BAB V

PERHITUNGAN

5.1. Pembebanan Struktur

A. Bangunan 4 Lantai

1. Beban Mati

Beban pelat beton, tebal 20 cm, bentang 11m, dengan Bj.2400 kg/m^3

M =3 x .2 x 24 =.14.4 KN/m

2. Beban Hidup

Gedung perkantoran menurut peraturan PPGR 1987 pasal 2.1.2 besarnya beban hidup 250 kg/m^2

H = 2.5 x 3 = 7.5 KN/m

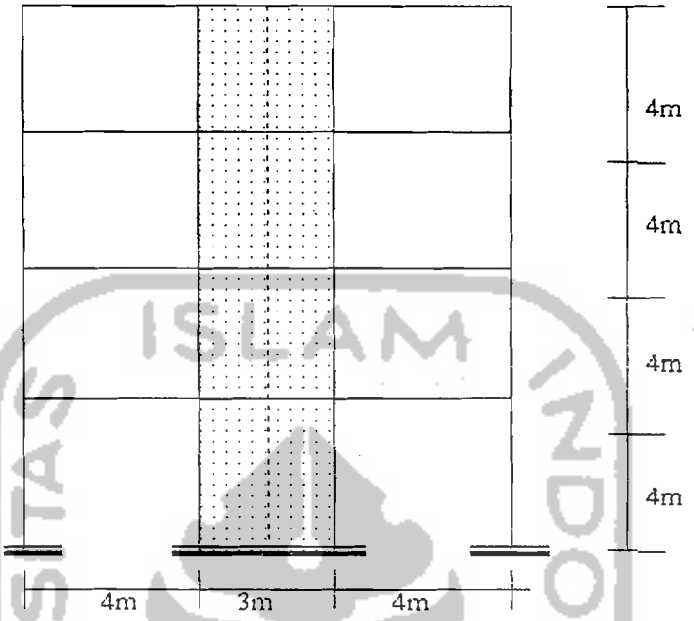
3. Beban Gempa

Zone 3 , tanah lunak diperoleh :

C = 0.07, I = 1.0, K = 1.0

V = 0.07 x 1 x 1x 4 x (400) = 120 KN

Lihat gambar 5.1.



Gambar 5.1. Model Struktur Bangunan 4 Lantai

B. Bangunan 5 Lantai

1. Beban Mati

Beban pelat beton, tebal 20 cm, bentang 12m, dengan Bj.2400 kg/m^3

M = 3 x .2 x 24 = 14.4 KN/m

2. Beban Hidup

Gedung perkantoran menurut peraturan PPGR 1987 pasal 2.1.2 besarnya beban hidup 250 kg/m^2

H = 2.5 x 3 = 7.5 KN/m

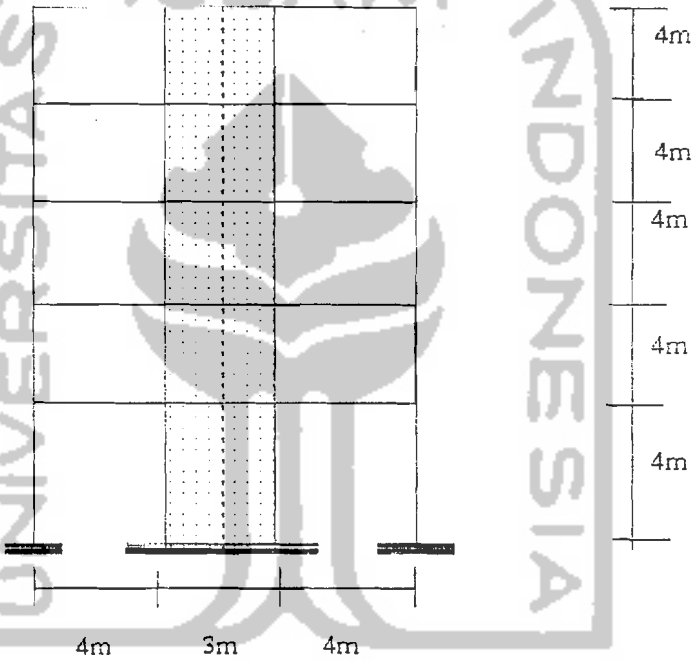
3. Beban Gempa

Zone 3 , tanah lunak diperoleh :

$C = 0.07$, $I = 1.0$, $K = 1.0$

$V = 0.07 \times 1 \times 1 \times 5 \times (400) = 140$ KN

Lihat gambar 5.2.



