BAB V

ANALISIS DAN DISAIN STRUKTUR

5.1. Data Perencanaan

Data perencanaan memuat data-data yang diperlukan dalam proses analisis

5.1.1. Parameter Bahan

fy = kuat leleh baja karakteristik = 400 Mpa

f'c = kuat desak beton karakteristik = 30 Mpa

e = modulus elastisistas beton = $4700\sqrt{f'c}$ = 25742,96 Mpa

5.1.2. Asumsi yang digunakan

a. Tebal pelat atap = 100 mm

b. Tebal pelat lantai = 120 mm

c. Dimensi kolom = 600 x 800 mm^2

d. Dimensi balok induk 1 = 250 x 500 mm^2

e. Dimensi balok induk 2 = 400 x 800 mm^2

f. Dimensi balok anak = 200 x 400 mm^2

g. Dimensi sloof = 200 x 400 mm^2

h. Tinggi antar tingkat = 4000 mm

i. Berat volume beton = 24 KN/m^3

j. Berat volume pasangan batu bata = 17 KN/m^3

k. Tata guna ruang sebagai perkantoran dengan beban hidup lantai 2,5 KN/m^2 dan beban hidup atap 1 KN/m^2

5.2. Perhitungan Gaya-Gaya Yang Bekerja Pada Struktur

5.2.1. Perhitungan Beban Akibat Beban Gravitasi

Pada bab ini dilakukan perhitungan terhadap portal arah X dan Y.

5.2.1.1. Beban Merata

a. Pembebanan pada balok atap

1) Beban mati pada pelat atap (w_D)

- Plat atap (100 mm) = 0,1 x 24 = 2,400 kN/m^2
- Lapis kedap air (20 mm) = 0,02 x 0,21 = 0,420 kN/m^2
- Dusting AC = 0,150 kN/m^2
- Penggantung + plafon = 0,11 + 0,07 = 0,180 kN/m^2 +

  W_D = 3,150 kN/m^2
- Berat sendiri balok induk dihitung langsung oleh SAP

2) Beban hidup pelat atap

W_L = 1,000 kN/m^2

b. Pembebanan Pada Balok LAntai

1) Beban mati pada pelat lantai (w_D)

- Pelat lantai (120 mm) = 0,12 x 24 = 2,880 kN/m^2
- Pasir (30 mm) = 0,03 x 18 = 0,540 kN/m^2
- Keramik = 1 x 0,24 = 0,240 kN/m^2

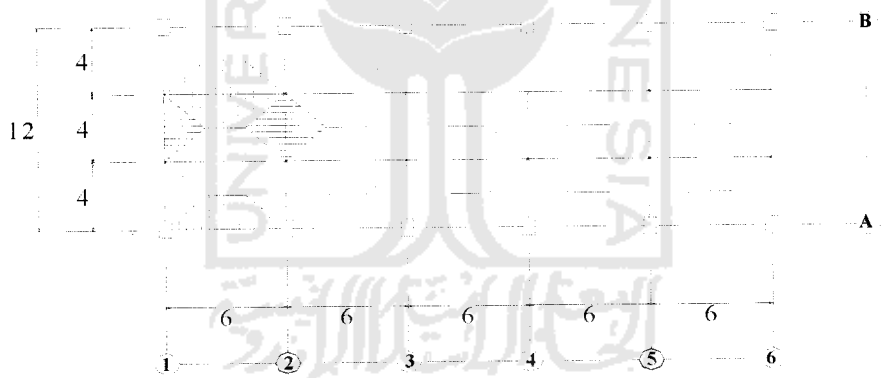
- Spesi = 3 x 0,21 = 0,630 kN/m^2
- Dusting AC = 0,150 kN/m^2
- Penggantung + plafon = 0,11 + 0,07 = 0,180 kN/m^2 +

  W_D = 4,62 kN/m^2
- Tembok ½ bata = 0,15 x 3,2 x 17 = 8,16 kN/m^2
- Berat sendiri balok induk dihitung langsung oleh SAP

2) Beban hidup lantai perkantoran

W_L = 2,500 kN/m^2

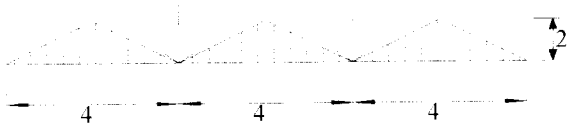
5.2.1.2. Pembebanan pada Portal Variasi 1



Gambar 5.1 Pembagian pembebanan pelat

a. Portal 1

1. Beban gravitasi pada balok atap



Gambar 5.2 Perhitungan beban merata dan terpusat balok atap portal 1

- Beban mati segitiga

$w_D = W_D \cdot 2$

$= 3{,}15 \cdot 2 \quad = 6{,}3$ KN/m'

- Beban hidup segitiga

$w_L = W_L \cdot 2$

$= 1 \cdot 2 \quad = 2$ KN/m'

- Beban terpusat

Beban terpusat diperoleh dari reaski pembebanan balok atap yang di hitung secara terpisah dengan pemodelan sebagi berikut :

Gambar 5.3 Perhitungan beban terpusat balok atap

$w_D = W_D \cdot 2$

$= 3{,}15 \cdot 2 \quad = 6{,}3$ KN/m'

$w_L = W_L \cdot 2$

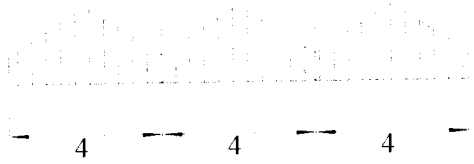
$= 1 \cdot 2 \quad = 2$ KN/m'

Data diatas dimasukkan dalam program SAP2000, sehingga didapat reaksi pembebanan sebagai berikut :

JOINT	BEBAN	F1	F2	F3
1	MATI	0	1.89E-30	30.85479
1	HIDUP	0	-3.14E-31	8
2	MATI	0	-8.42E-31	30.85479
2	HIDUP	0	3.76E-31	8
1	MATI	0	1.89E-30	30.85479

Tabel 5.1 Reaksi beban terpusat balok atap portal V-1

2. Beban gravitasi pada balok lantai



Gambar 5.4 Perhitungan beban merata dan titik balok lantai portal 1

- Beban mati segitiga

$w_D = W_D \cdot 2$

$= 4{,}62 \cdot 2 \qquad = 9{,}24$ KN/m'

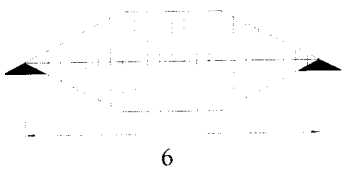
- Beban mati dinding = 8,16 KN/m'
- Beban hidup segitiga

$w_L = W_L \cdot 2$

$= 2{,}5 \cdot 2 \qquad = 5$ KN/m'

- Beban terpusat

Beban terpusat diperoleh dari reaski pembebanan balok lantai yang di hitung secara terpisah dengan pemodelan sebagai berikut :



Gambar 5.5 Perhitungan beban terpusat balok lantai portal 1

$w_D = W_D \cdot 2$

$= 4{,}62 \cdot 2 \qquad = 9{,}24$ KN/m'

$w_L = W_L \cdot 2$

$= 2{,}5 \cdot 2 \qquad = 5$ KN/m'

Data diatas dimasukkan dalam program SAP2000, sehingga didapat reaksi pembebanan sebagi berikut :

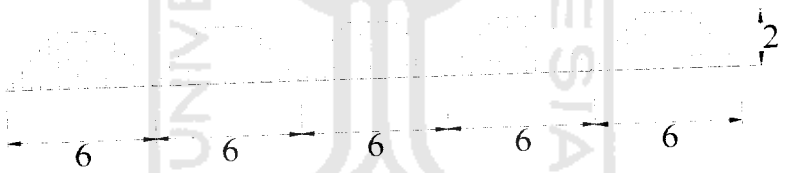
JOINT	BEBAN	F1	F2	F3
1	MATI	0	3.25E-31	42.61478
1	HIDUP	0	3.07E-31	20
2	MATI	0	-3.41E-31	42.61478
2	HIDUP	0	-1.03E-30	20

Tabel 5.2 Reaksi beban terpusat balok lantai portal V-1

Untuk portal tengah, pembebanannya merupakan 2 kali pembebanan portal tepi tanpa beban mati dinding.

b. Portal A

1. Beban gravitasi pada balok atap



Gambar 5.6 Perhitungan beban merata balok atap portal A

- Beban mati trapesium

$w_D = W_D \cdot 2$

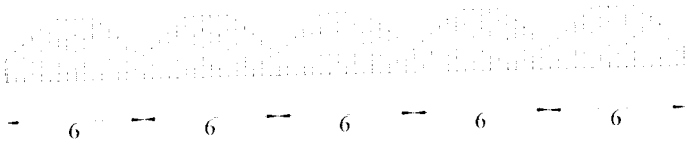
$= 3{,}15 \cdot 2 \qquad = 6{,}3$ KN/m'

- Beban hidup trapesium

$w_L = W_L \cdot 2$

$= 1 \cdot 2 \qquad = 2$ KN/m'

2. Beban gravitasi pada balok lantai



Gambar 5.7 Perhitungan beban merata lantai portal A

- Beban mati trapesium

$w_D = W_D \cdot 2$

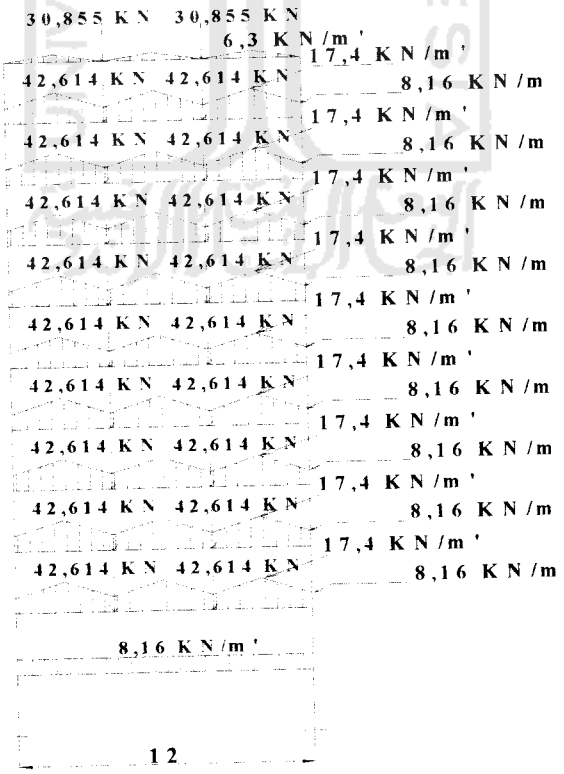
$= 4{,}62 \cdot 2 = 9{,}24$ KN/m'

- Beban mati dinding= 8,16 KN/m'

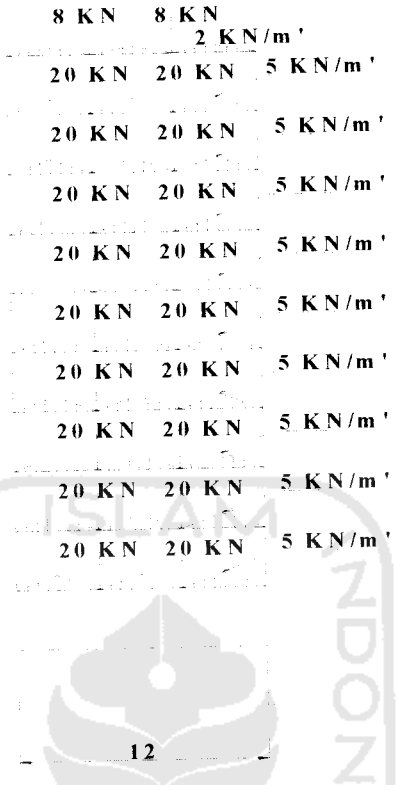
- Beban hidup trapesium

$w_L = W_L \cdot 2$

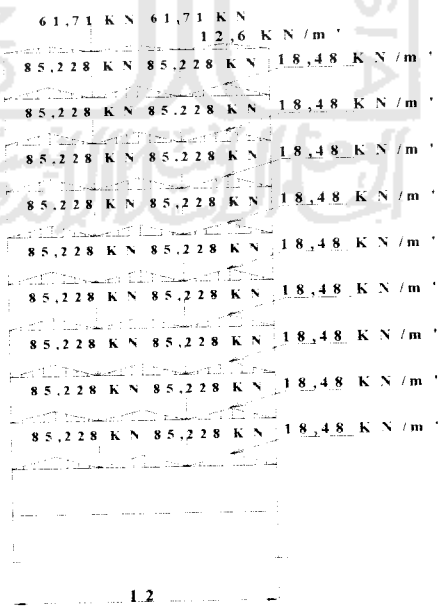
$= 2{,}5 \cdot 2 = 5$ KN/m'



