LAMPIRAN 1 : Prosedur Analisis dan Desain Struktur menggunakan Etabs ver.9.04

A. Prosedur Pemodelan Struktur Gedung (SRPMK) untuk Kontrol Simpangan Antar Tingkat Menggunakan Program ETABS v9.04

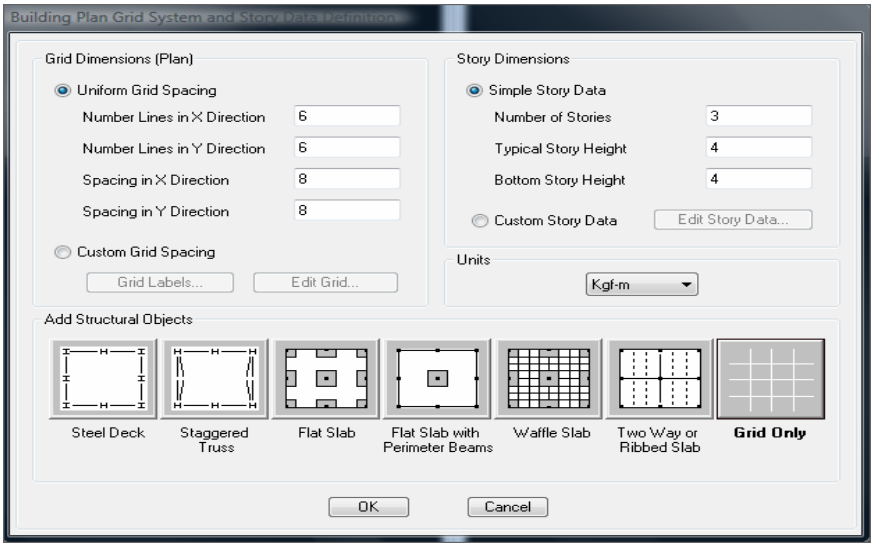
1. Input data-data pemodelan seperti :

- Satuan : kg-m
- Data-data dimensi gedung :

  Jumlah lantai = 4

  Tinggi lantai = 4,0 m

  Jarak antar kolom (as-ke-as) = 20 m,8 m dan 4 m



Gambar L-1-1 ***Building Plan Grid System and Story Data Definition***

- Data-data material/bahan :

  Berat per unit volume = 2400 kg/m^3

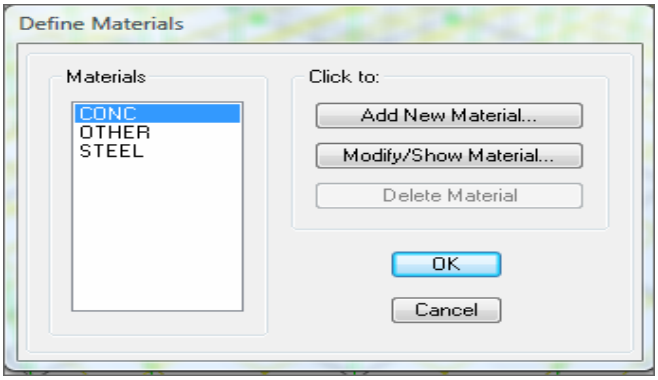
  Massa per unit = 244.648318 kg det^2/m^2

  Mutu beton : f'c = 30 MPa

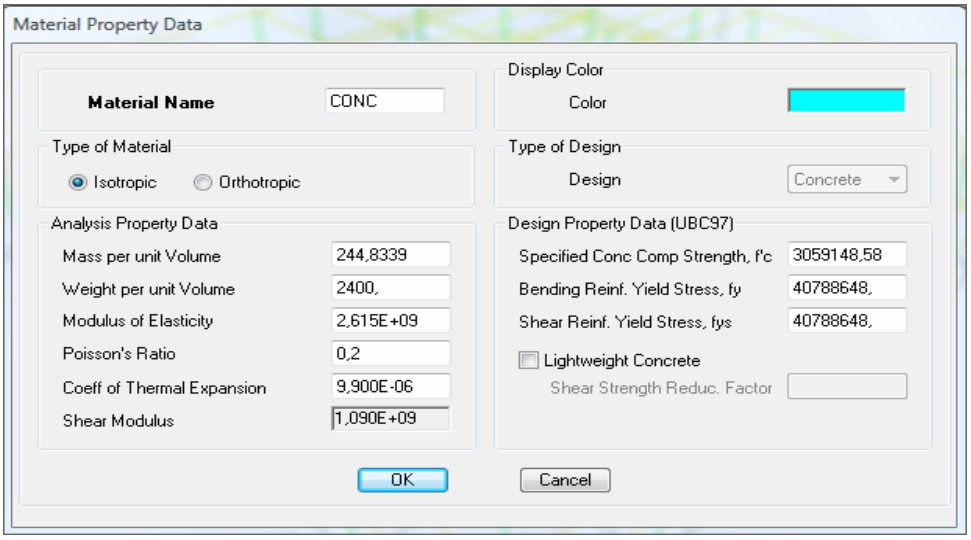
Mutu baja : fy = 400 MPa (tulangan longitudinal)

fys = 400 MPa (tulangan transversal)

Modulus elastisitas beton : Ec= 2.6154 x 10^{9} kg/m^2



Gambar L-1-2 *Define Materials*

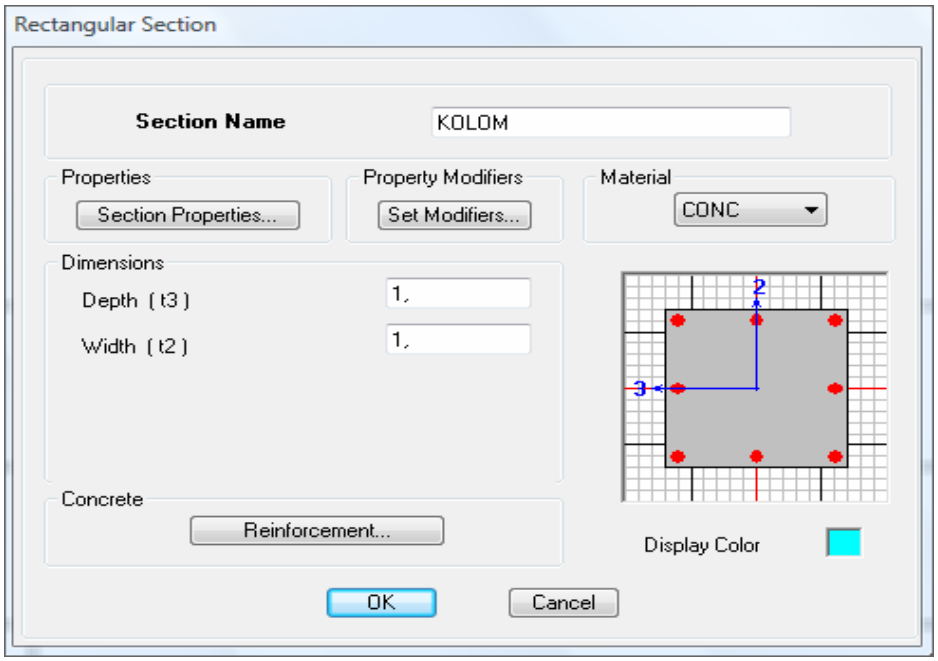


Gambar L-1-3 *Material Property Data*

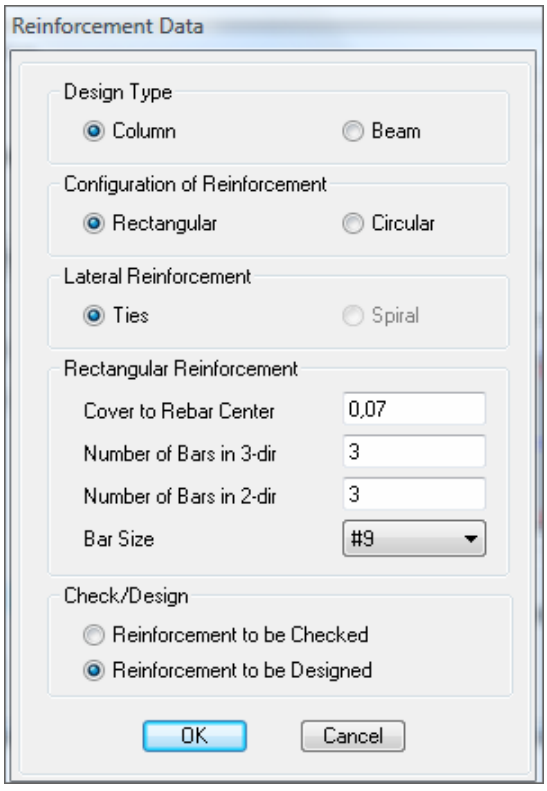
- Data-data dimensi kolom, balok, pelat :

Ukuran kolom dan balok

a. Kolom = 100x100 cm

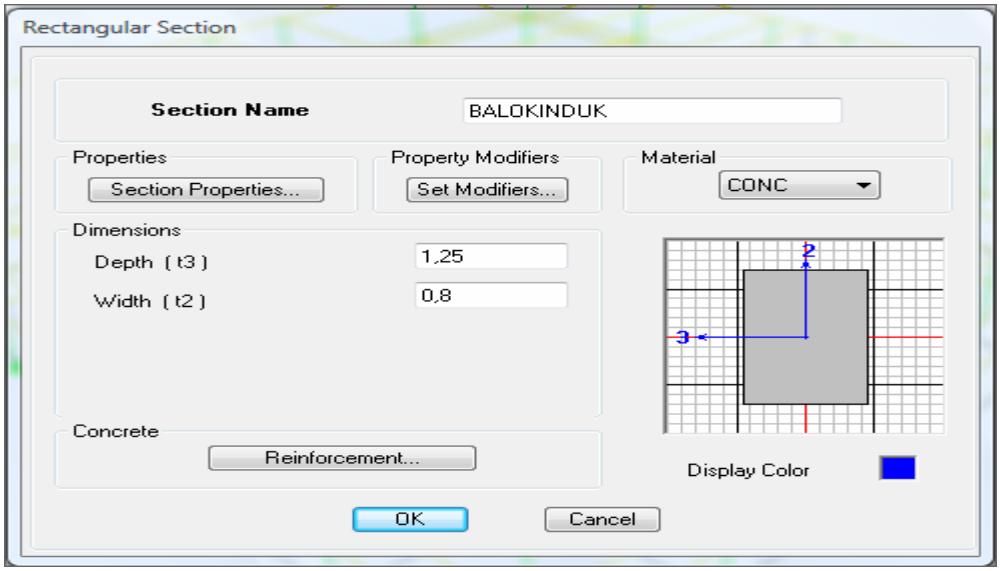


Gambar L-1-4 *Rectangular Section*

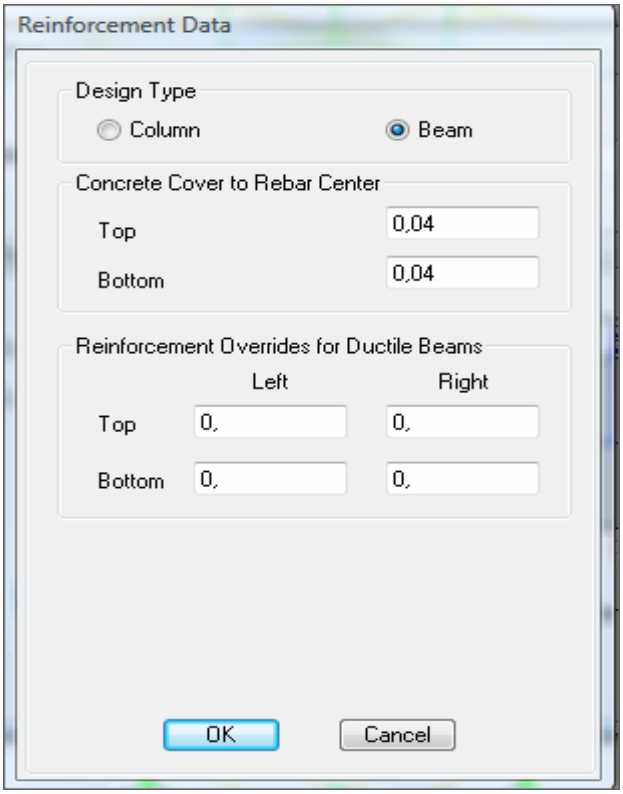


Gambar L-1-5 *Reinforcement Data*

b. Balok Induk = 80 x 125 cm

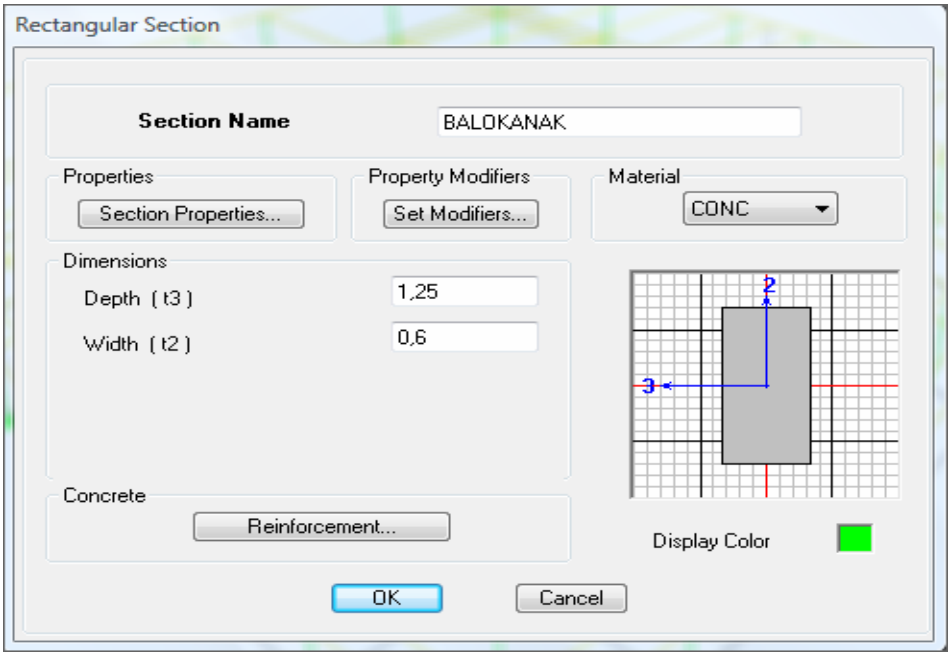


Gambar L-1-6 *Rectangular Section*

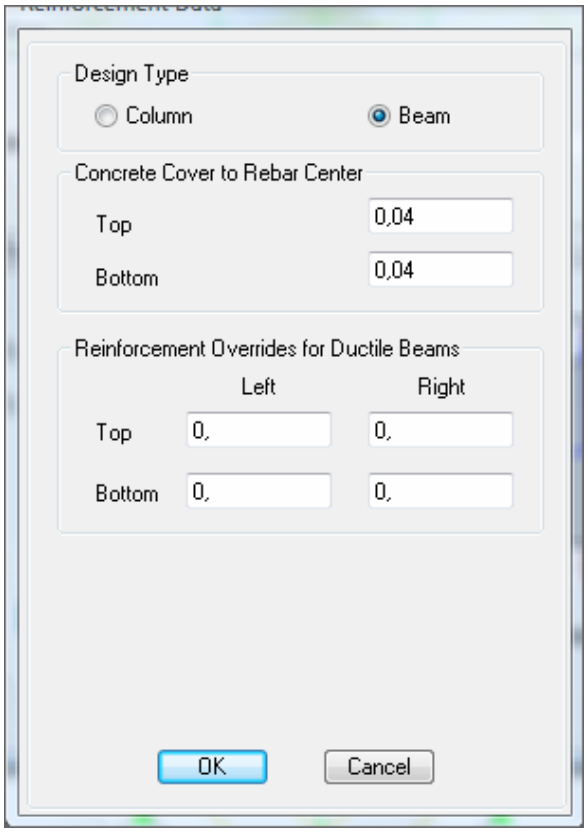


Gambar L-1-7 *Reinforcement Data*

c. Balok Anak = 60 x 125 cm

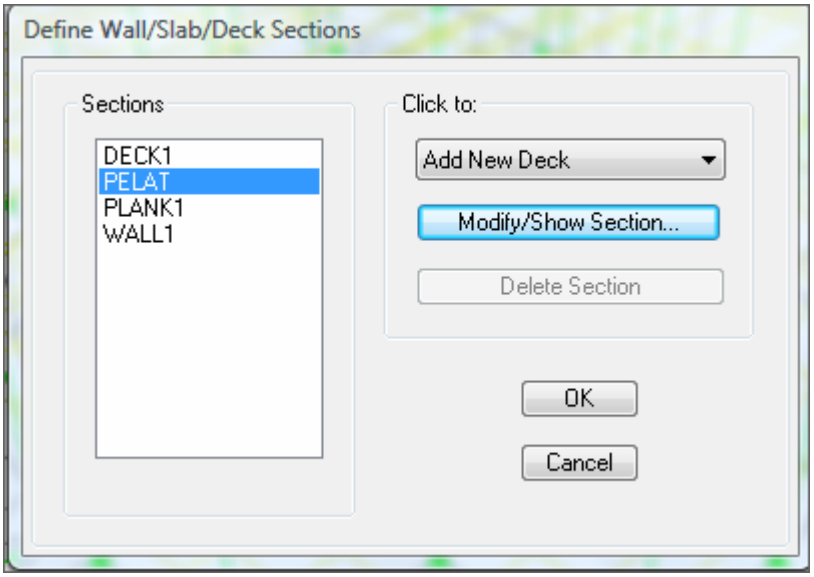


Gambar L-1-8 *Rectangular Section*

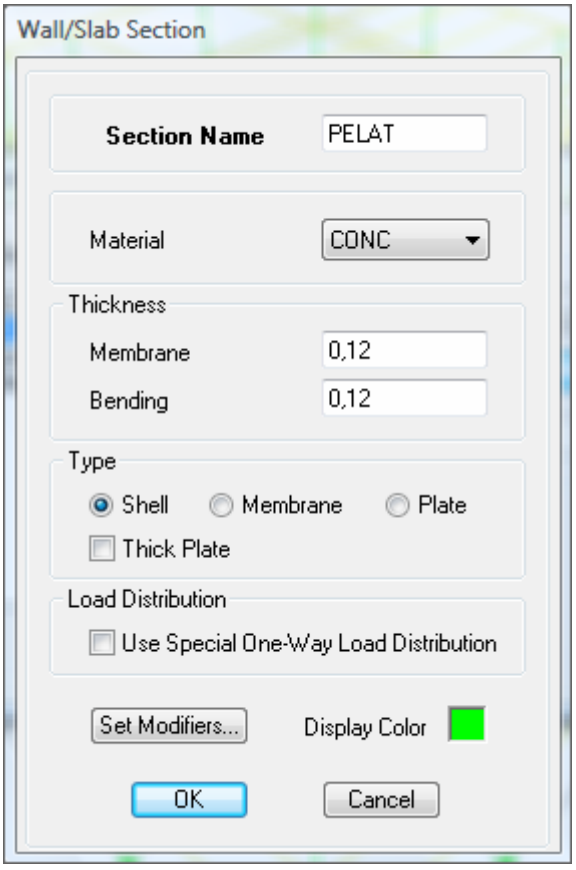


Gambar L-1-9 *Reinforcement Data*

d. Tebal Pelat = 12 cm



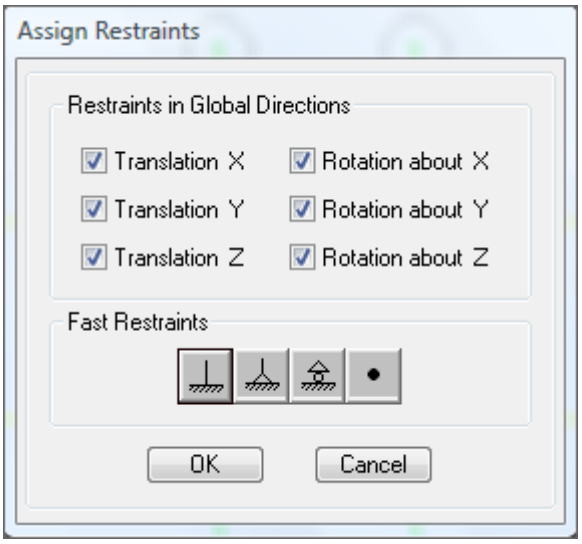
Gambar L-1-10 *Define Wall/Slab/Deck Section*



Gambar L-1-11 *Wall/Slab Section*

- Perletakan

Jenis perletakan yang dipakai adalah jepit

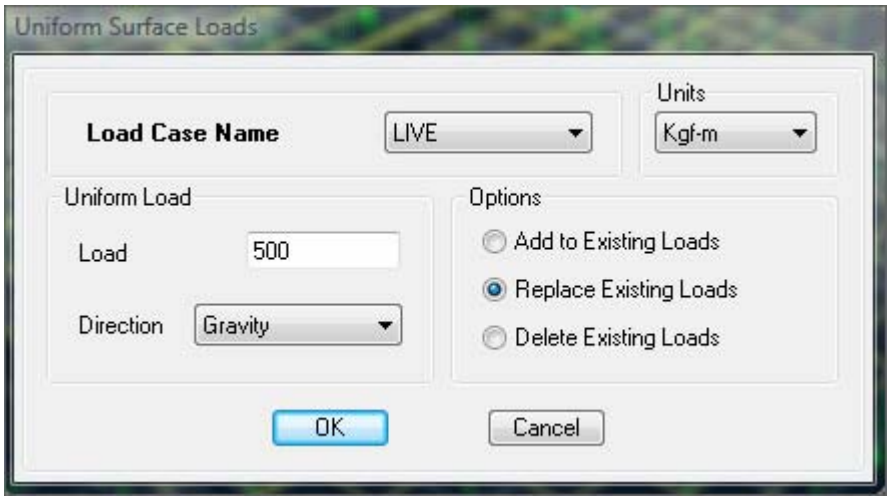


Gambar L-1-12 *Assign Restraints*

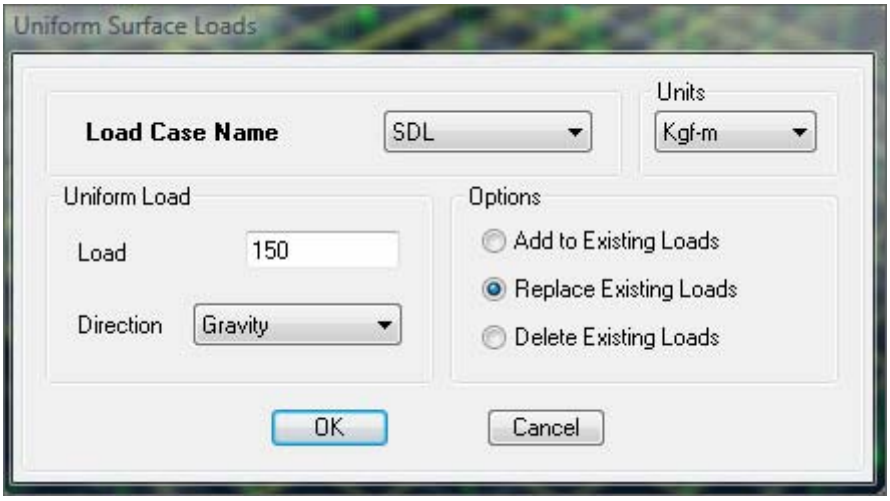
2. Input beban-beban grvitasi yang bekerja pada struktur gedung (DL,SDL,LL) :

Pada pelat : LL = 500 kg/m^2

SDL = 150 kg/m^2



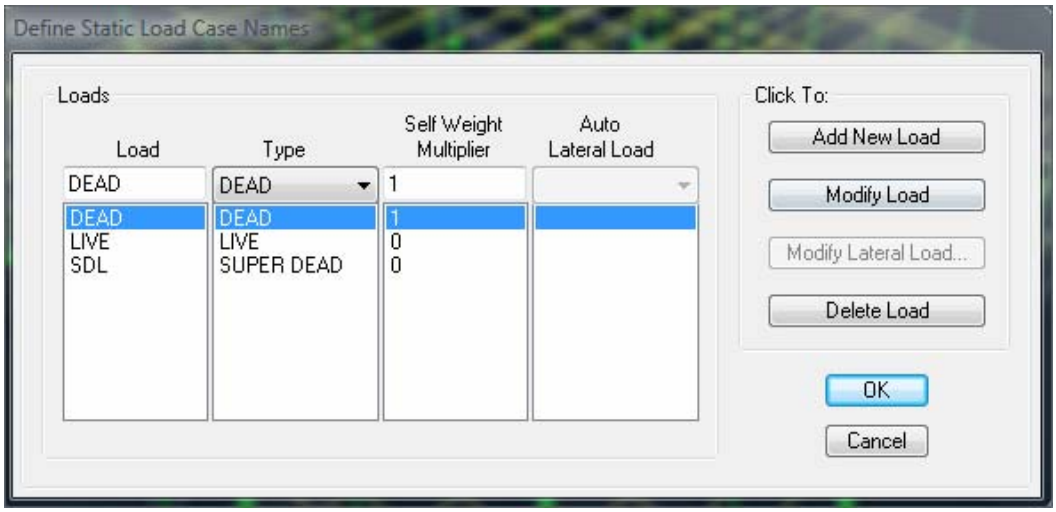
Gambar L-1-13 *Uniform Surface Loads*



Gambar L-1-14 *Uniform Surface Loads*

Catatan :

- Berat sendiri struktur dimasukkan dalam DL, sehingga *self weight multipliernya* = 1

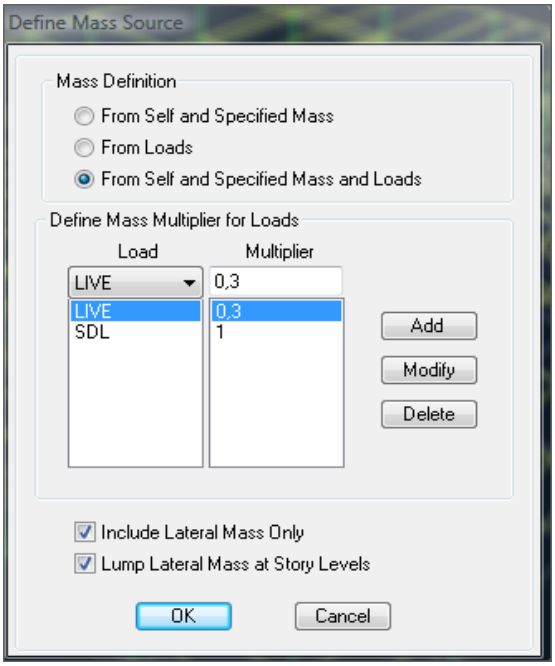


Gambar L-1-17 *Define Static Load Case Names*

- Define mass source

  Mass Definition : *From Self and Specified Mass and Loads Define Mass*

  Multiplier for loads : sesuai dengan peraturan pembebanan hanya LL yang menggunakan 30%, beban lainnya 100%.

