BAB II
PERENCANAAN STRUKTUR

2.1 Perencanaan Awal Struktur

2.1.1 Estimasi Dimensi Balok

Estimasi Dimensi Balok Induk

a) Panjang bentang (L) = 8000 mm

Tinggi balok minimum (h min) = 1/16 x 8000 = 500 mm

Digunakan tinggi balok (h) = 700 mm

Lebar balok minimum (b) = 0,5 x 700 = 350 mm

Digunakan lebar balok = 400 mm

Dimensi balok bentang 8000 mm diambil 400 x 700 mm

b) Panjang bentang (L) = 6500 mm

Tinggi balok minimum (h min) = 1/16 x 6500 = 406,25 mm

Digunakan tinggi balok (h) = 600 mm

Lebar balok minimum (b) = 0,5 x 600 = 300 mm

Digunakan lebar balok = 350 mm

Dimensi balok bentang 6500 mm diambil 350 x 600 mm

c) Panjang bentang (L) = 5000 mm

Tinggi balok minimum (h min) = 1/16 x 5000 = 312,5 mm

Digunakan tinggi balok (h) = 500 mm

Lebar balok minimum (b) = 0,5 x 500 = 250 mm

Digunakan lebar balok = 300 mm

Dimensi balok bentang 5000 mm diambil 300 x 500 mm

Dari hasil estimasi balok maka dalam perencanaan digunakan dimensi balok induk:

a. 400 x 700 mm
b. 350 x 600 mm

c. 300 x 500 mm

2.1.2 Estimasi Tebal Pelat Lantai

Dalam SNI 2847-2019, pelat lantai dibedakan menjadi 2 yaitu:

1. Pelat 1 arah adalah pelat yang kedua sisinya didukung, sehingga lenturan terjadi dalam 1 arah, memiliki perbandingan antara bentang panjang dibagi bentang pendek lebih dari 2 atau Ly/Lx > 2
2. Pelat 2 arah adalah pelat yang pada keempat sisinya didukung, sehingga lenturan terjadi dalam dua arah memiliki perbandingan anatar bentang panjang dibagi bentang pendek kurang dari 2 atau Ly/Lx < 2

Penetapan ketebalan minimum pelat lantai tercantum dalam SNI 2847-2019 Pasal 8 untuk pelat 2 arah. Ketentuan ini bertujuan untuk mengendalikan lendutan atau *defleksi* agar tidak melampaui batas kemampuan yang diizinkan. Untuk tebal minimum pelat lantai 2 arah ditentukan sebagai berikut :

1. Pelat tanpa *drop panel* menggunakan tebal minimum 125 mm
2. Pelat dengan *drop panel* menggunakan tebal minimum 100 mm

Berdasarkan peraturan SNI 2847-2019 tersebut dan perletakkan kolom struktur pada bangunan Hotel Rose Belle, dirancang pelat lantai untuk memenuhi kebutuhan pelat lantai bangunan ini.

- Ly = 8000 mm
- Lx = 6500 mm
- Cek $= \frac{ly}{lx}$

  $= \frac{8000}{6500}$

  = 1,23

1,23 mm < 2, sehingga digunakan pelat 2 arah.

Pengecekan Tebal Plat

Data Perencanaan :

- Lx = 6500 mm

- Ly = 8000 mm
- bw = 400 mm
- ht = 700 mm
- Lnx = Lx – bw
  = 6500 – 400
  = 6100 mm
- Lny = Ly – bw
  = 8000 – 400
  = 7600 mm
- Asumsi Tebal Plat (hf) = 125 mm
- hb = ht – hf
  = 700 – 125
  = 575 mm
- be 1 = bw + 2 x hb
  = 400 + (2 x 575)
  = 1550 mm
- be 2 = bw + 8 x hf
  = 400 + (8 x 125)
  = 1400 mm

Cek Tebal Plat :

- y1 $= \frac{hb}{2}$
  $= \frac{575}{2}$
  = 287,5 mm
- y2 = hb + ($\frac{asumsi\ tebal\ plat}{2}$)
  = 575 + ($\frac{125}{2}$)
  = 637,5 mm
- y $= \left(\frac{hb\ x\ bw\ x\ y1 + asumsi\ tebal\ plat\ x\ be\ 2\ x\ y2}{hb\ x\ bw + asumsi\ tebal\ plat\ x\ be\ 2} \right)$
  $= \left(\frac{575\ x\ 400\ x\ 287{,}5 + 125\ x\ 1400\ x\ 637{,}5}{575\ x\ 400 + 125\ x\ 1400} \right)$
  = 439

- Ib = $\frac{1}{12}$ x bw x hb^3 + hb x bw x y x bw x y – $y1^2$ + $\frac{1}{12}$ x be 2 x asumsi tebal $plat^3$ + asumsi tebal plat x be 2 x y2 - y^2

  = $\frac{1}{12}$ x 400 x 575^3 + 575 x 400 x 439 x 400 x 439 – 287,5

  + $\frac{1}{12}$ x 1400 x 125^3 + 125 x 1400 x 637,5 - 439^2

  = 18739226466,049 mm^4

Bentang Panjang

- Is = $\frac{1}{12}$ x Lx x asumsi tebal $plat^3$

  = $\frac{1}{12}$ x 11500 x 125^3

  = 789388020,8 mm

- af1 = $\frac{Ib}{Is}$

  = $\frac{18739226466,049}{789388020,8}$

  = 23,739 mm

Bentang Pendek

- Is = $\frac{1}{12}$ x Ly x asumsi tebal $plat^3$

  = $\frac{1}{12}$ x 8000 x 125^3

  = 569661458,3 mm

- af1 = $\frac{Ib}{Is}$

  = $\frac{18739226466,049}{569661458,3}$

  = 32,895 mm

- β = $\frac{Ly}{Lx}$

  = $\frac{8000}{6500}$

  = 1,23

- h min = $\frac{Lnx\ x\ (0{,}8+\left(\frac{fy}{1400}\right))}{36+(9\ x\ \beta)}$

  = $\frac{6500x\ (0{,}8+\left(\frac{420}{1400}\right))}{36+(9\ x\ 1{,}043)}$

  = 115,190 mm

- h pakai = 125 mm

Digunakan Tebal Pelat Lantai 125 mm

2.1.3 Estimasi Dimensi Kolom

Data Perencanaan :

- Jumlah lantai = 5
- Panjang = 8 m
- Lebar = 7,9 m
- Luasan plat = p x l
  = 8 x 7,9
  = 63,2 m2
- f'c = 30 MPa
- fy = 420 MPa
- Selimut beton = 20 mm
- Diameter tul.pokok = 10mm
- Diameter tul.pembagi = 8mm

a) Perhitungan Beban

- Beban Mati = 5,13
- Beban Hidup = 1,92
- Beban Ultimit = (1,2 x DL) + (1,6 x LL)
  = (1,2 x 5,13) + (1,6 x 1,92)
  = 9,228
- Beban Aksial = Beban Ultimit x Luasan Plat
  = 9,228 x 63,2
  = 583,2096

b) Estimasi Dimensi Kolom

- Tinggi Minimum Balok (h min) = 500 mm digunakan 700 mm
- Lebar Balok (b) = 350 mm digunakan 400 mm

- Asumsi Dimensi Kolom = 500 mm
- d = Tinggi Min. Balok – Selimut Beton - Diameter Tul. Pokok – $(\frac{Diameter\ Tul.Pembagi}{2})$
  = 700 – 20 – 10 - $(\frac{8}{2})$
  = 666 mm
- 4d = 4 x d
  = 4 x 666
  = 2664
- Ln = Panjang – Asumsi Dimensi Kolom
  = 8000 – 500
  = 7500
- Ln (4500) > 4d (2664) Memenuhi
- 0,3h = 0,3 x 700
  = 210
- bw = 400 mm
- Beban Aksial Kumulatif = Beban Aksial x Jumlah Lantai
  = 583,21 x 5
  = 2916,048
- Asumsi Rasio Penulangan (ρ) = 0,015
- Ag = $\frac{Pu}{0{,}85\ x\ (f'c+fy\ x\ \rho)}$
  = $\frac{2916{,}048}{0{,}85\ x\ (30+420\ x\ 0{,}015)}$
  = 124532,403
- Asumsi Panjang dan Lebar Kolom = $\sqrt{124532{,}403}$
  = 352,89
- Lebar Min. dan Tinggi Min. = bw
  = 400
- b = 500
- h = 500
- Rasio = $\frac{b}{h}$

$= \frac{500}{500}$

$= 1$

- Rasio b/h (1) ≥ 0,4 Memenuhi

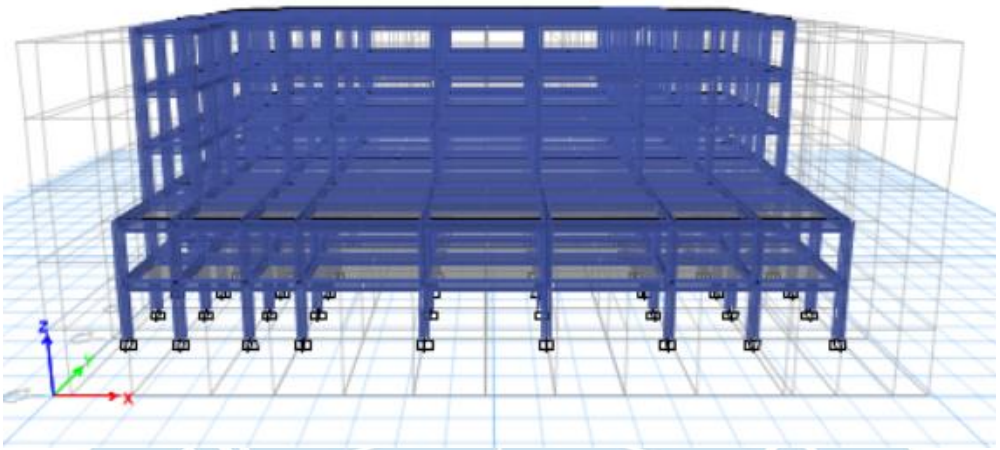
Digunakan Kolom dengan Ukuran 500 x 500 mm

2.1.4 Estimasi Dimensi Tangga

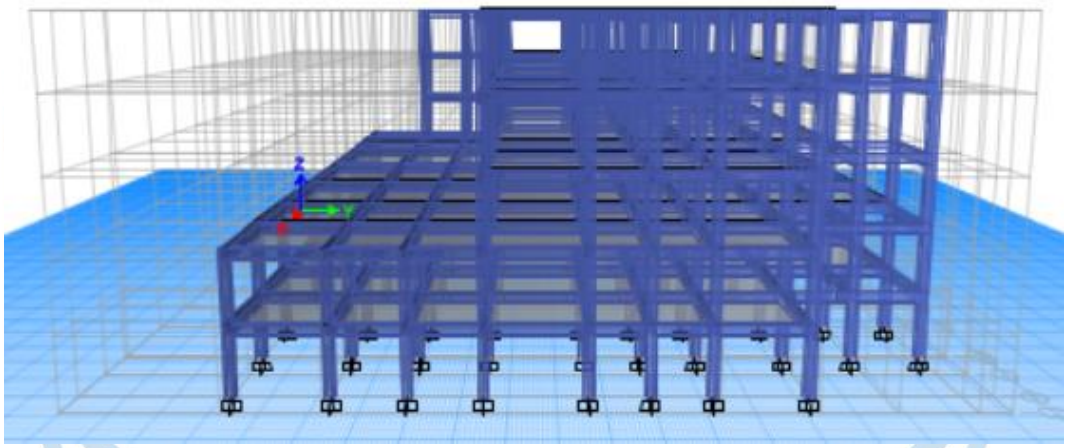
- Panjang ruang tangga = 400 cm
- Lebar ruang tangga = 350 cm
- f'c = 30 MPa
- fy = 420 MPa
- Tinggi tiap lantai = 400 cm
- Lebar tangga = 120 cm
- Optrede = 20 cm
- Antrede = 30 cm
- Diameter baja tulangan = 10 mm
- Selimut Beton = 20 mm
- Tebal plat = 125 mm
- d = 100 mm
- Jumlah anak tangga (n) = 20 buah
- Lebar tangga (Lt) = 270 cm
- Lebar bordes (Lb) = 130 cm
- α = 0,588

  = 33,690 º

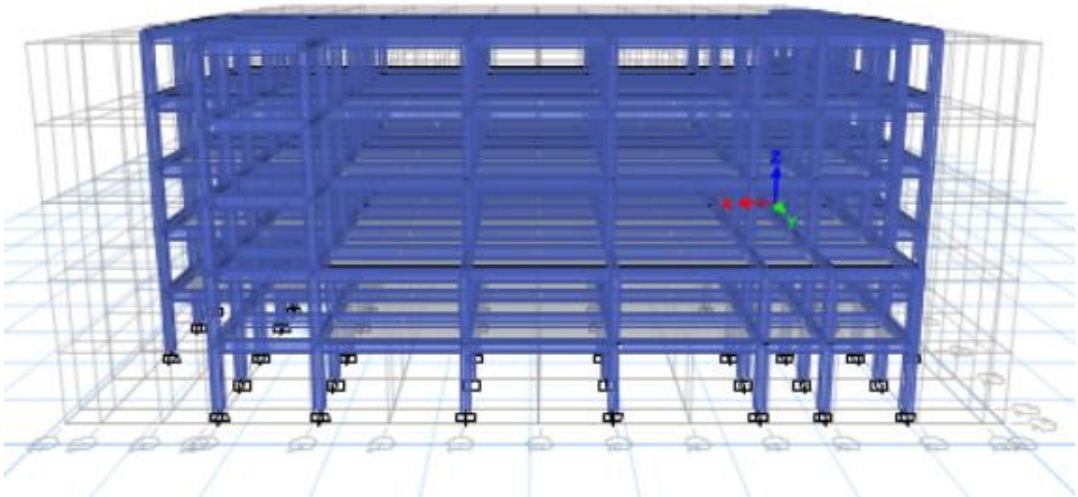
2.2 Pemodelan 3D Struktur menggunakan *ETABS*



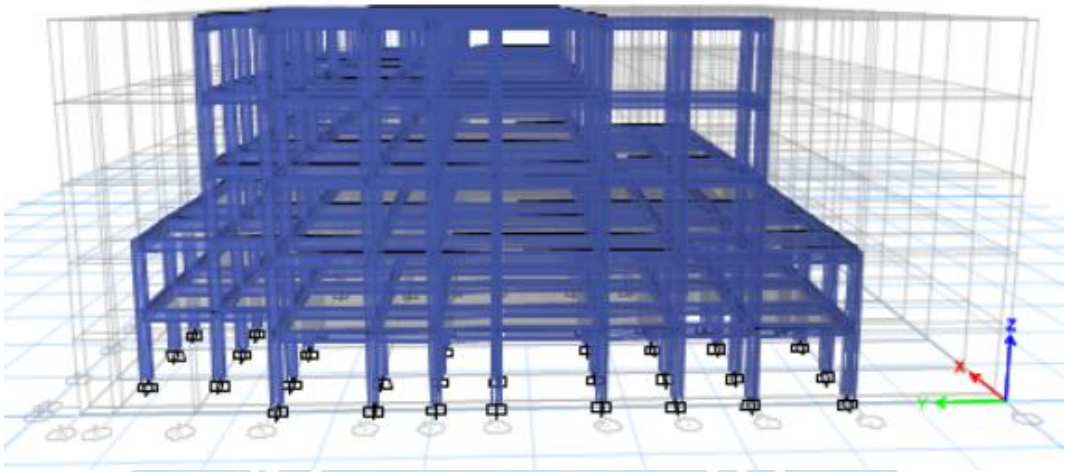
Gambar 2. 1 Pemodelan 3D Tampak Depan



Gambar 2. 2 Pemodelan 3D Tampak Samping



Gambar 2. 3 Pemodelan 3D Tampak Belakang



Gambar 2. 4 Pemodelan 3D Tampak Samping

2.3 Mutu Beton Struktur

- Mutu beton untuk balok, kolom, pelat lantai, dan tangga :

F'c = 30 MPa

- Mutu baja tulangan yang digunakan BJTS 420B :

fy = 420 MPa

2.4 Klasifikasi Tanah

Lokasi data tanah berasal dari hasil pengujian SPT di daerah Sleman, Yogyakarta. Berikut ini hasil data tanah dari daerah Sleman, Yogyakarta.

Tabel 2. 1 Data Tanah

Data Tanah SPT BOR HOLE 4							
Depth (m)	Material Description	Contact Depth (m)	Sample Number	Blow Counts (N Value)			
				N1	N2	N3	Nv
1	Lanau (coklat, abu-abu)	4					
2				1	1	2	3
3							
4				1	2	2	4

5	Pasir berlempung (coklat, abu-abu)	2	I				
6				2	2	3	5
7	Lanau pasir berlempung (hitam)	6					
8				3	5	7	12
9							
10			II	4	7	9	16
11							
12				5	8	10	18
13	Lanau (hitam, abu-abu)	4					
14				5	8	12	20
15							
16				5	8	13	21

Data Tanah SPT BOR HOLE 4

Depth (m)	Material Description	Contact Depth (m)	Sample Number	Blow Counts (N Value)			
				N1	N2	N3	Nv
17	Pasir berlempung (coklat, hitam)	5					
18				10	16	31	47
19							
20				12	15	29	44
21							
22	Lempung (coklat, hitam)	9		8	10	15	25
23							
24				6	8	13	21
25							
26				6	9	13	22
27							
28				7	9	15	24
29							
30				8	11	21	32

2.5 Perhitungan Beban Gempa

2.5.1 Input Data Percepatan Gempa

- Spektral Percepatan Periode Pendek (Ss) = 1,1070 g
- Spektral Percepatan Periode 1 Detik (S1) = 0,5070 g
- Koefisien Situs (Fa) = 1,200
- Koefisien Situs (Fv) = 1,493
- Percepatan Desain Periode Pendek (S_{DS}) = $\frac{2}{3}$ x Fa x Ss
  = $\frac{2}{3}$ x 1,200 x 1,1070
  = 0,8856 g
- Percepatan Desain Periode 1 Detik (S_{D1}) = $\frac{2}{3}$ x Fv x S1
  = $\frac{2}{3}$ x 1,493 x 0,5070
  = 0,5046 g
- T_0 = 0,2 x $\frac{SD1}{SDs}$
  = 0,2 x $\frac{0,5046}{0,8856}$
  = 0,1140 detik
- T_s = $\frac{SD1}{SDs}$
  = $\frac{0,5070}{0,8856}$
  = 0,5698 detik

2.5.2 Input Parameter Gempa

- Faktor Keutamaan Gempa (I_e) = 1,00
- Koefisien Modifikasi Respons (R) = 8
- Faktor Kuat Lebih Sistem (Ω_0) = 3
- Faktor Pembesaran Defleksi (C_d) = 5,5

2.5.3 Periode Struktur

- Percepatan Desain Periode 1 Detik (S_{D1}) = 0,5046 g
- Koefisien untuk Batas Periode (C_u) = 1,4
- Parameter Periode Pendekatan (C_t) = 0,0466

- Parameter Periode Pendekatan (x) = 0,9
- Tinggi Bangunan (Seismik) (h) = 20 m
- Periode Fundamental Pendekatan (T_a) = C_t x h^x

  = 0,0466 x $20^{0,9}$

  = 0,6907 detik
- Periode Maksimum (T_{max}) = C_u x T_a

  = 1,4 x 0,6907

  = 0,967 detik
- Periode Hasil Analisis Arah X ($T_{c,X}$) = 0,642 detik
- Periode Hasil Analisis Arah Y ($T_{c,Y}$) = 0,586 detik
- Periode Pakai Arah X (T_X) = 0,642 detik
- Periode Pakai Arah Y (T_Y) = 0,586 detik

2.5.4 Bentuk dan Jumlah Ragam

Modal Participating Mass Ratios

File Edit Format-Filter-Sort Select Options

Units: As Noted Hidden Columns: No Sort: None

Filter: None

Modal Participating Mass Ratios

Case	Mode	Period sec	UX	UY	UZ	SumUX	SumUY	SumUZ	RX	RY	RZ	SumRX	SumRY	SumRZ
Modal	1	0,642	0,001	0,713	0	0,001	0,713	0	0,3175	0,0005	0,0041	0,3175	0,0005	0,0041
Modal	2	0,586	0,6623	0,0028	0	0,6633	0,7159	0	0,0013	0,244	0,1311	0,3188	0,2445	0,1352
Modal	3	0,512	0,1007	0,0029	0	0,764	0,7187	0	0,001	0,0242	0,5542	0,3198	0,2687	0,6894
Modal	4	0,259	0,0004	0,21	0	0,7644	0,9287	0	0,4978	0,0005	0,0049	0,8176	0,2691	0,6943
Modal	5	0,234	0,1234	0,002	0	0,8878	0,9307	0	0,0054	0,316	0,1221	0,823	0,5851	0,8164
Modal	6	0,217	0,05	0,001	0	0,9378	0,9317	0	0,003	0,2387	0,1118	0,826	0,8237	0,9282
Modal	7	0,188	0,0052	6,318E-06	0	0,9431	0,9317	0	2,024E-05	0,0324	0,0051	0,826	0,8562	0,9334
Modal	8	0,158	0,0002	0	0	0,9433	0,9317	0	0	0,0029	0,0004	0,826	0,8591	0,9337
Modal	9	0,144	1,35E-05	0,0338	0	0,9433	0,9655	0	0,053	8,121E-06	0,0005	0,879	0,8591	0,9342
Modal	10	0,131	0,0267	0,0001	0	0,97	0,9656	0	0,0002	0,0365	0,0015	0,8792	0,8956	0,9356
Modal	11	0,123	0,003	0,0005	0	0,973	0,9661	0	0,0008	0,0052	0,0283	0,8801	0,9008	0,9639
Modal	12	0,1	2,521E-05	0	0	0,973	0,9661	0	0	0,0001	0	0,8801	0,9009	0,9639

Gambar 2. 5 Output dari *ETABS*

2.5.5 Gaya Geser Dasar Seismik

- Koefisien Respons Seismik (C_s) $= \frac{SDs}{(\frac{R}{Ie})}$

  $= \frac{0,8856}{(\frac{8}{1})}$

  $= 0,1107$
- Batas Atas ($C_{s,max}$) $= \frac{SD1}{(T\ x\ (\frac{R}{Ie}))}$

- $C_{s,max,X}$ $= \frac{0,5046}{(0,642\ x\ (\frac{8}{1}))}$

  $= 0,0983$
- $C_{s,max,Y}$ $= \frac{0,5046}{(0,586\ x\ (\frac{8}{1}))}$

  $= 0,1076$
- Batas Bawah ($C_{s,min,1}$) $= 0,044$ x SDs x $Ie >= 0,01$

  $= 0,0390$
- Batas Bawah (dipakai jika $S_1 >= 0,6$ g) ($C_{s,min,2}$) $= \frac{0,5\ x\ S1}{(\frac{R}{Ie})}$

  $= \frac{0,5\ x\ 0,5070}{(\frac{8}{1})}$

  $= 0,0317$
- Koefisien Respons Seismik Pakai ($C_{s,pakai,X}$) $= 0,0983$
- $C_{s,pakai,Y}$ $= 0,1076$
- Berat Seismik Efektif (W) = Massa tiap lantai x $\frac{9,80665}{1000}$

  = (582710,15 + 647584,88 + 647584,88

  1083510,57 + 1117149,31) x $\frac{9,80665}{1000}$

  = 39997 kN

2.5.6 Penskalaan Gaya

Gaya Geser Statik (Manual) (V)