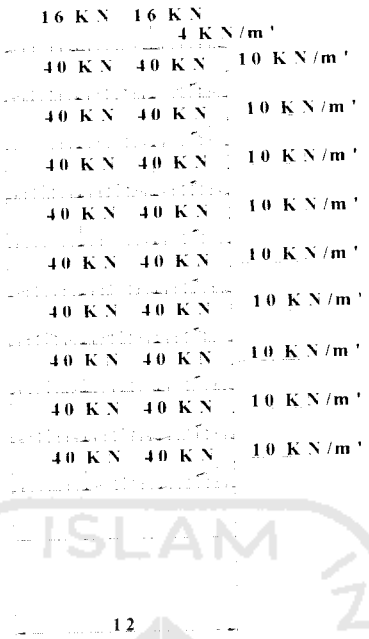
Gambar 5.8 Beban mati portal 1 V-1



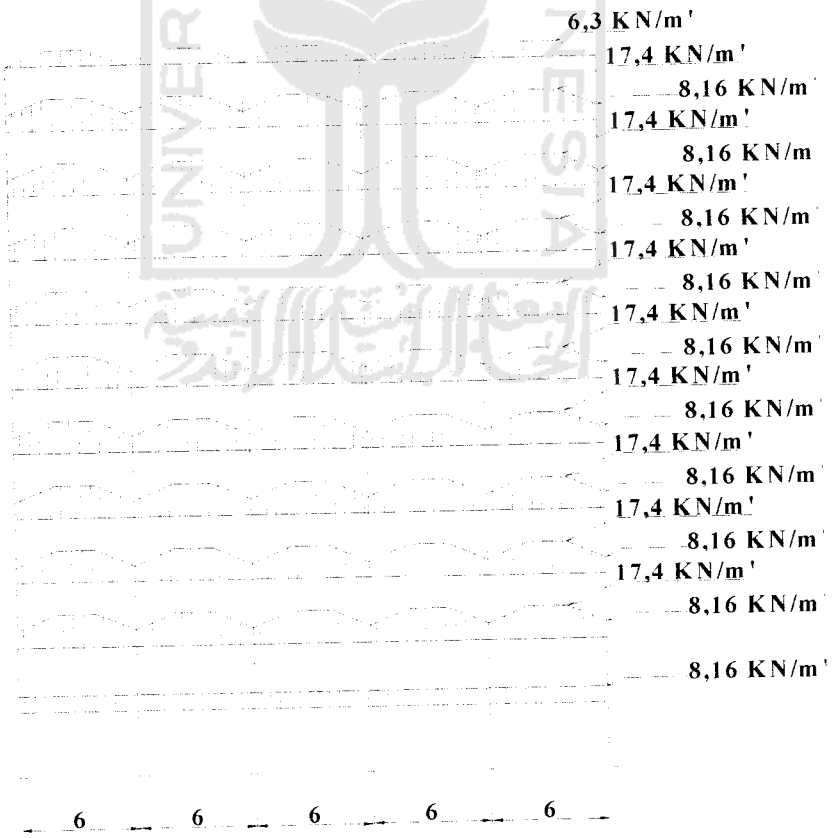
Gambar 5.9 Beban hidup portal 1 V-1



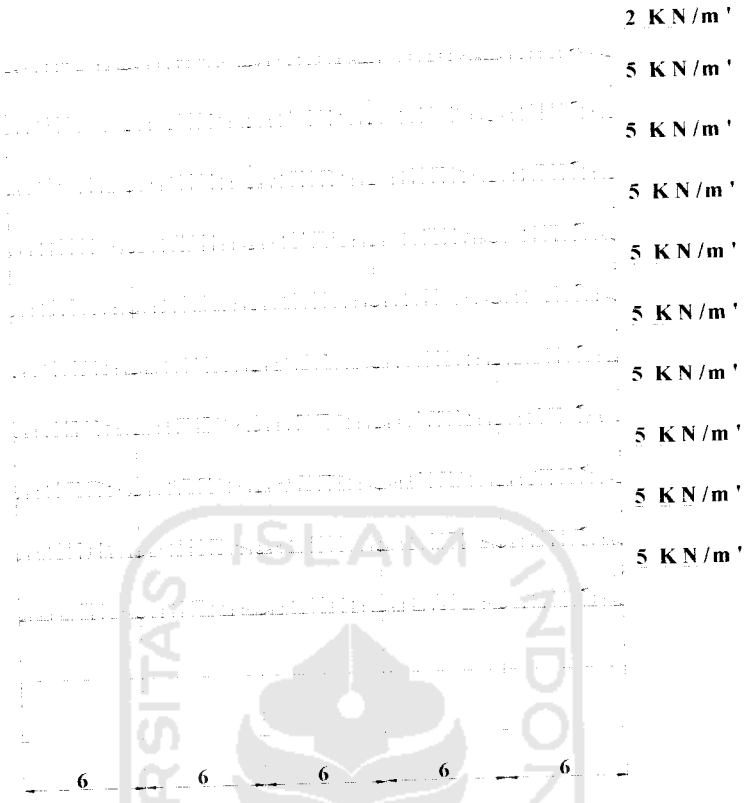
Gambar 5.10 Beban mati portal 2 V-1



Gambar 5.11 Beban hidup portal 2 V-1

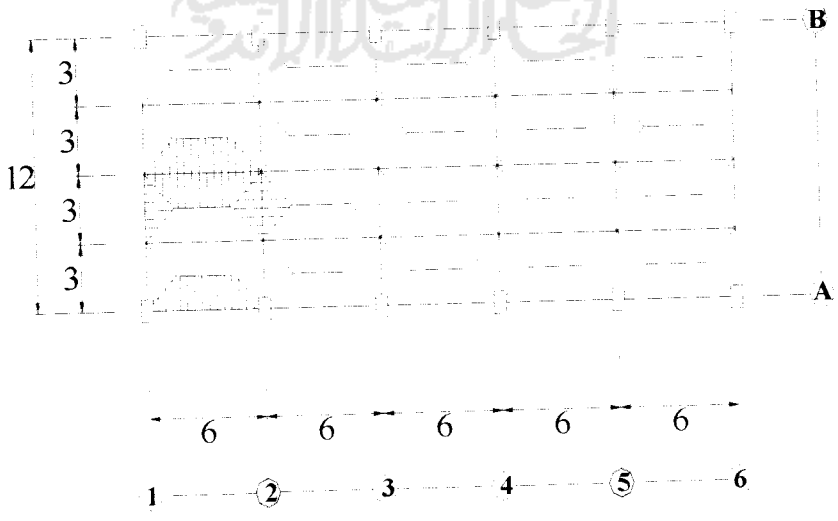


Gambar 5.12 Beban mati portal A V-1



Gambar 5.13 Beban hidup portal A V-1

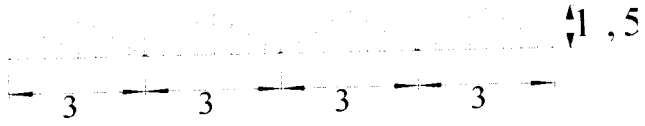
5.2.1.3. Pembebanan pada Portal Variasi 2



Gambar 5.14 Pembagian pembebanan pelat

a. Portal 1

1. Beban gravitasi pada balok atap



Gambar 5.15 Perhitungan beban merata dan terpusat balok atap portal 1

- Beban mati segitiga

$w_W = W_D \cdot 1,5$

$= 3,15 \cdot 1,5 = 4,725$ KN/m'

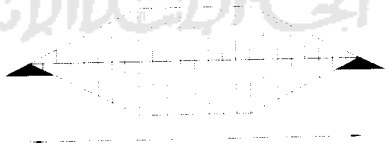
- Beban hidup segitiga

$w_L = W_L \cdot 1,5$

$= 1 \cdot 1,5 = 1,5$ KN/m'

- Beban terpusat

Beban terpusat diperoleh dari reaski pembebanan balok atap yang di hitung secara terpisah dengan pemodelan sebagi berikut :



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Gambar 5.16 Perhitungan beban terpusat balok atap

$w_D = W_D \cdot 1,5$

$= 3,15 \cdot 1,5 = 4,725$ KN/m'

$w_L = W_L \cdot 1,5$

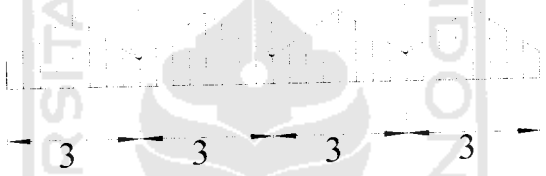
$= 1 \cdot 1,5 = 1,5$ KN/m'

Data diatas dimasukkan dalam program SAP2000, sehingga didapat reaksi pembebanan sebagai berikut :

JOINT	BEBAN	F1	F2	F3
1	MATI	0	3.61E-30	26.91728
1	HIDUP	0	1.55E-30	6.75
2	MATI	0	-3.97E-30	26.91728
2	HIDUP	0	-1.49E-30	6.75

Tabel 5.3 Reaksi beban terpusat balok atap portal V-2

2. Beban gravitasi pada balok lantai



Gambar 5.17 Perhitungan beban merata dan terpusat balok lantai portal 1

- Beban mati segitiga

$w_D = W_D \cdot 1,5$

$= 4,62 \cdot 1,5 = 6,93$ KN/m'

- Beban mati dinding = 8,16 KN/m'
- Beban hidup segitiga

$w_L = W_L \cdot 1,5$

$= 2,5 \cdot 1,5 = 3,75$ KN/m'

- Beban terpusat

Beban terpusat diperoleh dari reaski pembebanan balok lantai yang di hitung secara terpisah dengan pemodelan sebagai berikut :

Gambar 5.18 Perhitungan beban terpusat balok lantai portal 1

w_D $= W_D \cdot 1,5$

$= 4,62 \cdot 1,5$ $= 6,93$ KN/m'

w_L $= W_L \cdot 1,5$

$= 2,5 \cdot 1,5$ $= 3,75$ KN/m'

Data diatas dimasukkan dalam program SAP2000, sehingga didapat reaksi pembebanan sebagi berikut :

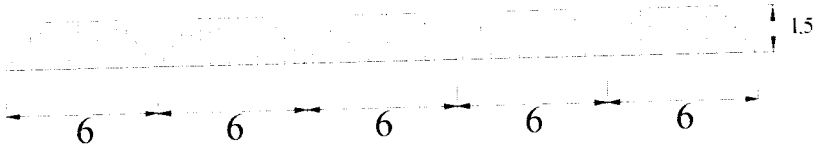
JOINT	BEBAN	F1	F2	F3
1	MATI	0	9.11E-30	36.83978
1	HIDUP	0	3.18E-30	16.875
2	MATI	0	-8.70E-30	36.83978
2	HIDUP	0	-3.48E-30	16.875

Tabel 5.4 Reaksi beban terpusat balok lantai portal V-1

Untuk portal tengah, pembebanannya merupakan 2 kali pembebanan portal tepi tanpa beban mati dinding.

b. Portal A

1. Beban gravitasi pada balok atap



Gambar 5.19 Perhitungan beban merata balok atap portal A

- Beban mati trapesium

$w_D = W_D \cdot 1,5$

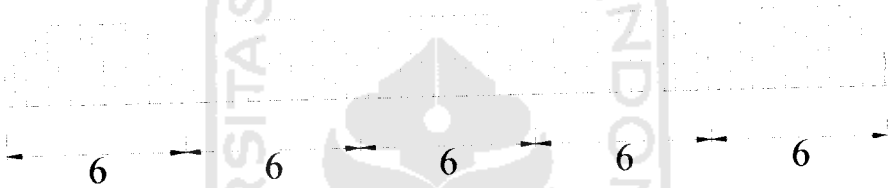
$= 3,15 \cdot 1,5 = 4,725$ KN/m'

- Beban hidup trapesium

$w_L = W_L \cdot 1,5$

$= 1 \cdot 1,5 = 1,5$ KN/m'

2. Beban gravitasi pada balok lantai



Gambar 5.20 Perhitungan beban merata lantai portal A

- Beban mati trapesium

$w_D = W_D \cdot 1,5$

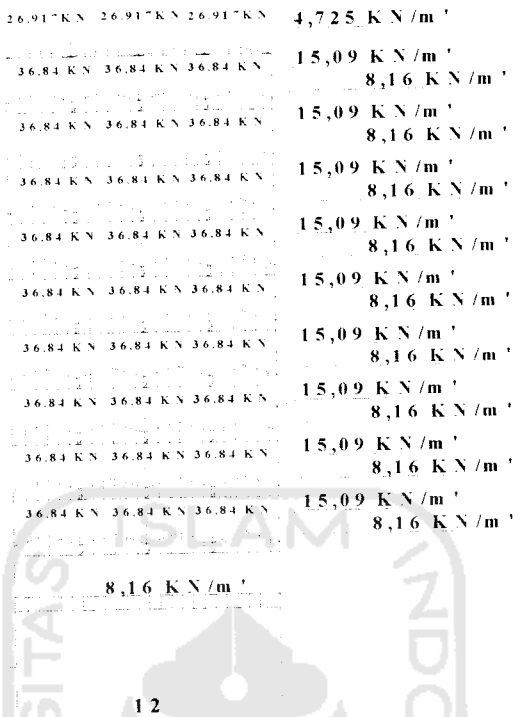
$= 4,62 \cdot 1,5 = 6,93$ KN/m'

- Beban mati dinding = 8,16 KN/m'

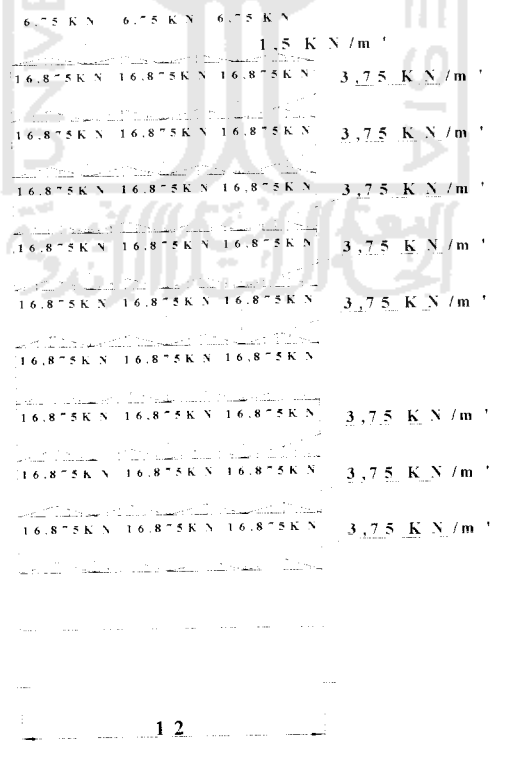
- Beban hidup trapesium

$w_L = W_L \cdot 1,5$

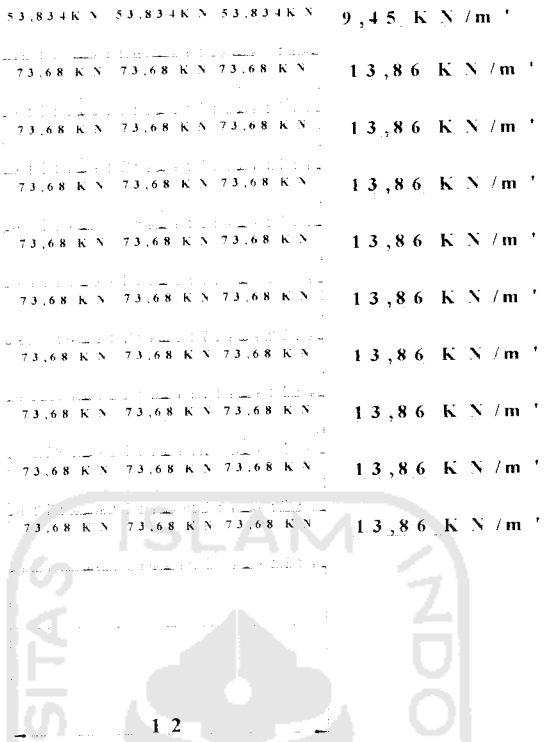
$= 2,5 \cdot 1,5 = 3,75$ KN/m'



