,}875\text{ N}$$

$$R = \sqrt{(Kx+Kx')^2 + (Ky)^2} = \sqrt{(0 + 5081{,}875)^2 + (72485)^2} = 72662{,}93\text{ N}$$

SNI 03-1729-2002 TCPSBUBG Hal 100 Pasal 13.2.2.3 (Baut tipe tumpu memikul geser dan tarik)

Kekuatan Sebuah Baut:

$\phi V_n = \phi . r_l . f_u^b . Ab.m = 0{,}75.0{,}5.825.(0{,}25.\pi.16^2).2 = 124407{,}07$ N

$\phi R_n = 2{,}4.d_b.t_p.f_u = 0{,}75.2{,}4.16.9.\ 370 = 95904$ N (ambil nilai terkecil)

$\phi R_n = 95904 \text{ N} \geq R = 72662{,}93$ N (OK)

4. Baut Penyambung Sayap

Tiap Baut memikul gaya: $\frac{P}{n} = \frac{439455{,}39}{6} = 73242{,}565$ N

Catatan: n = dilihat tiap segmen

SNI 03-1729-2002 TCPSBUBG Hal 101 Pasal 13.2.2.4 (Kuat tumpu)

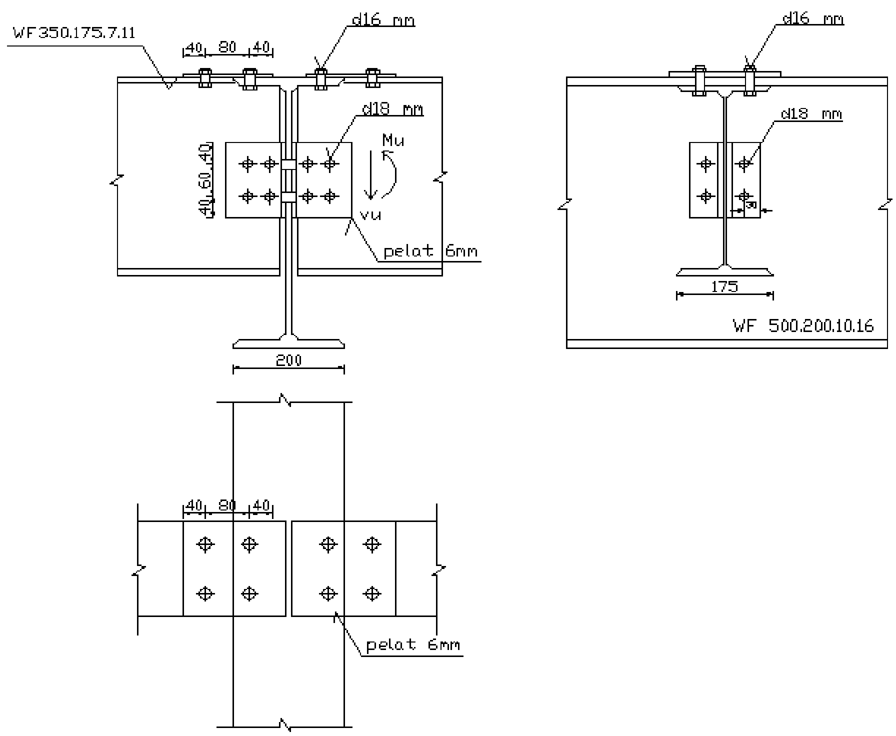
Kekuatan sebuah baut:

$\phi V_n = \phi . r_l . f_u^b . Ab.m = 0{,}75.0{,}5.825.(0{,}25.\pi.16^2).2 = 124407{,}07$ N

$\phi R_n = 2{,}4.d_b.t_p.fu = 0{,}75.2{,}4.16.9.\ 370 = 95904$ N (ambil nilai terkecil)

$\phi R_n = 95904 \text{ N} \geq \frac{P}{n} = 73242{,}565$ N (OK)

C. Sambungan Balok Induk dengan Balok Anak



Gambar L.4.14 Detail Sambungan Balok Induk-Balok Anak

Didapat dari data ETABS: M_u = 267,087 kgm = 2670870 Nmm

V_u = 178,06 kg = 1780,6 N

Balok Induk 500.200.10.16

Balok Anak 350.175.7.11

1. Plat Penyambung Badan

Menggunakan tipe tumpu, tanpa ulir pada bidang geser f_u^b = 825 Mpa; f_u = 370 MPa

An = [140- 4.(16+2)] .6 .2 = 816 mm^2

SNI 03-1729-2002 TCPSBUBG Hal 110 Pasal 13.5.4

$\phi R_n = \phi.(0{,}6.f_u).An = 0{,}75.(0{,}6.370).816 = 135864 \text{ N} \geq V_u = 1780{,}6 \text{ N}$ (Baut kuat)

2. Plat Penyambung Sayap

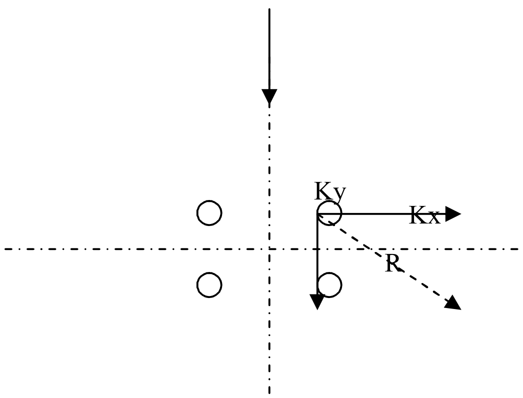
$$T_u = \frac{M_u}{h'} = \frac{2670870}{(350\text{-}2.11)} = 8142{,}89 \text{ N}$$

An = [160-2.(16+2)] .6 = 744 mm^2

ϕ.Ag.fy=0,9.(160.6).240=207360 N $\geq$ T_u = 8142,89 N (OK)

ϕ.An.fu=0,75.744.370=206460 N $\geq$ T_u = 8142,89 N (OK)

3. Baut Penyambung Badan



Σx^2 = (40^2.4) = 6400 mm^2

Σy^2 = (30^2 . 4) = 3600 mm^2

= 10000 mm^2

<u>Akibat Momen:</u>

$$K_x = \frac{M.y}{\Sigma x^2 + \Sigma y^2} = \frac{2670870.30}{10000} = 80162{,}61 \text{ N}$$

$$K_y = \frac{M.x}{\Sigma x^2 + \Sigma y^2} = \frac{2670870.40}{10000} = 10683{,}48 \text{ N}$$

<u>Akibat Lintang:</u>

$$K_{y'} = \frac{V_u}{n} = \frac{1780{,}6}{4} = 445{,}15 \text{ N}$$

$$R = \sqrt{Kx^2 + (Ky + Ky')^2} = \sqrt{(8012{,}61)^2 + (10683{,}48 + 445{,}15)^2} = 13713{,}07 \text{ N}$$

Kekuatan Sebuah Baut:

SNI 03-1729-2002 TCPSBUBG Hal 100 Pasal 13.2.2.3

$\phi V_n = \phi.r_1.f_u^b.Ab.m = 0{,}75.0{,}5.825.(0{,}25.\pi.16^2).2 = 124407{,}07$ N

$\phi R_n = 2{,}4.d_b.t_p.fu = 0{,}75.2{,}4.16.6.\ 370 = 63936$ N (ambil nilai terkecil)

$\phi R_n = 63936$ N $\geq$ R = 13713,07 N (OK)

4. Baut Penyambung Sayap

Tiap Baut memikul gaya : $\frac{Tu}{n} = \frac{8142{,}89}{4} = 2035{,}7225$ N

Catatan: n = dilihat tiap segmen

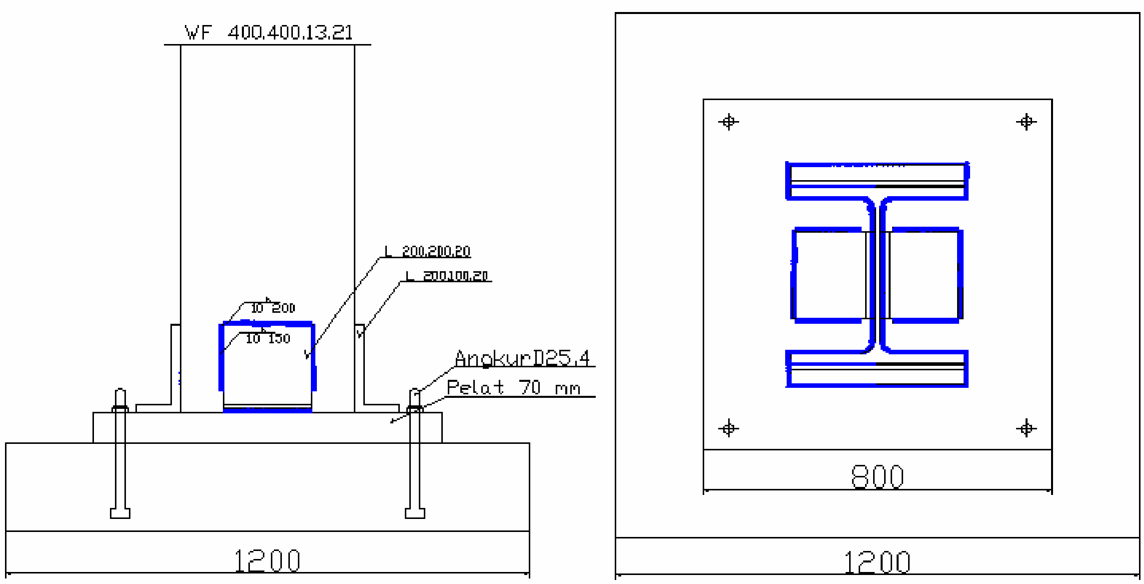
Kekuatan sebuah baut:

$\phi V_n = \phi.r_1.f_u^b.Ab.m = 0{,}75.0{,}5.825.(0{,}25.\pi.16^2).2 = 124407{,}07$ N

$\phi R_n = 2{,}4.d_b.t_p.fu = 0{,}75.2{,}4.16.6.370 = 63936$ N (ambil nilai terkecil)

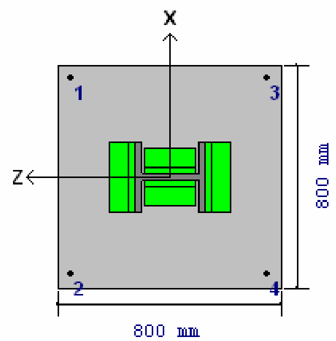
$\phi R_n = 63936$ N $\geq \frac{Tu}{n} = 2035{,}7225$ N (OK)

D. Sambungan Kolom dengan Perletakan



Gambar L.4.15 Detail Sambungan Kolom-Perletakan

Company : **RISA Technologies** July 28, 2009
Designer :
Job Number : **AISC ASD 9th Base Plate Example 12, pg 3 - 108** Checked By:_____



Bolt	X (mm)	Z (mm)
1	350.	350.
2	-350.	350.
3	350.	-350.
4	-350.	-350.