- V_X = Cs x W

  = 0,0983 x 39997

  = 3929,86 kN
- V_Y = Cs x W

  = 0,1076 x 39997

  = 4305,41 kN

Gaya Geser Statik (ETABS)

- V_X = 3900,76 kN
- V_Y = 3900,76 kN
- Faktor Skala Awal (SF) $= \frac{g}{(\frac{R}{Ie})}$

$$= \frac{9{,}80665}{(\frac{8}{1})}$$

= 1,226 m/s²

= 1225,83 mm/s²

Gaya Geser Respon Spektra Unscaled

- $V_{i,X}$ = 2831,208 kN
- $V_{i,Y}$ = 2920,532 kN

Penakalaan Gaya Gempa

- f_X $= \frac{Vx}{Vix}$

  $= \frac{3929{,}86}{2831{,}208}$

  = 1,388
- f_Y $= \frac{Vy}{Viy}$

  $= \frac{3900{,}76}{2920{,}532}$

  = 1,474

Faktor Skala Baru

- SF_X = SF x f_X

  = 1225,83 x 1,388

  = 1701,52 mm/s²
- SF_Y = SF x f_Y

  = 1225,83 x 1,474

  = 1807,10 mm/s²

2.5.7 Distribusi Vertikal Gaya Seismik

- Eksponen terkait periode struktur :
- kx = 1,1
- ky = 1

Tabel 2. 2 Distribusi Vertikal Gaya Seismik Arah x

Arah x								
Lantai	Wi (kg)	Wi (kN)	hi (m)	hi^k	Wi hi^k	Cvi	Fi (kN)	Vi (kN)

Story5	582710,15	5714,44	20	21	122403,30	0,272	1067,006	1067,006
Story4	647584,88	6350,64	16	17	108824,57	0,241	948,639	2015,645
Story3	647584,88	6350,64	12	13	81618,43	0,181	711,479	2727,124
Story2	1083510,57	10625,61	8	9	91040,23	0,202	793,610	3520,734
Story1	1117149,31	10955,49	4	4	46933,32	0,104	409,124	3929,858
	4078539,79	39996,82			450819,84		3929,858	

Tabel 2. 3 Distribusi Vertikal Gaya Seismik Arah y

Arah y								
Lantai	Wi (kg)	Wi (kN)	hi (m)	hi^k	Wi hi^k	Cvi	Fi (kN)	Vi (kN)
Story5	582710,15	5714,44	20	21	122403,30	0,272	1168,973	1168,973
Story4	647584,88	6350,64	16	17	108824,57	0,241	1039,293	2208,266
Arah y								
Story3	647584,88	6350,64	12	13	81618,43	0,181	779,470	2987,736
Story2	1083510,57	10625,61	8	9	91040,23	0,202	869,450	3857,186
Story1	1117149,31	10955,49	4	4	46933,32	0,104	448,221	4305,408
	4078539,79	39996,82			450819,84		4305,408	

2.5.8 Simpangan

- Simpangan Antar Tingkat Izin (Δ_a) = 0,02 h
- Faktor Redundansi (ρ) =1,3
- Story Drift Inelastik Izin (Δ_{max}) $= \frac{\Delta a}{\rho}$

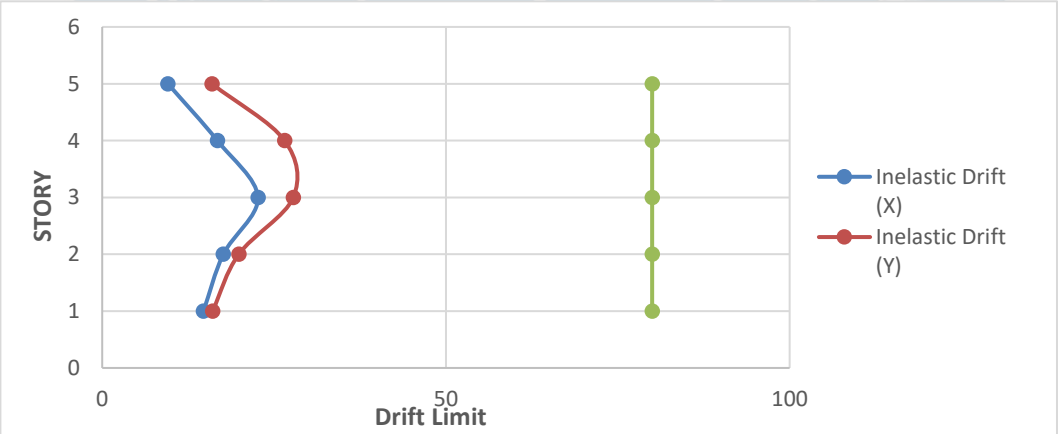
  $= \frac{0,02}{1,3}$

  = 0,0154 h
- Faktor Pembesaran Defleksi (C_d) = 5,5
- Faktor Keutamaan Gempa (I_e) = 1

Tabel 2. 4 Simpangan

Story	Displacement	Elastic	h	Inelastic Drift	Drift Limit	CEK

	δe x	δe y	δe x	δe y		Δ_X	Δ_Y		
	mm	mm	mm	mm	mm	mm	mm	mm	
5	14,782	19,31	1,738	2,901	4000	9,559	15,9555	80,000	OK
4	13,044	16,409	3,045	4,825	4000	16,7475	26,5375	80,000	OK
3	9,999	11,584	4,118	5,054	4000	22,649	27,797	80,000	OK
2	5,881	6,53	3,203	3,611	4000	17,6165	19,8605	80,000	OK
1	2,678	2,919	2,678	2,919	4000	14,729	16,0545	80,000	OK



Gambar 2. 6 Grafik Simpangan

2.5.9 Pengaruh P-Delta

- Rasio kebutuhan geser (β) = 1
- Batas koefisien stabilitas (θ_{max}) $= \frac{0,5}{(\beta \ x \ Cd)} \leq 0,25$

$= \frac{0,5}{(1 \ x \ 5,5)} \leq 0,25$

$= 0,0909$

Tabel 2. 5 P-Delta

Stor	Inelastic	Story Forces	h	Koefisien	Batas	Batas	CEK

y	Drift						Stabilitas		Pengaruh P-Delta	Stabilitas Struktur	
	Δ_X	Δ_Y	P	Vx	Vy						
	mm	mm	kN	kN	kN	mm	θx	θy			
5	9,56	15,96	8808,48	1081,73	1096,60	4000	0,00354	0,00583	0,1	0,09	OK
4	16,75	26,54	18889,37	2034,31	2056,23	4000	0,00707	0,01108	0,1	0,09	OK
3	22,65	27,80	28970,27	2740,00	2761,41	4000	0,01088	0,01326	0,1	0,09	OK
2	17,62	19,86	45951,85	3513,61	3525,68	4000	0,01047	0,01177	0,1	0,09	OK
1	14,73	16,05	63593,21	3900,76	3900,76	4000	0,01091	0,01190	0,1	0,09	OK

2.6 Perencanaan Pelat

2.6.1 Beban Pelat Lantai

Tabel 2. 6 Perencanaan Beban Pelat Lantai

Beban Plat Lantai						
Macam Pembebanan	Tebal	Beban Volume	Beban Mati (D)	Beban Mati Plat	Beban Hidup (L)	Wu = 1,2D+1,6L
	mm	kN/m3	kN/m2	kN/m2	kN/m2	kN/m2
Beban sendiri	125	24	3			
Beban pasir	50	18	0,9			
Beban ubin + spesi	50	21	1,05			
Beban Plafon			0,180			
Total			5,130	2,130	1,92	9,228

2.6.2 Ukuran Balok (B1) 400 x 700

Data Perencanaan

- ly = 7
- lx = 4
- rasio $= \frac{ly}{lx}$

$= \frac{7}{4}$

= 1,8

- ctx = 82
- clx = 40
- cty = 57
- cly = 13
- Qu = 1,2 DL + 1,6 LL
  = (1,2 x 5,130) + (1,6 x 1,92)
  = 9,228 kN/m²
- f'c = 30 MPa
- fy = 420 MPa

a) Hitung momen tumpuan x

- Mtx = 0,001 x Qu x lx² x ctx
  = 0,001 x 9,228 x 4² x 82
  = 12,107 kN/m

b) Desain momen tumpuan x

- d = H – Sb – $\left(\frac{Db}{2}\right)$
  = 125 – 20 – $\left(\frac{10}{2}\right)$
  = 100 mm

- Mu > Mtx = 12,107 kN/m
- Ø = 0,9
- cc x z = $\frac{Mu}{Ø}$
- (0,85 x f'c x a x B) (d - $\frac{a}{2}$) = $\frac{Mu}{Ø}$
- (0,85 x 30 x a x 1000) (100 - $\frac{a}{2}$) = 13452373,33
- a = 5,985 mm

- As min 1 = 0,0018 x $\frac{420}{fy}$ x B x d
- As min 1 = 0,0018 x $\frac{420}{420}$ x 1000 x 105
  = 189 mm²

- As min 2 = 0,0014 x B x d
- As min 2 = 0,0014 x $1000\ x\ 105$
  = 147 mm²
- As pakai = 189 mm²
- Adb = $\frac{1}{4}$ x π x 10²
  = $\frac{1}{4}$ x 3,14 x 10²
  = 78,5 mm²
- S = B x $\frac{Adb}{As\ pakai}$
  = 1000 x $\frac{78,5}{189}$
  = 349 mm
- S pakai = 200 mm
- S max I = 2 x hf
  = 2 x 150
  = 250 mm
- S max II = 450 mm

Digunakan D10-200

- As terpasang (cek memenuhi as min) = B x $\frac{Adb}{S\ terpasang}$
  = 1000 x $\frac{78,5}{200}$
  = 393 mm²
- a = $\frac{As\ x\ fy}{0,85\ x\ f'c\ x\ B}$
  = $\frac{393\ x\ 420}{0,85\ x\ 30\ x\ 1000}$
  = 6,468 mm
- Mn = Ts x z
  = (As x fy) x (d - $\frac{a}{2}$)
  = (393 x 420) x (100 - $\frac{6,468}{2}$)
  = 15959967,37 N/mm
  = 15,9600 kN/m

- Ø x Mn = 14,3640 kN/m > Mu : 12,107 kN/m

Momen yang mampu disediakan 14,3640 kN/m lebih besar dari momen ultimityang dibutuhkan yaitu 12,107136 kN/m (memenuhi syarat).

c) Tulangan Susut

- Diameter Tulangan = 8 mm
- Adb $= \frac{1}{4}$ x π x D²
  $= \frac{1}{4}$ x π x 8²
  = 50,3 mm²
- As min = 0,002 x B x hf
  = 0,002 x 1000 x 125
  = 250 mm²
- S $= \frac{Adb\ x\ B}{As\ min}$
  $= \frac{50{,}3\ x\ 1000}{250}$
  = 201,06 mm

Digunakan Tulangan Susut D8-200

a) Hitung momen untuk lapangan x

- Mlx = 0,001 x Qu x lx² x clx
  = 0,001 x 9,228 x 4² x 40
  = 5,906 kN/m

b) Desain momen lapangan x

- d = H – Sb - ($\frac{Db}{2}$)
  = 125 – 20 - ($\frac{10}{2}$)
  = 100 mm
- Mu > Mtx = 5,906 kN/m

- Ø = 0,9
- cc x z $= \frac{Mu}{Ø}$
- (0,85 x f'c x a x B) (d - $\frac{a}{2}$) $= \frac{Mu}{Ø}$
- (0,85 x 30 x a x 1000) (100 - $\frac{a}{2}$) = 6562133,33
- a = 2,873 mm
- As min 1 = 0,0018 x $\frac{420}{fy}$ x B x d
- As min 1 = 0,0018 x $\frac{420}{420}$ x 1000 x 105
  = 189 mm²
- As min 2 = 0,0014 x B x d
- As min 2 = 0,0014 x 1000 x 105
  = 147 mm²
- As pakai = 189 mm²
- Adb = $\frac{1}{4}$ x π x 10²
  = $\frac{1}{4}$ x 3,14 x 10²
  = 78,5 mm²
- S = B x $\frac{Adb}{As\ pakai}$
  = 1000 x $\frac{78,5}{189}$
  = 349 mm
- S pakai = 300 mm
- S max I = 2 x hf
  = 2 x 125
  = 250 mm
- S max II = 450 mm

Digunakan D10-300

- As terpasang (cek memenuhi as min) = B x $\frac{Adb}{S\ terpasang}$
  = 1000 x $\frac{78,5}{300}$
  = 262 mm²

- a $= \frac{As\ x\ fy}{0{,}85\ x\ f'c\ x\ B}$

  $= \frac{262\ x\ 420}{0{,}85\ x\ 30\ x\ 1000}$

  = 4,310 mm

- Mn = Ts x z

  = (As x fy) x (d - $\frac{a}{2}$)

  = (262 x 420) x (100 - $\frac{4{,}310}{2}$)

  = 10753176,27 N/mm

  = 10,7532 kN/m

- Ø x Mn = 9,6779 kN/m > Mu : 5,906 kN/m

Momen yang mampu disediakan 9,6779 kN/m lebih besar dari momen ultimit yang dibutuhkan yaitu 5,906 kN/m (memenuhi syarat)

c) Tulangan Susut

- Diameter Tulangan = 8 mm
- Adb $= \frac{1}{4}$ x π x D²

  $= \frac{1}{4}$ x π x 8²

  = 50,3 mm²
- As min = 0,002 x B x hf

  = 0,002 x 1000 x 125

  = 250 mm²
- S $= \frac{Adb\ x\ B}{As\ min}$

  $= \frac{50{,}3\ x\ 1000}{250}$

  = 201,06 mm

Digunakan Tulangan Susut D8-200

a) Hitung momen untuk tumpuan y

- Mty = 0,001 x Qu x lx² x clx

= 0,001 x 9,228 x 4² x 57

= 8,416 kN/m

b) Desain momen tumpuan y

- d = H – Sb - ($\frac{Db}{2}$)

  = 125 – 20 - ($\frac{10}{2}$)

  = 100 mm

- Mu > Mtx = 8,416 kN/m
- Ø = 0,9
- cc x z = $\frac{Mu}{Ø}$
- (0,85 x f'c x a x B) (d - $\frac{a}{2}$) = $\frac{Mu}{Ø}$
- (0,85 x 30 x a x 1000) (100 - $\frac{a}{2}$) = 9351040
- a = 4,121 mm
- As min 1 = 0,0018 x $\frac{420}{fy}$ x B x d
- As min 1 = 0,0018 x $\frac{420}{420}$ x 1000 x 105

  = 189 mm²
- As min 2 = 0,0014 x B x d
- As min 2 = 0,0014 x 1000 x 105

  = 147 mm²
- As pakai = 189 mm²
- Adb = $\frac{1}{4}$ x π x 10²

  = $\frac{1}{4}$ x 3,14 x 10²

  = 78,5 mm²
- S = B x $\frac{Adb}{As\ pakai}$

  = 1000 x $\frac{78,5}{189}$

  = 349 mm
- S pakai = 250 mm

- S max I = 2 x hf
  = 2 x 150
  = 250 mm
- S max II = 450 mm

Digunakan D10-250

- As terpasang (cek memenuhi as min) = B x $\frac{Adb}{S\ terpasang}$
  = 1000 x $\frac{78,5}{250}$
  = 314 mm²
- a = $\frac{As\ x\ fy}{0,85\ x\ f'c\ x\ B}$
  = $\frac{314\ x\ 420}{0,85\ x\ 30\ x\ 1000}$
  = 5,172 mm
- Mn = Ts x z
  = (As x fy) x (d - $\frac{a}{2}$)
  = (314 x 420) x (100 - $\frac{5,172}{2}$)
  = 12846973,84 N/mm
  = 12,8470 kN/m
- Ø x Mn = 11,5623 kN/m > Mu : 8,416 kN/m

Momen yang mampu disediakan 11,5623 kN/m lebih besar dari momen ultimit yang dibutuhkan yaitu 8,416 kN/m (memenuhi syarat).

c) Tulangan Susut

- Diameter Tulangan = 8 mm
- Adb = $\frac{1}{4}$ x π x D²
  = $\frac{1}{4}$ x π x 8²
  = 50,3 mm²
- As min = 0,002 x B x hf
  = 0,002 x 1000 x 125

= 250 mm²

- S $= \frac{Adb\ x\ B}{As\ min}$

$= \frac{50{,}3\ x\ 1000}{250}$

= 201,06 mm

Digunakan Tulangan Susut D8-200

a) Hitung momen untuk lapangan y

- Mly = 0,001 x Qu x lx² x clx

= 0,001 x 9,228 x 4² x 13

= 1,919 kN/m

b) Desain momen lapangan y

- d = H – Sb - ($\frac{Db}{2}$)

= 125 – 20 - ($\frac{10}{2}$)

= 100 mm

- Mu > Mlx = 1,919 kN/m
- Ø = 0,9
- cc x z $= \frac{Mu}{Ø}$
- (0,85 x f'c x a x B) (d - $\frac{a}{2}$) $= \frac{Mu}{Ø}$
- (0,85 x 30 x a x 1000) (100 - $\frac{a}{2}$) = 2132693,333
- a = 0,925 mm

- As min 1 = 0,0018 x $\frac{420}{fy}$ x 1000 x Ag
- As min 1 = 0,0018 x $\frac{420}{420}$ x 1000 x 125

= 225 mm²

- As min 2 = 0,0014 x Ag
- As min 2 = 0,0018 x $1000\ x\ 125$

= 175 mm²

- As pakai = 225 mm²
- Adb = $\frac{1}{4}$ x π x 10²
  = $\frac{1}{4}$ x 3,14 x 10²
  = 78,5 mm²
- S = B x $\frac{Adb}{As\ pakai}$
  = 1000 x $\frac{78,5}{225}$
  = 349 mm
- S pakai = 300 mm
- S max I = 2 x hf
  = 2 x 125
  = 250 mm
- S max II = 450 mm

Digunakan D10-300

- As terpasang (cek memenuhi as min) = B x $\frac{Adb}{S\ terpasang}$
  = 1000 x $\frac{78,5}{300}$
  = 262 mm²
- a = $\frac{As\ x\ fy}{0,85\ x\ f'c\ x\ B}$
  = $\frac{262\ x\ 420}{0,85\ x\ 30\ x\ 1000}$
  = 4,310 mm
- Mn = Ts x z
  = (As x fy) x (d - $\frac{a}{2}$)
  = (262 x 420) x (100 - $\frac{4,310}{2}$)
  = 10753176,27 N/mm
  = 10,7532 kN/m
- Ø x Mn = 9,6779 kN/m > Mu : 1,919 kN/m

Momen yang mampu disediakan 9,6779 kN/m lebih besar dari momen ultimit yang dibutuhkan yaitu 1,919 kN/m (memenuhi syarat).

c) Tulangan Susut

- Diameter Tulangan = 8 mm
- Adb $= \frac{1}{4}$ x π x D²

  $= \frac{1}{4}$ x π x 8²

  = 50,3 mm²
- As min = 0,002 x B x hf

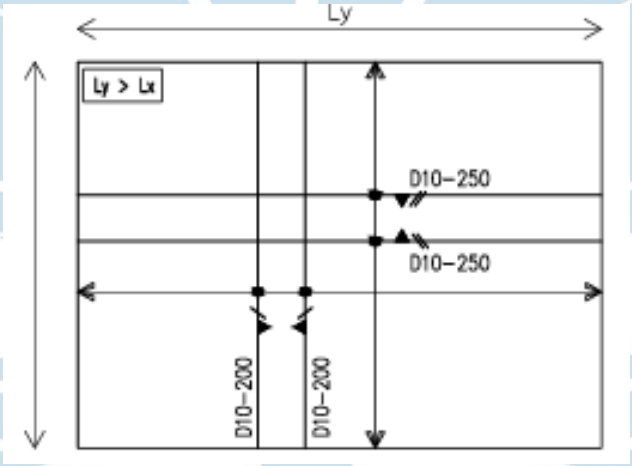
  = 0,002 x 1000 x 125

  = 250 mm²
- S $= \frac{Adb\ x\ B}{As\ min}$

  $= \frac{50{,}3\ x\ 1000}{250}$

  = 201,06 mm

Digunakan Tulangan Susut D8-200



Gambar 2. 7 Detail Penulangan Pelat Lantai

2.6.3 Ukuran Balok (B2) 350 x 600

Data Perencanaan

- ly = 6
- lx = 3,5
- rasio $= \frac{ly}{lx}$

  $= \frac{6}{3{,}5}$

= 1,7

- ctx = 81
- clx = 38
- cty = 57
- cly = 14
- Qu = 1,2 DL + 1,6 LL

  = (1,2 x 5,130) + (1,6 x 1,92)

  = 9,228 kN/m²
- f'c = 30 Mpa
- fy = 420 Mpa

a) Hitung momen tumpuan x

- Mtx = 0,001 x Qu x lx² x ctx

  = 0,001 x 9,228 x 4² x 82

  = 12,107 kN/m

b) Desain momen tumpuan x

- d = H – Sb – $\left(\frac{Db}{2}\right)$

  = 125 – 20 – $\left(\frac{10}{2}\right)$

  = 100 mm
- Mu > Mtx = 12,107 kN/m
- Ø = 0,9
- cc x z = $\frac{Mu}{Ø}$
- (0,85 x f'c x a x B) (d - $\frac{a}{2}$) = $\frac{Mu}{Ø}$
- (0,85 x 30 x a x 1000) (100 - $\frac{a}{2}$) = 13452373,33
- a = 5,985 mm
- As min 1 = 0,0018 x $\frac{420}{fy}$ x 1000 x Ag
- As min 1 = 0,0018 x $\frac{420}{420}$ x 1000 x 125

  = 225 mm²

- As min 2 = 0,0014 x Ag
- As min 2 = 0,0018 x $1000\ x\ 125$
  = 175 mm²
- As pakai = 225 mm²
- Adb = $\frac{1}{4}$ x π x 10²
  = $\frac{1}{4}$ x 3,14 x 10²
  = 78,5 mm²
- S = B x $\frac{Adb}{As\ pakai}$
  = 1000 x $\frac{78,5}{225}$
  = 349 mm
- S pakai = 200 mm
- S max I = 2 x hf
  = 2 x 150
  = 250 mm
- S max II = 450 mm

Digunakan D10-200

- As terpasang (cek memenuhi as min) = B x $\frac{Adb}{S\ terpasang}$
  = 1000 x $\frac{78,5}{200}$
  = 393 mm²
- a = $\frac{As\ x\ fy}{0,85\ x\ f'c\ x\ B}$
  = $\frac{393\ x\ 420}{0,85\ x\ 30\ x\ 1000}$
  = 6,468 mm
- Mn = Ts x z
  = (As x fy) x (d - $\frac{a}{2}$)
  = (393 x 420) x (100 - $\frac{6,468}{2}$)
  = 15959967,37 N/mm
  = 15,9600 kN/m

- Ø x Mn = 14,3640 kN/m > Mu : 12,107 kN/m

Momen yang mampu disediakan 14,3640 kN/m lebih besar dari momen ultimit yang dibutuhkan yaitu 12,107136 kN/m (memenuhi syarat)

c) Tulangan Susut

- Diameter Tulangan = 8 mm
- Adb $= \frac{1}{4}$ x π x D²
  $= \frac{1}{4}$ x π x 8²
  = 50,3 mm²
- As min = 0,002 x B x hf
  = 0,002 x 1000 x 125
  = 250 mm²
- S $= \frac{Adb\ x\ B}{As\ min}$
  $= \frac{50{,}3\ x\ 1000}{250}$
  = 201,06 mm