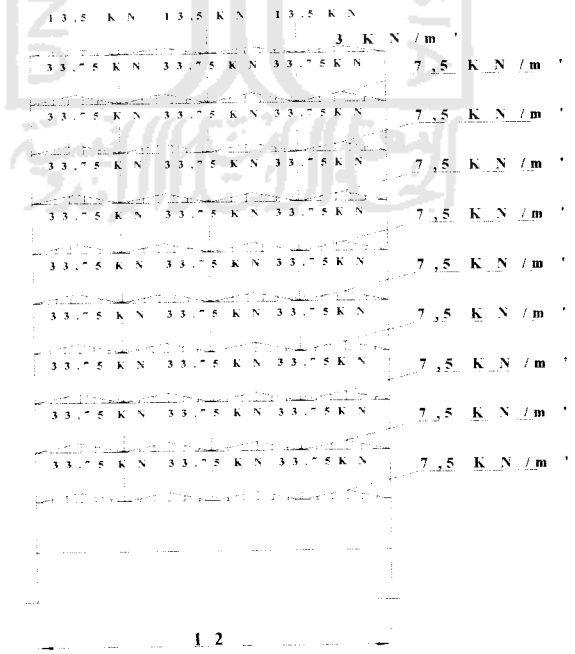
Gambar 5.21 Beban mati portal 1 V-2



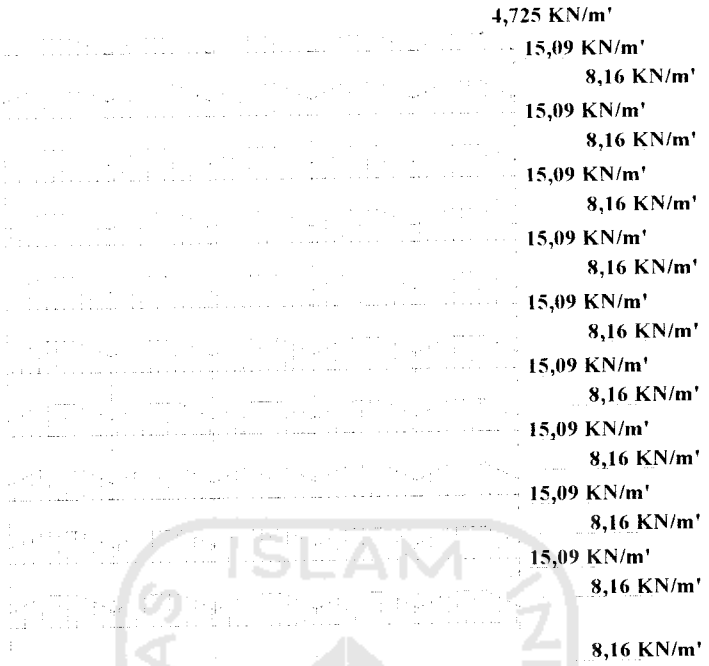
Gambar 5.22 Beban hidup portal 1 V-2



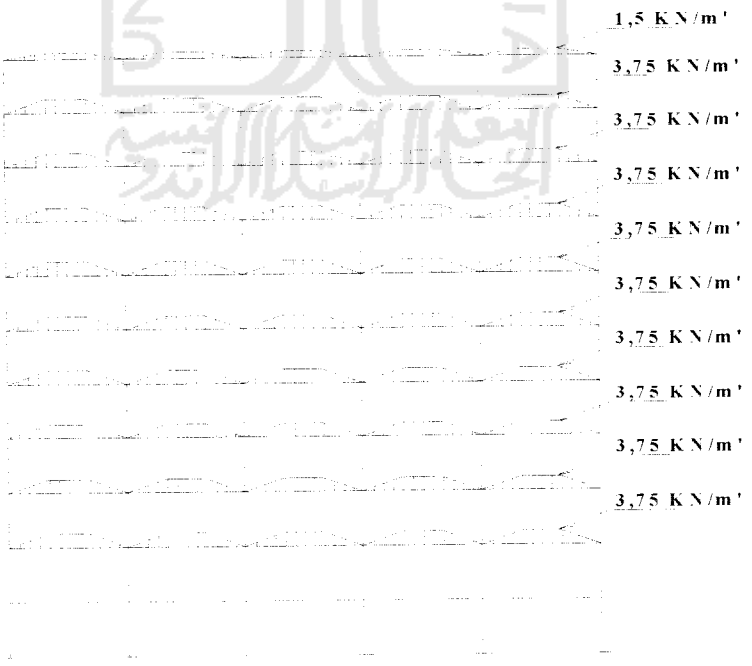
Gambar 5.23 Beban mati portal 2 V-2



Gambar 5.24 Beban hidup portal 2 V-2

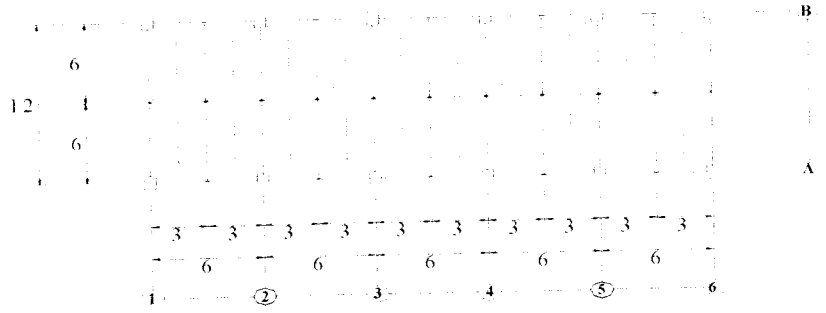


Gambar 5.25 Beban mati portal A V-2



Gambar 5.26 Beban hidup portal A V-2

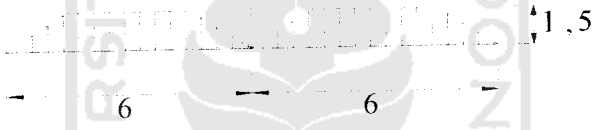
5.2.1.4. Pembebanan pada Portal Variasi 3



Gambar 5.27 Pembagian pembebanan pelat

a. Portal 1

1. Beban gravitasi pada balok atap



Gambar 5.28 Perhitungan beban merata dan titik balok atap portal 1

- Beban mati trapesium

$w_D = W_D \cdot 1,5$

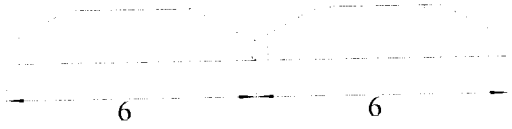
$= 3,15 \cdot 1,5 = 4,725$ KN/m'

- Beban hidup trapesium

$w_L = W_L \cdot 1,5$

$= 1 \cdot 1,5 = 1,5$ KN/m'

2. Beban gravitasi pada balok lantai



Gambar 5.29 Perhitungan beban merata dan terpusat balok lantai portal 1

- Beban mati trapesium

$w_D = W_D \cdot 1,5$

$= 4,62 \cdot 1,5 = 6,93$ KN/m'

- Beban mati dinding = 8,16 KN/m'

- Beban hidup trapesium

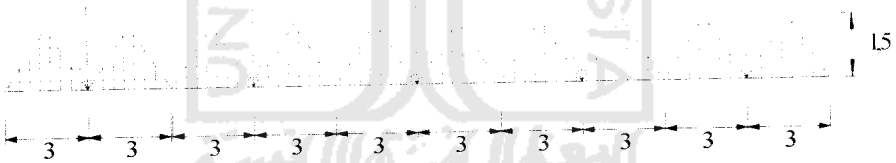
$w_L = W_L \cdot 1,5$

$= 2,5 \cdot 1,5 = 3,75$ KN/m'

Untuk portal tengah, pembebanannya merupakan 2 kali pembebanan portal tepi tanpa beban mati dinding.

b. Portal A

1. Beban gravitasi pada balok atap



Gambar 5.30 Perhitungan beban merata dan terpusat untuk balok atap portal A

- Beban mati segitiga

$w_D = W_D \cdot 1,5$

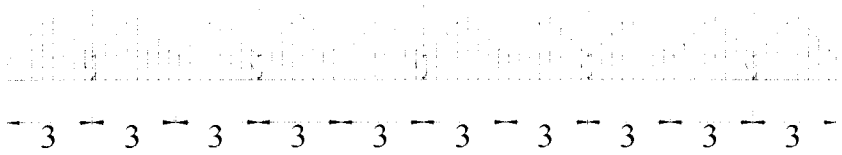
$= 3,15 \cdot 1,5 = 4,725$ KN/m'

- Beban hidup segitiga

$w_L = W_L \cdot 1,5$

$= 1 \cdot 1,5 = 1,5$ KN/m'

2. Beban gravitasi pada balok lantai



Gambar 5.31 Perhitungan beban merata dan terpusat untuk balok lantai portal A

- Beban mati segitiga

$w_D = W_D \cdot 1,5$

$= 4,62 \cdot 1,5 = 6,93$ KN/m'

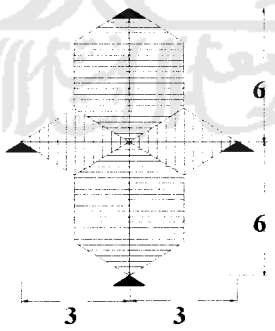
- Beban mati dinding = 8,16 KN/m'
- Beban hidup segitiga

$w_L = W_L \cdot 1,5$

$= 2,5 \cdot 1,5 = 3,75$ KN/m'

c. Beban Terpusat

1. Beban terpusat untuk balok atap



Gambar 5.32 Perhitungan beban terpusat balok atap

- Beban mati segitiga

$w_D = W_D \cdot 1,5$

$= 3,15 \cdot 1,5 = 4,725$ KN/m'

- Beban hidup segitiga

w_L $= W_L \cdot 1{,}5$

$= 1 \cdot 1{,}5$ $= 1{,}5$ KN/m'

- Beban mati trapesium

w_D $= W_D \cdot 1{,}5$

$= 3{,}15 \cdot 1{,}5$ $= 4{,}725$ KN/m'

- Beban hidup trapesium

w_L $= W_L \cdot 1{,}5$

$= 1 \cdot 1{,}5$ $= 1{,}5$ KN/m'

Data untuk beban terpusat dimasukkan kedalam program SAP2000, kemudian didapatkan data beban terpusat sebagai berikut :

JOINT	BEBAN	F1	F2	F3
1	MATI	-3.8E-15	-4.8E-16	24.5294
1	HIDUP	-9.4E-16	-1.2E-16	6.062608
2	MATI	3.81E-15	4.84E-16	49.13496
2	HIDUP	9.39E-16	1.19E-16	11.93739
4	MATI	3.81E-15	4.84E-16	49.13496
4	HIDUP	9.39E-16	1.19E-16	11.93739
5	MATI	-3.8E-15	-4.8E-16	24.5294
5	HIDUP	-9.4E-16	-1.2E-16	6.062608

Tabel 5.5 Reaksi beban terpusat balok atap portal V-3

2. Beban terpusat untuk balok lantai

- Beban mati segitiga

w_D $= W_D \cdot 1{,}5$

$= 4{,}62 \cdot 1{,}5$ $= 6{,}93$ KN/m'

- Beban hidup segitiga

w_L = W_L . 1,5

= 2,5 . 1,5 = 3,75 KN/m'

- Beban mati trapesium

w_D = W_D . 1,5

= 4,62 . 1,5 = 6,93 KN/m'

- Beban hidup trapesium

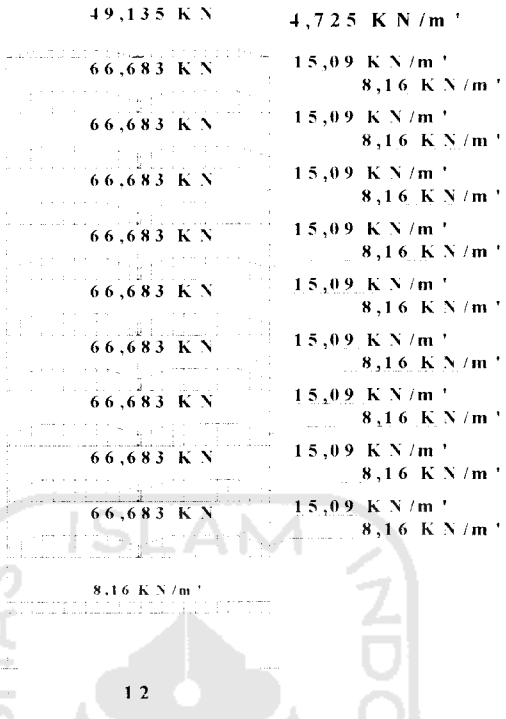
w_L = W_L . 1,5

= 2,5 . 1,5 = 3,75 KN/m'

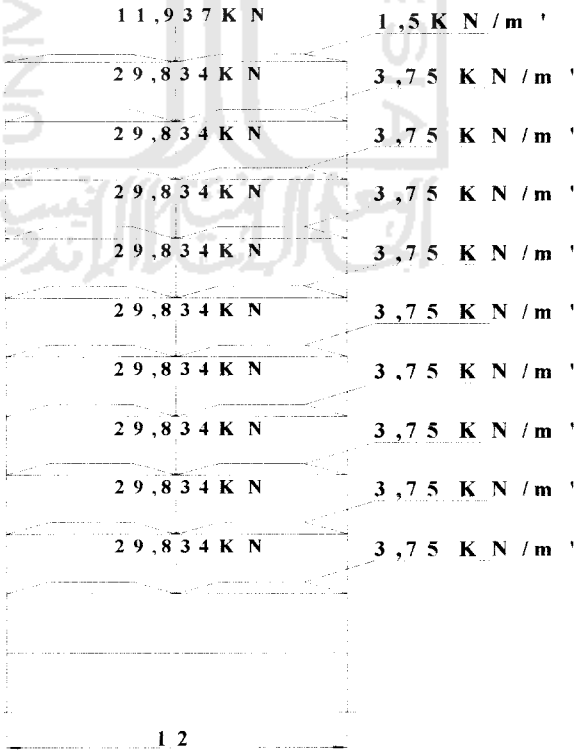
Data untuk beban terpusat dimasukkan kedalam program SAP2000, kemudian didapatkan data beban terpusat sebagai berikut :

JOINT	BEBAN	F1	F2	F3
1	MATI	-5.2E-15	-6.6E-16	33.44143
1	HIDUP	-2.3E-15	-3E-16	15.15652
2	MATI	5.19E-15	6.6E-16	66.68292
2	HIDUP	2.35E-15	2.99E-16	29.84348
4	MATI	5.19E-15	6.6E-16	66.68292
4	HIDUP	2.35E-15	2.99E-16	29.84348
5	MATI	-5.2E-15	-6.6E-16	33.44143
5	HIDUP	-2.3E-15	-3E-16	15.15652

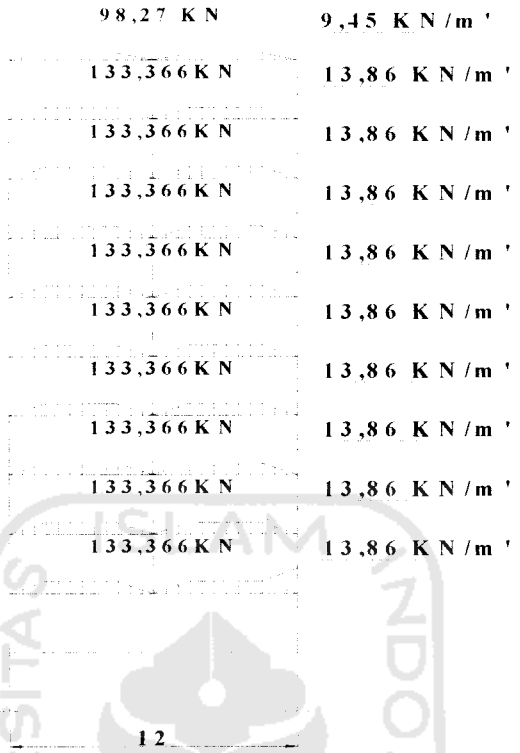
Tabel 5.6 Reaksi beban terpusat balok lantai portal V-3