Geometry and Materials

Length **800. mm**
Width **800. mm**
Thickness **70. mm**
Base Plate Fy **240. MPa**
Base Plate E **200000 MPa**
Bearing Fp **15. MPa**
Bearing Fc' **25. MPa**
Pedestal Length **1200 mm**
Pedestal Width **1200 mm**
Analyze Base Plate as Rigid
Fp is User Defined
AISC LRFD 2nd

Column Shape **NEW_WF**
Column eX **0. mm**
Column eZ **0. mm**
Column to Edge Min (X) **100. mm**
Column to Edge Min (Z) **100. mm**
WF Flanges welded
WF Web welded
Clip Angle Base Plate Connection
Vx Shear Lug NOT present
Vz Shear Lug NOT present

Anchor Bolt Diameter **25.4 mm**
Anchor Bolt Material **A307**
Anchor Bolt Fu **413.684 MPa**
Anchor Bolt E **199947 MPa**
AB Projected Length **150 mm**
AB to AB Min Spacing **80 mm**
AB to Stiffner Min Spacing **40 mm**
AB to Column Min Spacing **38.1 mm**
AB to Edge Min Spacing **50 mm**
AB Row Min Spacing **76.2 mm**
Priority is AB to Edge Spacing
Include Threads for AB Design
AB Fv, Ft are User Defined

Loads

	P (kg)	Vx (kg)	Vz (kg)	Mx (N-mm)	Mz (N-mm)	Reverse
DL	52342.	46.85	60.62	758690	572370	Yes
LL	43485.5	160.51	38.55	490240	2.03877e+6	Yes
EL	2957.02	187.02	751.37	1.97324e+7	4.81397e+6	Yes

Base Plate Stress and Bearing Result

		Base Plate Stress (MPa)			Bearing Pressure (MPa)		
Description	Load Sets	Allowable	ASIF	U.C.	Allowable	ABIF	U.C.
AISC (A4-1)	1.4DL	216.	1.	.415	15.	1.	.076
AISC (A4-2)	1.2DL+1.6LL	216.	1.	.757	15.	1.	.139
AISC (A4-2)	1.2DL-1.6LL	216.	1.	0.	15.	1.	0.
AISC (A4-4)	1.2DL+.5LL+1.3WL	216.	1.	.481	15.	1.	.088
AISC (A4-4)	1.2DL-.5LL+1.3WL	216.	1.	.232	15.	1.	.042
AISC (A4-4)	1.2DL+.5LL-1.3WL	216.	1.	.481	15.	1.	.088
AISC (A4-4)	1.2DL-.5LL-1.3WL	216.	1.	.232	15.	1.	.042
AISC (A4-4)	1.2DL+1.3WL	216.	1.	.355	15.	1.	.065
AISC (A4-4)	1.2DL-1.3WL	216.	1.	.355	15.	1.	.065
AISC (A4-5)	1.2DL+.5LL+1EL	216.	1.	.56	15.	1.	.11
AISC (A4-5)	1.2DL-.5LL+1EL	216.	1.	.309	15.	1.	.064
AISC (A4-5)	1.2DL+.5LL-1EL	216.	1.	.509	15.	1.	.1
AISC (A4-5)	1.2DL-.5LL-1EL	216.	1.	.275	15.	1.	.057
AISC (A4-5)	1.2DL+1EL	216.	1.	.434	15.	1.	.087
AISC (A4-5)	1.2DL-1EL	216.	1.	.392	15.	1.	.079
AISC (A4-6)(W)	.9DL+1.3WL	216.	1.	.267	15.	1.	.049
AISC (A4-6)(W)	.9DL-1.3WL	216.	1.	.267	15.	1.	.049
AISC (A4-6)(E)	.9DL+1EL	216.	1.	.345	15.	1.	.071
AISC (A4-6)(E)	.9DL-1EL	216.	1.	.306	15.	1.	.063

Gambar L.4.16 Output Program *RISABase Plate*

LAMPIRAN V

DATA SONDIR

DATA SONDIR PADA RENCANA PEMBANGUNAN PERKANTORAN JALAN CIWARUGA BANDUNG

Test Point : S-2 Form No. : I/2
Elevation : + 0,00 m dari Elevasi Muka Tanah Setempat
D a t e : 24 April 2007

Depth (m)	R1 = qc (kgf/sqcm)	R2 (kgf/sqcm)	fs (kgf/sqcm)	LF (kgf/cm)	TF (kgf/cm)	fs/qc (%)
-0.20	15	30	1.00	20.00	20.00	6.67
-0.40	20	30	0.67	13.33	33.33	3.33
-0.60	20	30	0.67	13.33	46.67	3.33
-0.80	15	30	1.00	20.00	66.67	6.67
-1.00	20	35	1.00	20.00	86.67	5.00
-1.20	20	30	0.67	13.33	100.00	3.33
-1.40	15	20	0.33	6.67	106.67	2.22
-1.60	10	20	0.67	13.33	120.00	6.67
-1.80	10	20	0.67	13.33	133.33	6.67
-2.00	10	22	0.80	16.00	149.33	8.00
-2.20	15	25	0.67	13.33	162.67	4.44
-2.40	10	20	0.67	13.33	176.00	6.67
-2.60	10	18	0.53	10.67	186.67	5.33
-2.80	8	16	0.53	10.67	197.33	6.67
-3.00	10	18	0.53	10.67	208.00	5.33
-3.20	10	18	0.53	10.67	218.67	5.33
-3.40	12	25	0.87	17.33	236.00	7.22
-3.60	15	22	0.47	9.33	245.33	3.11
-3.80	10	15	0.33	6.67	252.00	3.33
-4.00	15	25	0.67	13.33	265.33	4.44
-4.20	20	35	1.00	20.00	285.33	5.00
-4.40	20	30	0.67	13.33	298.67	3.33
-4.60	25	35	0.67	13.33	312.00	2.67
-4.80	25	40	1.00	20.00	332.00	4.00
-5.00	20	30	0.67	13.33	345.33	3.33
-5.20	10	20	0.67	13.33	358.67	6.67
-5.40	30	50	1.33	26.67	385.33	4.44
-5.60	25	50	1.67	33.33	418.67	6.67
-5.80	40	55	1.00	20.00	438.67	2.50
-6.00	40	60	1.33	26.67	465.33	3.33
-6.20	30	50	1.33	26.67	492.00	4.44
-6.40	25	40	1.00	20.00	512.00	4.00
-6.60	40	55	1.00	20.00	532.00	2.50
-6.80	35	55	1.33	26.67	558.67	3.81
-7.00	40	55	1.00	20.00	578.67	2.50
-7.20	40	55	1.00	20.00	598.67	2.50
-7.40	60	80	1.33	26.67	625.33	2.22
-7.60	65	80	1.00	20.00	645.33	1.54
-7.80	55	70	1.00	20.00	665.33	1.82
-8.00	55	75	1.33	26.67	692.00	2.42
-8.20	50	70	1.33	26.67	718.67	2.67
-8.40	60	80	1.33	26.67	745.33	2.22
-8.60	60	80	1.33	26.67	772.00	2.22
-8.80	70	90	1.33	26.67	798.67	1.90
-9.00	70	90	1.33	26.67	825.33	1.90
-9.20	50	70	1.33	26.67	852.00	2.67
-9.40	60	80	1.33	26.67	878.67	2.22
-9.60	70	90	1.33	26.67	905.33	1.90
-9.80	80	95	1.00	20.00	925.33	1.25
-10.00	60	80	1.33	26.67	952.00	2.22
-10.20	75	95	1.33	26.67	978.67	1.78
-10.40	80	100	1.33	26.67	1005.33	1.67
-10.60	70	110	2.67	53.33	1058.67	3.81
-10.80	80	105	1.67	33.33	1092.00	2.08
-11.00	75	110	2.33	46.67	1138.67	3.11
-11.20	80	115	2.33	46.67	1185.33	2.92

Test Point : S.2

Elevation : + 0.00 m dari Elevasi Muka Tanah Setempat

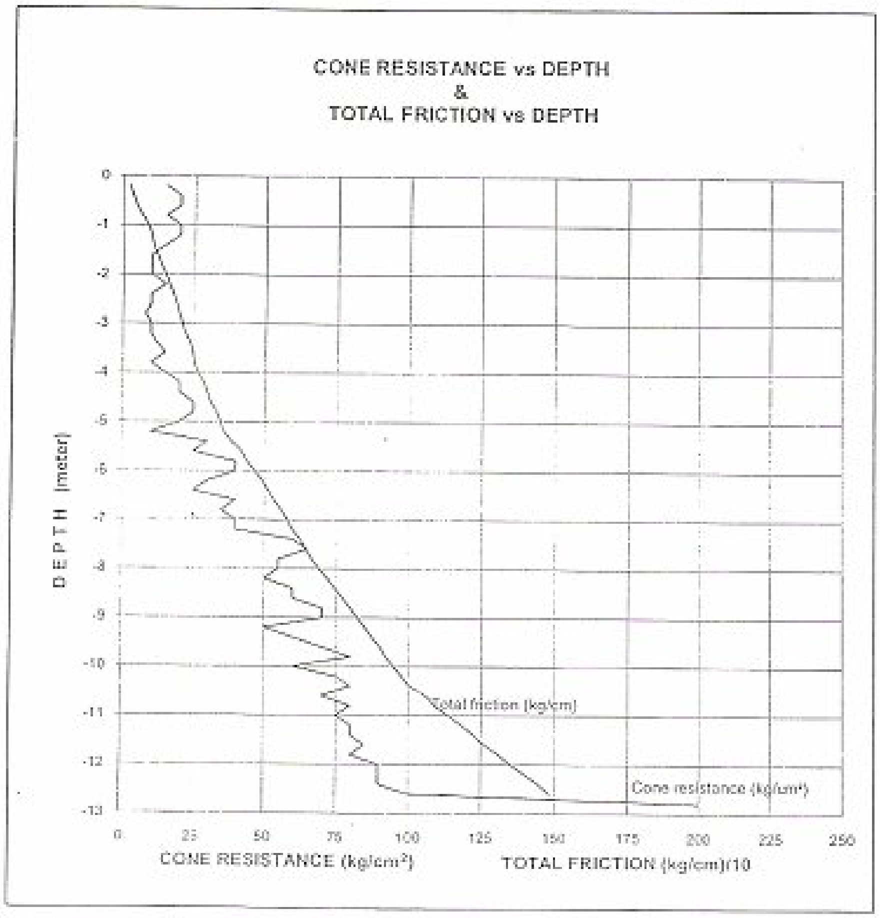
Form No. : II/2

Date : 24 April 2007

Depth (m)	R1 = qc (kg/sq.cm)	R2 (kg/sq.cm)	fs (kg/sq.cm)	LF (kg/cm)	TF (kg/cm)	Rf (%)
-11.40	80	110	2.00	40.00	1225.33	2.50
-11.60	85	115	2.00	40.00	1265.33	2.35
-11.80	80	115	2.33	46.67	1312.00	2.92
-12.00	90	120	2.00	40.00	1352.00	2.22
-12.20	90	125	2.33	46.67	1398.67	2.59
-12.40	90	125	2.33	46.67	1445.33	2.59
-12.60	100	130	2.00	40.00	1485.33	2.00
-12.80	200					