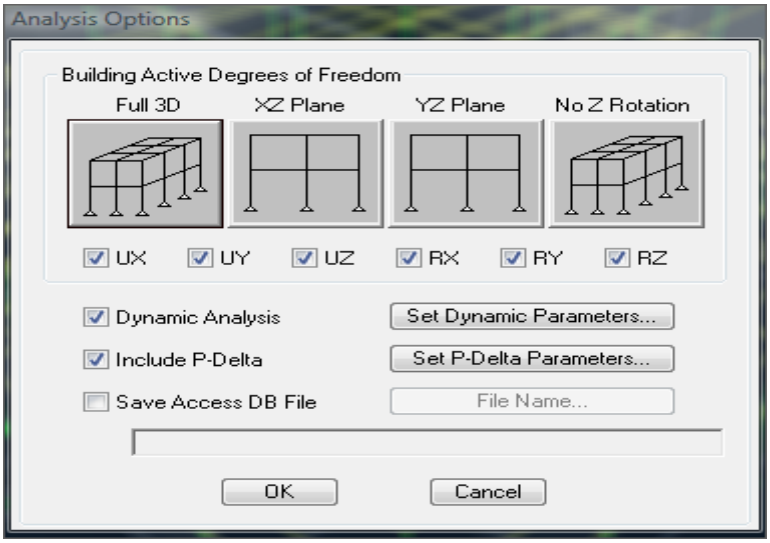


Gambar L-1-18 *Define Mass Source*

3. Lakukan Analisis tahap 1

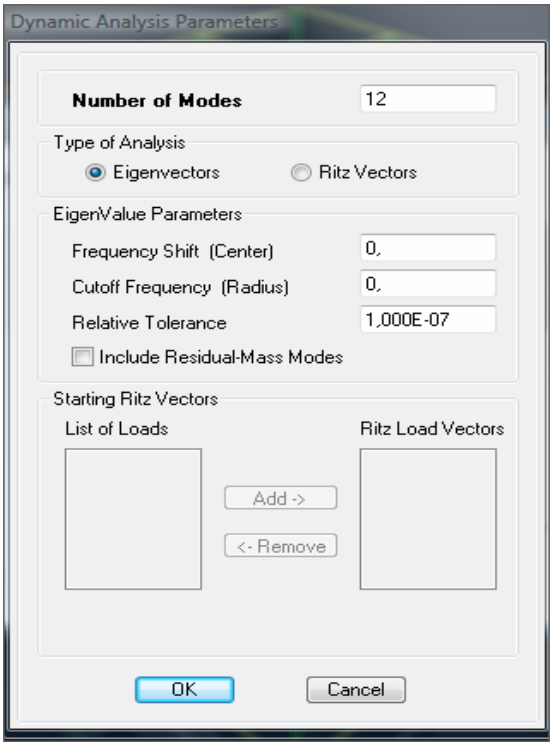
Catatan :

Set Analysis Option



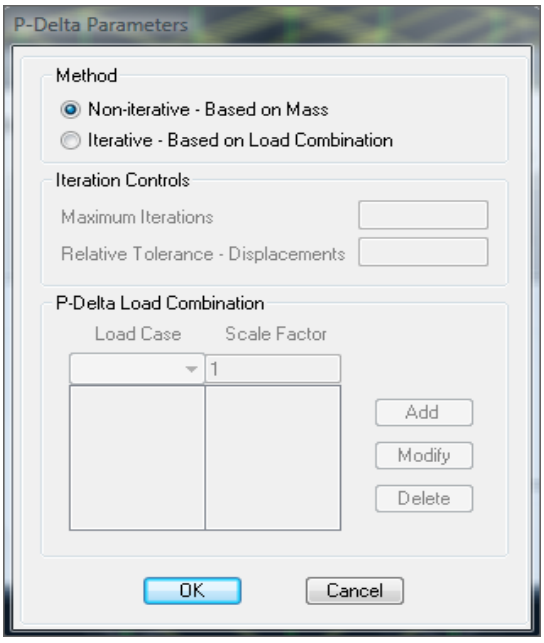
Gambar L-1-19 *Analysis Options*

- *Set Dynamic Parameters : Type of Analysis = Eigenvectors*



Gambar L-1-20 Dynamic *Analysis Parameters*

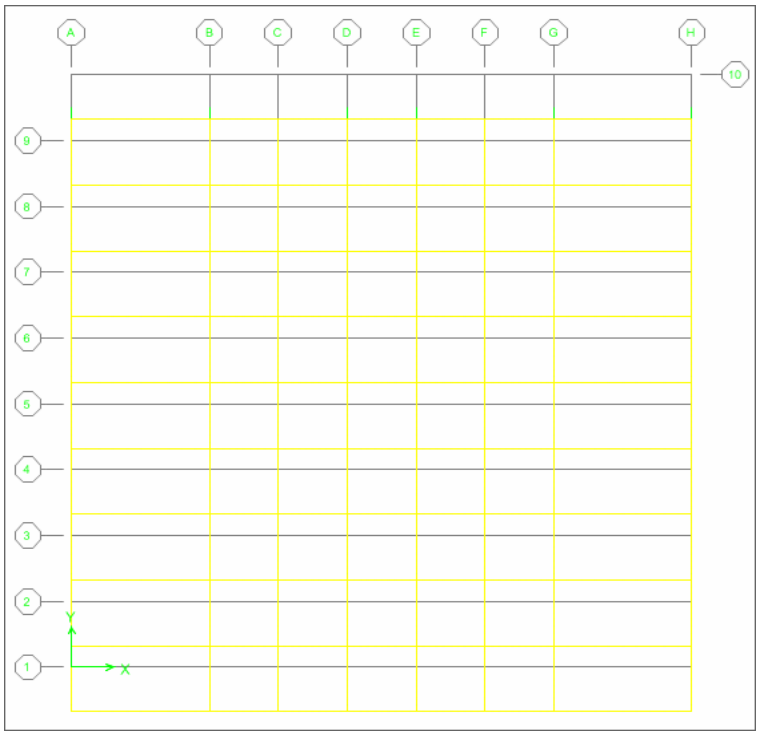
- *Set P-Delta Parameters : Non-iterative-Based on Mass*



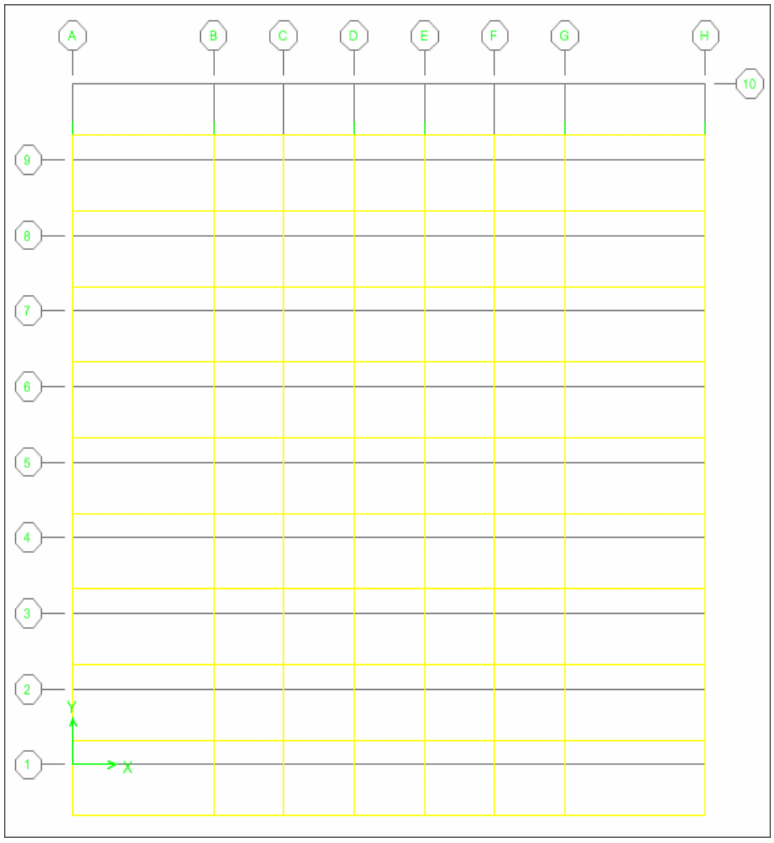
Gambar L-1-21 *P-Delta Parameters*

4. Berdasarkan analisa tahap 1 dilakukan pengecekan terhadap :

Mode : apakah *Mode* 1 dan *Mode* 2 dominan translasi, bila dominan rotasi maka struktur diperbaiki karena menunjukkan perilaku yang buruk dan tidak nyaman bagi penghuni saat terjadi gempa, sehingga perlu dilakukan analisis tahap 1 lagi

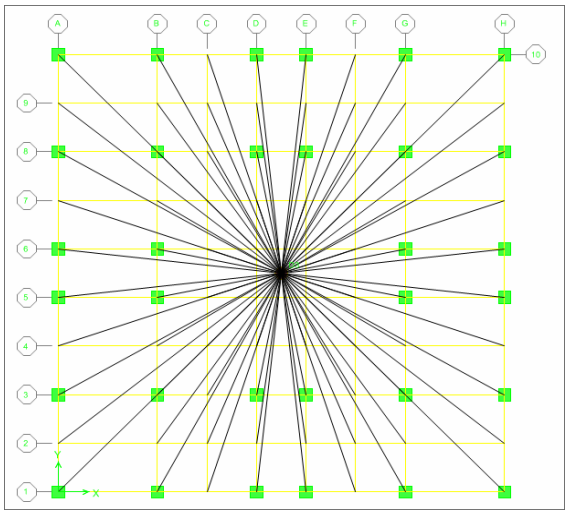


Gambar L-1-22 *Plan View Mode 1*



Gambar L-1-23 *Plan View Mode 2*

5. Buat Diafragma tiap lantai



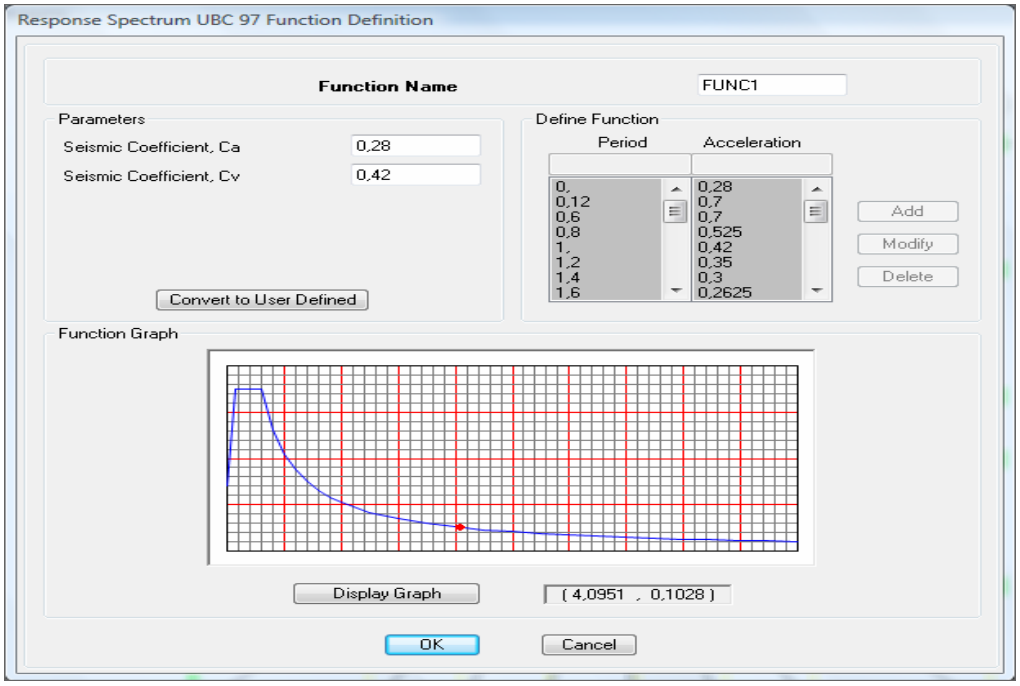
Gambar L-1-24 *Plan View Rigid Diaphragms*

6. Input beban dinamik respons spektrum

- Gunakan UBC 97 *Respons Spectrum*. Menurut SNI 03 – 1726 – 2002, masukkan koefisien Ca dan Cv sesuai dengan wilayah gempa Indonesia (lihat Gambar 3.2)

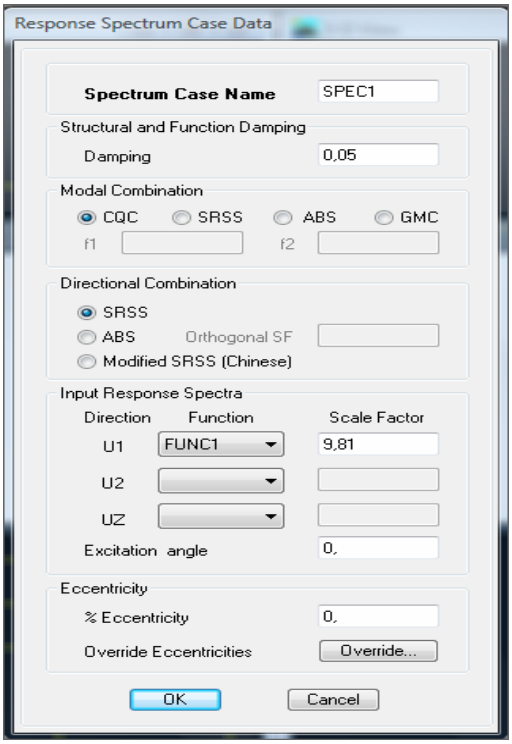
  Wilayah gempa 4 tanah sedang : Ca = 0,28

  Cv = 0,42

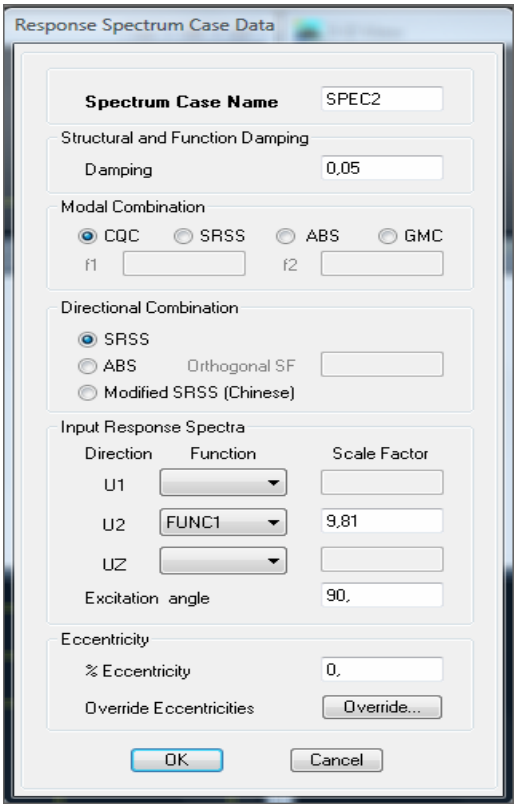


Gambar L-1-25 *Response Spectrum UBC 97 Function Definition*

- Definisikan *Respon Spectra Case*, untuk arah U1 (sumbu mayor gunakan SPECI) dan U2 (sumbu minor gunakan SPEC2), Gunakan Damping = 5%, *Modal Combination* = CQC, *Directional Combination* = SRSS, *Scale Factor* = 9,81 (percepatan gravitasi), *Excition Angle* = sudut sumbu utama yang telah ditentukan sebelumnya



Gambar L-1-26 ***Response Spectrum Case Data***

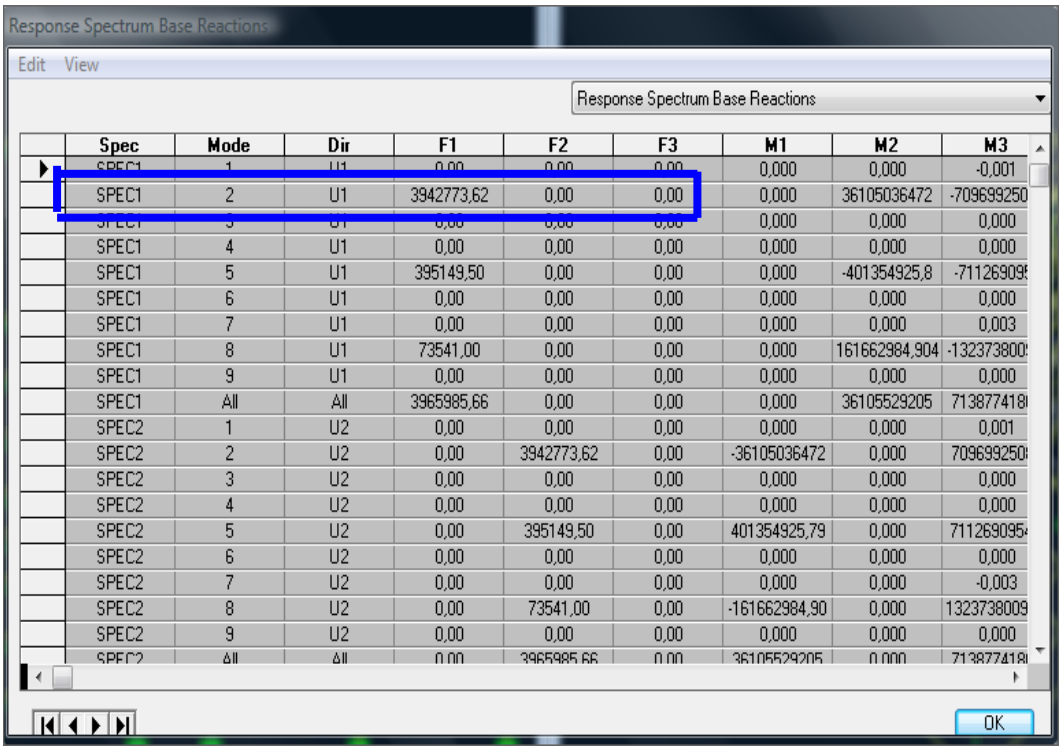


Gambar L-1-27 ***Response Spectrum Case Data***

7. **Lakukan analisis tahap 2**

8. **Berdasarkan analisis tahap 2, dilakukan pemeriksaan sebagai berikut:**

   - *Response Spec Base Reaction* : apakah menghasilkan nilai terbesar pada arah sumbu utama (F1) dan 0 pada sumbu minor (F2), apabila belum menghasilkan nilai seperti di atas maka arah gempa yang diberikan belum tepat pada sumbu utama. Lakukan lagi dengan cara mengubah sudutnya.



Spec	Mode	Dir	F1	F2	F3	M1	M2	M3
SPEC1	1	U1	0,00	0,00	0,00	0,000	0,000	-0,001
SPEC1	2	U1	3942773,62	0,00	0,00	0,000	36105036472	-709699250
SPEC1	3	U1	0,00	0,00	0,00	0,000	0,000	0,000
SPEC1	4	U1	0,00	0,00	0,00	0,000	0,000	0,000
SPEC1	5	U1	395149,50	0,00	0,00	0,000	-401354925,8	-711269095
SPEC1	6	U1	0,00	0,00	0,00	0,000	0,000	0,000
SPEC1	7	U1	0,00	0,00	0,00	0,000	0,000	0,003
SPEC1	8	U1	73541,00	0,00	0,00	0,000	161662984,904	-1323738005
SPEC1	9	U1	0,00	0,00	0,00	0,000	0,000	0,000
SPEC1	All	All	3965985,66	0,00	0,00	0,000	36105529205	713877418
SPEC2	1	U2	0,00	0,00	0,00	0,000	0,000	0,001
SPEC2	2	U2	0,00	3942773,62	0,00	-36105036472	0,000	709699250
SPEC2	3	U2	0,00	0,00	0,00	0,000	0,000	0,000
SPEC2	4	U2	0,00	0,00	0,00	0,000	0,000	0,000
SPEC2	5	U2	0,00	395149,50	0,00	401354925,79	0,000	711269095
SPEC2	6	U2	0,00	0,00	0,00	0,000	0,000	0,000
SPEC2	7	U2	0,00	0,00	0,00	0,000	0,000	-0,003
SPEC2	8	U2	0,00	73541,00	0,00	-161662984,90	0,000	1323738009
SPEC2	9	U2	0,00	0,00	0,00	0,000	0,000	0,000
SPEC2	All	All	0,00	3965985,66	0,00	36105529205	0,000	713877418

Gambar L-1-28 *Response Spectrum Base Reactions*

Diketahui hasil ETABS : F1 = 3942773,62 kg

F2 = 0

- Nilai akhir respon dinamik struktur gedung terhadap pembebanan gempa nominal akibat gempa rencana dalam suatu arah tertentu, tidak boleh

kurang dari 80% nilai respon ragam yang pertama. Untuk memenuhinya, maka gaya geser tingkat akibat pengaruh gempa rencana sepanjang tinggi struktur gedung hasil analisis ragam spektrum respon dalam arah tertentu harus dikalikan dengan faktor skala:

-

$$f = \frac{0{,}8Vs}{Vd} \geq \frac{1}{R} \qquad \text{(L.1.1)}$$

dimana : Vs = gaya geser dasar statik (kg)

Vd = gaya geser dasar dinamik (kg)

R = faktor reduksi gempa (lihat Tabel 3.2)

- Hitung faktor skala dengan melihat output *Respon Spec Base Reaction* untuk menentukan nilai Vd (gaya geser dasar dinamik) sedangkan Vs (gaya geser dasar static) dihitung dengan rumus sebagai berikut:

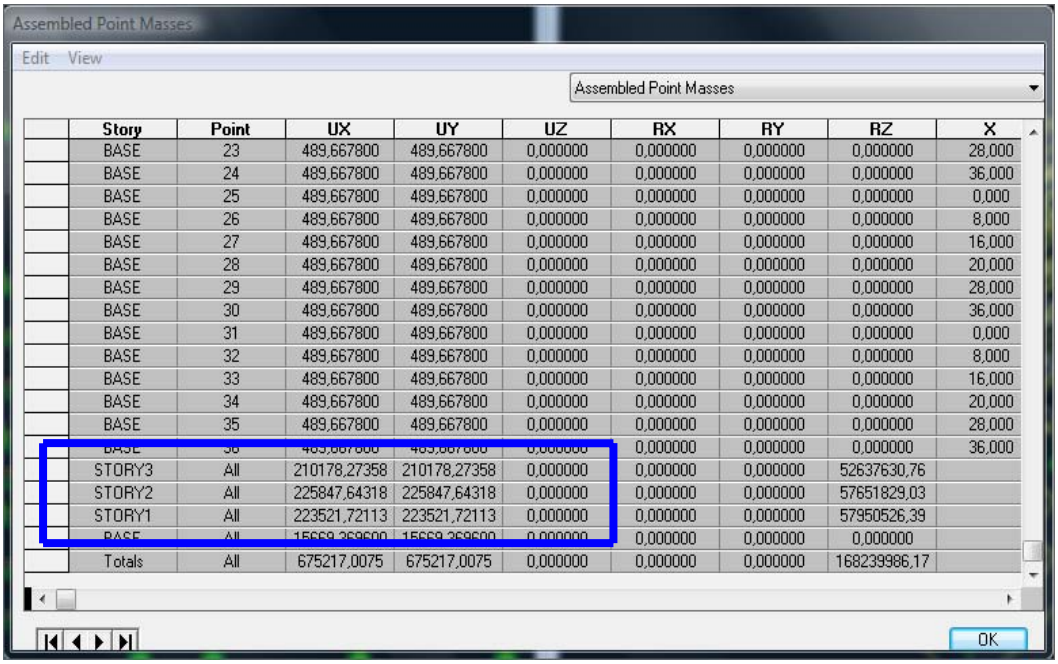
$$Vs = \min \left[\frac{2{,}5CaI}{R} Wt, \frac{CvI}{RT} W_T \right] \qquad \text{(L.1.2)}$$

dimana: *Wt* = berat total seluruh lantai kecuali base (kg)

T = periode (det.)

Perhitungan Faktor Skala

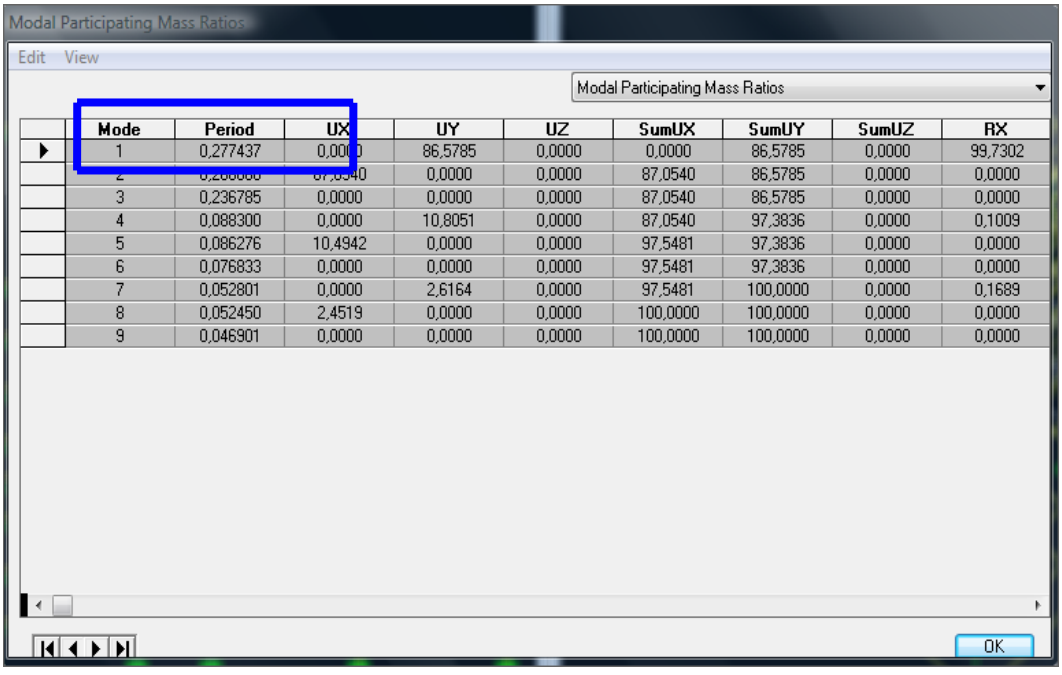
Gambar L-1-29 adalah Massa perlantai gedung yang didapatkan dari langkah perhitungan tahap 1 dan tahap 2



Story	Point	UX	UY	UZ	RX	RY	RZ	X
BASE	23	489,667800	489,667800	0,000000	0,000000	0,000000	0,000000	28,000
BASE	24	489,667800	489,667800	0,000000	0,000000	0,000000	0,000000	36,000
BASE	25	489,667800	489,667800	0,000000	0,000000	0,000000	0,000000	0,000
BASE	26	489,667800	489,667800	0,000000	0,000000	0,000000	0,000000	8,000
BASE	27	489,667800	489,667800	0,000000	0,000000	0,000000	0,000000	16,000
BASE	28	489,667800	489,667800	0,000000	0,000000	0,000000	0,000000	20,000
BASE	29	489,667800	489,667800	0,000000	0,000000	0,000000	0,000000	28,000
BASE	30	489,667800	489,667800	0,000000	0,000000	0,000000	0,000000	36,000
BASE	31	489,667800	489,667800	0,000000	0,000000	0,000000	0,000000	0,000
BASE	32	489,667800	489,667800	0,000000	0,000000	0,000000	0,000000	8,000
BASE	33	489,667800	489,667800	0,000000	0,000000	0,000000	0,000000	16,000
BASE	34	489,667800	489,667800	0,000000	0,000000	0,000000	0,000000	20,000
BASE	35	489,667800	489,667800	0,000000	0,000000	0,000000	0,000000	28,000
BASE	36	489,667800	489,667800	0,000000	0,000000	0,000000	0,000000	36,000
STORY3	All	210178,27358	210178,27358	0,000000	0,000000	0,000000	52637630,76	
STORY2	All	225847,64318	225847,64318	0,000000	0,000000	0,000000	57651829,03	
STORY1	All	223521,72113	223521,72113	0,000000	0,000000	0,000000	57950526,39	
BASE	All	15669,269600	15669,269600	0,000000	0,000000	0,000000	0,000000	
Totals	All	675217,0075	675217,0075	0,000000	0,000000	0,000000	168239986,17	

