

BAB VII

PERENCANAAN STRUKTUR PORTAL BETON BERTULANG DENGAN DAKTILITAS PENUH

Pada bab ini merupakan perencanaan kelanjutan dari bahasan analisa struktur sebelumnya untuk daktilitas penuh meliputi, desain balok, desain kolom, dan desain pertemuan balok kolom. Pada perencanaan dengan daktilitas penuh ini struktur diberi beban gempa dikalikan faktor pengali $K = 1$, tetapi dengan persyaratan daktilitas yang ketat.

7.1 Desain Balok

7.1.1 Momen Rencana Balok

Momen rencana balok dihitung berdasarkan tipe-tipe pembebanan menurut SK SNI T-15-1991-03 adalah sebagai berikut.

$$M_{u1} = 1,2 \cdot M_D + 1,6 \cdot M_L$$

$$M_{u2} = 1,05 (M_D + 0,9 \cdot M_L + M_{Gki})$$

$$M_{u3} = 1,05 (M_D + 0,9 \cdot M_L + M_{Gka})$$

$$M_{u4} = 0,9 (M_D + M_{Gki})$$

$$M_{u5} = 0,9 (M_D + M_{Gka})$$

Contoh perhitungan diambil pada Balok lantai 1 tumpuan kiri

Diketahui:

$$M_D = -145,7200 \text{ kN} \cdot \text{m} \quad ; \quad M_L = -80,6300 \text{ kN} \cdot \text{m}$$

$$M_{Gki} = 200,4200 \text{ kN} \cdot \text{m} \quad ; \quad M_{Gka} = -201,5200 \text{ kN} \cdot \text{m}$$

$$M_u = 1,05 (M_D + 0,9 M_L + M_{Gka})$$

$$= 1,05 (-145,7200 + 0,9 \cdot (-80,6300) + (-201,5200)) = -440,7974 \text{ kN} \cdot \text{m}$$

Hasil perhitungan momen rencana balok lainnya disajikan pada Tabel 7.1.

Tabel 7.1 Momen Rencana Balok Daktilitas Penuh (Satuan kNm)

Portal	No. Elm Balok	Letak Momen	M mati				M_{u1}	M_{u2}	M_{u3}	M_{u4}	M_{u5}	Balok
			M _D	M _L	M _{Gki}	M _{Gka}						
			[4]	[5]	[6]	[7]						
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]
As 1 dan As 6	25	Tump ki	-27,3300	-2,4300	81,2100	-80,6500	-36,6840	54,2777	-115,6754	48,4920	-97,1820	Sloof
		Lap	12,2700	1,6300	81,2100	79,2600	17,3320	99,6944	97,6469	84,1320	82,3770	
		Tump ka	-22,8500	1,6300	-79,6500	79,2600	-24,8120	-106,0847	60,7709	-92,2500	50,7690	
	26	Tump ki	-24,9300	-0,0300	78,7700	-78,6900	-29,9640	56,5037	-108,8294	48,4560	-93,2580	Balok Lantai 1
		Lap	12,3900	-0,0300	78,7700	78,7700	14,8200	95,6897	95,6897	82,0440	82,0440	
		Tump ka	-24,9300	-0,0300	-78,6900	78,7700	-29,9640	-108,8294	56,5037	-93,2580	48,4560	
	27	Tump ki	-22,8500	1,6300	79,2600	-79,6500	-24,8120	60,7709	-106,0847	50,7690	-92,2500	Balok Lantai 1
		Lap	12,2700	1,6300	79,2600	81,2100	17,3320	97,6469	99,6944	82,3770	84,1320	
		Tump ka	-23,3300	-2,4300	-80,6500	81,2100	-31,8840	-111,4754	58,4777	-93,5820	52,0920	
	28-30	Tump ki	-130,9800	-71,3500	216,1500	-214,4400	-271,3360	22,0028	-430,1168	76,6530	-310,8780	Balok Lantai 1
		Lap	77,8100	42,9700	216,1500	200,4200	162,1240	349,2647	332,7482	264,5640	250,4070	
		Tump ka	-145,7200	-80,6300	-201,5200	200,4200	-303,8720	-440,7974	-18,7604	-312,5160	49,2300	
	31-33	Tump ki	-144,1700	-79,3600	191,3900	-191,1800	-299,9800	-25,4142	-427,1127	42,4980	-301,8150	Balok Lantai 1
		Lap	71,8900	39,5500	191,3900	191,3900	149,5480	313,8188	313,8188	236,9520	236,9520	
		Tump ka	-144,1700	-79,3600	-191,1800	191,3900	-299,9800	-427,1127	-25,4142	-301,8150	42,4980	
	34-36	Tump ki	-145,7200	-80,6300	200,4200	-201,5200	-303,8720	-18,7604	-440,7974	49,2300	-312,5160	Balok Lantai 1
		Lap	77,8100	42,9700	200,4200	216,1500	162,1240	332,7482	349,2647	250,4070	264,5640	
		Tump ka	-130,9800	-71,3500	-214,4400	216,1500	-271,3360	-430,1168	22,0028	-310,8780	76,6530	
	37-39	Tump ki	-139,1000	-76,3000	200,6300	-199,4000	-289,0000	-7,4970	-427,5285	55,3770	-304,6500	Balok Lantai 2
		Lap	76,4700	42,0700	200,6300	187,8600	159,0760	330,7112	317,3027	249,3900	237,8970	
		Tump ka	-140,0800	-77,3600	-188,6400	187,8600	-291,8720	-418,2612	-22,9362	-295,8480	43,0020	
	40-42	Tump ki	-143,6600	-79,0700	182,9500	-182,7800	-298,9040	-33,4667	-417,4832	35,3610	-293,7960	Balok Lantai 2
		Lap	72,4000	39,8400	182,9500	182,9500	150,6240	305,7663	305,7663	229,8150	229,8150	
		Tump ka	-143,6600	-79,0700	-182,7800	182,9500	-298,9040	-417,4832	-33,4667	-293,7960	35,3610	
43-45	Tump ki	-140,0800	-77,3600	187,8600	-188,6400	-291,8720	-22,9362	-418,2612	43,0020	-295,8480	Balok Lantai 2	
	Lap	76,4700	42,0700	187,8600	200,6300	159,0760	317,3027	330,7112	237,8970	249,3900		
	Tump ka	-139,1000	-71,3500	-199,4000	200,6300	-281,0800	-422,8508	-2,8193	-304,6500	55,3770		
46-48	Tump ki	-142,1900	-77,8400	159,2700	-158,4100	-295,1720	-55,6248	-389,1888	15,3720	-270,5400	Balok Lantai 3	
	Lap	76,5000	42,0800	159,2700	149,0900	159,1280	287,3241	276,6351	212,1930	203,0310		
	Tump ka	-136,9400	-75,8100	-149,6500	149,0900	-285,6240	-372,5600	-58,8830	-257,9310	10,9350		
49-51	Tump ki	-143,5600	-79,0100	147,3500	-147,1800	-298,6880	-70,6850	-379,9415	3,4110	-261,6660	Balok Lantai 3	
	Lap	72,5000	39,9000	147,3500	147,3500	150,8400	268,5480	268,5480	197,8650	197,8650		
	Tump ka	-143,5600	-79,0100	-147,1800	147,3500	-298,6880	-379,9415	-70,6850	-261,6660	3,4110		
52-54	Tump ki	-136,9400	-75,8100	149,0900	-149,6500	-285,6240	-58,8830	-372,5600	10,9350	-257,9310	Balok Lantai 3	
	Lap	76,5000	42,0800	149,0900	159,2700	159,1280	276,6351	287,3241	203,0310	212,1930		
	Tump ka	-142,1900	-77,8400	-158,4100	159,2700	-295,1720	-389,1888	-55,6248	-270,5400	15,3720		
55-57	Tump ki	-140,1800	-75,7700	111,5000	-107,1000	-289,4480	-101,7167	-331,2467	-25,8120	-222,5520	Balok Lantai 4	
	Lap	77,4500	42,8400	111,5000	100,8400	161,4840	238,8813	227,6883	170,0550	160,4610		
	Tump ka	-137,0600	-76,3600	-103,7000	100,8400	-286,6480	-324,9582	-110,1912	-216,6840	-32,5980		
58-60	Tump ki	-143,4000	-78,9700	103,2900	-102,7300	-298,4320	-116,7422	-333,0632	-36,0990	-221,5170	Balok Lantai 4	
	Lap	72,6600	39,9300	103,2900	103,2900	151,0800	222,4814	222,4814	158,3550	158,3550		
	Tump ka	-143,4000	-78,9700	-102,7300	103,2900	-298,4320	-333,0632	-116,7422	-221,5170	-36,0990		
61-63	Tump ki	-137,0600	-76,3600	100,8400	-103,7000	-286,6480	-110,1912	-324,9582	-32,5980	-216,6840	Balok Lantai 4	
	Lap	77,4500	42,8400	100,8400	111,5000	161,4840	227,6883	238,8813	160,4610	170,0550		
	Tump ka	-140,1800	-75,7700	-107,1000	111,5000	-289,4480	-331,2467	-101,7167	-222,5520	-25,8120		
64-65	Tump ki	-55,7000	-18,6400	39,2300	-35,6000	-96,6640	-34,9083	-113,4798	-14,8230	-82,1700	Balok Ring	
	Lap	49,7200	16,4000	39,2300	34,1100	85,9040	108,8955	103,5195	80,0550	75,4470		
	Tump ka	-52,7900	-13,3500	-36,4800	34,1100	-84,7080	-106,3493	-32,2298	-80,3430	-16,8120		
66-67	Tump ki	-60,2300	-15,8800	36,6000	-36,1600	-97,6840	-39,8181	-116,2161	-21,2670	-86,7510	Balok Ring	
	Lap	54,9100	16,5200	36,6000	36,6000	92,3240	111,6969	111,6969	82,3590	82,3590		
	Tump ka	-60,2300	-15,8800	-36,1600	36,6000	-97,6840	-116,2161	-39,8181	-86,7510	-21,2670		
68-69	Tump ki	-52,7900	-13,3500	34,1100	-36,4800	-84,7080	-32,2298	-106,3493	-16,8120	-80,3430	Balok Ring	
	Lap	49,7200	16,4000	34,1100	39,2300	85,9040	103,5195	108,8955	75,4470	80,0550		
	Tump ka	-55,7000	-18,6400	-35,6000	39,2300	-96,6640	-113,4798	-34,9083	-82,1700	-14,8230		
As 2 dan As 5 (A-B)	13	Tump ki	-5,6300	-0,2400	53,6600	-53,6300	-7,1400	50,2047	-62,4498	43,2270	-53,3340	Balok Sloof
		Lap	3,7800	0,1200	53,6600	64,7600	4,7280	60,4254	72,0804	51,6960	61,6860	
		Tump ka	-5,4700	0,1200	-64,7500	64,7600	-6,3720	-73,6176	62,3679	-63,1980	53,3610	
	14	Tump ki	-12,9200	-2,0500	79,5200	-79,4600	-18,7840	67,9928	-98,9363	59,9400	-83,1420	Balok Lantai 1
		Lap	11,1700	1,8500	79,5200	99,2800	16,3640	96,9728	117,7208	81,6210	99,4050	
		Tump ka	-15,3500	-2,5400	-99,2500	99,2800	-22,4840	-122,7303	85,7262	-103,1400	75,5370	
	15	Tump ki	-14,0200	-2,3000	80,1800	-80,1500	-20,5040	67,2945	-101,0520	59,5440	-84,7530	Balok Lantai 2
		Lap	10,9800	1,7800	80,1800	99,0500	16,0240	97,4001	117,2136	82,0440	99,0270	
		Tump ka	-14,7800	-2,4200	-99,0100	99,0500	-21,6080	-121,7664	86,1966	-102,4110	75,8430	
	16	Tump ki	-14,0400	-2,3000	64,6400	-64,5900	-20,5280	50,9565	-84,7350	45,5400	-70,7670	Balok Lantai 3
		Lap	10,9200	1,7900	64,6400	79,7900	15,9680	81,0296	96,9371	68,0040	81,6390	
		Tump ka	-14,7100	-2,4100	-79,7600	79,7900	-21,5080	-101,4710	66,0566	-85,0230	58,5720	
	17	Tump ki	-13,6900	-2,2100	45,5300	-43,5200	-19,9640	31,3436	-62,1590	28,6560	-51,4890	Balok Lantai 4
		Lap	11,0400	1,8200	45,5300	52,7600	16,1600	61,1184	68,7099	50,9130	57,4200	
		Tump ka	-14,8100	-2,4400	-52,7500	52,7600	-21,6760	-73,2438	37,5417	-60,8040	34,1550	

Tabel 7.1 Lanjutan

Portal	No. Elm Balok	Letak Momen	M mati				Mu1	Mu2	Mu3	Mu4	Mu5	Balok
			M D	M L	M Gki	M Gka						
			[4]	[5]	[6]	[7]						
	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]
As 2, As 5 (A-B)	18	Tump ki Lap Tump ka	-5,8900 5,6700 -5,6400	-0,8800 0,7900 -0,7800	19,6800 19,6800 -28,3500	-19,7100 28,2400 28,2400	-8,4760 8,0680 -8,0160	13,6479 27,3641 -36,4266	-27,7116 36,3521 22,9929	12,4110 22,8150 -30,5910	-23,0400 30,5190 20,3400	Balok Atap
As 2 dan As 5 (E-G)	19	Tump ki Lap Tump ka	-8,86 3,69 -2,89	-0,5600 0,6100 0,6100	80,4300 80,4300 -31,1700	-80,3100 31,1200 31,1200	-11,5280 5,4040 -2,4920	74,6193 88,9025 -35,1866	-94,1577 37,1270 30,2180	64,4130 75,7080 -30,6540	-80,2530 31,3290 48,2580	Balok Sloof
	20	Tump ki Lap Tump ka	-2,48 3,99 -8,73	0,6900 0,6900 -0,7600	23,3400 23,3400 -61,9600	-23,4100 62,1200 62,1200	-1,8720 5,8920 -11,6920	22,5551 29,3486 -74,9427	-26,5325 70,0676 55,3413	18,7740 24,5970 -63,6210	-23,3010 59,4990 48,0510	
	21	Tump ki Lap Tump ka	-22,39 10,23 -10,87	-3,8800 1,8400 -2,2300	125,6000 125,6000 -43,4700	-125,3800 43,3900 43,3900	-33,0760 15,2200 -16,6120	104,7039 144,3603 -59,1644	-158,8251 58,0398 32,0387	92,8890 122,2470 -48,9060	-132,9930 48,2580 29,2680	Balok Lantai 1
	22	Tump ki Lap Tump ka	-10,2 11,63 -20,11	-2,1200 2,1100 -3,4200	30,7400 30,7400 -93,7700	-30,8600 94,0700 94,0700	-15,6320 17,3320 -29,6040	19,5636 46,4825 -122,8059	-45,1164 112,9790 74,4261	18,4860 38,1330 -102,4920	-36,9540 95,1300 66,5640	
	23	Tump ki Lap Tump ka	-26,51 11,17 -6,19	-4,5400 1,9700 -1,4900	124,5000 124,5000 -43,5900	-124,3300 43,5400 43,5400	-39,0760 16,5560 -9,8120	98,5992 144,3152 -53,6771	-162,6723 59,3072 37,8095	88,1910 122,1030 -44,8020	-135,7560 49,2390 33,6150	Balok Lantai 2
	24	Tump ki Lap Tump ka	-5,14 12,43 -24,96	-1,3100 2,1900 -4,2600	32,6300 32,6300 -94,8900	-32,6900 95,0500 95,0500	-8,2640 18,4200 -36,7680	27,6266 49,3826 -129,8682	-40,9595 114,9236 69,5688	24,7410 40,5540 -107,8650	-34,0470 96,7320 63,0810	
	25	Tump ki Lap Tump ka	-29,22 12,01 -3,07	-4,9200 2,0700 -1,0500	98,6800 98,6800 -34,3100	-98,5100 34,2500 34,2500	-42,9360 17,7240 -5,3640	68,2836 118,1807 -40,2413	-138,7659 50,5292 31,7468	62,5140 99,6210 -33,6420	-114,9570 41,6340 28,0620	Balok Lantai 3
	26	Tump ki Lap Tump ka	-1,72 13,42 -27,72	-0,8500 2,3000 -4,6400	27,1900 27,1900 -76,6000	-27,2700 76,8300 76,8300	-3,4240 19,7840 -40,6880	25,9403 44,8140 -113,9208	-31,2428 96,9360 47,1807	36,5490 -93,8880 28,5840	81,2250 44,1990 -84,7080	
	27	Tump ki Lap Tump ka	-31,18 12,82 -0,67	-5,0800 2,1200 -0,8500	62,9400 62,9400 -21,6000	-62,9400 21,6200 21,6200	-45,5440 18,7760 -2,1640	28,5474 81,5514 -24,1868	-103,6266 38,1654 21,1943	28,5840 68,1840 -20,0430	-84,7080 30,9960 18,8550	Balok Lantai 4
	28	Tump ki Lap Tump ka	1,17 13,91 -31,47	-0,6200 2,3600 -4,8500	19,5900 19,5900 -51,6700	-19,5700 51,6500 51,6500	0,4120 20,4680 -45,5240	21,2121 37,4052 -91,8803	-19,9059 71,0682 16,6058	18,6840 30,1500 -74,8260	-16,5600 59,0040 18,1620	
	29	Tump ki Lap Tump ka	-26,36 13,3 -2,76	-2,7900 1,5000 1,2500	35,0500 35,0500 -8,6100	-35,2000 8,6900 8,6900	-36,0960 18,3600 -1,3120	6,4880 52,1850 -10,7573	-67,2746 24,5070 7,4078	7,8210 43,5150 -10,2330	-55,4040 19,7910 5,3370	Balok Atap
	30	Tump ki Lap Tump ka	-1,78 15,66 -21,92	1,3800 1,6600 -2,5200	6,9900 6,9900 -24,3500	-6,8900 24,1400 24,1400	0,0720 21,4480 -30,3360	6,7746 25,3512 -50,9649	-7,7994 43,3587 -0,0504	4,6890 20,3850 -41,6430	-7,8030 35,8200 1,9980	
As 3 dan As 4	41	Tump ki Lap Tump ka	-4,6300 5,1000 -3,8400	-0,8500 1,7900 1,7900	53,9200 53,9200 -100,0200	-53,2600 99,2300 99,2300	-6,9160 8,9840 -1,7440	50,9513 63,6626 -107,3615	-61,5878 111,2381 101,8511	44,3610 53,1180 -93,4740	-52,1010 93,8970 85,8510	Balok Sloof
	42	Tump ki Lap Tump ka	-26,7100 12,2300 -23,5200	-0,8600 0,5500 0,5500	79,6500 79,6500 -81,0300	-78,6200 80,2400 80,2400	-33,4280 15,5560 -27,3440	54,7743 96,9938 -109,2578	-111,4092 97,6133 60,0758	47,6460 82,6920 -94,0950	-94,7970 83,2230 51,0480	
	43	Tump ki Lap Tump ka	-24,8300 12,4000 -25,0300	0,0200 0,0200 -0,0500	82,2900 82,2900 -82,1400	-82,0200 82,1200 82,1200	-29,7640 14,9120 -30,1160	60,3519 99,4434 -112,5758	-112,1736 99,2649 59,8973	51,7140 85,2210 -96,4530	-96,1650 85,0680 51,3810	
	44	Tump ki Lap Tump ka	-23,2900 12,1800 -27,0500	0,6300 0,6300 -0,9700	80,3000 80,3000 -78,7100	-80,8100 79,4600 79,4600	-26,9400 15,6240 -34,0120	60,4559 97,6994 -111,9647	-108,7097 96,8174 54,1139	51,3090 83,2320 -95,1840	-93,6900 82,4760 47,1690	
	45	Tump ki Lap Tump ka	-7,1100 3,8400 -4,0100	0,7800 0,7800 0,2000	95,8800 95,8800 -42,5100	-96,5400 42,6800 42,6800	-7,2840 5,8560 -4,4920	93,9456 105,4431 -48,6570	-108,0954 49,5831 40,7925	79,8930 89,7480 -41,8680	-93,2850 41,8680 34,8030	
	46	Tump ki Lap Tump ka	-3,6600 4,6600 -5,7500	0,5700 0,5700 -0,8400	17,5700 17,5700 -39,4700	-18,4500 40,7300 40,7300	-3,4800 6,5040 -8,2440	15,1442 23,8802 -48,2748	-22,6769 48,1982 35,9352	12,5190 20,0070 -40,6980	-19,8990 40,8510 31,4820	
	47	Tump ki Lap Tump ka	-8,3400 16,7100 -44,3200	-1,6900 3,1000 -9,6200	60,9500 60,9500 -112,7700	-60,3500 112,6800 112,6800	-12,7120 25,0120 -68,5760	53,6435 84,4725 -174,0354	-73,7216 138,7890 62,6871	47,3490 69,8940 -141,3810	-61,8210 116,4510 61,5240	Balok Lantai 1
	48-50	Tump ki Lap Tump ka	-163,9700 95,0200 -183,6900	-43,1100 25,3400 -48,7700	216,4600 216,4600 -208,2200	-213,0300 205,6800 205,6800	-265,7400 154,5680 -298,4600	14,3756 351,0003 -457,5932	-436,5890 339,6813 -22,9982	47,2410 280,3320 -352,7190	-339,3000 270,6300 19,7910	
	51-53	Tump ki Lap Tump ka	-178,9600 89,2800 -179,8700	-47,4200 23,6600 -47,6800	200,6800 200,6800 -200,3400	-199,9000 200,2600 200,2600	-290,6240 144,9920 -292,1320	-22,0059 326,8167 -444,2781	-442,6149 326,3757 -23,6481	19,5480 260,9640 -342,1890	-340,9740 260,5860 18,3510	
	54-56	Tump ki Lap Tump ka	-182,9500 94,9000 -164,9000	-48,5500 25,3000 -43,3900	206,1800 206,1800 -213,7900	-207,7900 216,2400 216,2400	-297,2200 154,3600 -267,3040	-21,4883 340,0425 -438,6281	-456,1568 350,6055 12,9035	20,9070 270,9720 -340,8210	-351,6660 280,0260 46,2060	

Tabel 7.1 Lanjutan

Portal	No Elm Balok	Letak Momen	M mati	M hidup	M Gempa		Mu1	Mu2	Mu3	Mu4	Mu5	Balok
			M _D	M _L	M _{Gki}	M _{Gka}						
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]
As 3 dan As 4	57	Tump ki	-47,9500	-10,6100	110,6500	-110,7800	-74,5160	55,8086	-176,6930	56,4300	-142,8570	Balok Lantai 1
		Lap	9,3200	1,7000	110,6500	47,3800	13,9040	127,5750	61,1415	107,9730	51,0300	
		Tump ka	-20,3100	-4,5100	-47,6900	47,3800	-31,5880	-75,6620	24,1616	-61,2000	-24,3630	
58	Tump ki	-22,9400	-5,0100	21,6000	-23,2600	-35,5440	-6,1415	-53,2445	-1,2060	-41,5800	Balok Lantai 2	
	Lap	24,4100	5,1900	21,6000	49,6000	37,5960	53,2151	82,6151	41,4090	66,6090		
	Tump ka	-13,1700	-2,6900	-47,5800	49,6000	-20,1080	-66,3296	35,7095	-54,6750	32,7870		
59	Tump ki	-10,4500	-2,3100	53,1600	-53,8800	-16,2360	42,6626	-69,7295	38,4390	-57,8970	Balok Lantai 2	
	Lap	17,3400	3,3300	53,1600	98,7000	26,1360	77,1719	124,9889	63,4500	104,4360		
	Tump ka	-39,5900	-8,1200	-96,8600	98,7000	-60,5000	-150,9459	54,3921	-122,8050	53,1990		
60-62	Tump ki	-168,8000	-44,7000	196,8000	-193,6100	-274,0800	-12,8415	-422,7720	25,2000	-326,1690	Balok Lantai 1	
	Lap	94,0400	25,0000	196,8000	188,4200	152,8480	329,0070	320,2080	261,7560	254,2140		
	Tump ka	-180,6200	-47,7600	-190,3500	188,4200	-293,1600	-434,6517	-36,9432	-333,8730	7,0200		
63-65	Tump ki	-178,2900	-47,2500	185,2900	-184,8400	-289,5480	-37,3013	-425,9378	6,3000	-326,8170	Balok Lantai 1	
	Lap	89,5700	20,9400	185,2900	184,8100	140,9880	308,3913	307,8873	247,3740	246,9420		
	Tump ka	-179,9500	-47,6800	-185,4100	184,8100	-292,2280	-428,6856	-39,9546	-328,8240	4,3740		
66-68	Tump ki	-178,7900	-47,3200	188,7900	-189,4900	-290,2600	-34,2174	-431,4114	9,0000	-331,4520	Balok Lantai 1	
	Lap	93,6000	24,8900	188,7900	195,7700	152,1440	320,0306	320,0306	254,1510	260,4330		
	Tump ka	-171,4400	-45,3300	-193,9700	195,7700	-278,2560	-426,5174	-17,2904	-328,8690	21,8970		
69	Tump ki	-49,3100	-10,3400	98,4200	-97,0700	-75,7160	41,7942	-163,4703	44,1990	-131,7420	Balok Lantai 1	
	Lap	11,0400	2,1300	98,4200	41,0300	16,6560	116,9459	56,6864	98,5140	46,8630		
	Tump ka	-16,4400	-3,9700	-42,4700	41,0300	-26,0800	-65,6072	-22,0679	-53,0190	22,1310		
70	Tump ki	-18,9800	-4,3800	21,1200	-23,0100	-29,7840	-1,8921	-48,2286	1,9260	-27,7910	Balok Lantai 1	
	Lap	24,6500	5,1200	21,1200	45,2900	37,7720	52,8969	78,2754	41,1930	62,9460		
	Tump ka	-16,3900	-3,4000	-43,7300	45,2900	-25,1080	-66,3390	27,1320	-54,1080	26,0100		
71	Tump ki	-10,7700	-2,4600	37,8100	-38,6700	-16,8600	26,0673	-54,2367	24,3360	-44,4960	Balok Lantai 3	
	Lap	17,8600	3,4900	37,8100	70,9500	27,0160	61,7516	96,5486	50,1030	79,9290		
	Tump ka	-37,8700	-7,5100	-64,9100	70,9500	-57,4600	-115,0160	27,6371	-92,5020	29,7720		
72-74	Tump ki	-170,1200	-45,1800	147,0500	-146,6300	-276,4320	-66,9186	-375,2826	-20,7630	-285,0750	Balok Lantai 3	
	Lap	93,6100	24,8700	147,0500	142,2200	152,1240	276,1952	271,1237	216,5940	212,2470		
	Tump ka	-180,1300	-47,5300	-145,3800	142,2200	-292,2040	-386,7014	-84,7214	-292,9590	-34,1190		
75-77	Tump ki	-177,1400	-46,9500	143,4500	-140,8800	-287,6880	-79,7423	-378,2888	-30,3210	-286,2180	Balok Lantai 3	
	Lap	89,9700	23,8600	143,4500	142,1000	146,1400	267,6387	266,2212	210,0780	208,8630		
	Tump ka	-180,3100	-47,7400	-141,9800	142,1000	-292,7560	-383,5188	-85,2348	-290,0610	-34,3890		
78-80	Tump ki	-177,0500	-46,8100	142,9300	-143,8700	-287,3560	-80,0615	-381,2015	-30,7080	-288,8280	Balok Lantai 3	
	Lap	93,1900	24,7800	142,9300	145,9900	151,4760	271,3431	274,5561	212,5080	215,2620		
	Tump ka	-173,9500	-46,0500	-147,5200	145,9900	-282,4200	-381,0608	-72,8753	-289,3230	-25,1640		
78-80	Tump ki	-177,0500	-46,8100	142,9300	-143,8700	-287,3560	-80,0615	-381,2015	-30,7080	-288,8280	Balok Lantai 3	
	Lap	93,1900	24,7800	142,9300	145,9900	151,4760	271,3431	274,5561	212,5080	215,2620		
	Tump ka	-173,9500	-46,0500	-147,5200	145,9900	-282,4200	-381,0608	-72,8753	-289,3230	-25,1640		
81	Tump ki	-51,6200	-10,5100	73,4500	-67,8900	-78,7600	12,9896	-135,4175	19,6470	-107,5590	Balok Lantai 3	
	Lap	11,9200	2,3000	73,4500	28,2600	17,9840	91,8120	44,3625	76,8330	36,1620		
	Tump ka	-13,4700	-3,5500	-30,9600	28,2600	-21,8440	-50,0063	12,1748	-39,9870	13,3110		
82	Tump ki	-16,1400	-3,9400	16,5900	-20,4500	-25,6720	-3,2508	-42,1428	0,4050	-32,9310	Balok Lantai 3	
	Lap	25,3800	5,2000	16,5900	35,4200	38,7760	48,9825	68,7540	37,7730	54,7200		
	Tump ka	-17,7500	-3,6500	-33,2100	35,4200	-27,1400	-56,9573	15,1043	-45,8640	15,9030		
83	Tump ki	-7,1000	-1,1600	37,1500	-18,7100	-10,3760	30,4563	-28,1967	27,0450	-23,2290	Balok Lantai 4	
	Lap	15,7500	2,9800	37,1500	31,4300	23,6680	58,3611	52,3551	47,6100	42,4620		
	Tump ka	-48,8300	-10,8800	-63,6300	31,4300	-76,0040	-128,3646	-28,5516	-101,2140	-15,6600		
84-86	Tump ki	-155,5100	-40,7700	124,4700	-76,7400	-251,8440	-71,1197	-282,3902	-27,9360	-209,0250	Balok Lantai 4	
	Lap	98,5200	26,4000	124,4700	75,3400	160,4640	259,0875	207,5010	200,6910	156,4740		
	Tump ka	-185,5800	-49,1800	-96,6400	75,3400	-301,3840	-342,8061	-162,2271	-253,9980	-99,2160		
87-89	Tump ki	-178,4300	-47,3000	73,1700	-74,3400	-289,7960	-155,2215	-310,1070	-94,7340	-227,4930	Balok Lantai 4	
	Lap	89,2400	23,6500	73,1700	72,7500	144,9280	192,8798	192,4388	146,1690	145,7910		
	Tump ka	-180,4700	-47,8200	-75,4300	72,7500	-293,0760	-313,8849	-158,2959	-230,3100	-96,9480		
90-92	Tump ki	-181,5600	-48,2200	74,6900	-91,9600	-295,0240	-157,7814	-332,7639	-96,1830	-246,1680	Balok Lantai 4	
	Lap	96,7600	25,9500	74,6900	115,0800	157,6320	204,5453	246,9548	154,3050	190,6560		
	Tump ka	-162,6000	-42,4600	-73,9700	115,0800	-263,0560	-288,5232	-90,0207	-212,9130	-42,7680		
93	Tump ki	-62,7100	-13,6100	33,1000	-60,4800	-97,0280	-43,9520	-142,2110	-26,6490	-110,8710	Balok Atap	
	Lap	10,9900	1,9000	33,1000	24,2400	16,2280	48,0900	38,7880	39,6810	31,7070		
	Tump ka	-8,6000	-2,3500	-13,7000	24,2400	-14,0800	-25,6358	14,2013	-20,0700	14,0760		
94	Tump ki	-13,5800	-3,6400	10,6800	-19,3900	-22,1200	-6,4848	-38,0583	-2,6100	-29,6730	Balok Atap	
	Lap	27,0600	5,6700	10,6800	31,5300	41,5440	44,9852	66,8777	33,9660	52,7310		
	Tump ka	-16,9700	-3,0300	-17,6400	31,5300	-25,2120	-39,2039	12,4247	-31,1490	13,1040		
95	Tump ki	-2,3800	0,0300	24,6500	-4,4300	-2,8080	23,4119	-7,1222	20,0430	-6,1290	Balok Atap	
	Lap	15,3100	1,8000	24,6500	11,2100	21,2520	43,6590	29,5470	35,9640	23,8680		
	Tump ka	-20,5700	-3,5200	-83,2200	11,2100	-30,3160	-112,3059	-13,1544	-93,4110	-8,4240		
96	Tump ki	-29,0300	-5,1300	10,2200	-75,6200	-43,0440	-24,5984	-114,7304	-16,9290	-94,1850	Balok Atap	
	Lap	11,6500	1,6700	10,2200	20,6900	16,6520	24,5417	35,5352	19,6830	29,1060		
	Tump ka	-2,9100	0,6100	-2,1500	20,6900	-2,5160	-4,7366	19,2455	-4,5540	16,0020		