Test Point : S-2
Elevation : + 0.00 m dari Elevasi
Muka Tanah Setempat

Form No. : II/2
D a t e : 24 April 2007



LAMPIRAN VI

OUTPUT PROGRAM LPILE Plus 4.0

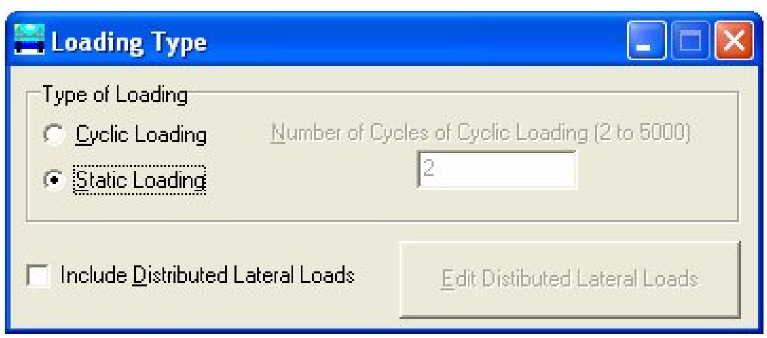
A. Struktur Gedung yang didesain Berdasarkan SNI 03-1726-2002

Adapun langkah-langkah dalam pemodelan Program LPile Plus 4.0 adalah sebagai berikut:

1. Defenisikan tiang yang akan digunakan. Input yang dimasukkan adalah panjang tiang, dan dimensi tiang.

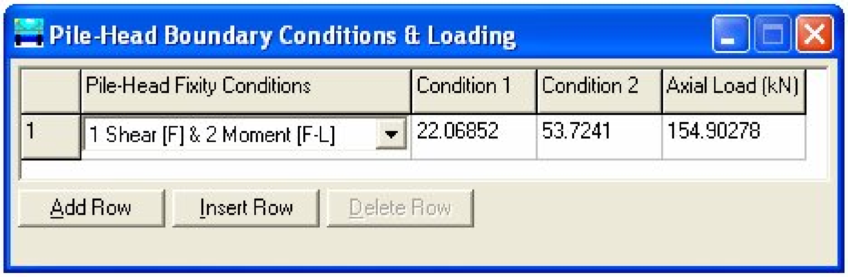
Gambar L.6.1 Defenisi Tiang

2. Tentukan jenis beban yang bekerja.



Gambar L.6.2 Jenis Beban

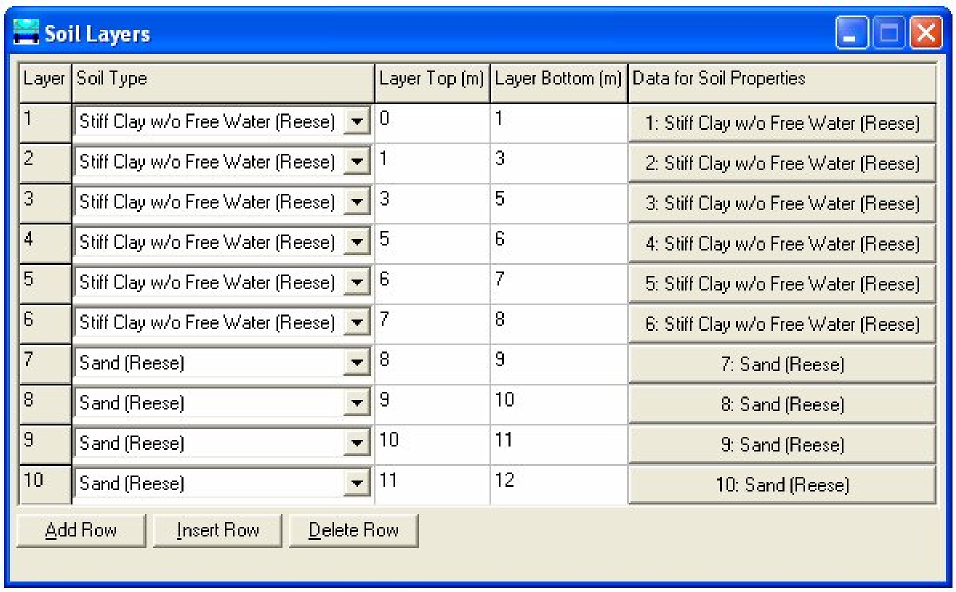
3. Input nilai N_u, V_u, dan M_u.



	Pile-Head Fixity Conditions	Condition 1	Condition 2	Axial Load (kN)
1	1 Shear [F] & 2 Moment [F-L]	22.06852	53.7241	154.90278

Gambar L.6.3 Input Beban

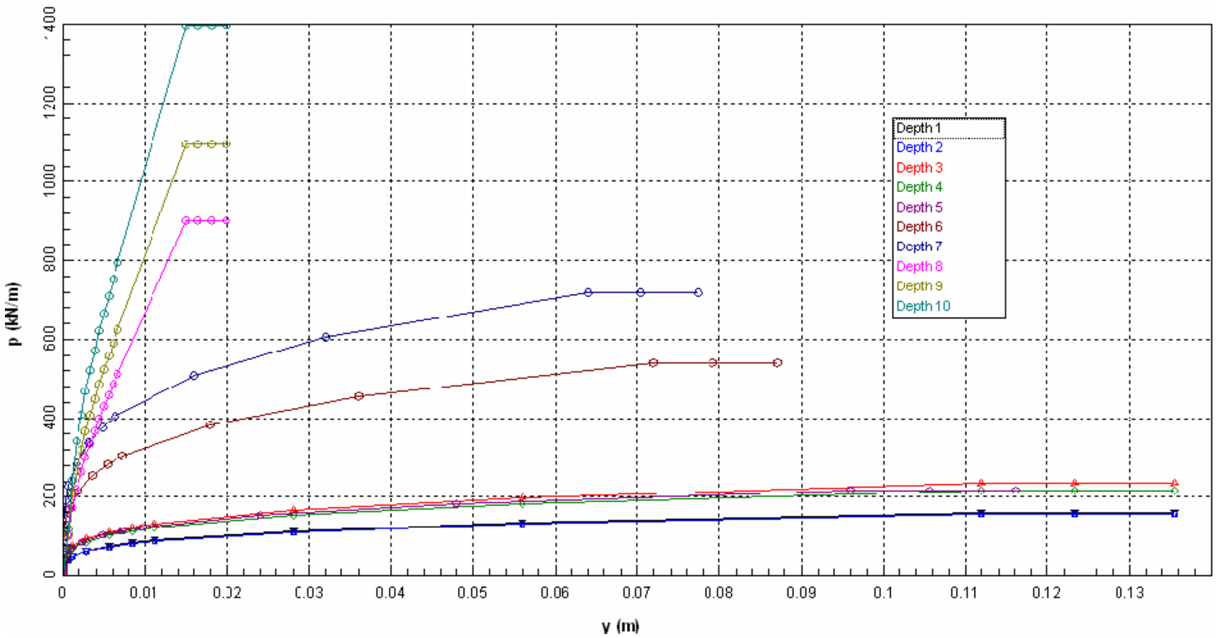
4. Tentukan jenis tanah tiap kedalaman.



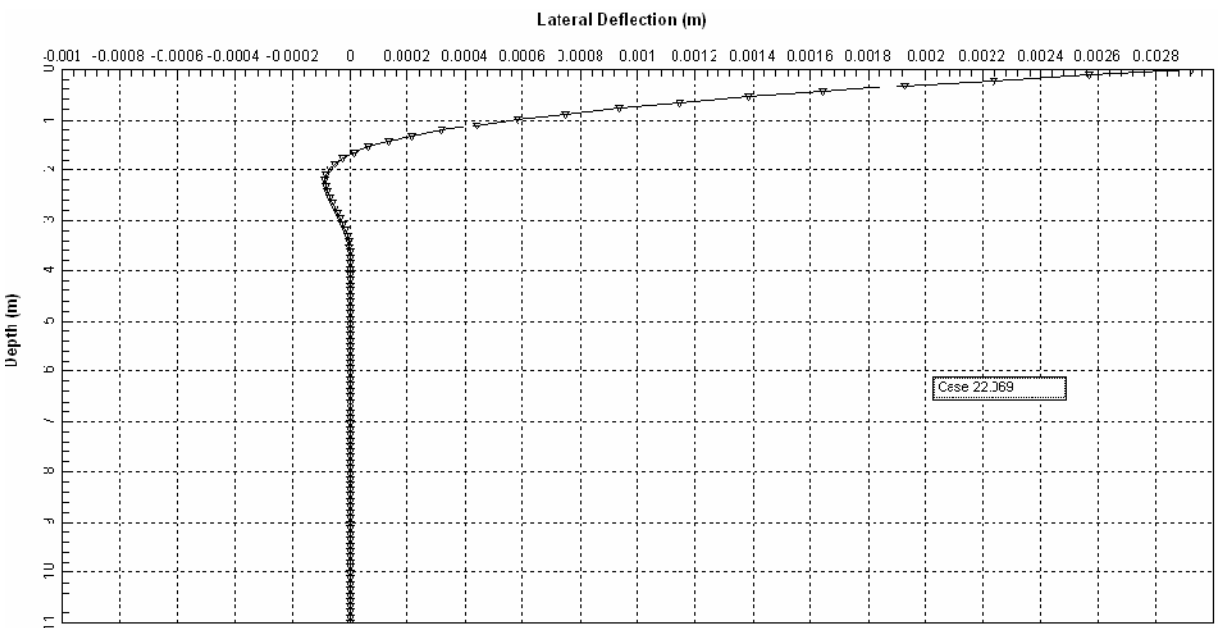
Layer	Soil Type	Layer Top (m)	Layer Bottom (m)	Data for Soil Properties
1	Stiff Clay w/o Free Water (Reese)	0	1	1: Stiff Clay w/o Free Water (Reese)
2	Stiff Clay w/o Free Water (Reese)	1	3	2: Stiff Clay w/o Free Water (Reese)
3	Stiff Clay w/o Free Water (Reese)	3	5	3: Stiff Clay w/o Free Water (Reese)
4	Stiff Clay w/o Free Water (Reese)	5	6	4: Stiff Clay w/o Free Water (Reese)
5	Stiff Clay w/o Free Water (Reese)	6	7	5: Stiff Clay w/o Free Water (Reese)
6	Stiff Clay w/o Free Water (Reese)	7	8	6: Stiff Clay w/o Free Water (Reese)
7	Sand (Reese)	8	9	7: Sand (Reese)
8	Sand (Reese)	9	10	8: Sand (Reese)
9	Sand (Reese)	10	11	9: Sand (Reese)
10	Sand (Reese)	11	12	10: Sand (Reese)

Gambar L.6.4 Jenis tanah tiap kedalaman

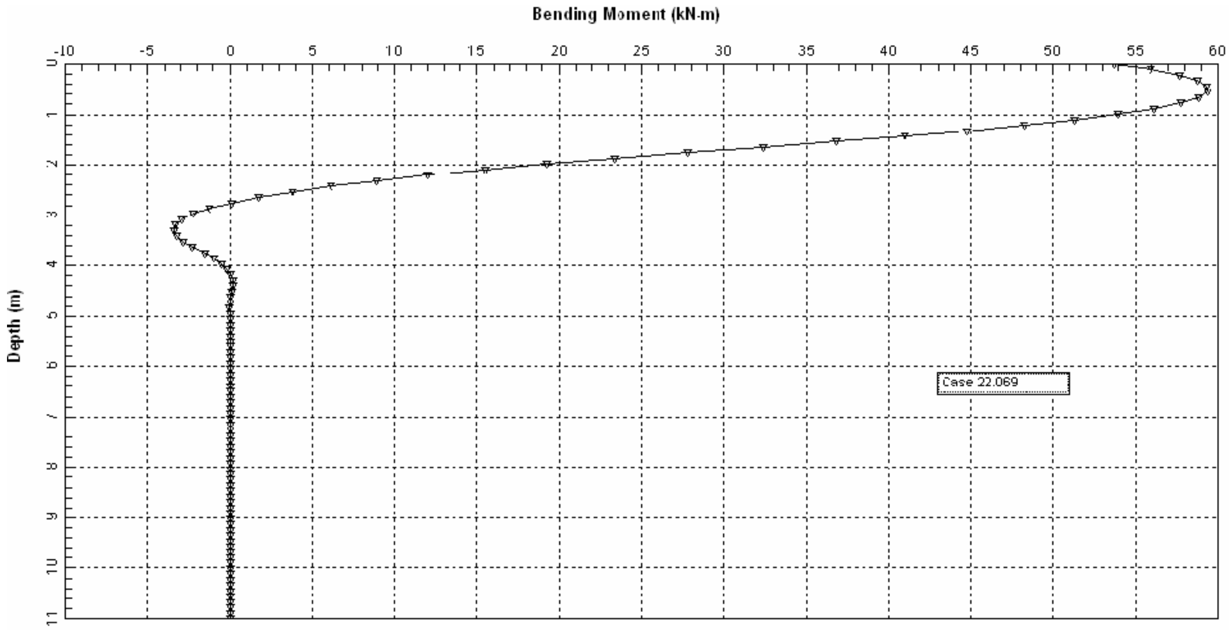
5. Setelah input data-data yang diperlukan, maka program bisa di run.