Gambar 5.2. Model Struktur Bangunan 5 Lantai

C. Bangunan 8 Lantai

1. Beban Mati

Beban pelat beton, tebal 20 cm, bentang 12m, dengan Bj.2400 kg/m^3

$M = 3 \times .2 \times 24 = 14.4$ KN/m

2. Beban Hidup

Gedung perkantoran menurut peraturan PPGR 1987 pasal 2.1.2 besarnya beban hidup 250 kg/m^2

H = 2.5 x 3 = 7.5 KN/m

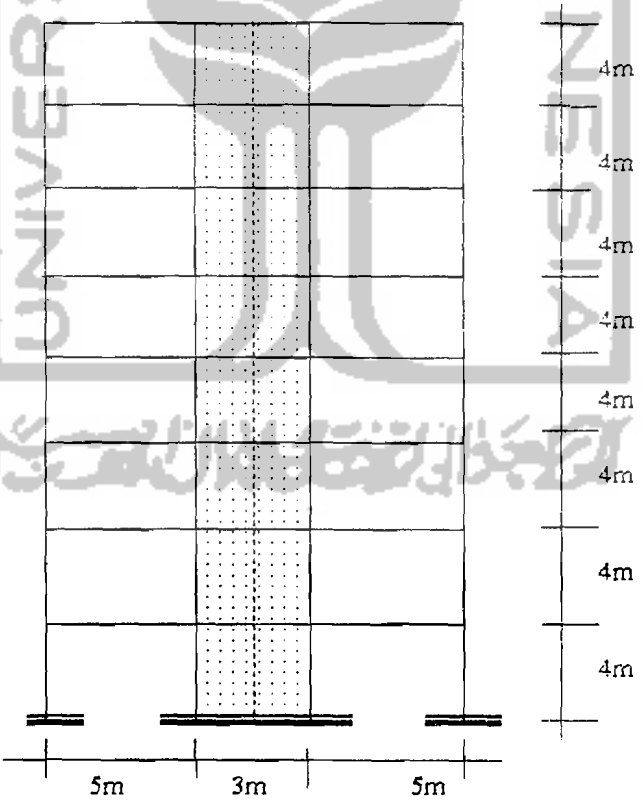
3. Beban Gempa

Zone 3 , tanah lunak diperoleh :

C = 0.07, I = 1.0, K = 1.0

V = 0.07 x 1 x 1x 8 x (400) = 224 KN

Lihat gambar 5.3.



Gambar 5.3. Model Struktur Bangunan 8 Lantai

D. Bangunan 10 Lantai

1. Beban Mati

Beban pelat beton, tebal 20 cm, bentang 12m, dengan Bj.2400 kg/m^3

$M = 3 \times .2 \times 24 = 15$ KN/m

2. Beban Hidup

Gedung perkantoran menurut peraturan PPGR 1987 pasal 2.1.2 besarnya beban hidup 250 kg/m^2

$H = 2.5 \times 3 = 7.5$ KN/m

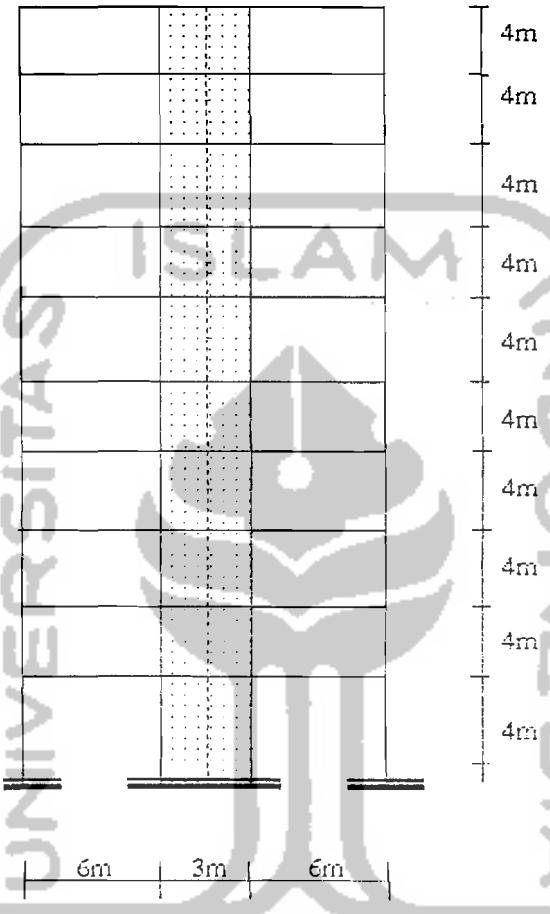
3. Beban Gempa

Zone 3 , tanah lunak diperoleh :

$C = 0.07$, $I = 1.0$, $K = 1.0$

$V = 0.07 \times 1 \times 1 \times 10 \times (400) = 280$ KN

Lihat gambar 5.4.