Tabel 7.1 Lanjutan

Portal	No. Elm Balok	Letak Momen	M mati	M hidup	M Gempa		Mu1	Mu2	Mu3	Mu4	Mu5	Balok
			MD	ML	M Gki	M Gka						
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]
As 3 dan As 4	97	Tump ki	-5,6600	-0,2400	3,6300	-3,8100	-7,1760	-2,3583	-10,1703	-1,8270	-8,5230	Balok
		Lap	19,4200	2,7400	3,6300	17,6000	27,6880	26,7918	41,4603	20,7450	33,3180	Atap
		Tump ka	-7,4800	-0,9200	-4,5100	17,6000	-10,4480	-13,4589	9,7566	-10,7910	9,1080	
As A dan As G	25	Tump ki	-11,5900	-0,6900	58,5500	-58,2700	-15,0120	48,6560	-74,0051	42,2640	-62,8740	Balok
		Lap	6,2400	0,2500	58,5500	54,3300	7,8880	68,2658	63,8348	58,3110	54,5130	Sloof
		Tump ka	-9,1400	0,2500	-54,4900	54,3300	-10,5680	-66,5753	47,6858	-57,2670	40,6710	
	26	Tump ki	-3,3900	0,2800	71,6900	-71,6500	-3,6200	71,9796	-78,5274	61,4700	-67,5360	
		Lap	0,8900	0,4000	71,6900	71,6900	1,7080	76,5870	76,5870	65,3220	65,3220	
		Tump ka	-3,1300	0,4000	-71,6500	71,6900	-3,1160	-78,1410	72,3660	-67,3020	61,7040	
	27	Tump ki	-9,0000	0,3200	54,3300	-54,4900	-10,2880	47,8989	-66,3621	40,7970	-57,1410	
		Lap	6,2600	0,3200	54,3300	58,5500	8,0240	63,9219	68,3529	54,5310	58,3290	
		Tump ka	-11,7100	-0,7400	-58,2700	58,5500	-15,2360	-74,1783	48,4827	-62,9620	42,1560	
	28-29	Tump ki	-33,6600	-7,4800	84,5600	-84,0400	-52,3600	46,3764	-130,6536	45,8100	-105,9300	Balok
		Lap	31,1000	8,7900	84,5600	79,7700	51,3840	129,7496	124,7201	104,0940	99,7830	Lantai 1
		Tump ka	-34,9600	-8,5600	-80,0500	79,7700	-55,6480	-128,8497	38,9613	-103,5090	40,3290	
30	Tump ki	-13,4900	-2,8300	94,9100	-94,8500	-20,7160	82,8167	-116,4314	73,2780	-97,5060		
	Lap	-2,6500	-1,2400	94,9100	94,9100	-5,1640	95,7012	95,7012	83,0340	83,0340		
	Tump ka	-12,8500	-2,5300	-94,8500	94,9100	-19,4680	-115,4759	83,7722	-96,9300	73,8540		
31-32	Tump ki	-34,6000	-8,3800	79,7700	-80,0500	-54,9280	39,5094	-128,3016	40,6530	-103,1850		
	Lap	31,1400	8,8100	79,7700	84,5600	51,4640	124,7810	129,8105	99,8190	104,1300		
	Tump ka	-33,9400	-7,6200	-84,0400	84,5600	-52,9200	-131,0799	45,9501	-106,1820	45,5580		
33-34	Tump ki	-37,2300	-8,2200	80,1900	-79,8300	-57,8280	37,3401	-130,6809	38,6640	-105,3540	Balok	
	Lap	30,4100	8,5500	80,1900	76,9800	50,1720	124,2098	120,8393	99,5400	96,6510	Lantai 2	
	Tump ka	-32,7600	-8,3000	-77,1700	76,9800	-52,5920	-123,2700	38,5875	-98,9370	39,7980		
35	Tump ki	-12,2100	-2,5500	81,8800	-81,8300	-18,7320	70,7438	-101,1518	62,7030	-84,6360		
	Lap	-1,0900	-0,8100	81,8800	81,8800	-2,6040	84,0641	84,0641	72,7110	72,7110		
	Tump ka	-11,0200	-1,9800	-81,8300	81,8800	-16,3920	-99,3636	72,5319	-83,5650	63,7740		
36-37	Tump ki	-32,0900	-7,9800	76,9800	-77,1700	-51,2760	39,5934	-122,2641	40,4010	-98,3340		
	Lap	30,4800	8,5800	76,9800	80,1900	50,3040	120,9411	124,3116	96,7140	99,6030		
	Tump ka	-37,7600	-8,4700	-79,8300	80,1900	-58,8640	-131,4737	36,5474	-105,8310	38,1870		
38-39	Tump ki	-38,4400	-8,3500	64,5000	-64,0800	-59,4880	19,4723	-115,5368	23,4540	-92,2680	Balok	
	Lap	30,6900	8,5800	64,5000	62,6900	50,5560	108,0576	106,1571	85,6710	84,0420	Lantai 3	
	Tump ka	-31,0000	-8,1100	-62,9100	62,6900	-50,1760	-106,2695	25,6106	-84,5190	28,5210		
40	Tump ki	-12,5100	-2,6800	57,3900	-57,3300	-19,3000	44,5914	-75,8646	40,3920	-62,8560		
	Lap	-1,1300	-0,8100	57,3900	57,3900	-2,6520	58,3076	58,3076	50,6340	50,6340		
	Tump ka	-10,8200	-1,8800	-57,3300	57,3900	-15,9920	-73,3341	47,1219	-61,3350	41,9130		
41-42	Tump ki	-29,9400	-7,6000	62,6900	-62,9100	-48,0880	27,2055	-104,6745	29,4750	-83,5650		
	Lap	30,8700	8,6600	62,6900	64,5000	50,9000	106,4217	108,3222	84,2040	85,8330		
	Tump ka	-39,1400	-8,6900	-64,0800	64,5000	-60,8720	-116,5931	18,4160	-92,8980	22,8240		
43-44	Tump ki	-40,9100	-8,2800	42,2900	-42,3000	-62,3400	-6,3756	-95,1951	1,2420	-74,8890	Balok	
	Lap	29,9500	8,6400	42,2900	42,2700	49,7640	84,0168	83,9958	65,0160	64,9980	Lantai 4	
	Tump ka	-30,0200	-8,0700	-42,2600	42,2700	-48,9360	-83,5202	5,2364	-65,0520	11,0250		
45	Tump ki	-12,2000	-3,1800	26,7800	-26,7700	-19,7280	12,3039	-43,9236	13,1220	-35,0730		
	Lap	0,5400	-0,5700	26,7800	26,7800	-0,2640	28,1474	28,1474	24,5880	24,5880		
	Tump ka	-7,9700	-1,1800	-26,7700	26,7800	-11,4520	-37,5921	18,6354	-31,2660	16,9290		
46-47	Tump ki	-28,4900	-7,3400	42,2700	-42,2600	-45,9320	7,5327	-81,2238	12,4020	-63,6750		
	Lap	29,6800	8,5100	42,2700	42,2900	49,2320	83,5895	83,6105	64,7550	64,7730		
	Tump ka	-42,9600	-9,2500	-42,3000	42,2900	-66,3520	-98,2643	-9,4448	-76,7340	-0,6030		
48-49	Tump ki	-28,8000	-3,4200	19,1100	-19,4400	-40,0320	-13,4064	-53,8839	-8,7210	-43,4160	Balok	
	Lap	32,9400	3,7000	19,1100	22,6600	45,4480	58,1490	61,8765	46,8450	50,0400	Atap	
	Tump ka	-29,2500	-2,6200	-22,4800	22,6600	-39,2920	-56,7924	-9,3954	-46,5570	-5,9310		
50	Tump ki	-15,3200	-1,0500	1,0000	-1,0100	-20,0640	-16,0283	-18,1388	-12,8880	-14,6970		
	Lap	-6,5400	-1,0100	1,0000	1,0000	-9,4640	-6,7715	-6,7715	-4,9860	-4,9860		
	Tump ka	-18,9500	-2,7700	-1,0100	1,0000	-27,1720	-23,5757	-21,4652	-17,9640	-16,1550		
51-52	Tump ki	-39,2600	-7,3700	22,6600	-22,4800	-58,9040	-24,3947	-71,7917	-14,9400	-55,5660		
	Lap	47,8600	10,7700	22,6600	19,1100	74,6640	84,2237	80,4962	63,4680	60,2730		
	Tump ka	-35,6000	-6,6400	-19,4400	19,1100	-53,3440	-64,0668	-23,5893	-49,5360	-14,8410		
As B dan As E	37	Tump ki	-1,5000	-15,3200	71,5400	-70,4100	-26,3120	59,0646	-89,9829	63,0360	-64,7190	Balok
		Lap	1,4100	5,8000	71,5400	68,3100	10,9720	82,0785	78,6870	65,6550	62,7480	Sloof
		Tump ka	1,4100	-6,8100	-69,2100	68,3100	-9,2040	-77,6255	66,7706	-61,0200	62,7480	
	38	Tump ki	0,5000	-9,4400	68,4500	-67,9200	-14,5040	63,4767	-79,7118	62,0550	-60,6780	
		Lap	0,5000	5,4200	68,4500	66,5100	9,2720	77,5194	75,4824	62,0550	60,3090	
		Tump ka	-0,7400	-12,9900	-66,8300	66,5100	-21,6720	-83,2241	56,7830	-60,8130	59,1930	
	39	Tump ki	0,2600	-2,6600	101,3100	-101,2200	-3,9440	104,1348	-108,5217	91,4130	-90,8640	
		Lap	0,2600	1,4900	101,3100	101,3100	2,6960	108,0566	108,0566	91,4130	91,4130	
		Tump ka	0,2600	-2,6600	-101,2200	101,3100	-3,9440	-108,5217	104,1348	-90,8640	91,4130	
	40	Tump ki	-0,7400	-12,9900	66,5100	-66,8300	-21,6720	56,7830	-83,2241	59,1930	-60,8130	
		Lap	0,5000	5,4200	66,5100	68,4500	9,2720	75,4824	77,5194	60,3090	62,0550	
		Tump ka	0,5000	-9,4400	-67,9200	68,4500	-14,5040	-79,7118	63,4767	-60,6780	62,0550	

Tabel 7.1 Lanjutan

Portal	No. Elm Balok	Letak Momen	M mati		M hidup		M Gempa		Mu1	Mu2	Mu3	Mu4	Mu5	Balok
			MD	ML	M Gki	M Gka								
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]		
As B dan As E	41	Tump ki	1,4100	-6,8100	68,3100	-69,2100	-9,2040	66,7706	-77,6255	62,7480	-61,0200	Balok		
		Lap	1,4100	5,8000	68,3100	71,5400	10,9720	78,6870	82,0785	62,7480	65,6550	Stoof		
		Tump ka	-1,5000	-15,3200	-70,4100	71,5400	-26,3120	-89,9829	59,0646	-64,7190	63,0360			
42-43	Tump ki	-14,8200	-66,8700	169,7700	-166,7000	-124,7760	99,5054	-253,7882	139,4550	-163,3680	Balok			
		Lap	11,7100	47,5400	169,7700	151,0500	90,1160	235,4793	215,8233	163,3320	146,4840	Lantai 1		
		Tump ka	-10,7600	-54,3700	-153,2500	151,0500	-99,9040	-223,5902	95,9249	-147,6090	126,2610			
44-45	Tump ki	-18,9200	-71,8300	150,9100	-149,7200	-137,6320	70,7102	-244,9514	118,7910	-151,7760				
		Lap	20,3200	64,1900	150,9100	147,1800	127,0880	240,4511	236,5346	154,1070	150,7500			
		Tump ka	-23,0700	-83,0400	-147,8900	147,1800	-160,5480	-257,9808	51,8427	-153,8640	111,6990			
46	Tump ki	-6,1400	-25,2800	179,5300	-179,3500	-47,8160	158,1699	-218,6541	156,0510	-166,9410				
		Lap	-3,2600	-8,4100	179,5300	179,5300	-17,3680	177,1361	177,1361	158,6430	158,6430			
		Tump ka	-6,1400	-25,2800	-179,3500	179,5300	-47,8160	-218,6541	158,6430	158,6430	156,0510			
47-48	Tump ki	-23,0700	-83,0400	147,1800	-147,8900	-160,5480	51,8427	-257,9808	111,6990	-153,8640				
		Lap	20,3200	64,1900	147,1800	150,9100	127,0880	236,5346	240,4511	150,7500	154,1070			
		Tump ka	-18,9200	-71,8300	-149,7200	150,9100	-137,6320	-244,9514	70,7102	-151,7760	118,7910			
49-50	Tump ki	-10,7600	-54,3700	151,0500	-153,2500	-99,9040	95,9249	-223,5902	126,2610	-147,6090				
		Lap	11,7100	47,5400	151,0500	169,7700	90,1160	215,8233	235,4793	146,4840	163,3320			
		Tump ka	-11,7100	-66,8700	-166,7000	169,7700	-92,9400	-225,9317	127,3619	-139,4910	163,3320			
51-52	Tump ki	-18,1800	-78,4000	150,5800	-148,2300	-147,2560	64,9320	-248,8185	119,1600	-149,7690				
		Lap	11,7300	47,3700	150,5800	135,1100	89,8680	215,1902	198,9467	146,0790	132,1560			
		Tump ka	-7,3800	-43,1800	-136,8300	135,1100	-77,9440	-192,2256	93,3114	-129,7890	114,9570			
53-54	Tump ki	-17,0500	-65,0900	143,9600	-142,8900	-124,6040	71,7455	-229,4471	114,2190	-143,9460				
		Lap	20,1900	63,9800	143,9600	141,6300	126,5960	232,8186	230,3721	147,7350	145,6380			
		Tump ka	-25,1900	-90,2000	-142,2600	141,6300	-174,5480	-261,0615	37,0230	-150,7050	104,7960			
55	Tump ki	-5,7600	-24,3000	150,2100	-150,0600	-45,7920	128,7090	-186,5745	130,0050	-140,2380				
		Lap	-2,8800	-7,4300	150,2100	150,2100	-15,3440	147,6752	147,6752	132,5970	132,5970			
		Tump ka	-5,7600	-24,3000	-150,0600	150,2100	-45,7920	-186,5745	128,7090	-140,2380	130,0050			
56-57	Tump ki	-25,1900	-90,2000	141,6300	-142,2600	-174,5480	37,0230	-261,0615	104,7960	-150,7050				
		Lap	20,1900	63,9800	141,6300	143,9600	126,5960	230,3721	232,8186	145,6380	147,7350			
		Tump ka	-17,0500	-65,0900	-142,8900	143,9600	-124,6040	-229,4471	71,7455	-143,9460	114,2190			
58-59	Tump ki	-7,3800	-43,1800	135,1000	-136,8300	-77,9440	93,3009	-192,2256	114,9480	-129,7890				
		Lap	11,7300	47,3700	135,1100	150,5800	89,8680	198,9467	215,1902	132,1560	146,0790			
		Tump ka	-18,1800	-78,4000	-148,2300	150,5800	-147,2560	-248,8185	64,9320	-149,7690	119,1600			
60-61	Tump ki	-20,0300	-84,7500	116,8900	-114,4800	-159,6360	21,6143	-221,3243	87,1740	-121,0590				
		Lap	11,7800	47,5300	116,8900	103,5700	90,1840	180,0194	166,0334	115,8030	103,8150			
		Tump ka	-11,7800	-36,5000	-105,2700	103,5700	-44,2640	-132,6570	86,6250	-84,1410	103,8150			
62-63	Tump ki	-15,8700	-61,0500	118,0800	-117,0400	-116,7240	49,6283	-197,2478	91,9890	-119,6190				
		Lap	20,2900	64,3300	118,0800	117,2300	127,2760	206,0804	205,1879	124,5330	123,7680			
		Tump ka	-26,1700	-93,5300	-117,8500	117,2300	-181,0520	-239,6069	7,2272	-129,6180	81,9540			
64	Tump ki	-6,0100	-25,2200	104,0300	-103,8800	-47,5640	79,0881	-139,2174	88,2180	-98,9010				
		Lap	-3,1300	-8,3500	104,0300	104,0300	-17,1160	98,0543	98,0543	90,8100	90,8100			
		Tump ka	-6,0100	-25,2200	-103,8800	104,0300	-47,5640	-139,2174	79,0881	-98,9010	88,2180			
65-66	Tump ki	-26,1700	-93,5300	117,2300	-117,8500	-181,0520	7,2272	-239,6069	81,9540	-129,6180				
		Lap	20,2900	64,3300	117,2300	118,0800	127,2760	205,1879	206,0804	123,7680	124,5330			
		Tump ka	-15,8700	-61,0500	-117,0400	118,0800	-116,7240	-197,2478	49,6283	-119,6190	91,9890			
67-68	Tump ki	-5,4200	-36,5000	103,5700	-105,2700	-64,9040	68,5650	-150,7170	88,3350	-99,6210				
		Lap	11,7800	47,5300	103,5700	116,8900	90,1840	166,0334	180,0194	103,8150	115,8030			
		Tump ka	-20,0300	-84,7500	-114,4800	116,8900	-159,6360	-221,3243	21,6143	-121,0590	87,1740			
69-70	Tump ki	-20,6400	-86,8400	72,3400	-71,2400	-163,7120	-27,7788	-178,5378	46,5300	-82,6920				
		Lap	11,8400	48,0600	72,3400	64,1000	91,1040	133,8057	125,1537	75,7620	68,3460			
		Tump ka	-4,7000	-33,3700	-64,8500	64,1000	-59,0320	-104,5622	30,8354	-62,5950	53,4600			
71-72	Tump ki	-15,0700	-58,8000	82,9600	-82,3900	-112,1640	15,7185	-157,8990	61,1010	-87,7140				
		Lap	20,4200	64,4000	82,9600	83,7000	127,5440	169,4070	170,1840	93,0420	93,7080			
		Tump ka	-26,7100	-95,6500	-84,0500	83,7000	-185,0920	-206,6873	-30,5498	-99,6840	51,2910			
73	Tump ki	-6,2000	-25,1900	50,0400	-49,9600	-47,7440	22,2275	-82,7726	39,4560	-50,5440				
		Lap	-3,3200	-8,3200	50,0400	50,0400	-17,2960	41,1936	41,1936	42,0480	42,0480			
		Tump ka	-6,2000	-25,1900	-49,9600	50,0400	-47,7440	-82,7726	22,2275	-50,5440	39,4560			
74-75	Tump ki	-26,7100	-95,6500	83,7000	-84,0500	-185,0920	-30,5498	-206,6873	51,2910	-99,6840				
		Lap	20,4200	64,4000	83,7000	82,9600	127,5440	170,1840	169,4070	93,7080	93,0420			
		Tump ka	-15,0700	-58,8000	-82,3900	82,9600	-112,1640	-157,8990	15,7185	-87,7140	61,1010			
76-77	Tump ki	-4,7000	-33,3700	64,1000	-64,8500	-59,0320	30,8354	-104,5622	53,4600	-62,5950				
		Lap	11,8400	48,0600	64,1000	72,3400	91,1040	125,1537	133,8057	68,3460	75,7620			
		Tump ka	-20,6400	-86,8400	-71,2400	72,3400	-163,7120	-178,5378	-27,7788	-82,6920	46,5300			
78-79	Tump ki	-9,7000	-40,3300	27,1600	-27,3200	-76,1680	-19,7789	-76,9829	15,7140	-33,3180				
		Lap	9,5400	27,4700	27,1600	23,1400	55,4000	64,4942	60,2732	33,0300	29,4120			
		Tump ka	-5,6500	-25,4600	-23,0100	23,1400	-47,5160	-54,1527	-5,6952	-25,7940	15,7410			
80-81	Tump ki	-9,8100	-41,7500	36,6400	-36,5500	-78,5720	-11,2823	-88,1318	24,1470	-41,7240				
		Lap	14,6500	53,2000	36,6400	38,6100	102,7000	104,1285	106,1970	46,1610	47,9340			
		Tump ka	-17,5300	-68,0700	-38,6600	38,6100	-129,9480	-123,3257	-42,1922	-50,5710	18,9720			

Tabel 7.1 Lanjutan

Portal	No. Elm Balok	Letak Momen	M mati	M hidup	M Gempa		Mu1	Mu2	Mu3	Mu4	Mu5	Balok
			MD	ML	M Gki	M Gka						
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]
As B dan As E	82-83	Tump ki	-8,100	-30,580	8,700	-8,700	-58,6480	-28,2681	-46,5381	0,5400	-15,1200	Balok Atap
		Lap	3,280	7,890	8,700	8,700	16,5600	20,0351	20,0351	10,7820	10,7820	
	Tump ka	-8,100	-30,580	-8,700	8,700	-58,6480	-46,5381	-28,2681	-15,1200	0,5400		
	84-85	Tump ki	-17,530	-68,070	38,610	-38,660	-129,9480	-42,1922	-123,3257	18,9720	-50,5710	
		Lap	14,650	53,200	38,610	36,640	102,7000	106,1970	104,1285	47,9340	46,1610	
	Tump ka	-9,810	-41,750	-36,550	36,640	-78,5720	-88,1318	-11,2823	-41,7240	24,1470		
86-87	Tump ki	-5,650	-25,460	23,140	-23,010	-47,5160	-5,6952	-54,1527	15,7410	-25,7940		
	Lap	9,540	27,470	23,140	27,160	55,4000	60,2732	64,4942	29,4120	33,0300		
Tump ka	-9,700	-40,330	-27,320	27,160	-76,1680	-76,9829	-19,7789	-33,3180	15,7140			
As C dan As D	21	Tump ki	-48,8800	-1,8800	84,7600	-84,0000	-61,6640	35,8974	-141,3006	32,2920	-119,5920	Balok Sloof
		Lap	20,4400	0,1300	84,7600	80,3400	24,7360	110,5829	105,9419	94,6800	90,7020	
Tump ka	-43,0200	0,1300	-80,7800	80,3400	-51,4160	-129,8672	39,3089	-111,4200	33,5880			
22	Tump ki	0,4100	2,1900	220,2100	-220,0700	3,9960	233,7206	-228,5735	198,5580	-197,6940		
	Lap	4,5600	2,1900	220,2100	220,2100	8,9760	238,0781	238,0781	202,2930	202,2930		
	Tump ka	0,4100	2,1900	-220,0700	220,2100	3,9960	-228,5735	233,7206	-197,6940	198,5580		
23	Tump ki	-43,0200	0,1300	80,3400	-80,7800	-51,4160	39,3089	-129,8672	33,5880	-111,4200		
	Lap	20,4400	0,1300	80,3400	84,7600	24,7360	105,9419	110,5829	90,7020	94,6800		
	Tump ka	-48,8800	-1,8800	-84,0000	84,7600	-61,6640	-141,3006	35,8974	-119,5920	32,2920		
24-27	Tump ki	-441,4100	-129,4600	238,4900	-235,9600	-736,8280	-335,4057	-833,5782	-182,6280	-609,6330	Balok Lantai 1	
	Lap	311,3300	95,3000	238,4900	212,9300	526,0760	667,3695	640,5315	494,8380	471,8340		
Tump ka	-460,1200	-135,3800	-214,2600	212,9300	-768,7520	-836,0331	-387,4836	-606,9420	-222,4710			
28	Tump ki	-100,9000	-29,0400	411,2200	-410,9900	-167,5440	298,3932	-564,9273	279,2880	-460,7010		
	Lap	-84,0600	-26,1600	411,2200	411,2200	-142,7280	318,7968	318,7968	294,4440	294,4440		
	Tump ka	-100,9000	-29,0400	-410,9900	411,2200	-167,5440	-564,9273	298,3932	-460,7010	279,2880		
29-32	Tump ki	-460,1200	-135,3800	212,9300	-214,2600	-768,7520	-387,4836	-836,0331	-222,4710	-606,9420		
	Lap	311,3300	95,3000	212,9300	238,4900	526,0760	640,5315	667,3695	471,8340	494,8380		
	Tump ka	-441,4100	-129,4600	-235,9600	238,4900	-736,8280	-833,5782	-335,4057	-609,6330	-182,6280		
33-36	Tump ki	-452,4800	-133,0100	222,9800	-221,1100	-755,7920	-366,6695	-832,9640	-206,5500	-606,2310	Balok Lantai 2	
	Lap	306,0300	93,5400	222,9800	204,9300	516,9000	643,8558	624,9033	476,1090	459,8640		
	Tump ka	-459,6600	-135,3400	-205,9200	204,9300	-768,1360	-826,7553	-395,3628	-599,0220	-229,2570		
37	Tump ki	-86,5900	-24,2600	334,5900	-334,3500	-142,7240	237,4743	-464,9127	223,2000	-378,8460		
	Lap	-69,7400	-21,3800	334,5900	334,5900	-117,8960	257,8884	257,8884	238,3650	238,3650		
	Tump ka	-86,5900	-24,2600	-334,3500	334,5900	-142,7240	-464,9127	237,4743	-378,8460	223,2000		
38-41	Tump ki	-459,6600	-135,3400	204,9300	-205,9200	-768,1360	-395,3628	-826,7553	-229,2570	-599,0220		
	Lap	306,0300	93,5400	204,9300	222,9800	516,9000	624,9033	643,8558	459,8640	476,1090		
	Tump ka	-452,4800	-133,0100	-221,1100	222,9800	-755,7920	-832,9640	-366,6695	-606,2310	-206,5500		
42-45	Tump ki	-459,3900	-134,9800	173,8300	-171,8700	-767,2360	-427,3941	-790,3791	-257,0040	-568,1340	Balok Lantai 3	
	Lap	302,0600	92,3900	173,8300	162,6700	510,2960	586,9931	575,2751	428,3010	418,2570		
	Tump ka	-460,6800	-135,6700	-163,7000	162,6700	-769,8880	-783,8072	-441,1187	-561,9420	-268,2090		
46	Tump ki	-74,0700	-20,6500	194,1900	-193,9500	-121,9240	106,6118	-300,9353	108,1080	-241,2180		
	Lap	-57,2200	-17,7700	194,1900	194,1900	-97,0960	127,0259	127,0259	123,2730	123,2730		
	Tump ka	-74,0700	-20,6500	-193,9500	194,1900	-121,9240	-300,9353	106,6118	-241,2180	108,1080		
47-50	Tump ki	-460,6800	-135,6700	162,6700	-163,7000	-769,8880	-441,1187	-783,8072	-268,2090	-561,9420		
	Lap	302,0600	92,3900	162,6700	173,8300	510,2960	575,2751	586,9931	418,2570	428,3010		
	Tump ka	-459,3900	-134,9800	-171,8700	173,8300	-767,2360	-790,3791	-427,3941	-568,1340	-257,0040		
51-54	Tump ki	-400,5800	-117,7300	112,7100	-111,1000	-669,0640	-413,5184	-648,5189	-259,0830	-460,5120	Balok Lantai 4	
	Lap	332,8400	101,4700	112,7100	109,4400	561,7600	563,7167	560,2832	400,9950	398,0520		
	Tump ka	-457,9400	-134,7700	-110,2300	109,4400	-765,1600	-723,9362	-493,2827	-511,3530	-313,6500		
55	Tump ki	-158,8000	-45,8000	44,5600	-44,5100	-263,8400	-163,2330	-256,7565	-102,8160	-182,9790		
	Lap	-141,9500	-42,9200	44,5600	44,5600	-239,0120	-142,8189	-142,8189	-87,6510	-87,6510		
	Tump ka	-158,8000	-45,8000	-44,5100	44,5600	-263,8400	-256,7565	-163,2330	-182,9790	-102,8160		
56-59	Tump ki	-457,9400	-134,7700	109,4400	-110,2300	-765,1600	-493,2827	-723,9362	-313,6500	-511,3530		
	Lap	332,8400	101,4700	109,4400	112,7100	561,7600	560,2832	563,7167	398,0520	400,9950		
	Tump ka	-400,5800	-117,7300	-111,1000	112,7100	-669,0640	-413,5184	-648,5189	-259,0830	-460,5120		
As F	25	Tump ki	-12,3900	-0,9700	66,4100	-66,2100	-16,4200	55,8044	-83,4467	48,6180	-70,7400	Balok Sloof
		Lap	5,9200	0,4400	66,4100	58,6000	7,8080	76,3623	68,1618	65,0970	58,0680	
Tump ka	-9,0200	0,4400	-58,7100	58,6000	-10,1200	-70,7007	52,4748	-60,9570	44,6220			
26	Tump ki	-1,9500	1,0600	72,8800	-72,8600	-0,6440	75,4782	-77,5488	63,8370	-67,3290		
	Lap	0,9900	1,0600	72,8800	72,8800	2,8840	78,5652	78,5652	66,4830	66,4830		
	Tump ka	-4,5600	-0,2800	-72,8600	72,8800	-5,9200	-81,5556	71,4714	-69,6780	61,4880		
27	Tump ki	-9,8800	-0,0100	58,6000	-58,7100	-11,8720	51,1466	-72,0290	43,8480	-61,7310		
	Lap	5,9700	-0,0100	58,6000	66,4100	7,1480	67,7891	75,9896	58,1130	65,1420		
	Tump ka	-11,3700	-0,4400	-66,2100	66,4100	-14,3480	-81,8748	57,3762	-69,8220	49,5360		
28	Tump ki	-43,4500	-13,1200	85,4100	-85,1200	-73,1320	31,6596	-147,3969	37,7640	-115,7130	Balok Lantai 1	
	Lap	26,6100	8,2200	85,4100	77,0300	45,0840	125,3889	116,5899	100,8180	93,2760		
	Tump ka	-41,1700	-12,5600	-77,1800	77,0300	-69,5000	-136,1367	25,7838	-106,5150	32,2740		
29	Tump ki	-12,8800	-3,0800	96,4800	-96,4400	-20,3840	84,8694	-117,6966	75,2400	-98,3880		
	Lap	-0,4800	-0,5700	96,4800	96,4800	-1,4880	100,2614	100,2614	86,4000	86,4000		
	Tump ka	-14,1900	-3,8400	-96,4400	96,4800	-23,1720	-119,7903	82,7757	-99,5670	74,0610		

Tabel 7.1 Lanjutan

Portal	No. Elm Balok	Letak Momen	M Gempa				Mu1	Mu2	Mu3	Mu4	Mu5	Balok
			M mati	M hidup	M Gki	M Gka						
[1]	[2]	[3]	MD	ML	M Gki	M Gka	[8]	[9]	[10]	[11]	[12]	[13]
As F	30-31	Tump ki	-33,4400	-8,8100	77,0300	-77,1800	-54,2240	37,4441	-124,4765	39,2310	-99,5580	Balok
		Lap	25,2500	8,1700	77,0300	85,4100	43,3720	115,1147	123,9137	92,0520	99,5940	Lantai 1
		Tump ka	-34,0600	-8,4600	-85,1200	85,4100	-54,4080	-133,1337	45,9228	-107,2620	46,2150	
	32	Tump ki	-46,0300	-13,9600	83,4800	-83,2900	-77,5720	26,1303	-148,9782	33,7050	-116,3880	Balok
		Lap	26,0500	8,0000	83,4800	76,3500	44,0600	122,5665	115,0800	98,5770	92,1600	Lantai 2
		Tump ka	-39,7700	-12,1800	-76,4400	76,3500	-67,2120	-133,5306	26,8989	-104,5890	32,9220	
	33	Tump ki	-10,6900	-2,1300	88,0400	-88,0100	-16,2360	79,2047	-105,6479	69,6150	-88,8300	
		Lap	0,6100	-0,1400	88,0400	88,0400	0,5080	92,9502	92,9502	79,7850	79,7850	
		Tump ka	-14,3200	-4,0700	-88,0100	88,0400	-23,6960	-111,2927	73,5599	-92,0970	66,3480	
	34-35	Tump ki	-32,7600	-8,8100	76,3500	-76,4400	-53,4080	37,4441	-122,9855	39,2310	-98,2800	
		Lap	24,7400	7,9800	76,3500	83,4800	42,4560	113,6856	121,1721	90,9810	97,3980	
		Tump ka	-35,7600	-8,8400	-83,2900	83,4800	-57,0560	-133,3563	41,7522	-107,1450	42,9480	
	36	Tump ki	-46,8100	-14,1800	66,8300	-66,6400	-78,8600	7,6209	-132,5226	18,0180	-102,1050	Balok
		Lap	26,2700	8,0500	66,8300	61,7100	44,4040	105,3623	99,9863	83,7900	79,1820	Lantai 3
		Tump ka	-38,6100	-11,8700	-61,8000	61,7100	-65,3240	-116,6477	13,0379	-90,3690	20,7900	
	37	Tump ki	-10,4400	-1,9600	62,9200	-62,8900	-15,6640	53,2518	-78,8487	47,2320	-65,9970	
		Lap	0,4900	-0,1300	62,9200	62,9200	0,3800	66,4577	66,4577	57,0690	57,0690	
		Tump ka	-14,8600	-4,3100	-62,8900	62,9200	-24,7280	-85,7105	46,3901	-69,9750	43,2540	
	38-39	Tump ki	-32,0300	-8,7200	61,7100	-61,8000	-52,3880	22,9236	-106,7619	26,7120	-84,4470	
		Lap	24,9000	8,0100	61,7100	66,8300	42,6960	98,5100	103,8860	77,9490	82,5570	
		Tump ka	-36,1800	-8,8700	-66,6400	66,8300	-57,6080	-116,3432	23,8004	-92,5380	27,5850	
	40	Tump ki	-48,1300	-14,3100	42,8500	-42,6600	-80,6520	-19,0670	-108,8525	-4,7520	-81,7110	Balok
		Lap	25,9000	8,0700	42,8500	40,2200	43,9920	79,8137	77,0522	61,8750	59,5080	Lantai 4
		Tump ka	-38,0900	-11,7100	-40,3200	40,2200	-64,4440	-93,3965	-8,8295	-70,5690	1,9170	
41	Tump ki	-9,9800	-2,0500	30,4600	-30,4300	-15,2560	15,5668	-44,3678	18,4320	-36,3690		
	Lap	1,1900	-0,1300	30,4600	30,4600	1,2200	33,1097	33,1097	28,4850	28,4850		
	Tump ka	-13,8700	-4,1600	-30,4300	30,4600	-23,3000	-50,4462	13,4883	-39,8700	14,9310		
42-43	Tump ki	-31,6400	-8,6300	40,2200	-40,3200	-51,7760	0,8536	-83,7134	7,7220	-64,7640		
	Lap	24,3800	7,9700	40,2200	42,8500	42,0080	75,3617	78,1232	58,1400	60,5070		
	Tump ka	-37,6000	-9,0500	-42,6600	42,8500	-59,6000	-92,8253	-3,0398	-72,2340	4,7250		
44-45	Tump ki	-33,2500	-7,3600	24,7100	-24,5500	-51,6760	-15,9222	-67,6452	-7,6860	-52,0200	Balok	
	Lap	35,8100	7,3400	24,7100	25,6700	54,7160	70,4823	71,4903	54,4680	55,3320	Atap	
	Tump ka	-27,3500	-4,8400	-25,7300	25,6700	-40,5640	-60,3078	-6,3378	-47,7720	-1,5120		
46	Tump ki	-9,6500	-0,5300	0,4500	-0,4300	-12,4280	-10,1609	-11,0849	-8,2800	-9,0720		
	Lap	-6,0900	-0,4800	0,4500	0,4500	-8,0760	-6,3756	-6,3756	-5,0760	-5,0760		
	Tump ka	-16,6400	-4,1500	-0,4300	0,4500	-26,6080	-21,8453	-20,9213	-15,3630	-14,5710		
47-48	Tump ki	-31,0500	-6,7700	25,6700	-25,7300	-48,0920	-12,0467	-66,0167	-4,8420	-51,1020		
	Lap	35,3900	7,1200	25,6700	24,7100	53,8600	70,8414	69,8334	54,9540	54,0900		
	Tump ka	-30,3900	-5,8800	-24,5500	24,7100	-45,8760	-63,2436	-11,5206	-49,4460	-5,1120		

Keterangan Tabel 7.1:

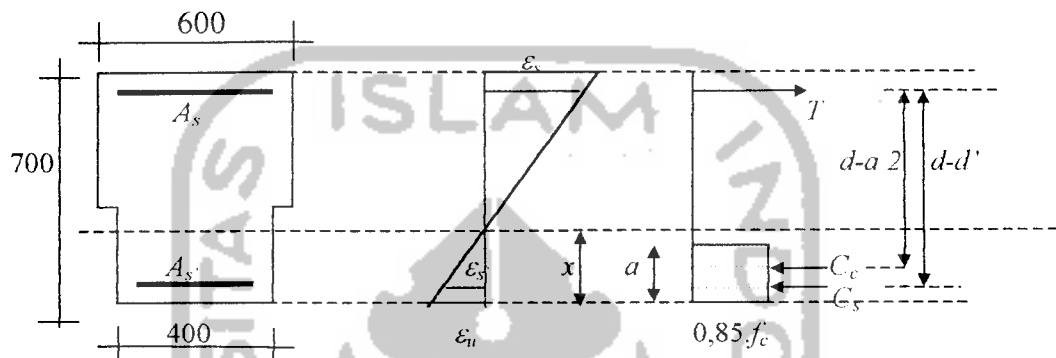
- [1] Portal yang ditinjau
- [2] Nomor elemen balok
- [3] Letak momen: Tumpuan kiri, Tumpuan kanan, dan Lapangan
- [4] MD = Momen akibat beban mati
- [5] ML = Momen akibat beban hidup
- [6] MGki = Momen akibat beban gempa kiri
- [7] MGka = Momen akibat beban gempa kanan
- [8] Mu1 = 1,2MD + 1,6ML
- [9] Mu2 = 1,05 (MD + 0,9ML + MGki)
- [10] Mu3 = 1,05 (MD + 0,9ML + MGka)
- [11] Mu4 = 0,9 (MD + MGki)
- [12] Mu5 = 0,9 (MD + MGka)
- [13] Keterangan Balok: sloof, lantai 1 s/d 4, dan atap
Angka yang dicetak tebal adalah Mu terbesar

7.1.2 Penulangan Lentur Balok dan Perhitungan Momen Nominal Aktual Balok

Sebagai contoh perhitungan penulangan lentur balok dan perhitungan momen nominal aktual balok ditinjau pada Portal as 1 dan as 6, untuk balok lantai 1 sebagai berikut ini. (Cara perhitungan menurut: Dipohusodo,1996):

1. Tulangan tumpuan balok Lantai 1

- Untuk momen negatif ($M_u = - 440,7974 \text{ kNm}$)



Gambar 7.1 Analisis balok bertulangan rangkap tumpuan untuk momen negatif

$$\rho_b = \frac{0,85 \cdot f_c}{f_y} \beta_1 \left(\frac{600}{600 + f_y} \right) = \frac{0,85 \cdot 25}{400} \cdot 0,85 \left(\frac{600}{600 + 400} \right) = 0,02709$$

$$\rho_{min} = 1,4/f_y = 1,4/400 = 0,0035 ; \rho_{maks} = 0,75 \cdot \rho_b = 0,75 \cdot 0,02709 = 0,02032$$

$$\rho_{min} < \rho \leq \rho_{maks} \quad \text{diambil } \rho = (0,0035 + 0,02709)/4 = 0,007146$$

$$d' = p(\text{selimut beton}) + \varnothing_{\text{tul.sengkang}} + \frac{1}{2} \cdot \varnothing_{\text{tul.lentur}} = 50 + 10 + \frac{1}{2} \cdot 25 = 72,5 \text{ mm}$$

$$d = h - d' = 700 - 72,5 = 627,5 \text{ mm}$$

$$x = [600/(600 + f_y)] \cdot d = [600/(600 + 400)] \cdot 627,5 = 376,5 \text{ mm}$$

$$a = \beta_1 \cdot x = 0,85 \cdot 376,5 = 320,025 \text{ mm}$$

$$\text{Luas tulangan tarik: } A_{s1} = \rho \cdot b \cdot d = 0,007146 \cdot 400 \cdot 627,5 = 1793,646 \text{ mm}^2$$

$$T_1 = A_{s1} \cdot f_y = 1793,646 \cdot 400 = 717458,4 \text{ N}$$

$$M_{n1} = T_1 \cdot (d - a/2) = 717458,4 \cdot (627,5 - 320,025/2) \cdot 10^{-6}$$

$$= 335,4028 \text{ kNm} < (M_u/0,8 = 550,9958 \text{ kNm})$$

$$M_{n2} = M_n - M_{n1} = 550,9958 - 335,4028 = 215,593 \text{ kNm}$$

$$M_{n2} = C_s \cdot (d - d') \quad \text{atau} \quad M_{n2} = T_2 \cdot (d - d')$$

$$T_2 = C_s = M_{n2}/(d - d') = 215,593 \cdot 10^6 / (627,5 - 72,5) = 388468,47 \text{ N}$$

Periksa regangan tulangan tekan:

$$\varepsilon_s = [(x-d')/x] \cdot \varepsilon_{cu} = [(376,5 - 72,5)/367,5] \cdot 0,003 = 0,0024$$

$$\varepsilon_y = f_y/E_s = 400/200000 = 0,002$$

$$\varepsilon_s > \varepsilon_y$$

dianggap baja tekan telah leleh saat beton tekan mencapai regangan hancur 0,003 dan $f_s = f_y = 400$ MPa

$$\text{Luas tulangan tekan: } A_s = C_c/f_s = 388468,47/400 = 971,17 \text{ mm}^2$$

$$\text{Tambahan luas tulangan tarik: } A_{s2} = T_2/f_y = 388468,47/400 = 971,17 \text{ mm}^2$$

$$\text{Luas tulangan tarik: } A_s = A_{s1} + A_{s2} = 1793,646 + 971,17 = 2764,82 \text{ mm}^2$$

Dipakai tulangan: - tulangan tarik/atas : **6D25** = 2945,24 mm² > $A_s = 2764,82$ mm²
- tulangan tekan/bawah : **3D25** = 1472,62 mm² > $A_s = 971,17$ mm²

Periksa kapasitas penampang: (lihat Gambar 7.1)

Anggap tulangan tarik dan tulangan tekan telah leleh :

$$C_c = 0,85 \cdot f_c \cdot b \cdot a = 0,85 \cdot 25 \cdot 400 \cdot a = 8500 \cdot a$$

$$C_s = A_s \cdot (f_y - 0,85 \cdot f_c) = 1472,6217 \cdot (400 - 0,85 \cdot 25) = 557755,4689 \text{ N}$$

$$T = A_s \cdot f_y = 2945,24 \cdot 400 = 1178096 \text{ N}$$

Keseimbangan gaya-gaya dalam:

$$T = C_c + C_s$$

$$1178096 = 8500 \cdot a + 557755,50, \text{ didapat } a = 72,98 \text{ mm}$$

$$x = a/\beta_1 = 72,98/0,85 = 72,98/0,85 = 85,86 \text{ mm}$$

$$\varepsilon_s = [(x-d')/x] \cdot \varepsilon_{cu} = [(85,86-72,5)/85,86]0,003 = 0,00046 < (\varepsilon_y = 0,002)$$

$$\varepsilon_s = [(d-x)/x] \cdot \varepsilon_{cu} = [(627,5-85,86)/85,86]0,003 = 0,0189 > (\varepsilon_y = 0,002)$$

Anggapan tidak benar, tulangan tekan belum leleh diperlukan mencari garis netral terlebih dahulu:

untuk mendapatkan nilai x digunakan persamaan sebagai berikut:

$$(0,85 \cdot f_c \cdot b \cdot \beta_1) \cdot x^2 + (600 \cdot A_s - A_s \cdot f_y) \cdot x - 600 \cdot d' \cdot A_s = 0$$

$$(0,85 \cdot 25 \cdot 400 \cdot 0,85) \cdot x^2 + (600 \cdot 1472,6217 - 2945,2434 \cdot 400) \cdot x - 600 \cdot 72,5 \cdot 1472,6217 = 0$$

$$7225 \cdot x^2 - 294524,34 \cdot x - 64059043,95 = 0$$

dari persamaan diatas didapat $x = 116,72$ mm

$$f_s = [(x-d')/x]600 = [(116,72-72,5)/116,72]600 = 227,313 \text{ MPa} < (f_y = 400 \text{ MPa})$$

Periksa rasio tulangan

$$\rho = A_{s1} / (b \cdot d) = [A_s - (A_s \cdot f_s) / f_y] / (b \cdot d)$$

$$= [2945,24 - (1472,62 \cdot 227,313)/400]/(400 \cdot 627,5) = 0,0084$$

$(\rho_{min} = 0,0035) < \rho = 0,0084 \leq (\rho_{maks} = 0,0203)$, memenuhi syarat

$$a = 0,85 \cdot x = 0,85 \cdot 116,72 = 99,22 \text{ mm}$$

Hitung momen nominal aktual negatif tumpuan.

$$C_c = 0,85 \cdot f_c \cdot b \cdot a = 0,85 \cdot 25 \cdot 400 \cdot 99,22 = 843331,6 \text{ N}$$

$$C_s = A_s \cdot f_s = 1472,6217 \cdot 227,313 = 334765,6 \text{ N}$$

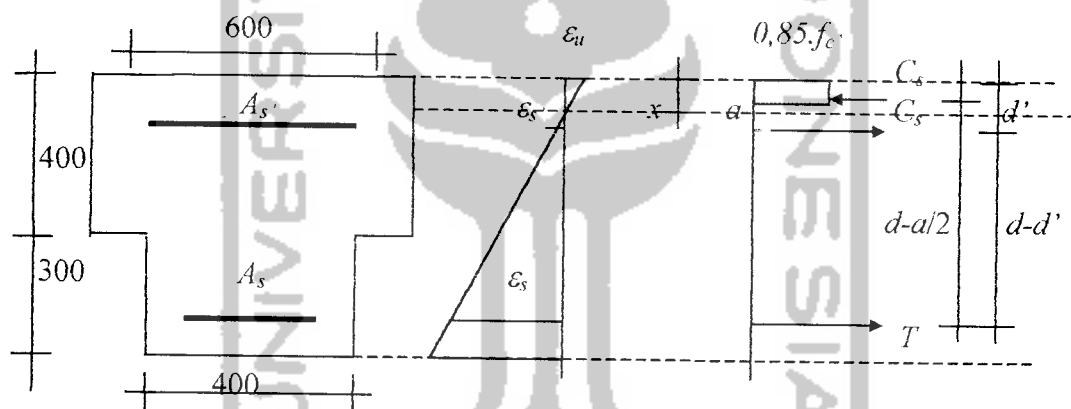
$$M_{nak} = C_c \cdot [d - (a/2)] + C_s \cdot (d - d')$$

$$= (843331,6 \cdot [627,5 - (99,22/2)] + 334765,6 \cdot (637,5 - 62,5)) \cdot 10^{-6}$$

$$= 673,1497 \text{ kNm}$$

$(\phi M_{nak} = 0,8 \cdot 673,1497 = 538,5198 \text{ kNm}) > (M_u = 440,7974 \text{ kNm})$ - aman -

- Untuk momen tumpuan positif ($M_u = 76,6530 \text{ kNm}$)



Gambar 7.2 Analisis balok bertulangan rangkap tumpuan untuk momen positif

Periksa kapasitas penampang (lihat Gambar 7.2):

Anggap tulangan tarik dan tulangan tekan telah leleh :

$$C_c = 0,85 \cdot f_c \cdot b \cdot a = 0,85 \cdot 25 \cdot 600 \cdot a = 12750 \cdot a$$

$$C_s = A_s' \cdot (f_y - 0,85 \cdot f_c) = 2945,2434 \cdot (400 - 0,85 \cdot 25) = 1115510,938 \text{ N}$$

$$T = A_s \cdot f_y = 1472,6217 \cdot 400 = 589048,68 \text{ N}$$

Keseimbangan gaya-gaya dalam:

$$T = C_c + C_s$$

$$589048,68 = 12750 \cdot a + 1115510,938, \text{ didapat } a = -41,29 \text{ mm}$$

$$x = a/\beta_1 = 41,29/0,85 = -48,58 \text{ mm}$$

$$\epsilon_s = [(x-d')/x] \cdot \epsilon_{cu} = [(48,58-72,5)/48,58] \cdot 0,003 = -0,00148 < (\epsilon_y = 0,002)$$

$$\varepsilon_s = [(d-x)/x] \cdot \varepsilon_{cu} = [(627,5-48,58)/48,58] \cdot 0,003 = 0,0358 > (\varepsilon_y = 0,002)$$

Anggapan tidak benar, tulangan tekan belum leleh dicari garis netral terlebih dahulu:
untuk mendapatkan nilai x digunakan persamaan sebagai berikut:

$$(0,85 \cdot f_c' \cdot b \cdot \beta_1) x^2 + (600 \cdot A_s - A_s' \cdot f_y) x - 600 \cdot d' \cdot A_s' = 0$$

$$(0,85 \cdot 25 \cdot 600 \cdot 0,85) x^2 + (600 \cdot 2945,2434 - 1472,6217 \cdot 400) x - 600 \cdot 72,5 \cdot 2945,2434 = 0$$

$$10837,5 \cdot x^2 + 1178097,36 \cdot x - 128118087,9 = 0$$

dari persamaan diatas didapat $x = 67,2$ mm

$$f_s = [(x-d')/x] 600 = [(67,2-72,5)/67,2] 600 = -47,29 \text{ MPa} < (f_y = 400 \text{ MPa})$$

Periksa rasio tulangan

$$\rho = A_s / (b \cdot d) = [A_s - (A_s' \cdot f_s) / f_y] / (b \cdot d)$$

$$= [1472,62 - (2945,24 \cdot -47,29) / 400] / (400 \cdot 627,5) = 0,0048$$

$(\rho_{min} = 0,0035) < \rho = 0,0048 \leq (\rho_{maks} = 0,0203)$, memenuhi syarat

$$a = 0,85 \cdot x = 0,85 \cdot 67,2 = 57,12 \text{ mm}$$

Hitung momen nominal aktual balok positif tumpuan.

$$C_c = 0,85 \cdot f_c' \cdot b \cdot a = 0,85 \cdot 25 \cdot 600 \cdot 57,12 = 728319,17 \text{ N}$$

$$C_s = A_s' \cdot f_s' = 2945,2434 \cdot (-47,29) = -139270,56 \text{ N}$$

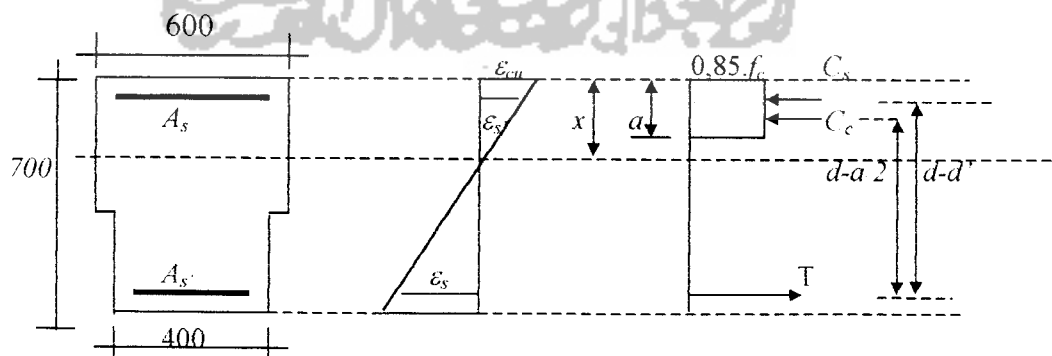
$$M_{nak}^+ = C_c \cdot [d - (a/2)] + C_s \cdot (d - d')$$

$$= (728319,17 \cdot [627,5 - (35,27/2)]) - 139270,56 \cdot (627,5 - 72,5) \cdot 10^{-6}$$

$$= 358,9232 \text{ kNm}$$

$(\phi M_{nak}^+ = 0,8 \cdot 358,9232 = 287,1386 \text{ kNm}) > (M_u = 76,6530 \text{ kNm})$ - aman -

2. Tulangan lapangan balok Lantai 1 ($M_u = 349,2647 \text{ kNm}$)



Gambar 7.3 Analisis balok bertulangan rangkap lapangan

$$\rho_b = \frac{0,85 \cdot f_c}{f_y} \beta_1 \left(\frac{600}{600 + f_y} \right) = \frac{0,85 \cdot 25}{400} \cdot 0,85 \left(\frac{600}{600 + 400} \right) = 0,02709$$

$$\rho_{min} = 1,4/f_y = 1,4/400 = 0,0035 \quad ; \quad \rho_{maks} = 0,75 \cdot \rho_b = 0,75 \cdot 0,02709 = 0,02032$$

$$\rho_{min} < \rho \leq \rho_{maks} \quad \text{diambil } \rho = 0,0048$$

$$d' = p_{\text{(selimut beton)}} + \varnothing_{\text{tul sengkang}} + \frac{1}{2} \cdot \varnothing_{\text{tul lentur}} = 50 + 10 + \frac{1}{2} \cdot 25 = 72,5 \text{ mm}$$

$$d = h - d' = 700 - 72,5 = 627,5 \text{ mm}$$

$$x = [600/(600+f_y)] \cdot d = [600/(600+400)] \cdot 627,5 = 376,5 \text{ mm}$$

$$a = \beta_1 \cdot x = 0,85 \cdot 376,5 = 320,025 \text{ mm}$$

$$\text{Luas tulangan tarik: } A_{s1} = \rho \cdot b \cdot d = 0,004866 \cdot 600 \cdot 627,5 = 1832,049 \text{ mm}^2$$

$$T_1 = A_{s1} \cdot f_y = 1832,049 \cdot 400 = 732819,6 \text{ N}$$

$$M_{n1} = T_1 \cdot (d - a/2) = 732819,6 \cdot (627,5 - 320,025/2)$$

$$= 342584002,755 \text{ N mm}$$

$$= 342,584 \text{ kN.m} < (M_u/0,8 = 349,2647/0,8 = 436,5809 \text{ kNm})$$

$$M_{n2} = M_u - M_{n1} = 436,5809 - 342,584 = 93,9969 \text{ kNm}$$

$$M_{n2} = C_s \cdot (d - d') \quad \text{atau} \quad M_{n2} = T_2 \cdot (d - d')$$

$$T_2 = C_s = M_{n2}/(d - d') = 93,9969 \cdot 10^6 / (627,5 - 72,5) = 169353,15 \text{ N}$$

Periksa regangan tulangan tekan:

$$\varepsilon_s = [(x - d')/x] \cdot \varepsilon_{cu} = [(376,5 - 72,5)/376,5] \cdot 0,003 = 0,0024$$

$$\varepsilon_y = f_y/E_s = 400/200000 = 0,002$$

$$\varepsilon_s > \varepsilon_y$$

dianggap baja tekan telah leleh saat beton tekan mencapai regangan hancur 0,003

dan $f_s' = f_y = 400 \text{ MPa}$

$$\text{Luas tulangan tekan: } A_s = C_s/f_s' = 169353,15/400 = 423,38 \text{ mm}^2$$

$$\text{Tambahan luas tulangan tarik: } A_{s2} = T_2/f_y = 169353,15/400 = 423,38 \text{ mm}^2$$

$$\text{Luas tulangan tarik: } A_s = A_{s1} + A_{s2} = 1832,05 + 423,38 = 2255,43 \text{ mm}^2$$

$$\text{Dipakai tulangan: - tulangan tarik/bawah : } \mathbf{5D25} = 2454,37 \text{ mm}^2 > A_s = 2255,43 \text{ mm}^2$$

$$\text{- tulangan tekan/atas : } \mathbf{3D25} = 1472,62 \text{ mm}^2 > A_s' = 423,38 \text{ mm}^2$$

Periksa kapasitas penampang (lihat Gambar 7.3):

Anggap tulangan tarik dan tulangan tekan telah leleh :

$$C_c = 0,85 \cdot f_c \cdot b \cdot a = 0,85 \cdot 25 \cdot 600 \cdot a = 12750 \cdot a$$

$$C_s = A_s' \cdot (f_y - 0,85 \cdot f_c) = 1472,62 \cdot (400 - 0,85 \cdot 25) = 557754,82 \text{ N}$$

$$T = A_s \cdot f_y = 2454,369 \cdot 400 = 981747,6 \text{ N}$$

Keseimbangan gaya-gaya dalam:

$$T = C_c + C_s$$

$$981747,6 = 12750 \cdot a + 557754,825, \text{ didapat } a = 47,84 \text{ mm}$$

$$x = a/\beta_1 = 47,84/0,85 = 56,28 \text{ mm}$$

$$\varepsilon_s = [(x-d')/x] \cdot \varepsilon_{cu} = [(56,28-72,5)/56,28]0,003 = -0,00086 < (\varepsilon_y = 0,002)$$

$$\varepsilon_s = [(d-x)/x] \cdot \varepsilon_{cu} = [(627,5-56,28)/56,28]0,003 = 0,0304 > (\varepsilon_y = 0,002)$$

Anggapan tidak benar, berarti tulangan tekan belum leleh diperlukan mencari garis netral terlebih dahulu:

untuk mendapatkan nilai x digunakan persamaan sebagai berikut:

$$(0,85 \cdot f_c \cdot b \cdot \beta_1) \cdot x^2 + (600 \cdot A_s' - A_s \cdot f_y) \cdot x - 600 \cdot d' \cdot A_s' = 0$$

$$(0,85 \cdot 25 \cdot 600 \cdot 0,85) x^2 + (600 \cdot 981,748 - 2454,369 \cdot 400) x - 600 \cdot 72,5 \cdot 981,748 = 0$$

$$10837,5 \cdot x^2 - 392698,8 \cdot x - 42706038 = 0$$

dari persamaan diatas didapat $x = 81,54 \text{ mm}$

$$f_s' = [(x-d')/x]600 = [(81,54-72,5)/81,54]600 = 66,55 \text{ MPa} < (f_y = 400 \text{ MPa})$$

Periksa rasio tulangan

$$\rho = A_s / (b \cdot d) = [A_s - (A_s' \cdot f_s') / f_y] / (b \cdot d)$$

$$= [2454,37 - (1472,62 \cdot 66,55) / 400] / (400 \cdot 627,5) = 0,0059$$

$$(\rho_{min} = 0,0035) < \rho = 0,0059 \leq (\rho_{maks} = 0,0203)$$

$$a = 0,85 \cdot x = 0,85 \cdot 81,54 = 69,31 \text{ mm} - \text{memenuhi syarat} -$$

Hitung momen nominal aktual balok lapangan

$$C_c = 0,85 \cdot f_c \cdot b \cdot a = 0,85 \cdot 25 \cdot 600 \cdot 69,31 = 883742,6 \text{ N}$$

$$C_s = A_s' \cdot f_s' = 1472,62 \cdot 66,55 = 98005,1 \text{ N}$$

$$M_{mak} = C_c \cdot [d - (a/2)] + C_s \cdot (d - d')$$

$$= (883742,6 \cdot [627,5 - (69,31/2)]) + 98005,1 \cdot (627,5 - 72,5) \cdot 10^{-6}$$

$$= 578,3138 \text{ kNm}$$

$$(\phi M_{mak} = 0,8 \cdot 578,3138 = 462,6511 \text{ kNm}) > (M_u = 349,2647 \text{ kNm})$$

Dengan cara yang sama dapat dihitung penulangan lentur dan perhitungan momen nominal aktual seluruh balok, yang disajikan pada lampiran Tabel 7.2.

Tabel 7.2 Penulangan Lentur dan Momen Nominal Aktual Balok Daktilitas Penuh

Por-tal	Balok	Ukuran [mm]	l [m]	Letak Tulangan	Tulangan terpakai [6]	As (mm ²)	ρ	Analisis	M _u (kNm)	b (mm)	d' (mm)	d (mm)	x (mm)	a (mm)	f _s ' (MPa)	C _c (kN)	C _s (kN)	M _{mak} (kN.m)	ϕ M _{mak} (kNm)	
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]	
As 1 dan As 6	Sloof	b = 400 h = 600	7,2	Tump	Atas	4 D 19	1134,11	0,0056	M.tump. -	115,6754	400	69,5	530,5	66,25	56,31	-29,42	478,6684	-25,0225	228,9204	183,1363
				Tump	Bawah	3 D 19	850,586	0,0052	M.tump. +	60,7709	400	69,5	530,5	60,72	51,61	-86,80	438,6757	-98,4412	176,0163	140,8130
				Lap	Atas	3 D 19	850,586	0,0056	M.lap.	99,6944	400	69,5	530,5	66,25	56,31	-29,42	478,6684	-25,0225	228,9204	183,1363
				Lap	Bawah	4 D 19	1134,11	0,0084	M.tump. -	440,7974	400	72,5	627,5	116,72	99,22	227,33	843,3316	334,7656	673,1497	538,5198
				Lap	Atas	3 D 25	1472,62	0,0048	M.tump. +	76,6530	600	72,5	627,5	67,20	57,12	-47,29	728,3192	-139,2706	358,9232	287,1386
				Lap	Bawah	3 D 25	1472,62	0,0059	M.lap.	349,2647	600	72,5	627,5	81,54	69,31	66,55	883,7426	98,0051	578,3138	462,6511
	Lantai 1	b = 600 h = 700	7,2	Tump	Atas	5 D 25	2454,37	0,0084	M.tump. -	427,5285	400	72,5	627,5	116,72	99,22	227,33	843,3316	334,7656	673,1497	538,5198
				Tump	Bawah	3 D 25	1472,62	0,0048	M.tump. +	55,3770	600	72,5	627,5	67,20	57,12	-47,29	728,3192	-139,2706	358,9232	287,1386
				Lap	Atas	3 D 25	1472,62	0,0059	M.lap.	330,7112	600	72,5	627,5	81,54	69,31	66,55	883,7426	98,0051	578,3138	462,6511
				Lap	Bawah	5 D 25	2454,37	0,0073	M.tump. -	389,1888	400	72,5	627,5	101,20	86,02	170,16	731,1696	250,5781	566,4322	453,1457
				Lap	Atas	3 D 25	1472,62	0,0048	M.tump. +	15,3720	600	72,5	627,5	66,53	56,55	-53,79	721,0728	-132,0242	358,8097	287,0478
				Lap	Bawah	3 D 25	1472,62	0,0052	M.lap.	287,3241	600	72,5	627,5	72,49	61,61	-0,12	785,5679	-0,1697	468,6490	374,9192
Lantai 2	b = 600 h = 700	7,2	Tump	Atas	5 D 25	2454,37	0,0073	M.tump. -	333,0632	400	72,5	627,5	101,20	86,02	170,16	731,1696	250,5781	566,4322	453,1457	
			Tump	Bawah	3 D 25	1472,62	0,0048	M.tump. +	0,0000	600	72,5	627,5	66,53	56,55	-53,79	721,0728	-132,0242	358,8097	287,0478	
			Lap	Atas	3 D 25	1472,62	0,0052	M.lap.	238,9813	600	72,5	627,5	72,49	61,61	-0,12	785,5679	-0,1697	468,6490	374,9192	
			Lap	Bawah	4 D 25	1963,5	0,0051	M.tump. -	116,2112	500	69,5	530,5	59,61	50,67	-99,57	538,3369	-84,6909	232,9072	186,3258	
			Lap	Atas	4 D 19	1134,11	0,0048	M.tump. +	0,0000	500	69,5	530,5	55,94	47,55	-145,46	505,1983	-164,9638	179,9488	143,9590	
			Lap	Bawah	3 D 19	850,586	0,0051	M.lap.	111,6969	500	69,5	530,5	59,61	50,67	-99,57	538,3369	-84,6909	232,9072	186,3258	
Ring	b = 500 h = 600	3,6	Tump	Atas	2 D 19	567,057	0,0042	M.tump. -	-73,6176	400	69,5	530,5	49,90	42,41	-235,74	360,4993	-133,6763	121,9754	97,5803	
			Tump	Bawah	2 D 19	567,057	0,0042	M.tump. +	62,3679	400	69,5	530,5	49,90	42,41	-235,74	360,4993	-133,6763	121,9754	97,5803	
			Lap	Atas	2 D 19	567,057	0,0042	M.lap.	72,0804	400	69,5	530,5	49,90	42,41	-235,74	360,4993	-133,6763	121,9754	97,5803	
			Lap	Bawah	2 D 19	567,057	0,0061	M.tump. -	-122,7303	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Atas	2 D 25	981,748	0,0061	M.tump. +	85,7262	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Bawah	2 D 25	981,748	0,0061	M.lap.	117,7208	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
Lantai 3	b = 200 h = 700	3,6	Tump	Atas	2 D 25	981,748	0,0061	M.tump. -	-121,7664	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Tump	Bawah	2 D 25	981,748	0,0061	M.tump. +	86,1966	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Atas	2 D 25	981,748	0,0061	M.lap.	117,2136	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Bawah	2 D 25	981,748	0,0061	M.tump. -	-101,4710	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Atas	2 D 25	981,748	0,0061	M.tump. +	66,0566	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Bawah	2 D 25	981,748	0,0061	M.lap.	96,9371	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
Lantai 4	b = 200 h = 700	3,6	Tump	Atas	2 D 25	981,748	0,0061	M.tump. -	-73,2438	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Tump	Bawah	2 D 25	981,748	0,0061	M.tump. +	37,5417	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Atas	2 D 25	981,748	0,0061	M.lap.	68,7099	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Bawah	2 D 25	981,748	0,0061	M.tump. -	-73,2438	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Atas	2 D 25	981,748	0,0061	M.tump. +	37,5417	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Bawah	2 D 25	981,748	0,0061	M.lap.	68,7099	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	

Tabel 7.2 Lanjutan

Por- tal	Balok	Ukuran [mm]	l [m]	Letak Tulangan	Tulangan terpakai	As (mm ²)	ρ	Analisis	Mu (kNm)	b (mm)	d' (mm)	d (mm)	x (mm)	a (mm)	f _{s'} (MPa)	C _c (kN)	C _s (kN)	M _{nak} (kN.m)	ϕM_{nak} (kNm)
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]
As 2 dan As 5 (A-B)	Atap	b = 200 h = 700	3,6	Tump	Atas	567,057	0,0048	M.tump.	-36,4266	200	69,5	630,5	66,72	56,71	-25,03	241,0152	-14,1923	137,1643	109,7315
				Bawah	Bawah	567,057	0,0048	M.tump.	22,9929	200	69,5	630,5	66,72	56,71	-25,03	241,0152	-14,1923	137,1643	109,7315
				Lap	Atas	567,057	0,0048	M.lap.	36,3521	200	69,5	630,5	66,72	56,71	-25,03	241,0152	-14,1923	137,1643	109,7315
	Sloof	b = 400 h = 600	3,6	Tump	Atas	567,057	0,0042	M.tump.	-94,1577	400	69,5	530,5	49,90	42,41	-235,74	360,4993	-133,6763	121,9754	97,5803
				Bawah	Bawah	567,057	0,0042	M.tump.	74,6193	400	69,5	530,5	49,90	42,41	-235,74	360,4993	-133,6763	121,9754	97,5803
				Lap	Atas	567,057	0,0042	M.lap.	88,9025	400	69,5	530,5	49,90	42,41	-235,74	360,4993	-133,6763	121,9754	97,5803
	Lantai 1	b = 200 h = 700	3,6	Tump	Atas	981,748	0,0061	M.tump.	-158,825	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938
				Bawah	Bawah	981,748	0,0061	M.tump.	104,7039	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938
				Lap	Atas	981,748	0,0061	M.lap.	144,3603	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938
	Lantai 2	b = 200 h = 700	3,6	Tump	Atas	981,748	0,0061	M.tump.	-162,672	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938
				Bawah	Bawah	981,748	0,0061	M.tump.	98,5992	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938
				Lap	Atas	981,748	0,0061	M.lap.	144,3152	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938
Lantai 3	b = 200 h = 700	3,6	Tump	Atas	981,748	0,0061	M.tump.	-138,766	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Bawah	Bawah	981,748	0,0061	M.tump.	68,2836	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Atas	981,748	0,0061	M.lap.	118,1807	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
Lantai 4	b = 200 h = 700	3,6	Tump	Atas	981,748	0,0061	M.tump.	-103,627	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Bawah	Bawah	981,748	0,0061	M.tump.	28,5840	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Atas	981,748	0,0061	M.lap.	81,5514	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
Atap	b = 200 h = 700	3,6	Tump	Atas	567,057	0,0048	M.tump.	-67,2746	200	69,5	630,5	66,72	56,71	-25,03	241,0152	-14,1923	137,1643	109,7315	
			Bawah	Bawah	567,057	0,0048	M.tump.	7,8210	200	69,5	630,5	66,72	56,71	-25,03	241,0152	-14,1923	137,1643	109,7315	
			Lap	Atas	567,057	0,0048	M.lap.	52,1850	200	69,5	630,5	66,72	56,71	-25,03	241,0152	-14,1923	137,1643	109,7315	
Sloof	b = 400 h = 600	7,2	Tump	Atas	1134,11	0,0056	M.tump.	-112,5758	400	69,5	530,5	66,25	56,31	-29,42	478,6684	-25,0225	228,9204	183,1363	
			Bawah	Bawah	850,586	0,0052	M.tump.	60,4559	400	69,5	530,5	60,72	51,61	-86,80	438,6757	-98,4412	176,0163	140,8130	
			Lap	Atas	850,586	0,0056	M.lap.	99,4434	400	69,5	530,5	66,25	56,31	-29,42	478,6684	-25,0225	228,9204	183,1363	
Lantai 1	bf = 600 bw = 400 hf = 400 h = 700	3,6	Tump	Atas	850,586	0,0050	M.tump.	-107,3615	400	69,5	530,5	59,28	50,38	-103,49	428,2656	-88,0311	175,8236	140,6589	
			Bawah	Bawah	850,586	0,0050	M.tump.	101,8511	400	69,5	530,5	59,28	50,38	-103,49	428,2656	-88,0311	175,8236	140,6589	
			Lap	Atas	850,586	0,0050	M.lap.	111,2381	400	69,5	530,5	59,28	50,38	-103,49	428,2656	-88,0311	175,8236	140,6589	
Lantai 1	bf = 600 bw = 400 hf = 400 h = 700	7,2	Tump	Atas	2945,24	0,0084	M.tump.	-457,5932	400	72,5	627,5	116,72	99,22	227,33	843,3316	334,7656	673,1497	538,5198	
			Bawah	Bawah	1472,62	0,0048	M.tump.	47,2410	600	72,5	627,5	67,20	57,12	-47,29	728,3192	-139,2706	358,9232	287,1386	
			Lap	Atas	1472,62	0,0059	M.lap.	351,0003	600	72,5	627,5	81,54	69,31	66,55	883,7426	98,0051	578,3138	462,6511	
Lantai 1	bf = 600 bw = 400 hf = 400 h = 700	3,6	Tump	Atas	2454,37	0,0055	M.tump.	-176,6930	400	72,5	627,5	75,96	64,57	27,33	548,8073	40,2413	348,9935	279,1948	
			Bawah	Bawah	1472,62	0,0046	M.tump.	62,6871	600	72,5	627,5	64,49	54,81	-74,57	698,8619	-109,8133	358,4362	286,7490	
			Lap	Atas	1472,62	0,0046	M.lap.	138,7890	600	72,5	627,5	64,49	54,81	-74,57	698,8619	-109,8133	358,4362	286,7490	