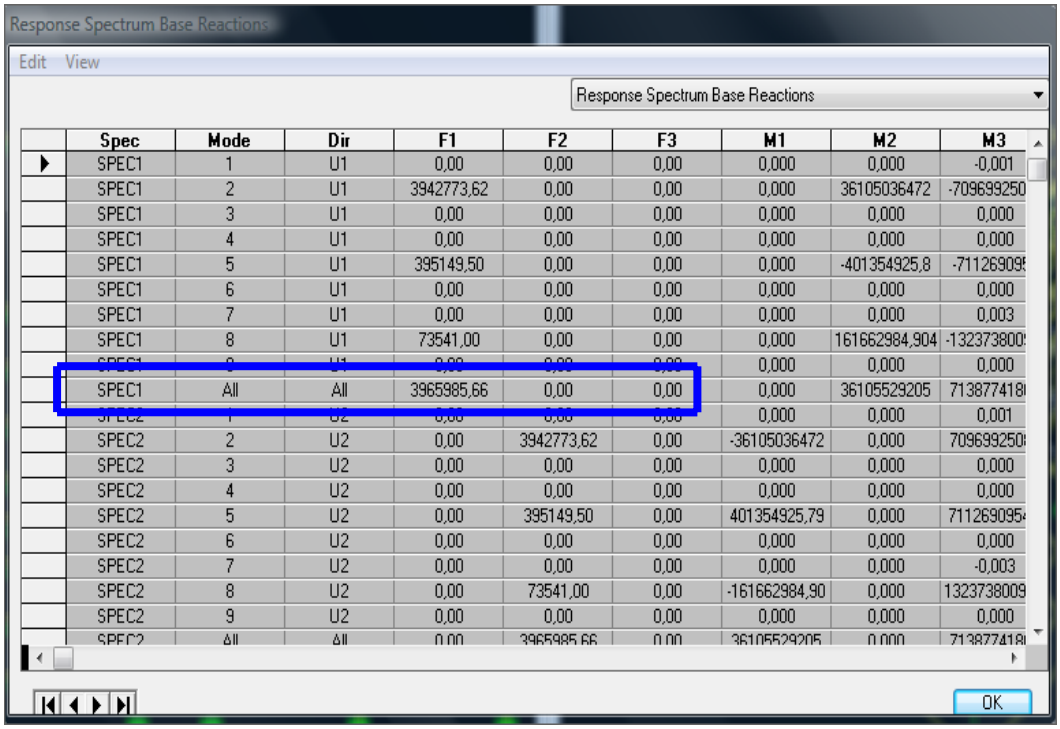
Gambar L-1-29 *Assembled Point Masses*

Gambar L-1-30 adalah periode getar atau waktu getar yang didapatkan dari langkah perhitungan tahap 1 dan tahap 2



Mode	Period	UX	UY	UZ	SumUX	SumUY	SumUZ	RX
1	0,277437	0,0000	86,5785	0,0000	0,0000	86,5785	0,0000	99,7302
2	0,266660	87,0540	0,0000	0,0000	87,0540	86,5785	0,0000	0,0000
3	0,236785	0,0000	0,0000	0,0000	87,0540	86,5785	0,0000	0,0000
4	0,088300	0,0000	10,8051	0,0000	87,0540	97,3836	0,0000	0,1009
5	0,086276	10,4942	0,0000	0,0000	97,5481	97,3836	0,0000	0,0000
6	0,076833	0,0000	0,0000	0,0000	97,5481	97,3836	0,0000	0,0000
7	0,052801	0,0000	2,6164	0,0000	97,5481	100,0000	0,0000	0,1689
8	0,052450	2,4519	0,0000	0,0000	100,0000	100,0000	0,0000	0,0000
9	0,046901	0,0000	0,0000	0,0000	100,0000	100,0000	0,0000	0,0000

Gambar L-1-30 *Modal Participating Mass Ratios*



Spec	Mode	Dir	F1	F2	F3	M1	M2	M3
SPEC1	1	U1	0,00	0,00	0,00	0,000	0,000	-0,001
SPEC1	2	U1	3942773,62	0,00	0,00	0,000	36105036472	-709699250
SPEC1	3	U1	0,00	0,00	0,00	0,000	0,000	0,000
SPEC1	4	U1	0,00	0,00	0,00	0,000	0,000	0,000
SPEC1	5	U1	395149,50	0,00	0,00	0,000	-401354925,8	-711269095
SPEC1	6	U1	0,00	0,00	0,00	0,000	0,000	0,000
SPEC1	7	U1	0,00	0,00	0,00	0,000	0,000	0,003
SPEC1	8	U1	73541,00	0,00	0,00	0,000	161662984,904	-1323738005
SPEC1	9	U1	0,00	0,00	0,00	0,000	0,000	0,000
SPEC1	All	All	3965985,66	0,00	0,00	0,000	36105529205	713877418
SPEC2	1	U2	0,00	0,00	0,00	0,000	0,000	0,001
SPEC2	2	U2	0,00	3942773,62	0,00	-36105036472	0,000	709699250
SPEC2	3	U2	0,00	0,00	0,00	0,000	0,000	0,000
SPEC2	4	U2	0,00	0,00	0,00	0,000	0,000	0,000
SPEC2	5	U2	0,00	395149,50	0,00	401354925,79	0,000	711269095
SPEC2	6	U2	0,00	0,00	0,00	0,000	0,000	0,000
SPEC2	7	U2	0,00	0,00	0,00	0,000	0,000	-0,003
SPEC2	8	U2	0,00	73541,00	0,00	-161662984,90	0,000	1323738009
SPEC2	9	U2	0,00	0,00	0,00	0,000	0,000	0,000
SPEC2	All	All	0,00	3965985,66	0,00	36105529205	0,000	713877418

Gambar L-1-31 *Response Spectrum Base Reactions*

Diketahui : I = 1

R = 8,5

Ca = 0,28 ; Cv = 0,42

Dari ETABS : Wt = mt x g

= (210178,27538 + 225847,64318 + 223521,72113) x 9,81

= 6470162,343 kg

T = 0,277437 det

Vd = 3965985,66 kg

$$Vs = \min\left[\frac{2{,}5CaI}{R}Wt, \frac{CvI}{RT}Wt\right]$$

$$Vs = \min\left[\frac{2,5x0,28x1}{8,5}x6470162,343\,,\frac{0,42x1}{8,5x0,277437}6470162,343\right]$$

Vs = min [532836.8988 , 1152341.394]

Vs = 532836.8988 kg

$$f = \frac{0,8Vs}{Vd}$$

$$f = \frac{0,8x532836.8988}{3965985,66}$$

f = 0,107481

$$f = \max\left[\frac{0,8Vs}{Vd},\frac{I}{R}\right]$$

f = max [0.107481 , 0.11765]

f = 0.11765

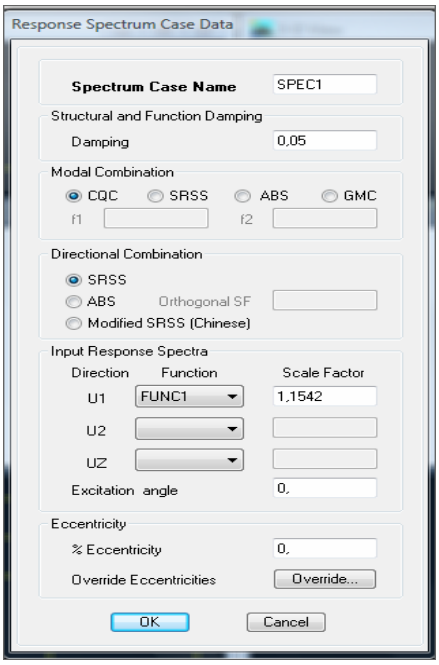
f* = f x g

= 0.11765 x 9.81

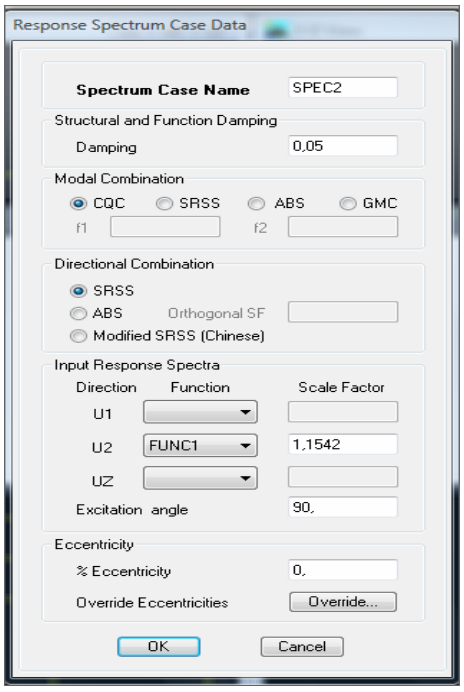
= 1.15415 m/det^2

(kemudian f* dimasukkan ke dalam ETABS untuk analisis berikutnya) Kemudian digunakan *SPEC1* dan *SPEC2* dengan data sebagai berikut : *Directional Combination: SRSS*

Input *Response Spectra* diisikan untuk SPEC1 dengan arah U1 dan SPEC2 dengan arah U2, dan dengan faktor skala f* yang telah didapat di atas



Gambar L-1-32 *Response Spectrum Case Data*



Gambar L-1-33 *Response Spectrum Case Data*

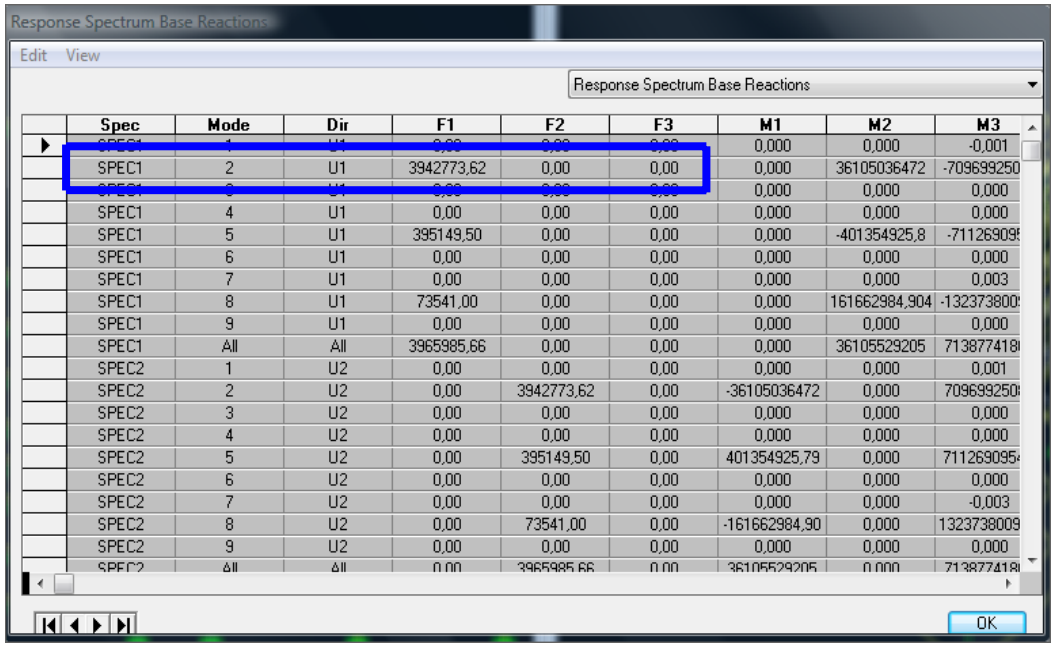
Lakukan analisis tahap 3, kemudian lakukan kontrol simpangan antar tingkat berdasarkan output ETABS. (Pada Tugas Akhir ini gedung dianggap cukup jauh dari bangunan-bangunan lain sehingga batas lahan tidak perlu dikontrol).

B. **Prosedur pemodelan struktur gedung (SRPMK) untuk keperluan desain menggunakan program ETABS V9.04**

Untuk langkah-langkah pemodelan hamper sama dengan langkah-langkah pemodelan untuk kontrol simpangan antar tingkat, yaitu pada langkah 1 sampai langkah 7. Untuk selanjutnya ada sedikit perbedaan, seperti di bawah ini:

8. Berdasarkan analisis tahap 2, dilakukan pemeriksaan sebagai berikut:

- *Response Spec Base Reaction:* apakah menghasilkan nilai terbesar pada arah sumbu utama (F1) dan 0 pada sumbu minor (F2), apabila belum menghasilkan nilai seperti diatas maka arah gempa yang diberikan belum tepat pada sumbu utama. Lakukan lagi dengan mengubah sudutnya.



Spec	Mode	Dir	F1	F2	F3	M1	M2	M3
SPEC1	1	U1	0,00	0,00	0,00	0,000	0,000	-0,001
SPEC1	2	U1	3942773,62	0,00	0,00	0,000	36105036472	-709699250
SPEC1	3	U1	0,00	0,00	0,00	0,000	0,000	0,000
SPEC1	4	U1	0,00	0,00	0,00	0,000	0,000	0,000
SPEC1	5	U1	395149,50	0,00	0,00	0,000	-401354925,8	-711269095
SPEC1	6	U1	0,00	0,00	0,00	0,000	0,000	0,000
SPEC1	7	U1	0,00	0,00	0,00	0,000	0,000	0,003
SPEC1	8	U1	73541,00	0,00	0,00	0,000	161662984,904	-132373800
SPEC1	9	U1	0,00	0,00	0,00	0,000	0,000	0,000
SPEC1	All	All	3965985,66	0,00	0,00	0,000	36105529205	713877418
SPEC2	1	U2	0,00	0,00	0,00	0,000	0,000	0,001
SPEC2	2	U2	0,00	3942773,62	0,00	-36105036472	0,000	709699250
SPEC2	3	U2	0,00	0,00	0,00	0,000	0,000	0,000
SPEC2	4	U2	0,00	0,00	0,00	0,000	0,000	0,000
SPEC2	5	U2	0,00	395149,50	0,00	401354925,79	0,000	711269095
SPEC2	6	U2	0,00	0,00	0,00	0,000	0,000	0,000
SPEC2	7	U2	0,00	0,00	0,00	0,000	0,000	-0,003
SPEC2	8	U2	0,00	73541,00	0,00	-161662984,90	0,000	1323738009
SPEC2	9	U2	0,00	0,00	0,00	0,000	0,000	0,000
SPEC2	All	All	0,00	3965985,66	0,00	36105529205	0,000	713877418

Gambar L-1-34 *Response Spectrum Base Reactions*

Diketahui hasil ETABS : F1 = 3942773,62 kg

F2 = 0 kg

Nilai akhir respon dinamik struktur gedung terhadap pembebanan gempa nominal akibat gempa rencana dalam suatu arah tertentu, tidak boleh kurang dari 80% nilai respon ragam yang pertama. Untuk memenuhinya, maka gaya geser tingkat akibat pengaruh gempa rencana sepanjang tinggi struktur gedung hasil analisis ragam spektrum respon dalam arah tertentu harus dikalikan dengan faktor skala:

$$f = \frac{0{,}8Vs}{Vd} \geq \frac{1}{R} \qquad \text{(L.2.1)}$$

dimana : Vs = gaya geser dasar statik (kg)

Vd = gaya geser dasar dinamik (kg)

R = faktor reduksi gempa (lihat Tabel 3.2)

- Hitung faktor skala dengan melihat output *Respon Spec Base Reaction* untuk menentukan nilai Vd (gaya geser dasar dinamik) sedangkan Vs (gaya geser dasar static) dihitung dengan rumus sebagai berikut:

$$Vs = \min\left[\frac{2{,}5CaI}{R}Wt, \frac{CvI}{RT}WT\right] \qquad \text{(L.2.2)}$$

dimana: *Wt* = berat total seluruh lantai kecuali base (kg)

T = periode (det.)

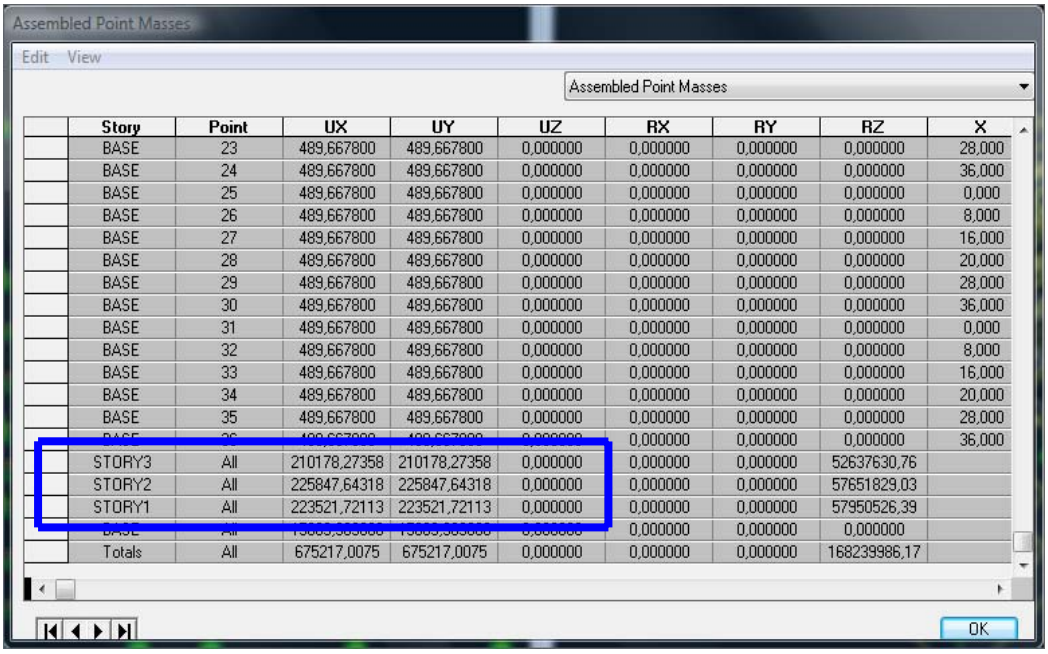
$T_{ETABS} \leq 1.2\ Ta \rightarrow T = T_{ETABS}$ (L.2.3)

$T > 1.2\ Ta \rightarrow T = Ta$ (L.2.4)

Dimana : $Ta = 0.0731\ H^{3/4}$

Perhitungan faktor skala

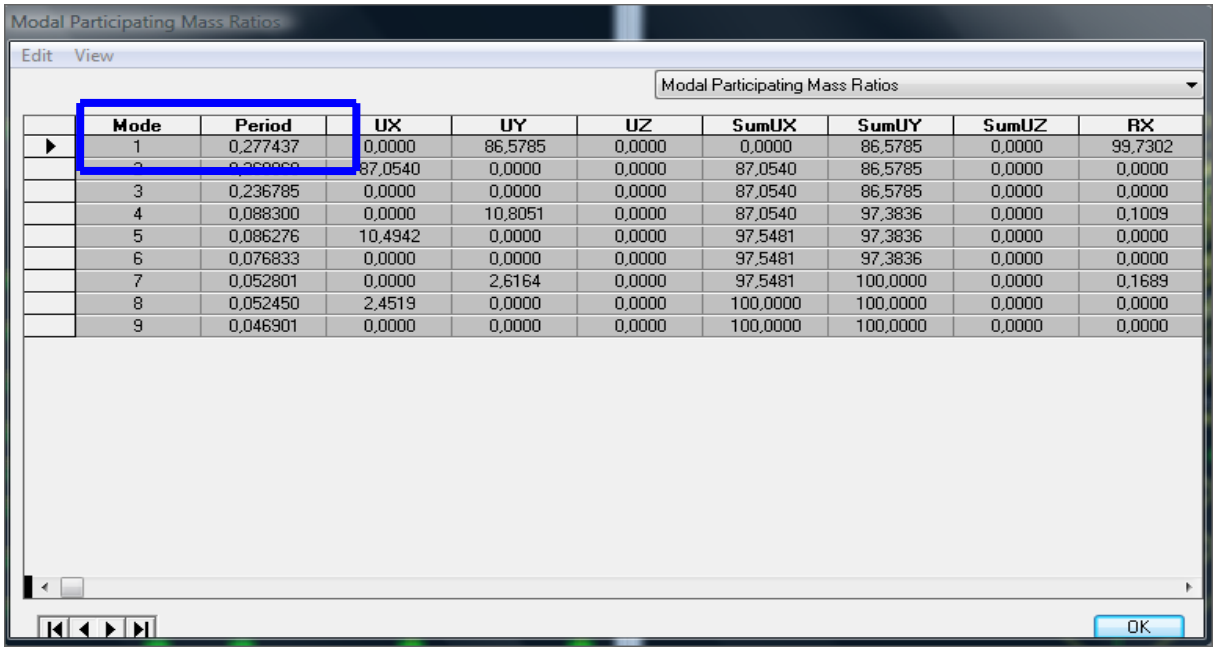
Gambar L-1-35 adalah massa perlantai gedung yang didapatkan dari langkah perhitungan tahap 1 dan tahap 2.



Story	Point	UX	UY	UZ	RX	RY	RZ	X
BASE	23	489,667800	489,667800	0,000000	0,000000	0,000000	0,000000	28,000
BASE	24	489,667800	489,667800	0,000000	0,000000	0,000000	0,000000	36,000
BASE	25	489,667800	489,667800	0,000000	0,000000	0,000000	0,000000	0,000
BASE	26	489,667800	489,667800	0,000000	0,000000	0,000000	0,000000	8,000
BASE	27	489,667800	489,667800	0,000000	0,000000	0,000000	0,000000	16,000
BASE	28	489,667800	489,667800	0,000000	0,000000	0,000000	0,000000	20,000
BASE	29	489,667800	489,667800	0,000000	0,000000	0,000000	0,000000	28,000
BASE	30	489,667800	489,667800	0,000000	0,000000	0,000000	0,000000	36,000
BASE	31	489,667800	489,667800	0,000000	0,000000	0,000000	0,000000	0,000
BASE	32	489,667800	489,667800	0,000000	0,000000	0,000000	0,000000	8,000
BASE	33	489,667800	489,667800	0,000000	0,000000	0,000000	0,000000	16,000
BASE	34	489,667800	489,667800	0,000000	0,000000	0,000000	0,000000	20,000
BASE	35	489,667800	489,667800	0,000000	0,000000	0,000000	0,000000	28,000
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0,000000	0,000000	0,000000	36,000
STORY3	All	210178,27358	210178,27358	0,000000	0,000000	0,000000	52637630,76	
STORY2	All	225847,64318	225847,64318	0,000000	0,000000	0,000000	57651829,03	
STORY1	All	223521,72113	223521,72113	0,000000	0,000000	0,000000	57950526,39	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0,000000	0,000000	0,000000	
Totals	All	675217,0075	675217,0075	0,000000	0,000000	0,000000	168239986,17	

Gambar L-1-35 *Assembled Point Masses*

Gambar L-1-36 adalah periode getar atau waktu getar yang didapatkan dari langkah perhitungan tahap 1 dan tahap 2.



Modal Participating Mass Ratios

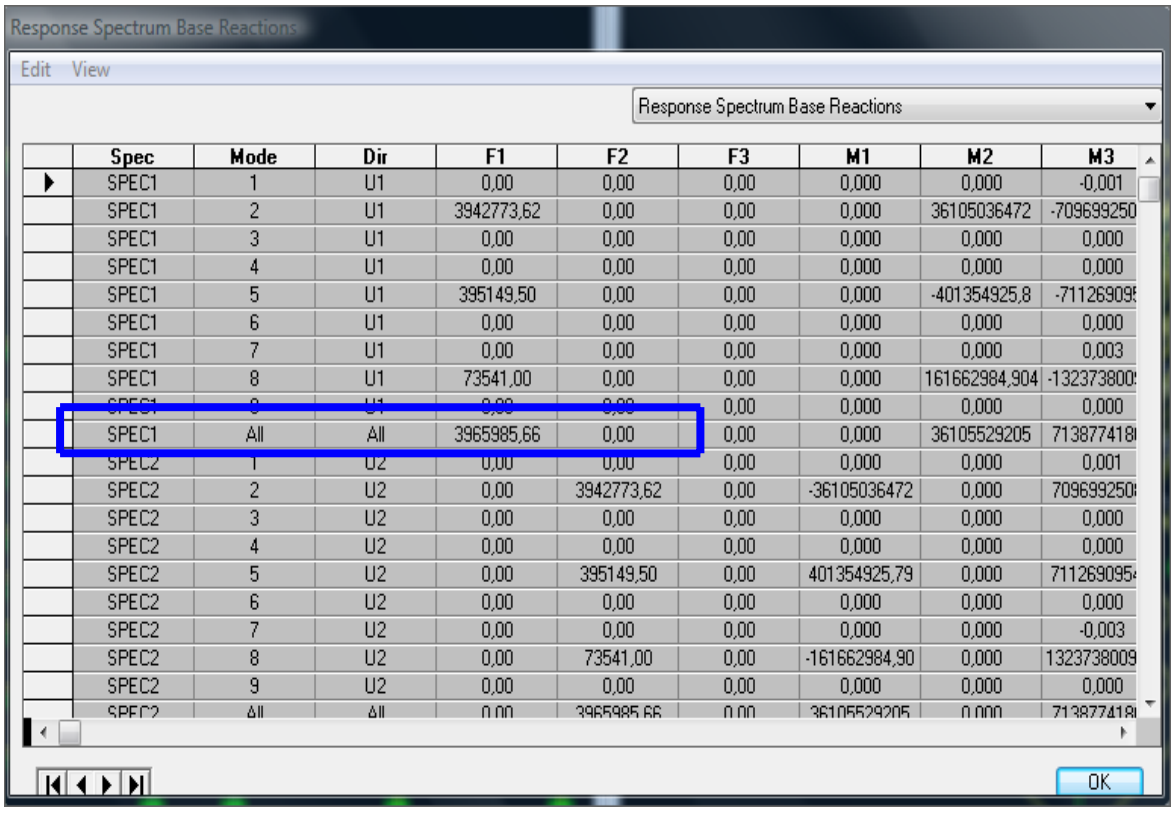
Edit View

Modal Participating Mass Ratios

Mode	Period	UX	UY	UZ	SumUX	SumUY	SumUZ	RX
1	0,277437	0,0000	86,5785	0,0000	0,0000	86,5785	0,0000	99,7302
2	0,268868	87,0540	0,0000	0,0000	87,0540	86,5785	0,0000	0,0000
3	0,236785	0,0000	0,0000	0,0000	87,0540	86,5785	0,0000	0,0000
4	0,088300	0,0000	10,8051	0,0000	87,0540	97,3836	0,0000	0,1009
5	0,086276	10,4942	0,0000	0,0000	97,5481	97,3836	0,0000	0,0000
6	0,076833	0,0000	0,0000	0,0000	97,5481	97,3836	0,0000	0,0000
7	0,052801	0,0000	2,6164	0,0000	97,5481	100,0000	0,0000	0,1689
8	0,052450	2,4519	0,0000	0,0000	100,0000	100,0000	0,0000	0,0000
9	0,046901	0,0000	0,0000	0,0000	100,0000	100,0000	0,0000	0,0000

OK

Gambar L-1-36 *Modal Participating Mass Ratios*



Response Spectrum Base Reactions

Edit View

Response Spectrum Base Reactions

Spec	Mode	Dir	F1	F2	F3	M1	M2	M3
SPEC1	1	U1	0,00	0,00	0,00	0,000	0,000	-0,001
SPEC1	2	U1	3942773,62	0,00	0,00	0,000	36105036472	-709699250
SPEC1	3	U1	0,00	0,00	0,00	0,000	0,000	0,000
SPEC1	4	U1	0,00	0,00	0,00	0,000	0,000	0,000
SPEC1	5	U1	395149,50	0,00	0,00	0,000	-401354925,8	-711269095
SPEC1	6	U1	0,00	0,00	0,00	0,000	0,000	0,000
SPEC1	7	U1	0,00	0,00	0,00	0,000	0,000	0,003
SPEC1	8	U1	73541,00	0,00	0,00	0,000	161662984,904	-132373800
SPEC1	9	U1	0,00	0,00	0,00	0,000	0,000	0,000
SPEC1	All	All	3965985,66	0,00	0,00	0,000	36105529205	713877418
SPEC2	1	U2	0,00	0,00	0,00	0,000	0,000	0,001
SPEC2	2	U2	0,00	3942773,62	0,00	-36105036472	0,000	709699250
SPEC2	3	U2	0,00	0,00	0,00	0,000	0,000	0,000
SPEC2	4	U2	0,00	0,00	0,00	0,000	0,000	0,000
SPEC2	5	U2	0,00	395149,50	0,00	401354925,79	0,000	711269095
SPEC2	6	U2	0,00	0,00	0,00	0,000	0,000	0,000
SPEC2	7	U2	0,00	0,00	0,00	0,000	0,000	-0,003
SPEC2	8	U2	0,00	73541,00	0,00	-161662984,90	0,000	1323738009
SPEC2	9	U2	0,00	0,00	0,00	0,000	0,000	0,000
SPEC2	All	All	0,00	3965985,66	0,00	36105529205	0,000	713877418