Digunakan Tulangan Susut D8-200

a) Hitung momen untuk lapangan x

- Mlx = 0,001 x Qu x lx² x clx
  = 0,001 x 9,228 x 4² x 38
  = 4,296 kN/m

b) Desain momen lapangan x

- d = H – Sb - ($\frac{Db}{2}$)
  = 125 – 20 - ($\frac{10}{2}$)
  = 100 mm
- Mu > Mtx = 4,296 kN/m
- Ø = 0,9
- cc x z $= \frac{Mu}{Ø}$

- (0,85 x f'c x a x B) (d - $\frac{a}{2}$) = $\frac{Mu}{\emptyset}$
- (0,85 x 30 x a x 1000) (100 - $\frac{a}{2}$) = 4772926,667
- a = 2,082 mm
- As min 1 = 0,0018 x $\frac{420}{fy}$ x 1000 x Ag
- As min 1 = 0,0018 x $\frac{420}{420}$ x 1000 x 125
  = 225 mm²
- As min 2 = 0,0014 x Ag
- As min 2 = 0,0018 x $1000\ x\ 125$
  = 175 mm²
- As pakai = 225 mm²
- Adb = $\frac{1}{4}$ x π x 10²
  = $\frac{1}{4}$ x 3,14 x 10²
  = 78,5 mm²
- S = B x $\frac{Adb}{As\ pakai}$
  = 1000 x $\frac{78,5}{225}$
  = 349 mm
- S pakai = 300 mm
- S max I = 2 x hf
  = 2 x 125
  = 250 mm
- S max II = 450 mm

Digunakan D10-300

- As terpasang (cek memenuhi as min) = B x $\frac{Adb}{S\ terpasang}$
  = 1000 x $\frac{78,5}{300}$
  = 262 mm²
- A = $\frac{As\ x\ fy}{0,85\ x\ f'c\ x\ B}$
  = $\frac{262\ x\ 420}{0,85\ x\ 30\ x\ 1000}$

= 4,312 mm

- Mn = Ts x z

  = (As x fy) x (d - $\frac{a}{2}$)

  = (262 x 420) x (100 - $\frac{4,312}{2}$)

  = 10758510,26 N/mm

  = 10,7585 kN/m

- Ø x Mn = 9,6827kN/m > Mu : 4,296 kN/m

Momen yang mampu disediakan 9,6779 kN/m lebih besar dari momen ultimit yang dibutuhkan yaitu 4,296 kN/m (memenuhi syarat)

c) Tulangan Susut

- Diameter Tulangan = 8 mm
- Adb = $\frac{1}{4}$ x π x D²

  = $\frac{1}{4}$ x π x 8²

  = 50,3 mm²
- As min = 0,002 x B x hf

  = 0,002 x 1000 x 125

  = 250 mm²
- S = $\frac{Adb\ x\ B}{As\ min}$

  = $\frac{50,3\ x\ 1000}{250}$

  = 201,06 mm

Digunakan Tulangan Susut D8-200

a) Hitung momen untuk tumpuan y

- Mty = 0,001 x Qu x lx² x clx

  = 0,001 x 9,228 x 4² x 57

  = 6,443 kN/m

b) Desain momen tumpuan y

- d = H – Sb - ($\frac{Db}{2}$)
  = 125 – 20 - ($\frac{10}{2}$)
  = 100 mm

- Mu > Mtx = 6,443 kN/m
- Ø = 0,9
- cc x z = $\frac{Mu}{Ø}$
- (0,85 x f'c x a x B) (d - $\frac{a}{2}$) = $\frac{Mu}{Ø}$
- (0,85 x 30 x a x 1000) (100 - $\frac{a}{2}$) = 7159390
- a = 3,139 mm

- As min 1 = 0,0018 x $\frac{420}{fy}$ x 1000 x Ag
- As min 1 = 0,0018 x $\frac{420}{420}$ x 1000 x 125
  = 225 mm²
- As min 2 = 0,0014 x Ag
- As min 2 = 0,0018 x $1000\ x\ 125$
  = 175 mm²
- As pakai = 225 mm²
- Adb = $\frac{1}{4}$ x π x 10²
  = $\frac{1}{4}$ x 3,14 x 10²
  = 78,5 mm²
- S = B x $\frac{Adb}{As\ pakai}$
  = 1000 x $\frac{78,5}{225}$
  = 349 mm
- S pakai = 250 mm
- S max I = 2 x hf
  = 2 x 150
  = 250 mm

- S max II = 450 mm

Digunakan D10-250

- As terpasang (cek memenuhi as min) = B x $\frac{Adb}{S\ terpasang}$

  = 1000 x $\frac{78,5}{250}$

  = 314 mm²

- a = $\frac{As\ x\ fy}{0,85\ x\ f'c\ x\ B}$

  = $\frac{314\ x\ 420}{0,85\ x\ 30\ x\ 1000}$

  = 5,174 mm

- Mn = Ts x z

  = (As x fy) x (d - $\frac{a}{2}$)

  = (314 x 420) x (100 - $\frac{5,172}{2}$)

  = 112853316,95 N/mm

  = 12,8533 kN/m

- Ø x Mn = 11,5680 kN/m > Mu : 6,443 kN/m

Momen yang mampu disediakan 11,5680 kN/m lebih besar dari momen ultimit yang dibutuhkan yaitu 6,443 kN/m (memenuhi syarat)

c) Tulangan Susut

- Diameter Tulangan = 8 mm
- Adb = $\frac{1}{4}$ x π x D²

  = $\frac{1}{4}$ x π x 8²

  = 50,3 mm²

- As min = 0,002 x B x hf

  = 0,002 x 1000 x 125

  = 250 mm²

- S = $\frac{Adb\ x\ B}{As\ min}$

$$= \frac{50{,}3\ x\ 1000}{250}$$

= 201,06 mm

Digunakan Tulangan Susut D8-200

a) Hitung momen untuk lapangan y

- Mly = 0,001 x Qu x lx² x clx
  = 0,001 x 9,228 x 4² x 13
  = 1,583 kN/m

b) Desain momen lapangan y

- d = H – Sb - ($\frac{Db}{2}$)
  = 125 – 20 - ($\frac{10}{2}$)
  = 100 mm
- Mu > Mtx = 1,583 kN/m
- Ø = 0,9
- cc x z = $\frac{Mu}{Ø}$
- (0,85 x f'c x a x B) (d - $\frac{a}{2}$) = $\frac{Mu}{Ø}$
- (0,85 x 30 x a x 1000) (100 - $\frac{a}{2}$) = 1758446,667
- a = 0,762 mm
- As min 1 = 0,0018 x $\frac{420}{fy}$ x 1000 x Ag
- As min 1 = 0,0018 x $\frac{420}{420}$ x 1000 x 125
  = 225 mm²
- As min 2 = 0,0014 x Ag
- As min 2 = 0,0018 x $1000\ x\ 125$
  = 175 mm²
- As pakai = 225 mm²
- Adb = $\frac{1}{4}$ x π x 10²
  = $\frac{1}{4}$ x 3,14 x 10²
  = 78,5 mm²

- S = B x $\frac{Adb}{As\ pakai}$
  = 1000 x $\frac{78,5}{225}$
  = 349 mm
- S pakai = 300 mm
- S max I = 2 x hf
  = 2 x 125
  = 250 mm
- S max II = 450 mm

Digunakan D10-300

- As terpasang (cek memenuhi as min) = B x $\frac{Adb}{S\ terpasang}$
  = 1000 x $\frac{78,5}{300}$
  = 262 mm²
- a = $\frac{As\ x\ fy}{0,85\ x\ f'c\ x\ B}$
  = $\frac{262\ x\ 420}{0,85\ x\ 30\ x\ 1000}$
  = 4,310 mm
- Mn = Ts x z
  = (As x fy) x (d - $\frac{a}{2}$)
  = (262 x 420) x (100 - $\frac{4,310}{2}$)
  = 10753176,27 N/mm
  = 10,7532 kN/m
- Ø x Mn = 9,6779 kN/m > Mu : 1,583 kN/m

Momen yang mampu disediakan 9,6779 kN/m lebih besar dari momen ultimit yang dibutuhkan yaitu 1,583 kN/m (memenuhi syarat)

c) Tulangan Susut

- Diameter Tulangan = 8 mm

- Adb $= \frac{1}{4}$ x π x D²

  $= \frac{1}{4}$ x π x 8²

  = 50,3 mm²
- As min = 0,002 x B x hf

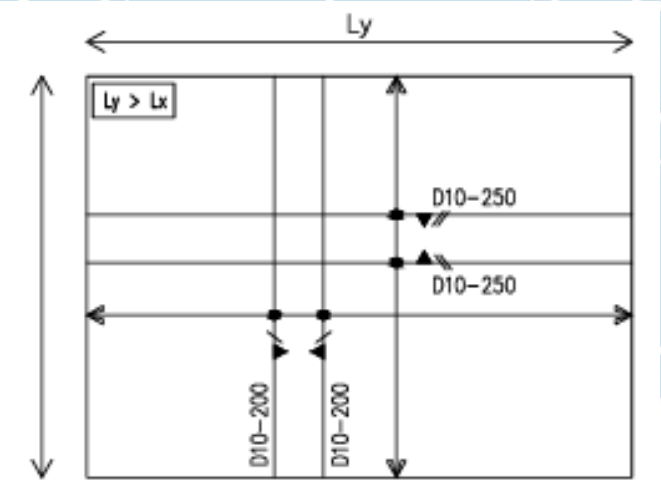
  = 0,002 x 1000 x 125

  = 250 mm²
- S $= \frac{Adb\ x\ B}{As\ min}$

  $= \frac{50{,}3\ x\ 1000}{250}$

  = 201,06 mm

Digunakan Tulangan Susut D8-200



Gambar 2. 8 Detail Penulangan Pelat Lantai

2.6.4 Ukuran Balok (B3) 300 x 500

Data Perencanaan :

- ly = 5
- lx = 3
- rasio $= \frac{ly}{lx}$

  $= \frac{5}{3}$

  = 1,7
- ctx = 81
- clx = 38

- cty = 57
- cly = 14
- Qu = 1,2 DL + 1,6 LL

  = (1,2 x 5,130) + (1,6 x 1,92)

  = 9,228 kN/m²
- f'c = 30 MPa
- fy = 420 MPa

a) Hitung momen untuk tumpuan x

- Mtx = 0,001 x Qu x lx² x ctx

  = 0,001 x 9,228 x 4² x 81

  = 6,727 kN/m

b) Desain Mtx

- d = H – Sb – ($\frac{Db}{2}$)

  = 125 – 20 – $\left(\frac{10}{2}\right)$

  = 100 mm

- Mu > Mtx = 6,727 kN/m
- Ø = 0,9
- cc x z = $\frac{Mu}{Ø}$
- (0,85 x f'c x a x B) (d - $\frac{a}{2}$) = $\frac{Mu}{Ø}$
- (0,85 x 30 x a x 1000) (100 - $\frac{a}{2}$) = 7474680
- a = 1,735 mm

- As min 1 = 0,0018 x $\frac{420}{fy}$ x 1000 x Ag
- As min 1 = 0,0018 x $\frac{420}{420}$ x 1000 x 125

  = 225 mm²
- As min 2 = 0,0014 x Ag

- As min 2 = 0,0018 x 1000 x 125
  = 175 mm²
- As pakai = 225 mm²
- Adb = $\frac{1}{4}$ x π x 10²
  = $\frac{1}{4}$ x 3,14 x 10²
  = 78,5 mm²
- S = B x $\frac{Adb}{As\ pakai}$
  = 1000 x $\frac{78,5}{225}$
  = 349 mm
- S pakai = 250 mm
- S max I = 2 x hf
  = 2 x 150
  = 250 mm
- S max II = 450 mm

Digunakan D10-250

- As terpasang (cek memenuhi as min) = B x $\frac{Adb}{S\ terpasang}$
  = 1000 x $\frac{78,5}{250}$
  = 314 mm²
- a = $\frac{As\ x\ fy}{0,85\ x\ f'c\ x\ B}$
  = $\frac{314\ x\ 420}{0,85\ x\ 30\ x\ 1000}$
  = 5,174 mm
- Mn = Ts x z
  = (As x fy) x (d - $\frac{a}{2}$)
  = (314 x 420) x (100 - $\frac{5,174}{2}$)
  = 12853316,95 N/mm
  = 12,8533 kN/m
- Ø x Mn = 11,5680 kN/m > Mu : 6,727 kN/m

Momen yang mampu disediakan 11,5680 kN/m lebih besar dari momen ultimit yang dibutuhkan yaitu 6,727 kN/m (memenuhi syarat)

d) Tulangan Susut

- Diameter Tulangan = 8 mm
- Adb $= \frac{1}{4}$ x π x D²

  $= \frac{1}{4}$ x π x 8²

  = 50,3 mm²
- As min = 0,002 x B x hf

  = 0,002 x 1000 x 125

  = 250 mm²
- S $= \frac{Adb\ x\ B}{As\ min}$

  $= \frac{50{,}3\ x\ 1000}{250}$

  = 201,06 mm

Digunakan Tulangan Susut D8-200

a) Hitung momen untuk lapangan x

- Mlx = 0,001 x Qu x lx² x clx

  = 0,001 x 9,228 x 4² x 38

  = 3,156 kN/m

b) Desain momen lapangan x

- d = H – Sb - ($\frac{Db}{2}$)

  = 125 – 20 - ($\frac{10}{2}$)

  = 100 mm

- Mu > Mtx = 3,156 kN/m
- Ø = 0,9

- cc x z $= \frac{Mu}{\emptyset}$
- (0,85 x f'c x a x B) (d - $\frac{a}{2}$) $= \frac{Mu}{\emptyset}$
- (0,85 x 30 x a x 1000) (100 - $\frac{a}{2}$) = 3506640
- a = 0,810 mm
- As min 1 = 0,0018 x $\frac{420}{fy}$ x 1000 x Ag
- As min 1 = 0,0018 x $\frac{420}{420}$ x 1000 x 125
  = 225 mm²
- As min 2 = 0,0014 x Ag
- As min 2 = 0,0018 x $1000\ x\ 125$
  = 175 mm²
- As pakai = 225 mm²
- Adb = $\frac{1}{4}$ x π x 10²
  = $\frac{1}{4}$ x 3,14 x 10²
  = 78,5 mm²
- S = B x $\frac{Adb}{As\ pakai}$
  = 1000 x $\frac{78,5}{225}$
  = 349 mm
- S pakai = 300 mm
- S max I = 2 x hf
  = 2 x 125
  = 250 mm
- S max II = 450 mm

Digunakan D10-300

- As terpasang (cek memenuhi as min) = B x $\frac{Adb}{S\ terpasang}$
  = 1000 x $\frac{78,5}{300}$
  = 262 mm²

- a $= \frac{As\ x\ fy}{0{,}85\ x\ f'c\ x\ B}$

  $= \frac{262\ x\ 420}{0{,}85\ x\ 30\ x\ 1000}$

  = 4,310 mm

- Mn = Ts x z

  = (As x fy) x (d - $\frac{a}{2}$)

  = (262 x 420) x (100 - $\frac{4{,}312}{2}$)

  = 10753176,27 N/mm

  = 10,7532 kN/m

- Ø x Mn = 9,6779 kN/m > Mu : 3,473 kN/m

Momen yang mampu disediakan 9,6779 kN/m lebih besar dari momen ultimit yang dibutuhkan yaitu 3,473 kN/m (memenuhi syarat)

c) Tulangan Susut

- Diameter Tulangan = 8 mm
- Adb $= \frac{1}{4}$ x π x D²

  $= \frac{1}{4}$ x π x 8²

  = 50,3 mm²
- As min = 0,002 x B x hf

  = 0,002 x 1000 x 125

  = 250 mm²
- S $= \frac{Adb\ x\ B}{As\ min}$

  $= \frac{50{,}3\ x\ 1000}{250}$

  = 201,06 mm

Digunakan Tulangan Susut D8-200

a) Hitung momen untuk tumpuan y

- Mty = 0,001 x Qu x lx² x clx
  = 0,001 x 9,228 x 4² x 57
  = 4,734 kN/m

b) Desain momen tumpuan y

- d = H – Sb - ($\frac{Db}{2}$)
  = 125 – 20 - ($\frac{10}{2}$)
  = 100 mm

- Mu > Mtx = 4,734 kN/m
- Ø = 0,9
- cc x z = $\frac{Mu}{Ø}$
- (0,85 x f'c x a x B) (d - $\frac{a}{2}$) = $\frac{Mu}{Ø}$
- (0,85 x 30 x a x 1000) (100 - $\frac{a}{2}$) = 5259960
- a = 1,218 mm
- As min 1 = 0,0018 x $\frac{420}{fy}$ x 1000 x Ag
- As min 1 = 0,0018 x $\frac{420}{420}$ x 1000 x 125
  = 225 mm²
- As min 2 = 0,0014 x Ag
- As min 2 = 0,0018 x 1000 x 125
  = 175 mm²
- As pakai = 225 mm²
- Adb = $\frac{1}{4}$ x π x 10²
  = $\frac{1}{4}$ x 3,14 x 10²
  = 78,5 mm²
- S = B x $\frac{Adb}{As\ pakai}$
  = 1000 x $\frac{78,5}{225}$
  = 349 mm

- S pakai = 300 mm
- S max I = 2 x hf
  = 2 x 150
  = 250 mm
- S max II = 450 mm

Digunakan D10-300

- As terpasang (cek memenuhi as min) = B x $\frac{Adb}{S\ terpasang}$
  = 1000 x $\frac{78,5}{300}$
  = 262 mm²
- a = $\frac{As\ x\ fy}{0,85\ x\ f'c\ x\ B}$
  = $\frac{262\ x\ 420}{0,85\ x\ 30\ x\ 1000}$
  = 4,310 mm
- Mn = Ts x z
  = (As x fy) x (d - $\frac{a}{2}$)
  = (314 x 420) x (100 - $\frac{5,172}{2}$)
  = 10753176,27 N/mm
  = 10,7532 kN/m
- Ø x Mn = 9,6779 kN/m > Mu : 5,210 kN/m

Momen yang mampu disediakan 9,6779 kN/m lebih besar dari momen ultimit yang dibutuhkan yaitu 5,210 kN/m (memenuhi syarat)

c) Tulangan Susut

- Diameter Tulangan = 8 mm
- Adb = $\frac{1}{4}$ x π x D²
  = $\frac{1}{4}$ x π x 8²

= 50,3 mm²

- As min = 0,002 x B x hf
  = 0,002 x 1000 x 125
  = 250 mm²
- S = $\frac{Adb\ x\ B}{As\ min}$
  = $\frac{50,3\ x\ 1000}{250}$
  = 201,06 mm

Digunakan Tulangan Susut D8-200

a) Hitung momen untuk lapangan y

- Mty = 0,001 x Qu x lx² x clx
  = 0,001 x 9,228 x 4² x 13
  = 1,163 kN/m

b) Desain momen lapangan y

- d = H – Sb - ($\frac{Db}{2}$)
  = 125 – 20 - ($\frac{10}{2}$)
  = 100 mm

- Mu > Mtx = 1,163 kN/m
- Ø = 0,9
- cc x z = $\frac{Mu}{Ø}$
- (0,85 x f'c x a x B) (d - $\frac{a}{2}$) = $\frac{Mu}{Ø}$
- (0,85 x 30 x a x 1000) (100 - $\frac{a}{2}$) = 1291920
- a = 0,298 mm
- As min 1 = 0,0018 x $\frac{420}{fy}$ x 1000 x Ag
- As min 1 = 0,0018 x $\frac{420}{420}$ x 1000 x 125
  = 225 mm²

- As min 2 = 0,0014 x Ag
- As min 2 = 0,0018 x $1000\ x\ 125$
  = 175 mm²
- As pakai = 225 mm²
- Adb = $\frac{1}{4}$ x π x 10²
  = $\frac{1}{4}$ x 3,14 x 10²
  = 78,5 mm²
- S = B x $\frac{Adb}{As\ pakai}$
  = 1000 x $\frac{78,5}{225}$
  = 349 mm
- S pakai = 300 mm
- S max I = 2 x hf
  = 2 x 125
  = 250 mm
- S max II = 450 mm

Digunakan D10-300

- As terpasang (cek memenuhi as min) = B x $\frac{Adb}{S\ terpasang}$
  = 1000 x $\frac{78,5}{300}$
  = 262 mm²
- a = $\frac{As\ x\ fy}{0,85\ x\ f'c\ x\ B}$
  = $\frac{262\ x\ 420}{0,85\ x\ 30\ x\ 1000}$
  = 4,310 mm

- Mn = Ts x z
  = (As x fy) x (d - $\frac{a}{2}$)
  = (262 x 420) x (100 - $\frac{4,310}{2}$)
  = 10753176,27 N/mm

= 10,7532 kN/m

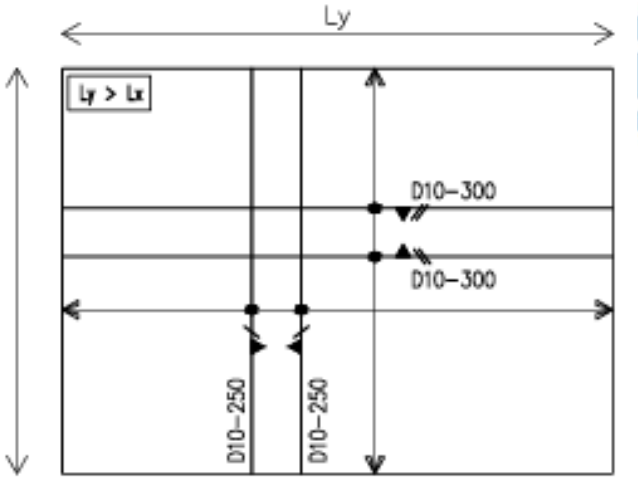
- Ø x Mn = 9,6779 kN/m > Mu : 1,280 kN/m

Momen yang mampu disediakan 9,6779 kN/m lebih besar dari momen ultimit yang dibutuhkan yaitu 1,280 kN/m (memenuhi syarat)

c) Tulangan Susut

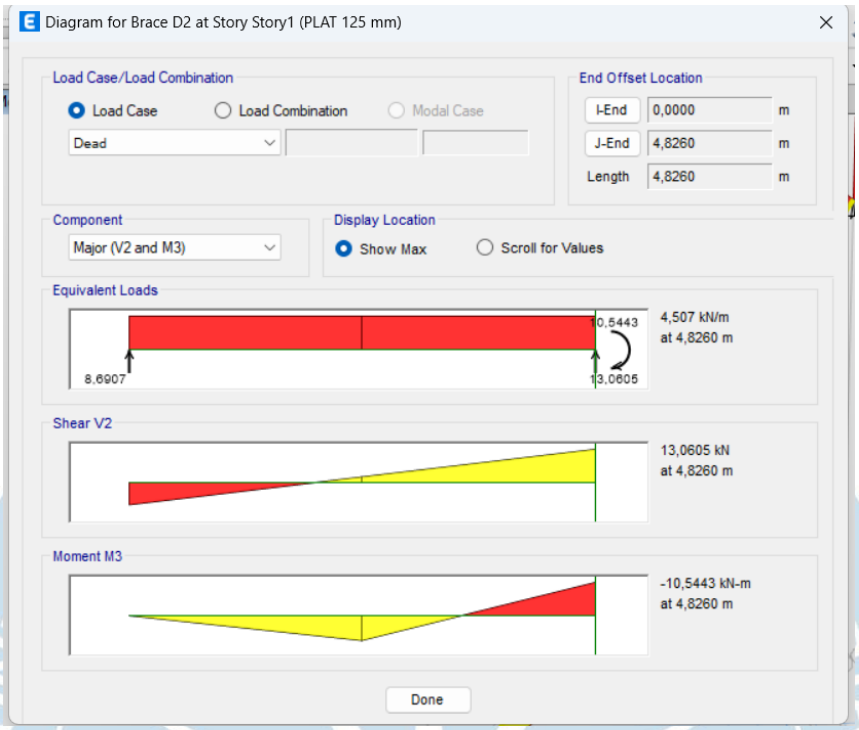
- Diameter Tulangan = 8 mm
- Adb $= \frac{1}{4}$ x π x D²
  $= \frac{1}{4}$ x π x 8²
  = 50,3 mm²
- As min = 0,002 x B x hf
  = 0,002 x 1000 x 125
  = 250 mm²
- S $= \frac{Adb\ x\ B}{As\ min}$
  $= \frac{50{,}3\ x\ 1000}{250}$
  = 201,06 mm