Gambar 5.4. Model Struktur Bangunan 10 Lantai

Dari semua model struktur di atas lebar dinding geser divariasikan dengan lebar 3m, 4m, 6m, 7m.

2. Perencanaan Tulangan Lentur

Kasus bangunan 4 Lantai

1. Data yang diketahui :

   a. $fc' = 30$ Mpa

   b. $fy = 400$ Mpa

   c. $E = 2.5.10^7$ kN/m^2

   d. $M = 15$ KN/m $H = 10$ KN/m , $V = 120$ KN

   Spesifikasi bahan digunakan pada seluruh hitungan, lihat tabel 5.2 dan pembebanan lihat pada tabel 5.1.

2. Stabilitas dinding geser

   $bw = hs/20 = 4000/20 = 200$ mm > 150 mm

   $Lc = 0.15 \times Lw$

   $= 0.15 \times 3000 = 450$ mm

   atau $= 1.5 \times bw$

   $= 1.5 \times 200 = 300$ mm dipakai $Lc = 450$ mm

   Dimensi dinding geser yang digunakan dalam perhitungan dapat dilihat dalam tabel 5.3.

3. Rasio Penulangan

$$\rho b = \frac{0.85.fc'}{fy}.\beta 1.\frac{600}{(600 + fy)}$$

$$= \frac{0.85.30}{400}.0.85.\frac{600}{(600 + 400)} = 0.033$$

ρ max = 0.75 x ρb = 0.75x 0.033 = 0.24

$$\rho \text{perlu} = \frac{1}{m}\left[1 - \sqrt{1 - \frac{2.m.Rn}{fy}}\right]$$

dimana :

$$m = \frac{fy}{0.85.fc'} = \frac{400}{0.85 \times 30} = 15.686$$

$$\rho min = 1.4 / fy = 0.0035$$

$$Rn = \rho \min .fy.(1 - 1/2.\rho \min .m) = 0.0035 \times 400 \times (1 - 1/2 \times 0.0035 \times 15.686) = 1.36$$

maka :

$$\rho \text{perlu} = \frac{1}{15.686}\left[1 - \sqrt{1 - \frac{2 \times 15.686 \times 1.36}{400}}\right] = 0.003495$$

4. Hitung luas tulangan tarik

Mu didapat dari perhitungan SAP-90, dapat dilihat pada tabel 5.4.

$$Mn = \frac{Mu}{\phi} = \frac{763.84}{0.8} = 954.80 \text{ kN-m}$$

$$Rn = \frac{Mn}{bw.d^2} = \frac{954.8 \times 10^6}{200 \times (0.8 \times 3000)^2} = 0.828 \text{ Mpa}$$

$$\rho \text{pendekatan} = \rho \text{ lama } \frac{Rn(baru)}{Rn(lama)} = 0.0035 \times \frac{0.828}{1.36} = 0.00213 < \rho min$$

maka luas tulangan yang dibutuhkan digunakan rasio tulangan minimum

As pendekatan = ρ . $bw.d$

$= 0.0035 \times 200 \times 2400$

$= 1680 \text{ mm}^2$

dipakai 6ϕ 20

As dipakai = 6 x 314.159 = 1885 mm^2

5. Pemeriksaan Kapasitas Tampang

Asumsi baja tarik telah mencapai regangan leleh, saat beton tekan mencapai tegangan hancur 0.003, lihat gambar 5.5.

Gambar 5.5 Kapasitas tampang

Gaya dalam yang bekerja :

$Cc = 0.85..fc.\ bw.\ a. = 5100.a.$

$T = As \times fy = 1885 \times 400 = 754000 \text{ N}$

$Cc = T \qquad 5100.a = 754000$

$$a = 147.84 \text{ mm}$$

$$y = a/\beta 1 = 147.84/0.85 = 173.93 \text{ mm}$$

6. Kontribusi Gaya Tekan Beton

$$Cc = 0.85.fc'.\beta 1.\ y.\ bw = 0.85 \times 30 \times 0.85 \times 173.93 \times 200 = 754000 \text{ N}$$

$$Lmc = d - \beta 1 \times \frac{y}{2}$$

$$= 2400 - 0.85 \times 173.93/2$$

$$= 2326.079 \text{ mm}$$

7. Kontrol Regangan Baja Tarik

$$\varepsilon_y = \frac{f_y}{E_s} = \frac{400}{200000} = 0.002 \quad \text{(regangan leleh)}$$

$$\varepsilon_s = \frac{d - y}{y} \times \varepsilon_{cu} = \frac{2400 - 111.314}{111.314} \times 0.003 = 0.06168 > 0.002 \text{ OK!}$$