OK

Gambar L-1-37 *Response Spectrum Base Reactions*

Diketahui : I = 1

R = 8,5

Ca = 0,28 ; Cv = 0,42

Dari ETABS : Wt = mt x g

= (210178,27538 + 225847,64318 + 223521,72113) x 9,81

= 6470162,343 kg

T = 0,277437 det

Vd = 3965985,66 kg

$Ta = 0.0731\ H^{3/4}$

$Ta = 0.0731\ 12^{3/4}$

Ta = 0.4713

1.2 Ta = 1.2 x 0.4713

= 0.56557

$T_{ETABS} \leq 1.2\ Ta \rightarrow T = T_{ETABS}$

$0.277437 \leq 0.56557 \rightarrow T = 0.277437$ det

$$Vs = \min\left[\frac{2,5CaI}{R}Wt, \frac{CvI}{RT}Wt\right]$$

$$Vs = \min\left[\frac{2,5x0,28x1}{8,5}x6470162,343, \frac{0,42x1}{8,5x0,277437}6470162,343\right]$$

Vs = min [532836.8988 , 1152341.394]

Vs = 532836.8988 kg

$$f = \frac{0,8Vs}{Vd}$$

$$f = \frac{0{,}8x532836.8988}{3965985{,}66}$$

$f = 0{,}107481$

$$f = \max\left[\frac{0{,}8Vs}{Vd}, \frac{I}{R}\right]$$

$f = \max [\ 0.107481\ ,\ 0.11765\ ]$

$f = 0.11765$

$f^* = f \times g$

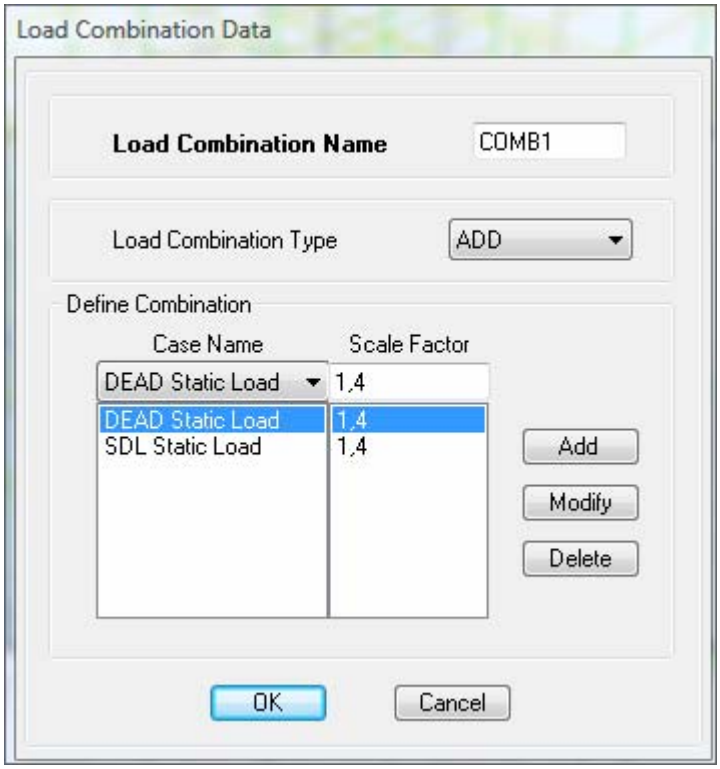
$= 0.11765 \times 9.81$

$= 1.15415\ m/det^2$

(kemudian f* dimasukkan ke dalam ETABS untuk analisis berikutnya)

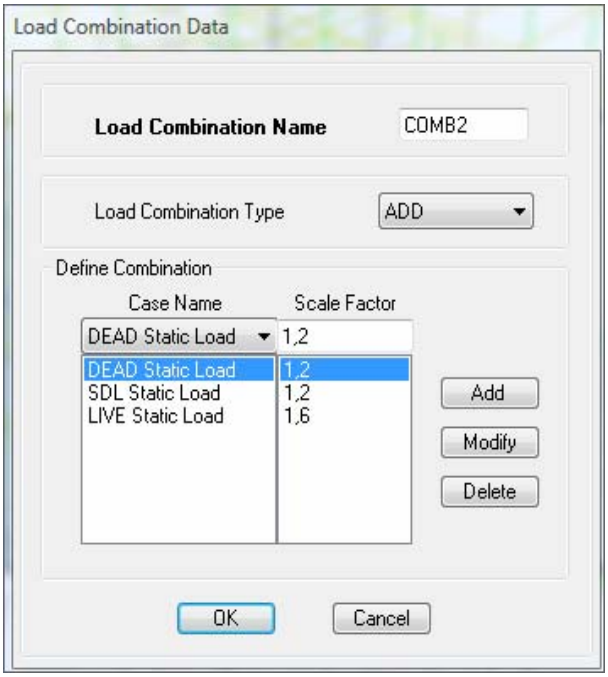
9. Berdasarkan analisis tahap 2, dilakukan pemeriksaan sebagai berikut : adapun kombinasinya adalah :

   1) 1.4 DL + 1.4 SDL (Gambar L-1-38)



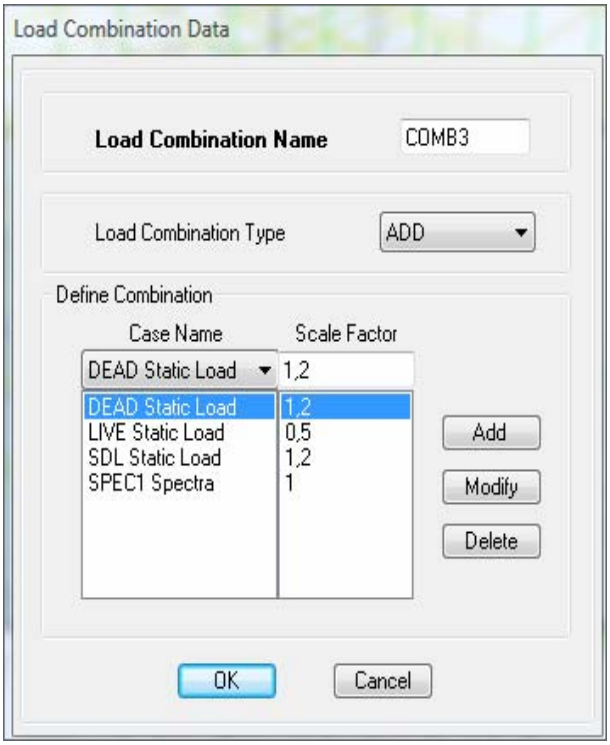
Gambar L-1-38 ***Load Combination Data***

2) 1.2 DL + 1.2 SDL + 1.6 LL (Gambar L-1-39)



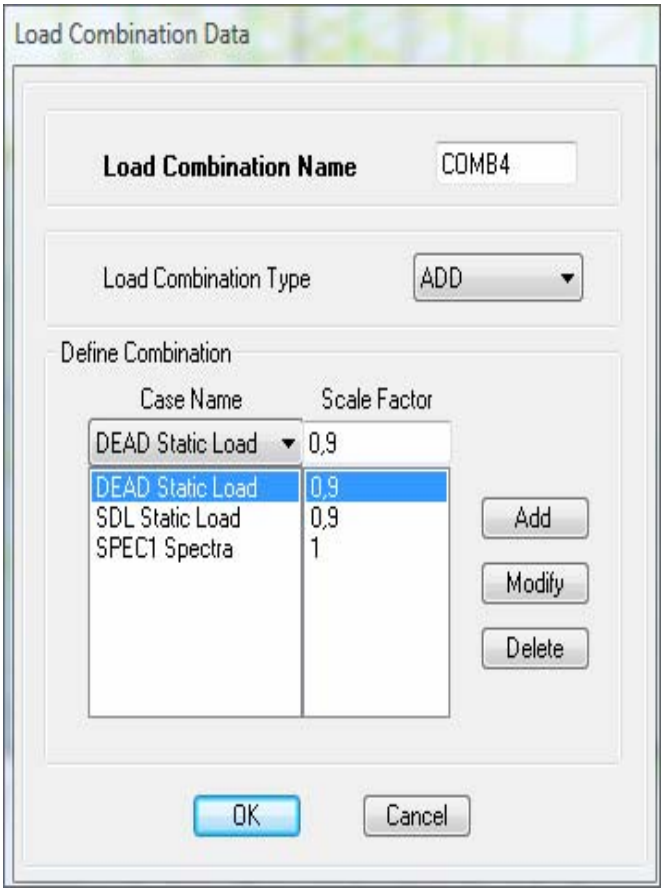
Gambar L-1-39 ***Load Combination Data***

3) 1.2 DL + 1.2 SDL + 0.5 LL ± E (Gambar L-1-40)



Gambar L-1-40 ***Load Combination Data***

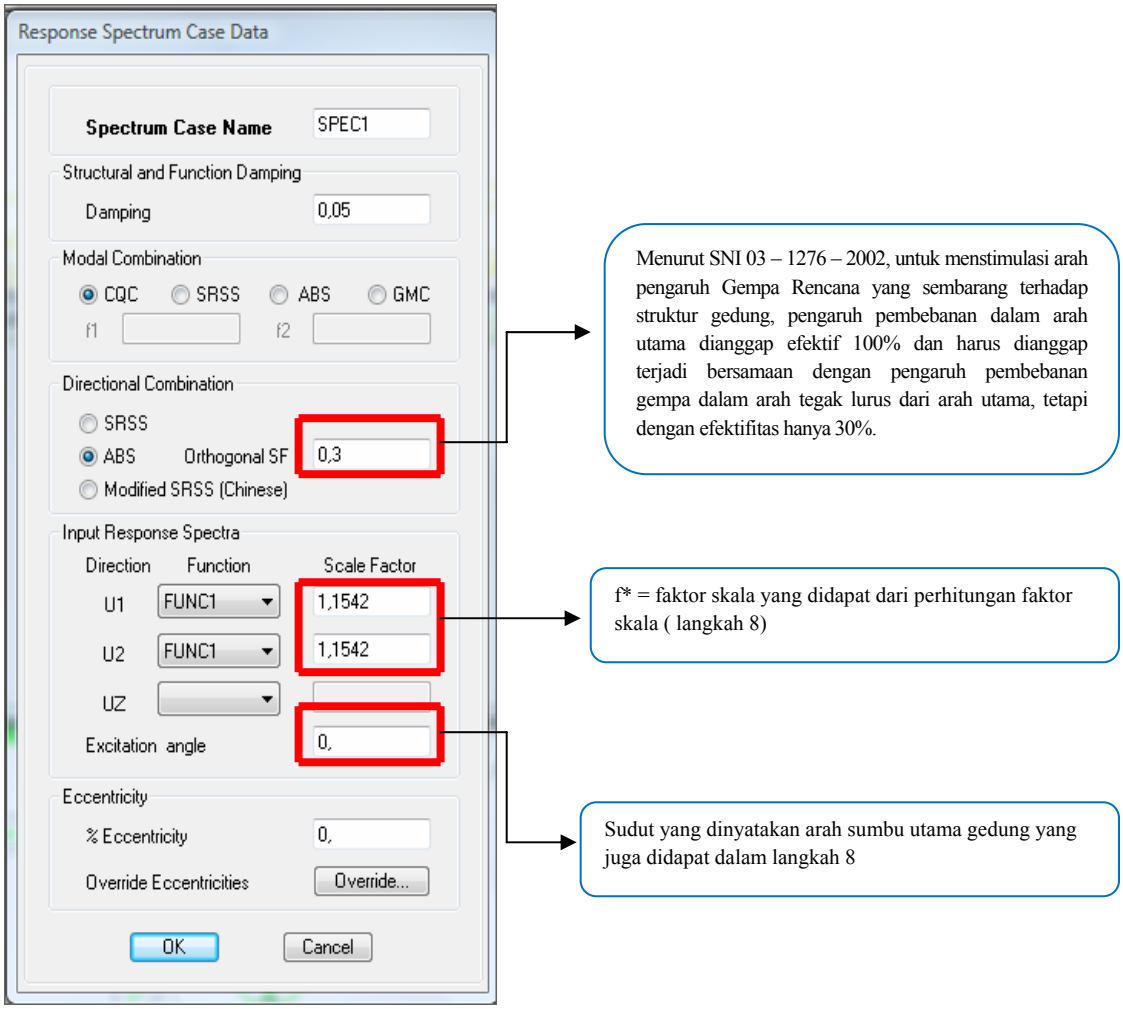
4) 0.9 DL + 0.9 SDL ± E(Gambar L-1-41)



Gambar L-1-41 ***Load Combination Data***

Pada tahap ini digunakan hanya SPEC1 dengan data sebagai berikut: *Directional Combination:* ABS dengan *Scale Factor* = 0,3 (mengakomodasi 30% arah tegak lurus sumbu utama)

Input *Response Spectra* diisikan untuk arah U1 dan U2 dengan factor skala f* yang telah didapat di atas



Gambar L-1-42 *Response Spectrum Case Data*

10. Input faktor-faktor reduksi kapasitas untuk desain penulangannya.

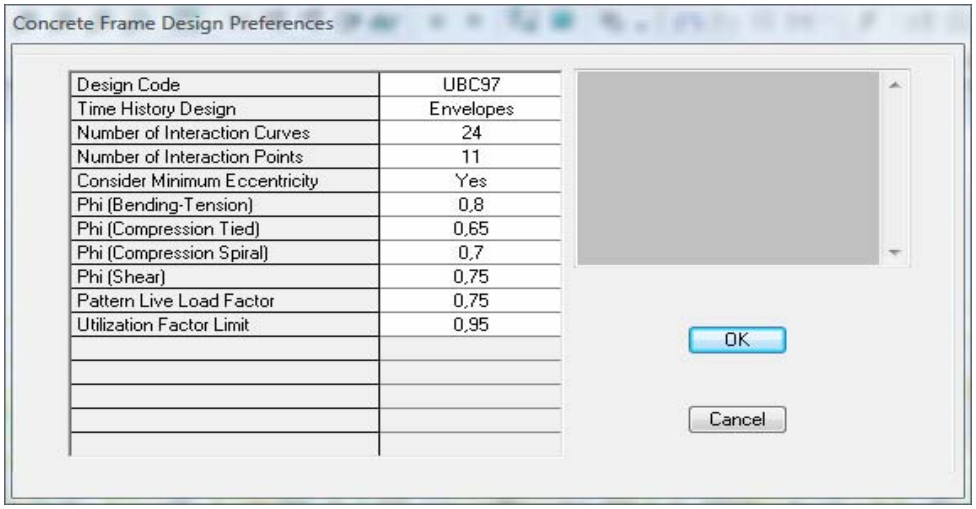
    Inputkan faktor-faktor sesuai dengan SNI 03-1726-2002, pada *Concrete Frame Design Preference*, dapat dilihat pada gambar L-1-43.

    Phi Bending Tension = 0,8

    Phi Compression Tide = 0,65

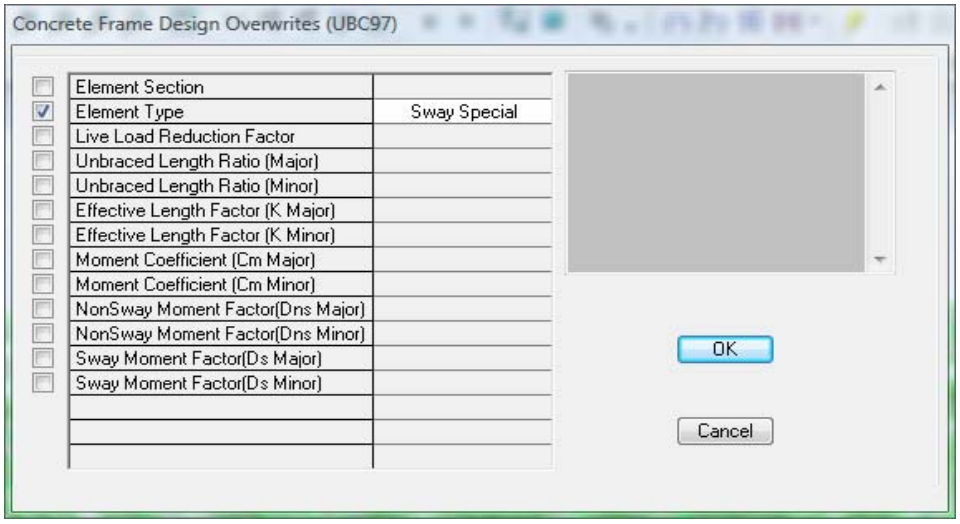
    Phi Compression Spiral = 0,7

Phi Shear = 0,75



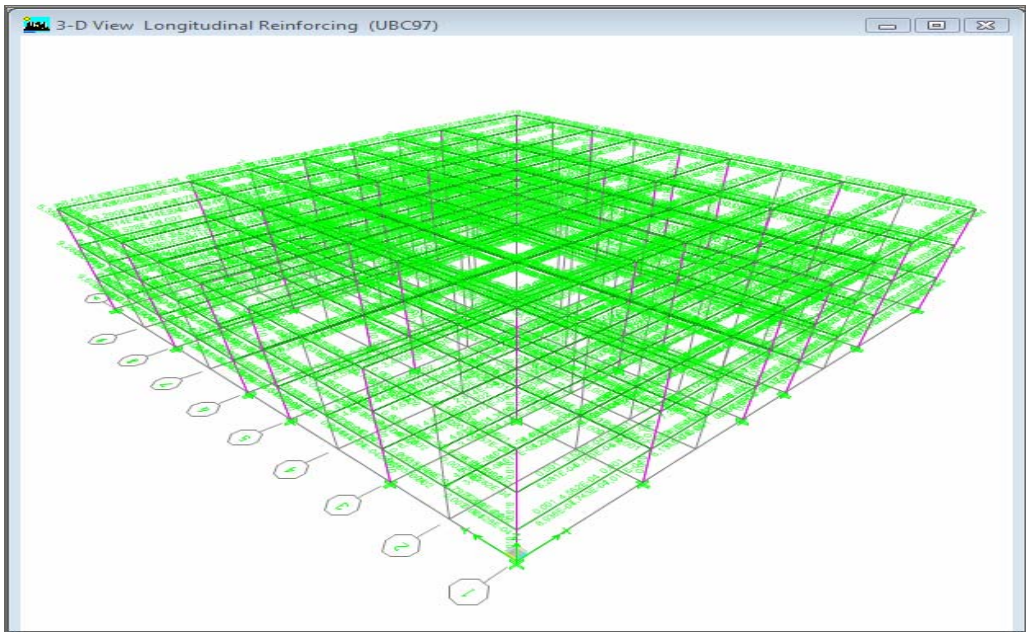
Gambar L-1-43 *Concrete Frame Design Preferences*

11. Untuk jenis rangka pemikul momen khusus (SPRMK), maka dapat diinputkan pada *Concrete Frame Design Overwrites* dengan memberikan tanda / *check mark* pada Element Type dan memilih *Sway Special*, dapat dilihat pada gambar L-1-44.

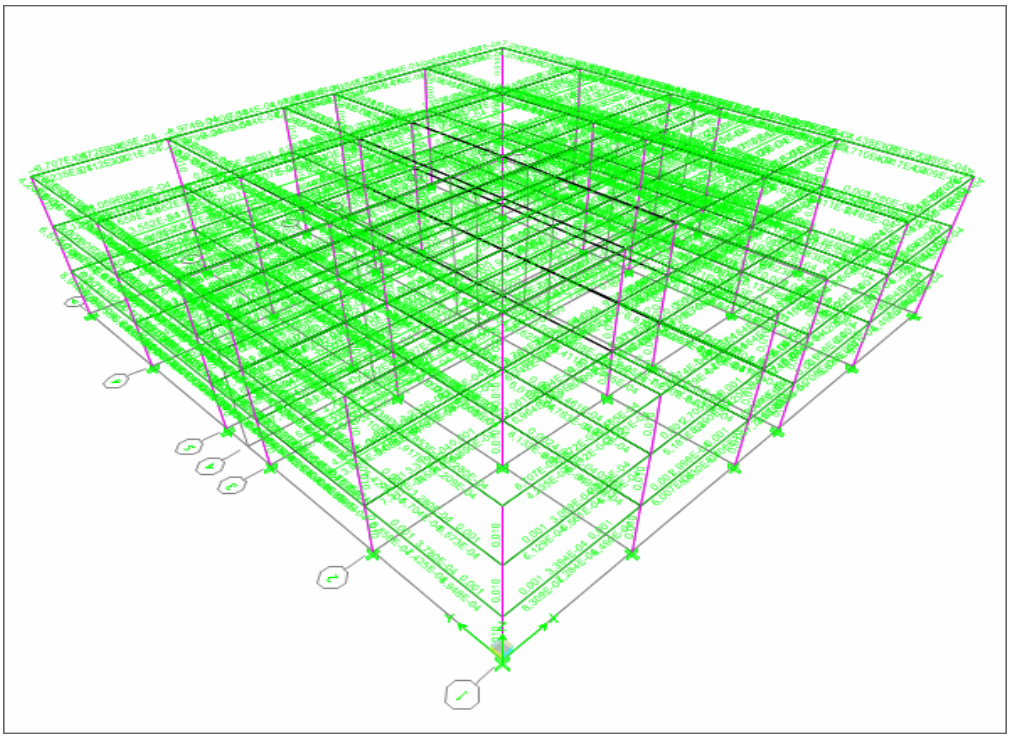


Gambar L-1-44 *Concrete Frame Design Overwrites (UBC 97)*

Lampiran 2 : Output ETABS Ver.9.04



Gambar L-2-1 ***Longitudinal Reinforcing Model 1***

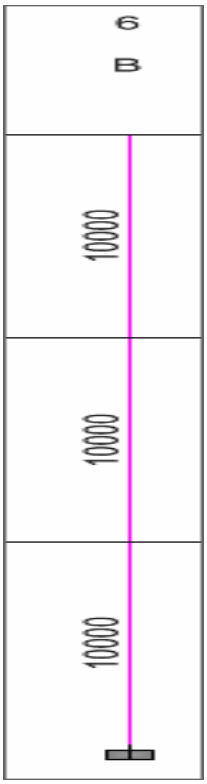


Gambar L-2-2 ***Longitudinal Reinforcing Model 2***

Lampiran 3 : Langkah perhitungan tulangan

1. Penulangan kolom

Untuk model 1



As = 10000 mm^2

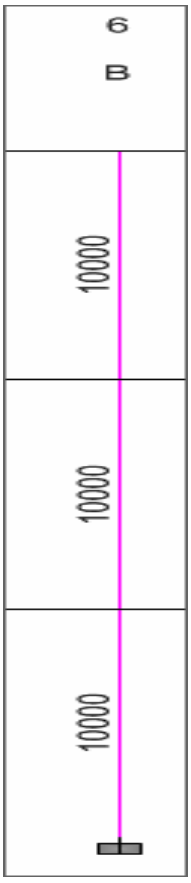
As (D-25) = $\frac{1}{4}$ x π x d^2 = 491 mm^2

Jumlah tulangan kolom = $\frac{As}{\frac{1}{4} x \pi x d^2}$

= $\frac{10000}{491}$ = 20,36 ≈ 24

Tulangan yang dipasang 24 buah D-25, karena berjumlah genap

Untuk model 2



As = 10000 mm^2

As (D-25) = $\frac{1}{4}$ x π x d^2 = 491 mm^2

Jumlah tulangan kolom = $\frac{As}{\frac{1}{4} x \pi x d^2}$

= $\frac{10000}{491}$ = 20,36 ≈ 24

Tulangan yang dipasang 24 buah D-25, karena berjumlah genap

2. Penulangan Balok Induk (80 x 125)

Untuk model 1

Lantai 3

Perhitungan balok induk pada model 1 diambil portal 6 yang memiliki jumlah penulangan maksimum.

5294 3337 1695	1096 1096 1096	961 961 961	1096 1096 1096	1695 3337 5294
3337 1695 1695	1669 3337 3371	3337 3337 3337	3371 3337 1669	1695 1695 3337

Tulangan yang dipakai adalah D-22 = $\frac{1}{4}$ x π x d^2 = 380 mm^2

Tulangan tumpuan : - Tarik

$$\text{Jumlah tulangan} = \frac{5294}{380} = 13.93 \approx 14$$

- Tekan

$$\text{Jumlah tulangan} = \frac{3337}{380} = 8{,}78 \approx 9$$

Tulangan lapangan : - Tekan

$$\text{Jumlah tulangan} = \frac{961}{380} = 2{,}53 \approx 3$$

- Tarik

$$\text{Jumlah tulangan} = \frac{3337}{380} = 8{,}78 \approx 9$$

Lantai 2

Perhitungan balok induk pada model 1 diambil portal 6 yang memiliki jumlah penulangan maksimum.

5760 3337 1837	1030 1030 1030	901 901 901	1030 1030 1030	1837 3337 5760
3337 1837 1837	1361 3337 3337	3337 3337 3337	3337 3337 1361	1837 1837 3337

Tulangan yang dipakai adalah D-22 = $\frac{1}{4}$ x π x d^2 = 380 mm^2

Tulangan tumpuan : - Tarik

Jumlah tulangan = $\frac{5760}{380}$ = 15,16 ≈ 16

- Tekan

Jumlah tulangan = $\frac{3337}{380}$ = 8,78 ≈ 9

Tulangan lapangan : - Tekan

Jumlah tulangan = $\frac{901}{380}$ = 2,37 ≈ 3

- Tarik

Jumlah tulangan = $\frac{3337}{380}$ = 8,78 ≈ 9

Lantai 1

Perhitungan balok induk pada model 1 diambil portal 6 yang memiliki jumlah penulangan maksimum.

5600	3337	1788	1041	1041	1041	911	911	911	1041	1041	1041	1788	3337	5600
3337	1788	1788	1428	3337	3337	3337	3337	3337	3337	3337	1428	1788	1788	3337

Tulangan yang dipakai adalah D-22 = $\frac{1}{4}$ x π x d^2 = 380 mm^2

Tulangan tumpuan : - tarik

Jumlah tulangan = $\frac{5600}{380}$ = 14,74 ≈ 15

- Tekan

Jumlah tulangan = $\frac{3337}{380}$ = 8,78 ≈ 9

Tulangan lapangan : - Tekan

$$\text{Jumlah tulangan} = \frac{911}{380} = 2{,}40 \approx 3$$

- Tarik

$$\text{Jumlah tulangan} = \frac{3337}{380} = 8{,}78 \approx 9$$

Untuk model 2

- **Lantai 3**

Perhitungan balok induk pada model 2 diambil portal 5 yang memiliki jumlah penulangan maksimum.

5611 3337	1805 5825	5611 3337

Tulangan yang dipakai adalah D-22 = $\frac{1}{4} \text{ x } \pi \text{ x } d^2 = 380 \text{ mm}^2$

Tulangan tumpuan : - tarik

$$\text{Jumlah tulangan} = \frac{5611}{380} = 14{,}77 \approx 15$$

- Tekan

$$\text{Jumlah tulangan} = \frac{3337}{380} = 8{,}78 \approx 9$$

Tulangan lapangan : - Tekan

$$\text{Jumlah tulangan} = \frac{1805}{380} = 4{,}75 \approx 5$$

- Tarik

$$\text{Jumlah tulangan} = \frac{5825}{380} = 15{,}33 \approx 16$$

Lantai 2

Perhitungan balok induk pada model 2 diambil portal 5 yang memiliki jumlah penulangan maksimum.