Digunakan Tulangan Susut D8-200

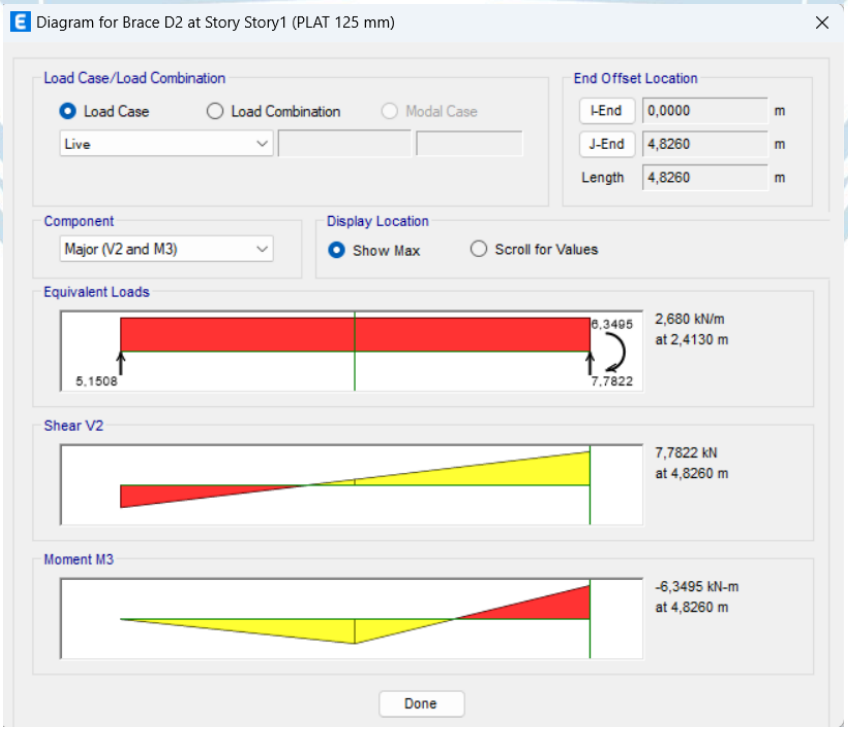


Gambar 2. 9 Detail Penulangan Pelat Lantai

2.7 Perencanaan Tangga



Gambar 2. 10 Output ETABS Beban Mati



Gambar 2. 11 Output ETABS Beban Hidup

Tabel 2. 7 Pembebanan Tangga

PEMBEBANAN			
MDL	=	10,544	kNm
VDL	=	13,06	kN
MLL	=	6,35	kNm
VLL	=	7,78	kN
KOMBINASI			
MU1	=	14,7616	kNm
MU2	=	22,8128	kNm
VU1	=	18,284	kN
VU2	=	28,12	kN
DIPILIH YANG TERBESAR			
Mur	=	22,8128	kNm
Vur	=	28,12	kN

a) Perhitungan Beban Tangga

Tabel 2. 8 Perhitungan Pembebanan Tangga

PERHITUNGAN BEBAN TANGGA			
Perhitungan Beban Tangga			
Beban tangga			
Berat sendiri tangga	=	3,606	kN/m2
Berat anak tangga	=	2,4	kN/m2
Berat ubin & spesi (5 cm)	=	1,05	kN/m2
Berat railing (diperkirakan)	=	1	kN/m2
Total Beban Tangga	=	8,056	kN/m2

Beban Bordes			
Berat sendiri tangga	=	3	kN/m2
Berat ubin & spesi (5 cm)	=	1,05	kN/m2
Berat railing	=	1	kN/m2
Total Beban Bordes	=	5,05	kN/m2
Total Beban Mati	=	13,106	kN/m2
Beban Hidup	=	4,79	kN/m2

b) Rencana Penulangan Tangga Tumpuan

- Mux = 0,5 x Mur
  = 0,5 x 22,8128
  = 11,4064 kNm
  = 11406400 Nmm

Direncanakan :

- Diameter tulangan pokok (D) = 13
- Luas tulangan pokok = $\frac{1}{4}$ x π x D²
  = $\frac{1}{4}$ x π x 13²
  = 132,732 mm²
- Diameter tulangan susut (D) = 8
- Luas tulangan susut = $\frac{1}{4}$ x π x D²
  = $\frac{1}{4}$ x π x 8²
  = 50,265 mm²
- Fy tulangan pokok = 420 MPa
- Fy tulangan susut = 420 MPa
- F'c = 30 MPa
- B = 1000 mm
- Selimut beton = 20 mm
- htg = 125 mm
- β1 = 0,85

- ds = htg – selimut beton – $(\frac{D}{2})$

  = 125 – 20 – $(\frac{13}{2})$

  = 98,5 mm
- θ = 0,9
- ρ = $(\frac{0{,}85\ x\ f'c}{fy})$ x (1- $(\sqrt{1-(\frac{(4\ x\ Mux)}{(1{,}7\ x\ \theta\ x\ f'c\ x\ B\ x\ ds^2)}}$

  = $(\frac{0{,}85\ x\ 30}{420})$ x (1- $(\sqrt{1-\left(\frac{(4\ x\ 11406400)}{(1{,}7\ x\ 0{,}9\ x\ 30\ x\ 1000\ x\ 98{,}5^2)}\right)}$

  = 0,003194
- As min = 0,002 x B x htg

  = 0,002 x 1000 x 125

  = 250 mm²
- As perlu = ρ x B x ds

  = 0,003194 x 1000 x 98,5

  = 314,628 mm²
- S = $\frac{0{,}25\ x\ \pi\ x\ D^2\ x\ B}{As\ perlu}$

  = $\frac{0{,}25\ x\ \pi\ x\ 13^2\ x\ 100}{314{,}628}$

  = 421,870 mm

Digunakan Tulangan Pokok D13-400

Cek Gaya Geser :

- Vc = 0,17 x 1 x $\sqrt{f'c}\ x\ B\ x\ ds$

  = 0,17 x 1 x $\sqrt{30}\ x\ 1000\ x\ 98{,}5$

  = 91716,14225 N

  = 91,7161 kN
- θVc = 0,75 x Vc

  = 0,75 x 91,7161

  = 68,787 kN
- θVc = 68,787 kN > Vur

  = 28,12 kN (AMAN)

Tulangan Susut

- As min = 0,002 x B x htg
  = 0,002 x 1000 x 125
  = 250 mm²
- S = $\frac{Luas\ tulangan\ susut\ x\ B}{As\ min}$
  = $\frac{50{,}265\ x\ 1000}{250}$
  = 201,0619298 mm

Digunakan Tulangan Susut D8-200

c) Rencana Penulangan Tangga Lapangan

- Mux = 18,25024 kNm
  = 18250240 Nmm

Direncanakan

- Diameter tulangan pokok (D) = 13
- Luas tulangan pokok = $\frac{1}{4}$ x π x D²
  = $\frac{1}{4}$ x π x 13²
  = 132,732 mm²
- Diameter tulangan susut (D) = 8
- Luas tulangan susut = $\frac{1}{4}$ x π x D²
  = $\frac{1}{4}$ x π x 8²
  = 50,265 mm²
- Fy tulangan pokok = 420 MPa
- Fy tulangan susut = 420 MPa
- F'c = 30 MPa
- B = 1000 mm
- Selimut beton = 20 mm
- htg = 125 mm
- β1 = 0,85

- ds = htg – selimut beton – $(\frac{D}{2})$
  = 125 – 20 – $(\frac{13}{2})$
  = 98,5 mm
- θ = 0,9
- ρ = $(\frac{0{,}85\ x\ f'c}{fy})$ x (1- $(\sqrt{1-(\frac{(4\ x\ Mux)}{(1{,}7\ x\ \theta\ x\ f'c\ x\ B\ x\ ds^2)}}$
  = $(\frac{0{,}85\ x\ 30}{420})$ x (1- $(\sqrt{1-(\frac{(4\ x\ 18250240)}{(1{,}7\ x\ 0{,}9\ x\ 30\ x\ 1000\ x\ 98{,}5^2)})}$)
  = 0,005199
- As min = 0,002 x B x htg
  = 0,002 x 1000 x 125
  = 250 mm²
- As perlu = ρ x B x ds
  = 0,005199 x 1000 x 98,5
  = 512,088 mm²
- S = $\frac{0{,}25\ x\ \pi\ x\ D^2\ x\ B}{As\ perlu}$
  = $\frac{0{,}25\ x\ \pi\ x\ 13^2\ x\ 100}{512{,}088}$
  = 259,198 mm

Digunakan Tulangan Pokok D13-400

Cek Gaya Geser

- Vc = 0,17 x 1 x $\sqrt{f'c}\ x\ B\ x\ ds$
  = 0,17 x 1 x $\sqrt{30}\ x\ 1000\ x\ 98{,}5$
  = 91716,14225 N
  = 91,7161 kN
- θVc = 0,75 x Vc
  = 0,75 x 91,7161
  = 68,787 kN
- θVc = 68,787 kN > Vur
  = 28,12 kN (AMAN)

Tulangan Susut

- As min = 0,002 x B x htg
  = 0,002 x 1000 x 125
  = 250 mm²
- S = $\frac{Luas\ tulangan\ susut\ x\ B}{As\ min}$
  = $\frac{50{,}265\ x\ 1000}{250}$
  = 201,0619298 mm

Digunakan Tulangan Susut D8-200

2.8 Perencanaan Balok

a) Data Perencanaan

Tabel 2. 9 Output Momen dari ETABS

Kode Balok	Lantai	Momen Tumpuan (kNm)		Momen Lapangan (kNm)	
		Momen Negatif (M-) kNm	Momen Positif (M+) kNm	Momen Negatif (M-) kNm	Momen Positif (M+) kNm
B1	1-5 (Horizontal)	-261,0123	168,9411	-350,9673	186,2594
B2	1-2 (Vertikal)	-288,0722	214,2029	-309,3802	205,1225
B3	3-5 (Vertikal)	-246,8317	184,6816	-265,1498	176,4403

Tabel 2. 10 Redistribusi Momen Balok

REDISTRIBUSI MOMEN BALOK		
∑Momen Tumpuan	50% M-	CEK
92,0712	130,50615	OK
73,8693	144,0361	OK
62,1501	123,41585	OK

Tabel 2. 11 Gaya Geser

Gaya Geser		
Vu Tumpuan (kN)	Vu Lapangan (kN)	Vg Tumpuan (kN)
155,0564	139,3885	185,409

Vu Tumpuan (kN)	Vu Lapangan (kN)	Vg Tumpuan (kN)
198,9274	209,0568	180,1798
173,075	181,9281	156,2111

Tabel 2. 12 Torsi

TORSI		
B1	23,6025	kNm
B2	14,201	kNm
B3	12,135	kNm

2.8.1 Perencanaan Balok (B1) 400 x 700

a) Desain Lentur

Properti Material dan Penampang

- Panjang Balok, L = 8000 mm
- Lebar Balok, b = 400 mm
- Tinggi Balok, h = 700 mm
- Panjang Tumpuan = 2 x h
  = 1400 mm
- Diameter Tulangan Longitudinal, db = 16 mm
- Diameter Tulangan Sengkang, ds = 13 mm
- Selimut Bersih, cc = 20 mm
- Kuat Tekan Beton, fc' = 30 MPa
- Kuat Leleh Tul. Longitudinal, fy = 420 MPa
- Kuat Leleh Tul. Transversal, fyv = 420 MPa
- β1 = $0{,}65 \leq 0{,}85 - 0{,}05\ x\ \frac{(f'c-28)}{7} \leq 0{,}85$
  = 0,8357
- Panjang Kolom, c1 = 500 mm
- Lebar Kolom, c2 = 500 mm
- Ln = L – c1
  = 800 – 500
  = 7500 mm

- λ = 1

Gaya Dalam

- Mu,tumpuan (-) = - 261,0123 kNm
- Mu,tumpuan (+) = 168,9411 kNm
- Mu,lapangan (-) = - 350,9673 kNm
- Mu,lapangan (+) = 186,2594 kNm
- Pu = 155,0564 kN

Syarat Gaya dan Geometri

- Syarat Gaya Aksial = Pu x B <= 0,1 x b x h x f'c
  = 155056,4 <= 840000 (**OK**)
- Syarat Tinggi Efektif = Ln >= 4 x h
  = 7500 >= 2800 (**OK**)
- Syarat Lebar 1 = b >= 0,3 x h
  = 400 >= 210 (**OK**)
- Syarat Lebar 2 = b <= c2 + 2 x 0,75 x c1
  = 400 <= 1250 (**OK**)

Penulangan Lentur Tumpuan Negatif

- Jumlah Tulangan Negatif Tumpuan, n = 6
- Db = 16 mm
- Jarak Bersih Antar Tulangan = $\frac{(b-2\ x\ cc-2\ x\ ds-n\ x\ db)}{(n-1)}$
  = 47,600 mm
- Spasi yang digunakan,s = 50 mm
- Cek Jarak Bersih = Jarak bersih >= db
  = 50 >= 16 (**IYA)**
- Jumlah Lapis = 1
- As Pasang = $\frac{\pi}{4}$ x db² x n
  = 1206,372 mm²
- As min,1 = $\frac{\frac{\sqrt{f'c}}{4}}{fy\ x\ b\ x\ h}$

= 912,871 mm²

- As min,2 = $\frac{1,4}{fy\ x\ b\ x\ h}$

= 933,333 mm²

- Cek As min = As pasang >= As min

= 1206,372 >= 933,333 (**OK**)

- ρ = $\frac{As\ pasang}{(b\ x\ h)}$

= 0,43 %

- ρ max,1 = $\frac{0,75\ x\ 0,85\ x\ \beta 1\ x\ f'c}{fy\ x\ (\frac{600}{(600+fy)})}$

= 2,24 %

- ρ max,2 = 2,50 %
- Cek As max = ρ <= ρ max

= 0,43 % <= 2,24 % (**OK**)

- a = $\frac{As\ x\ fy}{(0,85\ x\ f'c\ x\ b)}$

= 49,674 mm

- Mn = As x fy x (d-$\frac{a}{2}$)

= 342,089 kNm

- c = $\frac{a}{\beta 1}$

= 59,439 mm

- εs = $\frac{(d-c)}{c\ x\ 0,003}$

= 0,032

- ϕ = 0,9
- ϕMn = ϕ x Mn

= 307,880 kNm

- Mu = 261,012 kNm
- Cek Kapasitas = ϕMn >= Mu

= 307,880 >= 261,012 (**OK**)

- As Perlu = $\frac{Mu}{fy\ x\ (d-\frac{a}{2})}$

= 920,456 mm²

Digunakan Tulangan 6 D16

Penulangan Lentur Tumpuan Positif

- Jumlah Tulangan Tumpuan Positif, n = 5
- Db = 16 mm
- Jarak Bersih Antar Tulangan $= \frac{(b - 2\ x\ cc - 2\ x\ ds - n\ x\ db)}{(n-1)}$

  = 63,500 mm
- Spasi yang digunakan,s = 75 mm
- Cek Jarak Bersih = Jarak bersih >= db

  = 75 >= 16 (**IYA)**
- Jumlah Lapis = 1
- As Pasang = $\frac{\pi}{4}$ x db² x n

  = 1005,310 mm²
- As min,1 $= \frac{\frac{\sqrt{f'c}}{4}}{fy\ x\ b\ x\ h}$

  = 912,871 mm²
- As min,2 $= \frac{1{,}4}{fy\ x\ b\ x\ h}$

  = 933,333 mm²
- Cek As min = As pasang >= As min

  = 1005,310 >= 933,333 (**OK**)
- ρ $= \frac{As\ pasang}{(b\ x\ h)}$

  = 0,36 %
- ρ max,1 $= \frac{0{,}75 \text{ x } 0{,}85 \text{ x } \beta 1 \text{ x } f'c}{fy\ x\ (\frac{600}{(600+fy)})}$

  = 2,24 %
- ρ max,2 = 2,50 %
- Cek As max = ρ <= ρ max

  = 0,36 % <= 2,24 % (**OK**)

- a $= \frac{As\ x\ fy}{(0{,}85\ x\ f'c\ x\ b)}$
  = 41,395 mm
- Mn = As x fy x (d-$\frac{a}{2}$)
  = 286,822 kNm
- c $= \frac{a}{\beta 1}$
  = 49,533 mm
- εs $= \frac{(d-c)}{c\ x\ 0{,}003}$
  = 0,039
- ϕ = 0,9
- ϕMn = ϕ x Mn
  = 0,9 x 286,822
  = 258,140 kNm
- Mu = 168,941 kNm
- Cek Kapasitas = ϕMn >= Mu
  = 258,140 >= 168,941 (**OK**)
- As Perlu $= \frac{Mu}{fy\ x\ (d-\frac{a}{2})}$
  = 754,063 mm²

Digunakan Tulangan 5 D16

Penulangan Lentur Lapangan Negatif

- Jumlah Tulangan Lapangan Negatif, n = 8
- Db = 16 mm
- Jarak Bersih Antar Tulangan $= \frac{(b-2\ x\ cc-2\ x\ ds-n\ x\ db)}{(n-1)}$

= 29,429mm

- Spasi yang digunakan,s = 50 mm
- Cek Jarak Bersih = Jarak bersih >= db

= 50 >= 16 (**IYA)**

- Jumlah Lapis = 1
- As Pasang = $\frac{\pi}{4}$ x db² x n

= 1608,495 mm²

- As min,1 $= \frac{\frac{\sqrt{f'c}}{4}}{fy\ x\ b\ x\ h}$

= 912,871mm²

- As min,2 $= \frac{1,4}{fy\ x\ b\ x\ h}$

= 933,333 mm²

- Cek As min = As pasang >= As min

= 1608,495 >= 700,000 (**OK**)

- ρ $= \frac{As\ pasang}{(b\ x\ h)}$

= 0,57 %

- ρ max,1 $= \frac{0,75 \text{ x } 0,85 \text{ x } \beta1 \text{ x } f'c}{fy\ x\ (\frac{600}{(600+fy)})}$

= 2,24 %

- ρ max,2 = 2,50 %
- Cek As max = ρ <= ρ max

= 0,57 % <= 2,24 % (**OK**)

- a $= \frac{As\ x\ fy}{(0,85\ x\ f'c\ x\ b)}$

= 66,232 mm

- Mn = As x fy x (d-$\frac{a}{2}$)

= 405,473 kNm

- c $= \frac{a}{\beta1}$

= 79,252 mm

- εs $= \frac{(d-c)}{c \text{ x } 0,003}$

= 0,023

- ϕ = 0,9
- ϕMn = ϕ x Mn

= 405,473 kNm

- Mu = 350,967 kNm
- Cek Kapasitas = ϕMn >= Mu

= 405,473 >= 350,967 (**OK**)

- As Perlu $= \frac{Mu}{fy\ x\ (d - \frac{a}{2})}$

= 1253,046 mm²

Digunakan Tulangan 8 D16

Penulangan Lentur Lapangan Positif

- Jumlah Tulangan Lapangan Positif, n = 5
- Db = 16 mm

- Jarak Bersih Antar Tulangan $= \frac{(b - 2\ x\ cc - 2\ x\ ds - n\ x\ db)}{(n-1)}$

= 63,500 mm

- Spasi yang digunakan,s = 75 mm
- Cek Jarak Bersih = Jarak bersih >= db

= 75 >= 16 (**IYA)**

- Jumlah Lapis = 1
- As Pasang $= \frac{\pi}{4}$ x db² x n

= 1005,310 mm²

- As min,1 $= \frac{\frac{\sqrt{f'c}}{4}}{fy\ x\ b\ x\ h}$

= 912,871 mm²

- As min,2 $= \frac{1,4}{fy\ x\ b\ x\ h}$

= 933,333 mm²

- Cek As min = As pasang >= As min

= 1005,310 >= 933,333 (**OK**)

- ρ $= \frac{As\ pasang}{(b\ x\ h)}$

= 0,36 %

- ρ max,1 $= \frac{0,75 \text{ x } 0,85 \text{ x } \beta 1 \text{ x } f'c}{fy\ x\ (\frac{600}{(600+fy)})}$

= 2,24 %

- ρ max,2 = 2,50 %
- Cek As max = ρ <= ρ max

= 0,36 % <= 2,24 % (**OK**)

- a $= \frac{As\ x\ fy}{(0{,}85\ x\ f'c\ x\ b)}$

= 41,395 mm

- Mn = As x fy x (d-$\frac{a}{2}$)

= 286,822 kNm

- c $= \frac{a}{\beta 1}$

= 49,533 mm

- εs $= \frac{(d-c)}{c\ x\ 0{,}003}$

= 0,039

- ϕ = 0,9
- ϕMn = ϕ x Mn

= 0,9 x 286,822

= 258,140 kNm

- Mu = 186,259 kNm
- Cek Kapasitas = ϕMn >= Mu

= 258,140 >= 186,259 (**OK**)

- As Perlu $= \frac{Mu}{fy\ x\ (d-\frac{a}{2})}$

= 652,838 mm²

b) Desain Geser

Properti Material dan Penampang

- Panjang Balok, L = 8000 mm
- Lebar Balok, b = 400 mm
- Tinggi Balok, h = 700 mm
- Panjang Tumpuan = 2 x h

  = 1400 mm
- Diameter Tulangan Longitudinal, db = 16 mm
- Diameter Tulangan Sengkang, ds = 13 mm
- Selimut Bersih, cc = 20 mm

- Kuat Tekan Beton, fc' = 30 MPa
- Kuat Leleh Tul. Longitudinal, fy = 420 MPa
- Kuat Leleh Tul. Transversal, fyv = 420 MPa
- β1 $= 0{,}65 \leq 0{,}85 - 0{,}05\ x\ \frac{(f'c-28)}{7} \leq\ 0{,}85$
  = 0,8357
- Panjang Kolom, c1 = 500 mm
- Lebar Kolom, c2 = 500 mm
- Ln = L – c1
  = 800 – 500
  = 7500 mm

Gaya Dalam

- Vu,tumpuan = 155,0564 kN
- Vu,lapangan = 139,3885 Kn

Gaya Desain

- Vg,tumpuan = 185,409 kN
- As+ Tumpuan = 1005,310 mm²
- As- Tumpuan = 1206,372 mm²
- apr+ = 1,25 x a (tumpuan positif)