Tabel 7.2 Lanjutan

Por- tel	Balok	Ukuran [mm]	l	Letak Tulangan	Tulangan terpakai	As (mm ²)	ρ	Analisis	Mu (kNm)	b (mm)	d' (mm)	d (mm)	x (mm)	θ (mm)	fs' (MPa)	Cc (kN)	Cs (kN)	Mnek (kNm)	ϕ Mnek (kNm)	
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]	
As 3 dan As 4	Lantai 2	bf = 600 bw = 400 hf = 400 h = 700	7,2	Tump	Atas	6 D 25	2945,24	0,0084	M.tump.	-434,6517	400	72,5	627,5	116,72	99,22	227,33	843,3316	334,7656	673,1497	538,5198
				Lap	Bawah	3 D 25	1472,62	0,0048	M.tump.	25,2000	600	72,5	627,5	67,20	57,12	-47,29	728,3192	-139,2706	358,9232	287,1386
				Lap	Atas	3 D 25	1472,62	0,0059	M.lap.	329,0070	600	72,5	627,5	81,54	69,31	66,55	883,7426	98,0051	578,3138	462,6511
				Lap	Bawah	5 D 25	2454,37	0,0055	M.tump.	-163,4703	400	72,5	627,5	75,96	64,57	27,33	548,8073	40,2413	348,9935	279,1948
				Lap	Atas	3 D 25	1472,62	0,0046	M.tump.	54,3921	600	72,5	627,5	64,49	54,81	-74,57	698,8619	-109,8133	358,4362	286,7490
				Lap	Bawah	3 D 25	1472,62	0,0046	M.lap.	124,9900	600	72,5	627,5	64,49	54,81	-74,57	698,8619	-109,8133	358,4362	286,7490
	Lantai 3	bf = 600 bw = 400 hf = 400 h = 700	7,2	Tump	Atas	5 D 25	2454,37	0,0073	M.tump.	-386,7014	400	72,5	627,5	101,20	86,02	170,16	731,1696	250,5781	566,4322	453,1457
				Lap	Bawah	3 D 25	1472,62	0,0048	M.tump.	0,0000	600	72,5	627,5	66,53	56,55	-53,79	721,0728	-132,0242	358,8097	287,0478
				Lap	Atas	3 D 25	1472,62	0,0052	M.lap.	276,1952	600	72,5	627,5	72,49	61,61	-0,12	785,5679	-0,1697	468,6490	374,9192
				Lap	Bawah	4 D 25	1963,5	0,0055	M.tump.	-135,4175	400	72,5	627,5	75,96	64,57	27,33	548,8073	40,2413	348,9935	279,1948
				Lap	Atas	3 D 25	1472,62	0,0046	M.tump.	29,7720	600	72,5	627,5	64,49	54,81	-74,57	698,8619	-109,8133	358,4362	286,7490
				Lap	Bawah	3 D 25	1472,62	0,0046	M.lap.	96,5486	600	72,5	627,5	64,49	54,81	-74,57	698,8619	-109,8133	358,4362	286,7490
Lantai 4	bf = 600 bw = 400 hf = 400 h = 700	7,2	Tump	Atas	5 D 25	2454,37	0,0073	M.tump.	-342,8061	400	72,5	627,5	101,20	86,02	170,16	731,1696	250,5781	566,4322	453,1457	
			Lap	Bawah	3 D 25	1472,62	0,0048	M.tump.	0,0000	600	72,5	627,5	66,53	56,55	-53,79	721,0728	-132,0242	358,8097	287,0478	
			Lap	Atas	3 D 25	1472,62	0,0052	M.lap.	259,0875	600	72,5	627,5	72,49	61,61	-0,12	785,5679	-0,1697	468,6490	374,9192	
			Lap	Bawah	4 D 25	1963,5	0,0055	M.tump.	-142,2110	400	72,5	627,5	75,96	64,57	27,33	548,8073	40,2413	348,9935	279,1948	
			Lap	Atas	3 D 25	1472,62	0,0046	M.tump.	30,4563	600	72,5	627,5	64,49	54,81	-74,57	698,8619	-109,8133	358,4362	286,7490	
			Lap	Bawah	3 D 25	1472,62	0,0046	M.lap.	66,8777	600	72,5	627,5	64,49	54,81	-74,57	698,8619	-109,8133	358,4362	286,7490	
Atap	b = 200 h = 700	3,6	Tump	Atas	3 D 19	850,586	0,0058	M.tump.	-112,3059	200	69,5	630,5	80,91	68,77	84,58	292,2708	47,9636	201,1347	160,9078	
			Lap	Bawah	2 D 19	567,057	0,0048	M.tump.	23,4119	200	69,5	630,5	67,33	57,23	-19,30	243,2428	-16,4198	137,1922	109,7538	
			Lap	Atas	2 D 19	567,057	0,0058	M.lap.	43,6590	200	69,5	630,5	80,91	68,77	84,58	292,2708	47,9636	201,1347	160,9078	
			Lap	Bawah	3 D 19	850,586	0,0058	M.tump.	-112,3059	200	69,5	630,5	80,91	68,77	84,58	292,2708	47,9636	201,1347	160,9078	
			Lap	Atas	2 D 19	567,057	0,0042	M.tump.	-78,5274	400	69,5	630,5	49,90	42,41	-235,74	360,4993	-133,6763	121,9754	97,5803	
			Lap	Bawah	2 D 19	567,057	0,0042	M.tump.	72,3660	400	69,5	630,5	49,90	42,41	-235,74	360,4993	-133,6763	121,9754	97,5803	
Lantai 1	b = 200 h = 700	4,8	Tump	Atas	2 D 19	567,057	0,0042	M.lap.	76,5870	400	69,5	630,5	49,90	42,41	-235,74	360,4993	-133,6763	121,9754	97,5803	
			Lap	Bawah	2 D 19	567,057	0,0061	M.tump.	-131,0799	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Atas	2 D 25	981,748	0,0061	M.tump.	83,7722	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Bawah	2 D 25	981,748	0,0061	M.lap.	129,8105	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Atas	2 D 25	981,748	0,0061	M.tump.	-131,4737	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Bawah	2 D 25	981,748	0,0061	M.tump.	72,5319	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
Lantai 2	b = 200 h = 700	4,8	Tump	Atas	2 D 25	981,748	0,0061	M.tump.	-116,5931	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Bawah	2 D 25	981,748	0,0061	M.tump.	47,1219	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Atas	2 D 25	981,748	0,0061	M.lap.	124,3116	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Bawah	2 D 25	981,748	0,0061	M.tump.	-116,5931	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Atas	2 D 25	981,748	0,0061	M.tump.	47,1219	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Bawah	2 D 25	981,748	0,0061	M.lap.	108,3222	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
Lantai 3	b = 200 h = 700	4,8	Tump	Atas	2 D 25	981,748	0,0061	M.tump.	-116,5931	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Bawah	2 D 25	981,748	0,0061	M.tump.	47,1219	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Atas	2 D 25	981,748	0,0061	M.lap.	108,3222	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Bawah	2 D 25	981,748	0,0061	M.tump.	-116,5931	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Atas	2 D 25	981,748	0,0061	M.tump.	47,1219	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Bawah	2 D 25	981,748	0,0061	M.lap.	108,3222	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	

Tabel 7.2 Lanjutan

Por- tal	Balok	Ukuran [mm]	<i>l</i> [m]	Letak Tulangan	Tulangan terpakai	<i>A_s</i> (mm ²)	<i>ρ</i>	Analisis	<i>M_u</i> (kNm)	<i>b</i> (mm)	<i>d'</i> (mm)	<i>d</i> (mm)	<i>x</i> (mm)	<i>a</i> (mm)	<i>f_s'</i> (MPa)	<i>C_c</i> (kN)	<i>C_s</i> (kN)	<i>M_{nak}</i> (kNm)	<i>φ M_{nak}</i> (kNm)		
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]		
As A dan As G	Lantai 4	b = 200 h = 700	4,8	Tump	Atas	2 D 25	981,748	0,0061	M.tump. -	-98,2643	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
				Lap	Bawah	2 D 25	981,748	0,0061	M.tump. +	18,6354	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
				Lap	Atas	2 D 25	981,748	0,0061	M.lap.	84,0168	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
				Lap	Bawah	2 D 25	981,748	0,0061	M.lap.	84,0168	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
				Lap	Atas	2 D 19	567,057	0,0048	M.tump. -	-71,7917	200	69,5	630,5	66,72	56,71	-25,03	241,0152	-14,1923	137,1643	109,7315	
				Lap	Bawah	2 D 19	567,057	0,0048	M.tump. +	0,0000	200	69,5	630,5	66,72	56,71	-25,03	241,0152	-14,1923	137,1643	109,7315	
	As B dan As E	Lantai 1	b = 400 h = 600	4,8	Tump	Atas	3 D 19	850,586	0,0050	M.tump. -	-108,5217	400	69,5	530,5	59,28	50,38	-103,49	428,2656	-88,0311	175,8236	140,6589
					Lap	Bawah	3 D 19	850,586	0,0050	M.tump. +	104,1348	400	69,5	530,5	59,28	50,38	-103,49	428,2656	-88,0311	175,8236	140,6589
					Lap	Atas	3 D 19	850,586	0,0050	M.lap.	108,0566	400	69,5	530,5	59,28	50,38	-103,49	428,2656	-88,0311	175,8236	140,6589
					Lap	Bawah	3 D 19	850,586	0,0050	M.lap.	108,0566	400	69,5	530,5	59,28	50,38	-103,49	428,2656	-88,0311	175,8236	140,6589
					Lap	Atas	3 D 19	850,586	0,0050	M.tump. -	-108,5217	400	69,5	530,5	59,28	50,38	-103,49	428,2656	-88,0311	175,8236	140,6589
					Lap	Bawah	3 D 19	850,586	0,0050	M.tump. +	104,1348	400	69,5	530,5	59,28	50,38	-103,49	428,2656	-88,0311	175,8236	140,6589
Lantai 2		b = 400 h = 700	2,4	Tump	Atas	3 D 25	1472,62	0,0046	M.tump. -	-218,6541	400	72,5	627,5	75,96	64,57	27,33	548,8073	40,2413	348,9935	279,1948	
				Lap	Bawah	3 D 25	1472,62	0,0046	M.tump. +	158,1699	600	72,5	627,5	65,67	64,49	-74,57	698,8619	-109,8133	358,4362	286,7490	
				Lap	Atas	3 D 25	1472,62	0,0046	M.lap.	177,1361	600	72,5	627,5	64,49	54,81	-74,57	698,8619	-109,8133	358,4362	286,7490	
				Lap	Bawah	3 D 25	1472,62	0,0046	M.lap.	177,1361	600	72,5	627,5	64,49	54,81	-74,57	698,8619	-109,8133	358,4362	286,7490	
				Lap	Atas	3 D 25	1472,62	0,0063	M.tump. -	-257,9808	400	72,5	627,5	87,61	74,47	103,49	632,9948	152,4033	458,2185	366,5748	
				Lap	Bawah	3 D 25	1472,62	0,0047	M.tump. +	158,1699	600	72,5	627,5	65,67	64,49	-74,57	698,8619	-109,8133	358,4362	286,7490	
Lantai 3	b = 400 h = 700	4,8	Tump	Atas	3 D 25	1472,62	0,0046	M.tump. -	-261,0615	400	72,5	627,5	87,61	74,47	103,49	632,9948	152,4033	458,2185	366,5748		
			Lap	Bawah	3 D 25	1472,62	0,0047	M.tump. +	130,0050	600	72,5	627,5	65,67	64,49	-74,57	698,8619	-109,8133	358,4362	286,7490		
			Lap	Atas	3 D 25	1472,62	0,0052	M.lap.	232,8186	600	72,5	627,5	72,49	61,61	-0,12	785,5679	-0,1697	468,6490	374,9192		
			Lap	Bawah	3 D 25	1472,62	0,0052	M.lap.	232,8186	600	72,5	627,5	72,49	61,61	-0,12	785,5679	-0,1697	468,6490	374,9192		
			Lap	Atas	3 D 25	1472,62	0,0055	M.tump. -	-186,5745	400	72,5	627,5	75,96	64,57	27,33	548,8073	40,2413	348,9935	279,1948		
			Lap	Bawah	3 D 25	1472,62	0,0046	M.tump. +	130,0050	600	72,5	627,5	64,49	54,81	-74,57	698,8619	-109,8133	358,4362	286,7490		
Lantai 4	b = 400 h = 700	4,8	Tump	Atas	3 D 25	1472,62	0,0046	M.tump. -	-239,6069	400	72,5	627,5	87,61	74,47	103,49	632,9948	152,4033	458,2185	366,5748		
			Lap	Bawah	3 D 25	1472,62	0,0047	M.tump. +	103,8150	600	72,5	627,5	65,67	64,49	-74,57	698,8619	-109,8133	358,4362	286,7490		
			Lap	Atas	3 D 25	1472,62	0,0052	M.lap.	206,0804	600	72,5	627,5	72,49	61,61	-0,12	785,5679	-0,1697	468,6490	374,9192		
			Lap	Bawah	3 D 25	1472,62	0,0052	M.lap.	206,0804	600	72,5	627,5	72,49	61,61	-0,12	785,5679	-0,1697	468,6490	374,9192		
			Lap	Atas	3 D 25	1472,62	0,0055	M.tump. -	-139,2174	400	72,5	627,5	75,96	64,57	27,33	548,8073	40,2413	348,9935	279,1948		
			Lap	Bawah	3 D 25	1472,62	0,0046	M.tump. +	88,2180	600	72,5	627,5	64,49	54,81	-74,57	698,8619	-109,8133	358,4362	286,7490		

Tabel 7.2 Lanjutan

Portel	Balok	Ukuran [mm]	l [m]	Letak Tulangan	Tulangan terpakai	As (mm ²)	ρ	Analisis	Mu (kNm)	b (mm)	d' (mm)	d (mm)	x (mm)	a (mm)	f's (MPa)	Cc (kN)	Cs (kN)	Mnak (kNm)	$\phi Mnak$ (kNm)	
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]	
As C dan As D	Lantai 4	bf = 600 bw = 400 hf = 400 h = 700	9,6	Tump	Atas	10 D 25	4908,74	0,0106	M.tump. -	-765,1600	400	72,5	627,5	147,44	125,33	304,97	1065,2794	898,2160	1100,2186	880,1748
				Lap	Bawah	6 D 25	2945,24	0,0058	M.tump. +	-	600	72,5	627,5	80,80	68,68	61,62	875,6411	302,4562	687,2594	549,8075
	As D	Lantai 4	hf = 400 h = 700	Lap	Atas	5 D 25	2454,37	0,0075	M.lap.	563,7167	600	72,5	627,5	103,89	88,30	181,28	1125,8770	444,9193	903,7083	722,9666
				Lap	Bawah	8 D 25	3926,99													
AS F	Sloof	b = 400 h = 600	4,8	Tump	Atas	2 D 19	567,057	0,0042	M.tump. -	-83,4467	400	69,5	530,5	49,90	42,41	-235,74	360,4993	-133,6763	121,9754	97,5803
				Lap	Bawah	2 D 19	567,057	0,0042	M.tump. +	75,4782	400	69,5	530,5	49,90	42,41	-235,74	360,4993	-133,6763	121,9754	97,5803
				Lap	Atas	2 D 19	567,057	0,0042	M.lap.	78,5652	400	69,5	530,5	49,90	42,41	-235,74	360,4993	-133,6763	121,9754	97,5803
				Lap	Bawah	3 D 25	1472,62													
	Lantai 1	b = 200 h = 700	4,8	Tump	Atas	2 D 25	981,748	0,0061	M.tump. -	-147,3669	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938
				Lap	Bawah	2 D 25	981,748	0,0061	M.tump. +	84,8694	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938
				Lap	Atas	2 D 25	981,748	0,0061	M.lap.	125,3889	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938
				Lap	Bawah	2 D 25	981,748													
	Lantai 2	b = 200 h = 700	4,8	Tump	Atas	2 D 25	981,748	0,0061	M.tump. -	-148,9782	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938
				Lap	Bawah	2 D 25	981,748	0,0061	M.tump. +	79,2047	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938
				Lap	Atas	2 D 25	981,748	0,0061	M.lap.	122,5665	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938
				Lap	Bawah	2 D 25	981,748													
Lantai 3	b = 200 h = 700	4,8	Tump	Atas	2 D 25	981,748	0,0061	M.tump. -	-132,5226	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Bawah	2 D 25	981,748	0,0061	M.tump. +	53,2518	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Atas	2 D 25	981,748	0,0061	M.lap.	105,3623	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Bawah	2 D 25	981,748														
Lantai 4	b = 200 h = 700	4,8	Tump	Atas	2 D 25	981,748	0,0061	M.tump. -	-108,8525	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Bawah	2 D 25	981,748	0,0061	M.tump. +	19,5668	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Atas	2 D 25	981,748	0,0061	M.lap.	79,8137	200	72,5	627,5	84,90	72,16	87,61	306,6879	86,0112	229,1173	183,2938	
			Lap	Bawah	2 D 25	981,748														
Atap	b = 200 h = 700	4,8	Tump	Atas	2 D 19	567,057	0,0048	M.tump. -	-67,6452	200	69,5	630,5	66,72	56,71	-25,03	241,0152	-14,1923	137,1643	109,7315	
			Lap	Bawah	2 D 19	567,057	0,0049	M.tump. +	0,0000	200	72,5	627,5	68,41	58,15	-35,84	247,1447	-20,3217	136,6188	109,2950	
			Lap	Atas	2 D 19	567,057	0,0049	M.lap.	71,4903	200	72,5	627,5	68,41	58,15	-35,84	247,1447	-20,3217	136,6188	109,2950	
			Lap	Bawah	2 D 19	567,057														

Keterangan Tabel 7.2:

- [1] Portal yang ditinjau
- [2] Balok Sloof, Lantai 1 s/d 4, dan Atap
- [3] Ukuran Balok: bf = lebar sayap, bw = lebar badan, hf = tinggi sayap, h = tinggi balok
- [4] l = bentang balok
- [5] Letak tulangan: Tumpuan & lapangan, Atas & bawah
- [6] Tulangan yang dipakai
- [7] Luas tulangan
- [8] $\rho = (A_s - A_s') / (b \cdot d)$ (rasio penulangan)
- [9] Analisis: Momen tumpuan, negatif, positif dan lapangan
- [10] Mu = momen rencana balok (dari Tabel 7.1)
- [11] b = lebar balok daerah desak
- [12] d' = D/2 + 10 + 50
- [13] d = h - d' (tinggi efektif)
- [14] x: didapat dari persamaan $(0,85 \cdot f_c \cdot b \cdot 0,85) x^2 + (600 A_s - A_s') x - 600 d' A_s = 0$
- [15] a = x · 0,85
- [16] fs' = [(x - d') / x] · 600
- [17] Cc = 0,85 · fc · b · a
- [18] Cs = As' · fs'
- [19] Mnak = Cc (d - a / 2) + Cs (d - d')
- [20] 0,8 · Mnak ≥ Mu

7.1.3 Gaya Geser Rencana Balok

Gaya geser rencana balok dapat dihitung dengan rumus (Kusuma dan Andriano, 1993):

$$V_{u,b} = 1,05.(V_{D,b} + V_{L,b}) + 0,7.1,25 \left[\frac{M_{nak,b} + M_{nak,b'}}{l_n} \right]$$

tetapi gaya geser terpakai balok tidak perlu lebih besar dari gaya geser maksimum,

$$V_{u,bmaks} = 1,05.(V_{D,b} + V_{L,b} + 4/k.V_{E,b})$$

Sebagai contoh perhitungan adalah gaya geser rencana balok Portal as 1 dan as 6 lantai 1, sebagai berikut ini.

Diketahui:

$$V_{D,b} = 100,9757 \text{ kN}$$

$$V_{L,b} = 57,3986 \text{ kN}$$

$$V_{E,b} = 58,0100 \text{ kN}$$

$$M_{nak,b} = 673,1497 \text{ kNm}$$

$$M_{nak,b'} = 358,9232 \text{ kNm}$$

$$l_n = 6,5 \text{ m}$$

$$\begin{aligned} V_{u,b} &= 1,05.(100,9757 + 57,3986) + 0,7.1,25 \left[\frac{673,1497 + 358,9232}{6,5} \right] \\ &= 305,2259 \text{ kNm} \end{aligned}$$

$$V_{u,bmax} = 1,05.(100,9757 + 57,3986 + 4/1.58,0100) = 409,9350 \text{ kN}$$

dipilih sebagai gaya geser balok terpakai adalah:

$$V_{u,b} = 305,2259 \text{ kN}$$

Dengan cara yang sama didapat gaya geser rencana dari semua balok, disajikan pada Tabel 7.3.

Tabel 7.3 Gaya Geser Rencana Balok Portal Daktilitas Penuh

Port- tal	Balok	l_n (m)	U - jung	V_D (kN)	V_L (kN)	V_E (kN)	M_{nak-} (kNm)	M_{nak+} (kNm)	$V_{u,b}$ (kN)	$V_{u,b maks}$ (kN)
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]
As 1- dan As 6	Sloof	6.5	1	19.3104	0.5146	22.3400	228.9204	176.0163	75,3270	114.6443
			2	19.3104	0.5146	22.3400	228.9204	176.0163	-33,6945	-73.0118
	Lantai 1	6.5	1	100.9757	57.3986	58.0100	673.1497	358.9232	305,2259	409.9350
			2	100.9757	57.3986	58.0100	673.1497	358.9232	27,3601	-77.3490
	Lantai 2	6.5	1	99.2063	56.3604	54.0700	673.1497	358.9232	302,2779	390.4390
			2	99.2063	56.3604	54.0700	673.1497	358.9232	24,4121	-63.7490
	Lantai 3	6.5	1	100.0819	56.4688	42.9000	566.4322	358.8097	288,9300	344.5582
			2	100.0819	56.4688	42.9000	566.4322	358.8097	39,8264	-15.8018
	Lantai 4	6.5	1	99.7750	56.1347	29.8900	566.4322	358.8097	282,2600	289.2432
			2	99.7750	56.1347	29.8900	566.4322	358.8097	39,1534	38.1672
Ring	6.5	1	44.0736	8.8021	10.5100	232.9072	179.9488	111.0962	99,6615	
		2	44.0736	8.8021	10.5100	232.9072	179.9488	-0.0573	11,3775	
As 2 dan As 5 (A-B)	Sloof	3.1	1	8.9642	0.0861	32.8900	175.5251	122.5780	67,4673	147.6408
			2	8.9642	0.0861	32.8900	175.5251	122.5780	-48,4617	-128.6352
	Lantai 1	3.1	1	24.7742	4.0817	49.6500	229.1173	229.1173	124,2867	238.8286
			2	24.7742	4.0817	49.6500	229.1173	229.1173	-53,9157	-178.2314
	Lantai 2	3.1	1	24.3781	3.9956	49.7800	229.1173	229.1173	118,8935	238.8683
			2	24.3781	3.9956	49.7800	229.1173	229.1173	-59,3089	-179.2837
	Lantai 3	3.1	1	24.3522	3.9869	40.1000	229.1173	229.1173	118,8573	198.1761
			2	24.3522	3.9869	40.1000	229.1173	229.1173	-59,3450	-138.6639
	Lantai 4	3.1	1	24.4642	4.0128	26.7400	229.1173	229.1173	119,0020	142.2088
			2	24.4642	4.0128	26.7400	229.1173	229.1173	-59,2004	-82.4072
Ring	3.1	1	11.0050	1.5758	13.3200	137.1643	137.1643	66.5515	69,1539	
		2	11.0050	1.5758	13.3200	137.1643	137.1643	-40,1318	-42.7341	
As 2 dan As 5 (E-G)	Sloof	3.1	1	10.4281	0.3444	31.0000	175.5251	122.5780	69,2756	141.5111
			2	10.4281	0.3444	31.0000	175.5251	122.5780	-46,6534	-118.8889
	Lantai 1	3.1	1	28.1583	5.0461	46.9600	229.1173	229.1173	123,9658	232.0967
			2	28.1583	5.0461	46.9600	229.1173	229.1173	-54,2365	-162.3673
	Lantai 2	3.1	1	30.2681	5.3819	46.6900	229.1173	229.1173	126,5337	233.5305
			2	30.2681	5.3819	46.6900	229.1173	229.1173	-51,6687	-158.6655
	Lantai 3	3.1	1	31.6631	5.5714	36.9400	229.1173	229.1173	128,1973	194.2442
			2	31.6631	5.5714	36.9400	229.1173	229.1173	-50,0050	-116.0518
	Lantai 4	3.1	1	33.2131	5.6661	23.4900	229.1173	229.1173	129,9243	139.4811
			2	33.2131	5.6661	23.4900	229.1173	229.1173	-48,2780	-57.8349
Ring	3.1	1	30.2250	2.5144	12.1900	137.1643	137.1643	87.7181	85,5744	
		2	30.2250	2.5144	12.1900	137.1643	137.1643	-18,9653	-16.8216	
As 3 dan As 4	Sloof	6.5	1	19.6444	0.1986	22.8400	228.9204	176.0163	75,3459	116.7632
			2	19.6444	0.1986	22.8400	228.9204	176.0163	-33,6755	-75.0928
		3.1	1	9.7483	0.6337	42.7600	175.8236	175.8236	58,2382	190.4930
			2	9.7483	0.6337	42.7600	175.8236	175.8236	-36,4361	-168.6910
	Lantai 1	6.5	1	122.5521	30.7486	58.8900	673.1497	358.9232	299,8986	408.3037
			2	122.5521	30.7486	58.8900	673.1497	358.9232	22,0328	-86.3723
		3.1	1	47.4826	10.1563	48.0600	348.9935	358.4362	155,7518	262.3728
			2	47.4826	10.1563	48.0600	348.9935	358.4362	-34,7101	-141.3312
	Lantai 2	6.5	1	119.8708	29.9813	53.5100	673.1497	358.9232	296,2776	382.0867
			2	119.8708	29.9813	53.5100	673.1497	358.9232	18,4118	-67.3973
		3.1	1	48.7413	10.2170	42.3800	348.9935	358.4362	157,1372	239.9023
			2	48.7413	10.2170	42.3800	348.9935	358.4362	-33,3247	-116.0898
	Lantai 3	6.5	1	121.3333	30.3333	40.6200	566.4322	358.8097	283,8018	329.8540
			2	121.3333	30.3333	40.6200	566.4322	358.8097	34,6982	-11.3540
		3.1	1	50.0174	10.3559	30.4500	348.9935	358.4362	158,6228	191.2819
			2	50.0174	10.3559	11.9300	348.9935	358.4362	-31,8390	13.2859
	Lantai 4	6.5	1	124.3396	31.0917	30.7100	566.4322	358.8097	285,7403	292.1848
			2	124.3396	31.0917	30.7100	566.4322	358.8097	38,6510	34.2208
	3.1	1	53.8628	11.3976	28.0000	348.9935	358.4362	163,7544	186.1234	
		2	53.8628	11.3976	28.0000	348.9935	358.4362	-26,7075	-49.0766	
Atap	3.1	1	31.3628	4.5747	29.9600	201.1347	137.1900	111.7429	163,5664	
		2	31.3628	4.5747	29.9600	210.1347	137.1900	-38,2429	-88.0976	

Tabel 7.3 Lanjutan

Por-tal	Balok	In (m)	U-jung	V_D (kN)	V_L (kN)	V_E (kN)	M_{nak-} (kNm)	M_{nak+} (kNm)	$V_{u,b}$ (kN)	$V_{u,b maks}$ (kN)
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]
As A dan As G	Sloof	4.1	1	12.2915	0.1879	23.5500	175.5251	122.5780	76,7229	112.0133
			2	12.2915	0.1879	23.5500	175.5251	122.5780	-50,5162	-85.8067
	1.7	1	4.9725	0.0354	39.8100	175.5251	122.5780	68,8779	172.4743	
		2	4.9725	0.0354	39.8100	175.5251	122.5780	-58,3613	-161.9577	
	Lantai 1	4.1	1	38.3777	8.1658	34.2900	229.1173	229.1173	146,6647	192.8887
			2	38.3777	8.1658	34.2900	229.1173	229.1173	-48,9233	-95.1473
		1.7	1	12.6083	1.7921	52.7100	229.1173	229.1173	112,9144	236.4884
			2	12.6083	1.7921	52.7100	229.1173	229.1173	-82,6735	-206.2476
	Lantai 2	4.1	1	39.2660	8.1231	32.7800	229.1173	229.1173	147,5526	187.4346
			2	39.2660	8.1231	32.7800	229.1173	229.1173	-48,0353	-87.9174
		1.7	1	12.7783	1.8700	45.4700	229.1173	229.1173	113,1747	206.3688
			2	12.7783	1.8700	45.4700	229.1173	229.1173	-82,4132	-175.6073
	Lantai 3	4.1	1	39.8981	8.2256	26.5400	229.1173	229.1173	148,3239	161.9979
			2	39.8981	8.2256	26.5400	229.1173	229.1173	-47,2640	-60.9381
		1.7	1	12.9200	1.9408	31.8700	229.1173	229.1173	113,3978	149.4439
			2	12.9200	1.9408	31.8700	229.1173	229.1173	-82,1901	-118.2361
	Lantai 4	4.1	1	40.8377	8.3708	17.6200	229.1173	229.1173	149.4629	125.6730
			2	40.8377	8.3708	17.6200	229.1173	229.1173	-46.1250	-22.3350
		1.7	1	13.6708	2.2950	14.8700	229.1173	229.1173	114.5581	79.2321
			2	13.6708	2.2950	14.8700	229.1173	229.1173	-81.0298	-45.7039
	Atap	4.1	1	45.9883	7.2775	8.7700	137.1643	137.1643	114.4749	92.7631
			2	45.9883	7.2775	8.7700	137.1643	137.1643	-2.6166	19.0951
		1.7	1	13.4938	1.1900	0.5600	137.1643	137.1643	73.9637	17.7699
			2	13.4938	1.1900	0.5600	137.1643	137.1643	-43.1278	13.0659
As B dan As E	Sloof	4.1	1	12.4367	0.2221	29.3200	228.9205	176.0163	79,7689	109.1486
			2	12.4367	0.2221	29.3100	228.9205	176.0163	-58,5022	-87.8483
	1.7	1	4.8946	0.0000	33.7600	175.8236	175.8236	64,1488	117.5316	
		2	4.8946	0.0000	33.7600	175.8236	175.8236	-55,9259	-109.3087	
	Lantai 1	4.1	1	76.4138	19.5433	67.3000	458.2185	358.6561	220,0703	306.7320
			2	76.4138	19.5433	67.3000	458.2185	358.6561	-58,8624	-145.5241
		1.7	1	19.9183	3.4000	59.8200	348.9935	358.4362	125,3286	220.5692
			2	19.9183	3.4000	59.8200	348.9935	358.4362	-90,3511	-181.3944
	Lantai 2	4.1	1	78.8908	20.2523	59.8800	458.2185	358.6561	222,7466	284.4770
			2	78.8908	20.2523	59.8800	458.2185	358.6561	-56,1862	-117.9166
		1.7	1	19.9183	3.4000	50.0400	348.9935	358.4362	125,3286	187.7352
			2	19.9183	3.4000	50.0400	348.9935	358.4362	-90,3511	-148.5604
	Lantai 3	4.1	1	80.1977	20.6367	49.1500	458.2185	358.6561	224,1673	249.8449
			2	80.1977	20.6367	49.1500	458.2185	358.6561	-54,7655	-80.4431
		1.7	1	19.9183	3.4000	34.6500	348.9935	358.4362	125,3286	136.0181
			2	19.9183	3.4000	34.6500	348.9935	358.4362	-90,3511	-96.8433
	Lantai 4	4.1	1	80.9750	20.8758	34.7900	458.2185	358.6561	225.0211	202,4491
			2	80.9750	20.8758	34.7900	458.2185	358.6561	-53.9117	-31.3397
		1.7	1	19.9183	3.4000	16.6700	348.9935	358.4362	140.3681	75.5919
			2	19.9183	3.4000	16.6700	348.9935	358.4362	-101.1933	-36.4171
	Ring	4.1	1	53.6160	12.2744	15.6900	232.9072	179.9488	112.3532	108,0664
			2	53.6160	12.2744	15.6900	232.9072	179.9488	-13.5176	2,6296
		1.7	1	27.0442	3.4000	2.9000	179.5403	179.5403	77.5710	37,1731
			2	27.0442	3.4000	2.9000	179.5403	179.5403	-31.9048	15,8291
As C dan As D	Sloof	8.9	1	26.1994	0.1947	17.2400	334.1879	334.1879	74,7399	80.0974
			2	26.1994	0.1947	17.2400	334.1879	334.1879	-30,3979	-35.7554
	1.7	1	4.8946	0.0000	52.4100	334.1879	334.1879	68,0164	180.2235	
		2	4.8946	0.0000	52.4100	334.1879	334.1879	-58,1489	-172.0006	
	Lantai 1	8.9	1	240.3185	67.9367	46.7600	1100.2186	687.2594	399,5225	416.0480
			2	240.3185	67.9367	46.7600	1100.2186	687.2594	118,3462	101.8208
		1.7	1	19.8900	3.4000	97.8800	782.4600	578.1200	132,9043	348.4500
			2	19.8900	3.4000	97.8800	782.4600	578.1200	-91,8207	-309.3228
	Lantai 2	8.9	1	239.2060	67.5844	44.6800	1100.2186	687.2594	398,2921	407.8288
			2	239.2060	67.5844	44.6800	1100.2186	687.2594	117,1158	107.5792