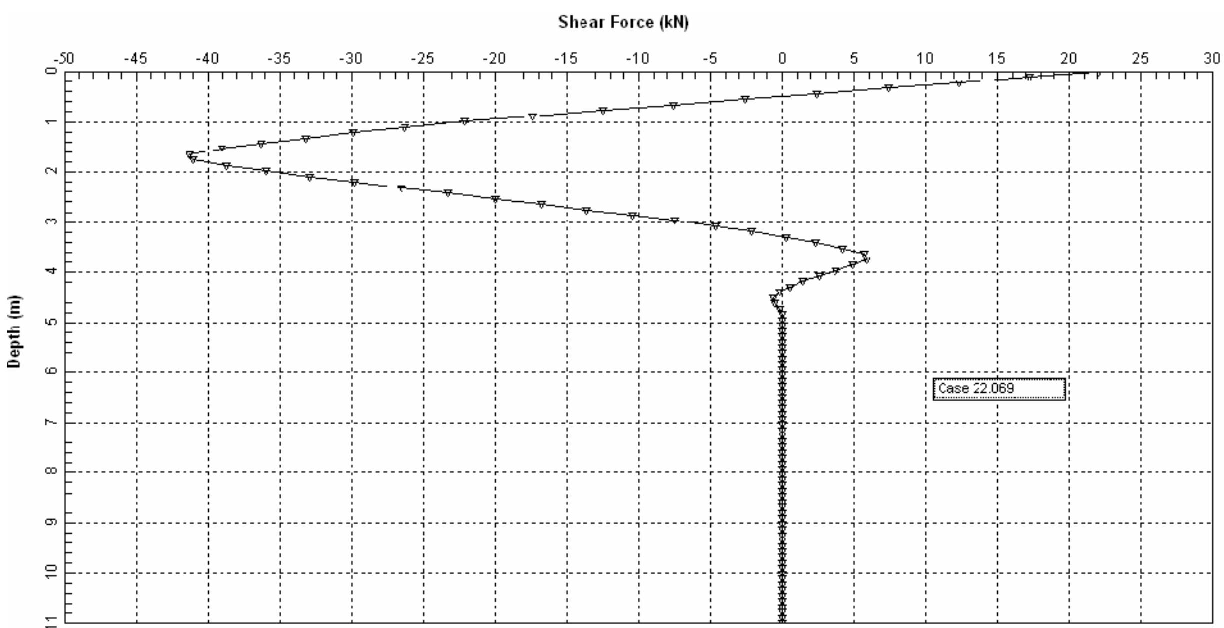
Gambar L.6.5 Kurva hubungan p-y



Gambar L.6.6 Kurva Lateral Deflection

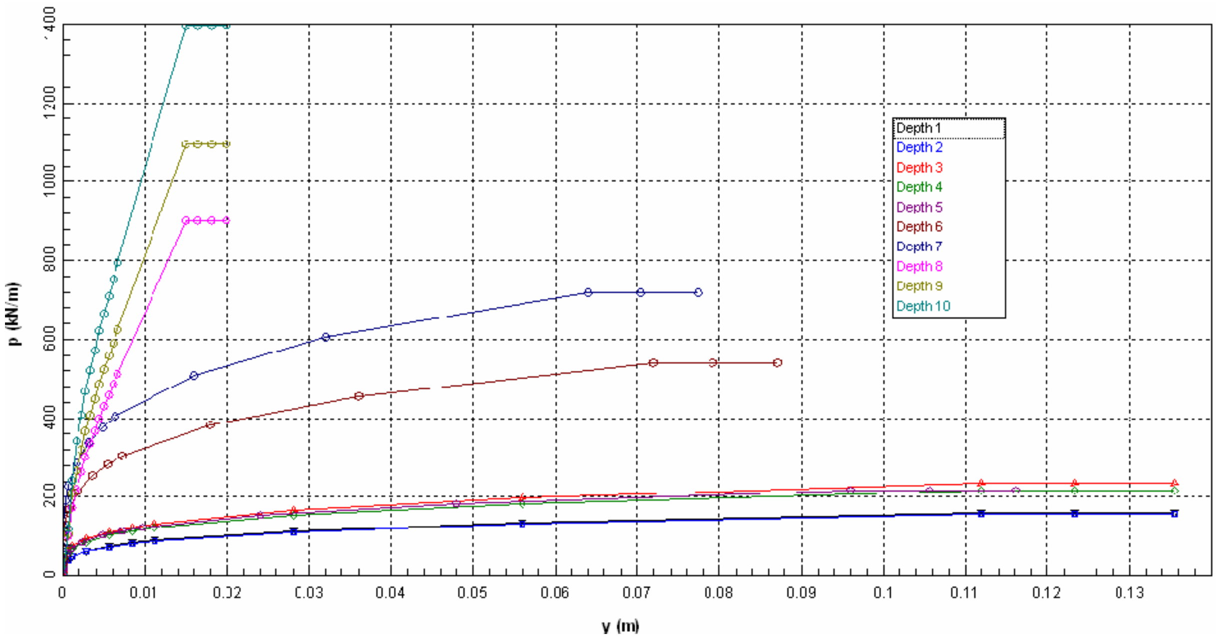


Gambar L.6.7 Bending Momen

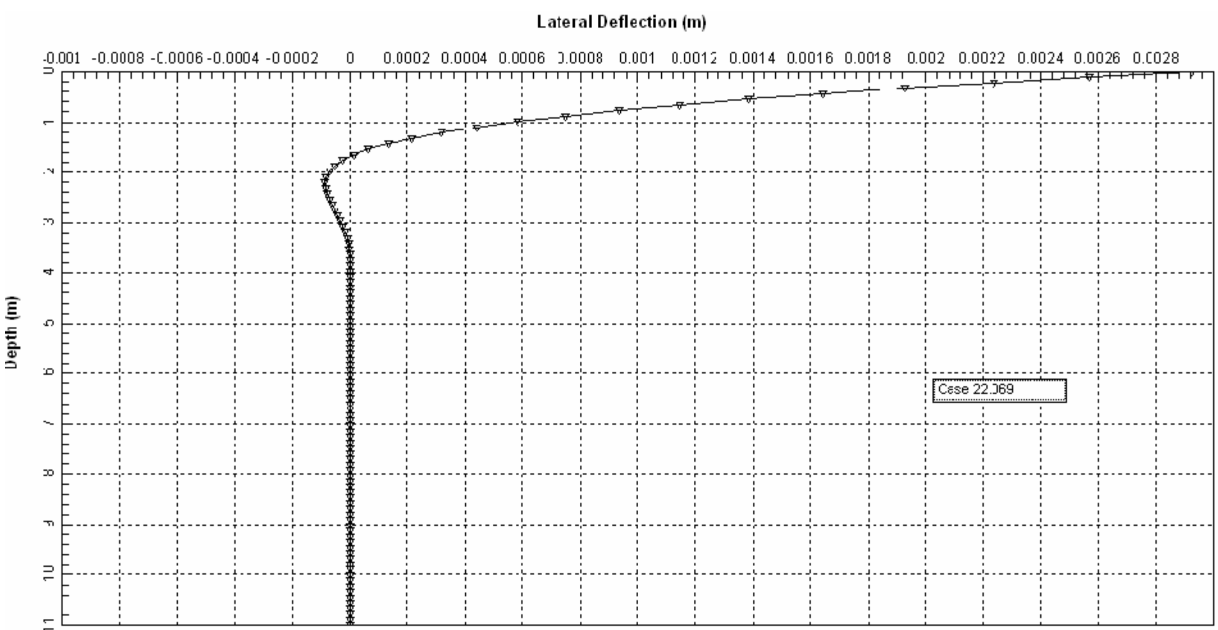


Gambar L.6.8 Gaya Geser

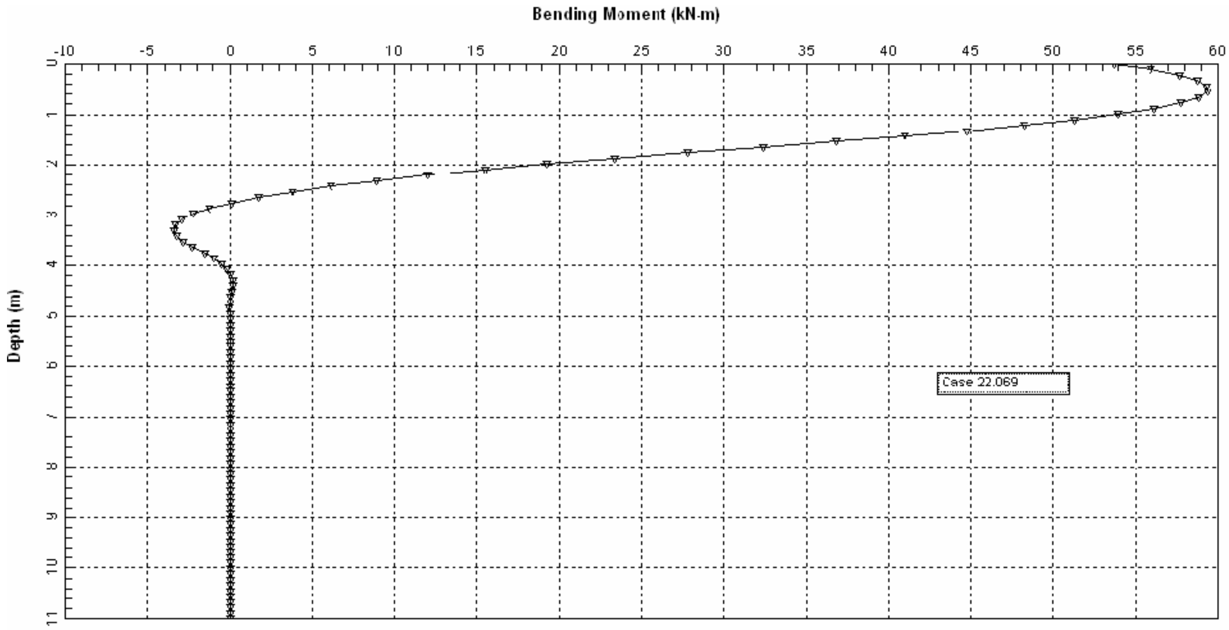
B. Struktur Gedung yang didesain Berdasarkan FEMA 450