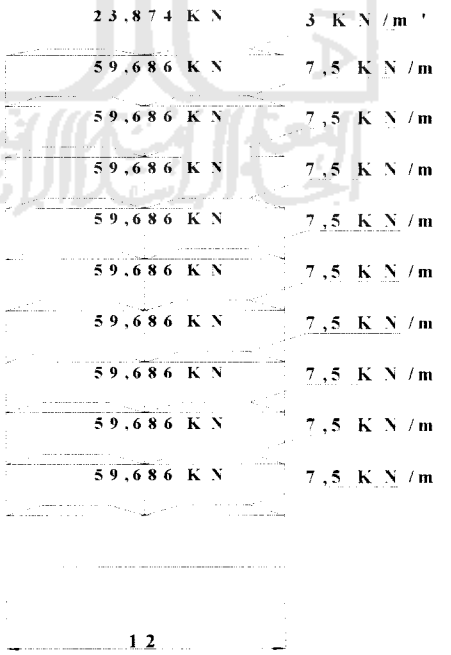
Gambar 5.33 Beban mati portal 1 V-3



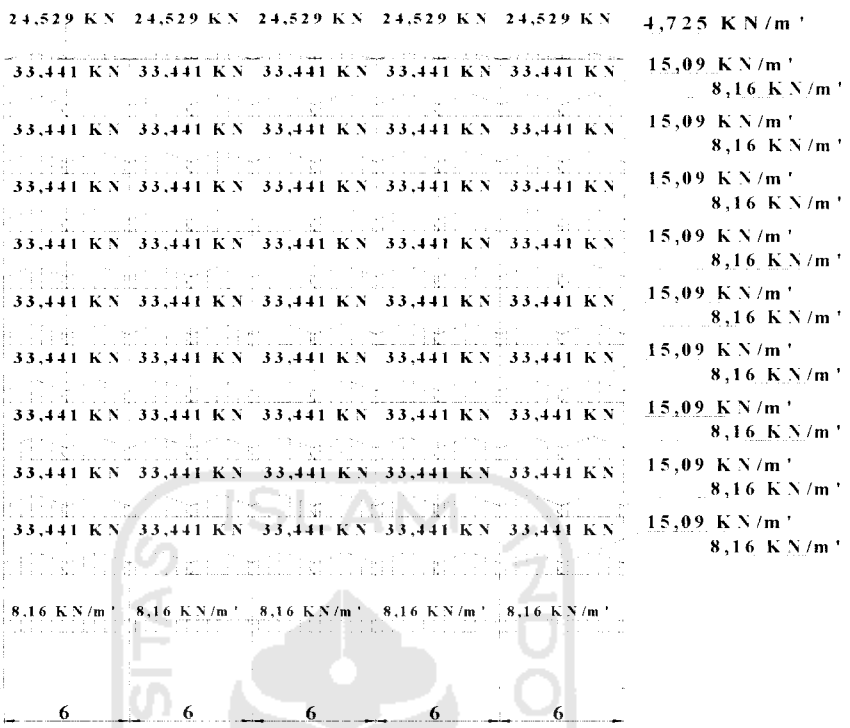
Gambar 5.34 Beban hidup portal 1 V-3



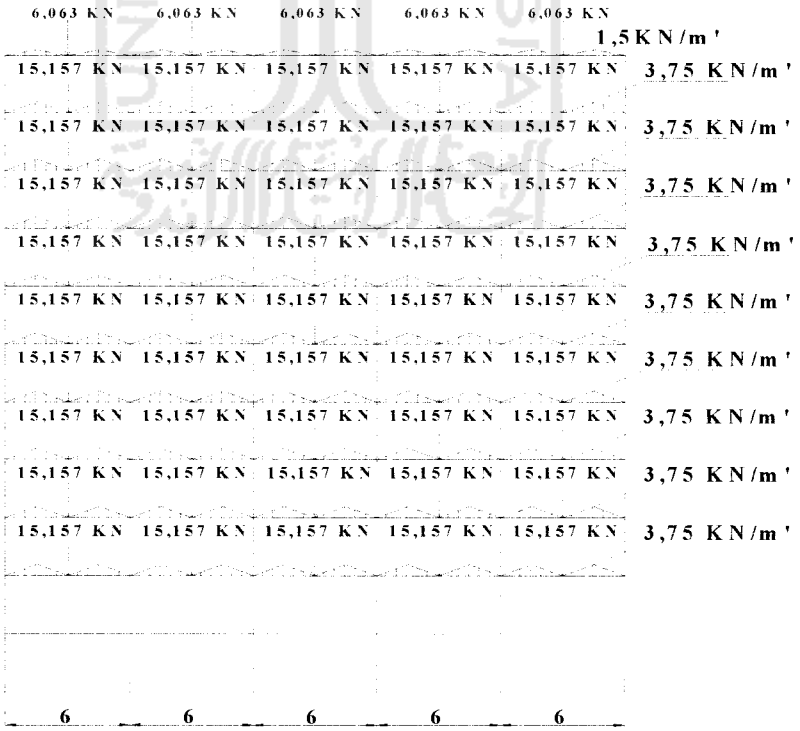
Gambar 5.35 Beban mati portal 2 V-3



Gambar 5.36 Beban hidup portal 2 V-3

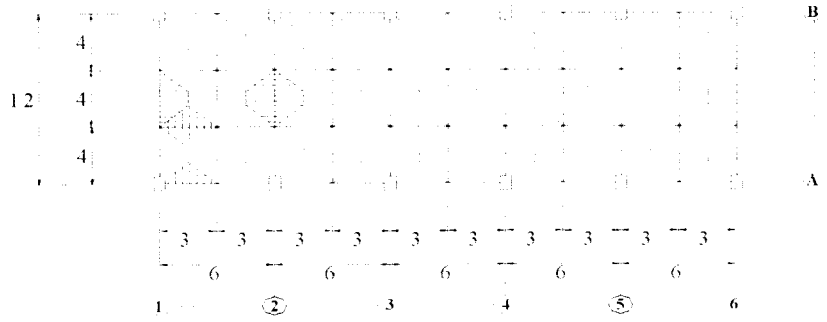


Gambar 5.37 Beban mati portal A V-3



Gambar 5.38 Beban hidup portal A V-3

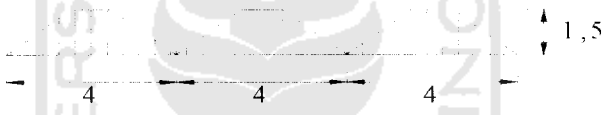
5.2.1.5. Pembebanan pada Portal Variasi 4



Gambar 5.39 Pembagian pembebanan pelat

a. Portal 1

1. Beban gravitasi pada balok atap



Gambar 5.40 Perhitungan beban merata dan titik balok atap portal 1

- Beban mati trapesium

$w_D = W_D \cdot 1{,}5$

$= 3{,}15 \cdot 1{,}5 = 4{,}725$ KN/m'

- Beban hidup trapesium

$w_L = W_L \cdot 1{,}5$

$= 1 \cdot 1{,}5 = 1{,}5$ KN/m'

2. Beban gravitasi pada balok lantai

Gambar 5.41 Perhitungan beban merata dan terpusat balok lantai portal 1

- Beban mati trapesium

$w_D = W_D \cdot 1,5$

$= 4,62 \cdot 1,5 = 6,93$ KN/m'

- Beban mati dinding = 8,16 KN/m'

- Beban hidup trapesium

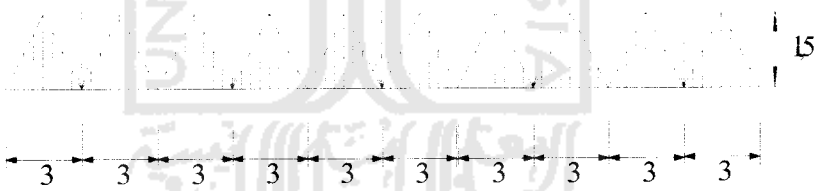
$w_L = W_L \cdot 1,5$

$= 2,5 \cdot 1,5 = 3,75$ KN/m'

Untuk portal tengah, pembebanannya merupakan 2 kali pembebanan portal tepi tanpa beban mati dinding.

b. Portal A

1. Beban gravitasi pada balok atap



Gambar 5.42 Perhitungan beban merata dan terpusat untuk balok atap portal A

- Beban mati segitiga

$w_D = W_D \cdot 1,5$

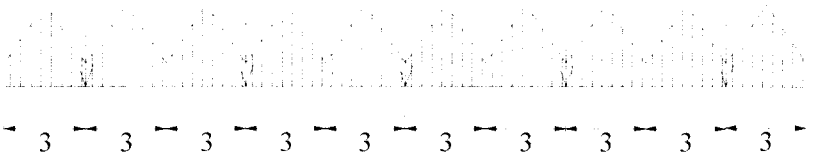
$= 3,15 \cdot 1,5 = 4,725$ KN/m'

- Beban hidup segitiga

$w_L = Q_L \cdot 1,5$

$= 1 \cdot 1,5 = 1,5$ KN/m'

2. Beban gravitasi pada balok lantai



Gambar 5.43 Perhitungan beban merata dan terpusat untuk balok lantai portal A

- Beban mati segitiga

$w_D = W_D \cdot 1,5$

$= 4,62 \cdot 1,5 = 6,93$ KN/m'

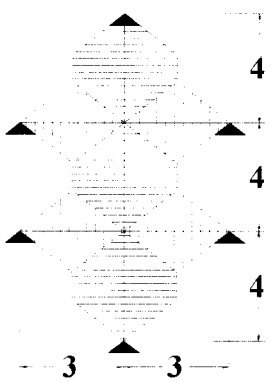
- Beban mati dinding = 8,16 KN/m'
- Beban hidup segitiga

$w_L = W_L \cdot 1,5$

$= 2,5 \cdot 1,5 = 3,75$ KN/m'

c. Beban Terpusat

1. Beban terpusat untuk balok atap



Gambar 5.44 Perhitungan beban terpusat balok atap

- Beban mati segitiga

$w_D = W_D \cdot 1,5$

$= 3,15 \cdot 1,5 = 4,725$ KN/m'

- Beban hidup segitiga

$w_L = W_L \cdot 1,5$

$= 1 \cdot 1,5 = 1,5$ KN/m'

- Beban mati trapesium

$w_D = W_D \cdot 1,5$

$= 3,15 \cdot 1,5 = 4,725$ KN/m'

- Beban hidup trapesium

$w_L = W_L \cdot 1,5$

$= 1 \cdot 1,5 = 1,5$ KN/m'

Data untuk beban terpusat dimasukkan kedalam program SAP2000, kemudian didapatkan data beban terpusat sebagai berikut :

JOINT	BEBAN	F1	F2	F3
1	MATI	-5.03E-15	-4.82E-16	16.66712
1	HIDUP	-1.19E-15	-1.15E-16	3.95061
4	MATI	-5.03E-15	-4.82E-16	16.66712
4	HIDUP	-1.19E-15	-1.15E-16	3.95061
5	MATI	2.46E-15	2.41E-16	34.86976
5	HIDUP	5.82E-16	5.75E-17	8.149694
6	MATI	2.57E-15	2.41E-16	34.86976
6	HIDUP	6.10E-16	5.75E-17	8.149694
7	MATI	2.57E-15	2.41E-16	34.86976
7	HIDUP	6.10E-16	5.75E-17	8.149694
8	MATI	2.46E-15	2.41E-16	34.86976
8	HIDUP	5.82E-16	5.75E-17	8.149694

Tabel 5.7 Reaksi beban terpusat balok atap portal V-4

2. Beban terpusat untuk balok lantai

- Beban mati segitiga

$w_D = W_D \cdot 1,5$

$= 4,62 \cdot 1,5 = 6,93$ KN/m'

- Beban hidup segitiga

$w_L = W_L \cdot 1,5$

$= 2,5 \cdot 1,5 = 3,75$ KN/m'

- Beban mati trapesium

$w_D = W_D \cdot 1,5$

$= 4,62 \cdot 1,5 = 6,93$ KN/m'

- Beban hidup trapesium

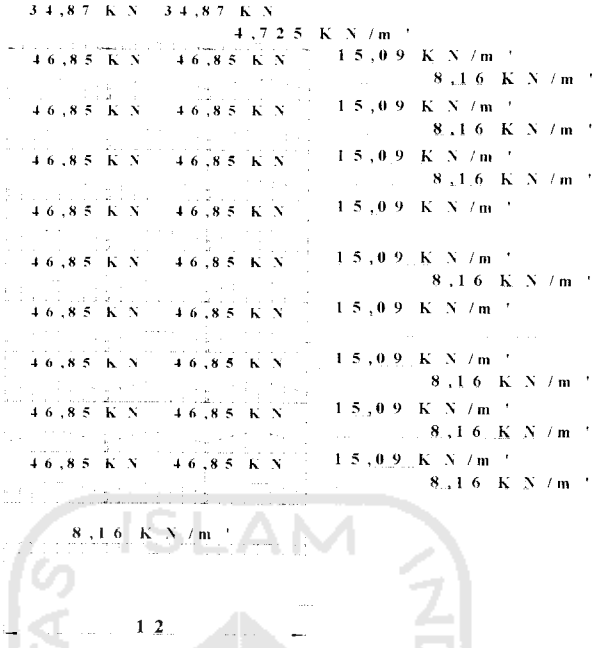
$w_L = W_L \cdot 1,5$

$= 2,5 \cdot 1,5 = 3,75$ KN/m'

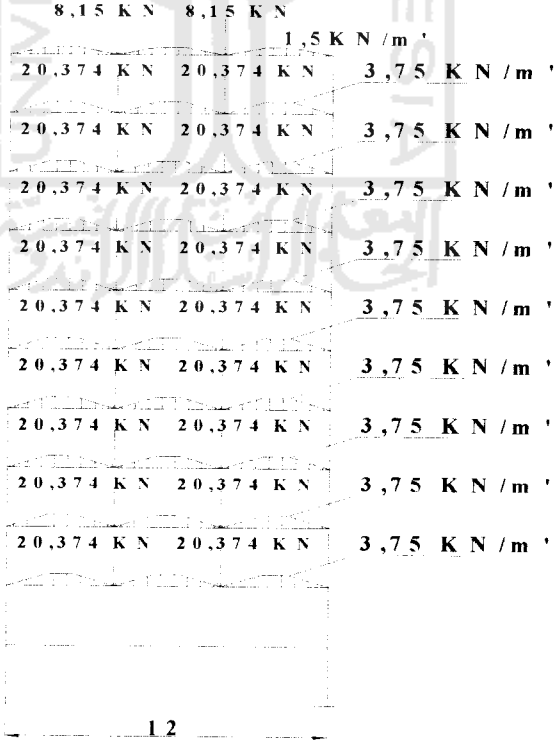
Data untuk beban terpusat dimasukkan kedalam program SAP2000, kemudian didapatkan data beban terpusat sebagai berikut :

JOINT	BEBAN	F1	F2	F3
1	MATI	-6.79E-15	-6.51E-16	22.47452
1	HIDUP	-2.98E-15	-2.88E-16	9.876526
4	MATI	-6.79E-15	-6.51E-16	22.47452
4	HIDUP	-2.98E-15	-2.88E-16	9.876526
5	MATI	3.32E-15	3.26E-16	46.84981
5	HIDUP	1.45E-15	1.44E-16	20.37424
6	MATI	3.47E-15	3.26E-16	46.84981
6	HIDUP	1.53E-15	1.44E-16	20.37424
7	MATI	3.47E-15	3.26E-16	46.84981
7	HIDUP	1.53E-15	1.44E-16	20.37424
8	MATI	3.32E-15	3.26E-16	46.84981
8	HIDUP	1.45E-15	1.44E-16	20.37424

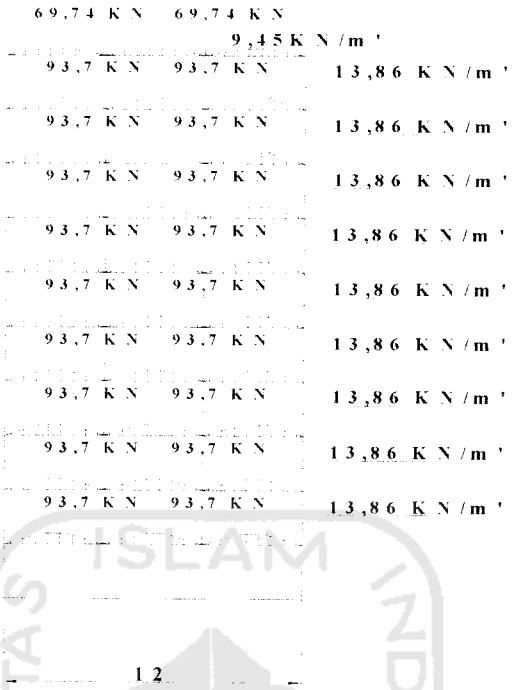
Tabel 5.8 Reaksi beban terpusat balok lantai portal V-4