6111	1959	6111
3337	5758	3337

Tulangan yang dipakai adalah D-22 = $\frac{1}{4}$ x π x d^2 = 380 mm^2

Tulangan tumpuan : - tarik

$$\text{Jumlah tulangan} = \frac{6111}{380} = 16{,}08 \approx 17$$

- Tekan

$$\text{Jumlah tulangan} = \frac{3337}{380} = 8{,}78 \approx 9$$

Tulangan lapangan : - Tekan

$$\text{Jumlah tulangan} = \frac{1959}{380} = 5{,}16 \approx 6$$

- Tarik

$$\text{Jumlah tulangan} = \frac{5758}{380} = 15{,}15 \approx 16$$

Lantai 1

Perhitungan balok induk pada model 2 diambil portal 5 yang memiliki jumlah penulangan maksimum.

5962	1914	5962
3337	5742	3337

Tulangan yang dipakai adalah D-22 = $\frac{1}{4}$ x π x d^2 = 380 mm^2

Tulangan tumpuan : - tarik

Jumlah tulangan = $\frac{5962}{380}$ = 15,69 ≈ 16

- Tekan

Jumlah tulangan = $\frac{3337}{380}$ = 8,78 ≈ 9

Tulangan lapangan : - Tekan

Jumlah tulangan = $\frac{1914}{380}$ = 5,04 ≈ 6

- Tarik

Jumlah tulangan = $\frac{5742}{380}$ = 15,11 ≈ 16

3. Perhitungan tulangan geser balok

➢ **Model 1**

❖ **Lantai 1**

Tulangan balok tumpuan i = tulangan balok tumpuan j

Berdasarkan Vu dari 4 kombinasi

V_{u1} = - 569089,99 N

V_{u2} = - 679526,80 N

V_{u3} = - 559052,30 N

V_{u4} = - 318321,10 N

V_u = max (V_{u1}, V_{u2}, V_{u3}, V_{u4})

= 679526,80 N

V_c = $\frac{1}{6}\sqrt{f'c}.bw.d$ → f'c = 30 MPa; bw = 800 mm

d = 1250 – 40 = 1210 mm

= 883659,059 N

Vs = Vu – Φs x Vc → Φs = 0,75

= 16782,50575 N

$V_{si\ max} = \frac{2}{3}\sqrt{f'c}.bw.d$

= 3534636,238 N

Vs = 16782,50575 N < $V_{si\ max}$ = 3534636,238 N

$\frac{Av}{S_1} = \frac{Vs}{\Phi s.fys.d}$ → fys = 400 MPa

= 0,0462328 mm

$\frac{Av}{S_{min}} = \frac{1}{3}\frac{bw}{fys}$

= 0,666666667 mm

$\frac{Av}{S_1} = \max\left(\frac{Av}{S_1}, \frac{Av}{S_{min}}\right)$

= 0,666666667 mm

Berdasarkan tulangan terpasang

$Asti = 15\left(\frac{1}{4}\pi.d^2\right)$

= 5701,990666 mm^2

$ati = \frac{Asti.\alpha.fy}{0,85.f'c.bw}$ → fy = 400 MPa; α = 1,25

= 139,7546732 mm

$Nmpi = Asti \times \alpha \times fy \times \left(d - \frac{ati}{2}\right)$

= 3250484392 Nmm

$Asbj = 9\left(\frac{1}{4}\pi.d^2\right)$

= 3421,1944 mm^2

abj $= \frac{Asbj.\alpha.fy}{0{,}85.f'c.bw}$

$= 83{,}8580392$ mm

Pmpj $=$ Asbj x α x fy x (d - $\frac{abj}{2}$)

$= 1998098948$ Nmm

Vp $= \frac{Nmpi + Pmpj}{Ln}$ → Ln = 20000-1000 = 19000 mm

$= 276239{,}6495$ N

$V_{g3} = 1{,}2\ (V_{SDL} + V_{DL}) + 0{,}5\ V_{LL}$ → $(V_{SDL} + V_{DL}) = 406492{,}85$ N

$V_{LL} = 119834{,}61$ N

$= 547708{,}725$ N

$V_{g4} = 0{,}9\ (V_{SDL} + V_{DL})$

$= 365843{,}565$ N

$V_{e3} = V_{g3} + Vp$

$= 823948{,}3745$ N

$V_{e4} = V_{g4} + Vp$

$= 642083{,}2145$ N

$\frac{Vp}{V_{e3}} = 0{,}3353 < 0{,}5$ tidak memenuhi

$\frac{Vp}{V_{e4}} = 0{,}4302 < 0{,}5$ tidak memenuhi

$V_{c3} = \frac{1}{6}\sqrt{f'c}.bw.d$

$= 608846{,}80$ N

$V_{c4} = \frac{1}{6}\sqrt{f'c}.bw.d$

$= 608846{,}80$ N

V_{s3} = V_{e3} – Φs x V_{c3}

= 367313,2745 N

V_{s4} = V_{e4} – Φs x V_{c4}

= 185448,1145 N

V_s = max (V_{s3}, V_{s4})

= 367313,2745 N

V_s = 367313,2745 N < $V_{si\ max}$ = 3534636,238 N

$$\frac{Av}{S_2} = \frac{Vs}{\Phi s.\,fys.d}$$

= 1,0118823 mm

$$\frac{Av}{S_{min}} = \frac{1}{3}\,\frac{bw}{fys}$$

= 0,666666667 mm

$$\frac{Av}{S_2} = \max\left(\frac{Av}{S_2}, \frac{Av}{S_{min}}\right)$$

= 1,0118823 mm

$$\frac{Av}{S} = \max\left(\frac{Av}{S_1}, \frac{Av}{S_2}\right)$$

= 1,0118823 mm

$$Av = 2\left(\frac{1}{4}\pi.d^2\right)$$

= 157,0796

$$S_1 = \frac{Av}{Av/s}$$

= 155,23505 mm

Syarat S max pada tulangan geser

- $\frac{d}{2}$ = 605 mm
- 8db = 176 mm
- 24 dbs = 240 mm
- 300 mm

S perlu = min (S_1,Smax)

= 155,23505 mm ≈ 150 mm

Digunakan tulangan D10 – 150 mm.

- Tulangan geser pada jarak 2h dari muka kolom

Berdasarkan Vu dari 4 kombinasi

V_{u1} = - 486629,99 N

V_{u2} = - 608846,80 N

V_{u3} = - 503108,30 N

V_{u4} = - 338913,10 N

V_u = max (V_{u1}, V_{u2}, V_{u3}, V_{u4})

= 608846,80 N

$V_c = \frac{1}{6}\sqrt{f'c}.bw.d$ → f'c = 30 MPa; bw = 800 mm

d = 1250 – 40 = 1210 mm

= 883659,059 N

Vs = Vu – Φs x Vc → Φs = 0,75

= - 53897,80 N

$V_{si\ max} = \frac{2}{3}\sqrt{f'c}.bw.d$

= 3534636,238 N

Vs = - 53897,80 N < $V_{si\ max}$ = 3534636,238 N

$\frac{Av}{S_1} = \frac{Vs}{\Phi s.fys.d}$ → fys = 400 MPa

= - 0,1484779456 mm

$\frac{Av}{S_{min}} = \frac{1}{3}\frac{bw}{fys}$

= 0,666666667 mm

$\frac{Av}{S_1} = \max\left(\frac{Av}{S_1}, \frac{Av}{S_{min}}\right)$

= 0,666666667 mm

Berdasarkan tulangan terpasang

Asti $= 15\left(\frac{1}{4}\pi.d^2\right)$

= 5701,990666 mm^2

ati $= \frac{Asti.\alpha.fy}{0,85.f'c.bw}$ → fy = 400 MPa; α = 1,25

= 139,7546732 mm

Nmpi = Asti x α x fy x $\left(d - \frac{ati}{2}\right)$

= 3250484392 Nmm

Asbj $= 9\left(\frac{1}{4}\pi.d^2\right)$

= 3421,1944 mm^2

abj $= \frac{Asbj.\alpha.fy}{0,85.f'c.bw}$

= 83,8580392 mm

Pmpj = Asbj x α x fy x $\left(d - \frac{abj}{2}\right)$

= 1950290636 Nmm

$Vp = \frac{Nmpi + Pmpj}{Ln}$ → Ln = 20000-1000 = 19000 mm

= 273725,0015 N

V_{g3} = 1,2 (V_{SDL} + V_{DL}) + 0,5 V_{LL} → (V_{SDL} + V_{DL}) = 347592,85 N

V_{LL} = 119834,61 N

= 477028,725 N

V_{g4} = 0,9 (V_{SDL} + V_{DL})

= 312833,565 N

V_{e3} = V_{g3} + Vp

= 750753,7265 N

V_{e4} = V_{g4} + Vp

= 586558,5665 N

$\frac{Vp}{V_{e3}}$ = 0,3646 < 0,5 tidak memenuhi

$\frac{Vp}{V_{e4}}$ = 0,4667 < 0,5 tidak memenuhi

$V_{c3} = \frac{1}{6}\sqrt{f'c}.bw.d$

= 608846,80 N

$V_{c4} = \frac{1}{6}\sqrt{f'c}.bw.d$

= 608846,80 N

V_{s3} = V_{e3} – Φs x V_{c3}

= 294118,6165 N

V_{s4} = V_{e4} – Φs x V_{c4}

= 129923,4665 N

V_s = max (V_{s3}, V_{s4})

= 294118,6165 N

V_s = 294118,6165 N < $V_{si\ max}$ = 3534636,238 N

$$\frac{Av}{S_2} = \frac{Vs}{\Phi s.\,fys.d}$$

= 0,810244 mm

$$\frac{Av}{S_{min}} = \frac{1}{3}\,\frac{bw}{fys}$$

= 0,666666667 mm

$$\frac{Av}{S_2} = \max\left(\frac{Av}{S_2}, \frac{Av}{S_{min}}\right)$$

= 0,810244 mm

$$\frac{Av}{S} = \max\left(\frac{Av}{S_1}, \frac{Av}{S_2}\right)$$

= 0,810244 mm

$$Av = 2\left(\frac{1}{4}\pi.d^2\right)$$

= 157,0796

$$S_1 = \frac{Av}{Av/s_1}$$

= 193,8670326 mm

Syarat S max pada tulangan geser sejarak 2h

- $\frac{d}{2}$ = 605 mm
- 8db = 176 mm
- 24 dbs = 240 mm
- 300 mm

S perlu = min (S_1,Smax)

= 176 mm ≈ 170 mm

Digunakan tulangan D10 – 170 mm.

❖ **Lantai 2**

- Tulangan balok tumpuan i = tulangan balok tumpuan j

Berdasarkan Vu dari 4 kombinasi

V_{u1} = - 575552,59 N

V_{u2} = - 687918,95 N

V_{u3} = - 562394,70 N

V_{u4} = - 381787,20 N

V_u = max (V_{u1}, V_{u2}, V_{u3}, V_{u4})

= 687918,95 N

$V_c = \frac{1}{6}\sqrt{f'c}.bw.d$ → f'c = 30 MPa; bw = 800 mm

d = 1250 – 40 = 1210 mm

= 883659,059 N

Vs = Vu – Φs x Vc → Φs = 0,75

= 25174,65575 N

$V_{si\ max} = \frac{2}{3}\sqrt{f'c}.bw.d$

= 3534636,238 N

Vs = 25174,65575 N < $V_{si\ max}$ = 3534636,238 N

$\frac{Av}{S_1} = \frac{Vs}{\Phi s.fys.d}$ → fys = 400 MPa

= 0,069351668 mm

$\frac{Av}{S_{min}} = \frac{1}{3}\frac{bw}{fys}$

= 0,666666667 mm

$\frac{Av}{S_1}$ = max ($\frac{Av}{S_1}$, $\frac{Av}{S_{min}}$)

= 0,666666667 mm

Berdasarkan tulangan terpasang

Asti = 16 ($\frac{1}{4}\pi.d^2$)

= 6082,123377 mm^2

ati = $\frac{Asti.\alpha.fy}{0,85.f'c.bw}$ → fy = 400 MPa; α = 1,25

= 149,0716514 mm

Nmpi = Asti x α x fy x (d - $\frac{ati}{2}$)

= 3453016599 Nmm

Asbj = 9 ($\frac{1}{4}\pi.d^2$)

= 3421,1944 mm^2

abj = $\frac{Asbj.\alpha.fy}{0,85.f'c.bw}$

= 83,8580392 mm

Pmpj = Asbj x α x fy x (d - $\frac{abj}{2}$)

= 1998098948 Nmm

Vp = $\frac{Nmpi + Pmpj}{Ln}$ → Ln = 20000-1000 = 19000 mm

= 286900,8183 N

V_{g3} = 1,2 (V_{SDL} + V_{DL}) + 0,5 V_{LL} → (V_{SDL} + V_{DL}) = 411108,99 N

V_{LL} = 121617,60 N

= 5543139,588 N

V_{g4} = 0,9 (V_{SDL} + V_{DL})

= 369998,091 N

V_{e3} = V_{g3} + Vp

= 841040,4063 N

V_{e4} = V_{g4} + Vp

= 656898,9093 N

$\frac{Vp}{V_{e3}}$ = 0,3411 < 0,5 tidak memenuhi

$\frac{Vp}{V_{e4}}$ = 0,4368 < 0,5 tidak memenuhi

V_{c3} = $\frac{1}{6}\sqrt{f'c}.bw.d$

= 608846,80 N

V_{c4} = $\frac{1}{6}\sqrt{f'c}.bw.d$

= 608846,80 N

V_{s3} = V_{e3} – Φs x V_{c3}

= 384405,3063 N

V_{s4} = V_{e4} – Φs x V_{c4}

= 200263,8093 N

V_s = max (V_{s3}, V_{s4})

= 384405,3063 N

V_s = 384405,3063 N < $V_{si\ max}$ = 3534636,238 N

$\frac{Av}{S_2}$ = $\frac{Vs}{\Phi s.fys.d}$

$= 1{,}058967786$ mm

$\frac{Av}{S_{min}} = \frac{1}{3}\frac{bw}{fys}$

$= 0{,}666666667$ mm

$\frac{Av}{S_2} = \max\left(\frac{Av}{S_2}, \frac{Av}{S_{min}}\right)$

$= 1{,}058967786$ mm

$\frac{Av}{S} = \max\left(\frac{Av}{S_1}, \frac{Av}{S_2}\right)$

$= 1{,}058967786$ mm

$Av = 2\left(\frac{1}{4}\pi.d^2\right)$

$= 157{,}0796$

$S_1 = \frac{Av}{Av/s}$

$= 148{,}3327464$ mm

Syarat S max pada tulangan geser

- $\frac{d}{2}$ = 605 mm
- 8db = 176 mm
- 24 dbs = 240 mm
- 300 mm

S perlu = min (S_1,Smax)

= 148,3327464 mm ≈ 145 mm

Digunakan tulangan D10 – 145 mm.

- Tulangan geser pada jarak 2h dari muka kolom

Berdasarkan Vu dari 4 kombinasi

V_{u1} = - 493092,59 N

V_{u2} = - 617238,95 N

V_{u3} = - 505850,70 N

V_{u4} = - 339379,20 N

V_u = max (V_{u1}, V_{u2}, V_{u3}, V_{u4})

= 617238,95 N

$V_c = \frac{1}{6}\sqrt{f'c}.bw.d$ → f'c = 30 MPa; bw = 800 mm

d = 1250 – 40 = 1210 mm

= 883659,059 N

Vs = Vu – Φs x Vc → Φs = 0,75

= - 45505,34425 N

$V_{si\ max} = \frac{2}{3}\sqrt{f'c}.bw.d$

= 3534636,238 N

Vs = - 45505,34425 N < $V_{si\ max}$ = 3534636,238 N

$\frac{Av}{S_1} = \frac{Vs}{\Phi s.fys.d}$ → fys = 400 MPa

= - 0,125359 mm

$\frac{Av}{S_{min}} = \frac{1}{3}\frac{bw}{fys}$

= 0,666666667 mm

$\frac{Av}{S_1}$ = max ($\frac{Av}{S_1}$, $\frac{Av}{S_{min}}$)

= 0,666666667 mm

Berdasarkan tulangan terpasang

Asti $= 16 \left(\frac{1}{4}\pi.d^2\right)$

$= 6082{,}123377 \text{ mm}^2$

ati $= \frac{Asti.\alpha.fy}{0{,}85.f'c.bw}$ → fy = 400 MPa; α = 1,25

$= 149{,}0716514$ mm

Nmpi $=$ Asti x α x fy x $\left(\text{d} - \frac{ati}{2}\right)$

$= 3453016599$ Nmm

Asbj $= 9 \left(\frac{1}{4}\pi.d^2\right)$

$= 3421{,}1944 \text{ mm}^2$

abj $= \frac{Asbj.\alpha.fy}{0{,}85.f'c.bw}$

$= 83{,}8580392$ mm

Pmpj $=$ Asbj x α x fy x $\left(\text{d} - \frac{abj}{2}\right)$

$= 1998098948$ Nmm

Vp $= \frac{Nmpi + Pmpj}{Ln}$ → Ln = 20000-1000 = 19000 mm

$= 286900{,}8183$ N

$V_{g3} = 1{,}2 (V_{SDL} + V_{DL}) + 0{,}5 V_{LL}$ → $(V_{SDL} + V_{DL}) = 388208{,}99$ N

$V_{LL} = 121617{,}60$ N

$= 526659{,}588$

$V_{g4} = 0{,}9 (V_{SDL} + V_{DL})$

$= 349388{,}091$ N

$V_{e3} = V_{g3} + Vp$

$= 813560{,}4063$ N

V_{e4} $= V_{g4} + Vp$

$= 636288{,}9093$ N

$\frac{Vp}{V_{e3}}$ $= 0{,}3526$ $<$ 0,5 tidak memenuhi

$\frac{Vp}{V_{e4}}$ $= 0{,}4509$ $<$ 0,5 tidak memenuhi

V_{c3} $= \frac{1}{6}\sqrt{f'c}.bw.d$

$= 608846{,}80$ N

V_{c4} $= \frac{1}{6}\sqrt{f'c}.bw.d$

$= 608846{,}80$ N

V_{s3} $= V_{e3} - \Phi s \times V_{c3}$

$= 204713{,}6063$ N

V_{s4} $= V_{e4} - \Phi s \times V_{c4}$

$= 27442{,}1093$ N

V_s $= \max (V_{s3}, V_{s4})$

$= 204713{,}6063$ N

V_s $= 204713{,}6063$ N $<$ $V_{si\ max} = 3534636{,}238$ N

$\frac{Av}{S_2}$ $= \frac{Vs}{\Phi s.fys.d}$

$= 0{,}5639493287$ mm

$\frac{Av}{S_{min}}$ $= \frac{1}{3}\frac{bw}{fys}$

$= 0{,}666666667$ mm

$\frac{Av}{S_2}$ $= \max\left(\frac{Av}{S_2}, \frac{Av}{S_{min}}\right)$

$= 0{,}666666667$ mm

$\frac{Av}{S}$ = max ($\frac{Av}{S_1}$, $\frac{Av}{S_2}$)

= 0,666666667 mm

Av = 2 ($\frac{1}{4}\pi.d^2$)

= 157,0796

S_1 = $\frac{Av}{Av/s}$

= 235,61940 mm

Syarat S max pada tulangan geser sejarak 2h

- $\frac{d}{2}$ = 605 mm
- 8db = 176 mm
- 24 dbs = 240 mm
- 300 mm

S perlu = min (S_1,Smax)

= 176 mm ≈ 170 mm

Digunakan tulangan D10 – 170 mm.

❖ Lantai 3

- Tulangan balok tumpuan i = tulangan balok tumpuan j

<u>Berdasarkan Vu dari 4 kombinasi</u>

V_{u1} = - 563446,38 N

V_{u2} = - 671959,70 N

V_{u3} = - 539622,60 N

V_{u4} = - 363353,80 N

V_u = max (V_{u1}, V_{u2}, V_{u3}, V_{u4})

= 671959,70 N

$V_c = \frac{1}{6}\sqrt{f'c}.bw.d$ → f'c = 30 MPa; bw = 800 mm

d = 1250 – 40 = 1210 mm

= 883659,059 N

Vs = Vu – Φs x Vc → Φs = 0,75

= 9215,40575 N

$V_{si\ max} = \frac{2}{3}\sqrt{f'c}.bw.d$

= 3534636,238 N

Vs = 9215,40575 N < $V_{si\ max}$ = 3534636,238 N

$\frac{Av}{S_1} = \frac{Vs}{\Phi s.fys.d}$ → fys = 400 MPa

= 0,0253867927 mm

$\frac{Av}{S_{min}} = \frac{1}{3}\frac{bw}{fys}$

= 0,666666667 mm

$\frac{Av}{S_1} = \max\left(\frac{Av}{S_1}, \frac{Av}{S_{min}}\right)$

= 0,666666667 mm

<u>Berdasarkan tulangan terpasang</u>

$Asti = 14\left(\frac{1}{4}\pi.d^2\right)$

= 5321,857955 mm^2

$ati = \frac{Asti.\alpha.fy}{0{,}85.f'c.bw}$ → fy = 400 MPa; α = 1,25

= 130,437695 mm

Nmpi = Asti x α x fy x (d - $\frac{ati}{2}$)

= 3046181342 Nmm

Asbj = 9 ($\frac{1}{4}\pi.d^2$)

= 3421,1944 mm^2

abj = $\frac{Asbj.\alpha.fy}{0{,}85.f'c.bw}$

= 83,8580392 mm

Pmpj = Asbj x α x fy x (d - $\frac{abj}{2}$)

= 1998098948 Nmm

Vp = $\frac{Nmpi + Pmpj}{Ln}$ → Ln = 20000-1000 = 19000 mm

= 265488,4363 N

V_{g3} = 1,2 (V_{SDL} + V_{DL}) + 0,5 V_{LL} → (V_{SDL} + V_{DL}) = 402461,70 N

V_{LL} = 118128,54 N

= 542018,31 N

V_{g4} = 0,9 (V_{SDL} + V_{DL})

= 362215,53 N

V_{e3} = V_{g3} + Vp

= 807506,7463 N

V_{e4} = V_{g4} + Vp

= 627703,9663 N

$\frac{Vp}{V_{e3}}$ = 0,3287755 < 0,5 tidak memenuhi

$\frac{Vp}{V_{e4}}$ = 0,4229517 < 0,5 tidak memenuhi

$V_{c3} = \frac{1}{6}\sqrt{f'c}.bw.d$

$= 608846{,}80$ N

$V_{c4} = \frac{1}{6}\sqrt{f'c}.bw.d$

$= 608846{,}80$ N

$V_{s3} = V_{e3} - \Phi s \times V_{c3}$

$= 350871{,}6463$ N

$V_{s4} = V_{e4} - \Phi s \times V_{c4}$

$= 171068{,}8663$ N

$V_s = \max (V_{s3}, V_{s4})$

$= 350871{,}6463$ N

$V_s = 350871{,}6463$ N $<$ $V_{si\ max} = 3534636{,}238$ N

$\frac{Av}{S_2} = \frac{Vs}{\Phi s.fys.d}$

$= 0{,}9665885573$ mm

$\frac{Av}{S_{min}} = \frac{1}{3}\frac{bw}{fys}$

$= 0{,}666666667$ mm

$\frac{Av}{S_2} = \max\left(\frac{Av}{S_2}, \frac{Av}{S_{min}}\right)$

$= 0{,}9665885573$ mm

$\frac{Av}{S} = \max\left(\frac{Av}{S_1}, \frac{Av}{S_2}\right)$

$= 0{,}9665885573$ mm

$Av = 2\left(\frac{1}{4}\pi.d^2\right)$

$= 157{,}0796$

$S_1 = \dfrac{Av}{Av/s}$

= 162,5092691 mm

Syarat S max pada tulangan geser

- $\dfrac{d}{2}$ = 605 mm
- 8db = 176 mm
- 24 dbs = 240 mm
- 300 mm

S perlu = min (S_1,Smax)

= 162,5092691 mm ≈ 160 mm

Digunakan tulangan D10 – 160 mm.

- Tulangan geser pada jarak 2h dari muka kolom

<u>Berdasarkan Vu dari 4 kombinasi</u>

V_{u1} = - 480986,38 N

V_{u2} = - 601279,70 N

V_{u3} = - 483078,60 N

V_{u4} = - 320945,80 N

V_u = max (V_{u1}, V_{u2}, V_{u3}, V_{u4})

= 601279,70 N

$V_c = \dfrac{1}{6}\sqrt{f'c}.bw.d$ → f'c = 30 MPa; bw = 800 mm

d = 1250 – 40 = 1210 mm

= 883659,059 N

Vs = Vu – Φs x Vc → Φs = 0,75

$= -61464{,}59425$ N

$V_{si\ max} = \frac{2}{3}\sqrt{f'c}.bw.d$

$= 3534636{,}238$ N

$Vs = -61464{,}59425$ N $<$ $V_{si\ max} = 3534636{,}238$ N

$\frac{Av}{S_1} = \frac{Vs}{\Phi s.fys.d}$ → fys = 400 MPa

$= -0{,}16932395$ mm

$\frac{Av}{S_{min}} = \frac{1}{3}\frac{bw}{fys}$

$= 0{,}666666667$ mm

$\frac{Av}{S_1} = \max\left(\frac{Av}{S_1}, \frac{Av}{S_{min}}\right)$

$= 0{,}666666667$ mm

Berdasarkan tulangan terpasang

$Asti = 14\left(\frac{1}{4}\pi.d^2\right)$

$= 5321{,}857955$ mm^2

$ati = \frac{Asti.\alpha.fy}{0{,}85.f'c.bw}$ → fy = 400 MPa; α = 1,25

$= 130{,}437695$ mm

$Nmpi = Asti \times \alpha \times fy \times \left(d - \frac{ati}{2}\right)$

$= 3046181342$ Nmm

$Asbj = 9\left(\frac{1}{4}\pi.d^2\right)$

$= 3421{,}1944$ mm^2

abj $= \frac{Asbj.\alpha.fy}{0{,}85.f'c.bw}$

$= 83{,}8580392$ mm

Pmpj $=$ Asbj x α x fy x (d - $\frac{abj}{2}$)

$= 1998098948$ Nmm

Vp $= \frac{Nmpi + Pmpj}{Ln}$ → Ln = 20000-1000 = 19000 mm

$= 265488{,}4363$ N

$V_{g3} = 1{,}2\ (V_{SDL} + V_{DL}) + 0{,}5\ V_{LL}$ → $(V_{SDL} + V_{DL}) = 343561{,}70$ N

$V_{LL} = 118128{,}54$ N

$= 471338{,}31$ N

$V_{g4} = 0{,}9\ (V_{SDL} + V_{DL})$

$= 309205{,}53$ N

$V_{e3} = V_{g3} + Vp$

$= 736826{,}7463$ N

$V_{e4} = V_{g4} + Vp$

$= 574693{,}9663$ N

$\frac{Vp}{V_{e3}} = 0{,}36031 < 0{,}5$ tidak memenuhi

$\frac{Vp}{V_{e4}} = 0{,}46196 < 0{,}5$ tidak memenuhi

$V_{c3} = \frac{1}{6}\sqrt{f'c}.bw.d$

$= 608846{,}80$ N

$V_{c4} = \frac{1}{6}\sqrt{f'c}.bw.d$

$= 608846{,}80$ N

V_{s3} $= V_{e3} - \Phi s \times V_{c3}$

$= 280191{,}6463$ N

V_{s4} $= V_{e4} - \Phi s \times V_{c4}$

$= 118058{,}8663$ N

V_s $= \max (V_{s3}, V_{s4})$

$= 280191{,}6463$ N

V_s $= 280191{,}6463$ N $<$ $V_{si\ max} = 3534636{,}238$ N

$$\frac{Av}{S_2} = \frac{Vs}{\Phi s.\, fys.d}$$

$= 0{,}7718778135$ mm

$$\frac{Av}{S_{min}} = \frac{1}{3}\,\frac{bw}{fys}$$

$= 0{,}666666667$ mm

$$\frac{Av}{S_2} = \max\left(\frac{Av}{S_2}, \frac{Av}{S_{min}}\right)$$

$= 0{,}7718778135$ mm

$$\frac{Av}{S} = \max\left(\frac{Av}{S_1}, \frac{Av}{S_2}\right)$$

$= 0{,}7718778135$ mm

$$Av = 2\left(\frac{1}{4}\pi.d^2\right)$$

$= 157{,}0796$

$$S_1 = \frac{Av}{Av/s}$$

$= 203{,}5031934$ mm

Syarat S max pada tulangan geser sejarak 2h

- $\frac{d}{2}$ = 605 mm
- 8db = 176 mm
- 24 dbs = 240 mm
- 300 mm

S perlu = min (S_1,Smax)

= 176 mm ≈ 170 mm

Digunakan tulangan D10 – 170 mm.