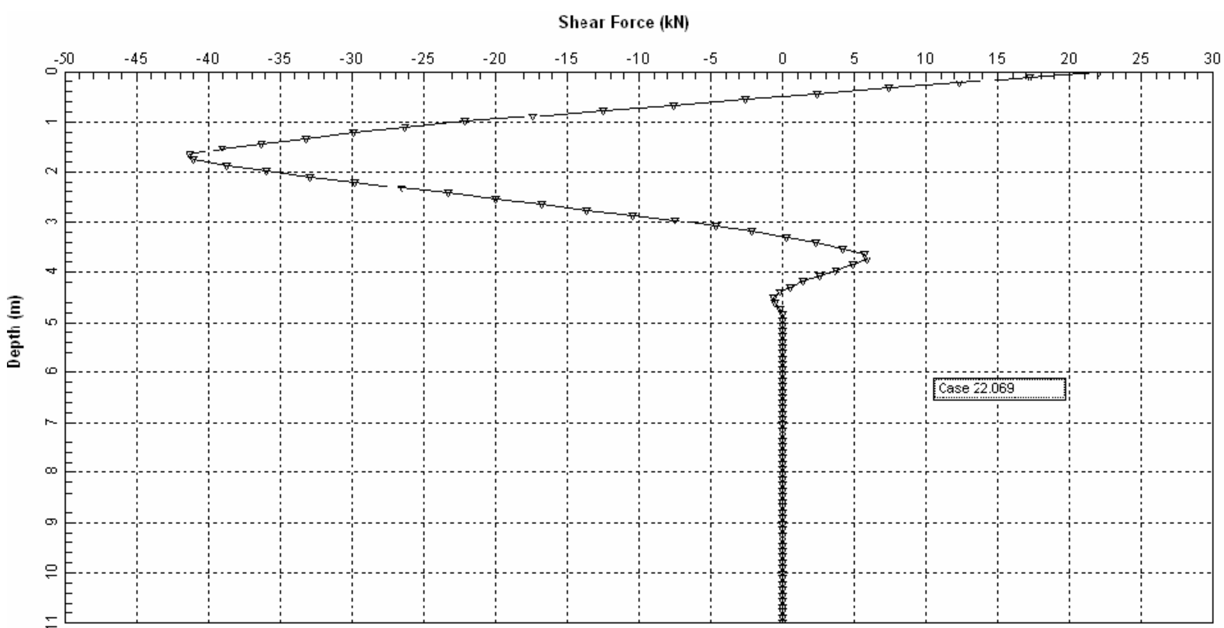
Gambar L.6.9 Kurva hubungan p-y



Gambar L.6.10 Kurva Lateral Deflection



Gambar L.6.11 Bending Momen



Gambar L.6.12 Gaya Geser

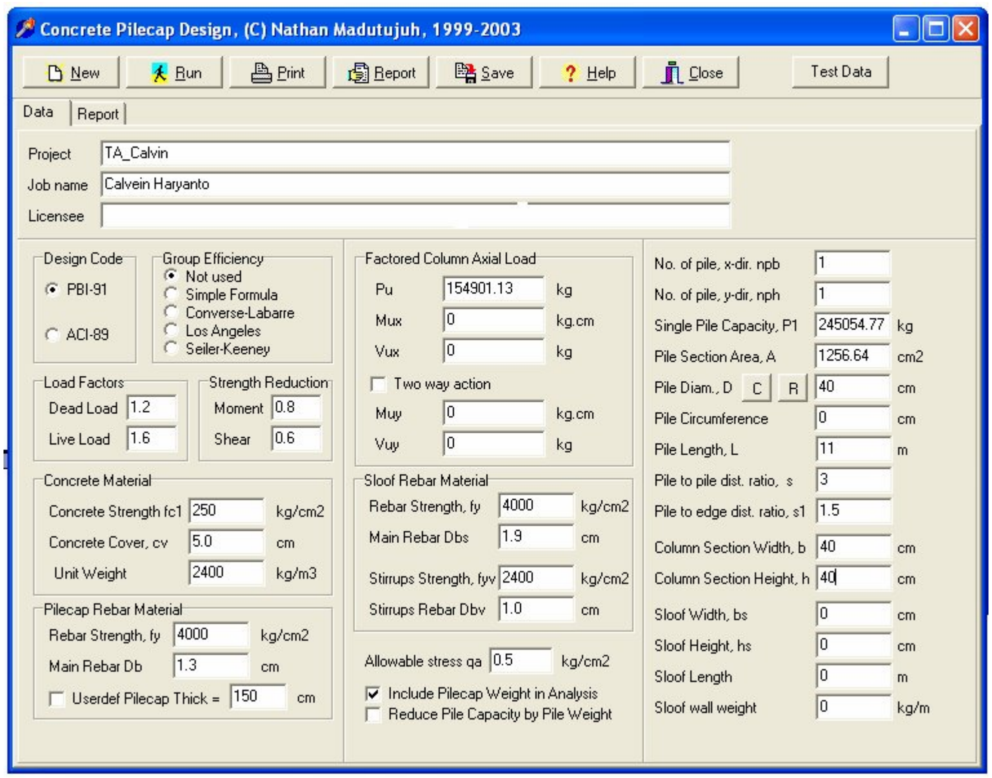
LAMPIRAN VII

OUTPUT PROGRAM CONCRETE PILECAP DESIGN

A. Struktur Gedung yang didesain Berdasarkan SNI 03-1726-2002

Langkah-langkah dalam mendesain Pilecap dengan menggunakan program Concrete PileCap adalah sebagai berikut:

1. Masukkan faktor pembebanan yang dipakai.
2. Defenisikan material pilecap yang akan digunakan.
3. Masukkan nilai beban aksial yang bekerja.
4. Tentukan jumlah tiang yang akan digunakan dalam satu pilecap.
5. Input kapasitas satu tiang, diameter tiang, panjang tiang, luas tiang, serta jarak antar tiang.
6. Input dimensi kolom yang dipakai.



Gambar L.7.1 Tampilan Program Pilecap

```
PILECAP - Pilecap Design V.1.1
    (C) Nathan Madutujuh, 1999-2003
    Engineering Software Research Center


      Project  : TA_Calvin
      Job Name : Calvein Haryanto


    PILECAP DESIGN

      Design Code     : PBI-91

        Factor for Dead Load = 1.20
        Factor for Live Load = 1.60
        Strength Reduction for Moment = 0.80
        Strength Reduction for Shear  = 0.60

      Concrete Unit Weight,     Gm  =  2400.00 kg/m3
      Concrete Compr. Strength, fc1 =   250.00 kg/cm2
      Concrete Cover,           cv  =     5.00 cm

      Pilecap Rebar Yield Strength, fy  =  4000.00 kg/cm2
      Pilecap Rebar Diameter,       db  =     1.30 cm

      Sloof Rebar Yield Strength,   fys   =  4000.00 kg/cm2
      Sloof Stirrups Yield Strength, fy   =  2400.00 kg/cm2
      Sloof Main Rebar Diameter,     dbs  =     1.90 cm
      Sloof Stirrups Rebar Diameter, dbsv =     1.00 cm

      Allowable Soil Stress,    qa  =     0.50 kg/cm2

    Unfactored Axial Load    P  =    110643.66 kg
    Single Pile Capacity     P1 =    245054.77 kg
    Single Pile Section Area A1 = 1256.64 cm2
    Pile Length              L1 =   11.00 m
    Pile Length Inside Pilecap L2 =   0.000 m
    Pile Diameter            dp =   40.00 cm
    Pile to Pile Dist. Ratio  s =    3.00 D
    Pile to Edge Dist. Ratio s1 =    2.00 D

    Column Section Width   b =   40.00 cm
    Column Section Height  h =   40.00 cm

    Sloof Section Width   b =    0.00 cm
    Sloof Section Height  h =    0.00 cm

      Factored Axial Load,      Pu  =    154901.13 kg
      Factored Moment,         Mux  =         0.00 kg.cm
      Factored Shear,          Vux  =         0.00 kg.cm

    Load Factor (Averaged) = 1.40

    PILE DESIGN:

      Pile to Pile Distance    ds =   120.00 cm
      Pile to Edge Distance   ds1 =    80.00 cm
      Number of Pile           np = 1
      Weight of One Pile       W1 =     0.00 kg
      Single Pile Capacity  P1-W1 = 245054.77 kg
      Unfactored load, 1 Pile  P3 = 110643.66 kg
      Weight of All Piles      Wp =     0.00 kg
      Weight of Pile Cap       Wc =  3379.20 kg
      Pilecap Width            bp =   160.00 cm
      Pilecap Length           hp =   160.00 cm
      Pilecap Thickness        tp =    55.00 cm (Included L2)

      Group Efficiency Method     = Not Applied
```

```
  Group Efficiency        eff = 1.000
  Total Pile Capacity    Pcap =    241675.57 kg

     Pcap > P   ----> OK

Shear Stress Checking:

   Beta Factor = h/b >= 1.0     =    1.00
   Punch Shear Force        Pp  =    110643.66 kg  (Unfactored)
   Punch Shear Force        Ppu =    154901.13 kg  (Factored)
   Critical Perimeter       Ko  =     380.0000 cm
   Punch Shear Stress       vc  =       8.3703 kg/cm2

Maximum shear stress (Without Phi factor)

   Punch Shear Capacity     vc1 =   16.67 kg/cm2  (Including Beta)
   Nett  Shear Capacity  vc min =    8.33 kg/cm2
   Nett  Shear Capacity  vc max =   16.67 kg/cm2
   Nett  Shear Average       vc =    8.33 kg/cm2

Maximum shear stress (With Phi factor = 0.6)

   Punch Shear Capacity     vc1 =   10.00 kg/cm2  (Including Beta)
   Nett  Shear Capacity  vc min =    5.00 kg/cm2
   Nett  Shear Capacity  vc max =   10.00 kg/cm2
   Nett  Shear Average       vc =    5.00 kg/cm2

Pilecap Thickness at Column Face:

   Punch Shear,         tp =   50.36 cm
   Nett  Shear, X-dir,  tp =   13.80 cm  ( 0 piles)
   Nett  Shear, Y-dir,  tp =   13.80 cm  ( 0 piles)

Pilecap Thickness at Edge:

   Nett  Shear, X-dir,  tp =    0.00 cm  ( 0 piles)
   Nett  Shear, Y-dir,  tp =    0.00 cm  ( 0 piles)

   Selected Pilecap Thickness tp =   55.00 cm (Included L2)

Pilecap Rebar Design:

  fc1 =  250.0 kg/cm2   Tp =  55.0 cm   db    =  1.3 cm
  fy  = 4000.0 kg/cm2   cv =   5.0 cm   romin = 0.00150

1. Bending Moment at Column Face, X-direction (0 piles)

     Not Applicable!

2. Bending Moment at Column Face, Y-direction (0 piles)

     Not Applicable!
```