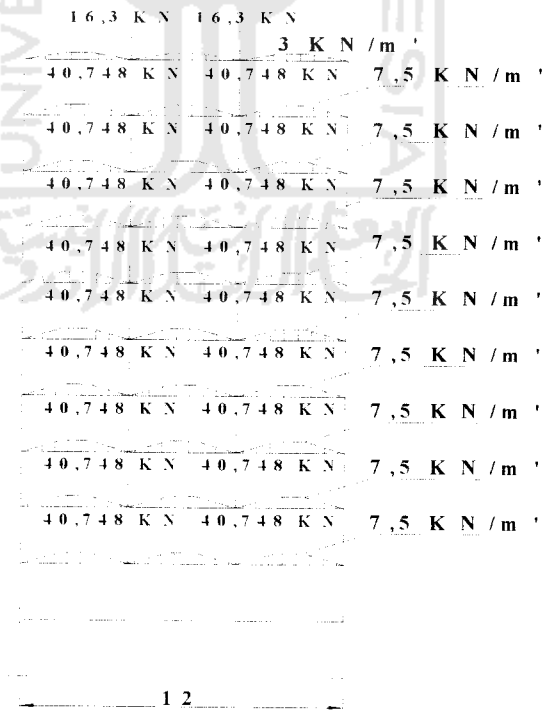
Gambar 5.45 Beban mati portal 1 V-4



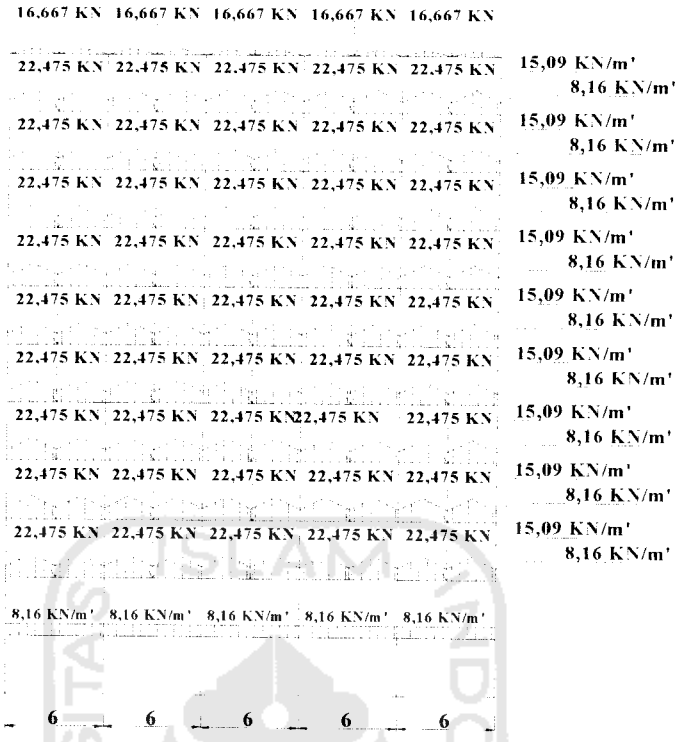
Gambar 5.46 Beban hidup portal 1 V-4



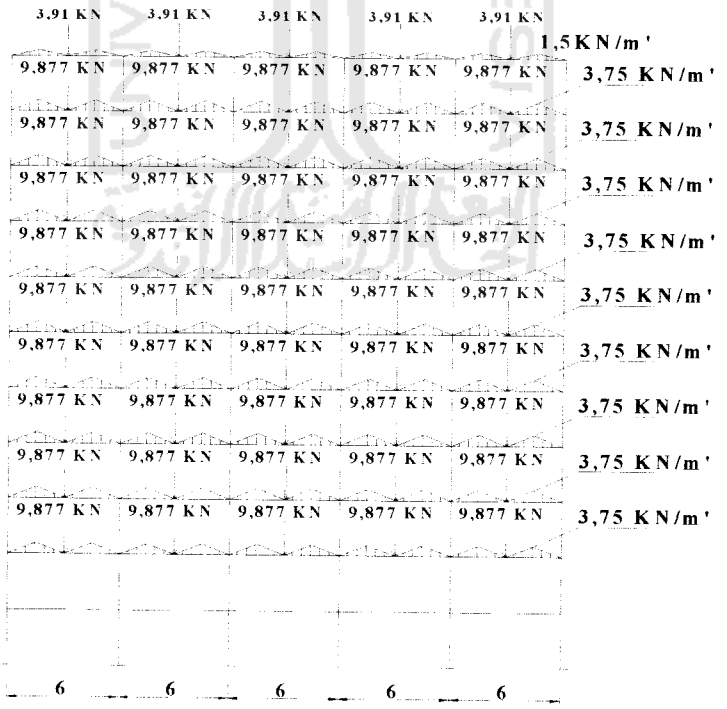
Gambar 5.47 Beban mati portal 2 V-4



Gambar 5.48 Beban hidup portal 2 V-4



Gambar 5.49 Beban mati portal A V-4



Gambar 5.50 Beban hidup portal A V-4

5.2.2. Perhitungan Beban Akibat Beban Gempa

Perhitungan gaya geser dasar horizontal akibat beban gempa diawali dengan menghitung berat total bangunan (Wt), menentukan waktu getar bangunan (T), koefisien gempa dasar (C), factor keutamaan (I) dan faktor jenis struktur (K).

5.2.2.1. Berat Bangunan Total

Contoh perhitungan portal Variasi 1

1. Atap

Beban Mati (W_D)

Plat atap	= A.B.Q_D atap	= 12,5.30,4.3,15	= 1197,0 KN
Balok Induk$_1$	= b.h.l.bj.jumlah	= 0,25.(0,5-0,1).(6-0,6).24.10	= 129,6 KN
Balok Induk$_2$	= b.h.l.bj.jumlah	= 0,4.(0,8-0,1).(12-0.8).24.6	= 451,584 KN
Balok Anak$_1$	= b.h.l.bj.jumlah	= 0,2.(0,4-0,1).(6-0,4).24.10	= 80,64 KN
Kolom	= b.h.1/2H.bj.jumlah	= 0,6.0,8.2.24.12	= 276,48 KN
			+
		W_D	= 2135,30 KN

Beban hidup (W_L)

W_L	= a.b.Q_L.koef feduksi	= 12,5.30,4.1.0,3	= 114,00 KN
			+
W_{total}			= 2249,30 KN

2. Lantai 10

Beban Mati (W_D)

Plat Lantai	= A.B.Q_{DL} Lantai	= 12,5.30,4.4,62	= 1755,6 KN
Balok Induk$_1$	= b.h.l.bj.jumlah	= 0,25.(0,5-0,12).(6-0,6).24.10	= 123,12 KN
Balok Induk$_2$	= b.h.l.bj.jumlah	= 0,4.(0,8-0,12).(12-0,8).24.6	= 438,682 KN
Balok Anak$_1$	= b.h.l.bj.jumlah	= 0,2.(0,4-0,12).(6-0,4).24.10	= 75,264 KN
Kolom	= b.h.H.bj.jumlah	= 0,6.0,8.4.24.12	= 552,96 KN
Tembok$_1$	= tebal.l.H.bj.jumlah	= 0,15.(4-0,8).(12-0,8).17.2	= 182,784 KN
Tembok$_2$	= tebal.l.H.bj.jumlah	= 0,15.(4-0,5).(6-0,6).17.10	= 481,95 KN
			+
		W_D	= 3610,36 KN

Beban hidup (W_L)

W_L	= a.b.Q_L.koef feduksi	= 12,5.30,4.2,5.0,3	= 285,00 KN
			+
W_{total}			= 3895,36 KN

3. Lantai 9,8,7,6,5,4,3,2 sama dengan lantai 10 (tipikal)

Maka berat total bangunan :

$Wt = W_2 + W_3 + W_4 + W_5 + W_6 + W_7 + W_8 + W_9 + W_{10} + W_{Atap}$

$= (9.3895,36) + 2249,3$

$= 37307,54$ KN

5.2.2.2. Waktu Getar Bangunan (T)

Dengan rumus empiris :

$Tx = Ty = 0,06.H^{3/4}$

Dimana H =10.4 = 40 m'

$Tx = Ty = 0{,}06.40^{3/4} = 0{,}954$ detik

5.2.2.3. Koefisien Gempa Dasar (C)

Koefisien gempa dasar (C) diperoleh dari grafik PPTGIUG 1987, dengan T = 0,954 detik. Respon spektra daerah gempa 3 jenis tanah keras diperoleh nilai C dari grafik PPTGIUG 1987 sebesar :

C = 0.035

5.2.2.4. Faktor Keutamaan (I) dan Faktor Jenis Struktur (K)

Berdasrkan PPTGIUG 1987 diperoleh nilai I = 1,0 dan K = 1,0 ; untuk struktur beton bertulang dengan tingkat daktilitas penuh.

5.2.2.5. Gaya GEser Dasar (V)

V = C.I.K.Wt

= 0,035.1.1. 37307,54

= 1305,764 KN

5.2.2.6. Distribusi Gaya Horisontal Tingkat

H = 40 m; B = 30 m

$$\frac{H}{B} = \frac{40}{30} = 1{,}33 < 3$$

Maka seluruh beban didistribusikan sebagi gaya horizontal dengan rumus :

$$F_1 = \frac{W_i F_i}{\Sigma W_i F_i} V$$

Sehingga didapatkan hasil yang disajikan dalam tabel berikut :

V= 1305.764KN

LANTAI	Wx.y KN	Hx.y m	Wx.y*Hx.y KNm	Fx.y KN	Gempa Tepi KN	Gempa Tengah KN
Atap	2249.3	40	89972	148.53175	14.853	29.706
10	3894.36	36	140196.96	231.44645	23.145	46.289
9	3894.36	32	124619.52	205.73018	20.573	41.146
8	3894.36	28	109042.08	180.01391	18.001	36.003
7	3894.36	24	93464.64	154.29763	15.430	30.860
6	3894.36	20	77887.2	128.58136	12.858	25.716
5	3894.36	16	62309.76	102.86509	10.287	20.573
4	3894.36	12	46732.32	77.148817	7.715	15.430
3	3894.36	8	31154.88	51.432544	5.143	10.287
2	3894.36	4	15577.44	25.716272	2.572	5.143
Σ			790956.8	1305.764		

Tabel 5.9 Distribusi gaya gempa portal V-1

Dengan cara yang samamaka didapatkan gaya-gaya akibat gempa untuk variasi portal yang lain yang disajikan dalam tabel berikut :

V= 1319.029KN

LANTAI	Wx.y KN	Hx.y m	Wx.y*Hx.y KNm	Fx.y KN	Gempa Tepi KN	Gempa Tengah KN
Atap	2289.62	40	91584.8	151.0938	15.109	30.219
10	3932.992	36	141587.7	233.587	23.359	46.717
9	3932.992	32	125855.7	207.6329	20.763	41.527
8	3932.992	28	110123.8	181.6788	18.168	36.336
7	3932.992	24	94391.81	155.7247	15.572	31.145
6	3932.992	20	78659.84	129.7706	12.977	25.954
5	3932.992	16	62927.87	103.8165	10.382	20.763
4	3932.992	12	47195.9	77.86234	7.786	15.572
3	3932.992	8	31463.94	51.90823	5.191	10.382
2	3932.992	4	15731.97	25.95411	2.595	5.191
Σ			799523.4	1319.029		

Tabel 5.10 Distribusi gaya gempa portal V-2

V= 1319.858KN

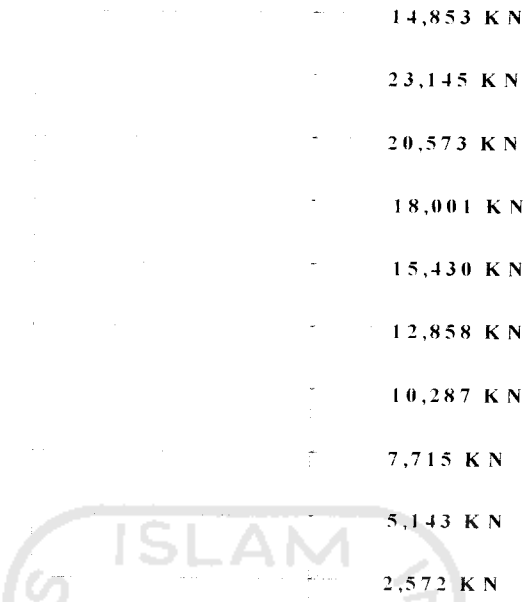
LANTAI	Wx.y KN	Hx.y m	Wx.y*Hx.y KNm	Fx.y KN	Gempa Tepi KN	Gempa Tengah KN
Atap	2292.14	40	91685.6	151.25598	15.126	30.251
10	3935.344	36	141672.384	233.7204	23.372	46.744
9	3935.344	32	125931.008	207.75147	20.775	41.550
8	3935.344	28	110189.632	181.78254	18.178	36.357
7	3935.344	24	94448.256	155.8136	15.581	31.163
6	3935.344	20	78706.88	129.84467	12.984	25.969
5	3935.344	16	62965.504	103.87574	10.388	20.775
4	3935.344	12	47224.128	77.906801	7.791	15.581
3	3935.344	8	31482.752	51.937868	5.194	10.388
2	3935.344	4	15741.376	25.968934	2.597	5.194
Σ			800047.52	1319.858		

Tabel 5.11 Distribusi gaya gempa portal V-3

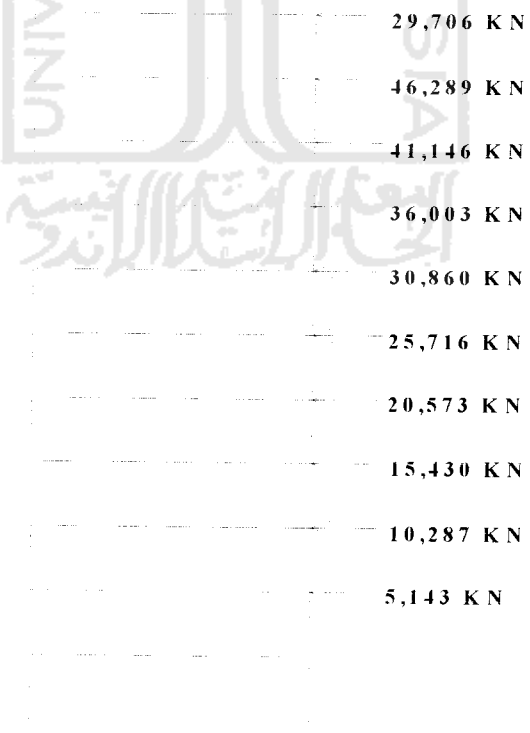
V= 1332.65KN

LANTAI	Wx.y KN	Hx.y m	Wx.y*Hx.y KNm	Fx.y KN	Gempa Tepi KN	Gempa Tengah KN
Atap	2331.02	40	93240.8	153.7582	15.376	30.752
10	3971.632	36	142978.8	235.7783	23.578	47.156
9	3971.632	32	127092.2	209.5807	20.958	41.916
8	3971.632	28	111205.7	183.3832	18.338	36.677
7	3971.632	24	95319.17	157.1856	15.719	31.437
6	3971.632	20	79432.64	130.988	13.099	26.198
5	3971.632	16	63546.11	104.7904	10.479	20.958
4	3971.632	12	47659.58	78.59278	7.859	15.719
3	3971.632	8	31773.06	52.39519	5.240	10.479
2	3971.632	4	15886.53	26.19759	2.620	5.240
Σ			808134.6	1332.65		