Tabel 7.3.Lanjutan

Porta- [1]	Balok [2]	ln (m) [3]	U- jung [4]	V_D (kN) [5]	V_L (kN) [6]	V_E (kN) [7]	M_{nak-} (kNm) [8]	M_{nak+} (kNm) [9]	$V_{u,b}$ (kN) [10]	$V_{u,b maks}$ (kN) [11]	
As C dan As D	Lantai 2	1.7	1	19.8900	3.4000	79.6400	782.4552	578.1163	132,9036	287.1444	
			2	19.8900	3.4000	79.6400	782.4552	578.1163	-91,8200	-248.0172	
	Lantai 3	8.9	1	238.6405	67.4268	34.8500	1100.2186	687.2594	397.6847	374,1925	
			2	238.6405	67.4268	34.8500	1100.2186	687.2594	116.5084	140,0005	
		1.7	1	19.8900	3.4000	46.2100	673.1497	358.9232	130,9592	174.8148	
			2	19.8900	3.4000	46.2100	673.1497	358.9232	-80,0939	-135.6876	
	Lantai 4	8.9	1	244.0547	69.0121	23.2200	1100.2186	687.2594	403.5642	340,9953	
			2	244.0547	69.0121	23.2200	1100.2186	687.2594	122.3879	184,9569	
	1.7	1	19.8900	3.4000	10.6000	566.4322	358.8097	92.3354	88,3027		
		2	19.8900	3.4000	10.6000	566.4322	358.8097	-53.2082	-25,6992		
	As F	Sloof	4.1	1	12.4110	0.2477	26.0700	175.8236	175.8236	88,3383	122.7857
				2	12.4110	0.2477	26.0700	175.8236	175.8236	-61,7550	-96.2023
1.7			1	5.6667	0.3967	40.4800	175.8236	175.8236	81,4132	176.3825	
			2	5.6667	0.3967	40.4800	175.8236	175.8236	-68,6802	-163.6495	
Lantai 1			4.1	1	49.4563	15.0931	33.8700	229.1173	229.1173	165.5708	210.0308
				2	49.4563	15.0931	33.8700	229.1173	229.1173	-30,0171	-74.4772
1.7		1	15.7888	3.6267	53.5900	229.1173	229.1173	115.2977	245.4502		
		2	15.7888	3.6267	53.5900	229.1173	229.1173	-75,5198	-204.6778		
Lantai 2		4.1	1	50.1652	15.3067	33.3200	229.1173	229.1173	166.5394	208.6895	
			2	50.1652	15.3067	33.3200	229.1173	229.1173	-29,0485	-71.1985	
		1.7	1	16.4688	12.6933	48.9000	229.1173	229.1173	116.7401	236.0002	
2			16.4688	12.6933	48.9000	229.1173	229.1173	-61,0671	-174.7598		
Lantai 3		4.1	1	50.5154	15.4006	26.8000	229.1173	229.1173	167.0058	181.7718	
			2	50.5154	15.4006	26.8000	229.1173	229.1173	-28,5821	-43.3482	
		1.7	1	16.7025	4.0942	34.9500	229.1173	229.1173	116.7127	168.6125	
2			16.7025	4.0942	34.9500	229.1173	229.1173	-74,1048	-124.9395		
Lantai 4		4.1	1	50.8400	15.4519	17.3300	229.1173	229.1173	167.4004	142.3925	
			2	51.1817	15.4519	17.3300	229.1173	229.1173	-27,8288	-2.8208	
		1.7	1	16.5538	4.0233	16.9100	229.1173	229.1173	116.4877	92.6419	
2			16.5538	4.0233	16.9100	229.1173	229.1173	-74,3298	-49.4301		
Atap		4.1	1	33.9617	6.8760	10.5100	137.1643	137.1643	101.4253	87.0216	
			2	33.9617	6.8760	10.5100	137.1643	137.1643	-15,6661	-1.2624	
		1.7	1	9.8388	2.4296	0.4900	137.1643	137.1643	71.4275	14.9258	
2			9.8388	2.4296	0.4900	137.1643	137.1643	-45,6640	10.8378		

Keterangan Tabel 7.3:

- [1] Portal yang ditinjau
 [2] Balok yang ditinjau
 [3] l_n = bentang bersih balok
 [4] Ujung: 1 = ujung balok, 2 = ujung balok yang lain
 [5] V_D = gaya geser balok akibat beban mati
 [6] V_L = gaya geser balok akibat beban hidup
 [7] V_E = gaya geser balok akibat beban gempa
 [8] M_{nak-} = Momen nominal aktual balok negatif
 [9] M_{nak+} = momen nominal aktual balok positif
 [10] Untuk ujung 1, $V_{u,b} = 1.05(V_D + V_L) + 0.7 \cdot 1.25 \cdot (M_{nak-} + M_{nak+}) / l_n$ (gaya geser rencana)
 Untuk ujung 2, $V_{u,b} = 1.05(V_D + V_L) - 0.7 \cdot 1.25 \cdot (M_{nak-} + M_{nak+}) / l_n$ (gaya geser rencana)
 [11] Untuk ujung 1, $V_{u,b maks} = 1.05(V_D + V_L + 4/1 \cdot V_E)$ (gaya geser maksimum)
 Untuk ujung 2, $V_{u,b maks} = 1.05(V_D + V_L - 4/1 \cdot V_E)$ (gaya geser maksimum)
 * Angka yang tercetak tebal adalah $V_{u,b}$ terpakai

7.1.4 Penulangan Geser Balok

Sebagai contoh perhitungan penulangan geser balok ditinjau pada portal as 1 dan as 6, untuk balok lantai 1, sebagai berikut ini. (Kusuma dan Andriyono, 1993)

a. Sepanjang daerah sendi plastis

Daerah sendi plastis diambil dari ujung muka kolom ke arah tengah bentang sesuai panjang penghentian tulangan desak (Dipohusodo, 1996)

$$\text{jarak daerah sendi plastis} = 0,3.l_n = 0,3.6,5 = 1,95 \text{ m} \approx 2 \text{ m}$$

$$2 \text{ m} > (2.h = 2.0,7 = 1,4 \text{ m}) \text{ memenuhi syarat SKSNI 1991}$$

$$V_{u,b1} = 305,2259 \text{ kN} ; V_{u,b2} = 27,3601 \text{ kN}$$

Tulangan geser dalam daerah 1 m dari muka kolom ke tengah bentang:

$$V_{u,b \text{ terpakai}} = [(V_{u,b1} + V_{u,b2}).(l_n - d)/l_n] - V_{u,b2} \quad (\text{lihat gambar 7.4})$$

$$V_{u,b \text{ terpakai}} = [(305,2259 + 27,3601).(6,5 - 0,6275)/6,5] - 27,3601 = 273,1161 \text{ kN}$$

$$V_s = V_{u,b}/\phi - V_c = 273,1161/0,6 - 0 = 455,1935 \text{ kN}$$

$$A_v = \frac{1}{4} \cdot \pi \cdot d^2 = \frac{1}{4} \cdot 3,14 \cdot 10^2 = 78,54 \text{ mm}^2$$

$$S = A_v \cdot f_y \cdot d / V_s = (4.78,54.240.627,5) / (455,1935 \cdot 10^3) = 103,94 \text{ mm}$$

digunakan sengkang **4P10-100**

Kontrol jarak sengkang maksimum pada lokasi sendi plastis (SK-SNI, 1991):

$$- d/4 = 627,5/4 = 156,88 \text{ mm}$$

$$- 8 \cdot \text{diameter tul. pokok} = 8 \cdot 25 = 200 \text{ mm}$$

$$- 24 \cdot \text{diameter sengkang} = 24 \cdot 10 = 240 \text{ mm}$$

$$- 200 \text{ mm}$$

$$- 1600 \cdot f_y \cdot A_{s1} / [(A_{s1} + A_{s2}) \cdot f_y] = 1600 \cdot 400 \cdot (1/4 \cdot \pi \cdot 10^2) / [(1/4 \cdot \pi \cdot 25^2) \cdot 400] = 256 \text{ mm}$$

$$S_{\text{terpakai}} = 100 \text{ mm} \leq S_{\text{maks}} = 156,88 \text{ mm} - \text{aman}$$

Kontrol kuat geser:

$$V_{u,b} \leq 0,6 \cdot (V_c + V_s)$$

$$273,1161 \text{ kN} \leq 0,6 \cdot (0 + (4.78,54.240.627,5)/100 \cdot 10^{-3}) = 283,7304 \text{ kN} - \text{aman}$$

Tulangan geser dalam daerah (1m – 2 m) dari muka kolom ke tengah bentang

$$V_{u,b \text{ terpakai}} = [(V_{u,b1} + V_{u,b2}).(l_n - 1)/l_n] - V_{u,b2} \quad (\text{lihat gambar 7.4})$$

$$V_{u,b \text{ terpakai}} = [(305,2232 + 27,3601).(6,5 - 1)/6,5] - 27,3601 = 254,0565 \text{ kN}$$

$$V_s = V_{u,b}/\phi - V_c = 254,0565/0,6 - 0 = 423,4276 \text{ kN}$$

$$A_v = \frac{1}{4} \cdot \pi \cdot d^2 = \frac{1}{4} \cdot 3,14 \cdot 10^2 = 78,54 \text{ mm}^2$$

Tabel 7.4 Penulangan Geser Balok Daktilitas Penuh

Por-tal	Ba-lok	f_n (m)	U- jung	$V_{u,b}$ (kN)	Lokasi	Jarak (m)	$V_{u,b'}$ (kN)	d (mm)	b_w (mm)	V_c (kN)	V_s (kN)	S (mm)	S_{max} (mm)	Tul.ges terpakai	$0,6(V_s+V_c)$ $\geq V_{u,b'}$ (kN)		
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]		
As 1 dan As 6	S	6,5	1	75,3270	Pada SP	0-1,2	66,3537	530,5	400	0,0000	110,5895	180,84	132,63	2P10-	100	119,93544	
			2	33,6945	Luar SP	sisa	55,2000	530,5	400	176,8333	-84,8334	-235,63	265,25	2P10-	250	154,07418	
	Lt.1	6,5	1	305,2232	Pada SP	0-1	273,1161	627,5	400	0,0000	455,1935	103,94	156,88	4P10-	100	283,73040	
			2	27,3601	Luar SP	1-2,0	254,0565	627,5	400	0,0000	423,4276	111,74	156,88	4P10-	110	257,93673	
		6,5	2			Luar SP	sisa	202,8899	627,5	400	209,1667	128,9831	183,41	313,75	2P10-	150	220,07680
						Pada SP	0-1	270,7398	627,5	400	0,0000	451,2329	104,80	156,88	4P10-	100	283,73040
		6,5	2			Luar SP	1-2,0	252,0179	627,5	400	0,0000	420,0298	112,58	156,88	4P10-	110	257,93673
						Luar SP	sisa	201,7579	627,5	400	209,1667	127,0965	186,03	313,75	2P10-	150	220,07680
	Lt.3	6,5	2			Pada SP	0-1	257,2573	627,5	400	0,0000	428,7622	110,29	156,88	4P10-	100	257,93673
						Luar SP	1-2,0	238,4556	627,5	400	0,0000	397,4261	121,37	156,88	4P10-	120	236,44200
		6,5	2			Luar SP	sisa	187,9813	627,5	400	209,1667	104,1354	227,05	313,75	2P10-	150	220,07680
						Pada SP	0-1	251,2312	627,5	400	0,0000	418,7187	112,94	156,88	4P10-	110	257,93673
	Lt.4	6,5	2			Luar SP	1-2,0	232,8118	627,5	400	0,0000	388,0196	121,87	156,88	4P10-	120	236,44200
						Luar SP	sisa	183,3636	627,5	400	209,1667	96,4393	245,17	313,75	2P10-	150	220,07680
R	6,5	2			Pada SP	0-1,2	90,4358	530,5	500	0,0000	150,7263	132,62	132,63	2P10-	100	119,93544	
					Luar SP	sisa	78,7928	530,5	500	221,0417	-89,7204	-222,79	265,25	2P10-	150	212,58196	
As 2 dan As 5 (A-B)	S	3,1	1	67,4673	Pada SP	0-1	64,2149	530,5	400	0,0000	107,0248	186,77	132,63	2P10-	130	92,25803	
			2	-48,4617	Luar SP	1-1,2	60,9341	530,5	400	0,0000	101,5569	255,88	265,25	2P10-	250	62,36643	
		3,1	2			Luar SP	sisa	58,8841	530,5	400	176,8333	-78,6931	-254,02	265,25	2P10-	250	154,07418
						Pada SP	0-1	110,0422	627,5	200	0,0000	183,4037	128,92	156,88	2P10-	100	141,86520
	Lt.1	3,1	2			Luar SP	1-1,4	100,0967	627,5	200	0,0000	166,8278	151,65	156,88	2P10-	150	101,19718
						Luar SP	sisa	92,5062	627,5	200	104,5833	49,5937	476,76	313,75	2P10-	150	157,32680
	Lt.2	3,1	2			Pada SP	0-1	106,8397	627,5	200	0,0000	178,0662	132,78	156,88	2P10-	100	141,86520
						Luar SP	1-1,4	98,4237	627,5	200	0,0000	164,0395	154,23	156,88	2P10-	150	101,19718
		3,1	2			Luar SP	sisa	92,0006	627,5	200	104,5833	48,7510	485,00	313,75	2P10-	150	157,32680
						Pada SP	0-1	106,8335	627,5	200	0,0000	178,0559	132,79	156,88	2P10-	100	141,86520
	Lt.3	3,1	2			Luar SP	1-1,4	98,4186	627,5	200	0,0000	164,0310	154,23	156,88	2P10-	150	101,19718
						Luar SP	sisa	91,9964	627,5	200	104,5833	48,7439	485,07	313,75	2P10-	150	157,32680
	Lt.4	3,1	2			Pada SP	0-1	106,8970	627,5	200	0,0000	178,1617	132,71	156,88	2P10-	100	141,86520
						Luar SP	1-1,4	98,4452	627,5	200	0,0000	164,0753	154,19	156,88	2P10-	150	101,19718
	3,1	2			Luar SP	sisa	91,9948	627,5	200	104,5833	48,7414	485,10	313,75	2P10-	150	157,32680	
					Pada SP	0-1	61,2036	627,5	200	0,0000	102,0061	231,79	156,88	2P10-	100	141,86520	
A	3,1	2			Luar SP	1-1,4	57,4697	627,5	200	0,0000	95,7829	264,13	156,88	2P10-	150	101,19718	
					Luar SP	sisa	54,6200	627,5	200	104,5833	-13,5500	-1744,96	313,75	2P10-	150	157,32680	
As 2 dan As 5 (E-G)	S	3,1	1	69,2276	Pada SP	0-1	65,3645	530,5	400	0,0000	108,9408	183,49	132,63	2P10-	130	92,25803	
			2	-46,6534	Luar SP	1-1,2	61,4677	530,5	400	0,0000	102,4462	253,66	265,25	2P10-	250	62,36643	
		3,1	2			Luar SP	sisa	59,0328	530,5	400	176,8333	-78,4454	-254,82	265,25	2P10-	250	154,07418
						Pada SP	0-1	109,8512	627,5	200	0,0000	183,0854	129,14	156,88	2P10-	100	141,86520
	Lt.1	3,1	2			Luar SP	1-1,4	99,9964	627,5	200	0,0000	166,6606	151,80	156,88	2P10-	150	101,19718
						Luar SP	sisa	92,4751	627,5	200	104,5833	49,5419	477,26	313,75	2P10-	150	157,32680
	Lt.2	3,1	2			Pada SP	0-1	111,3796	627,5	200	0,0000	185,6326	127,37	156,88	2P10-	100	141,86520
						Luar SP	1-1,4	100,7989	627,5	200	0,0000	167,9981	150,59	156,88	2P10-	150	101,19718
		3,1	2			Luar SP	sisa	92,7237	627,5	200	104,5833	49,9562	473,30	313,75	2P10-	150	157,32680
						Pada SP	0-1	112,3707	627,5	200	0,0000	187,2845	126,25	156,88	2P10-	100	141,86520
	Lt.3	3,1	2			Luar SP	1-1,4	101,3204	627,5	200	0,0000	168,8674	149,82	156,88	2P10-	150	101,19718
						Luar SP	sisa	92,8869	627,5	200	104,5833	50,2282	470,74	313,75	2P10-	150	157,32680
	Lt.4	3,1	2			Pada SP	0-1	113,3975	627,5	200	0,0000	188,9958	125,10	156,88	2P10-	100	141,86520
						Luar SP	1-1,4	101,8584	627,5	200	0,0000	169,7640	149,03	156,88	2P10-	150	101,19718
	3,1	2			Luar SP	sisa	93,0518	627,5	200	104,5833	50,5030	468,17	313,75	2P10-	150	157,32680	
					Pada SP	0-1	71,6575	627,5	200	0,0000	119,4292	197,98	156,88	2P10-	100	141,86520	
A	3,1	2			Luar SP	1-1,4	61,9406	627,5	200	0,0000	103,2344	245,07	156,88	2P10-	150	101,19718	
					Luar SP	sisa	54,5247	627,5	200	104,5833	-13,7088	-1724,75	313,75	2P10-	150	157,32680	
As 3 dan As 4	S	6,5	1	75,3459	Pada SP	0-1,2	66,4481	530,5	400	0,0000	110,7468	180,49	132,63	2P10-	130	92,25803	
			2	33,6755	Luar SP	sisa	55,2189	530,5	400	176,8333	-84,8019	-235,72	265,25	2P10-	250	154,07418	
		3,1	2			Luar SP	sisa	54,5283	530,5	400	0,0000	90,8805	126,69	132,63	2P10-	130	59,04514
						Pada SP	0-1	50,5020	530,5	400	0,0000	84,1700	261,24	265,25	2P10-	250	52,77159
		6,5	2			Luar SP	1-1,2	48,0639	530,5	400	176,8333	-96,7269	-206,66	265,25	2P10-	250	136,80347
						Pada SP	0-1	268,8198	627,5	400	0,0000	448,0331	105,55	156,88	4P10-	100	283,73040
	Lt.1	6,5	2			Luar SP	1-2,0	250,3707	627,5	400	0,0000	417,2845	113,32	156,88	4P10-	110	257,93673
						Luar SP	sisa	200,8428	627,5	400	209,1667	125,5713	188,29	313,75	2P10-	150	220,07680
		3,1	2			Pada SP	0-1	131,2506	627,5	400	0,0000	218,7510	108,09	156,88	2P10-	100	141,86520
						Luar SP	1-1,4	107,6268	627,5	400	0,0000	179,3780	151,58	156,88	2P10-	150	108,76332
					Luar SP	sisa	99,2657	627,5	400	209,1667	-43,7239	-540,76	313,75	2P10-	150	220,07680	

Tabel 7.4. Lanjutan

Portai	Balok	In (m)	Ujung	Vu,b (kN)	Lokasi	Jarak (m)	Vu,b' (kN)	d (mm)	bw (mm)	Vc (kN)	Vs (kN)	S (mm)	Smax (mm)	Tul.ges terpakai	$0,6(Vs+Vc) \geq Vu,b'$ (kN)		
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]		
As 3 dan As 4	Lt.2	6,5	1	296,2776	Pada SP	0-1	265,8980	627,5	400	0,0000	443,1633	106,71	156,88	4P10-	100	283,73040	
			2	18,4118	Luar SP	sisa	247,8638	627,5	400	0,0000	413,1064	114,47	156,88	4P10-	110	257,93673	
		3,1	1	157,1372	Pada SP	0-1	132,0752	627,5	400	0,0000	220,1253	107,41	156,88	2P10-	100	141,86520	
			2	-33,3247	Luar SP	sisa	107,9105	627,5	400	0,0000	179,8509	151,19	156,88	2P10-	150	108,76332	
		6,5	1	283,8018	Pada SP	0-1	253,0543	627,5	400	0,0000	421,7572	112,12	156,88	4P10-	110	257,93673	
			2	34,6982	Luar SP	sisa	234,8018	627,5	400	0,0000	391,3363	120,84	156,88	4P10-	120	236,44200	
	3,1	1	158,6228	Pada SP	0-1	132,9795	627,5	400	0,0000	221,6326	106,68	156,88	2P10-	100	141,86520		
		2	-31,9390	Luar SP	sisa	108,2545	627,5	400	0,0000	180,4242	150,70	156,88	2P10-	150	108,76332		
	Lt.3	6,5	1	285,7403	Pada SP	0-1	254,4241	627,5	400	0,0000	424,0401	111,52	156,88	4P10-	110	257,93673	
			2	38,6510	Luar SP	sisa	235,8339	627,5	400	0,0000	393,0566	120,31	156,88	4P10-	120	236,44200	
		3,1	1	163,7544	Pada SP	0-1	136,0135	627,5	400	0,0000	226,6891	104,30	156,88	2P10-	100	141,86520	
			2	-26,7075	Luar SP	sisa	108,5265	627,5	400	0,0000	180,8776	150,33	156,88	2P10-	150	108,76332	
A		1	111,7429	Pada SP	0-1	96,8651	630,5	200	0,0000	161,4418	161,87	157,63	2P10-	100	156,79778		
		2	-38,2429	Luar SP	sisa	82,5200	630,5	200	0,0000	137,5333	198,65	157,63	2P10-	150	109,28330		
As A dan As G	S	4,1	1	76,7229	Pada SP	0-1,2	73,3320	530,5	400	0,0000	122,2200	163,55	132,63	2P10-	130	92,25803	
			2	-50,5162	Luar SP	sisa	69,0526	530,5	400	176,8333	-61,7456	-323,74	265,25	2P10-	250	154,07418	
		1,7	1	68,8779	Pada SP	0-1	65,5961	530,5	400	0,0000	109,3268	182,84	132,63	2P10-	130	92,25803	
			2	-58,3613	Luar SP	sisa											
		Lt.1	4,1	1	146,6647	Pada SP	0-1,4	131,7055	627,5	200	0,0000	219,5092	107,71	156,88	2P10-	100	141,86520
				2	-48,9233	Luar SP	Sisa	113,2896	627,5	200	104,5833	84,2326	280,70	313,75	2P10-	150	157,32680
	1,7		1	112,9144	Pada SP	0-1,7	101,7520	627,5	200	0,0000	169,5866	153,36	156,88	2P10-	150	104,03448	
			2	-82,6735	Luar SP	sisa											
	Lt.2	4,1	1	147,5526	Pada SP	0-1,4	132,3216	627,5	200	0,0000	220,5360	107,21	156,88	2P10-	100	141,86520	
			2	-48,0353	Luar SP	Sisa	113,5711	627,5	200	104,5833	84,7018	279,15	313,75	2P10-	150	157,32680	
		1,7	1	113,1747	Pada SP	0-1,7	101,8201	627,5	200	0,0000	169,7001	153,26	156,88	2P10-	150	104,03448	
			2	-82,4132	Luar SP	sisa											
	Lt.3	4,1	1	148,3239	Pada SP	0-1,4	132,0916	627,5	200	0,0000	220,1526	107,40	156,88	2P10-	100	141,86520	
			2	-42,2640	Luar SP	Sisa	112,1083	627,5	200	104,5833	82,2639	287,42	313,75	2P10-	150	157,32680	
		1,7	1	113,3978	Pada SP	0-1,7	101,8785	627,5	200	0,0000	169,7975	153,17	156,88	2P10-	150	104,03448	
			2	-82,1901	Luar SP	sisa											
	Lt.4	4,1	1	125,6730	Pada SP	0-1,4	112,3777	627,5	200	0,0000	187,2961	107,30	156,88	2P10-	100	120,58542	
			2	-22,3350	Luar SP	Sisa	90,3869	627,5	200	104,5833	46,0614	513,32	313,75	2P10-	150	157,32680	
		1,7	1	79,2321	Pada SP	0-1,7	66,8562	627,5	200	0,0000	111,4271	212,19	156,88	2P10-	150	94,57680	
			2	-45,7039	Luar SP	sisa											
	A	4,1	1	92,7631	Pada SP	0-1,4	81,4883	630,5	200	0,0000	135,8138	174,93	157,63	2P10-	150	95,02896	
		2	-19,0951	Luar SP	Sisa	67,6082	630,5	200	105,0833	7,5970	3127,21	315,25	2P10-	150	158,07896		
	As B dan As E	S	4,1	1,2	79,7689	Pada SP	0-1,2	77,0172	530,5	400	0,0000	128,3620	155,73	132,63	2P10-	130	92,25803
				2	-58,5022	Luar SP	sisa	73,5445	530,5	400	176,8333	-54,2592	-368,40	265,25	2P10-	250	154,07418
1,7			1	64,1488	Pada SP	0-1	61,5828	530,5	400	0,0000	102,6380	194,75	132,63	2P10-	130	92,25803	
			2	-55,9259	Luar SP	sisa											
Lt.1			4,1	1,2	220,0720	Pada SP	0-1,4	195,3993	627,5	400	0,0000	325,6655	108,90	156,88	3P10-	100	212,79780
				2	-58,8640	Luar SP	Sisa	157,1616	627,5	400	209,1667	52,7693	470,47	313,75	2P10-	150	220,07680
		1,7	1	125,3286	Pada SP	0-1,7	110,3603	627,5	400	0,0000	183,9338	154,26	156,88	2P10-	150	113,49216	
			2	-90,3511	Luar SP	sisa											
Lt.2		4,1	1,2	222,7466	Pada SP	0-1,4	197,2547	627,5	400	0,0000	328,7579	107,88	156,88	3P10-	100	212,79780	
			2	-56,1862	Luar SP	Sisa	157,7474	627,5	400	209,1667	53,7457	461,92	313,75	2P10-	150	220,07680	
		1,7	1	125,3286	Pada SP	0-1,7	113,3345	627,5	400	0,0000	188,8909	150,21	156,88	2P10-	150	113,49216	
			2	-97,3012	Luar SP	sisa											
Lt.3		4,1	1,2	224,1673	Pada SP	0-1,4	198,2406	627,5	400	0,0000	330,4009	107,34	156,88	3P10-	100	212,79780	
			2	-54,7655	Luar SP	Sisa	158,0593	627,5	400	209,1667	54,2655	457,50	313,75	2P10-	150	220,07680	
		1,7	1	125,3286	Pada SP	0-1,7	110,3603	627,5	400	0,0000	183,9338	154,26	156,88	2P10-	150	113,49216	
			2	-90,3511	Luar SP	sisa											
Lt.4		4,1	1,2	202,4491	Pada SP	0-1,4	176,2610	627,5	400	0,0000	293,7684	120,73	156,88	3P10-	100	212,79780	
			2	-31,3397	Luar SP	Sisa	152,3683	627,5	400	209,1667	44,7805	528,00	313,75	2P10-	150	220,07680	

Tabel 7.4. Lanjutan

Por-tal	Ba-lok	In (m)	U-ujung	Vu,b (kN)	Lokasi	Jarak (m)	Vu,b' (kN)	d (mm)	bw (mm)	Vc (kN)	Vs (kN)	S (mm)	Smax (mm)	Tul.ges terpakai	0,6(Vs+Vc) ≥ Vu,b' (kN)		
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]		
As B dan As E	Lt.4	1,7	1	75,5919	Pada SP	0-1,7	61,1318	627,5	400	0,0000	101,8863	249,47	156,88	2P10-	150	101,67006	
			2	-36,4171													
	R	4,1	1,2	1	108,0664	Pada SP	0-1,2	91,1245	530,5	500	0,0000	151,8742	131,62	132,63	2P10-	100	119,93544
2				2,6296	Luar SP	Sisa	70,2678	530,5	500	221,0417	-103,9287	-96,17	265,25	2P10-	150	188,59487	
		1,7	1	37,1731	Pada SP	0-1,7	17,6091	530,5	500	0,0000	29,3484	681,10	132,63	2P10-	150	79,95696	
			2	15,8291													
As C dan AsD	S	9,6	1	1	74,7399	Pada SP	0-1,2	68,4730	530,5	400	0,0000	114,1216	175,16	132,63	2P10-	130	92,25803
				2	-30,3979	Luar SP	Sisa	42,8442	530,5	400	176,8333	71,4069	279,93	132,63	2P10-	250	154,07418
			1,7	1	68,0164	Pada SP	0-1,7	28,6454	530,5	400	0,0000	47,7423	418,69	132,63	2P10-	130	92,25803
				2	-58,1489												
	Lt.1	9,6	1	1	399,5200	Pada SP	0-1,3	363,0077	627,5	400	0,0000	605,0128	107,47	156,88	5P10-	100	390,12930
				2	118,3440	Luar SP	Sisa	318,0582	627,5	400	0,0000	530,0971	122,66	156,88	5P10-	120	325,10775
				1	132,9043	Pada SP	0-1,7	115,3229	627,5	400	0,0000	194,8587	151,68	313,75	2P10-	150	243,72100
				2	-91,8207							192,2049	153,77	156,88	2P10-	150	141,86520
	Lt.2	8,9	1	1	398,2921	Pada SP	0-1,3	361,9529	627,5	400	0,0000	603,2549	107,78	156,88	5P10-	100	390,12930
				2	117,1158	Luar SP	Sisa	317,2167	627,5	400	0,0000	528,6945	122,99	156,88	5P10-	120	325,10775
				1	132,9036	Pada SP	0-1,7	117,7389	627,5	400	0,0000	194,0540	152,30	313,75	2P10-	150	243,72100
				2	-91,8200							209,1667	150,61	156,88	2P10-	150	141,86520
Lt.3	8,9	1	1	374,1925	Pada SP	0-1,3	337,9390	627,5	400	0,0000	563,2317	115,44	156,88	5P10-	110	354,66300	
			2	140,0005	Luar SP	Sisa	293,3082	627,5	400	0,0000	488,8470	133,01	156,88	5P10-	130	300,09946	
			1	130,9592	Pada SP	0-1,7	112,1839	627,5	400	0,0000	154,5023	191,29	313,75	2P10-	150	243,72100	
			2	-80,0939							209,1667	158,07	156,88	2P10-	150	141,86520	
Lt.4	8,9	1	1	340,9953	Pada SP	0-1,3	303,9127	627,5	400	0,0000	506,5212	128,37	156,88	5P10-	110	354,66300	
			2	184,9569	Luar SP	Sisa	258,2612	627,5	400	0,0000	430,4354	151,06	156,88	5P10-	130	300,09946	
			1	88,3027	Pada SP	0-1,7	65,1946	627,5	400	0,0000	93,2279	317,02	313,75	2P10-	150	243,72100	
			2	-25,6992							108,6577	272,00	156,88	2P10-	150	141,86520	
As F	S	4,1	1	1	88,3383	Pada SP	0-1,2	68,9177	530,5	400	0,0000	114,8628	174,03	132,63	2P10-	130	92,25803
				2	-61,7550	Luar SP	sisa	44,4086	530,5	400	176,8333	-102,8191	-194,41	265,25	2P10-	250	154,07418
			1,7	1	81,4132	Pada SP	0-1,7	34,5752	530,5	400	0,0000	57,6254	346,88	132,63	2P10-	130	92,25803
				2	-68,6802												
	Lt.1	4,1	1	1	165,5708	Pada SP	0-1,4	144,8245	627,5	200	0,0000	241,3741	102,85	156,88	2P10-	100	148,95846
				2	-30,0171	Luar SP	Sisa	119,2842	627,5	200	104,5833	94,2236	250,94	313,75	2P10-	150	157,32680
				1	115,2977	Pada SP	0-1,7	100,6150	627,5	200	0,0000	167,6916	141,00	156,88	2P10-	150	94,57680
				2	-75,5198												
	Lt.2	4,1	1	1	166,5394	Pada SP	0-1,4	145,4966	627,5	200	0,0000	242,4943	102,38	156,88	2P10-	100	148,95846
				2	-29,0485	Luar SP	Sisa	119,5913	627,5	200	104,5833	94,7355	249,58	313,75	2P10-	150	157,32680
				1	116,7401	Pada SP	0-1,7	96,1902	627,5	200	0,0000	160,3170	147,48	156,88	2P10-	150	94,57680
				2	-61,0671												
Lt.3	4,1	1	1	167,0058	Pada SP	0-1,4	145,8202	627,5	200	0,0000	243,0337	102,15	156,88	2P10-	100	148,95846	
			2	-28,5821	Luar SP	Sisa	119,7392	627,5	200	104,5833	94,9820	248,93	313,75	2P10-	150	157,32680	
			1	116,7127	Pada SP	0-1,7	100,9854	627,5	200	0,0000	168,3090	140,48	156,88	2P10-	150	94,57680	
			2	-74,1048													
Lt.4	4,1	1	1	142,3925	Pada SP	0-1,4	121,0312	627,5	200	0,0000	201,7187	107,84	156,88	2P10-	100	130,51598	
			2	-2,8208	Luar SP	Sisa	94,7339	627,5	200	104,5833	53,3065	443,55	313,75	2P10-	150	157,32680	
			1	92,6419	Pada SP	0-1,7	76,6917	627,5	200	0,0000	127,8194	184,98	156,88	2P10-	150	94,57680	
			2	-49,4301													
A	4,1	1	1	87,0216	Pada SP	0-1,4	73,8963	627,5	200	0,0000	123,1604	191,98	156,88	2P10-	100	141,86520	
			2	-1,2624	Luar SP	Sisa	57,7380	627,5	200	104,5833	-8,3534	-2830,49	313,75	2P10-	150	157,32680	
			1	14,9258	Pada SP	0-1,7	5,4160	627,5	200	0,0000	9,0267	2619,37	156,88	2P10-	150	94,57680	
			2	10,8378													

Keterangan Tabel 7.4:

- [1] Portal yang ditinjau
 [2] Balok: Sloof, Lantai 1 s/d 4. dan Atap/Ring
 [3] In = bentang bersih balok
 [4] Ujung: 1 = ujung balok, 2 = ujung balok yang lain
 [5] Vu,b = gaya geser rencana balok dari Tabel 7.3

- [6] Lokasi tulangan geser: Pada atau Luar Sendi Plastik
 [7] Jarak penulangan dari ujung ke tengah bentang balok
 [8] Vu,b' = gaya geser terpakai sesuai lokasi tulangan
 [9] d = tinggi efektif balok
 [10] bw = lebar badan balok

$$[11] V_c = 1/6 \cdot f_c \cdot 0,5 \cdot d \cdot bw \text{ (untuk luar sendi plastis), } V_c = 0 \text{ (pada sendi plastis)}$$

$$[12] V_s = V_{u,b} / 0,6 \cdot V_c$$

$$[13] S = (A_v \cdot f_y \cdot d) / V_s, \text{ dengan diameter tul. geser 10 mm (P10) jika } S > S_{max} \text{ dipakai } S_{max}$$

$$[14] S_{max} = d/4 \text{ (pada sendi plastis), } S_{maks} = d/2 \text{ (luar sendi plastis)}$$

$$[15] \text{ Tulangan geser terpakai}$$

$$[16] V_{u,b} \leq (V_c + V_s) / 0,6 \text{ dengan } V_c = 1/6 \cdot f_c \cdot 0,5 \cdot d \cdot bw, V_s = (A_v \cdot f_y \cdot d) / \text{Sterpakai}$$

$$f_y = 240 \text{ Mpa, dan } f_c' = 25 \text{ Mpa}$$

7.2 Desain Kolom

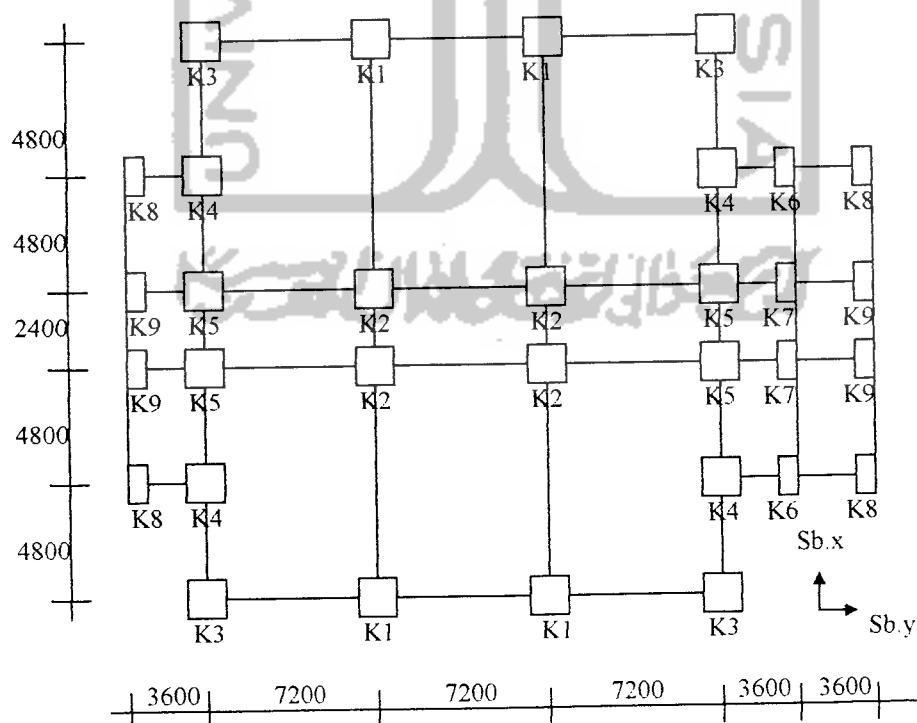
Kolom yang akan didesain telah ditentukan terlebih dahulu letak pada denah portal dan ukuran dimensinya. Kolom-kolom yang didesain adalah sebagai berikut ini:

- K1, K2, K3, K4, K5, dan, K6 dengan dimensi 700 mm x 700 mm
- K7, K8, dan K9 dengan dimensi 250 mm x 700 mm

Letak kolom-kolom yang dimaksud diatas dapat dilihat pada Gambar 7.5

Desain kolom pada pembahasan ini meliputi.