➢ Model 2

❖ Lantai 1

Tulangan balok tumpuan i = tulangan balok tumpuan j

Berdasarkan Vu dari 4 kombinasi

V_{u1} = - 486835,40 N

V_{u2} = - 584003,29 N

V_{u3} = - 465939,80 N

V_{u4} = - 313649,67 N

V_u = max (V_{u1}, V_{u2}, V_{u3}, V_{u4})

= 584003,29 N

$V_c = \frac{1}{6}\sqrt{f'c}.bw.d$ → f'c = 30 MPa; bw = 800 mm

d = 1250 – 40 = 1210 mm

= 883659,059 N

Vs = Vu – Φs x Vc → Φs = 0,75

= -78741,00425 N

$V_{si\ max} = \frac{2}{3}\sqrt{f'c}.bw.d$

= 3534636,238 N

Vs = -78741,00425 N < $V_{si\ max}$ = 3534636,238 N

$\frac{Av}{S_1} = \frac{Vs}{\Phi s.fys.d}$ → fys = 400 MPa

= -0,216917 mm

$\frac{Av}{S_{min}} = \frac{1}{3}\frac{bw}{fys}$

= 0,666666667 mm

$\frac{Av}{S_1} = \max\left(\frac{Av}{S_1}, \frac{Av}{S_{min}}\right)$

= 0,666666667 mm

Berdasarkan tulangan terpasang

Asti $= 16\left(\frac{1}{4}\pi.d^2\right)$

= 6082,1233771 mm^2

ati $= \frac{Asti.\alpha.fy}{0{,}85.f'c.bw}$ → fy = 400 MPa; α = 1,25

= 149,0716514 mm

Nmpi = Asti x α x fy x $\left(d - \frac{ati}{2}\right)$

= 3453016613 Nmm

Asbj $= 9\left(\frac{1}{4}\pi.d^2\right)$

= 3421,1944 mm^2

abj $= \frac{Asbj.\alpha.fy}{0{,}85.f'c.bw}$

= 83,8580392 mm

Pmpj = Asbj x α x fy x (d - $\frac{abj}{2}$)

= 1998098948 Nmm

Vp = $\frac{Nmpi + Pmpj}{Ln}$ → Ln = 20000-1000 = 19000 mm

= 286900,819 N

V_{g3} = 1,2 (V_{SDL} + V_{DL}) + 0,5 V_{LL} → (V_{SDL} + V_{DL}) = 347739,57 N

V_{LL} = 104197,37 N

= 469386,169 N

V_{g4} = 0,9 (V_{SDL} + V_{DL})

= 312965,613 N

V_{e3} = V_{g3} + Vp

= 756286,988 N

V_{e4} = V_{g4} + Vp

= 599866,432 N

$\frac{Vp}{V_{e3}}$ = 0,3886 < 0,5 tidak memenuhi

$\frac{Vp}{V_{e4}}$ = 0,4931 < 0,5 tidak memenuhi

V_{c3} = $\frac{1}{6}\sqrt{f'c}.bw.d$

= 608846,80 N

V_{c4} = $\frac{1}{6}\sqrt{f'c}.bw.d$

= 608846,80 N

V_{s3} = V_{e3} – Φs x V_{c3}

= 299651,888 N

V_{s4} = V_{e4} – Φs x V_{c4}

= 14231,332 N

V_s = max (V_{s3}, V_{s4})

= 299651,888 N

V_s = 299651,888 N < $V_{si\ max}$ = 3534636,238 N

$$\frac{Av}{S_2} = \frac{Vs}{\Phi s.fys.d}$$

= 0,82549 mm

$$\frac{Av}{S_{min}} = \frac{1}{3}\frac{bw}{fys}$$

= 0,666666667 mm

$$\frac{Av}{S_2} = \max\left(\frac{Av}{S_2}, \frac{Av}{S_{min}}\right)$$

= 0,82549 mm

$$\frac{Av}{S} = \max\left(\frac{Av}{S_1}, \frac{Av}{S_2}\right)$$

= 0,82549 mm

$$Av = 2\left(\frac{1}{4}\pi.d^2\right)$$

= 157,0796

$$S_1 = \frac{Av}{Av/s}$$

= 190,2871 mm

Syarat S max pada tulangan geser

- $\frac{d}{2}$ = 605 mm
- 8db = 176 mm
- 24 dbs = 240 mm

- 300 mm

S perlu = min (S_1,Smax)

= 176 mm ≈ 170 mm

Digunakan tulangan D10 – 170 mm.

- Tulangan geser pada jarak 2h dari muka kolom

Berdasarkan Vu dari 4 kombinasi

V_{u1} = - 404459,54 N

V_{u2} = - 513395,41 N

V_{u3} = - 409453,5 N

V_{u4} = - 270684,94 N

V_u = max (V_{u1}, $V_{u2,}$ V_{u3}, V_{u4})

= 513395,41 N

$V_c = \frac{1}{6}\sqrt{f'c}.bw.d$ → f'c = 30 MPa; bw = 800 mm

d = 1250 – 40 = 1210 mm

= 883659,059 N

Vs = Vu – Φs x Vc → Φs = 0,75

= -149348,8843 N

$V_{si\ max} = \frac{2}{3}\sqrt{f'c}.bw.d$

= 3534636,238 N

Vs = -149348,8843 N < $V_{si\ max}$ = 3534636,238 N

$\frac{Av}{S_1} = \frac{Vs}{\Phi s.fys.d}$ → fys = 400 MPa

= -0,4114294 mm

$\frac{Av}{S_{min}} = \frac{1}{3}\frac{bw}{fys}$

= 0,666666667 mm

$\frac{Av}{S_1} = \max\left(\frac{Av}{S_1}, \frac{Av}{S_{min}}\right)$

= 0,666666667 mm

Berdasarkan tulangan terpasang

Asti $= 16\left(\frac{1}{4}\pi.d^2\right)$

= 6082,1233771 mm^2

ati $= \frac{Asti.\alpha.fy}{0{,}85.f'c.bw}$ → fy = 400 MPa; α = 1,25

= 149,0716514 mm

Nmpi = Asti x α x fy x $\left(d - \frac{ati}{2}\right)$

= 3453016613 Nmm

Asbj $= 9\left(\frac{1}{4}\pi.d^2\right)$

= 3421,1944 mm^2

abj $= \frac{Asbj.\alpha.fy}{0{,}85.f'c.bw}$

= 83,8580392 mm

Pmpj = Asbj x α x fy x $\left(d - \frac{abj}{2}\right)$

= 1998098948 Nmm

Vp $= \frac{Nmpi + Pmpj}{Ln}$ → Ln = 20000-1000 = 19000 mm

= 286900,819 N

V_{g3} = 1,2 (V_{SDL} + V_{DL}) + 0,5 V_{LL} → (V_{SDL} + V_{DL}) = 570169,67 N

V_{LL} = 104197,37 N

= 736302,289 N

V_{g4} = 0,9 (V_{SDL} + V_{DL})

= 513152,703 N

V_{e3} = V_{g3} + Vp

= 1023203,108 N

V_{e4} = V_{g4} + Vp

= 800053,522 N

$\frac{Vp}{V_{e3}}$ = 0,2804 < 0,5 tidak memenuhi

$\frac{Vp}{V_{e4}}$ = 0,3586 < 0,5 tidak memenuhi

V_{c3} = $\frac{1}{6}\sqrt{f'c}.bw.d$

= 608846,80 N

V_{c4} = $\frac{1}{6}\sqrt{f'c}.bw.d$

= 608846,80 N

V_{s3} = V_{e3} – Φs x V_{c3}

= 566568,01 N

V_{s4} = V_{e4} – Φs x V_{c4}

= 343418,422 N

V_s = max (V_{s3}, V_{s4})

= 566568,01 N

V_s = 566568,01 N < $V_{si\ max}$ = 3534636,238 N

$$\frac{Av}{S_2} = \frac{Vs}{\Phi s.\, fys.d}$$

$$= 1{,}561 \text{ mm}$$

$$\frac{Av}{S_{min}} = \frac{1}{3}\frac{bw}{fys}$$

$$= 0{,}666666667 \text{ mm}$$

$$\frac{Av}{S_2} = \max\left(\frac{Av}{S_2}, \frac{Av}{S_{min}}\right)$$

$$= 1{,}561 \text{ mm}$$

$$\frac{Av}{S} = \max\left(\frac{Av}{S_1}, \frac{Av}{S_2}\right)$$

$$= 1{,}561 \text{ mm}$$

$$Av = 2\left(\frac{1}{4}\pi.d^2\right)$$

$$= 157{,}0796 \text{ mm}^2$$

$$S_1 = \frac{Av}{Av/s}$$

$$= 100{,}64 \text{ mm}$$

Syarat S max pada tulangan geser sejarak 2h

- $\frac{d}{2}$ = 605 mm
- 8db = 176 mm
- 24 dbs = 240 mm
- 300 mm

S perlu = min (S_1,Smax)

= 100,64 mm ≈ 100 mm

Digunakan tulangan D10 – 100 mm.

❖ **Lantai 2**

- Tulangan balok tumpuan i = tulangan balok tumpuan j

Berdasarkan Vu dari 4 kombinasi

V_{u1} = - 491117,68 N

V_{u2} = - 589675,83 N

V_{u3} = - 468292 N

V_{u4} = - 313858,55 N

V_u = max (V_{u1}, V_{u2}, V_{u3}, V_{u4})

= 589675,83 N

$V_c = \frac{1}{6}\sqrt{f'c}.bw.d$ → f'c = 30 MPa; bw = 800 mm

d = 1250 – 40 = 1210 mm

= 883659,059 N

Vs = Vu – Φs x Vc → Φs = 0,75

= -73068,46425 N

$V_{si\ max} = \frac{2}{3}\sqrt{f'c}.bw.d$

= 3534636,238 N

Vs = - 73068,46425 N < $V_{si\ max}$ = 3534636,238 N

$\frac{Av}{S_1} = \frac{Vs}{\Phi s.fys.d}$ → fys = 400 MPa

= - 0,201291 mm

$\frac{Av}{S_{min}} = \frac{1}{3}\frac{bw}{fys}$

= 0,666666667 mm

$\frac{Av}{S_1}$ = max ($\frac{Av}{S_1}$, $\frac{Av}{S_{min}}$)

= 0,666666667 mm

Berdasarkan tulangan terpasang

Asti = 17 ($\frac{1}{4}\pi.d^2$)

= 6462,256088 mm^2

ati = $\frac{Asti.\alpha.fy}{0,85.f'c.bw}$ → fy = 400 MPa; α = 1,25

= 158,3886296 mm

Nmpi = Asti x α x fy x (d - $\frac{ati}{2}$)

= 3653777962 Nmm

Asbj = 9 ($\frac{1}{4}\pi.d^2$)

= 3421,1944 mm^2

abj = $\frac{Asbj.\alpha.fy}{0,85.f'c.bw}$

= 83,8580392 mm

Pmpj = Asbj x α x fy x (d - $\frac{abj}{2}$)

= 19980989,48 Nmm

Vp = $\frac{Nmpi + Pmpj}{Ln}$ → Ln = 20000-1000 = 19000 mm

= 297467,2058 N

V_{g3} = 1,2 (V_{SDL} + V_{DL}) + 0,5 V_{LL} → (V_{SDL} + V_{DL}) = 350798,34 N

V_{LL} = 105448,64 N

= 473682,328 N

V_{g4} = 0,9 (V_{SDL} + V_{DL})

= 315718,506 N

V_{e3} = V_{g3} + Vp

= 771149,5338 N

V_{e4} = V_{g4} + Vp

= 613185,7118 N

$\frac{Vp}{V_{e3}}$ = 0,385745 < 0,5 tidak memenuhi

$\frac{Vp}{V_{e4}}$ = 0,485118 < 0,5 tidak memenuhi

V_{c3} = $\frac{1}{6}\sqrt{f'c}.bw.d$

= 608846,80 N

V_{c4} = $\frac{1}{6}\sqrt{f'c}.bw.d$

= 608846,80 N

V_{s3} = V_{e3} – Φs x V_{c3}

= 314514,4338 N

V_{s4} = V_{e4} – Φs x V_{c4}

= 156550,6118 N

V_s = max (V_{s3}, V_{s4})

= 314514,4338 N

V_s = 314514,4338 N < $V_{si\ max}$ = 3534636,238 N

$\frac{Av}{S_2}$ = $\frac{Vs}{\Phi s.fys.d}$

= 0,86643 mm

$\frac{Av}{S_{min}} = \frac{1}{3}\frac{bw}{fys}$

= 0,666666667 mm

$\frac{Av}{S_2} = \max\left(\frac{Av}{S_2}, \frac{Av}{S_{min}}\right)$

= 0,86643 mm

$\frac{Av}{S} = \max\left(\frac{Av}{S_1}, \frac{Av}{S_2}\right)$

= 0,86643 mm

$Av = 2\left(\frac{1}{4}\pi.d^2\right)$

= 157,0796 mm^2

$S_1 = \frac{Av}{Av/s}$

= 181,295 mm

Syarat S max pada tulangan geser

- $\frac{d}{2}$ = 605 mm
- 8db = 176 mm
- 24 dbs = 240 mm
- 300 mm

S perlu = min (S_1,Smax)

= 176 mm ≈ 170 mm

Digunakan tulangan D10 – 170 mm.

- Tulangan geser pada jarak 2h dari muka kolom

<u>Berdasarkan Vu dari 4 kombinasi</u>

V_{u1} = - 408741,82 N

V_{u2} = - 519067,95 N

V_{u3} = - 411805,70 N

V_{u4} = - 271493,82 N

V_u = max (V_{u1}, $V_{u2,}$ V_{u3}, V_{u4})

= 519067,95 N

$V_c = \frac{1}{6}\sqrt{f'c}.bw.d$ → f'c = 30 MPa; bw = 800 mm

d = 1250 – 40 = 1210 mm

= 883659,059 N

Vs = Vu – Φs x Vc → Φs = 0,75

= -143676,3443N

$V_{si\ max} = \frac{2}{3}\sqrt{f'c}.bw.d$

= 3534636,238 N

Vs = - 143676,3443N < $V_{si\ max}$ = 3534636,238 N

$\frac{Av}{S_1} = \frac{Vs}{\Phi s.fys.d}$ → fys = 400 MPa

= - 0,3958026 mm

$\frac{Av}{S_{min}} = \frac{1}{3}\frac{bw}{fys}$

= 0,666666667 mm

$\frac{Av}{S_1} = \max\left(\frac{Av}{S_1}, \frac{Av}{S_{min}}\right)$

= 0,666666667 mm

Berdasarkan tulangan terpasang

Asti $= 17\ (\frac{1}{4}\pi.d^2)$

$= 6462{,}256088\ mm^2$

ati $= \frac{Asti.\alpha.fy}{0{,}85.f'c.bw}$ → fy = 400 MPa; α = 1,25

$= 158{,}3886296$ mm

Nmpi $=$ Asti x α x fy x (d - $\frac{ati}{2}$)

$= 3653777962$ Nmm

Asbj $= 9\ (\frac{1}{4}\pi.d^2)$

$= 3421{,}1944\ mm^2$

abj $= \frac{Asbj.\alpha.fy}{0{,}85.f'c.bw}$

$= 83{,}8580392$ mm

Pmpj $=$ Asbj x α x fy x (d - $\frac{abj}{2}$)

$= 1998098948$ Nmm

Vp $= \frac{Nmpi + Pmpj}{Ln}$ → Ln = 20000-1000 = 19000 mm

$= 297467{,}2058$ N

$V_{g3} = 1{,}2\ (V_{SDL} + V_{DL}) + 0{,}5\ V_{LL}$ → $(V_{SDL} + V_{DL}) = 291958{,}44$ N

$V_{LL} = 105448{,}64$ N

$= 403074{,}448$ N

$V_{g4} = 0{,}9\ (V_{SDL} + V_{DL})$

$= 262762{,}596$ N

$V_{e3} = V_{g3} + Vp$

$= 700541{,}6538$ N

V_{e4} $= V_{g4} + Vp$

$= 560229{,}8018$ N

$\frac{Vp}{V_{e3}}$ $= 0{,}4246$ $<$ 0,5 tidak memenuhi

$\frac{Vp}{V_{e4}}$ $= 0{,}5310$ $<$ 0,5 tidak memenuhi

V_{c3} $= \frac{1}{6}\sqrt{f'c}.bw.d$

$= 608846{,}80$ N

V_{c4} $= 0$

V_{s3} $= V_{e3} - \Phi s \times V_{c3}$

$= 243906{,}5538$ N

V_{s4} $= V_{e4} - \Phi s \times V_{c4}$

$= 560229{,}8018$ N

V_s $= \max (V_{s3}, V_{s4})$

$= 560229{,}8018$ N

V_s $= 560229{,}8018$ N $<$ $V_{si\ max} = 3534636{,}238$ N

$\frac{Av}{S_2}$ $= \frac{Vs}{\Phi s.fys.d}$

$= 1{,}54333$ mm

$\frac{Av}{S_{min}}$ $= \frac{1}{3}\frac{bw}{fys}$

$= 0{,}666666667$ mm

$\frac{Av}{S_2}$ $= \max\left(\frac{Av}{S_2}, \frac{Av}{S_{min}}\right)$

$= 1{,}54333$ mm

$\frac{Av}{S}$ $= \max\left(\frac{Av}{S_1}, \frac{Av}{S_2}\right)$

= 1,54333 mm

Av = $2\left(\frac{1}{4}\pi.d^2\right)$

= 157,0796 mm^2

S_1 = $\frac{Av}{Av/s}$

= 101,779 mm

Syarat S max pada tulangan geser sejarak 2h

- $\frac{d}{2}$ = 605 mm
- 8db = 176 mm
- 24 dbs = 240 mm
- 300 mm

S perlu = min (S_1,Smax)

= 101,779 mm ≈ 100 mm

Digunakan tulangan D10 – 100 mm.

❖ **Lantai 3**

Tulangan balok tumpuan i = tulangan balok tumpuan j

<u>Berdasarkan Vu dari 4 kombinasi</u>

V_{u1} = - 481438,97 N

V_{u2} = - 576666,32 N

V_{u3} = - 453960,80 N

V_{u4} = - 303074,30 N

V_u = max (V_{u1}, V_{u2}, V_{u3}, V_{u4})

= 576666,32 N

$V_c = \frac{1}{6}\sqrt{f'c}.bw.d$ → f'c = 30 MPa; bw = 800 mm

d = 1250 – 40 = 1210 mm

= 883659,059 N

Vs = Vu – Φs x Vc → Φs = 0,75

= -86077,97425 N

$V_{si\ max} = \frac{2}{3}\sqrt{f'c}.bw.d$

= 3534636,238 N

Vs = -86077,97425 N < $V_{si\ max}$ = 3534636,238 N

$\frac{Av}{S_1} = \frac{Vs}{\Phi s.fys.d}$ → fys = 400 MPa

= - 0,237129 mm

$\frac{Av}{S_{min}} = \frac{1}{3}\frac{bw}{fys}$

= 0,666666667 mm

$\frac{Av}{S_1} = \max\left(\frac{Av}{S_1}, \frac{Av}{S_{min}}\right)$

= 0,666666667 mm

Berdasarkan tulangan terpasang

$Asti = 15\left(\frac{1}{4}\pi.d^2\right)$

= 5701,990666 mm^2

$ati = \frac{Asti.\alpha.fy}{0,85.f'c.bw}$ → fy = 400 MPa; α = 1,25

= 139,7546732 mm

Nmpi = Asti x α x fy x (d - $\frac{ati}{2}$)

= 3250484392 Nmm

Asbj = 9 ($\frac{1}{4}\pi.d^2$)

= 3421,1944 mm^2

abj = $\frac{Asbj.\alpha.fy}{0{,}85.f'c.bw}$

= 83,8580392 mm

Pmpj = Asbj x α x fy x (d - $\frac{abj}{2}$)

= 1998098948 Nmm

Vp = $\frac{Nmpi + Pmpj}{Ln}$ → Ln = 20000-1000 = 19000 mm

= 276239,6495 N

V_{g3} = 1,2 (V_{SDL} + V_{DL}) + 0,5 V_{LL} → (V_{SDL} + V_{DL}) = 343884,98 N

V_{LL} = 102502,72N

= 463913,336 N

V_{g4} = 0,9 (V_{SDL} + V_{DL})

= 309496,482 N

V_{e3} = V_{g3} + Vp

= 740152,9855 N

V_{e4} = V_{g4} + Vp

= 585736,1315 N

$\frac{Vp}{V_{e3}}$ = 0,3732 < 0,5 tidak memenuhi

$\frac{Vp}{V_{e4}}$ = 0,4716 < 0,5 tidak memenuhi

$V_{c3} = \frac{1}{6}\sqrt{f'c}.bw.d$

$= 608846{,}80$ N

$V_{c4} = \frac{1}{6}\sqrt{f'c}.bw.d$

$= 608846{,}80$ N

$V_{s3} = V_{e3} - \Phi s \times V_{c3}$

$= 283571{,}8855$ N

$V_{s4} = V_{e4} - \Phi s \times V_{c4}$

$= 129101{,}0315$ N

$V_s = \max (V_{s3}, V_{s4})$

$= 283571{,}8855$ N

$V_s = 283571{,}8855$ N $<$ $V_{si\ max} = 3534636{,}238$ N

$\frac{Av}{S_2} = \frac{Vs}{\Phi s.fys.d}$

$= 0{,}7810410069$ mm

$\frac{Av}{S_{min}} = \frac{1}{3}\frac{bw}{fys}$

$= 0{,}666666667$ mm

$\frac{Av}{S_2} = \max\left(\frac{Av}{S_2}, \frac{Av}{S_{min}}\right)$

$= 0{,}7810410069$ mm

$\frac{Av}{S} = \max\left(\frac{Av}{S_1}, \frac{Av}{S_2}\right)$

$= 0{,}7810410069$ mm

$Av = 2\left(\frac{1}{4}\pi.d^2\right)$

$= 157{,}0796$

$S_1 = \frac{Av}{Av/s}$

= 201,1156887 mm

Syarat S max pada tulangan geser

- $\frac{d}{2}$ = 605 mm
- 8db = 176 mm
- 24 dbs = 240 mm
- 300 mm

S perlu = min (S_1,Smax)

= 176 mm ≈ 170 mm

Digunakan tulangan D10 – 170 mm.

- Tulangan geser pada jarak 2h dari muka kolom

Berdasarkan Vu dari 4 kombinasi

V_{u1} = - 399063,11 N

V_{u2} = - 506058,44 N

V_{u3} = - 397474,50 N

V_{u4} = - 260709,57 N

V_u = max (V_{u1}, V_{u2}, V_{u3}, V_{u4})

= 506058,44 N

$V_c = \frac{1}{6}\sqrt{f'c}.bw.d$ → f'c = 30 MPa; bw = 800 mm

d = 1250 – 40 = 1210 mm

= 883659,059 N

Vs = Vu – Φs x Vc → Φs = 0,75

= -156685,8543 N

$V_{si\ max} = \frac{2}{3}\sqrt{f'c}.bw.d$

= 3534636,238 N

Vs = -156685,8543 N < $V_{si\ max}$ = 3534636,238 N

$\frac{Av}{S_1} = \frac{Vs}{\Phi s.fys.d}$ → fys = 400 MPa

= -0,431641 mm

$\frac{Av}{S_{min}} = \frac{1}{3}\frac{bw}{fys}$

= 0,666666667 mm

$\frac{Av}{S_1} = \max\left(\frac{Av}{S_1}, \frac{Av}{S_{min}}\right)$

= 0,666666667 mm

Berdasarkan tulangan terpasang

$Asti = 15\left(\frac{1}{4}\pi.d^2\right)$

= 5701,990666 mm^2

$ati = \frac{Asti.\alpha.fy}{0,85.f'c.bw}$ → fy = 400 MPa; α = 1,25

= 139,7546732 mm

$Nmpi = Asti \times \alpha \times fy \times \left(d - \frac{ati}{2}\right)$

= 3250484392 Nmm

$Asbj = 9\left(\frac{1}{4}\pi.d^2\right)$

= 3421,1944 mm^2

abj $= \dfrac{Asbj.\alpha.fy}{0{,}85.f'c.bw}$

$= 83{,}8580392$ mm

Pmpj $=$ Asbj x α x fy x (d - $\dfrac{abj}{2}$)

$= 1998098948$ Nmm

Vp $= \dfrac{Nmpi + Pmpj}{Ln}$ → Ln = 20000-1000 = 19000 mm

$= 276239{,}6495$ N

V_{g3} $= 1{,}2\ (V_{SDL} + V_{DL}) + 0{,}5\ V_{LL}$ → $(V_{SDL} + V_{DL}) = 285045{,}07$ N

$V_{LL} = 102502{,}72$N

$= 393305{,}444$ N

V_{g4} $= 0{,}9\ (V_{SDL} + V_{DL})$

$= 256540{,}563$ N

V_{e3} $= V_{g3} + Vp$

$= 669545{,}0935$ N

V_{e4} $= V_{g4} + Vp$

$= 532780{,}2125$ N

$\dfrac{Vp}{V_{e3}} = 0{,}412578 < 0{,}5$ tidak memenuhi

$\dfrac{Vp}{V_{e4}} = 0{,}518487 < 0{,}5$ tidak memenuhi

$V_{c3} = \dfrac{1}{6}\sqrt{f'c}.bw.d$

$= 608846{,}80$ N

$V_{c4} = 0$

V_{s3} $= V_{e3} - \Phi s$ x V_{c3}

$= 212909{,}9935$ N

V_{s4} $= V_{e4} - \Phi s \times V_{c4}$

$= 532780{,}2125$ N

V_s $= \max (V_{s3}, V_{s4})$

$= 532780{,}2125$ N

V_s $= 532780{,}2125$ N $<$ $V_{si\ max} = 3534636{,}238$ N

$$\frac{Av}{S_2} = \frac{Vs}{\Phi s.\, fys.d}$$

$= 1{,}467714084$ mm

$$\frac{Av}{S_{min}} = \frac{1}{3}\,\frac{bw}{fys}$$

$= 0{,}666666667$ mm

$$\frac{Av}{S_2} = \max\left(\frac{Av}{S_2}, \frac{Av}{S_{min}}\right)$$

$= 1{,}467714084$ mm

$$\frac{Av}{S} = \max\left(\frac{Av}{S_1}, \frac{Av}{S_2}\right)$$

$= 1{,}467714084$ mm

$$Av = 2\left(\frac{1}{4}\pi.d^2\right)$$

$= 157{,}0796$

$$S_1 = \frac{Av}{Av/s}$$

$= 107{,}0232968$ mm

Syarat S max pada tulangan geser sejarak 2h

- $\frac{d}{2}$ $= 605$ mm
- 8db $= 176$ mm

- 24 dbs = 240 mm
- 300 mm

S perlu = min (S_1,Smax)

= 107,0232968 mm ≈ 100 mm

Digunakan tulangan D10 – 100 mm.

4. Perhitungan Tulangan geser kolom

❖ Model 1

➢ Lantai 1

b = 1000 mm

bc = b – 2(selimut beton) = 1000 – 2 (70) = 860 mm

hc = h - 2(selimut beton) = 1000 – 2 (70) = 860 mm

Ac = bc x hc = 860 x 860 = 739600 mm^2

Ag = b x h = 1000 x 1000 = 1000000 mm^2

- Berdasarkan kombinasi pembebanan tetap : diambil dari kombinasi pembebanan 1 dan 2, diambil yang terbesar.