= 51,744 mm

- apr- = 1,25 x a (tumpuan negatif)

= 62,093 mm

- Mpr+ = As (+) x (1,25 x fy) x (d - $\frac{apr}{2}$)

= 355796408 Nmm

- Mpr- = As (-) x (1,25 x fy) x (d - $\frac{apr}{2}$)

= 423678517 Nmm

- Vsway atau Vpr = $\frac{(\mathrm{Mpr+ + Mpr-})}{Ln}$

= 103930 N

- Ve = Vg + Vpr

= 289339 N

Tahanan Geser Beton

- Vpr = 103930 N
- 1/2 Ve = $\frac{Ve}{2}$

= 144669 N

- Pu = 155056,4 N
- Ag fc' / 20 = $\frac{b\ x\ h\ x\ f'c}{20}$

= 420000 N

- Vc Diperhitungkan? = Vpr >= ½ Ve dan Pu < Ag fc' / 20

= 103930 >= 144669 dan 155056,4 < 420000

(**IYA**)

- Vc = 0,17 x $\sqrt{30}$ x b x fy

= 156430 N

Penulangan Geser Tumpuan

- Jumlah Kaki = 2
- Av = $\frac{\pi}{4}$ x db² x n

= 265,465 mm²

- Spasi = 75 mm
- Spasi Max 1 = $\frac{d}{4}$

= 175 mm

- Spasi Max 2 = 6 x db

= 96 mm

- Spasi Max 3 = 150 mm
- Cek Spasi = Spasi <= spasi max 1 + spasi max 2 + spasi max 3

= 75 <= 421 (**OK**)

- Vs = Av x fyv x $\frac{d}{s}$

= 1040621 N

- Batas Vs = 0.66 x $(fc')^{0,5}$ x b x d

= 1012191 N

- Φ = 0,75
- Vn = Vc + Vs

= 1168621 N

- Vu = 289339 N
- ϕVn / Vu = $\frac{\Phi Vn}{Vu}$

= 3,029

- Cek Kapasitas = ϕVn / Vu >= 1

= 3,029 >= 1 (**OK**)

Digunakan Tulangan 2 D13-75 mm

Penulangan Geser Lapangan

- Jumlah Kaki = 2
- Av = $\frac{\pi}{4}$ x db² x n

= 265,465 mm²

- Spasi = 150 mm
- Spasi Max = $\frac{d}{2}$

= 350 mm

- Cek Spasi = Spasi <= spasi max

= 150 <= 350 (**OK**)

- Vs = Av x fyv x $\frac{d}{s}$

= 520311 N

- Batas Vs = 0.66 x $(fc')^{0,5}$ x b x d

= 1012191 N

- Vc = 0,17 x $\sqrt{30}$ x b x d

= 260716 N

- Φ = 0,75
- Vn = Vc + Vs

= 781027 N

- Vu = 139388,5 N
- ϕVn / Vu = $\frac{\Phi Vn}{Vu}$

= 4,202

- Cek Kapasitas = ϕVn / Vu >= 1

= 4,202 >= 1 (**OK**)

Digunakan Tulangan 2 D13-150 mm

c) Desain Torsi

Properti Material dan Penampang

- Panjang Balok, L = 8000 mm
- Lebar Balok, b = 400 mm
- Tinggi Balok, h = 700 mm
- Panjang Tumpuan = 2 x h
  = 1400 mm
- Diameter Tulangan Longitudinal, db = 16 mm
- Diameter Tulangan Sengkang, ds = 13 mm
- Selimut Bersih, cc = 20 mm
- Kuat Tekan Beton, fc' = 30 MPa
- Kuat Leleh Tul. Longitudinal, fy = 420 MPa
- Kuat Leleh Tul. Transversal, fyv = 420 MPa
- β1 = $0{,}65 \leq 0{,}85 - 0{,}05\ x\ \frac{(f'c-28)}{7} \leq\ 0{,}85$
  = 0,8357
- Panjang Kolom, c1 = 500 mm
- Lebar Kolom, c2 = 500 mm
- Ln = L – c1
  = 800 – 500
  = 7500 mm

Parameter Geometri Penampang untuk Perhitungan Torsi

- Acp = b x h
  = 280000 mm²
- Pcp = 2 x (b + h)
  = 2200 mm
- xo = b – 2 x Cc – ds
  = 347 mm

- yo = b – 2 x Cc – ds
  = 647 mm
- Aoh = xo x yo
  = 224509 mm²
- Ao = 0,85 x Aoh
  = 190833 mm²
- Ph = 2 x (xo + yo)
  = 1988 mm

Gaya Dalam

- Tu = 23,6025 kNm
  = 23602500 Nmm

Pengecekan Kebutuhan Tulangan Torsi

- Tcr = $0,33 \times (f'c)^{0,5} \times \frac{Acp^2}{Pcp}$
  = 64412173 Nm
- Φ = 0,75
- ϕ Tcr / 4 = $\frac{\phi \, Tcr}{4}$
  = 12077282 Nmm
- Perlu Tulangan Torsi = Tu > ϕ Tcr / 4 ?
  = 23602500 > 12077282 (**IYA**)

Pengecekan Kecukupan Dimensi Penampang

- Jenis Torsi = Kompatibilitas
- Tu Pakai = Tu x 10^6
  = 23602500 Nmm
- Vu = 289339 N
- Vc = 0,17 x $\sqrt{30}$ x b x d
  = 260716 N
- Tegangan Utimate Geser+Torsi = $((\frac{Vu}{b \, x \, d})^2 + \left(\frac{Tu \, x \, Ph}{(1,7 \, x \, Aoh^2)}\right)^2)^{0,5}$
  = 1,169 MPa
- Kapasitas Tegangan Beton = Φ x $(\frac{Vc}{b \, x \, d})$ + 0,66 x $(f'c)^{0,5}$
  = 3,410 MPa

- Cek Dimensi Penampang = Ruas kiri <= ruas kanan
  = 1,169 <= 3,410 (**OK**)

Parameter Umum lainnya

- fy / fyt = 1
- θ = 45º

Penulangan Transversal Torsi

- n kaki Tumpuan = 2
- n kaki Lapangan = 2
- s Tumpuan = 75 mm
- s Lapangan = 150 mm
- s max 1 $= \frac{Ph}{8}$
  = 249 mm
- s max 2 = 300 mm
- Cek Spasi Tumpuan = s tumpuan <= s max
  = 75 <= 249 (**OK**)
- Cek Spasi Lapangan = s lapangan <= s max
  = 150 <= 249 (**OK**)
- Av+t / s Tumpuan Pasang $= \frac{\frac{\pi}{4} \text{ x } db^2 \text{ x } n}{s}$
  = 3,540 mm^2/mm
- Av+t / s Lapangan Pasang $= \frac{\frac{\pi}{4} \text{ x } db^2 \text{ x } n}{s}$
  = 1,770 mm^2/mm
- At / s $= \frac{Tu}{(2 \text{ x } \phi \text{ x Ao x fyv})}$
  = 0,196 mm^2/mm
- Av / s Tumpuan Perlu $= \frac{Vu}{(fyv \text{ x } d)}$
  = 0,984 mm^2/mm
- Av / s Lapangan Perlu $= \left(\frac{Vu}{\frac{(\phi \text{ x } Vc}{(fyv \text{ x } d)}} \right)$
  = 0,255 mm^2/mm
- Av+t / s Tumpuan Perlu = 2 x At/s +Av/s tumpuan perlu

= 1,377

- Av+t / s Lapangan Perlu = 2 x At/s +Av/s lapangan perlu
  = 0,647
- Av+t / s min 1 = $\frac{0{,}062 \text{ x } (f'c)0{,}5 \text{ x b}}{fyv}$
  = 0,323
- Av+t / s min 2 = $\frac{0{,}35 \text{ x b}}{fyv}$
  = 0,333
- Cek Geser + Torsi Tumpuan = A_{v+t} / s Pasang >= A_{v+t} / s Perlu dan min (**OK**)
- Cek Geser + Torsi Lapangan = A_{v+t} / s Pasang >= A_{v+t} / s Perlu dan min (**OK**)

Penulangan Longitudinal Torsi

- db atau dbt = 13 mm
- db, min = 0,042 x s
  = 6,3 mm
- Cek db = 13 >= 6,3 (**OK**)
- As Perlu Tumpuan Atas = 920,456 mm^2
- As Perlu Tumpuan Bawah = 592,138 mm^2
- As Perlu Lapangan Atas = 1253,046 mm^2
- As Perlu Lapangan Bawah = 652,838 mm^2
- Al = A_t / s * P_h
  = 390,284 mm^2
- Al min = $\frac{0{,}42 \text{ x } (f'c)0{,}5 \text{ x Acp}}{fy - At/s \text{ x } Ph}$
  = 1143,339 mm^2
- As + Al Perlu Tumpuan = A1 min + As Perlu Tumpuan Atas + As Perlu Tumpuan Bawah
  = 2655,933 mm^2
- As + Al Perlu Lapangan = A1 min + As Perlu lapangan Atas + As Perlu lapangan Bawah
  = 3049,224 mm^2

- n Tumpuan Atas = 6
- n Tumpuan Tengah = 4
- n Tumpuan Bawah = 5
- n Tumpuan Vertikal = 4
- n Lapangan Atas = 8
- n Lapangan Tengah = 4
- n Lapangan Atas = 5
- n Tumpuan Vertikal = 4
- Spasi Horizontal Tumpuan $= \frac{(b-2 \times Cc-2 \times ds-db)}{(n\ atas,n\ bawah)-1}$

  $= 80$ mm
- Spasi Vertikal Tumpuan $= \frac{(h-2 \times Cc-2 \times ds-db)}{(n\ vertikal-1)}$

  $= 88$ mm
- Spasi Horizontal Lapangan $= \frac{(b-2 \times Cc-2 \times ds-db)}{(n\ atas,n\ bawah)-1}$

  $= 80$ mm
- Spasi Vertikal Lapangan $= \frac{(h-2 \times Cc-2 \times ds-db)}{(5-1)}$

  $= 206$ mm

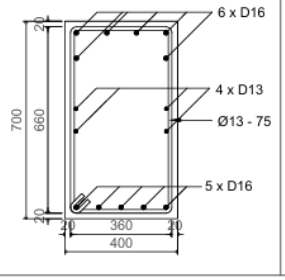
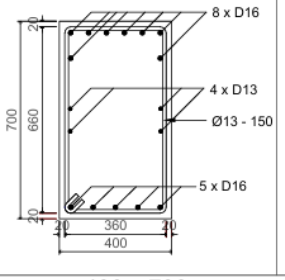
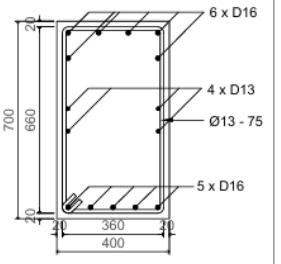
- Cek Spasi Tulangan Longitudinal Tumpuan = 88 <= 300 (**OK**)
- Cek Spasi Tulangan Longitudinal Lapangan = 206 <= 300 (**OK**)
- As + Al Pasang Tumpuan $= \frac{(\text{n tumpuan atas} + \text{n tumpuan bawah}) \times \pi}{\frac{4 \times db^2 + \text{n tumpuan tengah} \times \pi}{4\ x\ ds^2}}$

  $= 2742{,}610$ mm^2
- As + Al Pasang Lapangan $= \frac{(\text{n lapangan atas} + \text{n lapangan bawah}) \times \pi}{\frac{4 \times db^2 + \text{n lapangan tengah} \times \pi}{4\ x\ ds^2}}$

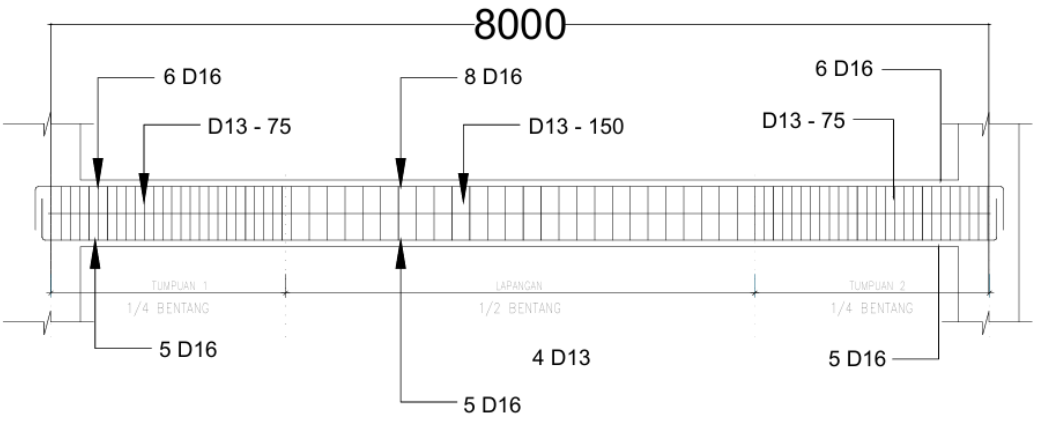
  $= 3144{,}734$ mm^2
- Cek Lentur + Torsi Tumpuan = $A_s + A_l$ Pasang >= $A_s + A_l$ (**OK**)
- Cek Lentur + Torsi Lapangan = $A_s + A_l$ Pasang >= $A_s + A_l$ (**OK**)

Digunakan Tulangan Tumpuan Tengah 4 D13

Digunakan Tulangan Lapangan Tengah 4 D13

TYPE BALOK / LANTAI	B1		
	TUMPUAN 1	LAPANGAN	TUMPUAN 2
			
UKURAN BALOK	400 x 700		
TULANGAN ATAS	6 D16	8 D16	6 D16
TULANGAN BAWAH	5 D16	5 D16	5 D16
TUL. PEMINGGANG	4 D13	4 D13	4 D13
SENGKANG	D13 - 75	D13 - 150	D13 - 75

Gambar 2. 12 Detail Penulangan Balok 1



Gambar 2. 13 Detail Penulangan Balok 1

2.8.2 Perencanaan Balok (B2) 350 x 600

a) Desain Lentur

Properti Material dan Penampang

- Panjang Balok, L = 6500 mm
- Lebar Balok, b = 350 mm
- Tinggi Balok, h = 600 mm
- Panjang Tumpuan = 2 x h
  = 1200 mm
- Diameter Tulangan Longitudinal, db = 16 mm
- Diameter Tulangan Sengkang, ds = 13 mm

- Selimut Bersih, cc = 20 mm
- Kuat Tekan Beton, fc' = 30 MPa
- Kuat Leleh Tul. Longitudinal, fy = 420 MPa
- Kuat Leleh Tul. Transversal, fyv = 420 MPa
- β1 = $0{,}65 \leq 0{,}85 - 0{,}05\ x\ \frac{(f'c-28)}{7} \leq\ 0{,}85$
  = 0,8357
- Panjang Kolom, c1 = 500 mm
- Lebar Kolom, c2 = 500 mm
- Ln = L – c1
  = 6500 – 500
  = 6000 mm
- λ = 1

Gaya Dalam

- Mu,tumpuan (-) = -288,0722 kNm
- Mu,tumpuan (+) = 214,2029 kNm
- Mu,lapangan (-) = -309,3802 kNm
- Mu,lapangan (+) = 205,1225 kNm
- Pu = 198,9274 kN

Syarat Gaya dan Geometri

- Syarat Gaya Aksial = Pu x B <= 0,1 x b x h x f'c
  = 198927,4 <= 840000 (**OK**)
- Syarat Tinggi Efektif = Ln >= 4 x h
  = 6000 >= 2400 (**OK**)
- Syarat Lebar 1 = b >= 0,3 x h
  = 350 >= 180 (**OK**)
- Syarat Lebar 2 = b <= c2 + 2 x 0,75 x c1
  = 350 <= 1250 (**OK**)

Penulangan Lentur Tumpuan Negatif

- Jumlah Tulangan Negatif Tumpuan, n = 6
- Db = 16 mm

- Jarak Bersih Antar Tulangan $= \frac{(b-2\ x\ cc-2\ x\ ds-n\ x\ db)}{(n-1)}$
  = 37,600 mm
- Spasi yang digunakan,s = 50 mm
- Cek Jarak Bersih = Jarak bersih >= db
  = 50 >= 16 (**IYA)**
- Jumlah Lapis = 1
- As Pasang $= \frac{\pi}{4}$ x db² x n
  = 1206,372 mm²
- As min,1 $= \frac{\frac{\sqrt{f'c}}{4}}{fy\ x\ b\ x\ h}$
  = 684,653 mm²
- As min,2 $= \frac{1,4}{fy\ x\ b\ x\ h}$
  = 700,000 mm²
- Cek As min = As pasang >= As min
  = 1206,372 >= 700,000 (**OK**)
- ρ $= \frac{As\ pasang}{(b\ x\ h)}$
  = 0,57 %
- ρ max,1 $= \frac{0,75 \text{ x } 0,85 \text{ x } \beta1 \text{ x } f'c}{fy\ x\ (\frac{600}{(600+fy)})}$
  = 2,24 %
- ρ max,2 = 2,50 %
- Cek As max = ρ <= ρ max
  = 0,43 % <= 2,24 % (**OK**)
- a $= \frac{As\ x\ fy}{(0,85\ x\ f'c\ x\ b)}$
  = 56,770 mm
- Mn = As x fy x (d-$\frac{a}{2}$)
  = 340,291 kNm
- c $= \frac{a}{\beta1}$
  = 67,930 mm
- εs $= \frac{(d-c)}{c \text{ x } 0,003}$

= 0,023

- ϕ = 0,9
- ϕMn = ϕ x Mn
  = 306,262 kNm
- Mu = 288,072 kNm
- Cek Kapasitas = ϕMn >= Mu
  = 306,262 >= 288,072 (**OK**)
- As Perlu = $\frac{Mu}{fy\ x\ (d-\frac{a}{2})}$
  = 1021,249 mm²

Digunakan Tulangan 6 D16

Penulangan Lentur Tumpuan Positif

- Jumlah Tulangan Tumpuan Positif, n = 5
- Db = 16 mm
- Jarak Bersih Antar Tulangan = $\frac{(b-2\ x\ cc-2\ x\ ds-n\ x\ db)}{(n-1)}$
  = 51,000 mm
- Spasi yang digunakan,s = 50 mm
- Cek Jarak Bersih = Jarak bersih >= db
  = 75 >= 16 (**IYA)**
- Jumlah Lapis = 1
- As Pasang = $\frac{\pi}{4}$ x db² x n
  = 1005,310 mm²
- As min,1 = $\frac{\frac{\sqrt{f'c}}{4}}{fy\ x\ b\ x\ h}$
  = 684,653 mm²
- As min,2 = $\frac{1,4}{fy\ x\ b\ x\ h}$
  = 700,000 mm²
- Cek As min = As pasang >= As min

= 1005,310 >= 700,000 (**OK**)

- ρ = $\frac{As\ pasang}{(b\ x\ h)}$
  = 0,48 %
- ρ max,1 = $\frac{0,75 \text{ x } 0,85 \text{ x } \beta1 \text{ x } f'c}{fy\ x\ (\frac{600}{(600+fy)})}$
  = 2,24 %
- ρ max,2 = 2,50 %
- Cek As max = ρ <= ρ max
  = 0,36 % <= 2,24 % (**OK**)
- a = $\frac{As\ x\ fy}{(0,85\ x\ f'c\ x\ b)}$
  = 47,309 mm
- Mn = As x fy x (d-$\frac{a}{2}$)
  = 243,350 kNm
- c = $\frac{a}{\beta1}$
  = 56,609 mm
- εs = $\frac{(d-c)}{\text{c x } 0,003}$
  = 0,029
- ϕ = 0,9
- ϕMn = ϕ x Mn
  = 0,9 x 243,350
  = 219,915 kNm
- Mu = 214,203 kNm
- Cek Kapasitas = ϕMn >= Mu
  = 219,915 >= 214,203 (**OK**)
- As Perlu = $\frac{Mu}{fy\ x\ (d-\frac{a}{2})}$
  = 754,063 mm²

Digunakan Tulangan 5 D16

Penulangan Lentur Lapangan Negatif

- Jumlah Tulangan Lapangan Negatif, n = 8

- Db = 16 mm
- Jarak Bersih Antar Tulangan = $\frac{(b-2\ x\ cc-2\ x\ ds-n\ x\ db)}{(n-1)}$
  = 22,286 mm
- Spasi yang digunakan,s = 50 mm
- Cek Jarak Bersih = Jarak bersih >= db
  = 50 >= 16 (**IYA)**
- Jumlah Lapis = 1
- As Pasang = $\frac{\pi}{4}$ x db² x n
  = 1608,495 mm²
- As min,1 = $\frac{\sqrt{f'c}}{\frac{4}{fy\ x\ b\ x\ h}}$
  = 684,653 mm²
- As min,2 = $\frac{1,4}{fy\ x\ b\ x\ h}$
  = 700,000 mm²
- Cek As min = As pasang >= As min
  = 1608,495 >= 700,000 (**OK**)
- ρ = $\frac{As\ pasang}{(b\ x\ h)}$
  = 0,77 %
- ρ max,1 = $\frac{0,75 \text{ x } 0,85 \text{ x } \beta1 \text{ x } f'c}{fy\ x\ (\frac{600}{(600+fy)})}$
  = 2,24 %
- ρ max,2 = 2,50 %
- Cek As max = ρ <= ρ max
  = 0,57 % <= 2,24 % (**OK**)
- a = $\frac{As\ x\ fy}{(0,85\ x\ f'c\ x\ b)}$
  = 75,694 mm
- Mn = As x fy x (d-$\frac{a}{2}$)
  = 379,773 kNm
- c = $\frac{a}{\beta1}$
  = 90,574 mm

- εs $= \frac{(d-c)}{c \times 0{,}003}$
  = 0,017
- ϕ = 0,9
- ϕMn = ϕ x Mn
  = 341,795 kNm
- Mu = 309,380 kNm
- Cek Kapasitas = ϕMn >= Mu
  = 341,795 >= 309,380 (**OK**)
- As Perlu $= \frac{Mu}{fy\ x\ (d-\frac{a}{2})}$
  = 1310,354 mm²

Digunakan Tulangan 8 D16

Penulangan Lentur Lapangan Positif

- Jumlah Tulangan Lapangan Positif, n = 5
- Db = 16 mm
- Jarak Bersih Antar Tulangan $= \frac{(b-2\ x\ cc-2\ x\ ds-n\ x\ db)}{(n-1)}$
  = 51,000 mm
- Spasi yang digunakan,s = 50 mm
- Cek Jarak Bersih = Jarak bersih >= db
  = 75 >= 16 (**IYA)**
- Jumlah Lapis = 1
- As Pasang $= \frac{\pi}{4}$ x db² x n
  = 1005,310 mm²
- As min,1 $= \frac{\frac{\sqrt{f'c}}{4}}{fy\ x\ b\ x\ h}$
  = 684,653 mm²
- As min,2 $= \frac{1{,}4}{fy\ x\ b\ x\ h}$
  = 700,000 mm²
- Cek As min = As pasang >= As min
  = 1005,310 >= 700,000 (**OK**)