1. Momen rencana kolom
2. Gaya aksial rencana kolom
3. Perhitungan diagram interaksi kolom
4. Cek kelangsingan kolom dan faktor pembesaran momen
5. Penulangan lentur dan aksial kolom
6. Gaya geser rencana kolom
7. Penulangan geser kolom
8. Perencanaan pertemuan balok kolom



Gambar 7.5 Denah rencana kolom lantai 1 s/d lantai 5 (Skala 1 : 280)

7.2.1 Momen Rencana Kolom

Momen rencana kolom dengan daktilitas penuh yang ditentukan pada muka balok $M_{u,k}$ dihitung berdasarkan terjadinya kapasitas lentur sendi plastis pada kedua ujung balok yang bertemu pada kolom tersebut. Momen rencana kolom ditentukan dengan mengambil nilai terkecil dari persamaan sebagai berikut (Kusuma dan Andriano, 1993):

$$M_{u,k} = \frac{h}{h_n} \cdot 0,7 \cdot \omega_d \cdot \alpha \cdot 1,25 \left[\begin{aligned} & \frac{I_{ki,x}}{I_{nki,x}} M_{nak,b,ki,x} + \frac{I_{ka,x}}{I_{nka,x}} M_{nak,b,ka,x} \\ & + 0,3 \left(\frac{I_{ki,y}}{I_{nki,y}} M_{nak,b,ki,y} + \frac{I_{ka,y}}{I_{nka,y}} M_{nak,b,ka,y} \right) \end{aligned} \right]$$

tetapi tidak perlu lebih besar dari

$$M_{u,k \max} = 1,05 \left[M_{D,k,x} + M_{L,x} + \frac{4}{k} \cdot (M_{E,k,x} + 0,3M_{E,k,y}) \right]$$

Sebagai contoh perhitungan ditinjau pada momen kolom atas K2 lantai 1 (sejajar sumbu x)

diketahui:

$$h = 5,4 \text{ m}$$

$$h_n = 5,4 - 0,7 - 0,6 = 4,1 \text{ m}$$

$\omega_d = 1$ untuk kolom lantai 1 dan lantai paling atas

$$M_{E,k \text{ lt atas}} = 182,5300 \text{ kNm}$$

$$M_{E,k \text{ lt } i-1 \text{ bawah}} = 192,7600 \text{ kNm}$$

$$\alpha_k \text{ atas} = (M_{E,k \text{ lt atas}}) / (M_{E,k \text{ lt atas}} + M_{E,k \text{ lt } i-1 \text{ bawah}})$$

$$= 182,5300 / (182,5300 + 192,7600)$$

$$= 0,49$$

$$M_{nak, \text{ kiri } b-x} = 1100,2186 \text{ kNm}$$

$$l_{ki,x} = 9,6 \text{ m}$$

$$l_{nki,x} = 9,6 - 0,7 = 8,9 \text{ m}$$

$$M_{nak, \text{ kanan } b-x} = 578,1163 \text{ kNm}$$

$$l_{ka,x} = 2,4 \text{ m}$$

$$l_{nka,x} = 2,4 - 0,7 = 1,7 \text{ m}$$

$$M_{nak, kiri b-y} = 358,9232 \text{ kNm}$$

$$l_{ki,x} = 7,2 \text{ m}$$

$$l_{nki,x} = 7,2 - 0,7 = 6,5 \text{ m}$$

$$M_{nak, kanan b-y} = 673,1497 \text{ kNm}$$

$$l_{ka,x} = 7,2 \text{ m}$$

$$l_{nka,x} = 7,2 - 0,7 = 6,5 \text{ m}$$

$$M_{D,k-x atas} = 111,7600 \text{ kNm}$$

$$M_{L,k-x atas} = 32,3400 \text{ kNm}$$

$$M_{Eki,k-x atas} = 182,5300 \text{ kNm (akibat gempa kiri)}$$

$$M_{Eki,k-y atas} = 198,6600 \text{ kNm (akibat gempa kiri)}$$

$$\begin{aligned} M_{u,k-x atas} &= 4,1/5,4 \cdot 0,7 \cdot 1,25 \cdot 1,0,49 [(9,6/8,9) \cdot 1100,2186 + (2,4/1,7) \cdot 578,1163 \\ &\quad + 0,3 \cdot [(7,2/6,5) \cdot 358,9232 + (7,2/6,5) \cdot 673,1497]] \\ &= 530,6030 \text{ kNm} \end{aligned}$$

$$\begin{aligned} M_{u,k atas maks} &= 1,05 [111,7600 + 32,3400 + 4/1 \cdot (182,5300 + 0,3 \cdot 198,6600)] \\ &= 934,5941 \text{ kNm} \end{aligned}$$

$$\text{dipakai } M_{u,k-x atas} = 530,6030 \text{ kNm}$$

Dengan cara yang sama dapat dihitung untuk momen rencana kolom-kolom disajikan pada lampiran Tabel 7.5, untuk momen maksimum kolom-kolom disajikan pada lampiran Tabel 7.6, dan untuk momen terpakai kolom-kolom disajikan dalam Tabel 7.7.

Tabel 7.5 Momen Rencana Kolom Daktililitas Penuh (Satuan kNm)

Ko- lom	Letak Momen	h (m)	h _n (m)	Sejajar Sumbu X				Sejajar Sumbu Y				M _{u,k-x}		M _{u,k-y}									
				Kiri		Kanan		Kiri		Kanan		M _{u,k-x} (kNm)	l _{nka} (m)	M _{u,k-y} (kNm)	l _{nky} (m)								
				M/E _k (kNm)	α _k	M _{nak,b} (kNm)	l _{nki} (m)	M _{nak,b} (kNm)	l _{nka} (m)	M _{nak,b} (kNm)	l _{nki} (m)					M _{nak,b} (kNm)	l _{nka} (m)						
K1	1	Atas	4,1	5	72,9200	0,51	0	0	1100,2186	9,6	8,9	187,0200	0,48	358,9232	7,2	6,5	673,1497	7,2	6,5	440,2161	402,9811		
		Bawah	4,1	5	139,9100	1,00	0	0	334,1879	9,6	8,9	225,8100	1,00	228,9204	7,2	6,5	176,0163	7,2	6,5	279,5463	314,3606		
		Bawah	3,8	3,1	88,2100	0,66	0	0	1100,2186	9,6	8,9	213,9600	0,58	358,9232	7,2	6,5	566,4322	7,2	6,5	527,4319	425,7166		
	2	Atas	3,8	3,1	70,1700	0,49	0	0	1100,2186	9,6	8,9	191,0300	0,64	358,8097	7,2	6,5	673,1497	7,2	6,5	401,6068	420,5932		
		Bawah	3,8	3,1	87,3400	0,84	0	0	1100,2186	9,6	8,9	157,6300	0,42	358,8097	7,2	6,5	566,4322	7,2	6,5	582,0603	431,1416		
		Bawah	3,8	3,1	45,5800	0,34	0	0	1100,2186	9,6	8,9	146,8800	0,71	358,8097	7,2	6,5	566,4322	7,2	6,5	236,1914	284,3381		
	3	Atas	3,8	3,1	16,9900	0,16	0	0	1100,2186	9,6	8,9	105,9600	0,36	358,8097	7,2	6,5	566,4322	7,2	6,5	119,7832	246,1781		
		Bawah	3,8	3,2	67,6300	1,00	0	0	1100,2186	9,6	8,9	73,0800	1,00	179,9488	7,2	6,5	232,9100	7,2	6,5	634,1018	389,5501		
		Bawah	3,8	3,2	16,9600	0,20	0	0	1100,2186	9,6	8,9	60,1100	0,29	358,8097	7,2	6,5	566,4300	7,2	6,5	143,4856	192,0656		
	K2	1	Atas	5,4	4,1	182,5300	0,49	1100,2186	9,6	8,9	578,1163	2,4	1,7	198,6600	0,49	358,9232	7,2	6,5	673,1497	7,2	6,5	530,6030	394,0670
			Bawah	5,4	4,1	212,4700	1,00	334,1879	9,6	8,9	334,1879	2,4	1,7	239,8800	1,00	228,9204	7,2	6,5	228,9204	7,2	6,5	457,7987	351,9595
			Bawah	3,8	3,1	195,1300	0,60	1100,2186	9,6	8,9	578,1163	2,4	1,7	225,2400	0,60	358,8097	7,2	6,5	566,4322	7,2	6,5	694,5736	487,0952
		2	Atas	3,8	3,1	192,7600	0,51	1100,2186	9,6	8,9	578,1163	2,4	1,7	210,2300	0,51	358,9097	7,2	6,5	673,1497	7,2	6,5	602,0597	448,0625
			Bawah	3,8	3,1	155,8300	0,73	1100,2186	9,6	8,9	578,9232	2,4	1,7	188,2700	0,65	358,8097	7,2	6,5	566,4322	7,2	6,5	699,6499	481,4479
			Bawah	3,8	3,1	129,1900	0,40	1100,2186	9,6	8,9	578,1163	2,4	1,7	150,4000	0,40	358,9097	7,2	6,5	566,4322	7,2	6,5	459,8639	325,2713
3		Atas	3,8	3,1	92,8700	1,00	1100,2186	9,6	8,9	358,8097	2,4	1,7	169,8200	1,00	358,8097	7,2	6,5	566,4322	7,2	6,5	714,0915	547,0954	
		Bawah	3,8	3,1	58,9000	0,27	1100,2186	9,6	8,9	358,9232	2,4	1,7	100,5600	0,35	358,9097	7,2	6,5	566,4322	7,2	6,5	264,4553	257,1727	
		Bawah	5,4	4,1	91,0200	0,54	0	0	458,2185	4,8	4,1	107,7700	0,47	107,7700	0,47	0	0	673,1497	7,2	6,5	270,7508	280,5154	
K3		1	Atas	5,4	4,1	124,3000	1,00	0	0	228,9200	4,8	4,1	179,0600	1,00	0	0	0	228,9204	7,2	6,5	228,5875	221,8766	
			Bawah	3,8	3,1	90,5600	0,60	0	0	458,2185	4,8	4,1	108,3800	0,58	0	0	0	673,1497	7,2	6,5	310,0298	359,3998	
			Bawah	3,8	3,1	78,7500	0,46	0	0	458,2185	4,8	4,1	123,6200	0,53	0	0	0	673,1497	7,2	6,5	239,1085	328,4423	
		2	Atas	3,8	3,1	81,8400	0,70	0	0	458,2185	4,8	4,1	116,8800	0,73	0	0	0	566,4322	7,2	6,5	325,9595	363,4159	
			Bawah	3,8	3,1	60,0100	0,40	0	0	458,2185	4,8	4,1	77,0100	0,42	0	0	0	673,1497	7,2	6,5	205,4427	255,3735	
			Bawah	3,8	3,1	65,8100	0,91	0	0	458,2185	4,8	4,1	88,2700	0,79	0	0	0	566,4322	7,2	6,5	329,4157	356,3726	
	3	Atas	3,8	3,1	35,0500	0,30	0	0	458,2185	4,8	4,1	42,3900	0,27	0	0	0	566,4322	7,2	6,5	147,3558	142,2879		
		Bawah	3,8	3,2	27,1600	1,00	0	0	232,9072	4,8	4,1	39,2300	1,00	0	0	0	232,9072	7,2	6,5	206,3563	200,2979		
		Bawah	3,8	3,2	6,5300	0,09	0	0	458,2185	4,8	4,1	23,2400	0,21	0	0	0	566,4322	7,2	6,5	48,2010	121,0670		
	K4	1	Atas	5,4	4,1	151,9400	0,50	458,2185	4,8	4,1	358,6561	4,8	4,1	41,0600	0,33	229,1173	3,6	2,9	0	0	345,6983	124,0823	
			Bawah	5,4	4,1	162,7800	1,00	228,9204	4,8	4,1	176,0163	4,8	4,1	173,1700	1,00	175,5251	3,6	2,9	0	0	358,3781	239,2430	
			Bawah	3,8	3,1	158,9800	0,57	458,2185	4,8	4,1	358,6561	4,8	4,1	82,7800	0,66	229,1173	3,6	2,9	0	0	399,9445	257,6013	
		2	Atas	3,8	3,1	152,2200	0,50	458,2185	4,8	4,1	358,6561	4,8	4,1	84,5400	0,67	229,1173	3,6	2,9	0	0	353,5155	260,7742	
			Bawah	3,8	3,1	139,7700	0,63	458,2185	4,8	4,1	358,6561	4,8	4,1	88,2200	0,89	229,1173	3,6	2,9	0	0	442,0256	346,3618	
			Bawah	3,8	3,1	121,8100	0,43	458,2185	4,8	4,1	358,6561	4,8	4,1	41,7200	0,34	229,1173	3,6	2,9	0	0	306,4363	129,8276	
3		Atas	3,8	3,1	106,8500	0,72	458,6600	4,8	4,1	358,6561	4,8	4,1	77,3300	0,84	229,1173	3,6	2,9	0	0	510,8872	326,6980		
		Bawah	3,8	3,1	83,5900	0,37	458,2185	4,8	4,1	358,6561	4,8	4,1	10,4600	0,11	229,1173	3,6	2,9	0	0	264,3551	41,0672		
		Bawah	3,8	3,1	59,6400	1,00	232,9072	4,8	4,1	179,9488	4,8	4,1	35,0500	1,00	137,1643	3,6	2,9	0	0	362,4073	213,7965		
4		Atas	3,8	3,1	40,9600	0,28	458,6600	4,8	4,1	358,6561	4,8	4,1	14,4000	0,16	229,1173	3,6	2,9	0	0	195,8441	60,8360		
		Bawah	5,4	4,1	124,3000	1,00	0	0	228,9200	4,8	4,1	179,0600	1,00	0	0	0	228,9204	7,2	6,5	228,5875	221,8766		
		Bawah	3,8	3,1	78,7500	0,46	0	0	458,2185	4,8	4,1	123,6200	0,53	0	0	0	673,1497	7,2	6,5	239,1085	328,4423		

Tabel 7.5 Lanjutan

Ko- lom	Letak Momen	h (m)	h/n	Sejajar Sumbu X						Sejajar Sumbu Y						M _{u,k-x}		M _{u,k-y}				
				Kiri			Kanan			Kiri			Kanan			M _{nek,x} (kNm)	I _{ka} (m)	I _{nka} (m)	M _{nek,y} (kNm)	I _{ka} (m)	I _{nka} (m)	
				M _{nek} (kNm)	α _k	I _{ki} (m)	I _{nki} (m)	M _{nek,b} (kNm)	I _{ka} (m)	I _{nka} (m)	M _{nek,b} (kNm)	I _{ki} (m)	I _{nki} (m)	M _{nek,b} (kNm)	I _{ka} (m)							I _{nka} (m)
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]	[21]	[22]	[23]
K5	1	Atas	3,7	3	165,0600	0,50	458,2185	4,8	4,1	358,4400	2,4	1,7	169,6900	0,52	358,9232	3,6	3,13	673,1497	7,2	6,5	397,7632	430,5694
		Bawah	3,7	3	176,1000	1,00	228,9204	4,8	4,1	175,8236	2,4	1,7	241,4700	1,00	176,0163	3,6	3,13	228,9204	7,2	6,5	370,6949	346,9041
	2	Atas	3,8	3,1	166,7100	0,57	458,2185	4,8	4,1	358,4362	2,4	1,7	179,4300	0,61	358,9232	3,6	3,13	673,1497	7,2	6,5	424,2382	481,4663
		Bawah	3,8	3,1	162,3700	0,50	458,2185	4,8	4,1	358,4362	2,4	1,7	159,5400	0,48	358,9232	3,6	3,13	673,1497	7,2	6,5	393,6819	407,3001
	3	Atas	3,8	3,1	141,0600	0,64	458,2185	4,8	4,1	358,4362	2,4	1,7	165,1400	0,72	358,8097	3,6	3,13	566,4322	7,2	6,5	436,4932	503,1892
		Bawah	3,8	3,1	125,7600	0,43	458,2185	4,8	4,1	358,4362	2,4	1,7	114,2300	0,39	358,9232	3,6	3,13	673,1497	7,2	6,5	320,0300	306,5145
	4	Atas	3,8	3,1	101,6900	0,76	458,2185	4,8	4,1	358,4362	2,4	1,7	136,7300	0,49	358,8097	3,6	3,13	566,4322	7,2	6,5	520,6833	353,7112
		Bawah	3,8	3,1	80,8200	0,36	458,2185	4,8	4,1	358,4362	2,4	1,7	63,1600	0,28	358,8097	3,6	3,13	566,4322	7,2	6,5	250,0878	192,4514
	5	Atas	3,8	3,2	47,3600	1,00	179,5400	4,8	4,1	179,5400	2,4	1,7	83,2200	1,00	137,1922	3,6	3,13	201,1347	7,2	6,5	319,3733	287,3348
		Bawah	3,8	3,2	32,4000	0,24	458,2185	4,8	4,1	358,4362	2,4	1,7	143,3800	0,51	358,8097	3,6	3,13	566,4322	7,2	6,5	183,3091	398,1945
K6	1	Atas	5,4	4,1	37,6500	0,44	0	0	0	229,1173	4,8	4,1	33,5800	0,45	175,5251	3,6	3,13	122,5780	3,6	3,35	53,9462	37,3680
		Bawah	5,4	4,1	77,7600	1,00	0	0	0	175,8236	4,8	4,1	32,9200	1,00	229,1173	3,6	3,13	229,1173	3,6	3,35	111,9496	73,9201
	2	Atas	3,8	3,1	49,6800	0,60	0	0	0	229,1173	4,8	4,1	40,3700	0,53	229,1173	3,6	3,13	229,1173	3,6	3,35	94,2106	89,1704
		Bawah	3,8	3,1	47,7600	0,56	0	0	0	229,1173	4,8	4,1	40,6400	0,55	229,1173	3,6	3,13	229,1173	3,6	3,35	84,0785	63,4843
	3	Atas	3,8	3,1	47,4200	0,71	0	0	0	229,1173	4,8	4,1	35,4700	0,58	229,1173	3,6	3,13	229,1173	3,6	3,35	101,2991	87,1390
		Bawah	3,8	3,1	33,8000	0,40	0	0	0	229,1173	4,8	4,1	35,8500	0,47	229,1173	3,6	3,13	229,1173	3,6	3,35	73,0542	77,8390
	4	Atas	3,8	3,1	38,9900	0,61	0	0	0	229,1173	4,8	4,1	25,5900	0,62	229,1173	3,6	3,13	229,1173	3,6	3,35	135,9795	77,8390
		Bawah	3,8	3,1	19,4100	0,29	0	0	0	229,1173	4,8	4,1	26,0300	0,42	229,1173	3,6	3,13	229,1173	3,6	3,35	69,8721	49,0719
	5	Atas	3,8	3,2	24,7100	1,00	0	0	0	137,1643	4,8	4,1	15,6100	1,00	137,1643	3,6	3,13	137,1643	3,6	3,35	143,8650	78,4227
		Bawah	3,8	3,2	24,5500	0,39	0	0	0	229,1173	4,8	4,1	15,6000	0,38	229,1173	3,6	3,13	229,1173	3,6	3,35	95,9494	47,7991
K7	1	Atas	5,4	4,1	79,8700	0,46	229,1173	4,8	4,1	229,1173	2,4	1,7	23,7500	0,50	358,4362	3,6	3,13	358,4362	3,6	3,35	101,5743	71,1766
		Bawah	5,4	4,1	111,3700	1,00	175,8236	4,8	4,1	175,8236	2,4	1,7	25,1300	1,00	140,6589	3,6	3,13	140,6589	3,6	3,35	141,9911	59,7138
	2	Atas	3,8	3,1	93,1000	0,57	229,1173	4,8	4,1	229,1173	2,4	1,7	24,2100	0,55	358,4362	3,6	3,13	358,4362	3,6	3,35	130,4349	78,5191
		Bawah	3,8	3,1	93,8000	0,54	229,1173	4,8	4,1	229,1173	2,4	1,7	23,8300	0,50	358,4362	3,6	3,13	358,4362	3,6	3,35	128,1713	73,2457
	3	Atas	3,8	3,1	80,5900	0,65	229,1173	4,8	4,1	229,1173	2,4	1,7	20,3800	0,61	358,4362	3,6	3,13	358,4362	3,6	3,35	132,5338	83,3292
		Bawah	3,8	3,1	71,3800	0,43	229,1173	4,8	4,1	229,1173	2,4	1,7	19,5100	0,45	358,4362	3,6	3,13	358,4362	3,6	3,35	99,8960	65,2619
	4	Atas	3,8	3,1	58,2600	0,57	229,1173	4,8	4,1	229,1173	2,4	1,7	14,1500	0,52	358,4362	3,6	3,13	358,4362	3,6	3,35	144,1921	75,4796
		Bawah	3,8	3,1	44,1300	0,35	229,1173	4,8	4,1	229,1173	2,4	1,7	12,8300	0,39	358,4362	3,6	3,13	358,4362	3,6	3,35	71,3723	64,5702
	5	Atas	3,8	3,1	26,1800	1,00	137,1643	4,8	4,1	137,1643	2,4	1,7	4,5100	1,00	137,1922	3,6	3,13	201,1347	3,6	3,35	133,3653	83,4121
		Bawah	3,8	3,1	44,1300	0,43	229,1173	4,8	4,1	229,1173	2,4	1,7	12,8300	0,48	358,4362	3,6	3,13	358,4362	3,6	3,35	89,4947	80,5444
K8	1	Atas	5,4	4,1	41,2400	0,49	0	0	0	229,1173	4,8	4,1	40,2600	0,43	0	0	0	229,1173	3,6	2,9	91,6445	92,6323
		Bawah	5,4	4,1	54,4100	1,00	0	0	0	175,5300	4,8	4,1	59,9800	1,00	0	0	0	175,5251	3,6	2,9	109,3404	93,3374
	2	Atas	3,8	3,1	45,0800	0,56	0	0	0	229,1173	4,8	4,1	52,8500	0,56	0	0	0	229,1173	3,6	2,9	110,2083	116,0553
		Bawah	3,8	3,1	43,3200	0,51	0	0	0	229,1173	4,8	4,1	53,5100	0,57	0	0	0	229,1173	3,6	2,9	103,4343	94,2069
3	Atas	3,8	3,1	40,3900	0,63	0	0	0	229,1173	4,8	4,1	49,0800	0,64	0	0	0	229,1173	3,6	2,9	112,3995	95,4678	
	Bawah	3,8	3,1	35,1100	0,44	0	0	0	229,1173	4,8	4,1	42,0400	0,44	0	0	0	229,1173	3,6	2,9	77,3499	92,3172	
4	Atas	3,8	3,1	31,5200	0,75	0	0	0	229,1173	4,8	4,1	37,3700	0,72	0	0	0	229,1173	3,6	2,9	114,1995	89,6000	
	Bawah	3,8	3,1	24,1100	0,37	0	0	0	229,1173	4,8	4,1	27,5100	0,36	0	0	0	229,1173	3,6	2,9	90,5648	87,9421	

Tabel 7.5 Lanjutan

Ko- lom	Letak Momen	h (m)	h _n (m)	Sejajar Sumbu X				Sejajar Sumbu Y				M _{u,k-x} (kNm)	M _{u,k-y} (kNm)									
				M _{E,k} (kNm)	α _k	Kiri M _{nak,b} (kNm)	/k _i (m)	/n _{k_i} (m)	M _{nak,b} (kNm)	/k _a (m)	/n _{k_a} (m)			Kanan M _{nak,b} (kNm)	/k _a (m)	/n _{k_a} (m)						
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]	[21]	[22]	[23]
K8	5 Atas	3,8	3,1	19,11	1	0	0	0	0	0	137,1643	4,8	4,1	24,3500	1,00	0	0	137,1643	3,6	2,9	105,7626	78,7307
	Bawah	3,8	3,1	10,7600	0,25	0	0	0	0	0	229,1173	4,8	4,1	14,3000	0,28	0	0	229,1173	3,6	2,9	64,2286	72,0855
K9	1 Atas	5,4	4,1	85,7100	0,49	0,49	229,1173	4,8	4,1	229,1173	4,8	4,1	30,6800	0,50	358,4362	3,6	3,13	0	0	0	107,4625	63,1824
	Bawah	5,4	4,1	106,4900	1,00	1,00	175,5300	4,8	4,1	175,5300	4,8	4,1	31,5900	1,00	140,6589	3,6	3,13	0	0	0	132,0508	47,3912
	2 Atas	3,8	3,1	89,9300	0,57	0,57	229,1173	4,8	4,1	229,1173	4,8	4,1	29,9500	0,56	358,4362	3,6	3,13	0	0	0	121,3087	73,0306
	Bawah	3,8	3,1	89,2400	0,51	0,51	229,1173	4,8	4,1	229,1173	4,8	4,1	30,2700	0,50	358,4362	3,6	3,13	0	0	0	120,2189	61,0312
	3 Atas	3,8	3,1	76,0500	0,63	0,63	229,1173	4,8	4,1	229,1173	4,8	4,1	23,0200	0,61	358,4362	3,6	3,13	0	0	0	123,2591	77,5051
	Bawah	3,8	3,1	69,1200	0,43	0,43	229,1173	4,8	4,1	229,1173	4,8	4,1	23,2100	0,44	358,4362	3,6	3,13	0	0	0	102,4230	71,5388
	4 Atas	3,8	3,1	54,6700	0,79	0,79	229,1173	4,8	4,1	229,1173	4,8	4,1	14,6000	0,39	358,4362	3,6	3,13	0	0	0	134,1056	70,2035
	Bawah	3,8	3,1	44,2500	0,37	0,37	229,1173	4,8	4,1	229,1173	4,8	4,1	14,7900	0,39	358,4362	3,6	3,13	0	0	0	104,0294	64,0934
	5 Atas	3,8	3,1	23,4900	1,00	1,00	137,1643	4,8	4,1	137,1643	4,8	4,1	24,6500	1,00	137,1922	3,6	3,13	0	0	0	124,0281	78,0842
	Bawah	3,8	3,1	14,3600	0,21	0,21	229,1173	4,8	4,1	229,1173	4,8	4,1	22,5500	0,61	358,4362	3,6	3,13	0	0	0	98,0559	74,5934

Keterangan Tabel 7.5:

- [1] Kolom yang ditinjau
- [2] Tingkat lantai pada kolom yang ditinjau
- [3] Letak momen pada kolom atas dan bawah
- [4] h = tinggi kolom dari titik pertemuan ke titik pertemuan
- [5] h_n = tinggi bersih kolom
- [6] M_{E,k} = momen kolom akibat gempa sejajar sb-x
- [7] α_k atas = (M_{E,k_{l_i+1} atas)/(M_{E,k_{l_i+1} atas + M_{E,k_{l_i} bawah)}}}
- α_k bawah = (M_{E,k_{l_i} bawah)/(M_{E,k_{l_i+1} atas + M_{E,k_{l_i} bawah)}}}
- [8] M_{nak,b-x} Kiri = momen nominal aktual balok positif/kiri sejajar sb-x
- [9] /k_i = bentang balok dari as ke as kiri kolom sejajar sb-x
- [10] /n_{k_i} = bentang bersih balok kiri kolom sejajar sb-x
- [11] M_{nak,b-x} Kanan = momen nominal aktual balok negatif/kanan sejajar sb-x
- [12] /k_a = bentang balok dari as ke as, kanan kolom sejajar sb-x
- [13] /n_{k_a} = bentang bersih balok kanan kolom sejajar sb-x
- [14] M_{E,k} = momen kolom akibat gempa sejajar sb-y
- [15] α_k atas = (M_{E,k_{l_i+1} atas)/(M_{E,k_{l_i+1} atas + M_{E,k_{l_i} bawah)}}}
- α_k bawah = (M_{E,k_{l_i} bawah)/(M_{E,k_{l_i+1} atas + M_{E,k_{l_i} bawah)}}}
- [16] M_{nak,b-x} Kiri = momen nominal aktual balok positif/kiri sejajar sb-y
- [17] /k_i = bentang balok dari as ke as kiri kolom sejajar sb-y
- [18] /n_{k_i} = bentang bersih balok kiri kolom sejajar sb-y
- [19] M_{nak,b-x} Kanan = momen nominal aktual balok negatif/kanan sejajar sb-y
- [20] /k_a = bentang balok dari as ke as, kanan kolom sejajar sb-y
- [21] /n_{k_a} = bentang bersih balok kanan kolom sejajar sb-y
- [22] M_{u,k-x} = h_n/h · 0,7 · 1,25 · ω_d · α [/k_i · /n_{k_i} · M_{nak,b-x} + /k_a · /n_{k_a} · M_{nak,b-x}]
(Momen rencana kolom sejajar sb-x) dengan ω_d=1 untuk lantai 1 dan 5 dan ω_d=1,3 untuk lantai 2,3,dan4
- [23] M_{u,k-y} = h_n/h · 0,7 · 1,25 · ω_d · α [/k_i · /n_{k_i} · M_{nak,b-y} + /k_a · /n_{k_a} · M_{nak,b-y}]
(Momen rencana kolom sejajar sb-y) dengan ω_d=1 untuk lantai 1 dan 5 dan ω_d=1,3 untuk lantai 2,3,dan4

Tabel 7.6 Momen Maksimum Kolom Daktililitas Penuh (Satuan: kNm)