  Gaya geser terfaktor (Vu) = 190772,42 N → kombinasi 1

  Gaya aksial terfaktor (Pu) = - 4404428 N → kombinasi 1

  Gaya geser terfaktor (Vu) = 242278,71 N → kombinasi 2

  Gaya aksial terfaktor (Pu) = -5344563 N → kombinasi 2

  $Vc = (1+\frac{Pu}{14Ag})\ \frac{1}{6}\sqrt{f'c}$. Ac → f'c = 30 MPa

  = 932904,4552 N

  $Vs = \frac{Vu}{0,75} - Vc$

  = -609866,1752 N < 0

Vs max = $\frac{2}{3}\sqrt{f'c}.Ac$

= 2700637,357 N

Vs = 0 N < Vs max = 2700637,357 N

Tulangan geser spiral

$\frac{Av}{S_1} = \frac{2Vs}{\Phi s.fys.d}$ → fys = 400 MPa ; Φs = 0,75 ; d = 1210 mm

= 0

- Berdasarkan kombinasi pembebanan sementara : diambil dari kombinasi pembebanan 3 dan 4, diambil yang terbesar. Didapat dari kombinasi 3

Vu = 342827,10 N

Pu = - 4463165 N

M_{ub} = 6,017 . 10^8

M_{ut} = 3,413 . 10^8

$V_{p1} = \frac{M_{ub} + M_{ut}}{Hn}$ → Hn = 2750 mm

= 342909,0909 N

$V_{p2} = \frac{\sum M_{balok}}{\frac{1}{2}(H1 + H2)}$ → Npmi = 3250484392 Nmm

Pmpj = 1998098948 Nmm

H1 = H2 = 4000 mm

= 2624291,67 N

Vp = min (V_{p1} , V_{p2})

= 342909,0909 N

$Vc = (1 + \frac{Pu}{14Ag}) + \frac{1}{6}\sqrt{f'c}.Ac$

= 675160,658 N

Vu = max (Vu , Vp)

= 342827,10 N

Pu > $\frac{f'c.Ag}{20}$

5344563 N < 1500000 N

Vc = 0

Vs = $\frac{Vu}{0,75} - Vc$

= 457102,8 N

Vs = 457102,8 N < Vs max = 2700637,357 N

$\frac{Av}{S_2} = \frac{2Vs}{\Phi s.fys.d}$

= 2,5184727 mm

$\frac{Av}{S_2}_{min} = \frac{1}{3}.\frac{c}{fys}$

= 0,83333 mm

$\frac{Av}{S_2}$ = max ($\frac{Av}{S_2}, \frac{Av}{S_2}_{min}$)

= 2,5184727 mm

$\frac{Av}{S}$ = max ($\frac{Av}{S_1}, \frac{Av}{S_2}$)

= 2,5184727 mm

Lo = max (D, $\frac{Hn}{6}$, 500 mm)

= max (1000 mm, $\frac{2750}{6}$, 500 mm)

= 1000 mm

Asp = 2 x 0,25 x π x dbs^2 → dbs = 10 mm

$= 157{,}0796327 \text{ mm}^2$

$\rho s = \max \left[0{,}12 \frac{f'c}{fys} ; 0{,}45\left(\frac{Ag}{Ac} - 1\right)\frac{f'c}{fys} \right]$

$= 0{,}011883 \text{ mm}$

$S_{o1} = 4 \frac{Asp}{bc.\rho s}$

$= 61{,}483038 \text{ mm}$

$S_{o2} = \frac{Asp}{\frac{Av}{s}}$

$= 62{,}37098 \text{ mm}$

$S_{max} = \min (100 \text{ mm} , 6db)$

$= 100 \text{ mm}$

$S_{perlu} = \min (S_{o1} , S_{o2}, S_{max})$

$= 61{,}483038 \text{ mm}$

$S_{min} = 25 \text{ mm} + dbs$

$= 35 \text{ mm}$

$S_0 = \max (S_{perlu}, S_{min})$

$= 61{,}483038 \text{ mm}$

Jadi jarak sengkang didaerah Lo = 60 mm → d10 – 60 mm

Jarak sengkang diluar daerah Lo :

$S = \min (150 \text{ mm}, 6db)$

$= 132 \text{ mm}$

Digunakan d10-130 mm.

- **Lantai 2**

b = 1000 mm

bc = b – 2(selimut beton) = 1000 – 2 (70) = 860 mm

hc = h - 2(selimut beton) = 1000 – 2 (70) = 860 mm

Ac = bc x hc = 860 x 860 = 739600 mm^2

Ag = b x h = 1000 x 1000 = 1000000 mm^2

- Berdasarkan kombinasi pembebanan tetap : diambil dari kombinasi pembebanan 1 dan 2, diambil yang terbesar.

  Gaya geser terfaktor (Vu) = 346123,20 N → kombinasi 1

  Gaya aksial terfaktor (Pu) = -2933587,4 N → kombinasi 1

  Gaya geser terfaktor (Vu) = 439098,80 N → kombinasi 2

  Gaya aksial terfaktor (Pu) = -3559462 N → kombinasi 2

  $Vc = (1+\frac{Pu}{14Ag})\ \frac{1}{6}\sqrt{f'c}$. Ac → f'c = 30 MPa

  = 846816,7686 N

  $Vs = \frac{Vu}{0,75} - Vc$

  = -261351,702 N < 0

  $Vs\ max = \frac{2}{3}\sqrt{f'c}.Ac$

  = 2700637,357 N

  Vs = 0 N < Vs max = 2700637,357 N

  Tulangan geser spiral

  $\frac{Av}{S_1} = \frac{2Vs}{\Phi s.\ fys.d}$ → fys = 400 MPa ; Φs = 0,75 ; d = 1210 mm

  = 0

- Berdasarkan kombinasi pembebanan sementara : diambil dari kombinasi pembebanan 3 dan 4, diambil yang terbesar. Didapat dari kombinasi 3

  Vu = 468802 N

  Pu = - 2850904,20 N

M_{ub} = 9,531 . 10^8

M_{ut} = 3,364 . 10^8

$V_{p1} = \frac{M_{ub} + M_{ut}}{Hn}$ → Hn = 2750 mm

= 468909,0909 N

$V_{p2} = \frac{\sum M_{balok}}{\frac{1}{2}(H1 + H2)}$ → Npmi = 3453016599 Nmm

Pmpj = 1998098948 Nmm

H1 = H2 = 4000 mm

= 2725557,774 N

Vp = min (V_{p1} , V_{p2})

= 519963,6364 N

$Vc = (1 + \frac{Pu}{14Ag}) + \frac{1}{6}\sqrt{f'c}.Ac$

= 675160,4435 N

Vu = max (Vu , Vp)

= 519963,6364 N

$Pu > \frac{f'c.Ag}{20}$

2850904,20 N < 1500000 N

Vc = 0

$Vs = \frac{Vu}{0,75} - Vc$

= 693284,8485 N

Vs = 693284,8485 N < Vs max = 2700637,357 N

$\frac{Av}{S_2} = \frac{2Vs}{\Phi s.fys.d}$

= 3,819751 mm

$\frac{Av}{S_2}_{min} = \frac{1}{3}.\frac{c}{fys}$

= 0,83333 mm

$\frac{Av}{S_2}$ = max ($\frac{Av}{S_2}$, $\frac{Av}{S_2}_{min}$)

= 3,819751 mm

$\frac{Av}{S}$ = max ($\frac{Av}{S1}$, $\frac{Av}{S_2}$)

= 3,819751 mm

Lo = max (D, $\frac{Hn}{6}$, 500 mm)

= max (1000 mm, $\frac{2750}{6}$, 500 mm)

= 1000 mm

Asp = 2 x 0,25 x π x dbs^2 → dbs = 10 mm

= 157,0796327 mm^2

ρs = max [0,12 $\frac{f'c}{fys}$; 0,45($\frac{Ag}{Ac}$ – 1) $\frac{f'c}{fys}$]

= 0,011883 mm

S_{o1} = 4 $\frac{Asp}{bc.\rho s}$

= 61,483038 mm

S_{o2} = $\frac{Asp}{\frac{Av}{s}}$

= 41,123 mm

S_{max} = min (100 mm , 6db)

= 100 mm

S_{perlu} = min (S_{o1} , S_{o2}, S_{max})

= 41,123 mm

S_{min} = 25 mm + dbs

= 35 mm

S_0 = max (S_{perlu}, S_{min})

= 41,123 mm

Jadi jarak sengkang didaerah Lo = 40 mm → d10– 40 mm

Jarak sengkang diluar daerah Lo :

S = min (150 mm, 6db)

= 132 mm

Digunakan d10-130 mm.

- **Lantai 3**

b = 1000 mm

bc = b – 2(selimut beton) = 1000 – 2 (70) = 860 mm

hc = h - 2(selimut beton) = 1000 – 2 (70) = 860 mm

Ac = bc x hc = 860 x 860 = 739600 mm^2

Ag = b x h = 1000 x 1000 = 1000000 mm^2

- Berdasarkan kombinasi pembebanan tetap : diambil dari kombinasi pembebanan 1 dan 2, diambil yang terbesar.

Gaya geser terfaktor (Vu) = 451819,6 N → kombinasi 1

Gaya aksial terfaktor (Pu) = -1486657,3 N → kombinasi 1

Gaya geser terfaktor (Vu) = 573772,13 N → kombinasi 2

Gaya aksial terfaktor (Pu) = -1803191,1 N → kombinasi 2

Vc = $(1+\frac{Pu}{14Ag})\ \frac{1}{6}\sqrt{f'c}$. Ac → f'c = 30 MPa

= 762119,4329 N

Vs $= \frac{Vu}{0,75} - Vc$

= 2910,0738 N > 0

Vs max = $\frac{2}{3}\sqrt{f'c}.Ac$

= 2700637,357 N

Vs = 2910,0738 N < Vs max = 2700637,357 N

Tulangan geser spiral

$\frac{Av}{S_1} = \frac{2Vs}{\Phi s.fys.d}$ → fys = 400 MPa ; Φs = 0,75 ; d = 1210 mm

= 0,016

- Berdasarkan kombinasi pembebanan sementara : diambil dari kombinasi pembebanan 3 dan 4, diambil yang terbesar. Didapat dari kombinasi 3

Vu = 519824,02 N

Pu = - 1460119,1 N

M_{ub} = 9,025 . 10^8

M_{ut} = 5,274 . 10^8

$V_{p1} = \frac{M_{ub} + M_{ut}}{Hn}$ → Hn = 2750 mm

= 519963,6364 N

$V_{p2} = \frac{\sum M_{balok}}{\frac{1}{2}(H1 + H2)}$ → Npmi = 3250484392 Nmm

Pmpj = 1950290636 Nmm

H1 = H2 = 4000 mm

= 1300193,757 N

Vp = min (V_{p1} , V_{p2})

= 519963,6364 N

Vc $= (1+\frac{Pu}{14Ag})+\frac{1}{6}\sqrt{f'c}.Ac$

= 675160,4435 N

Vu = max (Vu , Vp)

= 1460119,1 N

Pu > $\frac{f'c.Ag}{20}$

1460119,1 N < 1500000 N

Vc = 0

Vs $= \frac{Vu}{0,75}-Vc$

= 1946825,467 N

Vs = 1946825,467 N < Vs max = 2700637,357 N

$\frac{Av}{S_2} = \frac{2Vs}{\Phi s.fys.d}$

= 10,72631 mm

$\frac{Av}{S_2}_{\min} = \frac{1}{3}.\frac{c}{fys}$

= 0,83333 mm

$\frac{Av}{S_2} = \max(\frac{Av}{S_2}, \frac{Av}{S_2}_{\min})$

= 10,72631 mm

$\frac{Av}{S} = \max(\frac{Av}{S1}, \frac{Av}{S_2})$

= 10,72631 mm

Lo = max (D, $\frac{Hn}{6}$, 500 mm)

= max (1000 mm, $\frac{2750}{6}$, 500 mm)

= 1000 mm

Asp = 2 x 0,25 x π x dbs^2 → dbs = 10 mm

= 157,0796327 mm^2

ρs = max [0,12 $\frac{f'c}{fys}$; 0,45($\frac{Ag}{Ac}$ – 1) $\frac{f'c}{fys}$]

= 0,011883 mm

S_{o1} = 4 $\frac{Asp}{bc.\rho s}$

= 61,483038 mm

S_{o2} = $\frac{Asp}{\frac{Av}{s}}$

= 14,64432814 mm

S_{max} = min (100 mm , 6db)

= 100 mm

S_{perlu} = min (S_{o1} , S_{o2}, S_{max})

= 14,64432814 mm

S_{min} = 25 mm + dbs

= 35 mm

S_0 = max (S_{perlu}, S_{min})

= 35 mm

Jadi jarak sengkang didaerah Lo = 35 mm → d10–35 mm

Jarak sengkang diluar daerah Lo :

S = min (150 mm, 6db)

= 132 mm

Digunakan d10-130 mm.

❖ **Model 2**

➢ **Lantai 1**

b = 1000 mm

bc = b – 2(selimut beton) = 1000 – 2 (70) = 860 mm

hc = h - 2(selimut beton) = 1000 – 2 (70) = 860 mm

Ac = bc x hc = 860 x 860 = 739600 mm^2

Ag = b x h = 1000 x 1000 = 1000000 mm^2

- Berdasarkan kombinasi pembebanan tetap : diambil dari kombinasi pembebanan 1 dan 2, diambil yang terbesar.

  Gaya geser terfaktor (Vu) = 228046,09 N → kombinasi 1

  Gaya aksial terfaktor (Pu) = - 5777340 N → kombinasi 1

  Gaya geser terfaktor (Vu) = 302891,75 N → kombinasi 2

  Gaya aksial terfaktor (Pu) = -7069283 N → kombinasi 2

  $Vc = (1+\frac{Pu}{14Ag})\ \frac{1}{6}\sqrt{f'c}$. Ac → f'c = 30 MPa

  = 675160,8442 N

  $Vs = \frac{Vu}{0,75} - Vc$

  = -271305,1775 N < 0

  $Vs\ max = \frac{2}{3}\sqrt{f'c}.Ac$

  = 2700637,357 N

  Vs = 0 N < Vs max = 2700637,357 N

  Tulangan geser spiral

  $\frac{Av}{S_1} = \frac{2Vs}{\Phi s.\ fys.d}$ → fys = 400 MPa ; Φs = 0,75 ; d = 1210 mm

= 0

- Berdasarkan kombinasi pembebanan sementara : diambil dari kombinasi pembebanan 3 dan 4, diambil yang terbesar. Didapat dari kombinasi 3

Vu = 377456,9 N

Pu = - 5838915 N

M_{ub} = 6,299 . 10^8

M_{ut} = 4,083 . 10^8

$V_{p1} = \frac{M_{ub} + M_{ut}}{Hn}$ → Hn = 2750 mm

= 232072,7273 N

$V_{p2} = \frac{\sum M_{balok}}{\frac{1}{2}(H1 + H2)}$ → Npmi = 3250484392 Nmm

Pmpj = 1998098948 Nmm

H1 = H2 = 4000 mm

= 1736498,801 N

Vp = min (V_{p1} , V_{p2})

= 232072,7273 N

$Vc = (1 + \frac{Pu}{14Ag}) + \frac{1}{6}\sqrt{f'c}.Ac$

= 675160,7563 N

Vu = max (Vu , Vp)

= 377456,9 N

$Pu > \frac{f'c.Ag}{20}$

5838915 N < 1500000 N

Vc = 0

$$Vs = \frac{Vu}{0,75} - Vc$$

$$= 503275,8667 \text{ N}$$

$$Vs = 503275,8667 \text{ N} < Vs \text{ max} = 2700637,357 \text{ N}$$

$$\frac{Av}{S_2} = \frac{2Vs}{\Phi s.\, fys.d}$$

$$= 2,7728698 \text{ mm}$$

$$\frac{Av}{S_2}_{\min} = \frac{1}{3}.\frac{c}{fys}$$

$$= 0,83333 \text{ mm}$$

$$\frac{Av}{S_2} = \max\left(\frac{Av}{S_2}, \frac{Av}{S_2}_{\min}\right)$$

$$= 2,7728698 \text{ mm}$$

$$\frac{Av}{S} = \max\left(\frac{Av}{S1}, \frac{Av}{S_2}\right)$$

$$= 2,7728698 \text{ mm}$$

$$Lo = \max\left(D, \frac{Hn}{6}, 500 \text{ mm}\right)$$

$$= \max\left(1000 \text{ mm}, \frac{2750}{6}, 500 \text{ mm}\right)$$

$$= 1000 \text{ mm}$$

$$Asp = 2 \text{ x } 0,25 \text{ x } \pi \text{ x } dbs^2 \rightarrow dbs = 10 \text{ mm}$$

$$= 157,0796327 \text{ mm}^2$$

$$\rho s = \max\left[0,12\ \frac{f'c}{fys}; 0,45\left(\frac{Ag}{Ac} - 1\right)\frac{f'c}{fys}\right]$$

$$= 0,011883 \text{ mm}$$

$$S_{o1} = 4\ \frac{Asp}{bc.\rho s}$$

= 61,483038 mm

$S_{o2} = \frac{Asp}{\frac{Av}{s}}$

= 92,71247923 mm

S_{max} = min (100 mm , 6db)

= 100 mm

S_{perlu} = min (S_{o1} , S_{o2}, S_{max})

= 61,483038 mm

S_{min} = 25 mm + dbs

= 35 mm

S_0 = max (S_{perlu}, S_{min})

= 61,483038 mm

Jadi jarak sengkang didaerah Lo = 60 mm → d10 – 60 mm

Jarak sengkang diluar daerah Lo :

S = min (150 mm, 6db)

= 132 mm

Digunakan d10-130 mm.

- **Lantai 2**

b = 1000 mm

bc = b – 2(selimut beton) = 1000 – 2 (70) = 860 mm

hc = h - 2(selimut beton) = 1000 – 2 (70) = 860 mm

Ac = bc x hc = 860 x 860 = 739600 mm^2

Ag = b x h = 1000 x 1000 = 1000000 mm^2

- Berdasarkan kombinasi pembebanan tetap : diambil dari kombinasi pembebanan 1 dan 2, diambil yang terbesar.

Gaya geser terfaktor (Vu) = 422490,90 N → kombinasi 1

Gaya aksial terfaktor (Pu) = -3833805 N → kombinasi 1

Gaya geser terfaktor (Vu) = 360041,9 N → kombinasi 2

Gaya aksial terfaktor (Pu) = -4690751 N → kombinasi 2

$Vc = (1+\frac{Pu}{14Ag})\ \frac{1}{6}\sqrt{f'c}$. Ac → f'c = 30 MPa

= 675160,6743 N

$Vs = \frac{Vu}{0,75} - Vc$

= -195104,8076 N < 0

$Vs\ max = \frac{2}{3}\sqrt{f'c}.Ac$

= 2700637,357 N

Vs = 0 N < Vs max = 2700637,357 N

Tulangan geser spiral

$\frac{Av}{S_1} = \frac{2Vs}{\Phi s.\ fys.d}$ → fys = 400 MPa ; Φs = 0,75 ; d = 1210 mm

= 0

- Berdasarkan kombinasi pembebanan sementara : diambil dari kombinasi pembebanan 3 dan 4, diambil yang terbesar. Didapat dari kombinasi 3

Vu = 549808,2 N

Pu = - 3829614 N

$M_{ub} = 1,117 . 10^9$

$M_{ut} = 3,956 . 10^8$

$V_{p1} = \frac{M_{ub} + M_{ut}}{Hn}$ → Hn = 2750 mm

= 550036,3636 N

$V_{p2} = \dfrac{\sum M_{balok}}{\frac{1}{2}(H1 + H2)}$ → Npmi = 3250484392 Nmm

Pmpj = 1998098948 Nmm

H1 = H2 = 4000 mm

= 2624291,67 N

Vp = min (V_{p1} , V_{p2})

= 550036,3636 N

$Vc = (1 + \dfrac{Pu}{14Ag}) + \dfrac{1}{6}\sqrt{f'c}.Ac$

= 675160,6128 N

Vu = max (Vu , Vp)

= 550036,3636 N

$Pu > \dfrac{f'c.Ag}{20}$

2850904,20 N < 1500000 N

Vc = 0

$Vs = \dfrac{Vu}{0,75} - Vc$

= 733381,8181 N

Vs = 733381,8181 N < Vs max = 2700637,357 N

$\dfrac{Av}{S_2} = \dfrac{2Vs}{\Phi s.fys.d}$

= 4,04067 mm

$\left(\dfrac{Av}{S_2}\right)_{min} = \dfrac{1}{3}.\dfrac{c}{fys}$

= 0,83333 mm

$\frac{Av}{S_2}$ = max ($\frac{Av}{S_2}$, $\frac{Av}{S_2}$ min)

= 4,04067 mm

$\frac{Av}{S}$ = max ($\frac{Av}{S1}$, $\frac{Av}{S_2}$)

= 4,04067 mm

Lo = max (D, $\frac{Hn}{6}$, 500 mm)

= max (1000 mm, $\frac{2750}{6}$, 500 mm)

= 1000 mm

Asp = 2 x 0,25 x π x dbs^2 → dbs = 10 mm

= 157,0796327 mm^2

ρs = max [0,12 $\frac{f'c}{fys}$; 0,45($\frac{Ag}{Ac}$ – 1) $\frac{f'c}{fys}$]

= 0,011883 mm

S_{o1} = 4 $\frac{Asp}{bc.\rho s}$

= 61,483038 mm

S_{o2} = $\frac{Asp}{\frac{Av}{s}}$

= 38,8764 mm

S_{max} = min (100 mm , 6db)

= 100 mm

S_{perlu} = min (S_{o1} , S_{o2}, S_{max})

= 38,8764 mm

S_{min} = 25 mm + dbs

= 35 mm

S_0 = max (S_{perlu}, S_{min})

= 38,8764 mm

Jadi jarak sengkang didaerah Lo = 35 mm → d10– 35 mm

Jarak sengkang diluar daerah Lo :

S = min (150 mm, 6db)

= 132 mm

Digunakan d10-130 mm.

- **Lantai 3**

b = 1000 mm

bc = b – 2(selimut beton) = 1000 – 2 (70) = 860 mm

hc = h - 2(selimut beton) = 1000 – 2 (70) = 860 mm

Ac = bc x hc = 860 x 860 = 739600 mm^2

Ag = b x h = 1000 x 1000 = 1000000 mm^2

- Berdasarkan kombinasi pembebanan tetap : diambil dari kombinasi pembebanan 1 dan 2, diambil yang terbesar.

Gaya geser terfaktor (Vu) = 542668,80N → kombinasi 1

Gaya aksial terfaktor (Pu) = -1949755,7 N → kombinasi 1

Gaya geser terfaktor (Vu) = 719777,20 N → kombinasi 2

Gaya aksial terfaktor (Pu) = -2388034,3 N → kombinasi 2

$Vc = (1+\frac{Pu}{14Ag})\ \frac{1}{6}\sqrt{f'c}$. Ac → f'c = 30 MPa

= 675160,5098 N

$Vs = \frac{Vu}{0,75} - Vc$

= 284542,4235 N > 0

Vs max = $\frac{2}{3}\sqrt{f'c}.Ac$

= 2700637,357 N

Vs = 284542,4235 N < Vs max = 2700637,357 N

Tulangan geser spiral

$\frac{Av}{S_1} = \frac{2Vs}{\Phi s.fys.d}$ → fys = 400 MPa ; Φs = 0,75 ; d = 1210 mm

= 1,56772

- Berdasarkan kombinasi pembebanan sementara : diambil dari kombinasi pembebanan 3 dan 4, diambil yang terbesar. Didapat dari kombinasi 3

Vu = 472452,5 N

Pu = - 1870176,3 N

M_{ub} = 1,089 . 10^9

M_{ut} = 6,083 . 10^8

$V_{p1} = \frac{M_{ub} + M_{ut}}{Hn}$ → Hn = 2750 mm

= 617200 N

$V_{p2} = \frac{\sum M_{balok}}{\frac{1}{2}(H1 + H2)}$ → Npmi = 3250484392 Nmm

Pmpj = 1998098948 Nmm

H1 = H2 = 4000 mm

= 1725147,12 N

Vp = min (V_{p1} , V_{p2})

= 617200 N

Vc = $(1 + \frac{Pu}{14Ag}) + \frac{1}{6}\sqrt{f'c}.Ac$

= 675160,4728 N

Vu = max (Vu , Vp)

= 472452,5 N

Pu > $\frac{f'c.Ag}{20}$

1870176,5 N < 1500000 N

Vc = 0

Vs = $\frac{Vu}{0,75} - Vc$

= 629936,6667 N

Vs = 629936,6667 N < Vs max = 2700637,357 N

$\frac{Av}{S_2} = \frac{2Vs}{\Phi s.fys.d}$

= 3,4707254 mm

$\frac{Av}{S_2}_{min} = \frac{1}{3}.\frac{c}{fys}$

= 0,83333 mm

$\frac{Av}{S_2}$ = max ($\frac{Av}{S_2}, \frac{Av}{S_2}_{min}$)

= 3,4707254 mm

$\frac{Av}{S}$ = max ($\frac{Av}{S1}, \frac{Av}{S_2}$)

= 3,4707254 mm

Lo = max (D, $\frac{Hn}{6}$, 500 mm)

= max (1000 mm, $\frac{2750}{6}$, 500 mm)

= 1000 mm

Asp = 2 x 0,25 x π x dbs^2 → dbs = 10 mm

$= 157{,}0796327 \text{ mm}^2$

$\rho s = \max [\ 0{,}12\ \frac{f'c}{fys}; 0{,}45(\frac{Ag}{Ac} - 1)\frac{f'c}{fys}\ ]$

$= 0{,}011883 \text{ mm}$

$S_{o1} = 4\ \frac{Asp}{bc.\rho s}$

$= 61{,}483038 \text{ mm}$

$S_{o2} = \frac{Asp}{\frac{Av}{s}}$

$= 45{,}25844397 \text{ mm}$

$S_{max} = \min (100 \text{ mm} , 6db)$

$= 100 \text{ mm}$

$S_{perlu} = \min (S_{o1} , S_{o2}, S_{max})$

$= 45{,}25844397 \text{ mm}$

$S_{min} = 25 \text{ mm} + dbs$

$= 35 \text{ mm}$

$S_0 = \max (S_{perlu}, S_{min})$

$= 45{,}25844397 \text{ mm}$

Jadi jarak sengkang didaerah Lo = 45 mm → d10–45 mm

Jarak sengkang diluar daerah Lo :

$S = \min (150 \text{ mm}, 6db)$

$= 132 \text{ mm}$

Digunakan d10-130 mm.

Perhitungan Pelat

- **Model 1**

Pakai tabel koefisien momen ($\frac{ly}{lx}$) $= \frac{2}{2} = 1$

lx = - tx

= 36

ly = - ty

= 36

q_u = 1,2 DL + 1,6 LL

= 980 Kg/m^2

Tulangan lapangan arah x

Mu = 0,001 x q_u x l_x^2 x X

= 70,56 Kg/m

As = $\frac{Mu}{\Phi . fy . jd}$ → fy = 400 MPa = 400000 Kg/m

= 0,00233 m^2

ρ perlu = $\frac{As}{b.h}$

= 0,00972

ρ perlu = 0,00972 > ρ_{min} = 0,0018

As = ρ perlu x b x h

= 0,000432 m^2

= 432 mm^2

D10 – 20 disisi bawah lapis 1

Tulangan tumpuan arah x

Mtx = - Mlx → D10 – 20 disisi atas lapis 1

Tulangan lapangan arah y

Mu = 0,001 x q_u x l_x^2 x y

= 70,56 Kg/m

As = $\frac{Mu}{\Phi . fy . jd}$ → fy = 400 MPa = 400000 Kg/m

= 0,00233 m^2

ρ perlu = $\frac{As}{b.h}$

= 0,00972

ρ perlu = 0,00972 > ρ_{min} = 0,0018

As = ρ perlu x b x h

= 0,000432 m^2

= 432 mm^2

D10 – 20 disisi bawah lapis 2

Tulangan tumpuan arah y

Mtx = - M*l*x → D10 – 20 disisi atas lapis 2

Model 2

Perhitungan tulangan pelat dilakukan secara manual dimana ($As = \frac{Mn}{\Phi . fy . jd}$) pemasangan tulangan pada pelat arah x akan dipasang dengan nilai minimum yaitu D10-100. Sedangkan tulangan arah y akan dihitung menggunakan cara manual.