- ρ = $\frac{As\ pasang}{(b\ x\ h)}$
  = 0,48 %
- ρ max,1 = $\frac{0,75 \text{ x } 0,85 \text{ x } \beta1 \text{ x } f'c}{fy\ x\ (\frac{600}{(600+fy)})}$
  = 2,24 %
- ρ max,2 = 2,50 %
- Cek As max = ρ <= ρ max
  = 0,36 % <= 2,24 % (**OK**)
- a = $\frac{As\ x\ fy}{(0,85\ x\ f'c\ x\ b)}$
  = 47,309 mm
- Mn = As x fy x (d-$\frac{a}{2}$)
  = 243,350 kNm
- c = $\frac{a}{\beta1}$
  = 56,609 mm
- εs = $\frac{(d-c)}{c \text{ x } 0,003}$
  = 0,029
- ϕ = 0,9
- ϕMn = ϕ x Mn
  = 0,9 x 243,350
  = 219,915 kNm
- Mu = 205,123 kNm
- Cek Kapasitas = ϕMn >= Mu
  = 219,915 >= 205,123 (**OK**)
- As Perlu = $\frac{Mu}{fy\ x\ (d-\frac{a}{2})}$
  = 847,385 mm²

Digunakan Tulangan 5 D16

d) Desain Geser

Properti Material dan Penampang

- Panjang Balok, L = 6500 mm

- Lebar Balok, b = 350 mm
- Tinggi Balok, h = 600 mm
- Panjang Tumpuan = 2 x h
  = 1200 mm
- Diameter Tulangan Longitudinal, db = 16 mm
- Diameter Tulangan Sengkang, ds = 13 mm
- Selimut Bersih, cc = 20 mm
- Kuat Tekan Beton, fc' = 30 MPa
- Kuat Leleh Tul. Longitudinal, fy = 420 MPa
- Kuat Leleh Tul. Transversal, fyv = 420 MPa
- β1 $= 0{,}65 \leq 0{,}85 - 0{,}05\ x\ \frac{(f'c-28)}{7} \leq\ 0{,}85$
  = 0,8357
- Panjang Kolom, c1 = 500 mm
- Lebar Kolom, c2 = 500 mm
- Ln = L – c1
  = 6500 – 500
  = 6000 mm

Gaya Dalam

- Vu,tumpuan = 198,9274 kN
- Vu,lapangan = 209,0568 Kn

Gaya Desain

- Vg,tumpuan = 180,1798 kN
- As+ Tumpuan = 1005,310 mm²
- As- Tumpuan = 1206,372 mm²
- apr+ = 1,25 x a (tumpuan positif)
  = 59,136 mm
- apr- = 1,25 x a (tumpuan negatif)
  = 70,963 mm
- Mpr+ = As (+) x (1,25 x fy) x (d - $\frac{apr}{2}$)
  = 301066953 Nmm

- Mpr- = As (-) x (1,25 x fy) x (d - $\frac{apr}{2}$)
  = 357535003 Nmm
- Vsway atau Vpr = $\frac{(\text{Mpr+} + \text{Mpr−})}{Ln}$
  = 87814 N
- Ve = Vg + Vpr
  = 267993 N

Tahanan Geser Beton

- Vpr = 87814 N
- 1/2 Ve = $\frac{Ve}{2}$
  = 133997 N
- Pu = 198927,4 N
- Ag fc' / 20 = $\frac{b\ x\ h\ x\ f'c}{20}$
  = 315000 N
- Vc Diperhitungkan? = Vpr >= ½ Ve dan Pu < Ag fc' / 20
  = 87814 >= 133997 dan 198927,4 < 420000 (**IYA**)
- Vc = 0,17 x $\sqrt{30}$ x b x fy
  = 136876 N

Penulangan Geser Tumpuan

- Jumlah Kaki = 2
- Av = $\frac{\pi}{4}$ x db² x n
  = 265,465 mm²
- Spasi = 75 mm
- Spasi Max 1 = $\frac{d}{4}$
  = 150 mm
- Spasi Max 2 = 6 x db
  = 96 mm
- Spasi Max 3 = 150 mm
- Cek Spasi = Spasi <= spasi max 1 + spasi max 2 + spasi max 3
  = 75 <= 421 (**OK**)

- Vs = Av x fyv x $\frac{d}{s}$

= 891961 N

- Batas Vs = 0.66 x $(fc')^{0,5}$ x b x d

= 759143 N

- Φ = 0,75
- Vn = Vc + Vs

= 915573 N

- Vu = 267993 N
- ϕVn / Vu = $\frac{\Phi Vn}{Vu}$

= 3,029

- Cek Kapasitas = ϕVn / Vu >= 1

= 3,029 >= 1 (**OK**)

Digunakan Tulangan 2 D13-75 mm

Penulangan Geser Lapangan

- Jumlah Kaki = 2
- Av = $\frac{\pi}{4}$ x db^2 x n

= 265,465 mm^2

- Spasi = 150 mm
- Spasi Max = $\frac{d}{2}$

= 350 mm

- Cek Spasi = Spasi <= spasi max

= 150 <= 350 (**OK**)

- Vs = Av x fyv x $\frac{d}{s}$

= 445980 N

- Batas Vs = 0.66 x $(fc')^{0,5}$ x b x d

= 759143 N

- Vc = 0,17 x $\sqrt{30}$ x b x d

= 195537 N

- Φ = 0,75

- Vn = Vc + Vs

= 641517 N

- Vu = 209056,8 N
- ϕVn / Vu = $\frac{\Phi Vn}{Vu}$

= 2,301

- Cek Kapasitas = ϕVn / Vu >= 1

= 2,301 >= 1 (**OK**)

Digunakan Tulangan 2 D13-150 mm

e) Desain Torsi

Properti Material dan Penampang

- Panjang Balok, L = 6500 mm
- Lebar Balok, b = 350 mm
- Tinggi Balok, h = 600 mm
- Panjang Tumpuan = 2 x h

  = 1200 mm
- Diameter Tulangan Longitudinal, db = 16 mm
- Diameter Tulangan Sengkang, ds = 13 mm
- Selimut Bersih, cc = 20 mm
- Kuat Tekan Beton, fc' = 30 MPa
- Kuat Leleh Tul. Longitudinal, fy = 420 MPa
- Kuat Leleh Tul. Transversal, fyv = 420 MPa
- β1 = $0{,}65 \leq 0{,}85 - 0{,}05\ x\ \frac{(f'c-28)}{7} \leq\ 0{,}85$

  = 0,8357
- Panjang Kolom, c1 = 500 mm
- Lebar Kolom, c2 = 500 mm
- Ln = L – c1

= 6500 – 500

= 6000 mm

Parameter Geometri Penampang untuk Perhitungan Torsi

- Acp = b x h

= 210000 mm²

- Pcp = 2 x (b + h)

= 1900 mm

- xo = b – 2 x Cc – ds

= 297 mm

- yo = b – 2 x Cc – ds

= 547 mm

- Aoh = xo x yo

= 162459 mm²

- Ao = 0,85 x Aoh

= 138090 mm²

- Ph = 2 x (xo + yo)

= 1688 mm

Gaya Dalam

- Tu = 14,210 kNm

Pengecekan Kebutuhan Tulangan Torsi

- Tcr = $0{,}33 \times (f'c)^{0,5} \times \frac{Acp^2}{Pcp}$

= 41952665 Nm

- Φ = 0,75
- ϕ Tcr / 4 = $\frac{\phi\ Tcr}{4}$

= 7866125 Nmm

- Perlu Tulangan Torsi = Tu > ϕ Tcr / 4 ?

= 14,210 > 17866125 (**IYA**)

Pengecekan Kecukupan Dimensi Penampang

- Jenis Torsi = Kompatibilitas
- Tu Pakai = Tu x 10^6

= 14201000 Nmm

- Vu = 267993 N
- Vc = 0,17 x $\sqrt{30}$ x b x d

= 1955537 N

- Tegangan Utimate Geser+Torsi $= ((\frac{Vu}{b\ x\ d})^2 + \left(\frac{Tu\ x\ Ph}{(1{,}7\ x\ Aoh^2)}\right)^2)^{0,5}$

= 1,383 MPa

- Kapasitas Tegangan Beton $= \Phi$ x $(\frac{Vc}{b\ x\ d})$ + 0,66 x $(f'c)^{0,5}$

= 3,410 MPa

- Cek Dimensi Penampang = Ruas kiri <= ruas kanan

= 1,383 <= 3,410 (**OK**)

Parameter Umum lainnya

- fy / fyt = 1
- θ = 45º

Penulangan Transversal Torsi

- n kaki Tumpuan = 2
- n kaki Lapangan = 2
- s Tumpuan = 75 mm
- s Lapangan = 150 mm
- s max 1 $= \frac{Ph}{8}$

= 211 mm

- s max 2 = 300 mm
- Cek Spasi Tumpuan = s tumpuan <= s max

= 75 <= 211 (**OK**)

- Cek Spasi Lapangan = s lapangan <= s max

= 150 <= 211 (**OK**)

- Av+t / s Tumpuan Pasang $= \frac{\frac{\pi}{4}\ x\ db^2\ x\ n}{s}$

= 3,540 mm^2/mm

- Av+t / s Lapangan Pasang $= \frac{\frac{\pi}{4}\ x\ db^2\ x\ n}{s}$

= 1,770 mm^2/mm

- At / s $= \frac{Tu}{(2\ x\ \phi\ x\ Ao\ x\ fyv)}$

= 0,163 mm^2/mm

- Av / s Tumpuan Perlu $= \frac{Vu}{(fyv\ x\ d)}$

= 1,063 mm^2/mm

- Av / s Lapangan Perlu $= \left(\frac{Vu}{\frac{(\phi\ x\ Vc}{(fyv\ x\ d)}}\right)$

= 0,330 mm^2/mm

- Av+t / s Tumpuan Perlu = 2 x At/s +Av/s tumpuan perlu

= 1,390

- Av+t / s Lapangan Perlu = 2 x At/s +Av/s lapangan perlu

= 0,657

- Av+t / s min 1 $= \frac{0{,}062\ x\ (f'c)0{,}5\ x\ b}{fyv}$

= 0,283

- Av+t / s min 2 $= \frac{0{,}35\ x\ b}{fyv}$

= 0,292

- Cek Geser + Torsi Tumpuan = A_{v+t} / s Pasang >= A_{v+t} / s Perlu dan min (**OK**)
- Cek Geser + Torsi Lapangan = A_{v+t} / s Pasang >= A_{v+t} / s Perlu dan min (**OK**)

Penulangan Longitudinal Torsi

- db atau dbt = 13 mm
- db, min = 0,042 x s

= 6,3 mm

- Cek db = 13 >= 6,3 (**OK**)
- As Perlu Tumpuan Atas = 1021,249mm^2
- As Perlu Tumpuan Bawah = 754,063 mm^2
- As Perlu Lapangan Atas = 1310,354 mm^2
- As Perlu Lapangan Bawah = 847,385 mm^2
- Al = A_t / s * P_h

= 275,542 mm^2

- Al min $= \frac{0{,}42\ x\ (f'c)0{,}5\ x\ Acp}{fy - At/s\ x\ Ph}$

= 874,675 mm^2

- As + Al Perlu Tumpuan = A1 min + As Perlu Tumpuan Atas + As Perlu Tumpuan Bawah

= 2171,467 mm^2

- As + Al Perlu Lapangan = A1 min + As Perlu lapangan Atas + As Perlu lapangan Bawah

= 2171,467 mm^2

- n Tumpuan Atas = 6
- n Tumpuan Tengah = 4
- n Tumpuan Bawah = 5
- n Tumpuan Vertikal = 4
- n Lapangan Atas = 8
- n Lapangan Tengah = 4
- n Lapangan Atas = 5
- n Tumpuan Vertikal = 4
- Spasi Horizontal Tumpuan $= \frac{(b-2 \text{ x } Cc-2 \text{ x } ds-db)}{(n\ atas,n\ bawah)-1}$

= 62 mm

- Spasi Vertikal Tumpuan $= \frac{(h-2 \text{ x } Cc-2 \text{ x } ds-db)}{(n\ vertikal-1)}$

= 71 mm

- Spasi Horizontal Lapangan $= \frac{(b-2 \text{ x } Cc-2 \text{ x } ds-db)}{(n\ atas,n\ bawah)-1}$

= 62 mm

- Spasi Vertikal Lapangan $= \frac{(h-2 \text{ x } Cc-2 \text{ x } ds-db)}{(5-1)}$

= 166 mm

- Cek Spasi Tulangan Longitudinal Tumpuan = 71 <= 300 (**OK**)
- Cek Spasi Tulangan Longitudinal Lapangan = 166 <= 300 (**OK**)
- As + Al Pasang Tumpuan $= \frac{(\text{n tumpuan atas} + \text{n tumpuan bawah}) \text{x } \pi}{\frac{4 \text{ x } db^2 + \text{n tumpuan tengah x } \pi}{4\ x\ ds^2}}$

= 2742,610 mm^2

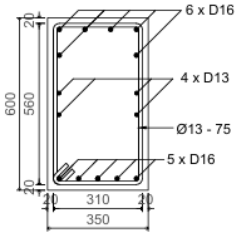
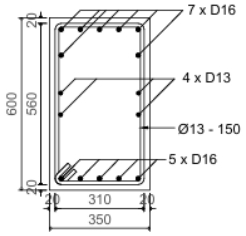
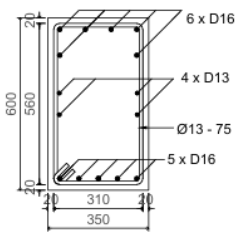
- As + Al Pasang Lapangan $= \frac{(\text{n lapangan atas} + \text{n lapangan bawah}) \times \pi}{\frac{4 \times db^2 + \text{n lapangan tengah} \times \pi}{4 \times ds^2}}$

= 3144,734 mm^2

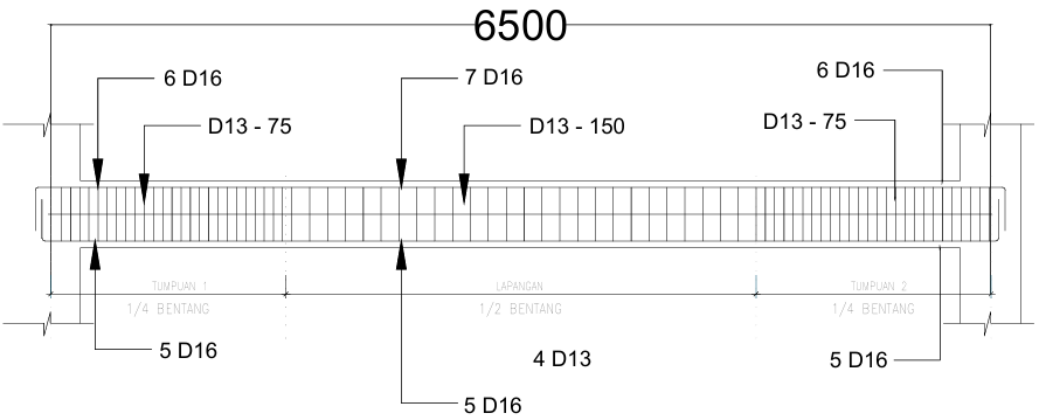
- Cek Lentur + Torsi Tumpuan = A_s + A_l Pasang >= A_s + A_l (**OK**)
- Cek Lentur + Torsi Lapangan = A_s + A_l Pasang >= A_s + A_l (**OK**)

Digunakan Tulangan Tumpuan Tengah 4 D13

Digunakan Tulangan LapanganTengah 4 D13

TYPE BALOK / LANTAI	B2		
	TUMPUAN 1	LAPANGAN	TUMPUAN 2
			
UKURAN BALOK	350 x 600		
TULANGAN ATAS	6 D16	7 D16	6 D16
TULANGAN BAWAH	5 D16	5 D16	5 D16
TUL. PEMINGGANG	4 D13	4 D13	4 D13
SENGKANG	D13 - 75	D13 - 150	D13 - 75

Gambar 2. 14 Detail Penulangan Balok 2



Gambar 2. 15 Detail Penulangan Balok 2

2.8.3 Perencanaan Balok (B3) 300 x 500

Properti Material dan Penampang

- Panjang Balok, L = 5000 mm

- Lebar Balok, b = 300 mm
- Tinggi Balok, h = 500 mm
- Panjang Tumpuan = 2 x h
  = 1000 mm
- Diameter Tulangan Longitudinal, db = 16 mm
- Diameter Tulangan Sengkang, ds = 13 mm
- Selimut Bersih, cc = 20 mm
- Kuat Tekan Beton, fc' = 30 MPa
- Kuat Leleh Tul. Longitudinal, fy = 420 MPa
- Kuat Leleh Tul. Transversal, fyv = 420 MPa
- β1 = $0{,}65 \leq 0{,}85 - 0{,}05\ x\ \frac{(f'c-28)}{7} \leq\ 0{,}85$
  = 0,8357
- Panjang Kolom, c1 = 500 mm
- Lebar Kolom, c2 = 500 mm
- Ln = L – c1

= 5000 – 500

= 4500 mm

- λ = 1

Gaya Dalam

- Mu,tumpuan (-) = -246,8317 kNm
- Mu,tumpuan (+) = 184,6816 kNm
- Mu,lapangan (-) = -265,1498 kNm
- Mu,lapangan (+) = 176,4403 kNm
- Pu = 173,075 kN

Syarat Gaya dan Geometri

- Syarat Gaya Aksial = Pu x B <= 0,1 x b x h x f'c

= 17307,5 <= 450000 (**OK**)

- Syarat Tinggi Efektif = Ln >= 4 x h

= 5000 >= 2000 (**OK**)

- Syarat Lebar 1 = b >= 0,3 x h

= 300 >= 150 (**OK**)

- Syarat Lebar 2 = b <= c2 + 2 x 0,75 x c1

= 300 <= 1250 (**OK**)

Penulangan Lentur Tumpuan Negatif

- Jumlah Tulangan Negatif Tumpuan, n = 8
- Db = 16 mm
- Jarak Bersih Antar Tulangan = $\frac{(b-2\ x\ cc-2\ x\ ds-n\ x\ db)}{(n-1)}$

= 15,143 mm

- Spasi yang digunakan,s = 50 mm
- Cek Jarak Bersih = Jarak bersih >= db

= 50 >= 16 (**IYA)**

- Jumlah Lapis = 1
- As Pasang = $\frac{\pi}{4}$ x db² x n

= 1608,495 mm²

- As min,1 = $\frac{\frac{\sqrt{f'c}}{4}}{fy\ x\ b\ x\ h}$

= 489,038 mm²

- As min,2 = $\frac{1,4}{fy\ x\ b\ x\ h}$

= 500,000 mm²

- Cek As min = As pasang >= As min

= 489,038 >= 500,000 (**OK**)

- ρ = $\frac{As\ pasang}{(b\ x\ h)}$

= 1,07 %

- ρ max,1 = $\frac{0,75\ x\ 0,85\ x\ \beta 1\ x\ f'c}{fy\ x\ (\frac{600}{(600+fy)})}$

= 2,24 %

- ρ max,2 = 2,50 %
- Cek As max = ρ <= ρ max

= 1,07 % <= 2,24 % (**OK**)

- a = $\frac{As\ x\ fy}{(0,85\ x\ f'c\ x\ b)}$

= 88,310 mm

- Mn = As x fy x (d-$\frac{a}{2}$)

= 307,954 kNm

- c = $\frac{a}{\beta 1}$

= 105,670 mm

- εs = $\frac{(d-c)}{c \text{ x } 0{,}003}$

= 0,011

- ϕ = 0,9
- ϕMn = ϕ x Mn

= 277,159 kNm

- Mu = 246,832 kNm
- Cek Kapasitas = ϕMn >= Mu

= 277,159 >= 246,832 (**OK**)

- As Perlu = $\frac{Mu}{fy\ x\ (d-\frac{a}{2})}$

= 896,087 mm²

Digunakan Tulangan 8 D16

Penulangan Lentur Tumpuan Positif

- Jumlah Tulangan Tumpuan Positif, n = 6
- Db = 16 mm

- Jarak Bersih Antar Tulangan = $\frac{(b-2\ x\ cc-2\ x\ ds-n\ x\ db)}{(n-1)}$

= 27,600 mm

- Spasi yang digunakan,s = 50 mm
- Cek Jarak Bersih = Jarak bersih >= db

= 50 >= 16 (**IYA)**

- Jumlah Lapis = 1
- As Pasang = $\frac{\pi}{4}$ x db² x n

= 1206,372 mm²

- As min,1 = $\frac{\frac{\sqrt{f'c}}{4}}{fy\ x\ b\ x\ h}$

= 489,038 mm²

- As min,2 $= \frac{1,4}{fy\ x\ b\ x\ h}$

= 500,000 mm²

- Cek As min = As pasang >= As min

= 1005,310 >= 500,000 (**OK**)

- ρ $= \frac{As\ pasang}{(b\ x\ h)}$

= 0,80 %

- ρ max,1 $= \frac{0,75\ x\ 0,85\ x\ \beta1\ x\ f'c}{fy\ x\ (\frac{600}{(600+fy)})}$

= 2,24 %

- ρ max,2 = 2,50 %
- Cek As max = ρ <= ρ max

= 0,80 % <= 2,24 % (**OK**)

- a $= \frac{As\ x\ fy}{(0,85\ x\ f'c\ x\ b)}$

= 66,232 mm

- Mn = As x fy x (d-$\frac{a}{2}$)

= 236,559 kNm

- c $= \frac{a}{\beta1}$

= 79,252 mm

- εs $= \frac{(d-c)}{c\ x\ 0,003}$

= 0,016

- ϕ = 0,9
- ϕMn = ϕ x Mn

= 0,9 x 243,350

= 212,903 kNm

- Mu = 184,682 kNm
- Cek Kapasitas = ϕMn >= Mu

= 212,903 >= 184,682 (**OK**)

- As Perlu $= \frac{Mu}{fy\ x\ (d-\frac{a}{2})}$

= 941,815 mm²

Digunakan Tulangan 6 D16

Penulangan Lentur Lapangan Negatif

- Jumlah Tulangan Lapangan Negatif, n = 8
- Db = 16 mm
- Jarak Bersih Antar Tulangan $= \frac{(b-2\ x\ cc-2\ x\ ds-n\ x\ db)}{(n-1)}$

= 15,143 mm

- Spasi yang digunakan,s = 50 mm
- Cek Jarak Bersih = Jarak bersih >= db

= 50 >= 16 (**IYA)**

- Jumlah Lapis = 1
- As Pasang $= \frac{\pi}{4}$ x db² x n

= 1608,495 mm²

- As min,1 $= \frac{\frac{\sqrt{f'c}}{4}}{fy\ x\ b\ x\ h}$

= 489,038 mm²

- As min,2 $= \frac{1,4}{fy\ x\ b\ x\ h}$

= 500,000 mm²

- Cek As min = As pasang >= As min

= 1608,495 >= 500,000 (**OK**)

- ρ $= \frac{As\ pasang}{(b\ x\ h)}$

= 1,07 %

- ρ max,1 $= \frac{0,75 \text{ x } 0,85 \text{ x } \beta 1 \text{ x } f'c}{fy\ x\ (\frac{600}{(600+fy)})}$

= 2,24 %

- ρ max,2 = 2,50 %
- Cek As max = ρ <= ρ max

= 0,57 % <= 2,24 % (**OK**)

- a $= \frac{As\ x\ fy}{(0,85\ x\ f'c\ x\ b)}$

= 88,310 mm

- Mn = As x fy x (d-$\frac{a}{2}$)

= 307,954 kNm

- c = $\frac{a}{\beta 1}$

= 105,670 mm

- εs = $\frac{(d-c)}{c \text{ x } 0{,}003}$

= 0,011

- ϕ = 0,9
- ϕMn = ϕ x Mn

= 277,159 kNm

- Mu = 265,150 kNm
- Cek Kapasitas = ϕMn >= Mu

= 277,159 >= 265,150 (**OK**)