B. Struktur Gedung yang didesain Berdasarkan FEMA 450

```
PILECAP - Pilecap Design V.1.1
(C) Nathan Madutujuh, 1999-2003
Engineering Software Research Center

  Project  : TA_Calvin
  Job Name : Calvein Haryanto


PILECAP DESIGN

  Design Code     : PBI-91

    Factor for Dead Load = 1.20
    Factor for Live Load = 1.60
    Strength Reduction for Moment = 0.80
    Strength Reduction for Shear  = 0.60

  Concrete Unit Weight,     Gm  =  2400.00 kg/m3
  Concrete Compr. Strength, fc1 =   250.00 kg/cm2
  Concrete Cover,           cv  =     5.00 cm

  Pilecap Rebar Yield Strength, fy  =  4000.00 kg/cm2
  Pilecap Rebar Diameter,       db  =     1.30 cm

  Sloof Rebar Yield Strength,   fys   =  4000.00 kg/cm2
  Sloof Stirrups Yield Strength, fy   =  2400.00 kg/cm2
  Sloof Main Rebar Diameter,     dbs  =     1.90 cm
  Sloof Stirrups Rebar Diameter, dbsv =     1.00 cm

  Allowable Soil Stress,    qa  =     0.50 kg/cm2

Unfactored Axial Load    P  =    110644.84 kg
Single Pile Capacity     P1 =    245054.77 kg
Single Pile Section Area A1 = 1256.64 cm2
Pile Length              L1 =   11.00 m
Pile Length Inside Pilecap L2 =   7.500 m
Pile Diameter            dp =   40.00 cm
Pile to Pile Dist. Ratio  s =    3.00 D
Pile to Edge Dist. Ratio s1 =    2.00 D

Column Section Width   b =   40.00 cm
Column Section Height  h =   40.00 cm

Sloof Section Width   b =    0.00 cm
Sloof Section Height  h =    0.00 cm

  Factored Axial Load,      Pu  =    154902.78 kg
  Factored Moment,         Mux  =         0.00 kg.cm
  Factored Shear,          Vux  =         0.00 kg.cm

Load Factor (Averaged) = 1.40

PILE DESIGN:

  Pile to Pile Distance    ds =   120.00 cm
  Pile to Edge Distance   ds1 =    80.00 cm
  Number of Pile           np = 1
  Weight of One Pile       W1 =     0.00 kg
  Single Pile Capacity  P1-W1 = 245054.77 kg
  Unfactored load, 1 Pile  P3 = 110644.84 kg
  Weight of All Piles      Wp =     0.00 kg
  Weight of Pile Cap       Wc =  3379.20 kg
  Pilecap Width            bp =   160.00 cm
  Pilecap Length           hp =   160.00 cm
  Pilecap Thickness        tp =    55.00 cm (Included L2)
```

```
  Group Efficiency Method     = Not Applied
  Group Efficiency        eff = 1.000
  Total Pile Capacity    Pcap =    241675.57 kg

     Pcap > P   ----> OK

Shear Stress Checking:

   Beta Factor = h/b >= 1.0     =    1.00
   Punch Shear Force        Pp  =    110644.84 kg  (Unfactored)
   Punch Shear Force        Ppu =    154902.78 kg  (Factored)
   Critical Perimeter       Ko  =     380.0000 cm
   Punch Shear Stress       vc  =       8.3704 kg/cm2

Maximum shear stress (Without Phi factor)

   Punch Shear Capacity     vc1 =   16.67 kg/cm2  (Including Beta)
   Nett  Shear Capacity  vc min =    8.33 kg/cm2
   Nett  Shear Capacity  vc max =   16.67 kg/cm2
   Nett  Shear Average       vc =    8.33 kg/cm2

Maximum shear stress (With Phi factor = 0.6)

   Punch Shear Capacity     vc1 =   10.00 kg/cm2  (Including Beta)
   Nett  Shear Capacity  vc min =    5.00 kg/cm2
   Nett  Shear Capacity  vc max =   10.00 kg/cm2
   Nett  Shear Average       vc =    5.00 kg/cm2

Pilecap Thickness at Column Face:

   Punch Shear,         tp =   50.36 cm
   Nett  Shear, X-dir,  tp =   13.80 cm  ( 0 piles)
   Nett  Shear, Y-dir,  tp =   13.80 cm  ( 0 piles)

Pilecap Thickness at Edge:

   Nett  Shear, X-dir,  tp =    0.00 cm  ( 0 piles)
   Nett  Shear, Y-dir,  tp =    0.00 cm  ( 0 piles)

   Selected Pilecap Thickness tp =   55.00 cm (Included L2)

Pilecap Rebar Design:

  fc1 =  250.0 kg/cm2   Tp =  55.0 cm   db    =  1.3 cm
  fy  = 4000.0 kg/cm2   cv =   5.0 cm   romin = 0.00150

1. Bending Moment at Column Face, X-direction (0 piles)

     Not Applicable!

2. Bending Moment at Column Face, Y-direction (0 piles)

     Not Applicable!
```

LAMPIRAN VIII

BATAS LAYAN DAN BATAS ULTIMATE

A. Struktur Gedung yang Didesain berdasarkan SNI 03-1726-2002

Story	Item	Load	DriftX	DriftY	h	Batas Layan			
						0.03*h/R	0.03	Syarat (arah x)	Syarat (arah y)
STORY6	Max Drift X	EQX	0.000312		3.5	0.012353	0.03	Memenuhi	
STORY6	Max Drift Y	EQX		0.000026	3.5	0.012353	0.03		Memenuhi
STORY6	Max Drift X	EQY	0.000027		3.5	0.012353	0.03	Memenuhi	
STORY6	Max Drift Y	EQY		0.000327	3.5	0.012353	0.03		Memenuhi
STORY5	Max Drift X	EQX	0.000541		3.5	0.012353	0.03	Memenuhi	
STORY5	Max Drift Y	EQX		0.000044	3.5	0.012353	0.03		Memenuhi
STORY5	Max Drift X	EQY	0.000045		3.5	0.012353	0.03	Memenuhi	
STORY5	Max Drift Y	EQY		0.000557	3.5	0.012353	0.03		Memenuhi
STORY4	Max Drift X	EQX	0.000639		3.5	0.012353	0.03	Memenuhi	
STORY4	Max Drift Y	EQX		0.000053	3.5	0.012353	0.03		Memenuhi
STORY4	Max Drift X	EQY	0.000056		3.5	0.012353	0.03	Memenuhi	
STORY4	Max Drift Y	EQY		0.000667	3.5	0.012353	0.03		Memenuhi
STORY3	Max Drift X	EQX	0.0007		3.5	0.012353	0.03	Memenuhi	
STORY3	Max Drift Y	EQX		0.000059	3.5	0.012353	0.03		Memenuhi
STORY3	Max Drift X	EQY	0.000062		3.5	0.012353	0.03	Memenuhi	
STORY3	Max Drift Y	EQY		0.00077	3.5	0.012353	0.03		Memenuhi
STORY2	Max Drift X	EQX	0.000617		3.5	0.012353	0.03	Memenuhi	
STORY2	Max Drift Y	EQX		0.000056	3.5	0.012353	0.03		Memenuhi
STORY2	Max Drift X	EQY	0.000057		3.5	0.012353	0.03	Memenuhi	
STORY2	Max Drift Y	EQY		0.000771	3.5	0.012353	0.03		Memenuhi
STORY1	Max Drift X	EQX	0.000417		4	0.014118	0.03	Memenuhi	
STORY1	Max Drift Y	EQX		0.000036	4	0.014118	0.03		Memenuhi
STORY1	Max Drift X	EQY	0.000036		4	0.014118	0.03	Memenuhi	
STORY1	Max Drift Y	EQY		0.000512	4	0.014118	0.03		Memenuhi

Story	Item	Load	DriftX	DriftY	Batas Ultimate	Batas Ultimate	
						Syarat (arah x)	Syarat (arah y)
STORY6	Max Drift X	EQX	0.001856		0.07	Memenuhi	
STORY6	Max Drift Y	EQX		0.000155	0.07		Memenuhi
STORY6	Max Drift X	EQY	0.000161		0.07	Memenuhi	
STORY6	Max Drift Y	EQY		0.001946	0.07		Memenuhi
STORY5	Max Drift X	EQX	0.003219		0.07	Memenuhi	
STORY5	Max Drift Y	EQX		0.000262	0.07		Memenuhi
STORY5	Max Drift X	EQY	0.000268		0.07	Memenuhi	
STORY5	Max Drift Y	EQY		0.003314	0.07		Memenuhi
STORY4	Max Drift X	EQX	0.003802		0.07	Memenuhi	
STORY4	Max Drift Y	EQX		0.000315	0.07		Memenuhi
STORY4	Max Drift X	EQY	0.000333		0.07	Memenuhi	
STORY4	Max Drift Y	EQY		0.003969	0.07		Memenuhi
STORY3	Max Drift X	EQX	0.004165		0.07	Memenuhi	
STORY3	Max Drift Y	EQX		0.000351	0.07		Memenuhi
STORY3	Max Drift X	EQY	0.000369		0.07	Memenuhi	
STORY3	Max Drift Y	EQY		0.004582	0.07		Memenuhi
STORY2	Max Drift X	EQX	0.003671		0.07	Memenuhi	
STORY2	Max Drift Y	EQX		0.000333	0.07		Memenuhi
STORY2	Max Drift X	EQY	0.000339		0.07	Memenuhi	
STORY2	Max Drift Y	EQY		0.004587	0.07		Memenuhi
STORY1	Max Drift X	EQX	0.002481		0.08	Memenuhi	
STORY1	Max Drift Y	EQX		0.000214	0.08		Memenuhi
STORY1	Max Drift X	EQY	0.000214		0.08	Memenuhi	
STORY1	Max Drift Y	EQY		0.003046	0.08		Memenuhi

B. Struktur Gedung yang Didesain berdasarkan FEMA 450

Story	Item	Load	DriftX	DriftY	h	Batas Layan			
						0.03*h/R	0.03	Syarat (arah x)	Syarat (arah y)
STORY6	Max Drift X	EQX	0.000313		3.5	0.012352941	0.03	Memenuhi	
STORY6	Max Drift Y	EQX		0.000026	3.5	0.012352941	0.03		Memenuhi
STORY6	Max Drift X	EQY	0.000027		3.5	0.012352941	0.03	Memenuhi	
STORY6	Max Drift Y	EQY		0.000328	3.5	0.012352941	0.03		Memenuhi
STORY5	Max Drift X	EQX	0.000542		3.5	0.012352941	0.03	Memenuhi	
STORY5	Max Drift Y	EQX		0.000044	3.5	0.012352941	0.03		Memenuhi
STORY5	Max Drift X	EQY	0.000045		3.5	0.012352941	0.03	Memenuhi	
STORY5	Max Drift Y	EQY		0.000558	3.5	0.012352941	0.03		Memenuhi
STORY4	Max Drift X	EQX	0.000639		3.5	0.012352941	0.03	Memenuhi	
STORY4	Max Drift Y	EQX		0.000053	3.5	0.012352941	0.03		Memenuhi
STORY4	Max Drift X	EQY	0.000056		3.5	0.012352941	0.03	Memenuhi	
STORY4	Max Drift Y	EQY		0.000668	3.5	0.012352941	0.03		Memenuhi
STORY3	Max Drift X	EQX	0.000701		3.5	0.012352941	0.03	Memenuhi	
STORY3	Max Drift Y	EQX		0.000059	3.5	0.012352941	0.03		Memenuhi
STORY3	Max Drift X	EQY	0.000062		3.5	0.012352941	0.03	Memenuhi	
STORY3	Max Drift Y	EQY		0.000771	3.5	0.012352941	0.03		Memenuhi
STORY2	Max Drift X	EQX	0.000617		3.5	0.012352941	0.03	Memenuhi	
STORY2	Max Drift Y	EQX		0.000056	3.5	0.012352941	0.03		Memenuhi
STORY2	Max Drift X	EQY	0.000058		3.5	0.012352941	0.03	Memenuhi	
STORY2	Max Drift Y	EQY		0.000772	3.5	0.012352941	0.03		Memenuhi
STORY1	Max Drift X	EQX	0.000418		4	0.014117647	0.03	Memenuhi	
STORY1	Max Drift Y	EQX		0.000036	4	0.014117647	0.03		Memenuhi
STORY1	Max Drift X	EQY	0.000036		4	0.014117647	0.03	Memenuhi	
STORY1	Max Drift Y	EQY		0.000512	4	0.014117647	0.03		Memenuhi