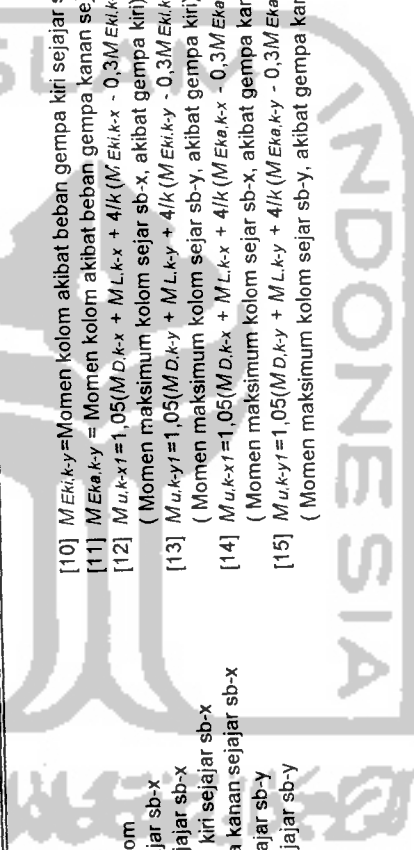
Ko- lom	Lan- tai	Letak Momen	Sejajar Sumbu x			Sejajar Sumbu y			Akibat Gempa kiri		Akibat Gempa kanan				
			MD,k-x	MEki,k-x	MEka,k-x	MD,k-y	MEki,k-y	MEka,k-y	Mu,k-x1	Mu,k-y1	Mu,k-x2	Mu,k-y2			
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	
K1	1	Atas	-139,8500	-40,1100	72,9200	-71,1800	-0,5200	0,4800	187,0200	-186,1700	300,0085	744,8662	-614,1150	-741,7532	
		Bawah	42,6500	8,5700	-139,9100	136,9500	0,4700	0,3900	-225,8100	224,8200	-695,6074	-955,2178	775,4076	950,0484	
	2	Atas	-172,0400	-50,6500	88,2100	-87,7300	-0,4800	0,0300	213,9600	-213,4000	345,3100	837,8549	-740,4983	-856,2520	
		Bawah	191,2100	56,9900	-70,1700	70,4000	1,0100	0,8300	-205,8900	205,4400	-249,4966	-808,5372	692,8727	810,4614	
	3	Atas	-154,2200	-45,3100	87,3400	-86,8000	-4,3400	-1,9100	191,0300	-190,6300	338,3164	769,9401	-692,1213	-779,0900	
		Bawah	167,3300	49,1200	-45,5800	44,9400	3,2300	1,7400	-157,6300	157,2400	-138,3607	-607,1196	522,0215	613,9133	
	4	Atas	-300,4400	-88,3000	67,6300	-66,6600	-1,1800	-1,3900	146,8800	-147,6300	295,4952	699,4113	-874,1628	-706,7361	
		Bawah	190,3200	55,9300	-16,9600	16,3100	1,1100	1,3000	-105,9600	105,6400	-242,7495	-463,8711	460,1709	466,7691	
	5	Atas	-300,4400	-88,3000	67,6300	-66,6600	-7,8700	-2,5700	73,0800	-70,2700	-510,1209	179,1462	-776,6892	-624,1402	
		Bawah	190,3200	55,9300	-16,9600	16,6600	5,7800	1,2200	-60,1100	55,9400	94,8531	-226,5094	399,0189	315,9475	
K2	1	Atas	111,7600	32,3400	182,5300	-181,9900	1,4100	0,4200	198,6600	-197,1400	934,5941	853,0250	-732,2320	-844,2991	
		Bawah	-44,6700	-10,4000	-212,4700	211,9600	-1,0900	-0,3400	-239,8800	237,9200	-1001,9570	-1021,3678	962,3595	1011,8657	
	2	Atas	147,8900	44,1500	195,1300	-194,7400	2,1900	0,6200	225,2400	-222,3600	1043,9923	955,8578	-761,9737	-941,0671	
		Bawah	-157,6500	-47,4200	-192,7600	192,3700	-3,3200	-0,9300	-210,2300	208,4400	-1031,8442	-904,2449	726,9752	890,6974	
	3	Atas	123,3800	36,7000	155,4800	-155,4800	1,6400	0,5900	188,2700	-193,3000	899,5722	840,6333	-619,2165	-854,6098	
		Bawah	-131,9100	-39,1600	-128,8300	128,8300	-0,1400	-0,1000	-150,4000	150,3000	-773,6815	-675,1191	468,8570	676,4757	
4	Atas	224,3600	66,7300	-92,3600	-92,3600	7,1500	1,8800	169,8200	-149,6800	111,9498	485,0815	-230,2347	-698,7707		
	Bawah	-166,5800	-49,5800	58,4900	58,4900	-4,6300	-1,1700	-100,5600	89,8000	-91,8133	-293,7957	112,0623	413,6337		
K3	1	Atas	-28,2900	-6,0400	91,0200	-88,5300	-57,4300	-29,8200	107,7700	-106,1100	482,0277	475,7067	-541,5711	-648,8223	
		Bawah	11,9200	1,8000	-124,3000	120,8600	22,5100	6,9100	-179,0600	176,4700	-733,2696	-877,7790	744,3702	924,3486	
	2	Atas	-38,0500	-8,7200	90,5600	-89,4300	-70,9800	-38,6300	108,3800	-123,0400	467,8023	454,2111	-579,7449	-744,5403	
		Bawah	38,5700	8,7700	-78,7500	78,1700	76,3500	42,4900	-123,6200	108,3300	-436,8042	-493,6470	514,5168	678,2622	
	3	Atas	-41,4000	-9,7900	81,8400	-80,7400	-71,5500	-38,9100	116,8800	-115,7800	437,2473	478,0314	-538,7403	-703,9914	
		Bawah	40,3500	9,4600	-60,0100	58,8000	71,1300	38,7000	-77,0100	76,3600	-296,7741	-283,7331	395,4741	510,1215	
4	Atas	-45,5400	-10,7600	65,8100	-63,4600	-77,7400	-44,3000	86,2700	-92,9900	328,5072	325,5126	-442,8144	-596,6596		
	Bawah	43,3500	10,2400	-35,0500	33,7400	73,5300	-39,9700	-42,3900	42,6400	-144,3519	-186,9630	251,7039	256,8384		
5	Atas	-40,3300	-9,7000	27,1600	-27,3200	-70,2400	-18,7000	39,2300	-35,6000	110,9703	105,6006	-212,1315	-277,3302		
	Bawah	41,3000	9,8800	-6,5300	7,7800	66,8400	32,4700	-23,2400	14,1000	-2,9694	-1,5603	104,1810	173,2983		
K4	1	Atas	-7,3600	-3,3800	151,9400	-149,8500	-11,9500	-2,0100	41,0600	-40,3600	678,6066	349,2384	-692,1306	-375,0810	
		Bawah	2,2800	1,0300	-162,7800	160,5300	2,8400	1,1700	-173,1700	172,7000	-898,3947	-929,2563	895,3035	930,7683	
	2	Atas	-10,2200	-4,6700	158,9800	-157,5600	-14,1000	-2,4000	82,7800	-82,6900	756,3843	530,6658	-781,5759	-563,1486	
		Bawah	10,1100	4,7700	-152,2200	150,9200	10,4400	1,8700	-84,5400	84,5200	-730,2204	-533,9397	755,9832	568,0687	
	3	Atas	-12,1500	-5,1300	139,7700	-138,3900	-15,4200	-2,5400	88,2200	-88,1200	680,0472	527,7762	-710,4132	-563,3334	
		Bawah	11,6900	5,0000	-121,8100	120,4500	12,4200	2,1400	-41,7200	41,6400	-546,6447	-313,4166	575,8809	341,9430	
4	Atas	-12,6900	-5,6400	106,8500	-105,0800	-15,7700	-2,6300	77,3300	-76,9300	606,0032	506,1116	-641,1414	-546,0508		
	Bawah	12,4100	5,3300	-83,5900	82,2200	13,8000	2,3800	-10,4600	10,3900	-397,4752	-152,1064	433,5988	188,8578		
5	Atas	-16,2900	-4,1600	59,6400	-59,6900	-26,3600	-2,7900	35,0500	35,0500	382,4499	268,4485	-318,9459	60,9335		
	Bawah	12,7300	4,7300	-40,9600	41,4000	15,4100	2,4500	-14,4000	13,9800	-206,2116	-112,0039	251,7934	129,6330		

Tabel 7.6 Lanjutan

Ko- lom	Lan- tai	Momen	Sejajar Sumbu x			Sejajar Sumbu y			Akibat Gempa kiri			Akibat Gempa kanan		
			MD,k-x	ML,k-x	MEki,k-x	MD,k-y	ML,k-y	MEka,k-y	Mu,k-x1	Mu,k-y1	Mu,k-x2	Mu,k-y2		
K8	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]
	5	Atas	-28,8000	-3,4200	19,1100	-19,4400	-21,9200	-2,5200	24,3500	-24,1400	77,1120	85,5836	-145,8954	-128,8127
		Bawah	22,4100	3,9300	-10,7600	11,2400	17,8100	2,4600	-14,3000	14,0100	-35,5530	-54,9508	97,1435	99,0023
K9	1	Atas	-9,5600	-2,4300	85,7100	-85,7100	5,5900	1,1100	23,7500	-24,9700	377,3175	139,6087	-404,0337	-133,7918
		Bawah	4,7800	0,7700	-106,4900	106,4900	-3,3800	-0,5600	-25,1300	26,4000	-473,0943	-158,5093	486,3495	156,5983
	2	Atas	-11,0700	-3,1400	89,9300	-89,9300	7,8000	1,6100	24,2100	-25,0800	393,2901	146,1683	-424,2273	-135,6987
		Bawah	12,1800	3,4200	-89,2400	89,2400	-7,5800	-1,5800	-23,8300	24,6300	-388,4538	-144,3952	422,2218	134,0758
	3	Atas	-10,2100	-2,9500	76,0500	-76,0500	8,8300	1,8300	20,3800	-21,1200	331,2708	125,1978	-359,8392	-112,6671
	Bawah	10,0100	2,8600	-69,1200	69,1200	-8,5900	1,7900	-19,5100	20,2000	-301,3731	-114,5126	329,2695	107,1143	
4	Atas	-7,5500	-2,6400	54,6700	-54,6700	9,2600	1,9200	14,1500	-14,6800	236,7435	105,0399	-258,8103	-89,1009	
	Bawah	8,9100	2,7800	-44,2500	44,2500	-8,9200	-1,8200	-12,8300	14,3000	-189,7413	-95,5252	216,1425	82,5850	
5	Atas	-20,3000	-4,6000	23,4900	-23,4900	7,4800	0,9200	4,5100	-17,5000	97,7445	86,0391	-176,3748	-94,6974	
	Bawah	12,9700	3,5200	-14,3600	14,3600	-7,7100	-1,1100	-3,4900	16,8500	-66,3529	-63,0189	138,4005	87,5629	

Keterangan Tabel 7.6:

- [1] Kolom yang ditinjau
- [2] Tingkat lantai tiap kolom yang ditinjau
- [3] Letak momen pada bagian atas dan bawah kolom
- [4] MD,k-x = Momen kolom akibat beban mati sejajar sb-x
- [5] ML,k-x = Momen kolom akibat beban hidup sejajar sb-x
- [6] MEki,k-x = Momen kolom akibat beban gempa kiri sejajar sb-x
- [7] MEka,k-x = Momen kolom akibat beban gempa kanan sejajar sb-x
- [8] MD,k-y = Momen kolom akibat beban mati sejajar sb-y
- [9] ML,k-y = Momen kolom akibat beban hidup sejajar sb-y
- [10] MEki,k-y = Momen kolom akibat beban gempa kiri sejajar sb-y
- [11] MEka,k-y = Momen kolom akibat beban gempa kanan sejajar sb-y
- [12] Mu,k-x1 = $1,05(MD,k-x + ML,k-x + 4/k(MEki,k-x - 0,3MEka,k-y))$
(Momen maksimum kolom sejajar sb-x, akibat gempa kiri) dengan k = 1
- [13] Mu,k-y1 = $1,05(MD,k-y + ML,k-y + 4/k(MEki,k-y - 0,3MEka,k-x))$
(Momen maksimum kolom sejajar sb-y, akibat gempa kiri) dengan k = 1
- [14] Mu,k-x2 = $1,05(MD,k-x + ML,k-x + 4/k(MEka,k-x - 0,3MEki,k-y))$
(Momen maksimum kolom sejajar sb-x, akibat gempa kanan) dengan k = 1
- [15] Mu,k-y2 = $1,05(MD,k-y + ML,k-y + 4/k(MEka,k-y - 0,3MEki,k-x))$
(Momen maksimum kolom sejajar sb-y, akibat gempa kanan) dengan k = 1



Tabel 7.7 Momen Terpakai Kolom Daktilitas Penuh (Satuan kNm)

Ko- lom	Lan- tai	Letak Momen	Rencana		Maksimum		Terpakai	
			$M_{u,k-x}$ (kNm)	$M_{u,k-y}$ (kNm)	$M_{u,k-x}$ (kNm)	$M_{u,k-y}$ (kNm)	$M_{u,k-x}$ (kNm)	$M_{u,k-y}$ (kNm)
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
K1	1	Atas	440,2161	402,9811	614,1150	744,8662	440,2161	402,9811
		Bawah	279,5463	314,3606	775,4076	955,2178	279,5463	314,3606
	2	Atas	527,4319	425,7166	740,4983	857,8549	527,4319	425,7166
		Bawah	401,6068	420,5932	692,8727	808,5372	401,6068	420,5932
	3	Atas	582,0603	431,1416	692,1213	779,0900	582,0603	431,1416
		Bawah	236,1914	284,3381	522,0215	613,9133	236,1914	284,3381
	4	Atas	596,9231	489,6239	874,1628	706,7361	596,9231	489,6239
		Bawah	119,7832	246,1781	460,1709	466,7691	119,7832	246,1781
	5	Atas	634,1018	389,5501	776,6892	624,1402	634,1018	389,5501
		Bawah	143,4856	192,0656	399,0189	315,9475	143,4856	192,0656
K2	1	Atas	530,6030	394,0670	934,5941	853,0250	530,6030	394,0670
		Bawah	457,7967	351,9595	1001,9570	1021,3678	457,7967	351,9595
	2	Atas	694,5736	487,0952	1043,9923	955,8578	694,5736	487,0952
		Bawah	602,0597	448,0625	1031,8442	904,2449	602,0597	448,0625
	3	Atas	699,6499	481,4479	899,5722	854,6098	699,6499	481,4479
		Bawah	459,8639	325,2713	773,6815	676,4757	459,8639	325,2713
	4	Atas	714,0915	547,0954	230,2347	698,7707	230,2347	547,0954
		Bawah	264,4553	257,1727	112,0623	413,6337	264,4553	257,1727
K3	1	Atas	270,7508	280,5154	-541,5711	-648,8223	270,7508	280,5154
		Bawah	228,5875	221,8766	744,3702	924,3486	228,5875	221,8766
	2	Atas	310,0298	359,3998	-579,7449	-744,5403	310,0298	359,3998
		Bawah	239,1085	328,4423	514,5168	678,2622	239,1085	328,4423
	3	Atas	325,9595	363,4159	-538,7403	-703,9914	325,9595	363,4159
		Bawah	205,4427	255,3735	395,4741	510,1215	205,4427	255,3735
	4	Atas	329,4157	356,3726	-442,8144	-598,6596	329,4157	356,3726
		Bawah	147,3558	142,2879	251,7039	256,8384	147,3558	142,2879
	5	Atas	206,3563	200,2979	-212,1315	-277,3302	206,3563	200,2979
		Bawah	48,2010	121,0670	104,1810	173,2983	48,2010	121,0670
K4	1	Atas	345,6983	124,0823	-692,1306	375,0810	345,6983	124,0823
		Bawah	358,3781	239,2430	-898,3947	930,7683	358,3781	239,2430
	2	Atas	399,9445	257,6013	-781,5759	563,1486	399,9445	257,6013
		Bawah	353,5155	260,7742	755,9832	558,0687	353,5155	260,7742
	3	Atas	442,0256	346,3618	-710,4132	563,3334	442,0256	346,3618
		Bawah	306,4363	129,8276	575,8809	341,9430	306,4363	129,8276
	4	Atas	510,8872	326,6980	-641,1414	546,0508	510,8872	326,6980
		Bawah	264,3551	41,0672	433,5988	188,8578	264,3551	41,0672
	5	Atas	362,4073	213,7965	382,4499	268,4485	362,4073	213,7965
		Bawah	195,8441	60,8360	251,7934	129,6330	195,8441	60,8360
K5	1	Atas	397,7632	430,5694	939,2754	-975,7125	397,7632	430,5694
		Bawah	370,6949	346,9041	1022,2149	-1211,5950	370,6949	346,9041
	2	Atas	424,2382	481,4663	971,1618	-1049,3616	424,2382	481,4663
		Bawah	393,6819	407,3001	-929,1744	963,2343	393,6819	407,3001
	3	Atas	436,4932	503,1892	846,3819	-926,8182	436,4932	503,1892
		Bawah	320,0300	306,5145	-716,8413	721,2723	320,0300	306,5145
	4	Atas	520,6833	353,7112	-539,0175	-786,9330	520,6833	353,7112
		Bawah	250,0878	192,4514	-445,4772	444,0114	250,0878	192,4514
	5	Atas	319,3733	287,3348	529,5528	383,9031	319,3733	287,3348
		Bawah	183,3091	398,1945	-365,0598	-622,4190	183,3091	398,1945

Tabel 7.7. Lanjutan

Ko- lom	Lan- tai	Letak Momen	Rencana		Maksimum		Terpakai	
			$M_{u,k-x}$ (kNm)	$M_{u,k-y}$ (kNm)	$M_{u,k-x}$ (kNm)	$M_{u,k-y}$ (kNm)	$M_{u,k-x}$ (kNm)	$M_{u,k-y}$ (kNm)
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
K6	1	Atas	53,9462	37,3680	224,2023	131,8664	53,9462	37,3680
		Bawah	111,9496	73,9201	378,1092	165,1707	111,9496	73,9201
	2	Atas	94,2106	89,1704	290,6862	162,3218	94,2106	89,1704
		Bawah	84,0785	63,4843	286,2279	161,9573	84,0785	63,4843
	3	Atas	101,2991	87,1390	275,2932	146,3855	101,2991	87,1390
		Bawah	73,0542	77,3367	217,9695	135,5458	73,0542	77,3367
	4	Atas	135,9795	77,8390	226,4724	110,1912	135,9795	77,8390
		Bawah	69,8721	49,0719	146,0823	112,9120	69,8721	49,0719
	5	Atas	143,9650	78,4227	190,2320	99,6137	143,9650	78,4227
		Bawah	95,9494	47,7991	105,3234	86,4728	95,9494	47,7991
K7	1	Atas	101,5743	71,1766	395,9613	-174,6492	101,5743	71,1766
		Bawah	141,9911	59,7138	-518,5572	202,1412	141,9911	59,7138
	2	Atas	130,4349	78,5191	456,3993	-187,1516	130,4349	78,5191
		Bawah	128,1713	73,2457	-460,4271	188,3496	128,1713	73,2457
	3	Atas	132,5338	83,3292	395,0226	-155,7950	132,5338	83,3292
		Bawah	99,8960	65,2619	-355,6245	148,2304	99,8960	65,2619
	4	Atas	144,1921	75,4796	287,4291	-112,0434	144,1921	75,4796
		Bawah	71,3723	64,5702	-228,7089	128,0324	71,3723	64,5702
	5	Atas	133,3653	83,4121	161,3775	-125,6378	133,3653	83,4121
		Bawah	89,4947	80,5444	-96,2690	118,7865	89,4947	80,5444
K8	1	Atas	91,6445	92,6323	-241,0863	-150,5609	91,6445	92,6323
		Bawah	109,3404	93,3374	311,9046	213,4082	109,3404	93,3374
	2	Atas	110,2083	116,0553	-279,1677	-190,6236	110,2083	116,0553
		Bawah	103,4343	94,2069	273,6069	191,1382	103,4343	94,2069
	3	Atas	112,3995	95,4678	-255,4965	-177,7899	112,3995	95,4678
		Bawah	77,3499	92,3172	223,6143	154,1863	77,3499	92,3172
	4	Atas	114,1995	89,6000	-201,8604	-139,1495	114,1995	89,6000
		Bawah	90,5648	87,9421	159,6273	106,5314	90,5648	87,9421
	5	Atas	105,7626	78,7307	-145,8954	-128,8127	105,7626	78,7307
		Bawah	64,2286	72,0855	97,1435	99,0023	64,2286	72,0855
K9	1	Atas	107,4625	63,1824	-404,0337	139,6067	107,4625	63,1824
		Bawah	132,0508	47,3912	486,3495	-158,5093	132,0508	47,3912
	2	Atas	121,3087	73,0306	-424,2273	146,1683	121,3087	73,0306
		Bawah	120,2189	61,0312	422,2218	-144,3952	120,2189	61,0312
	3	Atas	123,2591	77,5051	-359,8392	125,1978	123,2591	77,5051
		Bawah	102,4230	71,5388	329,2695	-114,5126	102,4230	71,5388
	4	Atas	134,1056	70,2035	-258,8103	105,0399	134,1056	70,2035
		Bawah	104,0294	64,0934	216,1425	95,5252	104,0294	64,0934
	5	Atas	124,0281	78,0842	-176,3748	-94,6974	124,0281	78,0842
		Bawah	98,0559	74,5934	138,4005	87,5629	98,0559	74,5934

Keterangan Tabel 7.7:

- [1] Kolom yang ditinjau
- [2] Tingkat lantai pada kolom yang ditinjau
- [3] Letak momen pada kolom atas dan bawah
- [4] $M_{u,k-x}$ = Momen kolom Rencana sejajar sumbu -x
- [5] $M_{u,k-y}$ = Momen kolom Rencana sejajar sumbu -y
- [6] $M_{u,k-x}$ = Momen kolom Maksimum sejajar sumbu -x
- [7] $M_{u,k-y}$ = Momen kolom Maksimum sejajar sumbu -y
- [8] $M_{u,k-x}$ = Momen kolom Terpakai sejajar sumbu -x
- [9] $M_{u,k-y}$ = Momen kolom Terpakai sejajar sumbu -y

7.2.2 Gaya Aksial Rencana Kolom

Gaya aksial rencana $N_{u,k}$ yang bekerja pada kolom portal dengan daktalitas penuh dihitung dengan rumus sebagai berikut, untuk gaya gravitasi dijumlah dengan arah tegak lurus nya, namun untuk gaya gempa arah tegak lurus nya hanya diambil 30% saja. (Kusuma dan Andriono, 1993)

$$N_{u,k} = 1,05 \cdot (N_{g,k,x} + N_{g,k,y}) + R_v \cdot 0,7 \cdot 1,25 \cdot \left[\left(\frac{\sum M_{nak,bk_i,x}}{l_{nb,ki,x}} + \frac{\sum M_{nak,bka,x}}{l_{nb,ka,x}} \right) + 0,3 \left(\frac{\sum M_{nak,bki,y}}{l_{nb,ki,y}} + \frac{\sum M_{nak,bka,y}}{l_{nb,ka,y}} \right) \right]$$

tetapi tidak perlu lebih besar dari

$$N_{u,k,maks} = 1,05 (N_{g,k,x} + N_{g,k,y} + 4/k \cdot (N_{E,k,x} + N_{E,k,y}))$$

dengan:

$$\sum M_{nak} = M_{nakb,ki} + M_{nakb,ka}$$

$$N_{g,k} = N_{D,k} + N_{L,k} \text{ (sesuai arah x dan arah y)}$$

Sebagai contoh perhitungan ditinjau pada kolom K2 lantai 1 diketahui:

$$\text{Berat sendiri kolom} = 24,0 \cdot 7,0 \cdot 7,7 \cdot (5,4 + 3,3,8) = 197,5700 \text{ kN}$$

$$N_{D,k,x} = 1150,2200 \text{ kN}, N_{L,k,x} = 312,5500 \text{ kN}$$

$$N_{g,k,x} = 197,5700 + 1150,2200 + 312,5500 = 1462,7700 \text{ kN}$$

$$N_{D,k,y} = 1072,9700 \text{ kN}, N_{L,k,y} = 268,5900 \text{ kN}$$

$$N_{g,k,y} = 1072,9700 + 268,5900 = 1341,5600 \text{ kN}$$

$\sum M_{nak,b}$ sebelah kiri kolom sejajar sumbu x

$$M_{nak,b-} = 673,1497 \text{ kNm}$$

$$M_{nak,b+} = 358,9232 \text{ kNm}$$

$$\sum M_{nak,b,ki,x} = 673,1497 + 358,9232 = 1033,0729 \text{ kNm}$$

$$l_{nb,ki} = 8,9 \text{ m}$$

$\sum M_{nak,b}$ sebelah kanan kolom sejajar sumbu x

$$M_{nak,b-} = 782,4552 \text{ kNm}$$

$$M_{nak,b+} = 578,1163 \text{ kNm}$$

$$\sum M_{nak,b,ka,x} = 782,4552 + 578,1163 = 1360,5715 \text{ kNm}$$

$$l_{nb,ka} = 1,7 \text{ m}$$

$\Sigma M_{nak,b}$ sebelah kiri kolom sejajar sumbu y

$$M_{nak,b-} = 1100,2186 \text{ kNm}$$

$$M_{nak,b+} = 687,2594 \text{ kNm}$$

$$\Sigma M_{nak,b,ki,y} = 1100,2186 + 687,2594 = 1787,4780 \text{ kNm}$$

$$l_{nb,ki} = 6,5 \text{ m}$$

$\Sigma M_{nak,b}$ sebelah kanan kolom sejajar sumbu y

$$M_{nak,b-} = 673,1497 \text{ kNm}$$

$$M_{nak,b+} = 358,9232 \text{ kNm}$$

$$\Sigma M_{nak,b,ka,y} = 673,1497 + 358,9232 = 1033,0729 \text{ kNm}$$

$$l_{nb,ka} = 6,5 \text{ m}$$

$$R_v = 1$$

$$N_{Eka,k,x} = 671,1900 \text{ kN}$$

$$N_{Eka,k,y} = 5,8100 \text{ kN}$$

$$N_{u,k,x} = 1,05 \cdot (1462,7700 + 1341,5600) + 1,0 \cdot 7,1,25 \cdot \left[\left(\frac{1033,0729}{8,9} + \frac{1360,5715}{1,7} \right) + 0,3 \left(\frac{1787,4780}{6,5} + \frac{1033,0729}{6,5} \right) \right]$$

$$= 3860,1750 \text{ kN}$$

$$N_{u,k,x,max} = 1,05 \cdot (1462,7700 + 1341,5600 + 4/1 \cdot (671,19 + 0,3 \cdot 5,81))$$

$$= 5963,6724 \text{ kN}$$

$$\text{dipakai } N_{u,k-x} = 3860,1750 \text{ kN}$$

Dengan cara yang sama didapat untuk gaya aksial rencana kolom-kolom disajikan pada lampiran Tabel 7.8, untuk gaya aksial maksimum kolom-kolom disajikan pada lampiran Tabel 7.9, dan untuk gaya aksial terpakai kolom-kolom disajikan dalam Tabel 7.10.

Tabel 7.8 Gaya Aksial Rencana Kolom Daktilitas Penuh (Satuan kN)

Ko-lom	Lan-tai	Arah Portal	Berat Kolom (kN)	Gaya Aksial			M _{nak,b} kiri			M _{nak,b} kanan			N _{u,k} (kN)	
				N _{D,k} (kN)	N _{L,k} (kN)	1,05N _{G,k} (kN)	M _{nak,b} - (kNm)	M _{nak,b} + (kNm)	I _{n,b} m	M _{nak,b} - (kNm)	M _{nak,b} + (kNm)	I _{n,b} m		
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	
K1	1	Sb-x	242,2600	1020,3000	287,9400	1628,0250	0	0	0	1100,219	687,2594	8,90	3274,0649	
		Sb-y	242,2600	1028,4300	534,7300	1895,6910	673,1497	358,9232	6,50	673,1497	358,9232	6,50	3345,5563	
	2	Sb-x	178,7500	764,9700	215,8900	1217,5905	0	0	0	1100,219	687,2594	8,90	2565,4514	
		Sb-y	178,7500	806,8000	408,8700	1464,1410	673,1497	358,9232	6,50	673,1497	358,9232	6,50	2636,9428	
	3	Sb-x	143,0600	508,4400	143,4700	834,7185	0	0	0	1100,219	687,2594	8,90	1849,8578	
		Sb-y	143,0600	587,1600	284,1600	1065,0990	566,4322	358,8097	6,50	566,4322	358,8097	6,50	1901,2156	
	4	Sb-x	89,3800	251,3000	70,8900	432,1485	0	0	0	1100,219	687,2594	8,90	1143,6173	
		Sb-y	89,3800	368,5400	159,8900	648,7005	566,4322	358,8097	6,50	566,4322	358,8097	6,50	1194,9751	
	5	Sb-x	44,6900	251,3000	70,8900	385,2240	0	0	0	0	0	8,90	565,9273	
		Sb-y	44,6900	149,7800	35,2500	241,2060	232,9100	179,9488	6,50	232,9100	179,9488	6,50	643,7353	
	K2	1	Sb-x	197,5700	1150,2200	312,5500	1743,3570	673,1497	358,9232	8,90	782,4552	578,1163	1,70	3860,1750
			Sb-y	197,5700	1072,9700	268,5900	1616,0865	1100,219	687,2594	6,50	673,1497	358,9232	6,50	3564,6300
2		Sb-x	134,0600	862,9200	234,4700	1293,0225	673,1497	358,9232	8,90	782,4552	578,1163	1,70	3119,4851	
		Sb-y	134,0600	804,3300	201,3000	1196,6745	1100,219	687,2594	6,50	566,4322	358,8097	6,50	2813,8734	
3		Sb-x	89,3800	576,8200	156,7700	864,1185	566,4322	358,8097	8,90	673,1497	358,9232	1,70	2206,8444	
		Sb-y	89,3800	536,8900	134,3900	798,6930	1100,219	687,2594	6,50	566,4322	358,8097	6,50	2026,9410	
4		Sb-x	44,6900	291,3300	79,2400	436,0230	566,4322	358,8097	8,90	566,4322	435,1457	1,70	1377,3457	
		Sb-y	44,6900	269,9200	67,6400	401,3625	201,1347	137,1922	6,50	201,1347	137,1922	6,50	1016,5694	
K3		1	Sb-x	242,2600	352,9900	69,2400	697,7145	0	0	0	458,2185	358,6561	4,10	1460,7144
			Sb-y	242,2600	501,6400	261,5600	1055,7330	673,1497	358,9232	6,50	0	0	0	1435,9343
		2	Sb-x	178,7500	281,4300	55,7900	541,7685	0	0	0	458,2185	358,6561	4,10	1194,3294
			Sb-y	178,7500	393,9100	200,6000	811,9230	673,1497	358,9232	6,50	0	0	0	1169,5493
	3	Sb-x	143,0600	205,1300	40,9300	408,5760	0	0	0	458,2185	358,6561	4,10	913,8965	
		Sb-y	143,0600	284,2200	138,4800	594,0480	566,4322	358,8097	6,50	0	0	0	879,0497	
	4	Sb-x	89,3800	126,1200	25,2700	252,8085	0	0	0	458,2185	358,6561	4,10	632,8115	
		Sb-y	89,3800	173,7400	75,9200	356,0025	566,4322	358,8097	6,50	0	0	0	597,9647	
	5	Sb-x	44,6900	46,0200	9,3400	105,0525	0	0	0	232,9072	179,9488	4,10	243,5505	
		Sb-y	44,6900	63,0500	13,7500	127,5645	232,9072	179,9488	6,50	0	0	0	220,7776	
	K4	1	Sb-x	242,2600	912,4900	234,6000	1458,8175	458,2185	358,6561	4,10	458,2185	358,6561	4,10	1811,6971
			Sb-y	242,2600	178,6500	28,1200	471,4815	0	0	0	229,1173	229,1173	2,90	1664,4132
2		Sb-x	178,7500	701,0800	179,4600	1112,2545	458,2185	358,6561	4,10	458,2185	358,6561	4,10	1491,3316	
		Sb-y	178,7500	145,9500	22,2600	364,3080	0	0	0	229,1173	229,1173	2,90	1344,0477	
3		Sb-x	143,0600	497,2900	126,5700	805,2660	458,2185	358,6561	4,10	458,2185	358,6561	4,10	1178,3476	
		Sb-y	143,0600	110,8000	16,0100	283,3635	0	0	0	229,1173	229,1173	2,90	1031,0637	
4		Sb-x	89,3800	297,7600	74,9100	485,1525	458,2185	358,6561	4,10	458,2185	358,6561	4,10	869,2066	
		Sb-y	89,3800	74,0400	9,5400	181,6080	0	0	0	229,1173	229,1173	2,90	721,9227	
5		Sb-x	44,6900	100,2300	23,8100	177,1665	458,2185	358,6561	4,10	458,2185	358,6561	4,10	561,3571	
		Sb-y	44,6900	36,0600	2,9600	87,8955	0	0	0	229,1173	229,1173	2,90	414,0732	
K5		1	Sb-x	242,2600	583,9300	138,7100	1013,1450	458,2185	358,6561	4,10	348,9935	358,4362	1,70	2428,7337
			Sb-y	242,2600	775,7400	179,7600	1257,6480	673,1497	358,9232	6,50	673,1497	358,9232	3,13	2351,0340
	2	Sb-x	178,7500	466,3500	111,0300	793,9365	458,2185	358,6561	4,10	348,9935	358,4362	1,70	2034,9522	
		Sb-y	178,7500	589,8500	135,8800	949,7040	673,1497	358,9232	6,50	673,1497	358,9232	3,13	1957,2525	
	3	Sb-x	143,0600	345,8800	82,5200	600,0330	458,2185	358,6561	4,10	348,9935	358,4362	1,70	1625,0619	
		Sb-y	143,0600	404,7600	92,2200	672,0420	566,4322	358,8097	6,50	566,4322	358,8097	3,13	1516,3900	
	4	Sb-x	89,3800	223,8700	53,5700	385,1610	458,2185	358,6561	4,10	348,9935	358,4362	1,70	1226,8074	
		Sb-y	89,3800	219,9800	48,6700	375,9315	566,4322	358,8097	6,50	566,4322	358,8097	3,13	1118,1355	
	5	Sb-x	44,6900	100,9500	24,3300	178,4685	232,9072	179,9500	4,10	179,5403	179,5403	1,70	495,0399	
		Sb-y	44,6900	33,9300	4,6700	87,4545	201,1347	137,1922	4,10	201,1347	137,1922	3,13	420,7373	
	K6	1	Sb-x	86,5200	523,0300	262,1300	915,2640	0	0	0	229,1173	229,1173	4,10	1299,8291
			Sb-y	86,5200	251,0700	37,7100	394,0650	229,1173	229,1173	3,13	229,1173	229,1173	3,35	1404,9690
2		Sb-x	63,8400	393,9100	200,6000	691,2675	0	0	0	229,1173	229,1173	4,10	1015,2581	
		Sb-y	63,8400	180,6800	27,7300	285,8625	229,1173	229,1173	3,13	229,1173	229,1173	3,35	1120,3980	
3		Sb-x	47,8800	284,2200	138,4800	494,1090	0	0	0	229,1173	229,1173	4,10	775,0181	
		Sb-y	47,8800	132,8300	18,5900	209,2650	229,1173	229,1173	3,13	229,1173	229,1173	3,35	880,1580	
4		Sb-x	31,9200	174,7400	75,9300	296,7195	0	0	0	229,1173	229,1173	4,10	538,5476	
		Sb-y	31,9200	88,3200	9,9200	136,6680	229,1173	229,1173	3,13	229,1173	229,1173	3,35	643,6875	
5		Sb-x	15,9600	63,0500	13,7500	97,3980	0	0	0	137,1643	137,1643	4,10	234,4654	
		Sb-y	15,9600	46,8500	1,4700	67,4940	137,1643	137,1900	3,13	137,1643	137,1900	3,35	297,4186	