- As Perlu = $\frac{Mu}{fy\ x\ (d-\frac{a}{2})}$

= 1384,920 mm²

Digunakan Tulangan 8 D16

Penulangan Lentur Lapangan Positif

- Jumlah Tulangan Lapangan Positif, n = 5
- Db = 16 mm

- Jarak Bersih Antar Tulangan = $\frac{(b-2\ x\ cc-2\ x\ ds-n\ x\ db)}{(n-1)}$

= 38,500 mm

- Spasi yang digunakan,s = 50 mm
- Cek Jarak Bersih = Jarak bersih >= db

= 50 >= 16 (**IYA)**

- Jumlah Lapis = 1
- As Pasang = $\frac{\pi}{4}$ x db² x n

= 1005,310 mm²

- As min,1 $= \frac{\frac{\sqrt{f'c}}{4}}{fy \; x \; b \; x \; h}$

= 489,038 mm²

- As min,2 $= \frac{1,4}{fy \; x \; b \; x \; h}$

= 500,000 mm²

- Cek As min = As pasang >= As min

= 1005,310 >= 500,000 (**OK**)

- ρ $= \frac{As \; pasang}{(b \; x \; h)}$

= 0,67 %

- ρ max,1 $= \frac{0,75 \text{ x } 0,85 \text{ x } \beta 1 \text{ x } f'c}{fy \; x \; (\frac{600}{(600+fy)})}$

= 2,24 %

- ρ max,2 = 2,50 %
- Cek As max = ρ <= ρ max

= 0,67 % <= 2,24 % (**OK**)

- a $= \frac{As \; x \; fy}{(0,85 \; x \; f'c \; x \; b)}$

= 55,193 mm

- Mn = As x fy x (d-$\frac{a}{2}$)

= 199,463 kNm

- c $= \frac{a}{\beta 1}$

= 66,043 mm

- εs $= \frac{(d-c)}{c \text{ x } 0,003}$

= 0,020

- ϕ = 0,9
- ϕMn = ϕ x Mn

= 0,9 x 199,463

= 179,517 kNm

- Mu = 176,440 kNm
- Cek Kapasitas = ϕMn >= Mu

= 179,517 >= 176,440 (**OK**)

- As Perlu $= \frac{Mu}{fy\ x\ (d-\frac{a}{2})}$

= 889,274 mm²

Digunakan Tulangan 5 D16

f) Desain Geser

Properti Material dan Penampang

- Panjang Balok, L = 5000 mm
- Lebar Balok, b = 300 mm
- Tinggi Balok, h = 500 mm
- Panjang Tumpuan = 2 x h
  = 1000 mm
- Diameter Tulangan Longitudinal, db = 16 mm
- Diameter Tulangan Sengkang, ds = 13 mm
- Selimut Bersih, cc = 20 mm
- Kuat Tekan Beton, fc' = 30 MPa
- Kuat Leleh Tul. Longitudinal, fy = 420 MPa
- Kuat Leleh Tul. Transversal, fyv = 420 MPa
- β1 $= 0{,}65 \leq 0{,}85 - 0{,}05\ x\ \frac{(f'c-28)}{7} \leq\ 0{,}85$
  = 0,8357
- Panjang Kolom, c1 = 500 mm
- Lebar Kolom, c2 = 500 mm
- Ln = L – c1

= 5000 – 500

= 4500 mm

Gaya Dalam

- Vu,tumpuan = 173,075 kN
- Vu,lapangan = 181,9281 Kn

Gaya Desain

- Vg,tumpuan = 156,2111 kN
- As+ Tumpuan = 1206,372 mm²

- As- Tumpuan = 1608,495 mm²
- apr+ = 1,25 x a (tumpuan positif)

= 82,790 mm

- apr- = 1,25 x a (tumpuan negatif)

= 110,387 mm

- Mpr+ = As (+) x (1,25 x fy) x (d - $\frac{apr}{2}$)

= 290455155 Nmm

- Mpr- = As (-) x (1,25 x fy) x (d - $\frac{apr}{2}$)

= 375621368 Nmm

- Vsway atau Vpr = $\frac{(\text{Mpr+} + \text{Mpr−})}{Ln}$

= 88810 N

- Ve = Vg + Vpr

= 245021 N

Tahanan Geser Beton

- Vpr = 88810 N
- 1/2 Ve = $\frac{Ve}{2}$

= 122511 N

- Pu = 17307,5 N
- Ag fc' / 20 = $\frac{b\ x\ h\ x\ f'c}{20}$

= 225000 N

- Vc Diperhitungkan? = Vpr >= ½ Ve dan Pu < Ag fc' / 20

= 88810 >= 122511 dan 17307,5 < 225000

(**IYA**)

- Vc = 0,17 x $\sqrt{30}$ x b x fy

= 117322 N

Penulangan Geser Tumpuan

- Jumlah Kaki = 2
- Av = $\frac{\pi}{4}$ x db² x n

= 265,465 mm²

- Spasi = 75 mm
- Spasi Max 1 = $\frac{d}{4}$

= 150 mm

- Spasi Max 2 = 6 x db

= 96 mm

- Spasi Max 3 = 150 mm
- Cek Spasi = Spasi <= spasi max 1 + spasi max 2 + spasi max 3

= 75 <= 421 (**OK**)

- Vs = Av x fyv x $\frac{d}{s}$

= 743301 N

- Batas Vs = 0.66 x $(fc')^{0,5}$ x b x d

= 542245 N

- Φ = 0,75
- Vn = Vc + Vs

= 698675 N

- Vu = 245021 N
- ϕVn / Vu = $\frac{\Phi Vn}{Vu}$

= 3,029

- Cek Kapasitas = ϕVn / Vu >= 1

= 3,029 >= 1 (**OK**)

Digunakan Tulangan 2 D13-75 mm

Penulangan Geser Lapangan

- Jumlah Kaki = 2
- Av = $\frac{\pi}{4}$ x db^2 x n

= 265,465 mm^2

- Spasi = 150 mm
- Spasi Max = $\frac{d}{2}$

= 250 mm

- Cek Spasi = Spasi <= spasi max

= 150 <= 250 (**OK**)

- Vs = Av x fyv x $\frac{d}{s}$

= 371650 N

- Batas Vs = 0.66 x $(fc')^{0,5}$ x b x d

= 542245 N

- Vc = 0,17 x $\sqrt{30}$ x b x d

= 139669 N

- Φ = 0,75
- Vn = Vc + Vs

= 511320 N

- Vu = 181928,1 N
- ϕVn / Vu = $\frac{\Phi Vn}{Vu}$

= 2,108

- Cek Kapasitas = ϕVn / Vu >= 1

= 2,108 >= 1 (**OK**)

Digunakan Tulangan 2 D13-150 mm

g) Desain Torsi

Properti Material dan Penampang

- Panjang Balok, L = 5000 mm
- Lebar Balok, b = 300 mm
- Tinggi Balok, h = 500 mm
- Panjang Tumpuan = 2 x h

  = 1000 mm
- Diameter Tulangan Longitudinal, db = 16 mm
- Diameter Tulangan Sengkang, ds = 13 mm
- Selimut Bersih, cc = 20 mm
- Kuat Tekan Beton, fc' = 30 MPa
- Kuat Leleh Tul. Longitudinal, fy = 420 MPa

- Kuat Leleh Tul. Transversal, fyv = 420 MPa
- β1 = $0{,}65 \leq 0{,}85 - 0{,}05\ x\ \frac{(f'c-28)}{7} \leq\ 0{,}85$

  = 0,8357
- Panjang Kolom, c1 = 500 mm
- Lebar Kolom, c2 = 500 mm
- Ln = L – c1

= 5000 – 500

= 4500 mm

Parameter Geometri Penampang untuk Perhitungan Torsi

- Acp = b x h

= 150000 mm²

- Pcp = 2 x (b + h)

= 1600 mm

- xo = b – 2 x Cc – ds

= 247 mm

- yo = b – 2 x Cc – ds

= 447 mm

- Aoh = xo x yo

= 110409 mm²

- Ao = 0,85 x Aoh

= 93848 mm²

- Ph = 2 x (xo + yo)

= 1388 mm

Gaya Dalam

- Tu = 12,135 kNm

Pengecekan Kebutuhan Tulangan Torsi

- Tcr = $0{,}33 \times (f'c)^{0,5} \times \frac{Acp^2}{Pcp}$

= 25417750 Nm

- Φ = 0,75
- ϕ Tcr / 4 = $\frac{\phi\ Tcr}{4}$

= 4765828 Nmm

- Perlu Tulangan Torsi = Tu > ϕ Tcr / 4 ?

= 12,135 > 4765828 (**IYA**)

Pengecekan Kecukupan Dimensi Penampang

- Jenis Torsi = Kompatibilitas
- Tu Pakai = Tu x 10^6

= 112135000 Nmm

- Vu = 245021 N
- Vc = 0,17 x $\sqrt{30}$ x b x d

= 139669 N

- Tegangan Utimate Geser+Torsi = $((\frac{Vu}{b\ x\ d})^2 + \left(\frac{Tu\ x\ Ph}{(1{,}7\ x\ Aoh^2)}\right)^2)^{0{,}5}$

= 1,825 MPa

- Kapasitas Tegangan Beton = Φ x $(\frac{Vc}{b\ x\ d})$ + 0,66 x $(f'c)^{0{,}5}$

= 3,410 MPa

- Cek Dimensi Penampang = Ruas kiri ≤ ruas kanan

= 1,825 ≤ 3,410 (**OK**)

Parameter Umum lainnya

- fy / fyt = 1
- θ = 45º

Penulangan Transversal Torsi

- n kaki Tumpuan = 2
- n kaki Lapangan = 2
- s Tumpuan = 75 mm
- s Lapangan = 150 mm
- s max 1 = $\frac{Ph}{8}$

= 174 mm

- s max 2 = 300 mm
- Cek Spasi Tumpuan = s tumpuan ≤ s max

= 75 ≤ 174 (**OK**)

- Cek Spasi Lapangan = s lapangan ≤ s max

= 150 ≤ 211 (**OK**)

- Av+t / s Tumpuan Pasang $= \frac{\frac{\pi}{4} \text{ x db}^2 \text{ x n}}{s}$

= 3,540 mm^2/mm

- Av+t / s Lapangan Pasang $= \frac{\frac{\pi}{4} \text{ x db}^2 \text{ x n}}{s}$

= 1,770 mm^2/mm

- At / s $= \frac{\text{Tu}}{(2\ x\ \phi \text{ x Ao x fyv})}$

= 0,205 mm^2/mm

- Av / s Tumpuan Perlu $= \frac{\text{Vu}}{(fyv\ x\ d)}$

= 1,167 mm^2/mm

- Av / s Lapangan Perlu $= \left(\frac{\text{Vu}}{\frac{(\phi\ x\ Vc}{(fyv\ x\ d)}} \right)$

= 0,490 mm^2/mm

- Av+t / s Tumpuan Perlu = 2 x At/s +Av/s tumpuan perlu

= 1,577

- Av+t / s Lapangan Perlu = 2 x At/s +Av/s lapangan perlu

= 0,901

- Av+t / s min 1 $= \frac{0{,}062 \text{ x } (f'c)0{,}5 \text{ x b}}{fyv}$

= 0,243

- Av+t / s min 2 $= \frac{0{,}35 \text{ x b}}{fyv}$

= 0,250

- Cek Geser + Torsi Tumpuan = A_{v+t} / s Pasang ≥ A_{v+t} / s Perlu dan min (**OK**)
- Cek Geser + Torsi Lapangan = A_{v+t} / s Pasang ≥ A_{v+t} / s Perlu dan min (**OK**)

Penulangan Longitudinal Torsi

- db atau dbt = 13 mm
- db, min = 0,042 x s

= 6,3 mm

- Cek db = 13 ≥ 6,3 (**OK**)

- As Perlu Tumpuan Atas = 896,087 mm^2
- As Perlu Tumpuan Bawah = 941,815 mm^2
- As Perlu Lapangan Atas = 1384,920 mm^2
- As Perlu Lapangan Bawah = 889,274 mm^2
- Al = A_t / s * P_h

= 284,882 mm^2

- Al min = $\frac{0,42 \text{ x } (f'c)0,5 \text{ x Acp}}{fy - At/s \text{ x } Ph}$

= 536,702 mm^2

- As + Al Perlu Tumpuan = A1 min + As Perlu Tumpuan Atas + As Perlu Tumpuan Bawah

= 2981,241 mm^2

- As + Al Perlu Lapangan = A1 min + As Perlu lapangan Atas + As Perlu lapangan Bawah

= 3417,533 mm^2

- n Tumpuan Atas = 8
- n Tumpuan Tengah = 4
- n Tumpuan Bawah = 6
- n Tumpuan Vertikal = 4
- n Lapangan Atas = 8
- n Lapangan Tengah = 4
- n Lapangan Atas = 5
- n Tumpuan Vertikal = 4
- Spasi Horizontal Tumpuan = $\frac{(b - 2 \text{ x } Cc - 2 \text{ x } ds - db)}{(n\ atas, n\ bawah) - 1}$

= 40 mm

- Spasi Vertikal Tumpuan = $\frac{(h - 2 \text{ x } Cc - 2 \text{ x } ds - db)}{(n\ vertikal - 1)}$

= 57 mm

- Spasi Horizontal Lapangan = $\frac{(b - 2 \text{ x } Cc - 2 \text{ x } ds - db)}{(n\ atas, n\ bawah) - 1}$

= 50 mm

- Spasi Vertikal Lapangan = $\frac{(h - 2 \text{ x } Cc - 2 \text{ x } ds - db)}{(5 - 1)}$

= 133 mm

- Cek Spasi Tulangan Longitudinal Tumpuan = 57 ≤ 300 (**OK**)
- Cek Spasi Tulangan Longitudinal Lapangan = 133 ≤ 300 (**OK**)
- As + Al Pasang Tumpuan $= \frac{(\text{n tumpuan atas} + \text{n tumpuan bawah}) \times \pi}{\frac{4 \times db^2 + \text{n tumpuan tengah} \times \pi}{4 \times ds^2}}$

= 3345,796 mm^2

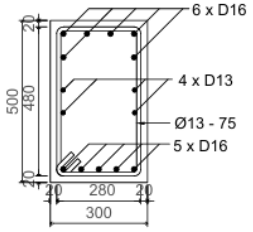
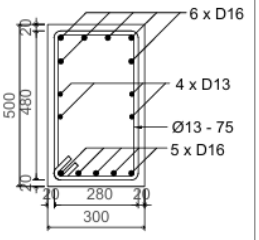
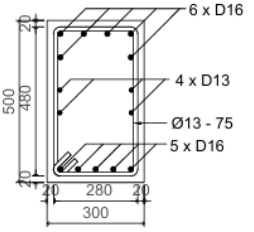
- As + Al Pasang Lapangan $= \frac{(\text{n lapangan atas} + \text{n lapangan bawah}) \times \pi}{\frac{4 \times db^2 + \text{n lapangan tengah} \times \pi}{4 \times ds^2}}$

= 3144,734 mm^2

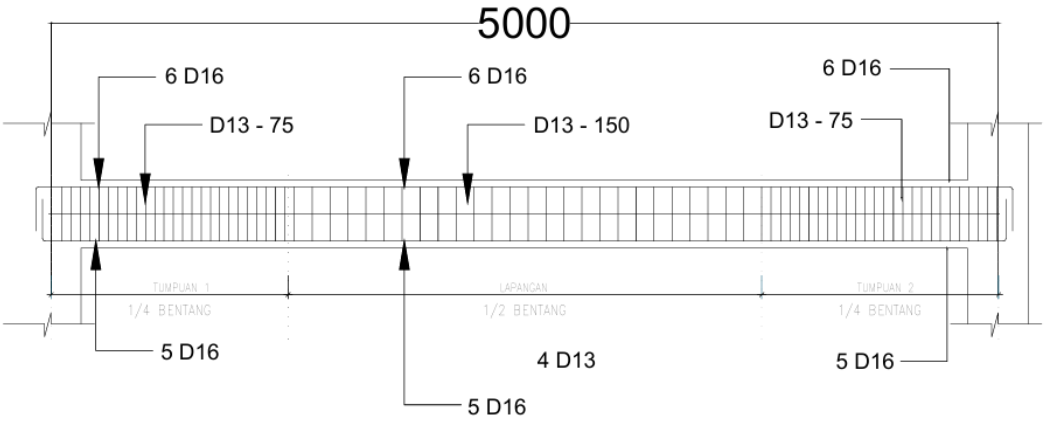
- Cek Lentur + Torsi Tumpuan = $A_s + A_l$ Pasang ≥ $A_s + A_l$ (**OK**)
- Cek Lentur + Torsi Lapangan = $A_s + A_l$ Pasang ≥ $A_s + A_l$ (**OK**)

Digunakan Tulangan Tumpuan Tengah 4 D13

Digunakan Tulangan LapanganTengah 4 D13

TYPE BALOK / LANTAI	B3		
	TUMPUAN 1	LAPANGAN	TUMPUAN 2
			
UKURAN BALOK	300 x 500		
TULANGAN ATAS	6 D16	6 D16	6 D16
TULANGAN BAWAH	5 D16	5 D16	5 D16
TUL. PEMINGGANG	4 D13	4 D13	4 D13
SENGKANG	D13 - 75	D13 - 150	D13 - 75

Gambar 2. 16 Detail Penulangan Balok 3



Gambar 2. 17 Detail Penulangan Balok 3

2.9 Perencanaan Kolom

a. Desain Longitudinal

Properti Material dan Penampang

- Panjang/Tinggi Kolom, L = 4000 mm
- Sisi Pendek Kolom, b = 500 mm
- Sisi Panjang Kolom, h = 500 mm
- Diameter Tulangan Longitudinal, db = 29 mm
- Diameter Tulangan Sengkang, ds = 16 mm
- Selimut Bersih, cc = 20 mm
- Kuat Tekan Beton, fc' = 30 MPa
- Kuat Leleh Tul. Longitudinal, fy = 420 MPa
- Kuat Leleh Tul. Transversal, fyv = 420 MPa
- Tinggi Balok, hb = 700 mm
- Ln = L – hb
  = 4000 - 700
  = 3300 mm

Syarat Gaya dan Geometri

- Syarat Gaya Aksial = Pu > 0.1 Ag fc'
  = 2709,03 x 10^3 > 0.1 x 500 x 500 x 30
  = 2709030 > 750000 **(OK)**
- Syarat Sisi Terpendek = b ≥ 300 mm
  = 500 ≥ 300 **(OK)**

- Syarat Rasio Dimensi Penampang = b/h ≥ 0,4
  = $\frac{500}{500} \geq 0,4$
  = 1 ≥ 0,4 **(OK)**

Pengecekan terhadap Gaya Dalam Aksial – Lentur (menggunakan SP Column)

- Jumlah Tulangan, n = 20
- Luas Tulangan Longitudinal, As = n x π/4 x db^2
  = 20 x π/4 x 29^2
  = 13210,4 mm^2
- Rasio Tulangan, ρ = As / (b x h)
  = 13210,4 / (500 x 500)%
  = 5,28%
- Cek ρmin dan ρmax = 1% ≤ ρ ≤ 6%
  = 1% ≤ 5,28% ≤ 6% **(OK)**

Tabel 2. 13 Pengecekan Strong Column – Weak Beam (SCWB)

ϕMnx	**ϕMny**	**ϕ**	**Mnx**	**Mny**
kNm	kNm			
805,7	357,97	0,807	998,3890954	443,5811648
ϕMnx	**ϕMny**	**ϕ**	**Mnx**	**Mny**
174,2	-694,5	0,65	268	-1068,461538
602,7	546,27	0,766	786,8146214	713,1462141
-606,21	-539,98	0,762	-795,5511811	-708,6351706

- Momen Nominal Kolom, Mnc = 268 kNm
- Mn- Tumpuan Balok = 261,012 kNm
- Mn+ Tumpuan Balok = 168,941 kNm
- Cek SCWB = 2 x Mnc ≥ 1,2 x (Mn- + Mn+)
  = 2 x 268 ≥ 1,2 x (261,012 + 168,941)
  = 536 ≥ 515,94 (OK)

Digunakan Tulangan Longitudinal 20 D29

b. Desain Transversal

Panjang Zona Sendi Plastis

- lo1 = 500 mm
- lo2 = Ln/6
  = 3300/6
  = 550 mm
- lo3 = 450 mm
- lo (max lo1 – lo 3) = 550 mm

Tulangan Transversal Zona Sendi Plastis/Tumpuan

- Jumlah Kaki Sisi Pendek, n1 = 4
- Jumlah Kaki Sisi Panjang, n2 = 4
- Spasi, s = 100 mm
- Spasi Kaki Terbesar, xi max = 300 mm
- Ash 1 = n x π/4 x ds^2

= 4 x π/4 x 16^2

= 804,248 mm^2

- Ash 2 = n x π/4 x ds^2

= 4 x π/4 x 16^2

= 804,248 mm^2

- Ash / s ,1 = 804,248 / 100

= 8,042 mm^2/mm

- Ash / s ,2 = 804,248 / 100

= 8,042 mm^2/mm

Digunakan tulangan 4 D16 – 100mm

Confinement/Kekangan Zona Sendi Plastis

- Lebar Penampang Inti Beton, bc = b – 2cc

= 460 mm

- Panjang Penampang Inti Beton, hc = h – 2cc

= 460 mm

- Luas Penampang Kolom, Ag = b x h

= 500 x 500

= 250000 mm^2

- Luas Penampang Inti Beton, Ach = bc x hc

= 460 x 460

= 211600 mm^2

Sisi Pendek/Sumbu Lemah

- Ash/s min, 1 = 0,3 x (bc x fc' / fyv) x (Ag / Ach – 1)

= 0,3 x (460 x 30 / 420) x (250000 / 211600 – 1)

= 1,789 mm^2

- Ash/s min, 2 = 0.09 x bc x fc' / fyv

= 0.09 x 460 x 30 / 420

= 2,957 mm^2

- Cek Ash/s 1 = Ash/s 1 ≥ Ash/s min

= 8,042 ≥ 1,789 **(OK)**

Sisi Panjang/Sumbu Kuat

- Ash/s min, 1 = 0,3 x (bc x fc' / fyv) x (Ag / Ach – 1)

= 0,3 x (460 x 30 / 420) x (250000 / 211600 – 1)

= 1,789 mm^2

- Ash/s min, 2 = 0.09 x bc x fc' / fyv

= 0.09 x 460 x 30 / 420

= 2,957 mm^2

- Cek Ash/s 2 = Ash/s 2 ≥ Ash/s min

= 8,042 ≥ 2,957 **(OK)**

Cek Spasi

- smax,1 = b/4

= 500/4

= 125 mm

- smax,2 = 6 x db

= 6 x 29

= 174 mm

- hx = 300 mm (xi max)
- smax,3 = so = 100 ≤ 100 + (350 - hx) / 3 ≤ 150

= 100 ≤ 116,67 ≤ 150

- smax = 116,67 mm
- Cek Spasi = smax ≤ s

= 116,67 ≤ 100 **(OK)**

Kuat Geser Zona Sendi Plastis

- Mpr Kolom = 1111,563 kNm (nilai terbesar
- Vu 1 = 2 x Mpr Kolom / Ln

= 2 x 1111,563 / 3300

= 673675 N

Tabel 2. 14 Gaya Geser Hasil Analisis Struktur Arah x

Arah x				
Kode Kolom	Kondisi	Pu (kN)	Mx (kNm) M2	Vx (kNm)
K1	Pu max	-162,6923	32,6288	77,7283
	Pu min	2709,0374	4,6769	
	Mx max	121,7858	166,9112	
	Mx min	175,8888	168,3702	