(asumsi tulangan sudah leleh adalah benar)

8. Momen Nominal

$$Mn = Cc.\ Lmc = 754000 \times 2326.079 = 1753.86 \text{ kN m}$$

$$MR = \phi Mn = 0.8 \times 1753.86 = 1403.09 \text{ kN m} > \text{Mu} \ldots\ldots \text{ Aman !!}$$

5.3 Perencanaan Tulangan Geser

1. Kontrol penampang akibat geser

$$Vu \leq \phi Vn$$

$$\leq 0.65 \times 5/6.\ \sqrt{fc'} \times bw \times d$$

$$\leq 0.65 \times 5/6 \sqrt{30} \cdot 200 \cdot 2400 = 1.4241 \times 10^6 \text{ N} > 2.827.10^5 \text{ N}$$

2. Menghitung tulangan geser

$$Vc = 0.25 . \sqrt{fc'} . bw . d + \frac{Nu . d}{4 . Lw}$$

$$= 0.25 \times \sqrt{30} \times 200 \times 2400 + \frac{909580 \times 2400}{4 \times 3000}$$

$$= 839.183 \text{ kN}$$

$$Vu = 282.69 \text{ kN}$$

$$Mu = (hw - hcr) . Vu$$

$$hcr = hw/2$$

$$Mu = (16000 - 8000) Vu = 8000.0 Vu$$

$$Vc = \left[\left(0.5\sqrt{30} + \frac{3000 \left(\sqrt{30} + 2 \times 909580 / 3000 \times 200 \right)}{8000.0 - (3000 / 2)} \right) \div 10 \right] \times 200 \times 2400$$

$$= 319.964 \text{ kN}$$

3. Menghitung gaya geser horisontal

$$Vu \leq \phi Vn$$

$$\leq \phi (Vc + Vs)$$

$$\leq \phi Vc + \phi \frac{Av . fy . d}{S_2}$$

$$\frac{Av}{S_2} = \frac{(Vu - 0{,}65\ Vc)}{\phi . fy . d}$$

$$= \frac{(282690 - 0.65 \times 319964)}{0.65 \times 400 \times 2400} = 0.12$$

Dipakai 2 ϕ 10 $S_2 = \frac{2 \times 78.54}{0.12} = 1309$ mm , dipakai jarak = 500 mm

Dipakai tulangan geser 2 ϕ 10 $S_2 = 500$ mm

$$\rho h = \frac{Av}{Ag} = \frac{2 \times 78.54}{200 \times 500} = 0.00137 < 0.0025 \quad \text{(tidak memenuhi)}$$

dicoba:

	Jarak hitungan (mm)	Jarak dipakai (mm)	Rasio (ρh) > 0.0025
ϕ12 =	1884.8	500	0.00226
ϕ16 =	3351	500	0.0040 (yang dipakai)
ϕ18 =	5235.9	500	0.0062

Jadi dipakai 2 ϕ 16 @ 500mm

4. Menghitung gaya geser vertikal

$$\rho n = 0.0025 + 0.5 \times [\ 2.5 - hw/Lw\ ] \times [\ \rho h - 0.0025\ ]$$

$$= 0.00039 < \rho min$$

Pakai rasio tulangan minimum 0.0025

Maka digunakan tul 2 ϕ 16 @ 500 mm

Perhitungan selanjutnya dimasukkan dalam tabel 5.5 dan tabel 5.6.