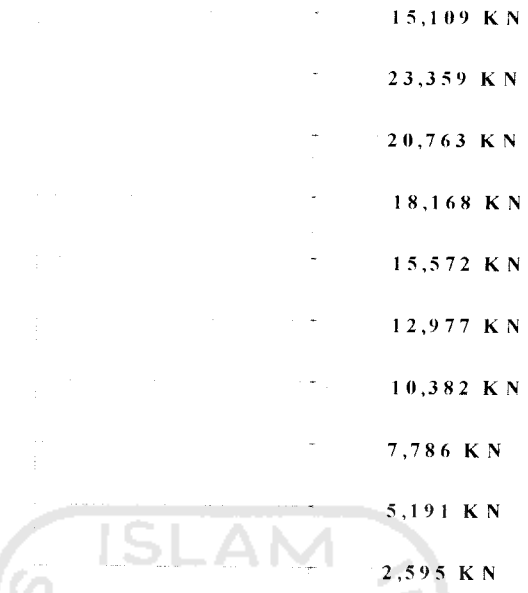
Tabel 5.12 Distribusi gaya gempa portal V-4



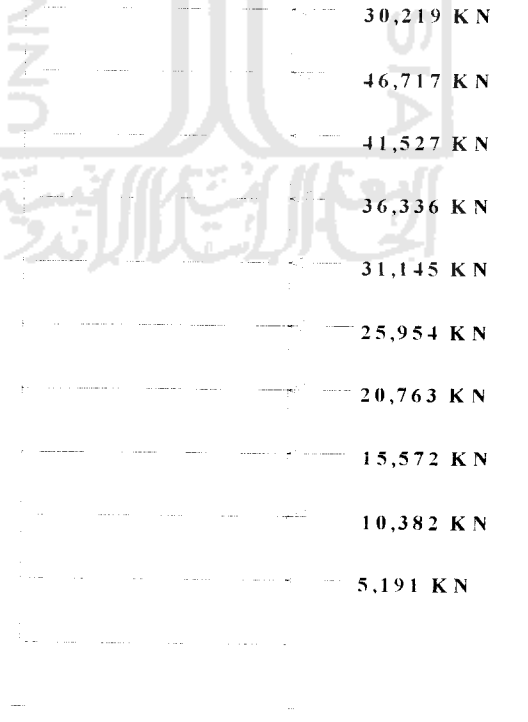
Gambar 5.51 Beban gempa portal 1 V-1



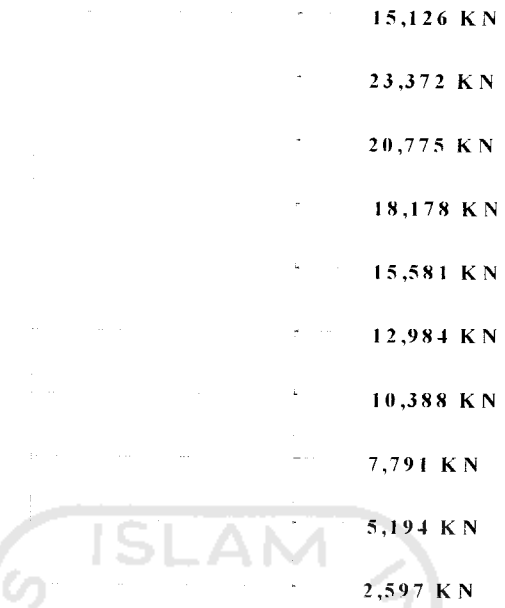
Gambar 5.52 Beban gempa portal 2 V-1



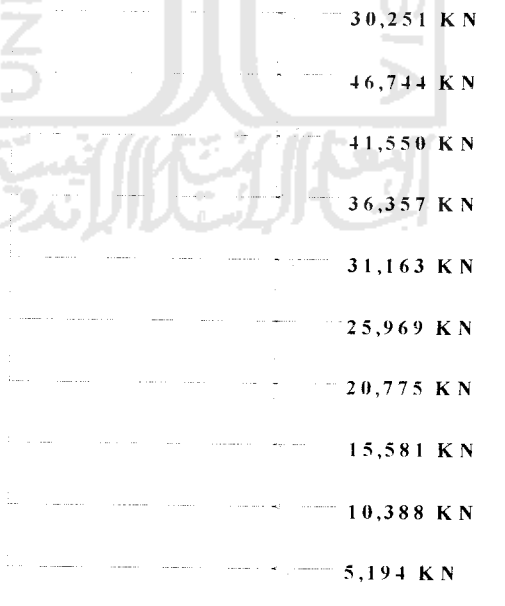
Gambar 5.53 Beban gempa portal 1 V-2



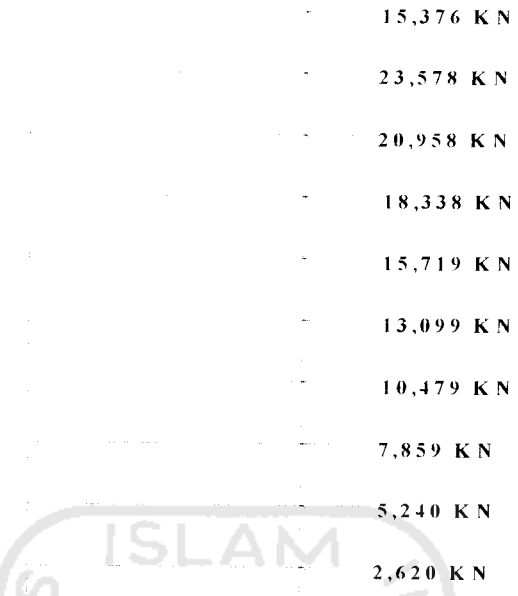
Gambar 5.54 Beban gempa portal 2 V-2



Gambar 5.55 Beban gempa portal 1 V-3



Gambar 5.56 Beban gempa portal 2 V-3



Gambar 5.57 Beban gempa portal 1 V-4

Gambar 5.58 Beban gempa portal 2 V-4

5.3. Perencanaan

Dalam perencanaan hanya diambil salah satu perwakilan dari beberapa elemen bangunan yang dihitung. Sedangkan data-data perencanaan diambil dari data-data analisis SAP2000 pada portal variasi 1 dengan balok anak sebagi satu kesatuan terhadap bangunan.

5.3.1. Perhitungan Plat Lantai

Data-data diambil dari portal variasi 1

lx = 4 m

ly = 6 m

Tebal Plat Lantai = 120 mm

Beban Lantai :

Beban Mati	= Beton	= 0,12 .24	= 2,88 KN/m^2	
	= Pasir	= 0,03.18	= 0,54 KN/m^2	
	= Spesi	= 0,03 .21	= 0,63 KN/m^2	
	= keramik	= 0,01.24	= 0,24 KN/m^2	
	= dusting AC	=	= 0,15 KN/m^2	
	= plafon	=	= 0,18 KN/m^2 +	
		qd	= 4,62 KN/m^2	

Ruang Kelas $\rightarrow$ ql = 2,5 KN/m^2

Qu = 1,2 qd + 1,6 ql

= (1,2.4,62) + (1,6 .2,5)

= 9,616 KN/m^2 $\approx$ 10 KN/m^2

$\frac{ly}{lx} = \frac{6}{4} = 1{,}5 < 2$ tul dua arah (Jepit Elastis)

Clx = Ctx = 76

Cly = Cty = 51

Mtx = Mlx $= 0{,}001.qu.lx^2.Ctx$

$= 0{,}001.10.\ 4^2.76$

$= 12{,}16\ KN/m^2$

$\frac{Mu}{\phi} = \frac{12{,}16}{0{,}8} = 15{,}2\ KN.m$

Mty = Mly $= 0{,}001.\ qu.lx^2.Cty$

$= 0{,}001.10.4^2.51$

$= 8{,}16\ KN.m$

$\frac{Mu}{\phi} = \frac{8{,}16}{0{,}8} = 10{,}2\ KN.m$

$\rho_b = \frac{0{,}85.fc'.\beta_1}{fy}\left(\frac{600}{600+fy}\right)$

$= \frac{0{,}85.20.0{,}85}{240}\left(\frac{600}{600+240}\right)$

$= 0{,}064509$

$\rho_{mak} = 0{,}75\ .\ \rho_b = 0{,}048382$

$\rho_{min} = \frac{1{,}4}{fy} = \frac{1{,}4}{240} = 0{,}005833$

dx $= h - P_b - (\ 0{,}5\emptyset_{tul.x}\ ) = 120 - 20 - (0{,}5.10) = 95$ mm

dy $= h - Pb - \emptyset_{tul.x} - (\ 0{,}5\emptyset_{tul.y}\ ) = 120 - 20 - 10 - (0{,}5.10) = 85$ mm

- **Tulangan lx dan tx**

$$Rn = \frac{\frac{Mu}{\phi}}{b.d^2} = \frac{15{,}2.10^6}{1000.95^2} = 1{,}684211 \text{ Mpa}$$

$$m = \frac{fy}{0{,}85.fc'} = \frac{240}{0{,}85.30} = 9{,}411765$$

$$\rho_{ada} = \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.Rn}{fy}}\right)$$

$$= \frac{1}{9{,}411765}\left(1-\sqrt{1-\frac{2.9{,}411765.1{,}684211}{240}}\right)$$

$$= 0{,}007266$$

Karena $\rho_{min} < \rho_{ada} < \rho_{max}$ maka dipakai $\rho_{perlu} = 0{,}007266$

$As_{perlu} = \rho_{perlu} . b . d = 0{,}007266.1000 .95 = 690{,}269 \text{ mm}^2$

$As_{susut} = 0{,}002 . b . h = 0{,}002 . 1000 . 120 = 240 \text{ mm}^2$

$As_{perlu} \geq As_{susut} \rightarrow$ Ok !!

Dipakai tulangan Ø 10 mm.

$A_1Ø = 0{,}25 .3{,}14 . Ø^2 = 0{,}25 . 3{,}14 . 10^2 = 78{,}5 \text{ mm}^2$

$$S \leq \frac{A_1\phi.b}{As} = \frac{78{,}5.1000}{690{,}269} = 113{,}7238 \text{ mm}$$

$S \leq 2 . h = 2 .120 = 240$ mm

$S \leq 250$ mm

Maka dipakai tulangan P_{10} – 110 mm

Kontrol Kapasitas :

$$As_{ada} = \frac{A_1\phi .b}{S} = \frac{78{,}5.1000}{110} = 713{,}6364 \text{mm}^2$$

$$a = \frac{As_{ada} \cdot fy}{0{,}85 \cdot fc' \cdot b} = \frac{713{,}6364 \cdot 240}{0{,}85 \cdot 30 \cdot 1000} = 6{,}716578$$

$$Mn = As_{ada} \cdot fy \cdot \left(d - \frac{a}{2}\right)$$

$$= 713{,}6364 \cdot 240 \cdot \left(95 - \frac{6{,}716578}{2}\right)$$

$$= 15.69573 \text{ KN.m} > \frac{Mu}{\phi} = 15{,}2 \text{ KN.m} \rightarrow \textbf{Ok !!}$$

- **Tulangan ty**

$$\frac{Mu}{\phi} = 10{,}2 \text{ KN.m}$$

$h = 120$ mm

$b = 1000$ mm

$d = 120 - 20 - (0{,}5 \cdot 10)$

$= 95$ mm

$$Rn = \frac{\frac{Mu}{\phi}}{b \cdot d^2} = \frac{10{,}2 \cdot 10^6}{1000 \cdot 95^2}$$

$= 1{,}13019391$Mpa

$$m = \frac{fy}{0{,}85 \cdot fc'} = \frac{240}{0{,}85 \cdot 30}$$

$= 9{,}411765$

$$\rho_{ada} = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2 \cdot m \cdot Rn}{fy}}\right)$$

$$= \frac{1}{9{,}411765}\left(1 - \sqrt{1 - \frac{2 \cdot 9{,}411765 \cdot 1{,}13019391}{240}}\right)$$

$= 0{,}0048184$

Karena $\rho_{ada} < \rho_{min}$ maka dipakai $\rho_{perlu} = \rho_{min} = 0{,}00583333$

$As_{perlu} = \rho_{perlu} \cdot b \cdot d = 0{,}00583333.1000 .95 = 554{,}166667 mm^2$

$As_{susut} = 0{,}002 \cdot b \cdot h = 0{,}002 \cdot 1000 \cdot 120 = 240\ mm^2$

$As_{perlu} \geq As_{susut} \rightarrow$ Ok !!

Dipakai tulangan Ø 10 mm.

$A_1Ø = 0{,}25 .3{,}14 . Ø^2$

$= 0{,}25 . 3{,}14 . 10^2$

$= 78{,}5\ mm^2$

$$S \leq \frac{A_1\phi.b}{As} = \frac{78{,}5.1000}{554{,}166667} = 141{,}654135 mm$$

$S \leq 2 . h = 2 .120 = 240\ mm$

$S \leq 250\ mm$

Maka dipakai tulangan P_{10} – 140 mm

Kontrol Kapasitas :

$$As_{ada} = \frac{A_1\phi .b}{S} = \frac{78{,}5.1000}{140} = 560{,}714286 mm^2$$

$$a = \frac{As_{ada}.fy}{0{,}85.fc'.b} = \frac{560{,}714286.240}{0{,}85.30.1000} = 5{,}27731092$$

$$Mn = As_{ada} . fy . \left(d - \frac{a}{2}\right)$$

$$= 560{,}714286. 240 . \left(95 - \frac{5{,}27731092}{2}\right)$$

$= 12{,}4291981 KN.m > Mu/\phi = 10{,}2\ KN.m \rightarrow$ **Ok !!**

- **Tulangan ly**

Mu/ϕ = 10,2 KN.m

h = 120 mm

b = 1000 mm

d = 85 mm

$$Rn = \frac{Mu}{b.d^2} = \frac{10,2.10^6}{1000.85^2} = 1,41176471 \text{ Mpa}$$

$$m = \frac{fy}{0,85.fc'} = \frac{240}{0,85.30} = 9,411765$$

$$\rho_{ada} = \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.Rn}{fy}}\right)$$

$$= \frac{1}{9,411765}\left(1-\sqrt{1-\frac{2.9,411765.1,41176471}{240}}\right)$$

$$= 0,0060548$$

Karena $\rho_{min} < \rho_{ada} < \rho_{max}$ maka dipakai $\rho_{perlu} = 0,0060548$

$As_{perlu} = \rho_{perlu} . b . d = 0,0060548.1000 .85 = 514,6646 mm^2$

$As_{susut} = 0,002 . b . h = 0,002 . 1000 . 120 = 240 mm^2$

$As_{perlu} \geq As_{susut} \rightarrow$ Ok !!

Dipakai tulangan Ø 10 mm.