Tabel 2. 15 Gaya Geser Hasil Analisis Struktur Arah y

Arah y				
Kode Kolom	Kondisi	Pu (kN)	Mx (kNm) M3	Vy (kNm)
K1	Pu max	162,6923	14,497	89,3746
	Pu min	-2709,0374	-18,6463	
	Mx max	-28,1241	151,2814	
	Mx min	-209,4668	-149,977	

- Vu 2, Sumbu Lemah = Vx x 10^3
  = 77,7283 x 10^3
  = 7772,83 N
- Vu 2, Sumbu Kuat = Vy x 10^3
  = 89,3746 x 10^3
  = 8937,46 N

Tahanan Geser Beton Sumbu Lemah

- Vu = Max (Vu1, Vu2)
  = 673675 N
- Φ = 0,75
- Vc = 0.17 [(1 + Nu/(14 Ag)] (fc') 0.5 h d; d = b - cc - ds - db / 2
  = 209278 N
- Vs Perlu = Vu / φ – Vc
  = 673675 / 0,75 - 209278
  = 688955 N
- As/s Perlu = Vs / (fyv x d); d = b - cc - ds - db / 2
  = 688955 / (420 x (500 – 20 – 16 – 29/2))
  = 3,6493 mm^2/mm
- As/s Min 1 = 0.062 (fc) 0.5 h / fyv
  = 0.062 (30) 0.5 x 500/420
  = 0,4043 mm^2/mm
- As/s Min 2 = 0.35 h / fyv
  = 0.35 x 500 / 420
  = 0,4167 mm^2/mm
- Cek As/s = Ash/s 2 ≥ Max (As/s Perlu, As/s Min)
  = 8,42 ≥ 3,6493 (OK)

Tulangan Transversal Luar Zona Sendi Plastis/Tumpuan

- Jumlah Kaki Sisi Pendek, n1 = 4
- Jumlah Kaki Sisi Panjang, n2 = 4
- Spasi, s = 150 mm
- Av Sumbu Lemah = n x π/4 x ds^2
  = 4 x π/4 x 16^2
  = 804,248 mm^2
- Av Sumbu Kuat = n x π/4 x ds2
  = 4 x π/4 x 16^2
  = 804,248 mm^2

Confinement/Kekangan Luar Zona Sendi Plastis

- Spasi max 1 = 6 x db

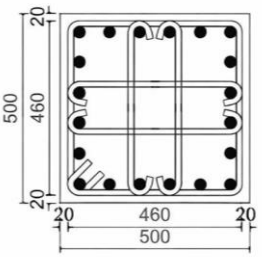
= 6 x 29

= 174 mm

- Spasi max 2 = 150 mm
- Cek Spasi = Spasi ≤ Spasi Max

= 150 ≤ 150 **(OK)**

Digunakan tulangan 4 D16 – 150 mm

KOLOM	TULANGAN
K1	
UKURAN BALOK	500 x 500
TULANGAN ATAS	20 D29
SENGKANG TUMPUAN ATAS	5 D16
SENGKANG LAAPANGAN	4 D13
SENGKANG TUMPUAN BAWAH	D13 - 75

Gambar 2. 18 Detail Penulangan Kolom

2.10 Hubungan Balok Kolom

a. Balok B1 dan B2

Properti Material dan Penampang

- Lebar Y Kolom, b = 500 mm
- Lebar X Kolom, h = 500 mm
- Panjang Kolom, L = 3500 mm
- Kuat Tekan Beton, fc' = 30 MPa
- Kuat Leleh Baja Tulangan, fy = 420 MPa
- Faktor Beton Ringan, λ = 1
- Tinggi Balok Terbesar, hb = 600 mm
- Panjang Bersih Kolom, Ln = L – hb

= 2900 mm

Data Lebar dan Eksentritas Balok

- Lebar Balok 1, bb1 = 350 mm
- Lebar Balok 2, bb2 = 350 mm
- Lebar Balok 3, bb3 = 400 mm
- Lebar Balok 4, bb4 = 400 mm
- x1a = (h-bb1)/2
  = (500 – 350)/2
  = 75 mm (OK)
- x1b = (h-bb1)/2
  = (500 – 350)/2
  = 75 mm
- Cek Lebar Sisi Kolom 1 = bb1 + x1a + x1b
  = 350 + 75 + 75
  = 500 mm
- x2a = (h-bb2)/2
  = (500 – 350)/2
  = 75 mm (OK)
- x2b = (h-bb2)/2
  = (500 – 350)/2
  = 75 mm
- Cek Lebar Sisi Kolom 1 = bb2 + x2a + x2b
  = 350 + 75 + 75
  = 500 mm
- x3a = (b-bb3)/2
  = (500 – 400)/2
  = 50 mm (OK)
- x3b = (b-bb3)/2
  = (500 – 400)/2
  = 50 mm
- Cek Lebar Sisi Kolom 1 = bb3 + x3a + x3b
  = 400 + 50 + 50
  = 500 mm
- x4a = (b-bb4)/2

= (500 – 400)/2

= 50 mm (OK)

- x4b = (b-bb4)/2

  = (500 – 400)/2

  = 50 mm

- Cek Lebar Sisi Kolom 1 = bb4 + x4a + x4b

  = 500 mm

Dimensi Joint

- x terkecil sisi 1, x1 = 75 mm
- x terkecil sisi 2, x2 = 75 mm
- x terkecil sisi 3, x3 = 50 mm
- x terkecil sisi 4, x4 = 50 mm
- Lebar Joint Sisi 1, bj1 = MIN (bb1+h, bb1+2 x x1)

  = MIN (350+500 , 350+2x75)

  = 500 mm

- Lebar Joint Sisi 2, bj2 = 500 mm

  = MIN (bb2+h, bb2+2 x x2)

  = MIN (350+500 , 350+2x75)

  = 500 mm

- Lebar Joint Sisi 3, bj3 = MIN (bb3+h, bb3+2*x3)

  = MIN (400+500 , 400+2x50)

  = 500 mm

- Lebar Joint Sisi 4, bj4 = MIN (bb4+h, bb4+2*x4)

  = MIN (400+500 , 400+2x50)

  = 500 mm

- Lebar Efektif Joint Y, bj = MIN (bj1, bj2)

  = 500 mm

- Lebar Efektif Joint X, hj = MIN (bj3, bj4)

  = 500 mm

- Luas Efektif Joint Gempa X, AjX = bj x h

  = 500 x 500

  = 250000 mm^2

- Luas Efektif Joint Gempa Y, AjY = b x hj
  = 500 x 500
  = 250000 mm^2
- Cek Tinggi Joint = hj ≥ 1/2 hb
  = 500 ≥ 250 (OK)

Data dan Gaya Tulangan Balok

- Diameter Tulangan Utama Balok, db = 16
- Cek Dimensi Kolom = b ≥ 20 x db
  = 500 ≥ 320 (OK)
- Tulangan Atas Balok 1, As-1 = n x π/4 x db^2
  = 6 x π/4 x 16^2
  = 1206,372 mm^2
- Tulangan Bawah Balok 1, As+1 = n x π/4 x db^2
  = 4 x π/4 x 16^2
  = 804,248 mm^2
- Tulangan Atas Balok 2, As-2 = n x π/4 x db^2
  = 6 x π/4 x 16^2
  = 1206,372 mm^2
- Tulangan Bawah Balok 2, As+2 = n x π/4 x db^2
  = 4 x π/4 x 16^2
  = 804,248 mm^2
- Tulangan Atas Balok 3, As-3 = n x π/4 x db^2
  = 6 x π/4 x 16^2
  = 1206,372 mm^2
- Tulangan Bawah Balok 3, As+3 = n x π/4 x db^2
  = 4 x π/4 x 16^2
  = 804,248 mm^2
- Tulangan Atas Balok 4, As-4 = n x π/4 x db^2
  = 6 x π/4 x 16^2
  = 1206,372 mm^2
- Tulangan Bawah Balok 4, As+4 = n x π/4 x db^2

= 4 x π/4 x 16^2

= 804,248 mm^2

- Tegangan Probable Tulangan, fpr = 1.25 x fy

  = 1.25 x 420

  = 525 MPa

- Gaya Tulangan Atas Balok 1, Fs-1 = As x fpr

  = 1206,372 x 525

  = 633345 N

- Gaya Tulangan Bawah Balok 1, Fs+1 = As x fpr

  = 804,248 x 525

  = 422230 N

- Gaya Tulangan Atas Balok 2, Fs-2 = As x fpr

  = 1206,372 x 525

  = 633345 N

- Gaya Tulangan Bawah Balok 2, Fs+2 = As x fpr

  = 804,248 x 525

  = 422230 N

- Gaya Tulangan Atas Balok 3, Fs-3 = As x fpr

  = 1206,372 x 525

  = 633345 N

- Gaya Tulangan Bawah Balok 3, Fs+3 = As x fpr

  = 804,248 x 525

  = 422230 N

- Gaya Tulangan Atas Balok 4, Fs-4 = As x fpr

  = 1206,372 x 525

  = 633345 N

- Gaya Tulangan Bawah Balok 4, Fs+4 = As x fpr

  = 804,248 x 525

  = 422230 N

Gaya Geser Akibat Balok

- Geser Ketika Arah Gempa X- = Fs-3 + Fs+4

  = 633345 + 422230

= 1055575 N

- Geser Ketika Arah Gempa X+ = Fs-4 + Fs+3
  = 633345 + 422230
  = 1055575 N
- Geser Ketika Arah Gempa Y- = Fs-1 + Fs+2
  = 633345 + 422230
  = 1055575 N
- Geser Ketika Arah Gempa Y+ = Fs-2 + Fs+1
  = 633345 + 422230
  = 1055575 N

Gaya Geser Kolom (Beam Hinging)

- Mpr- Balok 1 = 458487714 Nmm
- Mpr+ Balok 1 = 290271292 Nmm
- Mpr- Balok 2 = 458487714 Nmm
- Mpr+ Balok 2 = 290271292 Nmm
- Mpr- Balok 3 = 458487714 Nmm
- Mpr+ Balok 3 = 290271292 Nmm
- Mpr- Balok 4 = 458487714 Nmm
- Mpr+ Balok 4 = 290271292 Nmm
- Ve Balok 1 = [(Mpr+4+Mpr-3)+(Ve3+Ve4)*h/2]/Ln

= [(290271292+458487714) + (206966+206966) x 500/2]/2900

= 206966 N

- Ve Balok 2 = [(Mpr+3+Mpr-4)+(Ve3+Ve4)*h/2]/Ln

= 206966 N

- Ve Balok 3 = [(Mpr+2+Mpr-1)+(Ve1+Ve2)*h/2]/Ln

= 206966 N

- Ve Balok 4 = [(Mpr+1+Mpr-2)+(Ve1+Ve2)*h/2]/Ln

= 206966 N

- Geser Kolom Arah Gempa X- (C – Vcol)

= [(Mpr+4+Mpr3)+(Ve3+Ve4)*h/2]/Ln

= 293876 N

- Geser Kolom Arah Gempa X+ (C – Vcol)

= [(Mpr+3+Mpr-4)+(Ve3+Ve4)*h/2]/Ln

= 293876 N

- Geser Kolom Arah Gempa Y- (C – Vcol)

= [(Mpr+2+Mpr-1)+(Ve1+Ve2)*h/2]/Ln

= 293876 N

- Geser Kolom Arah Gempa Y+ (C – Vcol)

= [(Mpr+1+Mpr-2)+(Ve1+Ve2)*h/2]/Ln

= 293876 N

Gaya Geser Total Joint

- Geser Joint Ketika Arah Gempa X- = Fs + C – Vcol

= 1055575 – 293876

= 761699 N

- Geser Joint Ketika Arah Gempa X+ = Fs + C – Vcol

= 1055575 – 293876

= 761699 N

- Geser Joint Ketika Arah Gempa Y- = Fs + C – Vcol

= 1055575 – 293876

= 761699 N

- Geser Joint Ketika Arah Gempa Y+ = Fs + C – Vcol

= 1055575 – 293876

= 761699 N

Kuat Geser Joint

- Konfigurasi Joint = 2
- Faktor Pengali Kuat Geser, c = 1,2
- Kuat Geser Nominal Joint Gempa X, VnX = c x λ x √fc' x AjX

= 1,2 x 1 x √30 x 250000

= 164368 N

- Kuat Geser Nominal Joint Gempa Y, VnY = c x λ x √fc' x AjY

= 1,2 x 1 x √30 x 250000

= 164368 N

- Faktor Reduksi, Φ = 0,85
- Kuat Geser Joint Gempa X, ΦVnX = Φ * VnX

= 0, 85 x 164368

= 1396693 N

- Kuat Geser Joint Gempa X, ΦVnY = Φ * VnX

= 0, 85 x 164368

= 1396693 N

- Gaya Geser Joint Gempa X, VuX = MAX (Geser Joint Gempa X)

= 761699 N

- Gaya Geser Joint Gempa Y, VuY = MAX (Geser Joint Gempa Y)

= 761699 N

- Faktor Keamanan Gempa X, SFX = ΦVnX / VuX

= 1396693/761699

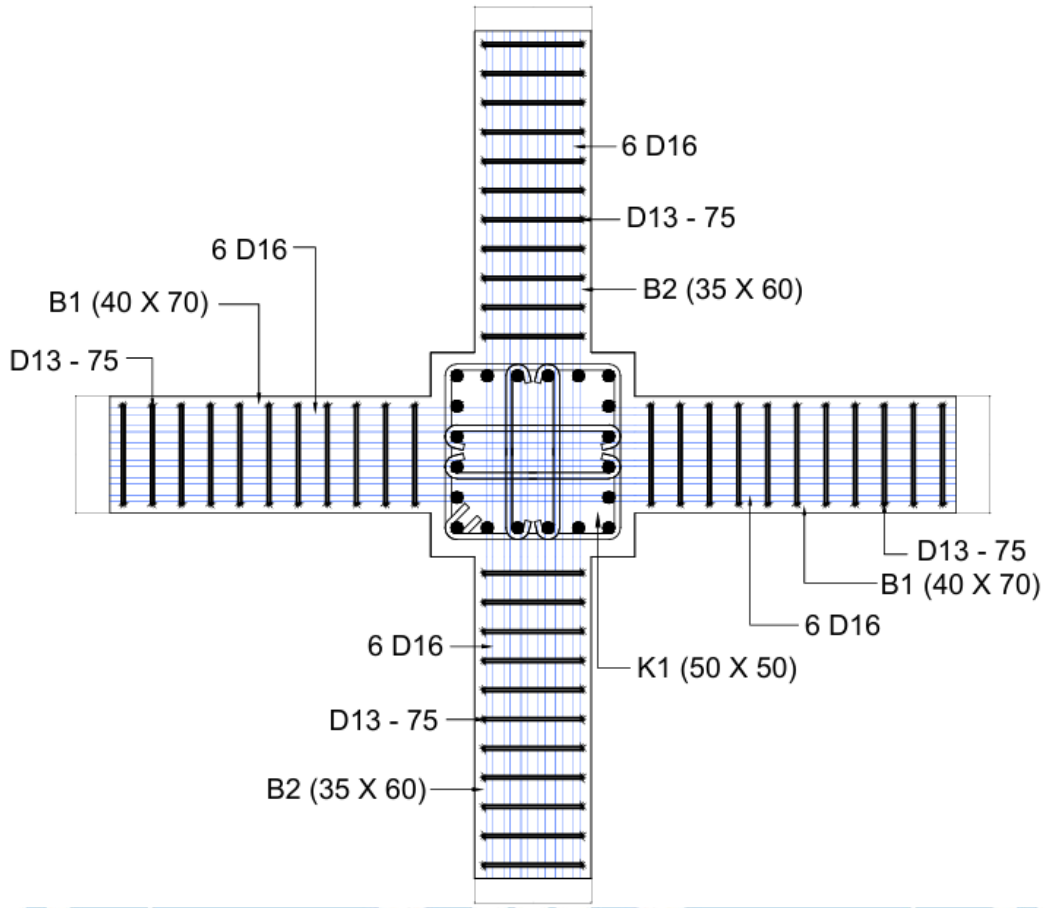
= 1,834

- Faktor Keamanan Gempa Y, SFY = ΦVnY / VuY

= 1396693/761699

= 1,834

- Cek Kuat Geser Joint = SF ≥ 1 (OK)



Gambar 2. 19 Detail Hubungan Balok Kolom

2.11 Pondasi

2.11.1 Perencanaan Pondasi Pancang

Dimensi Pondasi

- Beban Pondasi :
- P = 276244,88 kg
- Mutu Baja (fy) = 4283 kg/cm²

= 420 MPa

- Mutu Beton (f'c) = 306 kg/cm²

= 30 MPa

Daya Dukung Tiang

- Ukuran Tiang Pancang = 40 x 40 cm
- Luas Tiang (A) = p x l

= 40 x 40

= 1600 cm²

- Keliling Tiang = l x 4

= 40 x 4

= 160 cm

- P ijin = 0,33 x f'c x A

= 0,33 x 30 x 1600

= 161525,76 kg

Daya Dukung Tanah

- Qc = 150 kg/cm²
- Tf = 300 kg/cm²
- Kedalaman = 6 m
- P ijin $= \frac{\text{qc x A}}{3} + \frac{\text{Tf x keliling}}{5}$

$= \frac{150 \text{ x } 1600}{3} + \frac{300 \text{ x } 160}{5}$

= 89600 kg

- P ijin yang digunakan = 89600 kg
- N $= \frac{\text{P}}{P \text{ ijin yang digunakan}}$

$= \frac{276244{,}88}{89600}$

= 3,08

= 4 buah tiang

Digunakan Tiang 4 D32

- Cek $= \frac{P}{Jumlah\ tulangan}$

$= \frac{276244{,}88}{4}$

= 69061,22 (**OK**)

Tulangan Pondasi Pancang

- A = 1% x A tiang

  = 16 cm²

Tulangan Sengkang

- Diameter tulangan = 25 mm

- Luas profil tulangan = 0,25 x π x $\frac{\text{diameter tulangan}}{10^2}$

= 0,25 x π x $\frac{25}{10^2}$

= 4,91 cm²

- Jumlah tulangan = 12 buah
- A = Luas profil tulangan x jumlah tulangan

= 4,91 x 12

= 58,875 cm²

- Cek = A > A

= 58,875 > 16 (**OK**)

Digunakan Tulangan Sengkang D13-150

2.11.2 Perencanaan Pile Cap

Pile Cap

- Mutu Baja (fy) = 4283 kg/cm²
  = 420 MPa
- Mutu Beton (f'c) = 306 kg/cm²
  = 30 MPa
- P = 276244,88 kg
  = 276,24488 ton
- Rencana Tebal Pile Cap = 100 cm
- Selimut Beton = 7,5 cm
- d = rencana tebal pile cap – selimut beton
  = 100 – 7,5
  = 92,5
- Jumlah Tiang Pancang = 4 D40
- Jarak Tiang Pancang = Ø x 2
  = 40 x 2
  = 80 cm
- Jarak Tiang Pancang ke Tepi = jumlah tiang pancang x 1
  = 40 x 1
  = 40 cm

- Jarak Pondasi = 0,5 x d x 2
  = 0,5 x 92,5 x 2
  = 92,5 cm
- Jarak As Kolom ke As Pile $= \frac{\text{jarak tiang pancang}}{2}$
  $= \frac{80}{2}$
  = 40 cm
- Ukuran Kolom = 500 x 500 mm
- Jarak Luar Kolom ke As Pile $= (\frac{\text{jarak tiang pancang}}{2}) - (\frac{\text{panjang kolom}}{2})$
  $= (\frac{80}{2}) - (\frac{500}{2})$
  = 15 cm

Cek Tegangan

Terhadap Panjang Kolom

- Tegangan Ijin Pondasi = 0,65 x $(f'c)^{0,5}$
  = 0,65 x $(30)^{0,5}$
  = 11,37 kg/cm
- Tegangan Pondasi $= \frac{P}{(4\ x\ (panjang\ kolom + jarak\ pondasi) x\ d)}$
  $= \frac{276244,88}{(4\ x\ (500 + 92,5) x\ 92,5)}$
  = 5,24
- Cek = Tegangan Pondasi < Tegangan Ijin
  = Pondasi x 0,7
  = 5,24 < 11,37 x 0,7
  = 5,24 < 7,959 (**AMAN**)

Terhadap Lebar Kolom

- Tegangan Ijin Pondasi = 0,65 x $(f'c)^{0,5}$
  = 0,65 x $(30)^{0,5}$
  = 11,37 kg/cm
- Tegangan Pondasi $= \frac{P}{(4\ x\ (panjang\ kolom + jarak\ pondasi) x\ d)}$

$= \frac{276244,88}{(4\ x\ (500+\ 92,5) x\ 92,5)}$

= 5,24

- Cek = Tegangan Pondasi < Tegangan Ijin

  = Pondasi x 0,7

  = 5,24 < 11,37 x 0,7

  = 5,24 < 7,959 (**AMAN**)

Penulangan Tiang Pancang

- Momen,Mu = P x 1000 x 2 x $(\frac{\text{jarak luar kolom ke As Pile}}{100})$

  = 276,24488 x 1000 x 2 x $\left(\frac{15}{100}\right)$

  = 82873,464 Kgm

- As = $\frac{(\text{Mu x } 1,5 \text{ x } (1000))}{(0,8\ x\ 1000\ x\ (d\ x\ 10)^2)}$

  = $\frac{(82873,464 \text{ x } 1,5 \text{ x } (1000))}{(0,8\ x\ 1000\ x\ (92,5\ x\ 10)^2)}$

  = 0,1816 MPa

- ρ perlu = $(\frac{0,85 \text{ x } f'c}{fy})$ x (1- $(\frac{1-(2 \text{ x As})}{(0,85\ x\ (f'c)^{0,5})})$

  = $(\frac{0,85 \text{ x } 30}{420})$ x (1- $(\frac{1-(2 \text{ x } 0,1816)}{(0,85\ x\ (30)^{0,5})})$

  = 0,000434

- ρ min = $\frac{1,4}{fy}$

  = $\frac{1,4}{420}$

  = 0,00333

- A tul x = ρ perlu < ρ min x 100 x d

  = 0,000434 < 0,00333 x 100 x 92,5

  = 0,000434 < 30,83 cm²

Digunakan Tulangan

- Diameter Tulangan = 16 mm
- As 1 Tulangan = $\frac{\pi}{4}$ x D²

  = $\frac{\pi}{4}$ x 16²

  = 201,06 mm²

- As req = 0,0016 x (2 x jarak tiang pancang) x d

= 0,0016 x (2 x 80) x 92,5

= 23,68 cm²

- Jumlah Tulangan (n) = 16 buah
- Jarak Antar Tulangan (s) = $\frac{\text{(baris 1 x jarak tiang pancang)}}{(n-1)}$

  = $\frac{(2 \text{ x } 80)}{(16-1)}$

  = 10,67 cm
- A = n x As 1 tulangan

  = 16 x 2,01

  = 32,17 cm²
- Cek = A > A tulangan x

  = 32,17 > 30,83 (**OK**)

Digunakan Tulangan 16 D16