Tabel 5.1. Pembebanan

Jml.Tkt	bentang	tebal	Mati	Hidup	Gempa
	(m)	(cm)	kN/m	kN/m	kN
4	1100	20	15	10	120
5	1200	20	15	10	140
8	1600	20	15	10	230
10	1900	20	15	10	280

Tabel 5.2. Spesifikasi Bahan

Lnt	*Fc*	*fy*	*E*	*pb*	*p* max	*p* min	*m*	*Rn*	*p* perlu
	Mpa	MPa							
4	30	400	2,5E+7	3,25,E-2	2,44,E-2	2,5,E-3	1,569E+1	1.36	2,5E-3
5	30	400	2,5E+7	3,25,E-2	2,44,E-2	2,5,E-3	1,569E+1	1.36	2,5E-3
8	30	400	2,5E+7	3,25,E-2	2,44,E-2	2,5,E-3	1,569E+1	1.36	2,5E-3
10	30	400	2,5E+7	3,25,E-2	2,44,E-2	2,5,E-3	1,569E+1	1.36	2,5E-3

Tabel 5.3. Dimensi Dinding Geser

Lnt	*Hw*	*Hs*	*Lw*	*bw*	*Lc*	*d*
	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
4	16000	4000	3000	200	450	2400
			4000		600	3200
			6000		900	4800
			7000		1050	5600
5	20000	4000	3000	200	450	2400
			4000		600	3200
			6000		900	4800
			7000		1050	5600
8	32000	4000	3000	200	450	2400
			4000		600	3200
			6000		900	4800
			7000		1050	5600
10	40000	4000	3000	200	450	2400
			4000		600	3200
			6000		900	4800
			7000		1050	5600

Tabel 5.4. Output SAP-90

Lnt	*Hw*	*Lw*	*Hw/Lw*	*Vu*	*Mu*	*Mu*
	(mm)	(mm)		*(kN)*	*(kN)*	(kN-m)
4	16000	3000	5,33	282.69	909.58	763.84
	16000	4000	4,00	304.62	1039.98	889.59
	16000	6000	2,67	335.54	1299.72	1112.94
	16000	7000	2,29	347.31	1429.39	1215.26
5	20000	3000	6,67	411.45	1146.22	1124.45
	20000	4000	5,00	442.78	1311.57	1312.68
	20000	6000	3,33	486.92	1640.55	1651.24
	20000	7000	2,86	503.72	1804.79	1808.12
8	32000	3000	10,7	816.47	2211.01	1941.47
	32000	4000	8,00	895.55	2492.49	2267.82
	32000	6000	5,33	1006.94	3042.70	2851.36
	32000	7000	4,57	1049.63	3315.80	3125.24
10	40000	3000	13,3	1278.47	3094.35	3119.02
	40000	4000	10,0	1399.88	3449.91	3650.56
	40000	6000	6,67	1572.81	4142.70	4606.39
	40000	7000	5,71	1639.50	4486.06	5055.46

Tabel 5.5 Perhitungan tulangan lentur

LNT	*Lw*	*d*	*Mu*	*Mn*	*Rn* baru	*p*	As pendekatan	dipakai	As pakai	T	a	y	*Cc*	*Lmc*	*Mn*	0,8 *Mn*
	(mm)	(mm)	(kN-m)	(kN-m)		pendekatan	(mm2)	Tul	(mm2)	(mm)	(mm)	(mm)	(N)	(mm)	(kn-m)	
4	3000	2400	763,84	954,80	0,829	0,0021	1680,00	*6D20	1884,95	753980,0	147,84	173,93	753980,0	2326,08	1753,82	1403,05
4	4000	3200	889,59	1111,99	0,543	0,0014	2240,00	*8D20	2513,27	1005308,0	197,12	231,90	1005308,0	3101,44	3117,90	2494,32
4	6000	4800	1112,94	1391,18	0,302	0,0008	3360,00	*10D22	3801,33	1520530,8	298,14	350,76	1520530,8	4650,93	7071,88	5657,50
4	7000	5600	1215,26	1519,08	0,242	0,0006	3920,00	*8D25	3926,99	1570796,0	308,00	362,35	1570796,0	5446,00	8554,56	6843,64
5	3000	2400	1124,45	1405,56	1,220	0,0031	1680,00	*6D20	1884,95	753980,0	147,84	173,93	753980,0	2326,08	1753,82	1403,05
5	4000	3200	1312,68	1640,85	0,801	0,0021	2240,00	*8D20	2513,27	1005308,0	197,12	231,90	1005308,0	3101,44	3117,90	2494,32
5	6000	4800	1651,24	2064,05	0,448	0,0012	3360,00	*10D22	3801,33	1520530,8	298,14	350,76	1520530,8	4650,93	7071,88	5657,50
5	7000	5600	1808,12	2260,15	0,360	0,0009	3920,00	*8D25	3926,99	1570796,0	308,00	362,35	1570796,0	5446,00	8554,56	6843,64
8	3000	2400	1941,47	2426,84	2,107	0,0054	2602,31	6D25	2945,22	1178088,0	231,00	271,76	1178088,0	2284,50	2691,34	2153,07
8	4000	3200	2267,82	2834,78	1,384	0,0036	2279,81	*8D20	2513,27	1005308,0	197,12	231,90	1005308,0	3101,44	3117,90	2494,32
8	6000	4800	2851,36	3564,20	0,773	0,0020	3360,00	*10D22	3801,33	1520530,8	298,14	350,76	1520530,8	4650,93	7071,88	5657,50
8	7000	5600	3125,24	3906,55	0,623	0,0016	3920,00	*8D25	3926,99	1570796,0	308,00	362,35	1570796,0	5446,00	8554,56	6843,64
10	3000	2400	3119,02	3898,78	3,384	0,0087	4180,67	10D25	4908,74	1963495,2	385,00	452,94	1963495,2	2207,50	4334,42	3467,53
10	4000	3200	3650,56	4563,20	2,228	0,0057	3669,85	8D25	3926,99	1570796,0	308,00	362,35	1570796,0	3046,00	4784,65	3827,72
10	6000	4800	4606,39	5757,99	1,250	0,0032	3360,00	*8D25	3926,99	1570796,0	308,00	362,35	1570796,0	4646,00	7297,92	5838,34
10	7000	5600	5055,46	6319,33	1,008	0,0026	3920,00	*6D25	2945,24	1178096,0	231,00	271,76	1178096,0	5464,50	6461,27	5169,01