$A_1Ø = 0,25 .3,14 . Ø^2 = 0,25 . 3,14 . 10^2 = 78,5 mm^2$

$$S \leq \frac{A_1\phi.b}{As} = \frac{78,5.1000}{514,6646} = 152,5265 \text{ mm}$$

$S \leq 2 . h = 2 .120 = 240$ mm

S ≤ 250 mm

Maka dipakai tulangan P_{10} – 150 mm

Kontrol Kapasitas :

$$As_{ada} = \frac{A_1\phi \cdot b}{S} = \frac{78{,}5.1000}{150} = 523{,}333333 mm^2$$

$$a = \frac{As_{ada} \cdot fy}{0{,}85 \cdot fc' \cdot b} = \frac{560{,}714286.240}{0{,}85.30.1000} = 4{,}9254902$$

$$Mn = As_{ada} \cdot fy \cdot \left(d - \frac{a}{2}\right)$$

$$= 523{,}333333 \cdot 240 \cdot \left(85 - \frac{4{,}9254902}{2}\right)$$

$$= 10.3666792 KN.m > Mu/\phi = 10{,}2 KN.m \rightarrow \textbf{Ok !!}$$

5.3.2. Perhitungan balok induk

Mu = 753.79 KN.m

ρb = 0,033

ρmaks = 0,024

ρmin = 0,0035

ρ pakai = 0,5 . 0,024 = 0,012

m = 15,686

Rn = 4,411

$$\frac{Mu}{0{,}8} = \frac{753{,}79}{0{,}8} = 942{,}238 KNm$$

$$bd^2 = \frac{Mu / \varphi}{Rn} = \frac{942{,}238}{4{,}411} = 213{,}611 \cdot 10^6 \text{ mm}^3$$

b	300	350	400
d	843,86	781,26	730,811

Dipakai b = 400 mm

d = 700 mm < 730 mm ----- Tulangan Rangkap

$\rho 1 = 0{,}5 . \rho maks = 0{,}05 . 0{,}024 = 0{,}012$

$As\ 1 = \rho 1.b.d = 0{,}012.400.800 = 3413{,}813 \text{ mm}^2$

$$a = \frac{As1.fy}{0{,}85.fc'.b} = \frac{3413{,}813.400}{0{,}85.30.400} = 133{,}875$$

$$Mn\ 1 = As_1.fy\ (\ d - \frac{a}{2}\ )$$

$$= 3413{,}813.400\ (\ 700 - \frac{133{,}875}{2}\ )\ 10^{-6} = 864{,}462 \text{ KN.m}$$

$$< \frac{Mu}{\varphi} = 942{,}238 \text{ KNm}$$

$$Mn\ 2 = \frac{Mu}{\varphi} - Mn\ 1 = 942{,}238 - 864{,}462 = 77{,}775 \text{ KN.m}$$

$$fs' = 600\ \{\ 1 - (\ \frac{0{,}85.fc'.\beta}{\rho 1.fy}\ \frac{d'}{d}\ )\ \} = 600\ \{\ 1 - (\ \frac{0{,}85.30.0{,}85}{0{,}012.400}\ .\ \frac{60}{700}\ )\ \} = 371{,}492$$

< fy

----Sehingga dipakai fs' = 371,492

$$As' = \frac{Mn2}{fy(d - d')} = \frac{77{,}775.1000000}{400(700 - 60)} = 327{,}178 \text{ mm}^2$$

Coba Tulangan Diameter = D 22 = A1 = 379,940 mm^2

$$N = \frac{As'}{A1} = \frac{327,178}{379,94} = 0,861 = 2 \text{ batang ---- } \mathbf{2\ D22}$$

$As = As\ 1 + As' = 3413,813 + 327,178 = 3740,99\ mm^2$

Coba Tulangan Diameter = D 22 = A1 = 379,940 mm^2

$$N = \frac{As}{A1} = \frac{3740,99}{379,940} = 9,846 = 10 \text{ batang ---- } \mathbf{10\ D22}$$

Cek tulangan sebelah tumpuan

Mu = 119,022

$$\frac{Mu}{\varphi} = 148,777$$

$$R\ ada = \frac{Mu}{\varphi} / b\ d^2\ ada = 148,777 / 4000 \cdot 700^2 = 0,759$$

$$\rho\ ada = \frac{Rn\ ada}{Rn}\ \rho = \frac{0,759}{0,759} 0.014 = 0.002$$

As = ρ ada . b . d ada = 0.002 . 400 . 700 = 697,973

$$n = \frac{As}{Atul} = \frac{697,973}{379,94} = 1,837 = 2\ D\ 22$$

n pakai = minimal 0,5.n tumpuan – **5 D 22**

Kontrol kapasitas yang terjadi

$As = n \cdot As_{1tul} = 10.379,94 = 3799,4\ mm^2$

$As' = n \cdot As_{1tul} = 5 \cdot 379,940 = 1899,7\ mm^2$

$$\rho = \frac{As}{b \cdot d} = \frac{3799,4}{400.700} = 0,0135$$

$\rho' = \frac{As'}{b.d} = \frac{1899,4}{400.700} = 0,00678$

$fs' = 600 \{ 1 - (\frac{0,85.fc'.\beta}{(\rho - \rho').fy} \frac{d'}{d}) \}$

$= 600 \{ 1 - (\frac{0,85.30.0,85}{(0,0135 - 0,00678).400} . \frac{60}{700}) \} = 189,25 < fy = 400$

fs pakai = fs – 189,25

$a = \frac{As.fy - As'.fs'}{0,85.fc'.b} = \frac{3799,4.400 - 1899,7.189,25}{0,85.30.400} = 113,749$

$Mn = Mn_1 + Mn_2$

$= (As.fy - As'.fs').\left(d - \frac{a}{2}\right) + (As'.fs').(d - d')$

$= (3799,4.400 - 1899,7.189,25).\left(700 - \frac{113,749}{2}\right) + (1899,7.189,25).(700 - 60)$

$= 976,2727$ KNm $> \frac{Mu}{\Phi} = 942,238\ KNm$ -ok-

<u>Momen kapasitas:</u>

$a = \frac{As'.fy}{0,85.fc'.b} = \frac{1899,7.400}{0,85.30.400} = 74,498$

$Mkap^{+} = wd\ .\ As'\ .\ fy\ .\left(d - \frac{a}{2}\right) = 1,25\ .\ 1899,7\ .\ 400\left(700 - \frac{74,498}{2}\right)$

$= 629,514$ KNm

$Mkap^{-} = wd\ .\ Mn = 1,25\ .\ 976,2727 = 1220,341$ KNm

<u>Perhitungan Tulangan Geser :</u>

ln = 11,2 m

VD = 185,555 KN

VL = 70,68 KN

VE = 47,558 KN

Vg = VD + VL = 185,55 + 70,68 = 256,23 KN

$$Vu = \frac{0{,}7.(Mkap^{+} + Mkap^{-})}{ln} + 1{,}05.Vg$$

$$= \frac{0\,,7\,.\,(\,629{,}514\,+\,1220{,}341)}{11{,}2} + 1\,,05\,.\,256{,}23$$

= 384,6627 KN

Vu max = 1,05 . (VD + VL + 4/k . VE)

= 1,05 (185,555 + 70,68 + 4/1 . 47,558)

= 468,7904 KN

Vu = 384,6627 KN < Vumax = 468,7904 KN

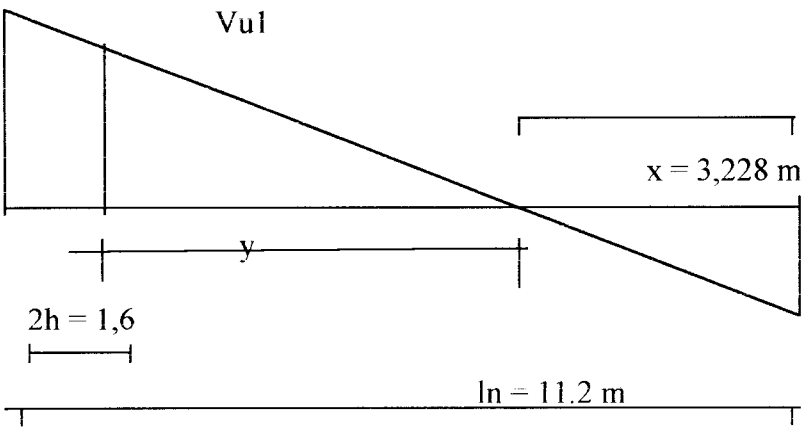
Jadi Vu pakai = Vu = 384,662 KN

$$Vu\ min = \frac{0{,}7.(Mkap^{+} + Mkap^{-})}{ln} - 1{,}05.Vg$$

$$= \frac{0\,,7\,.\,(\,629{,}514\,+\,1220{,}341\,)}{11{,}2} - 1\,,05\,.\,256{,}23$$

= -153,430KN

Vu = 384,6627KN



$$x = \frac{Vu\ \min}{Vu\ \min + Vu_{pakai}} . \ln = \frac{153{,}4308}{153{,}4308 + 384{,}6627} . 11{,}2 = 3{,}193\ m$$

y = ln – x – 2.h – 11,2 – 3,193 – 2.1,6 = 6,406

Penulangan pada daerah sendi plastis :

$$Vs = \frac{Vu}{\phi} = \frac{384\ ,6627}{0\ ,6} = 641\ ,1045$$

Ø sengkang = 10 mm < 12 mm → fy = fs = 240 MPa

jumlah kaki = 4

Av = 4 . ¼ . π . 10^2 = 314 mm^2

$$S = \frac{Av\ .fs\ .d}{Vs} = \frac{314\ .240\ .700}{641{,}145\ .10^{3}} = 82{,}2837 = 80\ mm > 70\ mm$$ –ok-

Penulangan di luar sendi plastis :

Vc = 1/6 . √ fc1 . b . d

= 1/6 . √ 30 . 400 . 700.10^{-3}

= 255,6 KN

$$Vu1 = \frac{Vu\ \min.y}{x} = \frac{153{,}43.6{,}406}{3{,}193} = 307{,}792KN$$

$$Vs = \frac{Vu^{1}}{\phi} - Vc = \frac{307{,}7922}{0\ ,6} - 255{,}60 = 257{,}383\ kn$$

Ø sengkang = 10 mm < 12 mm → fy = fs = 240 MPa

jumlah kaki = 2

Av = 2 . ¼ . π . 10^2 = 157 mm^2

$$S = \frac{Av\ .fs\ .d}{Vs} = \frac{157\ .300\ .700}{257{,}383\ .10^{3}} = 102{,}4776 = 100mm > 70\ mm$$ –ok-

5.3.3. Perhitungan kolom

Perhitungan Momen Rencana Kolom.

M_{kap+} = 629,514 KN.m

M_{kap-} = 1220,341 KN.m

ha = 4 m

hb = 4 m

Ka $= \frac{1}{ha}$

$= \frac{1}{4}$

$= 0,25$

αa $= \frac{ka}{ka+kb}$

$= \frac{0,25}{0,25+0,25}$

$= 0,5$

hn $= h - h_{balok}$

$= 4 - 0,8$

$= 3,2$ m

b_{kolom} = 0.6 m

h_{kolom} = 0.8 m

h = 4 m

l = 3,2 m

Kb $= \frac{1}{hb}$

$= \frac{1}{54}$

$= 0,25$

αb $= \frac{kb}{ka+kb}$

$= \frac{0,25}{0,25+0,25}$

$= 0,5$

ln $= l - h_{kolom}$

$= 12 - 0,8$

$= 11,2$ m

Muk a $= \frac{hn}{h} . \alpha_a . \omega_d . 0,7 . \left(\frac{l}{\ln} . M_{kap-} \right)$

$= \frac{3,2}{4} . 0,5.1,3 . 0,7 . \left(\frac{12}{11,2} . 629,514 \right)$

$= 213,866$ KN.m

Md = 234,177 KN.m

Ml = 90,837 KN.m

Me = 283,987 KN.m

K = 2

$M_{mak} = 1{,}05 \cdot \left(Md + Ml + \left(\frac{4}{K} \cdot Me \right) \right)$

$= 1{,}05 \cdot \left(234{,}177 + 90{,}873 + \left(\frac{4}{2} \cdot 283{,}987 \right) \right)$

= 937,6752 KN.m

Muk a < M_{mak} maka Mu pakai adalah **Muk a = 213,866 KN.m**

Muk b $= \frac{hn}{h} \cdot \alpha_b \cdot \omega_d \cdot 0{,}7 \cdot \left(\frac{l}{\ln} \cdot M_{kap} - \right)$

$= \frac{3{,}2}{4} \cdot 0{,}5 \cdot 1{,}3 \cdot 0{,}7 \cdot \left(\frac{12}{11{,}2} \cdot 1220{,}341 \right)$

= 414,5905 KN.m

Md = 184,874 KN.m

Ml = 71,739 KN.m

Me = 150,180 KN.m

K = 2

$M_{mak} = 1{,}05 \cdot \left(Md + Ml + \left(\frac{4}{K} \cdot Me \right) \right)$

$= 1{,}05 \cdot \left(184{,}874 + 71{,}739 + \left(\frac{4}{2} \cdot 150{,}180 \right) \right)$

= 584,8217 KN.m

Muk b < M_{mak} maka Mu pakai adalah **Muk b = 414,5905 KN.m**

Perencanaan Beban

Pd	= 3204,404 KN	M_1	= 629,514 KN.m
Pl	= 839,423 KN	M_2	= 1220,341 KN.m
Pe	= 422,918 KN	l	= 12 m
K	= 1		
Pg	= Pd + Pl = 3204,404 + 839,423		= 4043,827 KN
Σ M	= M_1 + M_2 = 629,514 + 1220,341		= 1849,855 KN.m

$$Pu_1 = \left\{0{,}7 \,.\, K \,.\, \left(\frac{\sum M}{l}\right)\right\} + (1{,}05 \,.\, Pg)$$

$$= \left\{0{,}7 \,.\, 1 \,.\, \left(\frac{1849{,}855}{12}\right)\right\} + (1{,}05 \,.\, 4043{,}827)$$

$$= 4353{,}927 \text{ KN}$$

$$Pu_{max} = 1{,}05 \,.\, \left(Pd + Pl + \left(\frac{4}{K} \,.\, Pe\right)\right)$$

$$= 1{,}05 \,.\, \left(3204{,}404 + 839{,}423 + \left(\frac{4}{1} \,.\, 422{,}918\right)\right)$$

$$= 6022{,}274 \text{ KN}$$

$Pu_1 < Pu_{mak}$ maka Pu pakai adalah **Pu_1 = 4353,927 KN**

Perhitungan Momen Rencana

Mb pendek	= 41,896 KN.m
100 % M pakai	= 100 % .41,896
	= 41,896 KN.m
30 % M pakai	= 30 % .41,896
	= 12,568 KN.m

Mb panjang = 414,590 KN.m

100 % M pakai = 100 % . 414,590 = 414,590 KN.m

30 % M pakai = 30 % . 414,590 = 124,377 KN.m

$$Mn = \frac{100\,\%\,M\,pakai + 30\,\%\,M\,pakai}{0,65} = \frac{41,896 + 124,377}{0,65}$$

$$= 255,806\ KN.m$$

$$Mn = \frac{30\,\%\,M\,pakai + 30\,\%\,M\,pakai}{0,65} = \frac{12,568 + 414,590}{0,65}$$

$$= 657,168\ KN.m$$

Diambil Mn mak = 657,168 KN.m

Pu pendek = 4269,466 KN

Pu panjang = 4353,927 KN

Pu = Pu pendek + Pu panjang = 4269,466 + 4353,927

= 8623,393KN

$$Pn = \frac{Pu}{0.65} = \frac{823,393}{0,65}$$

= **13266,73 KN**

Mn dan Pn di plot dalam grafik Mn-Pn didapat Ast = 1%

Tulangan Kolom :

Ag = b .h = 600 . 800 = 480000 mm²

Ast = 1 % Ag =1 % . 480000 = 4800 mm²

Diameter Tulangan = 22 mm

A1Ø = ¼ π D² = ¼ π 22²

= 379,94 mm²

N tulangan = Ast / A1Ø

= 4800 / 379,94 = 6,316 ≈ 7 tulangan

Pakai **7 D22**

Gaya Geser Kolom

$$Vu.k = \frac{Mu.k\ atas\ pakai + Mu.k\ bawah\ pakai}{Hn}$$

$$= \frac{213,869 + 414,5905}{3,2}$$

= 196,393 KN.

$$Vu.k\ maks = 1,05\ (\ VD + VL + \left(\frac{4}{k}\right).VE\ )$$

$$= 1,05\ (68,334 + 26,520 + (\frac{4}{1}(110,8))$$

= 564,956 KN.