Contoh perhitungan :

Tulangan arah y

Diketahui : - DL : 150 Kg/m^2

- LL : 500 Kg/m^2

- Tebal pelat : 12 cm
- Lebar pelat (L) : 2,267 m

q_u = 1,2 DL + 1,6 LL

= 980 Kg/m^2

$M_n = \frac{1}{10} \text{x } q_u \text{ x } L^2$

= 503,6503 kgm

= 50365,03 kgcm

Jd = 0,9 d → d = 12 – selimut beton = 12 – 1,5 = 10,5 cm

= 9,45 cm

$As = \frac{Mn}{\Phi . fy . jd}$ → fy = 400 MPa = 4000 Kg/cm

= 1,6655 cm^2

$A_{d10} = \frac{1}{4} . \pi . d^2$

= 0,785 cm^2

$S = \frac{A_{d10}}{As} \text{ x } 100$

= 47,133

Maka tulangan pelat dipasang D10- 45

5. Waktu getar

Untuk mencegah penggunaan struktur gedung yang terlalu *fleksibel*, nilai waktu getar alami *fundamental* (T_1) dari struktur gedung harus dibatasi, bergantung pada *koefisien* (ζ) untuk wilayah gempa tempat struktur gedung berada dan jumlah tingkatnya (n) menurut persamaan :

T_1 < ζ n

waktu getar yang didapat dari program komputer ETABS v9.04 untuk model 1 adalah 0,286209 (T_1).

Diketahui : T_1 = 0,286209

ζ = 0,17

n = 3

T_1 < ζ n

0,286209 < (0,17 x 3)

0,286209 < 0,51 ... ok!

Sedangkan waktu getar yang didapat dari program komputer ETABS v9.04 untuk model 2 adalah 0,277437 (T_1).

Diketahui : T_1 = 0,277437

ζ = 0,17

n = 3

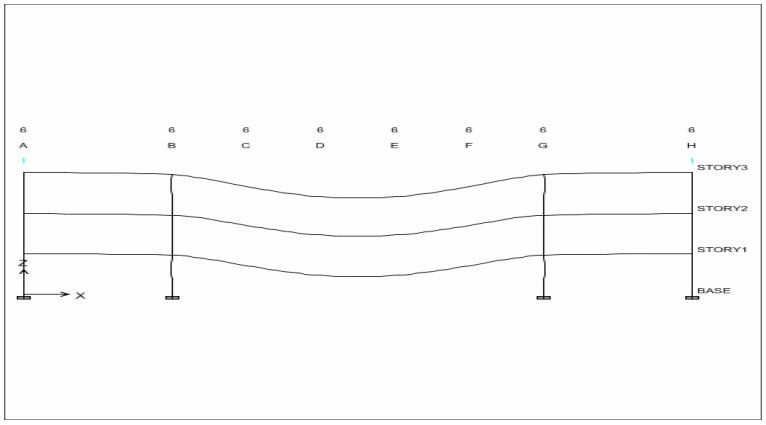
T_1 < ζ n

0,277437 < (0,17 x 3)

0,277437 < 0,51 ... ok!

6. Kontrol Lendutan

Model 1



Gambar 4.8 Lendutan maksimum

Lendutan maksimum yang terjadi untuk model 1 terletak pada portal 6. Dari tabel 9 halaman 65 SNI 03 – 1726 – 2002, diambil lendutan ijin adalah $\frac{L}{360}$, dengan L sebesar 2000 cm (panjang balok induk).

- Kontrol lendutan lantai 1

  $$\frac{2000}{360} = 5{,}556 \text{ cm} > 1{,}027 \text{ cm ok!}$$

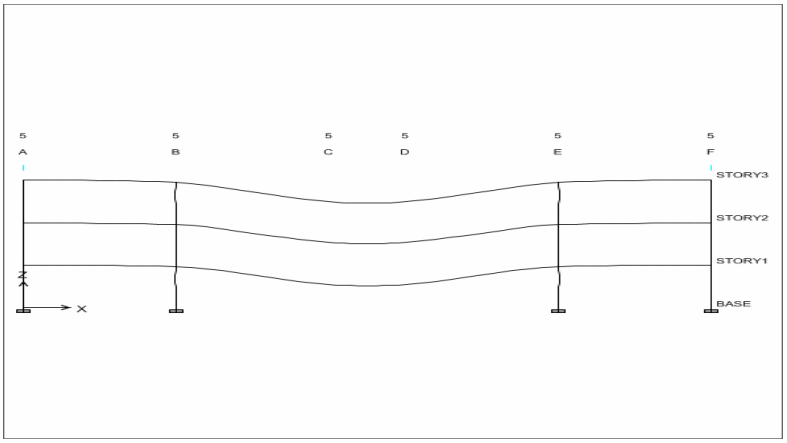
- Kontrol lendutan lantai 2

  $$\frac{2000}{360} = 5{,}556 \text{ cm} > 1{,}061 \text{ cm ok!}$$

- Kontrol lendutan lantai 3

  $$\frac{2000}{360} = 5{,}556 \text{ cm} > 1{,}198 \text{ cm ok!}$$

Model 2



Gambar 4.9 Lendutan maksimum

Lendutan maksimum yang terjadi untuk model 2 terletak pada portal 5. Dari tabel 9 halaman 65 SNI 03 – 1726 – 2002, diambil lendutan ijin adalah $\frac{L}{360}$, dengan L sebesar 2000 cm (panjang balok induk)

- Kontrol lendutan lantai 1

  $\frac{2000}{360} = 5{,}556 \text{ cm} > 1{,}298 \text{ cm}$ ok!

- Kontrol lendutan lantai 2

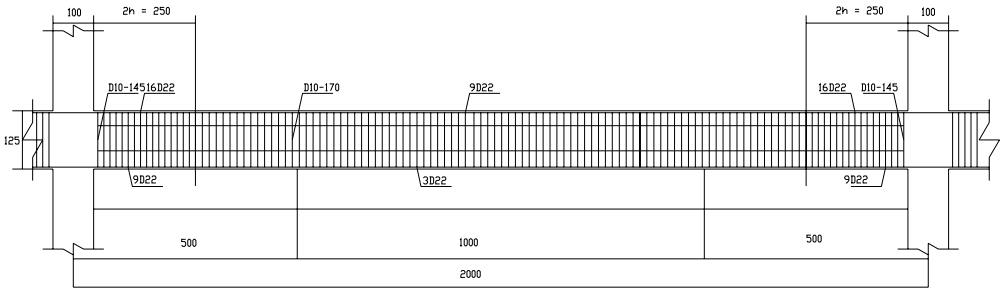
  $\frac{2000}{360} = 5{,}556 \text{ cm} > 1{,}350 \text{ cm}$ ok!

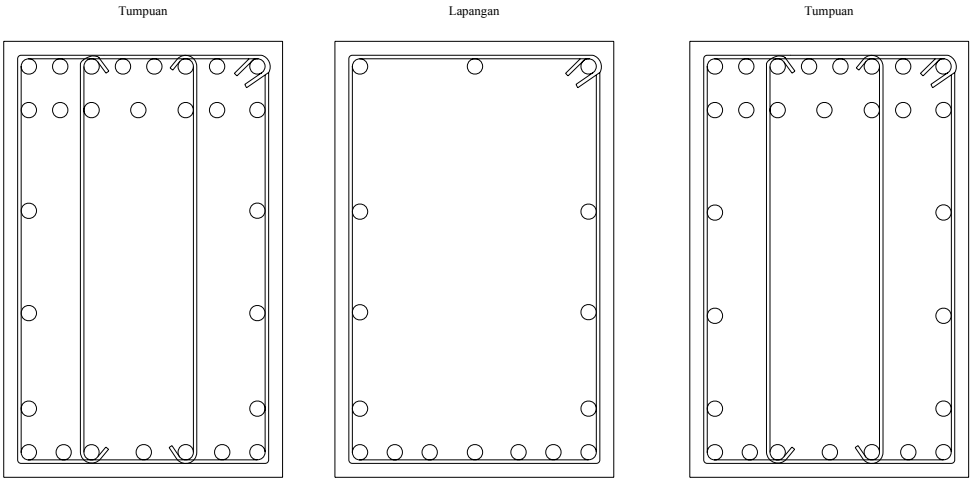
- Kontrol lendutan lantai 3

  $\frac{2000}{360} = 5{,}556 \text{ cm} > 1{,}505 \text{ cm}$ ok!

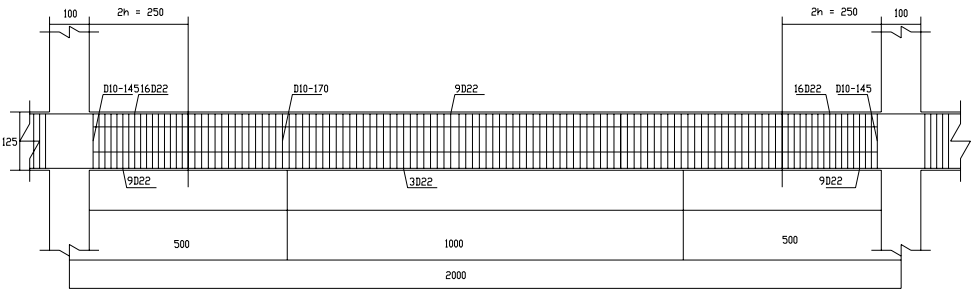
Lampiran 4 : Denah Penulangan

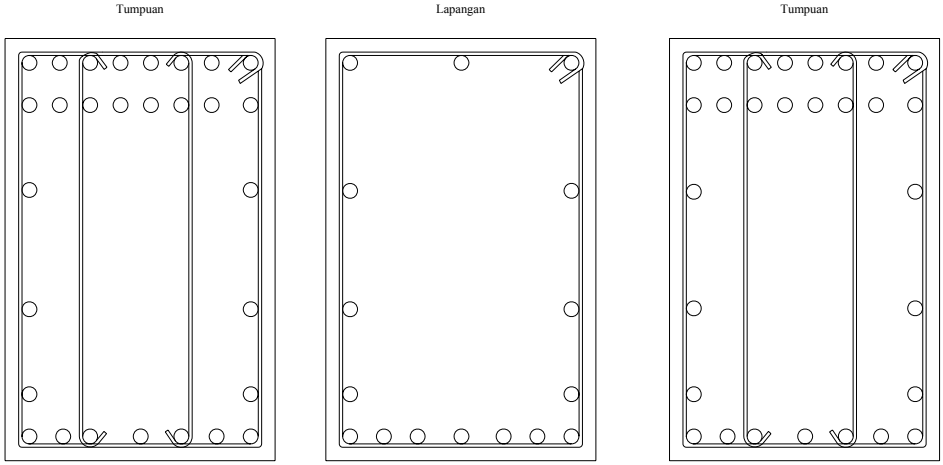
1. Penulangan Model 1



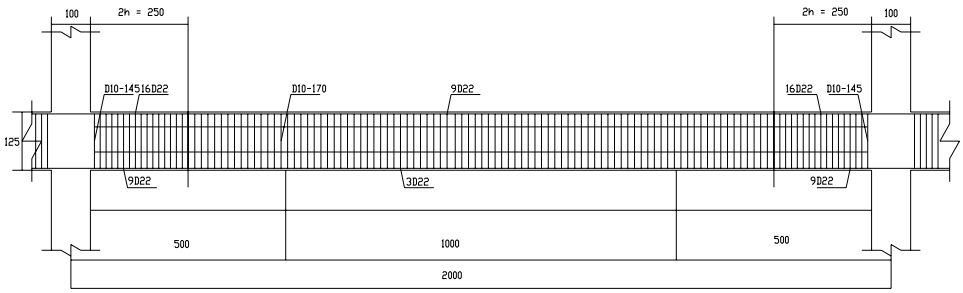


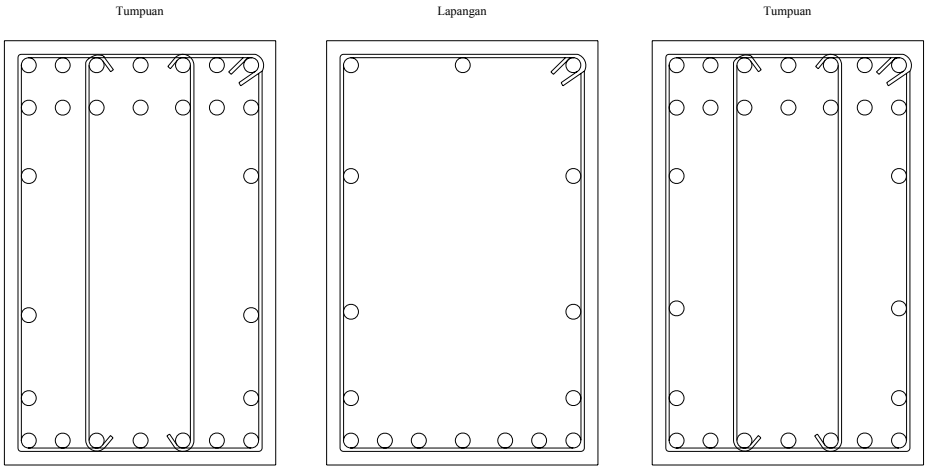
Gambar L-4-1 Detail penulangan balok induk 80/125 (cm) lantai 1 model 1



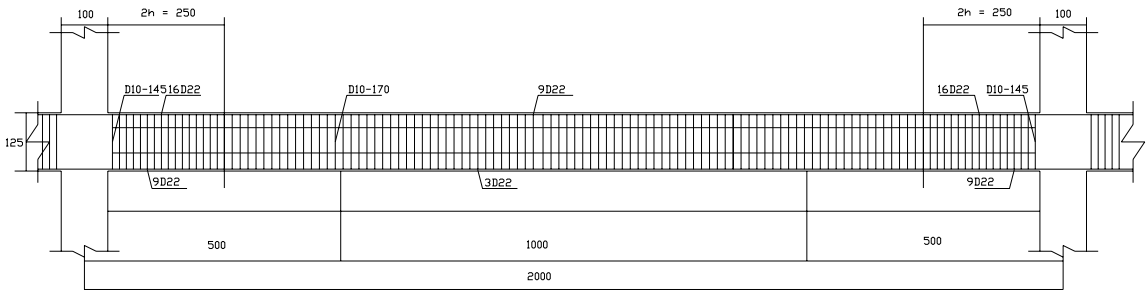


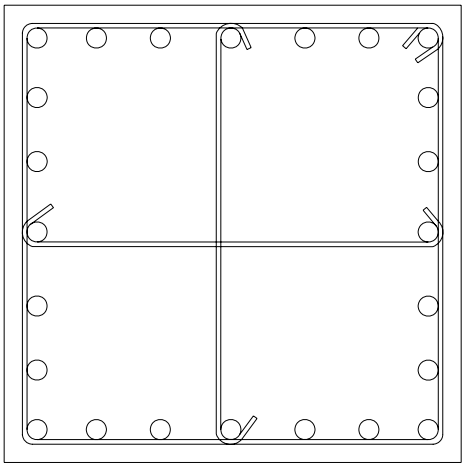
Gambar L-4-2 Detail penulangan balok induk 80/125 (cm) lantai 2 model 1



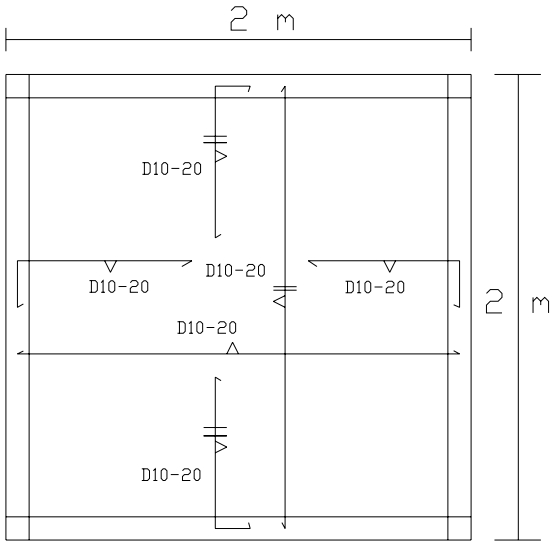


Gambar L-4-3 Detail penulangan balok induk 80/125 (cm) lantai 3 model 1



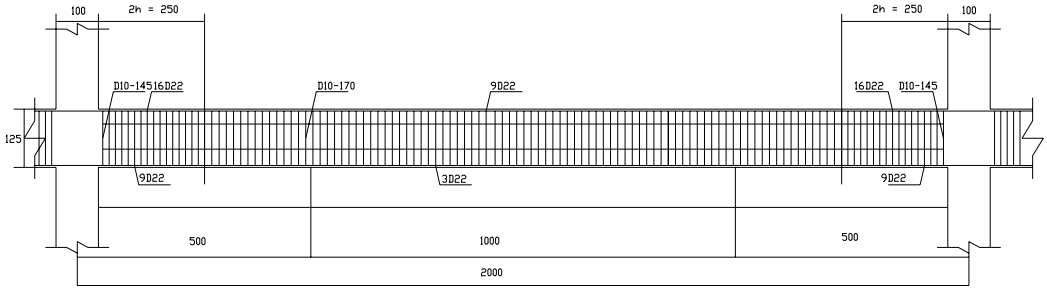


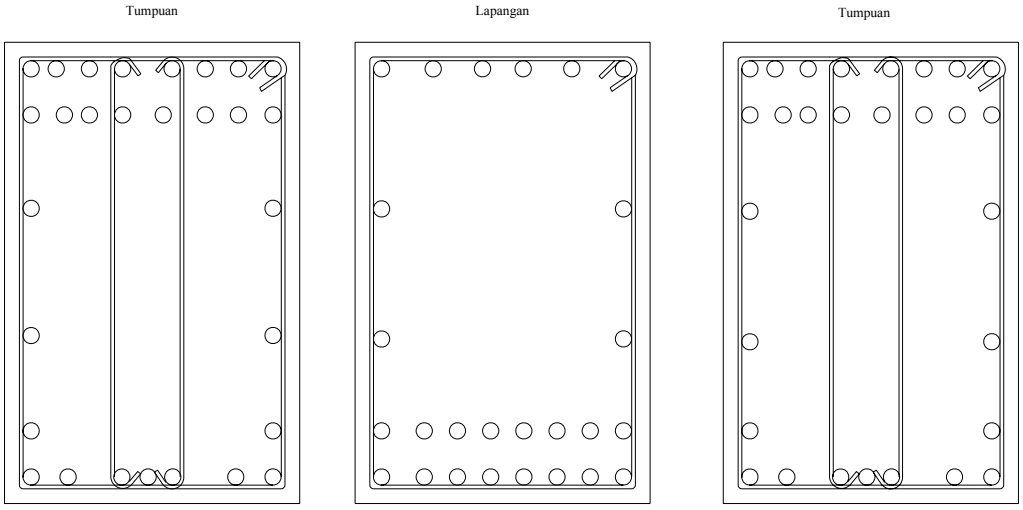
Gambar L-4-4 Detail penulangan kolom 100/100 (cm) model 1



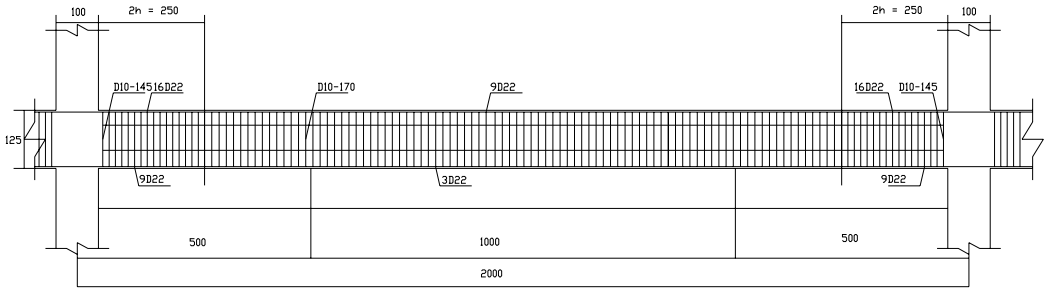
Gambar L-4-5 Detail penulangan pelat model 1

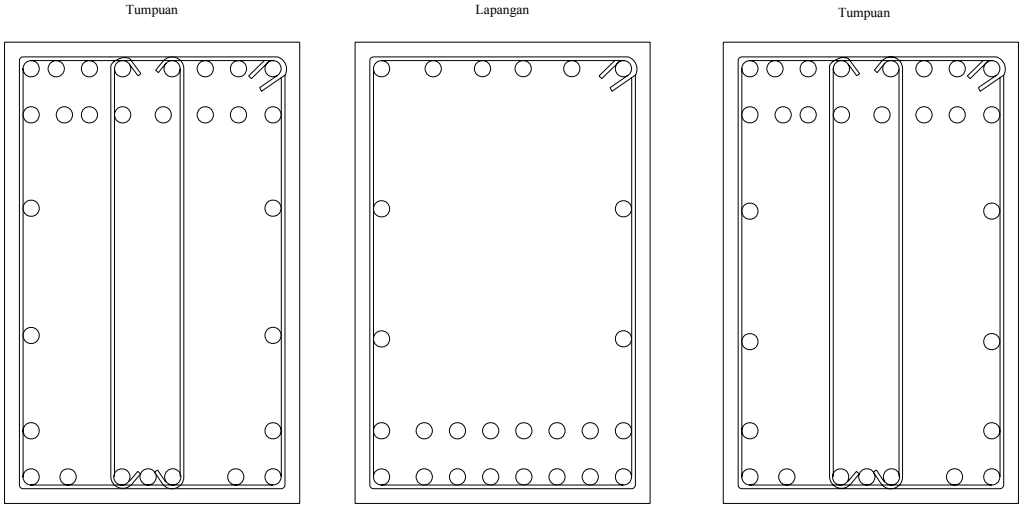
2. **Penulangan Model 1**



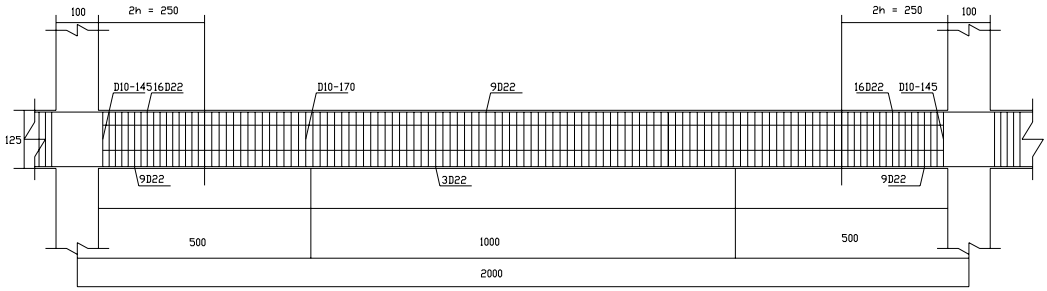


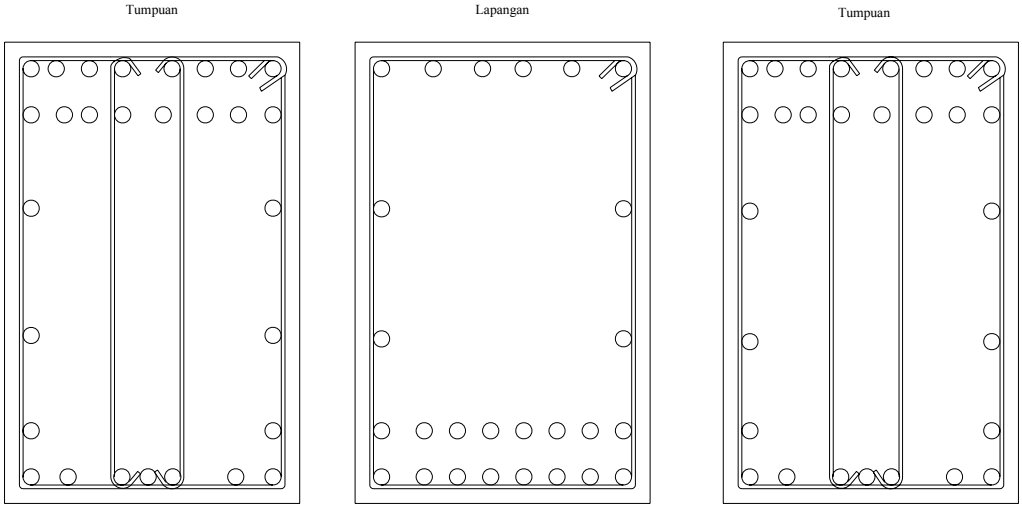
Gambar L-4-6 Detail penulangan balok induk 80/125 (cm) lantai 1 model 2



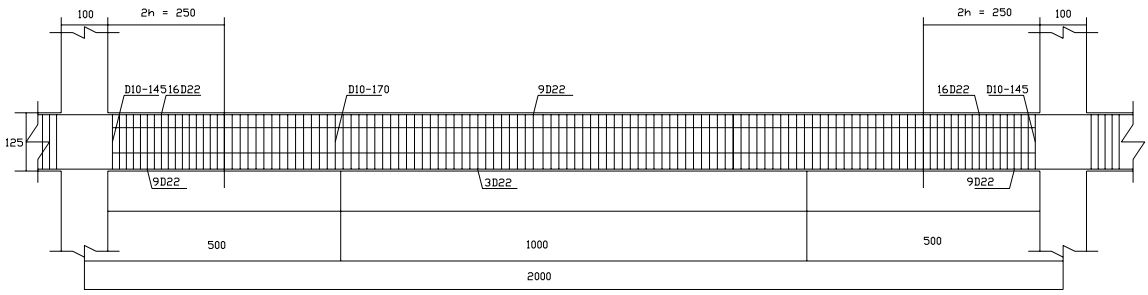


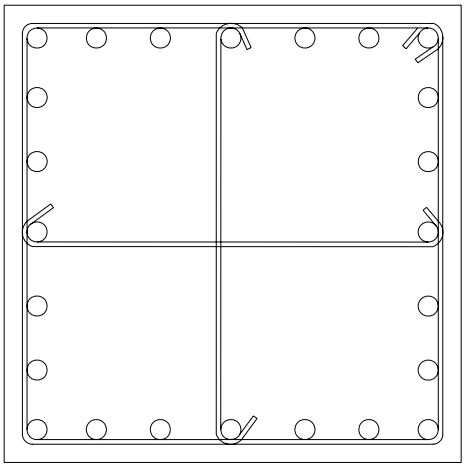
Gambar L-4-7 Detail penulangan balok induk 80/125 (cm) lantai 2 model 2



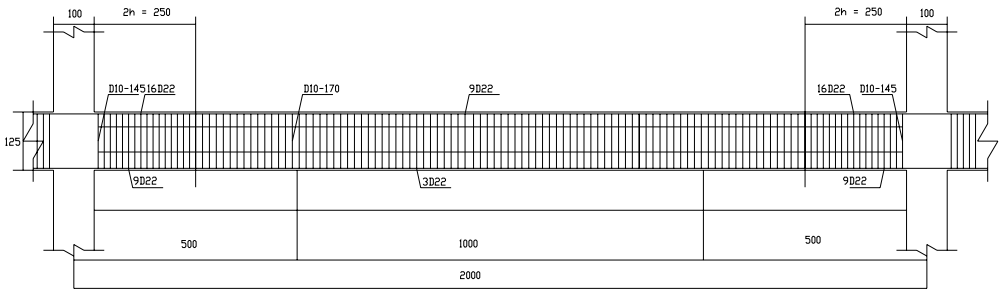


Gambar L-4-8 Detail penulangan balok induk 80/125 (cm) lantai 3 model 2





Gambar L-4-9 Detail penulangan kolom 100/100 (cm) model 2



Gambar L-4-10 Detail penulangan pelat model 2