PERHITUNGAN TULANGAN GESER

LNT	*Lw* (mm)	*hw* (mm)	*d* (mm)	*hcr* (mm)	*Vu* (kN)	*Nu* (kN)	0,65*Vn* (kN)	*Mu*	*Vc* (kN)	*Av/S2*	*dipakai. Tul. -H*	*S2* (mm)	*pH*	*dipakai Tul-V*	*S1* (mm)	*pV*
4	3000	16000	2400	8000.0	282.7	909.6	1424078.6	8000.0	320.0	0.120	2D16	500	0.0040	2D16	500	0.0040
4	4000	16000	3200	8000.0	304.6	1040.0	1898771.5	8000.0	519.9	-0.040	-	-	-	-	-	-
4	6000	16000	4800	8000.0	335.5	1299.7	2848157.3	8000.0	1143.4	-0.327	-	-	-	-	-	-
4	7000	16000	5600	8000.0	347.3	1429.4	3322850.2	8000.0	1616.7	-0.483	-	-	-	-	-	-
5	3000	20000	2400	10000.0	411.5	1146.2	1424078.6	10000.0	289.0	0.358	2D16	500	0.0040	2D16	500	0.0040
5	4000	20000	3200	10000.0	442.8	1311.6	1898771.5	10000.0	455.5	0.176	2D16	500	0.0040	2D16	500	0.0040
5	6000	20000	4800	10000.0	486.9	1640.6	2848157.3	10000.0	938.6	-0.099	-	-	-	-	-	-
5	7000	20000	5600	10000.0	503.7	1804.8	3322850.2	10000.0	1278.3	-0.225	-	-	-	-	-	-
8	3000	32000	2400	16000.0	816.5	2211.0	1424078.6	16000.0	259.0	1.039	2D10	150	0.0052	2D10	150	0.0052
8	4000	32000	3200	16000.0	895.6	2492.5	1898771.5	16000.0	389.4	0.772	2D8	130	0.0039	2D8	130	0.0039
8	6000	32000	4800	16000.0	1006.9	3042.7	2848157.3	16000.0	730.3	0.426	2D16	500	0.0040	2D16	500	0.0040
8	7000	32000	5600	16000.0	1049.6	3315.8	3322850.2	16000.0	947.4	0.298	2D16	500	0.0040	2D16	500	0.0040
10	3000	40000	2400	20000.0	1278.5	3094.4	1424078.6	20000.0	254.4	1.784	2D12	130	0.0087	2D12	130	0.0087
10	4000	40000	3200	20000.0	1399.9	3449.9	1898771.5	20000.0	375.8	1.389	2D12	160	0.0071	2D12	160	0.0071
10	6000	40000	4800	20000.0	1572.8	4142.7	2848157.3	20000.0	682.4	0.905	2D12	250	0.0045	2D12	250	0.0045
10	7000	40000	5600	20000.0	1639.5	4486.1	3322850.2	20000.0	871.5	0.737	2D12	300	0.0038	2D12	300	0.0038