Vu.k pakai = 196,393 KN.

Penulangan Geser Kolom

- Dalam Sendi Plastis

  f'c = 30 MPa, fy = 400 MPa

  b.kolom = 600 mm, h.kolom = 800 mm

  d = 800 – 100 = 700 mm

  Vu.k = 196,393 KN

  $$Vs1 = \frac{Vu.k}{0,6} = \frac{196,393}{0,6} = 327,321\ KN$$

  Pakai Tulangan Sengkang D = 10 mm → $A_{1O} = 78,5\ mm^2$

  Pakai Kaki Sengkang = 2 buah

$$S = \frac{n.A1\emptyset.fy.d}{Vs1} = \frac{2.78{,}5.400.700}{327{,}321.1000} = 134{,}34 \text{ mm}$$

S pakai = 130 mm

Pakai Tulangan **1,5P10 – 130**

- Luar Sendi Plastis

Pu.k = 4353,927 KN

Ag = 800 . 600 = 480000 mm^2

$$Vc = \left(1 + \frac{Pu.k}{14.Ag}\right).\left(\frac{1}{6}\right).\sqrt{f'c}.b.d$$

$$= \left(1 + \frac{4353{,}927.1000}{14.480000}\right).\left(\frac{1}{6}\right).\sqrt{30}.600.700$$

= 631816,627 N = 631,816 KN

$$Vs = \frac{Vu.k}{0{,}6} - Vc = \frac{196.393}{0{,}6} - 631{,}816 = -304{,}494 \text{ KN}$$

Pakai Tulangan Sengkang D = 10 mm → A_{1O} = 78,5 mm^2

Pakai Kaki Sengkang = 2 buah

S pakai = 200 mm

Pakai Tulangan **P10 – 200**

5.3.4. Perhitungan pondasi

$Mx_{kap\ klm}$	= 1975,5 KN.m	σ'_{tnh}	= 600 KN/m^2
$My_{kap\ klm}$	= 1750 KNm	γ_{ynh}	= 18 KN/m^3
Pu	= 6115,75KN	ht	= 3 m
b_{klm}	= 0,6 m	hp	= 1 m

h_{klm} = 0,8 m γ_{btn} = 24 KN/m^3

pb = 0,05 m

Berat tanah diatas pondasi :

qt = (h-t) . σ_{tnh} = (3-1) . 18 = 36 KN

Berat pondasi :

qp = hp . γ_{btn} = 1.24 =24 KN

Berat total :

q = qt + qp = 36 + 60 = 60 KN

Karena P = L , maka :

$$\sigma = \frac{Pu}{B^2} + \frac{Mx}{B^3} + \frac{My}{B^3} + q$$

$$= \frac{6115,75}{B^2} + \frac{1937,5}{B^3} + \frac{1750}{B^3} + 60 < \sigma' = 600 \text{ KN/m}^2$$

didapat B = 4

Tegangan yang terjadi pada pondasi :

$$\sigma u_{min} = \frac{Pu}{B^2} - \frac{Mx}{B^3} - \frac{My}{B^3} + q = \frac{6115,75}{B^2} - \frac{1937,5}{B^3} - \frac{1750}{B^3} - 60$$

$$= 384,6 \text{ KN/m}^2$$

$$\sigma u_{mak} = \frac{Pu}{B^2} + \frac{Mx}{B^3} + \frac{My}{B^3} + q = \frac{6115,75}{B^2} + \frac{1937,5}{B^3} + \frac{1750}{B^3} + 60$$

$$= 499,851 \text{ KN/m}^2$$

Cek Geser

d = h_{plat} – 0,1 - $\frac{1}{2}$Øtul = 1 – 0,1 – 0,011 = 0,889 m

$$m = \frac{P - h_{kolom} - (2.d)}{2} = \frac{4 - 0,8 - (2.0,889)}{2} = 0,711 \text{ m}$$

$$n = \frac{L - b_{kolom} - (2.d)}{2} = \frac{4 - 0{,}6 - (2.0{,}889)}{2} = 0{,}911 \text{ m}$$

$$\sigma_1 = \sigma_{u\min} + \left\{\left(\frac{N-m}{N}\right).\left(\sigma_{umak} - \sigma_{u\min}\right)\right\}$$

$$= 384{,}617 + \left\{\left(\frac{4 - 0{,}711}{4}\right).(499{,}851 - 384{,}617)\right\}$$

$$= 473{,}606 \text{ KN/m}^2$$

Geser 1 Arah

Arah P

$$Vu_1 = \frac{\sigma_1 + \sigma_{umak}}{2}.m.P = \frac{473{,}606 + 499{,}851}{2}.0{,}711.4 = 1384{,}257\text{KN}$$

$$Vu_1/\phi = \frac{134{,}257}{0.6} = 2307{,}094 \text{ KN}$$

$$Vc_1 = (1/6.\sqrt{fc'}.4.d).1000$$

$$= (1/6.\sqrt{30}.5.0{,}899).1000$$

$$= 3246{,}169 \text{ KN} > Vu_1/\phi = 2307{,}094 \text{ KN} \quad \text{maka } \textbf{Aman !!}$$

Arah L

$$Vu_2 = \frac{\sigma_{u\min} + \sigma_{umak}}{2}.n.N = \frac{384{,}617 + 499{,}851}{2}.0{,}911.4 = 1611{,}501 \text{ KN}$$

$$Vu_2/\phi = \frac{1611{,}501}{0.6} = 2685{,}834 \text{ KN}$$

$$Vc_2 = (1/6.\sqrt{fc'}.L.d).1000 = (1/6.\sqrt{30}.4.0{,}899).1000$$

$$= 3246{,}169 \text{ KN} > Vu_1/\phi = 2685{,}834 \text{ KN maka } \textbf{Aman !!}$$

Geser 2 Arah

δ_u rata-rata $= \frac{Pu}{P.L} = \frac{6155,75}{4.4} = 382,234$ KN/m^2

X $= h_{kolom} + d = 0,8 + 0,889 = 1,689$ m

Y $= b_{kolom} + d = 0,6 + 0,889 = 1,489$ m

Vu $= \delta u_{\text{rata-rata}} . \{ (P . L) - (X . Y) \}$

$= 382,234. \{ (4 . 4) - (1,689. 1,489) \}$

$= 5154,461$ KN

$Vu/\phi = \frac{5154,461}{0,6} = 8590,768$ KN

bo $= 2 . (X + Y) = 2 . (1,689 + 1,489) = 6,356$ m

Vc $= (4 . \sqrt{fc'} . bo . d) .1000$

$= (4 . \sqrt{30} . 6,356 . 0,889) .1000$

$= 123795,902$ KN $> Vu/\phi = 8590,768$ KN maka **Aman !!**

Perencanaan Tulangan Lentur

Arah P = 4 m

$Z_1 = \frac{P - h_{kolom}}{2} = \frac{4 - 0,8}{2} = 1,6$ m

$\sigma_2 = \sigma_{u\min} + \left\{ \left(\frac{P - Z_1}{P} \right) . \left(\sigma_{u\,mak} - \sigma_{u\min} \right) \right\}$

$= 384,617 + \left\{ \left(\frac{4 - 1,6}{4} \right) . (499,851 - 384,617) \right\}$

$= 453,757$ KN/m^2

$$Mu_1 = \left\{\left(\frac{\sigma_2 . Z_1}{2}\right).\frac{1}{3}.Z_1\right\} + \left\{\left(\frac{\sigma_{umak} . Z_1}{2}\right).\frac{2}{3}.Z_1\right\}$$

$$= \left\{\left(\frac{453{,}757.1{,}6}{2}\right).\frac{1}{3}.1{,}6\right\} + \left\{\left(\frac{499{,}851.1{,}6}{2}\right).\frac{2}{3}.1{,}6\right\}$$

$$= 620{,}143 \text{ KN.m}$$

Arah L = 4 m

$$Z_2 = \frac{B - b_{kolom}}{2} = \frac{4 - 0{,}6}{2} = 1{,}7 \text{ m}$$

$$Mu_2 = \left\{\left(\frac{\sigma_{umak} + \sigma_{umin}}{2}\right).\frac{1}{2}.(Z_2)^2\right\} = \left\{\left(\frac{49{,}851 + 384{,}617}{2}\right).\frac{1}{2}.(1{,}7)^2\right\}$$

$$= 639{,}028 \text{ KN.m}$$

Untuk arah L maka Mu pakai adalah 639,028 KN.m

$$Mu/\phi = \frac{639{,}028}{0{,}8} = 798{,}785 \text{ KN.m}$$

Pakai tulangan ϕ 25

$$A\phi_1 = \frac{1}{4}.\pi .\phi^2 = \frac{1}{4}.\pi .25^2 = 490{,}625 \text{ mm}^2$$

$$d_1 = h_{pelat} - 70 - \frac{\phi_{tul}}{2} = 1000 - 70 - \frac{25}{2} = 917{,}5 \text{ mm}$$

b ambil = 1000 mm

$$Rn = \frac{Mu}{\phi . b.d^2} = \frac{798{,}785}{1000.917{,}5^2} = 0{,}948 \text{ Mpa}$$

$$m = \frac{fy}{0.85 \quad fc'} = \frac{400}{0{,}85.30} = 15{,}686$$

$\rho_{ada} = \frac{1}{m}.\left\{1-\sqrt{1-\left(\frac{2.Rn.m}{fy}\right)}\right\} = \frac{1}{15,686}.\left\{1-\sqrt{1-\left(\frac{2.0,948.15,686}{400}\right)}\right\}$

$= 0,00241$

$\rho b = \frac{(0,85.fc')}{fy}.\beta.\frac{600}{(600+fy)} = \frac{(0,85.30)}{400}.0,85.\frac{600}{(600+400)}$

$= 0,0325$

$\rho_{mak} = 0,75 . \rho b$ $\qquad$ $\rho_{min} = \frac{1.4}{fy}$

$= 0,75 . 0,0325$ $\qquad$ $= \frac{1.4}{400}$

$= 0,0243$ $\qquad$ $= 0,0035$

$1,33\ \rho_{ada} = 1,33 . 0,0024 = 0,0032$

Maka ρ_{pakai} adalah $1.33\ \rho_{ada} = 0,0032$

As $= \rho_{pakai} . b . d = 0,0032. 1000 . 917,5 = 2950,742\ mm^2$

As susut $= 0,002 . b . h_{pelat} = 0,002 . 1000 .1000 = 2000\ mm^2$

As > As susut → Ok !!

As pakai adalah 2950,742 mm^2

<u>Jarak Tulangan</u>

Pakai tulangan Ø25 maka $A\phi_1$ adalah 490,625 mm^2

$S \leq \frac{A\phi_1 . b}{As}$

$\leq \frac{490,625.1000}{2950,742}$

$\leq 6,271$ mm

$S \leq 2 . h$

$\leq 2 \ .1400$

≤ 2800 mm

S ≤ 250 mm

Maka Pakai Tulangan **D_{25} – 160mm**

Untuk arah P maka Mu pakai adalah 620,143 KN.m

$$Mu/\phi = \frac{620,143}{0,8} = 775,178 \text{ KN.m}$$

Pakai tulangan ϕ_{25}

$$A\phi_1 = \frac{1}{4}.\pi \ .\phi^2 = \frac{1}{4}.\pi \ .25^2 = 490,625 \text{ mm}^2$$

$$d_1 = h_{pelat} - 70 - \frac{\phi_{tul}}{2} - \phi_{tul} = 1000 - 70 - \frac{25}{2} - 25$$

$= 892,5$ mm

b ambil $= 1000$ mm

$$Rn = \frac{Mu}{\phi} = \frac{1642,091}{1000.(892,5)^2} = 0,973 \text{ Mpa}$$

$$m = \frac{fy}{0,85.fc'} = \frac{400}{0,85.30} = 15,686$$

$$\rho_{ada} = \frac{1}{m}.\left\{1-\sqrt{1-\left(\frac{2.Rn.m}{fy}\right)}\right\} = \frac{1}{15,686}.\left\{1-\sqrt{1-\left(\frac{2.0,973.15,686}{400}\right)}\right\}$$

$= 0,0024$

$$\rho b = \frac{(0,85.fc')}{fy}.\beta.\frac{600}{(600+fy)} = \frac{(0,85 .30)}{400}.0.85.\frac{600}{(600+400)}$$

$= 0,0325$

$\rho_{mak} = 0{,}75 \cdot \rho b$ $\qquad$ $\rho_{min} = \frac{1.4}{fy}$

$= 0{,}75 \cdot 0{,}0325$ $\qquad$ $= \frac{1.4}{400}$

$= 0{,}0243$ $\qquad$ $= 0{,}0035$

$1{,}33\ \rho_{ada} = 1{,}33 \cdot 0{,}023 = 0{,}00307$

Maka ρ_{pakai} adalah $1{,}33\ \rho_{ada} = 0{,}00307$

As $= \rho_{pakai} \cdot b \cdot d = 0{,}00307 \cdot 1000 \cdot 892{,}5 = 2945{,}234\ mm^2$

As susut $= 0{,}002 \cdot b \cdot h_{pelat}$

$= 0.002 \cdot 1000 \cdot 1000$

$= 2000\ mm^2$

As > As susut -ok-

As pakai adalah $2945{,}234\ mm^2 mm^2$

Jarak Tulangan

Pakai tulangan Ø25 maka $A\phi_1$ adalah $490{,}625\ mm^2$

$$S \leq \frac{A\phi_1 . b}{As}$$

$$\leq \frac{490{,}625 . 1000}{2945{,}234}$$

$\leq 166{,}58$ mm

$S \leq 2 . h$

$\leq 2 . 1400$

≤ 2800 mm

$S \leq 250$ mm

Maka Pakai Tulangan **D_{25} – 160**

Tulangan Susut

As susut $= 0.002 \cdot b \cdot h_{pelat}$

$= 0.002 \cdot 1000 \cdot 1000$

$= 2000 \text{ mm}^2$

Pakai tulangan Ø22 maka $A\phi_1$ adalah 379,94 mm^2

$$S \leq \frac{A\phi_1 . b}{As}$$

$$\leq \frac{379{,}94 . 1000}{2000}$$

$\leq 189{,}97$ mm

Maka Pakai Tulangan **D_{22} - 180**