Story	Item	Load	DriftX	DriftY	Batas Ultimate	Batas Ultimate	
						Syarat (arah x)	Syarat (arah y)
STORY6	Max Drift X	EQX	0.001862		0.07	Memenuhi	
STORY6	Max Drift Y	EQX		0.000155	0.07		Memenuhi
STORY6	Max Drift X	EQY	0.000161		0.07	Memenuhi	
STORY6	Max Drift Y	EQY		0.001952	0.07		Memenuhi
STORY5	Max Drift X	EQX	0.003225		0.07	Memenuhi	
STORY5	Max Drift Y	EQX		0.000262	0.07		Memenuhi
STORY5	Max Drift X	EQY	0.000268		0.07	Memenuhi	
STORY5	Max Drift Y	EQY		0.003320	0.07		Memenuhi
STORY4	Max Drift X	EQX	0.003802		0.07	Memenuhi	
STORY4	Max Drift Y	EQX		0.000315	0.07		Memenuhi
STORY4	Max Drift X	EQY	0.000333		0.07	Memenuhi	
STORY4	Max Drift Y	EQY		0.003975	0.07		Memenuhi
STORY3	Max Drift X	EQX	0.004171		0.07	Memenuhi	
STORY3	Max Drift Y	EQX		0.000351	0.07		Memenuhi
STORY3	Max Drift X	EQY	0.000369		0.07	Memenuhi	
STORY3	Max Drift Y	EQY		0.004587	0.07		Memenuhi
STORY2	Max Drift X	EQX	0.003671		0.07	Memenuhi	
STORY2	Max Drift Y	EQX		0.000333	0.07		Memenuhi
STORY2	Max Drift X	EQY	0.000345		0.07	Memenuhi	
STORY2	Max Drift Y	EQY		0.004593	0.07		Memenuhi
STORY1	Max Drift X	EQX	0.002487		0.08	Memenuhi	
STORY1	Max Drift Y	EQX		0.000214	0.08		Memenuhi
STORY1	Max Drift X	EQY	0.000214		0.08	Memenuhi	
STORY1	Max Drift Y	EQY		0.003046	0.08		Memenuhi

LAMPIRAN IX

PRELIMINARY DESAIN

PRELIMINARY DESAIN

Pembebanan Lantai

a. Beban Mati

- Dead Load (DL)
  - Berat sendiri beton = 0,12 x 2400 = 288 kg/m^2

Total = 288 kg/m^2

- Superdead Load (SDL)
  - Finishing + M/E = 112 kg/m^2+

Total = 112 kg/m^2

b. Beban Hidup

Beban hidup pada lantai = 300 kg/m^2

Beban Dinding = 250 kg/m^2

1. Preliminary Design Dimensi Pelat

Menentukan tebal pelat minimum (TCPSBUS 2003, halaman 65, pasal 11.5.3)

Asumsi :

- Ln1 = 6000 mm
- Ln2 = 2400 mm

$$\beta = \frac{\text{bentang terpanjang}}{\text{bentang terpendek}}$$

$$\beta = \frac{\text{bentang terpanjang}}{\text{bentang terpendek}} = \frac{6000}{2400} = 2,5 \geq 2$$

Maka pelat merupakan pelat *one way slab* (1 arah)

Menentukan h pelat, α_m belum diketahui, digunakan rumus

$$h\min = \frac{\lambda_n \left(0,8 + \frac{f_y}{1500}\right)}{36 + 9\beta}$$

$$h\min = \frac{6000\left(0,8+\frac{240}{1500}\right)}{36+9\left(2,5\right)} = 98,46mm$$

$$hmaks = \frac{\lambda_n\left(0,8+\frac{f_y}{1500}\right)}{36}$$

$$hmaks = \frac{6000\left(0,8+\frac{240}{1500}\right)}{36} = 160mm$$

h min ≤ h ≤ h maks

98,46 mm ≤ h ≤ 160 mm

Maka tebal pelat yang digunakan (h) = 120 mm = 12 cm

Desain Tulangan

$f_c^{'} = 25MPa$ $\gamma_{beton} = 24kN/m^3$

Perhitungan Beban Rencana Terfaktor

$$q_{ult} = 1,2.\left(SDL+DL\right)+1,6.LL$$

$$q_{ult} = 1,2.\left(112+288\right)+1,6.300 = 960kg/m^2$$

M_u = 1035,033 kgm = 10350330 Nmm

$$d = h-25 = 120-25 = 95mm$$

$$A_s = \frac{M_u}{\phi.j.d.f_y}$$

$$A_s = \frac{10350330}{0,8.(0,9.95).400} = 378mm^2$$ (pakai tulangan diameter 10 mm)

$$A = \frac{1}{4}.\pi.d^2 = \frac{1}{4}.\pi.10^2 = 78,54mm^2$$

$$A = 78,54.5 = 393mm^2$$

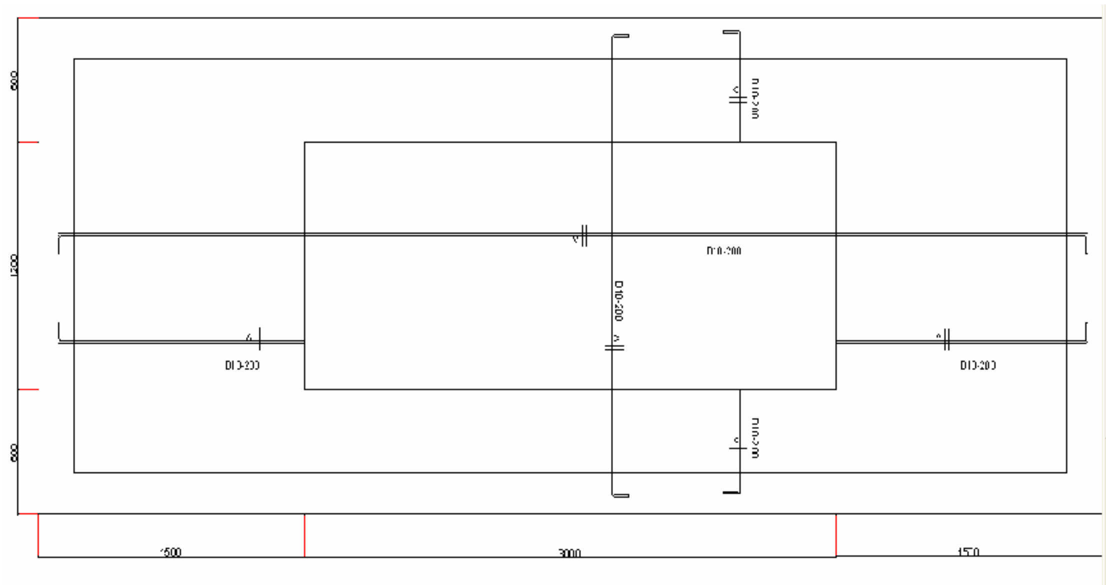
Dipakai 5D10-200mm

$$\rho = \frac{A_s}{b.h} = \frac{393}{1000.120} = 0,003275$$ cek: $\rho \geq \rho_{\min} (\rho_{\min} = 0,0018) \Rightarrow OK$

$$a = \frac{A_s . f_y}{0,85.f_c^{'}.b} = \frac{393.400}{0,85.25.1000} = 7,4$$

$$\phi M_n = \phi . A_s . f_y . \left(d - \frac{a}{2} \right) = 0,8.393.400. \left(95 - \frac{7,4}{2} \right) = 11481888 Nmm$$

$$\phi M_n \geq M_u = 11481888 Nmm \geq 10350330 Nmm \Rightarrow OK$$



DENAH PENULANGAN PELAT

2. Pendimensian Balok

A. Balok Anak

q = (1,2DL) + (1,6LL) = (1,2 x 288) + (1,2 x 112)+(1,6 x 300)

= 960 kg/m^2

qek= q x $\left[\frac{2,4 + 2,4}{2} \right]$

= 960x2,4

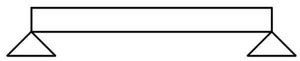
= 2304 kg/m

Mmax = 1/8 x q_{ek} x l^2

= 1/8 x 2304 x 6^2

= 10368 kgm

= 103680000 Nmm



Mu ≤ ϕ M_n

Mu ≤ 0.9 x 1,5 My

Mu ≤ 0.9 x 1,5 fy x Sx

$$Sx \geq \frac{M_u}{\phi.1,5.f_y}$$

$$Sx \geq \frac{103680000}{0,9.1,5.240}$$

$$Sx\ 320000 mm^3$$

Maka, profil baja IWF yang digunakan adalah 350x175x7x11

Sx = Zx = 775 cm^3 = 775.10^3 mm^3 > 320000.10^3 mm^3

B. Balok Induk

q = (1,2DL) + (1,6LL) = (1,2 x 288) + (1,2 x 112)+(1,6 x 300)

= 960 kg/m^2

$$q = q\ x\ \left[\frac{2,4+2,4}{2}\right]$$

q = 2304 kg/m

q_{ek} = 2304 + (250x3,5)

q_{ek} = 3179 kg/m

Mmax = 1/8 x q_{ek} x l^2

= 1/8 x 3179 kg/m x 6^2

= 14305,5 kgm

= 143055000 Nmm

Mu ≤ ϕ M_n

$Mu \leq 0.9 \times 1{,}5\ My$

$Mu \leq 0.9 \times 1{,}5\ fy \times Sx$

$$Sx \geq \frac{M_u}{\phi.1{,}5.f_y}$$

$$Sx \geq \frac{143055000}{0{,}9.1{,}5.240}$$

$$Sx \geq 441527{,}78 mm^3$$

Maka, profil baja IWF yang digunakan adalah 300x150x6,5x9

$Sx = Zx = 481\ cm^3 = 481.10^3\ mm^3 > 441{,}53.10^3\ mm^3$

3. Pendimensian Kolom

Berat Pelat

$2x(6x8{,}4)x960 = 96768$ kg

Balok

$(2x3)36{,}7 = 220{,}2kg$

$(1x4{,}8)36{,}7 = 176{,}16kg$

$(1x3{,}6)36{,}7 = 132{,}12kg$

Pasangan Dinding Bata

$2x(8{,}4x250) = 4200kg$

P_{total} = 101496,48 kg

P_{total} = 1014964,8 N

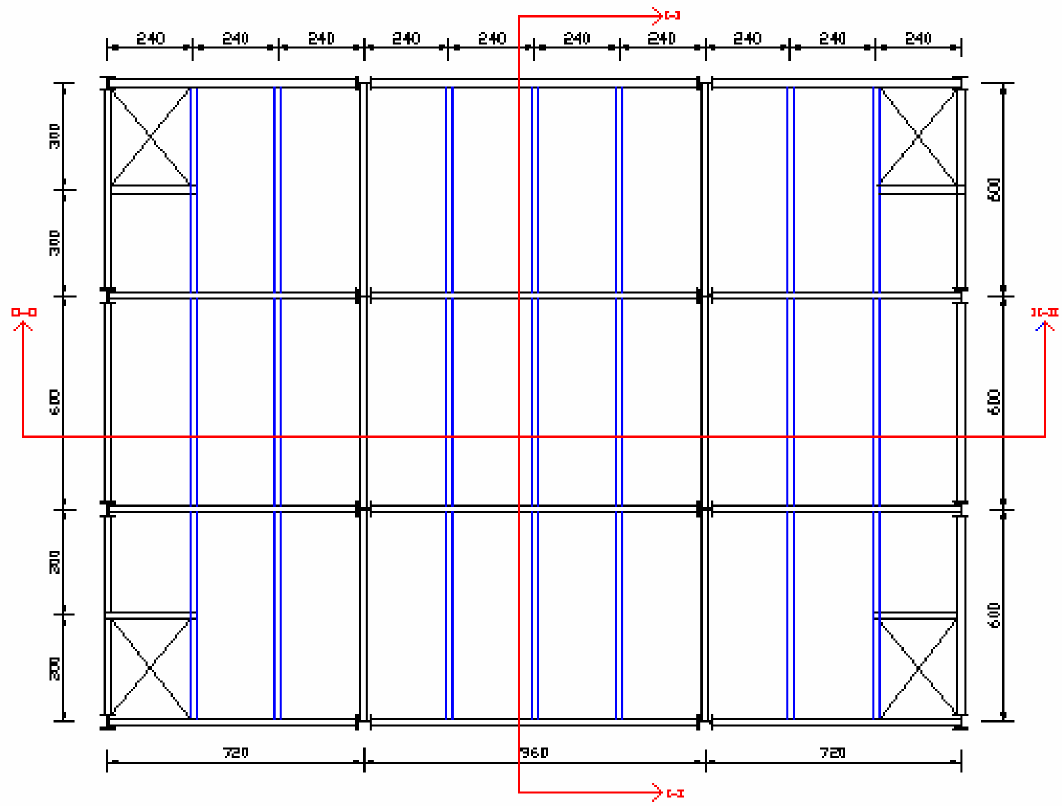
Nu	$\geq \Phi$ Nn
1014964,8	$\geq$ 0.85 x 0,6 x Ag x fy
Ag	$\geq$ 1014964,8 / (0.85 x 0,6 x 240)
Ag	$\geq 1313\ mm^2 = 13{,}13\ cm^2$
Ag	$\geq 8292{,}2\ mm^2 = 82{,}922\ cm^2$

Diambil Profil I dipakai $300x300x10x15$

Ag $= 94{,}0\ cm^2 > 82{,}922\ cm^2$

LAMPIRAN X

DENAH STRUKTUR


240
240
240
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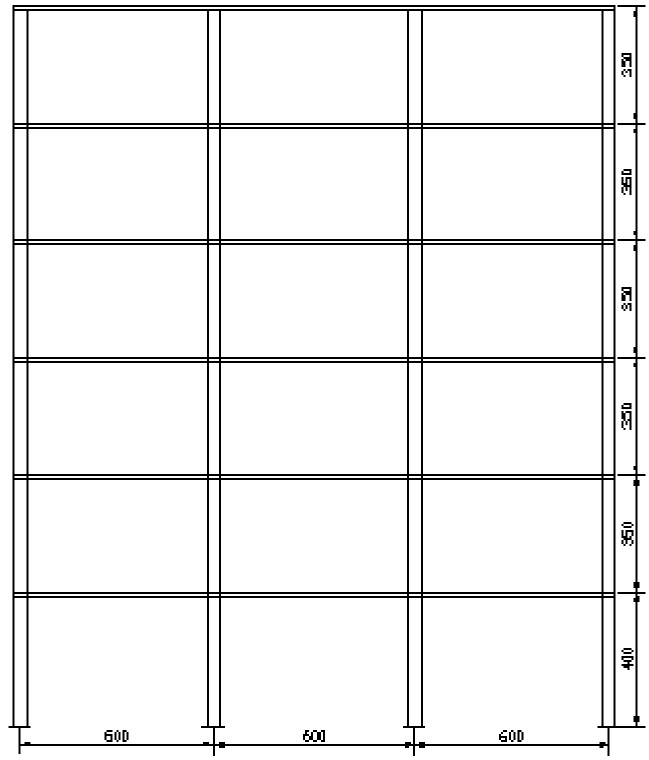
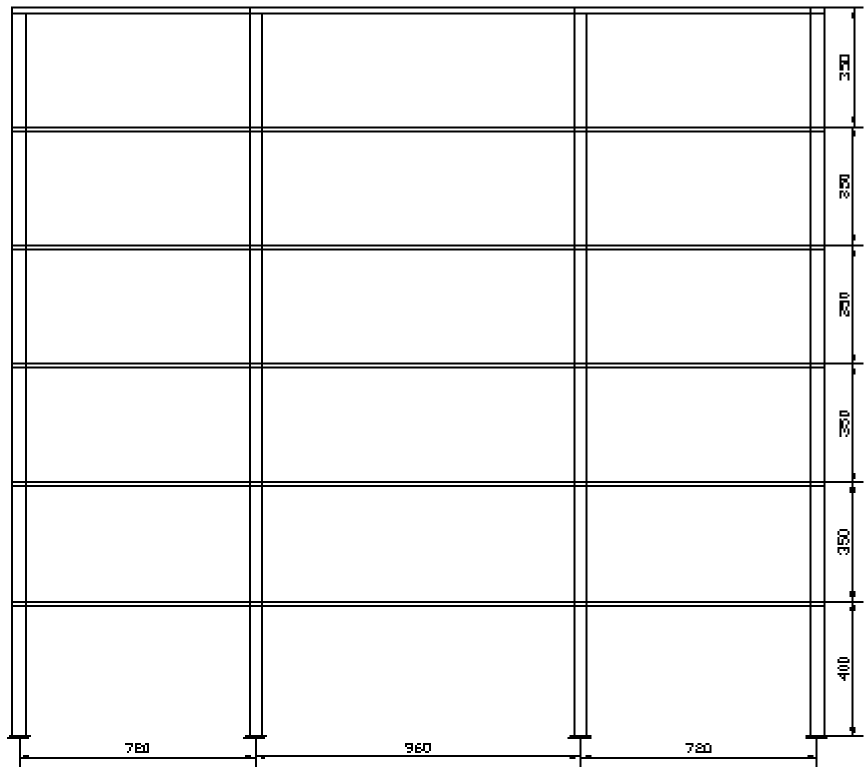
240
240
240
240
300
300
600
300
300
600
600
600
720
960
720

Tampak Atas



Potongan I-I



Potongan II-II

LAMPIRAN XI

REAKSI PERLETAKAN

A. Struktur Gedung yang Didesain Berdasarkan SNI 03-1726-2002

Story	Point	Load	FX	FY	FZ	MX	MY	MZ
BASE	2	COMB1	218.39	47.88	153822	-49.465	296.203	0.006
BASE	2	COMB2	-69.63	102.72	202000.1	-120.837	-72.315	0.005
BASE	2	COMB3	-1991.15	-185.92	152639.1	582.997	-5063.95	0.043
BASE	2	COMB4	-1878.93	264.9	154413.4	-600.947	-4775.11	0.094
BASE	2	COMB5	2205.02	306.55	154901.1	-716.818	5367.851	-0.032
BASE	2	COMB6	2092.8	-144.27	153126.9	467.125	5079.013	-0.084
BASE	2	COMB7	-692.68	-697.3	150740	1923.709	-1850.89	-0.062
BASE	2	COMB8	-318.63	805.43	156654	-2022.77	-888.097	0.11
BASE	2	COMB9	906.55	817.93	156800.3	-2057.53	2154.792	0.072
BASE	2	COMB10	532.5	-684.81	150886.3	1888.948	1191.997	-0.1
BASE	2	COMB11	-1957.69	-215.46	97754.56	618.108	-5025.49	0.042
BASE	2	COMB12	-1845.47	235.36	99528.77	-565.835	-4736.65	0.093
BASE	2	COMB13	2238.48	277.01	100016.6	-681.706	5406.318	-0.034
BASE	2	COMB14	2126.26	-173.81	98242.34	502.237	5117.479	-0.085
BASE	2	COMB15	-659.22	-726.84	95855.37	1958.821	-1812.43	-0.063
BASE	2	COMB16	-285.17	775.9	101769.4	-1987.66	-849.631	0.109
BASE	2	COMB17	940.01	788.39	101915.7	-2022.42	2193.259	0.071
BASE	2	COMB18	565.96	-714.34	96001.7	1924.059	1230.464	-0.101
BASE	2	COMB19	-4.52	72.75	153718.3	-84.356	7.697	0.004

B. Struktur Gedung yang Didesain Berdasarkan FEMA 450

Story	Point	Load	FX	FY	FZ	MX	MY	MZ
BASE	2	COMB1	218.39	47.88	153822	-49.465	296.203	0.006
BASE	2	COMB2	-69.63	102.72	202000.1	-120.837	-72.315	0.005
BASE	2	COMB3	-1992.98	-186.31	152637.5	584.011	-5068.51	0.043
BASE	2	COMB4	-1880.58	265.25	154414.6	-601.863	-4779.2	0.094
BASE	2	COMB5	2206.85	306.93	154902.8	-717.833	5372.41	-0.032
BASE	2	COMB6	2094.45	-144.62	153125.7	468.041	5083.101	-0.084
BASE	2	COMB7	-693.51	-698.53	150735.1	1926.942	-1852.97	-0.062
BASE	2	COMB8	-318.85	806.65	156658.8	-2025.97	-888.609	0.11
BASE	2	COMB9	907.38	819.16	156805.2	-2060.76	2156.874	0.072
BASE	2	COMB10	532.72	-686.03	150881.5	1892.151	1192.509	-0.1
BASE	2	COMB11	-1959.52	-215.84	97752.9	619.123	-5030.04	0.042
BASE	2	COMB12	-1847.12	235.71	99530.01	-566.751	-4740.73	0.093
BASE	2	COMB13	2240.31	277.4	100018.2	-682.721	5410.877	-0.034
BASE	2	COMB14	2127.91	-174.16	98241.1	503.153	5121.567	-0.085
BASE	2	COMB15	-660.05	-728.07	95850.48	1962.054	-1814.51	-0.063
BASE	2	COMB16	-285.39	777.12	101774.2	-1990.86	-850.143	0.109
BASE	2	COMB17	940.84	789.62	101920.6	-2025.65	2195.341	0.071
BASE	2	COMB18	566.18	-715.56	95996.94	1927.263	1230.976	-0.101
BASE	2	COMB19	-4.52	72.75	153718.3	-84.356	7.697	0.004