Tabel 7.8. Lanjutan

Kolom	Lantai	Arah Portal	Berat Kolom (kN)	Gaya Aksial			Mnak,b kiri			Mnak,b kanan			Nu,k (kN)
				ND,k (kN)	NL,k (kN)	1,05Ng,k (kN)	Mnak,b - (kNm)	Mnak,b + (kNm)	ln,b m	Mnak,b - (kNm)	Mnak,b + (kNm)	ln,b m	
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]
K7	1	Sb-x	86,5200	350,9500	92,3100	556,2690	229,1173	229,1173	4,10	229,1173	229,1173	1,70	1402,6841
		Sb-y	86,5200	385,7900	78,2300	578,0670	358,4362	358,4362	3,13	358,4362	358,4362	3,35	1440,7061
	2	Sb-x	63,8400	272,8000	70,3900	427,3815	229,1173	229,1173	4,10	229,1173	229,1173	1,70	1184,1791
		Sb-y	63,8400	296,7100	59,2800	440,8215	358,4362	358,4362	3,13	358,4362	358,4362	3,35	1222,2011
	3	Sb-x	47,8800	196,4500	49,2200	308,2275	229,1173	229,1173	4,10	229,1173	229,1173	1,70	972,4256
		Sb-y	47,8800	211,0700	40,7700	314,7060	358,4362	358,4362	3,13	358,4362	358,4362	3,35	1010,4476
	4	Sb-x	31,9200	120,8200	28,3400	190,1340	229,1173	229,1173	4,10	229,1173	229,1173	1,70	764,8826
		Sb-y	31,9200	128,0700	22,6200	191,7405	358,4362	358,4362	3,13	358,4362	358,4362	3,35	802,9046
	5	Sb-x	15,9600	45,3700	7,4100	72,1770	137,1643	137,1643	4,10	137,1643	137,1643	1,70	368,4419
		Sb-y	15,9600	49,9900	5,5800	75,1065	201,1347	137,1922	3,13	201,1347	137,1922	3,35	356,7913
K8	1	Sb-x	86,5200	226,9100	41,3900	372,5610	0	0	0	229,1173	229,1173	4,10	632,6766
		Sb-y	86,5200	177,6600	27,9300	306,7155	229,1173	229,1173	3,23	0	0	0	651,2499
	2	Sb-x	63,8400	182,3900	32,2100	292,3620	0	0	0	229,1173	229,1173	4,10	536,3706
		Sb-y	63,8400	145,4000	22,1700	242,9805	229,1173	229,1173	3,23	0	0	0	554,9439
	3	Sb-x	47,8800	136,6600	22,8300	217,7385	0	0	0	229,1173	229,1173	4,10	435,2136
		Sb-y	47,8800	110,3900	15,9500	182,9310	229,1173	229,1173	3,23	0	0	0	453,7869
	4	Sb-x	31,9200	90,3200	13,3700	142,3905	0	0	0	229,1173	229,1173	4,10	331,2846
		Sb-y	31,9200	73,6600	9,5000	120,8340	229,1173	229,1173	3,23	0	0	0	349,8579
	5	Sb-x	15,9600	43,2600	3,9300	66,3075	0	0	0	137,1643	137,1643	4,10	185,2567
		Sb-y	15,9600	35,1000	2,9200	56,6790	229,1173	229,1173	3,23	0	0	0	231,1690
K9	1	Sb-x	86,5200	333,0500	55,3100	498,6240	229,1173	229,1173	4,10	229,1173	229,1173	1,70	1080,7654
		Sb-y	86,5200	226,3800	43,3000	374,0100	358,44	358,44	3,35	0	0	0	978,2818
	2	Sb-x	63,8400	250,7800	43,4700	375,9945	229,1173	229,1173	4,10	229,1173	229,1173	1,70	889,9699
		Sb-y	63,8400	215,4300	-33,3500	258,2160	358,44	358,44	3,35	0	0	0	787,4863
	3	Sb-x	47,8800	190,1400	32,0100	283,5315	229,1173	229,1173	4,10	229,1173	229,1173	1,70	778,9429
		Sb-y	47,8800	124,8200	23,6200	206,1360	358,44	358,44	3,35	0	0	0	676,4593
	4	Sb-x	31,9200	130,4300	20,7600	192,2655	229,1173	229,1173	4,10	229,1173	229,1173	1,70	644,1754
		Sb-y	31,9200	77,3500	13,7000	129,1185	358,44	358,44	3,35	0	0	0	541,6918
	5	Sb-x	15,9600	72,8900	10,1900	103,9920	137,1643	137,1643	4,10	137,1643	137,1643	1,70	348,4015
		Sb-y	15,9600	29,3800	3,8700	51,6705	201,1347	137,1922	3,35	0	0	0	270,4388

Keterangan Tabel 7.8:

[1] Kolom yang ditinjau

[2] Tingkat lantai pada kolom yang ditinjau

[3] Arah portal yang ditinjau sejajar sb-x dan sejajar sb-y

[4] Berat sendiri kolom

[5] $N_{D,k}$ = gaya aksial kolom disebabkan beban mati[6] $N_{L,k}$ = gaya aksial kolom disebabkan beban hidup[7] $1,05N_{g,k}$ = 1,05 (Berat kolom + $N_{D,k}$ + $N_{L,k}$)[8] $M_{nak,b-}$ kiri = momen nominal aktual balok negatif sebelah kiri kolom[9] $M_{nak,b+}$ kiri = momen nominal aktual balok positif sebelah kiri kolom[10] l_{nb} = bentang bersih kolom sebelah kiri balok[11] $M_{nak,b-}$ kanan = momen nominal aktual balok negatif sebelah kanan kolom[12] $M_{nak,b+}$ kanan = momen nominal aktual balok positif sebelah kanan kolom[13] l_{nb} = bentang bersih kolom sebelah kanan balok[14] $N_{u,k,x} = 1,05(N_{g,k,x} + N_{g,k,y}) + 0,7.R_v \cdot 1,25 \cdot [(\sum M_{nak,b-x} ki / l_{nb-x} ki) + (\sum M_{nak,b-x} ka / l_{nb-x} ka) + 0,3 \cdot (\sum M_{nak,b-y} ki / l_{nb-y} ki) + 0,3 \cdot (\sum M_{nak,b-y} ka / l_{nb-y} ka)]$

(Gaya aksial rencana kolom untuk tinjauan sumbu x)

dengan: $R_v=1$ untuk $1 < n \leq 4$ dan $R_v=1,1-0,0025n$ untuk $4 < n \leq 20$ n = lantai ke-

$$\sum M_{nak,b} = M_{nak,b-} + M_{nak,b+}$$

Tabel 7.9 Gaya Aksial Maksimum Kolom Daktilitas Penuh (Satuan kN)

Ko- lom	Lantai	Berat Kolom	Sejajar Sumbu x					Sejajar Sumbu y					Akibat Gempa Kiri			Akibat Gempa Kanan		
			N _{D,k-x}	N _{L,k-x}	N _{Eki,k-x}	N _{Eka,k-x}	N _{D,k-y}	N _{L,k-y}	N _{Eki,k-y}	N _{Eka,k-y}	N _{u,k-x1}	N _{u,k-y1}	N _{u,k-x2}	N _{u,k-y2}				
K1	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]				
	1	-242,2600	-1020,3000	-287,9400	150,2200	-148,9600	-1028,4300	-534,7300	-11,8300	9,1200	-2653,3248	-3129,7518	-3883,4838	-3418,7286				
	2	-178,7500	-764,9700	-215,8900	103,0600	-102,2000	-806,8000	-408,8700	-6,9500	4,6300	-2069,9490	-2393,3784	-2917,4502	-2603,3700				
	3	-143,0600	-508,4400	-143,4700	58,3800	-57,8200	-587,1600	-284,1600	-3,6800	1,6400	-1509,0453	-1691,5017	-1990,3821	-1815,5697				
	4	-89,3800	-251,3000	-70,8900	23,2200	-22,9700	-368,5400	-159,8900	-1,6800	-0,1600	-891,5928	-964,7988	-1083,6756	-1016,6142				
5	-44,6900	-251,3000	-70,8900	23,2200	-22,9700	-149,7800	-35,2500	-0,4100	-0,4200	-482,4981	-551,9703	-676,5087	-610,2117					
K2	1	-197,5700	-1150,2200	-312,5500	669,9300	-671,1900	-1072,9700	-268,5900	-16,6200	5,8100	-359,2302	-2377,6872	-5963,6724	-3973,2924				
	2	-134,0600	-862,9200	-234,4700	374,5000	-375,3600	-804,3300	-201,3000	-13,3300	3,2300	-792,8298	-1933,0500	-3921,3762	-2808,3216				
	3	-89,3800	-576,8200	-156,7700	140,4500	-141,0100	-536,8900	-134,3900	-11,0400	1,5100	-992,9829	-1438,3635	-2159,3019	-1740,2931				
	4	-44,6900	-291,3300	-79,2400	13,8900	-14,1400	-269,9200	-67,6400	-10,0700	0,6900	-744,8112	-815,2536	-848,9796	-805,3794				
K3	1	-242,2600	-352,9900	-69,2400	212,4900	-209,3600	-501,6400	-261,5600	195,3800	-192,6800	-360,4377	-410,7411	-2621,1633	-2572,1241				
	2	-178,7500	-281,4300	-55,7900	145,1900	-143,1700	-393,9100	-200,6000	137,3700	-135,0600	-383,1198	-406,1106	-1937,4936	-1913,6502				
	3	-143,0600	-205,1300	-40,9300	85,3200	-84,1300	-284,2200	-138,4800	83,3100	-81,2700	-389,0964	-395,0058	-1308,1572	-1299,7488				
	4	-89,3800	-126,1200	-25,2700	39,0300	-38,7100	-173,7400	-75,9300	40,4000	-38,5600	-300,1320	-296,1042	-726,1296	-725,6886				
	5	-44,6900	-46,0200	-9,3400	10,4500	-10,5100	-63,0500	-13,7500	10,5100	-9,6800	-128,5599	-128,3835	-242,0313	-239,5911				
K4	1	-242,2600	-912,4900	-234,6000	9,0200	-10,8300	-178,6500	-28,1200	166,2100	-166,0700	-1428,6174	-966,4788	-1930,6602	-2387,0658				
	2	-178,7500	-701,0800	-179,4600	14,0700	-15,1800	-145,9500	-22,2600	119,2400	-119,1900	-1079,5386	-770,3388	-1502,8104	-1808,5998				
	3	-143,0600	-497,2900	-126,5700	14,3100	-14,9300	-110,8000	-16,0100	72,5500	-72,5600	-786,9015	-615,6759	-1092,5481	-1261,9803				
	4	-89,3800	-297,7600	-74,9100	11,4500	-11,5500	-74,0400	-9,5400	35,6100	-35,6800	-479,9529	-408,9225	-666,3783	-737,3205				
	5	-44,6900	-100,2300	-23,8100	5,2300	-5,1500	-36,0600	-2,9600	12,1300	-12,1900	-180,8877	-160,6017	-255,1269	-275,8245				
K5	1	-242,2600	-583,9300	-138,7100	188,6900	-190,0000	-775,7400	-179,7600	7,6600	-33,2800	-1214,2704	-1746,4986	-2856,3528	-2395,5960				
	2	-178,7500	-466,3500	-111,0300	101,4000	-102,3200	-589,8500	-135,8800	-3,0700	-23,1900	-1133,9412	-1441,0830	-2014,9164	-1782,2742				
	3	-143,0600	-345,8800	-82,5200	35,9100	-36,4800	-404,7600	-92,2200	-15,1700	-12,5100	-990,1542	-1140,3294	-1290,8406	-1220,3688				
	4	-89,3800	-223,8700	-53,5700	-1,5600	1,3400	-219,9800	-48,6700	-27,2500	-2,8500	-708,1305	-783,6591	-665,2065	-677,5251				
	5	-44,6900	-100,9500	-24,3300	-8,4300	8,4100	-33,9300	-4,6700	-29,9600	4,3500	-292,1541	-355,4523	-178,1955	-190,1319				
K6	1	-86,5200	-289,5800	-80,0500	147,8900	-147,5100	-251,0700	-37,7100	-46,1700	45,7600	-219,2127	-789,7491	-1344,0609	-775,8471				
	2	-63,8400	-217,1500	-62,0900	87,9500	-87,7300	-180,6800	-27,7300	-26,4900	26,3900	-243,0519	-579,5055	-914,2791	-578,7663				
	3	-47,8800	-158,4200	-44,1700	54,6300	-54,4700	-132,8300	-18,5900	-15,2200	15,2400	-211,7157	-417,0747	-631,5561	-426,6087				
	4	-31,9200	-99,2800	-26,1400	27,8400	-27,7300	-88,3200	-9,9200	-7,1100	7,2800	-160,3896	-263,1426	-375,6522	-272,7228				
	5	-15,9600	-39,7600	-8,0500	10,5100	-10,4600	-46,8500	-1,4700	-3,4200	3,5700	-77,8617	-118,8159	-157,1283	-115,8801				

Tabel 7.9. Lanjutan

Ko- lom	Lantai	Berat Kolom	Sejajar Sumbu x			Sejajar Sumbu y			Akibat Gempa Kiri		Akibat Gempa Kanan			
			$N_{D,k-x}$	$N_{L,k-x}$	$N_{Eki,k-x}$	$N_{D,k-y}$	$N_{L,k-y}$	$N_{Eki,k-y}$	$N_{u,k-x1}$	$N_{u,k-x2}$	$N_{u,k-y1}$	$N_{u,k-y2}$		
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]
K7	1	-86,52	-350,9500	-92,3100	110,0700	-110,3900	-385,7900	-78,2300	-67,3700	84,4700	-666,0822	-1187,7558	-1400,6958	-827,8074
	2	-63,84	-272,8000	-70,3900	63,5600	-63,7900	-296,7100	-59,2800	-42,6000	60,7800	-587,8950	-900,0054	-992,5062	-626,2704
	3	-47,88	-196,4500	-49,2200	23,5200	-23,6900	-211,0700	-40,7700	-21,4800	41,3800	-500,9403	-633,2403	-620,0187	-428,7129
	4	-31,92	-120,8200	-28,3400	-2,1000	2,0000	-128,0700	-22,6200	-6,3100	30,1900	-365,1291	-377,5065	-301,9191	-219,0405
	5	-15,96	-45,3700	-7,4100	-10,1400	10,0900	-49,9900	-5,5800	-1,1800	20,8000	-174,6003	-148,2579	-61,9395	-30,4521
K8	1	-86,52	-226,9100	-41,3900	119,9000	-119,5900	-177,6600	-27,9300	-127,3400	127,5100	-245,2989	-972,1845	-930,0459	-203,5719
	2	-63,84	-182,3900	-32,2100	85,6100	-85,4700	-145,4000	-22,1700	-92,7500	92,8000	-225,6135	-749,9919	-710,3565	-186,2427
	3	-47,88	-136,6600	-22,8300	52,8200	-52,8000	-110,3900	-15,9500	-57,3300	57,3200	-200,7873	-524,6283	-499,9323	-176,1795
	4	-31,92	-90,3200	-13,3700	26,2800	-26,3900	-73,6600	-9,5000	-28,5000	28,4000	-155,2425	-316,2957	-304,7625	-143,6799
	5	-15,96	-43,2600	-3,9300	8,6700	-8,7700	-35,1000	-2,9200	-8,7100	8,6200	-80,7891	-131,8863	-132,2013	-81,0747
K9	1	-86,52	-333,0500	-55,3100	134,5000	-134,9000	-226,3800	-43,3000	-77,0300	91,2600	-313,9458	-935,8440	-1233,3804	-568,4700
	2	-63,84	-250,7800	-43,4700	53,5600	-53,6900	-215,4300	-33,3500	-41,9700	54,5800	-465,1437	-746,0019	-793,9407	-475,6269
	3	-47,88	-190,1400	-32,0100	18,1300	-18,1500	-124,8200	-23,6200	-23,9600	35,6100	-393,4371	-517,1817	-470,7549	-312,7005
	4	-31,92	-130,4300	-20,7600	-3,1300	3,2400	-77,3500	-13,7000	-10,1300	20,0900	-313,7778	-334,3578	-248,9466	-199,4076
	5	-15,96	-72,8900	-10,1900	-7,8300	7,9300	-29,3800	-3,8700	-2,2600	5,9500	-174,6381	-158,2623	-98,1015	-103,9227

Keterangan Tabel 7.9:

- [1] Kolom yang ditinjau
- [2] Tingkat lantai pada kolom yang ditinjau
- [3] Berat sendiri kolom
- [4] $N_{D,k-x}$ = Gaya aksial kolom akibat beban mati sejajar sb-x
- [5] $N_{L,k-x}$ = Gaya aksial kolom akibat beban hidup sejajar sb-x
- [6] $N_{Eki,k-x}$ = Gaya aksial kolom akibat beban gempa kiri sejajar sb-x
- [7] $N_{Eka,k-x}$ = Gaya aksial kolom akibat beban gempa kanan sejajar sb-x
- [8] $N_{D,k-y}$ = Gaya aksial kolom akibat beban mati sejajar sb-y
- [9] $N_{L,k-y}$ = Gaya aksial kolom akibat beban hidup sejajar sb-y
- [10] $N_{Eki,k-y}$ = Gaya aksial kolom akibat beban gempa kiri sejajar sb-y
- [11] $N_{Eka,k-y}$ = Gaya aksial kolom akibat beban gempa kanan sejajar sb-y
- [12] $N_{u,k-x1} = 1,05(N_{D,k-x} + N_{L,k-x} + N_{D,k-y} + N_{L,k-y} + 4/k \cdot (N_{Eki,k-x} + 0,3 \cdot N_{Eka,k-x}))$ dengan $k = 1$
- [13] $N_{u,k-x2} = 1,05(N_{D,k-x} + N_{L,k-x} + N_{D,k-y} + N_{L,k-y} + 4/k \cdot (N_{Eki,k-y} + 0,3 \cdot N_{Eka,k-y}))$ dengan $k = 1$
- [14] $N_{u,k-x1} = 1,05(N_{D,k-x} + N_{L,k-x} + N_{D,k-y} + N_{L,k-y} + 4/k \cdot (N_{Eka,k-x} + 0,3 \cdot N_{Eki,k-x}))$ dengan, $k = 1$ (Gaya aksial maksimum atas akibat gempa kanan sejajar sb-x)
- [15] $N_{u,k-x2} = 1,05(N_{D,k-x} + N_{L,k-x} + N_{D,k-y} + N_{L,k-y} + 4/k \cdot (N_{Eka,k-y} + 0,3 \cdot N_{Eki,k-y}))$ dengan, $k = 1$ (Gaya aksial maksimum atas akibat gempa kanan sejajar sb-y)



Tabel 7.10 Gaya Aksial Terpakai Kolom Daktilitas Penuh

Kolom	Lantai	$N_{u,k}$ rencana (kN)	$N_{u,k}$ maksimum (kN)	$N_{u,k}$ terpakai (kN)
[1]	[2]	[3]	[4]	[5]
K1	1	3345,5563	3883,4838	3345,5563
	2	2636,9428	2917,4502	2636,9428
	3	1901,2156	1990,3821	1901,2156
	4	1194,9751	1083,6756	1083,6756
	5	643,7353	676,5087	643,7353
K2	1	3860,1750	5963,6724	3860,1750
	2	3119,4851	3921,3762	3119,4851
	3	22006,8444	2159,3019	2159,3019
	4	1377,3457	849,9796	849,9796
K3	1	1460,7144	2621,1633	1460,7144
	2	1194,3294	1937,4936	1194,3294
	3	913,8965	1308,1572	913,8965
	4	632,8115	726,1296	632,8115
	5	243,5505	242,0313	242,0313
K4	1	1811,6971	2387,0658	1811,6971
	2	1491,3316	1808,5998	1491,3316
	3	1178,3476	1261,9803	1178,3476
	4	869,2066	737,3205	737,3205
	5	561,3571	275,8245	275,8245
K5	1	2428,7337	2856,3528	2428,7337
	2	2034,9522	2014,9164	2014,9164
	3	1625,0619	1290,8406	1290,8406
	4	1226,8074	783,6591	783,6591
	5	495,0399	355,4523	355,4523
K6	1	1404,9690	1344,0609	1344,0609
	2	1120,3980	914,2791	914,2791
	3	880,1580	631,5561	631,5561
	4	643,6875	375,6522	375,6522
	5	297,4186	157,1283	157,1283
K7	1	1440,7061	1400,6958	1400,6958
	2	1222,2011	992,5062	992,5062
	3	1010,4476	633,2403	633,2403
	4	802,9046	377,5065	377,5065
	5	356,7913	174,6003	174,6003
K8	1	651,2499	972,1845	651,2499
	2	554,9544	749,9919	554,9544
	3	453,7869	524,6283	453,7869
	4	349,8579	316,2957	316,2957
	5	231,1690	132,2013	132,2013
K9	1	1080,7654	1233,3804	1080,7654
	2	889,9699	793,9407	793,9407
	3	778,9429	517,1817	517,1817
	4	644,1754	334,3578	334,3578
	5	348,4015	174,6381	174,6381

Keterangan Tabel 7.10:

[1] Kolom yang ditinjau

[2] Lantai kolom yang ditinjau

[3] $N_{u,k}$ rencana (dari Tabel 7.8)[4] $N_{u,k}$ maksimum (dari Tabel 7.9)[5] $N_{u,k}$ terpakai (dipilih yang terkecil)

7.2.3 Perhitungan Diagram Interaksi Kolom

Sebagai contoh perhitungan diagram interaksi kolom 700 mm x 700 mm ditinjau pada $\rho_g = 0,012$, dengan diketahui:

Tulangan yang dianalisis 12D25 (terdistribusi merata pada tiap sisi)

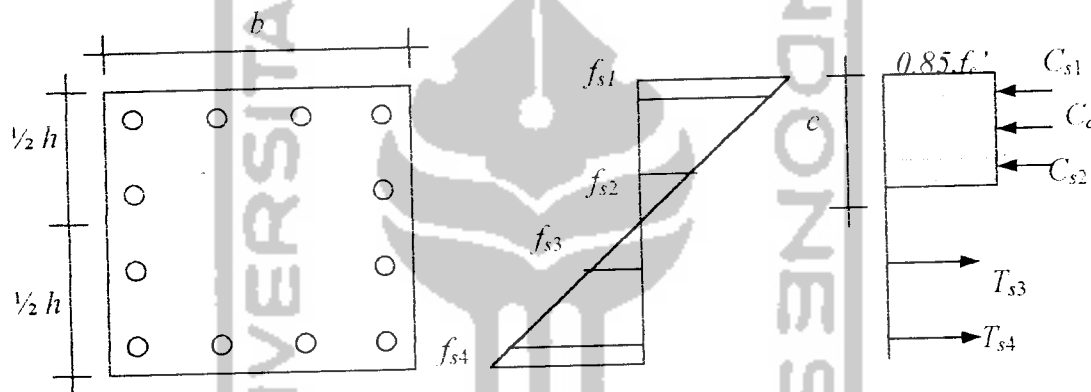
$$A_s = 5890,49 \text{ mm}^2$$

$$\rho = A_s/A_g = 0,012$$

$$f_c' = 25 \text{ MPa}, f_y = 400 \text{ MPa}$$

$$b = 700 \text{ mm}, h = 700 \text{ mm}, A_g = 700 \times 700 = 490000 \text{ mm}^2$$

$$d' = \text{selimut beton} + \text{diameter tul. sengkang} + \frac{1}{2} \text{ diameter tulangan pokok} \\ = 40 + 12 + \frac{1}{2} \cdot 25 = 64,5 \text{ mm}$$



Gambar 7.6 Penampang dengan tulangan terdistribusi merata pada keempat sisinya

Pada contoh perhitungan ini digunakan, kondisi $c = 350 \text{ mm}$ (seimbang)

Jarak masing-masing tulangan pada serat beton yang tertekan di ditentukan sebagai berikut:

lapis 1, $A_{s1} = 1962,5 \text{ mm}^2$

$$d_1 = d' = 64,5 \text{ mm}$$

$$f_{s1} = 600 \cdot (350 - 64,5) / 350 = 489,43 \text{ MPa} > f_y \text{ maka}$$

$$C_{s1} = 1962,5 \cdot (400 - 0,85 \cdot 25) = 78000 \text{ N}$$

lapis 2, $A_{s2} = 981,25 \text{ mm}^2$

$$d_2 = 64,5 + (700 - 2 \cdot 64,5) / 3 = 254,83 \text{ mm}$$

$$f_{s2} = 600 \cdot (350 - 254,83) / 350 = 163,14 \text{ MPa} < f_y \text{ maka}$$

$$C_{s2} = 981,25 \cdot (163,14 - 0,85 \cdot 25) = 160083,93 \text{ N}$$

lapis 3, $A_{s3} = 981,25 \text{ mm}^2$

$$d_3 = 64,5 + 2(700 - 2.64,5)/4 = 445,17 \text{ mm}$$

$$f_{s3} = 600.(350-445,17)/350 = -290,33 \text{ MPa} < -f_y \text{ maka}$$

$$C_{s3} = 981,25.(-290,33) = -160083,93 \text{ N}$$

lapis 4 $A_{s4} = 1962,5 \text{ mm}^2$

$$d_4 = 64,5 + 3(700 - 2.64,5)/4 = 635,5 \text{ mm}$$

$$f_{s4} = 600.(350-635,5)/350 = -489,43 \text{ MPa} > -f_y \text{ maka}$$

$$C_{s4} = 1962,5.(-400) = -785000 \text{ N}$$

Untuk gaya desak serat beton:

$$C_c = 0,85.f_c'.a.b = 0,85.25.(0,85.350).700 = 4425312,5 \text{ N}$$

Dengan demikian,

$$\begin{aligned} 0,65.P_n &= 0,65(C_c + C_{s1} + C_{s2} + C_{s3} + C_{s4}) \\ &= (4425312,5 + 785000 + 160083,93 - 160083,93 - 785000).10^{-3} \\ &= 2876,45 \text{ kN} \end{aligned}$$

Perhitungan momennya adalah sebagai berikut,

$$\begin{aligned} 0,65M_n &= 0,65[C_c.1/2.(h-a) + \sum C_{si}.(1/2h-d_i)] \\ &= 0,65.[4425312,5(350-148,75) + 785000(350-64,5) + 160083,93(350- \\ &\quad 254,83) - 160083,93(350-445,17) - 785000(350-635,50)].10^{-6} \\ &= 890,04 \text{ kNm} \end{aligned}$$

Dengan cara yang sama dihitung pula untuk kondisi c yang lain, sehingga dapat digambarkan diagram interaksi kolom. Dihitung pula untuk kolom ukuran 700×250 dan 250×700 . Seluruh perhitungan disajikan dalam Tabel 7.11 sampai dengan Tabel 7.13 dan beserta diagramnya dalam Gambar 7.7 – 7.9 untuk kepentingan penulangan kolom.

Tabel 7.11 Perhitungan Diagram Interaksi Kolom Ukuran 700 mm x 700 mm

Tulangan: 12D25			Kondisi	1	2	3	4	5	6	7	8	9	10	11	12
$\rho = 0,0012$			c	-	600	500	400	350	300	250	200	150	100	50	10
n	Asi	d	a	700	510	425	340	297,5	255	212,5	170	127,5	85	42,5	8,5
4	1962,5	64,50	fsi1	600	535,5	522,6	503,25	489,4286	471	445,2	406,5	342	213	-174	-3270
2	981,25	254,83	fsi2	600	345,1667	294,2	217,75	163,1429	90,3333	-11,6	-164,5	-419,333	-929	-2458	-14690
2	981,25	445,17	fsi3	600	154,8333	85,8	-67,75	-163,143	-290,33	-468,4	-735,5	-1180,67	-2071	-4742	-26110
4	1962,5	635,50	fsi4	600	-35,5	-162,6	-353,25	-489,429	-671	-925,2	-1306,5	-1942	-3213	-7026	-37530
4	1962,5	64,50	Cs1	785000	785000	785000	785000	785000	785000	785000	785000	671175	418012,5	-341475	-785000
2	981,25	254,83	Cs2	392500	338694,8	288683,8	213667,2	160083,9	88639,6	-11382,5	-161416	-392500	-392500	-392500	-392500
2	981,25	445,17	Cs3	392500	151930,2	64566,25	-66479,7	-160084	-284890	-392500	-392500	-392500	-392500	-392500	-392500
4	1962,5	635,50	Cs4	785000	-69668,8	-319103	-693253	-785000	-785000	-785000	-785000	-785000	-785000	-785000	-785000
Cc				10412500	7586250	6321875	5057500	4425313	3793125	3160938	2528750	1896563	1264375	632187,5	126437,5
0,65Pn				8298,87500	5714,934	4641,665	3442,682	2876,453	2337,97	1792,086	1283,642	648,5294	73,05188	-831,537	-1448,566
0,65Mn				0	638,609	783,7749	883,3837	890,044	863,039	815,7391	741,2244	623,1088	475,966	217,3977	28,415248
Tulangan: 16D25			Kondisi	1	2	3	4	5	6	7	8	9	10	11	12
$\rho = 0,0016$			c	-	600	500	400	350	300	250	200	150	100	50	10
n	Asi	d	a	700	510	425	340	297,5	255	212,5	170	127,5	85	42,5	8,5
5	2453,13	64,50	fsi1	600	535,5	522,6	503,25	489,4286	471	445,2	406,5	342	213	-174	-3270
2	981,25	207,25	fsi2	600	392,75	351,3	289,125	244,7143	185,5	102,6	-21,75	-229	-643,5	-1887	-11835
2	981,25	350,00	fsi3	600	250	180	75	0	-100	-240	-450	-800	-1500	-3600	-20400
2	981,25	492,75	fsi4	600	107,25	8,7	-139,125	-244,714	-385,5	-582,6	-878,25	-1371	-2356,5	-5313	-28965
5	2453,13	635,50	fsi5	600	-35,5	-162,6	-353,25	-489,429	-671	-925,2	-1306,5	-1942	-3213	-7026	-37530
5	2453,13	64,50	Cs1	981250	981250	981250	981250	981250	981250	981250	981250	838968,8	522515,6	-426844	-981250
2	981,25	207,25	Cs2	392500	385385,9	344713,1	283703,9	240125,9	182022	100676,3	-21342,2	-224706	-392500	-392500	-392500
2	981,25	350,00	Cs3	392500	245312,5	176625	73593,75	0	-98125	-235500	-392500	-392500	-392500	-392500	-392500
2	981,25	492,75	Cs4	392500	105239,1	8536,875	-136516	-240126	-378272	-392500	-392500	-392500	-392500	-392500	-392500
5	2453,13	635,50	Cs5	981250	-87085,9	-398878	-866566	-981250	-981250	-981250	-981250	-981250	-981250	-981250	-981250
Cc				10412500	7586250	6321875	5057500	4425313	3793125	3160938	2528750	1896563	1264375	632187,5	126437,5
0,65Pn				8809,1250	5990,629	4832,179	3505,427	2876,453	2274,19	1711,849	1119,565	483,9738	-241,709	-1269,71	-1958,816
0,65Mn				0	692,7015	852,3278	973,6272	987,6385	964,76	910,7626	834,2069	706,2354	531,7783	237,9745	28,415248
Tulangan: 20D25			Kondisi	1	2	3	4	5	6	7	8	9	10	11	12
$\rho = 0,0020$			c	-	600	500	400	350	300	250	200	150	100	50	10
n	Asi	d	a	700	510	425	340	297,5	255	212,5	170	127,5	85	42,5	8,5
6	2943,75	64,50	fsi1	600	535,5	522,6	503,25	489,4286	471	445,2	406,5	342	213	-174	-3270
2	981,25	178,70	fsi2	600	421,3	385,56	331,95	293,6571	242,6	171,12	63,9	-114,8	-472,2	-1544,4	-10122
2	981,25	292,90	fsi3	600	307,1	248,52	160,65	97,88571	14,2	-102,96	-278,7	-571,6	-1157,4	-2914,8	-16974
2	981,25	407,10	fsi4	600	192,9	111,48	-10,65	-97,8857	-214,2	-377,04	-621,3	-1028,4	-1842,6	-4285,2	-23826
2	981,25	521,30	fsi5	600	78,7	-25,56	-181,95	-293,657	-442,6	-651,12	-963,9	-1485,2	-2527,8	-5655,6	-30678
6	2943,75	635,50	fsi6	600	-35,5	-162,6	-353,25	-489,429	-671	-925,2	-1306,5	-1942	-3213	-7026	-37530
6	2943,75	64,50	Cs1	1177500	1177500	1177500	1177500	1177500	1177500	1177500	1177500	1006763	627018,8	-512213	-1177500
2	981,25	178,70	Cs2	392500	392500	378330,8	325725,9	288151,1	238051	167911,5	62701,88	-112648	-392500	-392500	-392500
2	981,25	292,90	Cs3	392500	301341,9	243860,3	157637,8	96050,36	13933,8	157637,8	-273474	-392500	-392500	-392500	-392500
2	981,25	407,10	Cs4	392500	189283,1	109389,8	-10450,3	-96050,4	-210184	-392500	-392500	-392500	-392500	-392500	-392500
2	981,25	521,30	Cs5	392500	77224,38	-25080,7	-178538	-288151	-392500	-392500	-392500	-392500	-392500	-392500	-392500
6	2943,75	635,50	Cs6	1177500	-104503	-478654	-1039880	-1177500	-1E+06	-1177500	-1177500	-1177500	-1177500	-1177500	-1177500
Cc				10412500	7586250	6321875	5057500	4425313	3793125	3160938	2528750	1896563	1264375	632187,5	126437,5
0,65Pn				9319,3750	6252,738	5022,694	3568,172	2876,453	2373,58	1755,966	996,4354	283,1904	-556,469	-1707,89	-2489,066
0,65Mn				0	745,6221	922,267	1065,604	1087,213	1064,14	1020,658	927,7084	789,3839	587,5905	258,5513	28,415248
Tulangan: 24D25			Kondisi	1	2	3	4	5	6	7	8	9	10	11	12
$\rho = 0,0024$			c	-	600	500	400	350	300	250	200	150	100	50	10
n	Asi	d	a	700	510	425	340	297,5	255	212,5	170	127,5	85	42,5	8,5
7	3434,38	64,50	fsi1	600	535,5	522,6	503,25	489,4286	471	445,2	406,5	342	213	-174	-3270
2	981,25	159,67	fsi2	600	440,3333	408,4	360,5	326,2857	280,667	216,8	121	-38,6667	-358	-1316	-8980
2	981,25	254,83	fsi3	600	345,1667	294,2	217,75	163,1429	90,3333	-11,6	-164,5	-419,333	-929	-2458	-14690
2	981,25	350,00	fsi4	600	250	180	75	0	-100	-240	-450	-800	-1500	-3600	-20400
2	981,25	445,17	fsi5	600	154,8333	85,8	-67,75	-163,143	-290,33	-468,4	-735,5	-1180,67	-2071	-4742	-26110
2	981,25	540,33	fsi6	600	59,66667	-48,4	-210,5	-326,286	-480,67	-696,8	-1021	-1561,33	-2642	-5884	-31820
7	3434,38	635,50	fsi7	600	-35,5	-162,6	-353,25	-489,429	-671	-925,2	-1306,5	-1942	-3213	-7026	-37530
7	3434,38	64,50	Cs1	1373750	1373750	1373750	1373750	1373750	1373750	1373750	1373750	1174556	731521,9	-597581	-1373750
2	981,25	159,67	Cs2	392500	392500	392500	353740,6	320167,9	275404	212735	118731,3	-37941,7	-351288	-392500	-392500
2	981,25	254,83	Cs3	392500	338694,8	288683,8	213667,2	160083,9	88639,6	213667,2	-161416	-392500	-392500	-392500	-392500
2	981,25	350,00	Cs4	392500	245312,5	176625	73593,75	0	-98125	-235500	-392500	-392500	-392500	-392500	-392500
2	981,25	445,17	Cs5	392500	151930,2	64566,25	-66479,7	-160084	-284890	-392500	-392500	-392500	-392500	-392500	-392500
2	981,25	540,33	Cs6	392500	58547,92	-47492,5	-206553	-320168	-392500	-392500	-392500	-392500	-392500	-392500	-392500
7	3434,38	635,50	Cs7	1373750	-121920	-558429	-1213193	-1373750	-1E+06	-1373750	-1373750	-1373750	-1373750	-1373750	-1373750
Cc				10412500	7586250	6321875	5057500	4425313	3793125	3160938	2528750	1896563	1264375	632187,5	126437,5
0,65Pn				9829,6250	6516,292	5207,851	3630,917	2876,453	2198,08	1668,446	850,5677	58,1276	-844,441	-2146,07	-2979,316
0,65Mn				0	798,8783	991,8797	1158,447	1187,779	1164,18	1123,052	1022,987	869,6459	648,5015	279,1281	28,415248

Tabel 7.11 Lanjutan

Tulangan: 28D25				Kondisi												
$\rho = 0,0028$				c	1	2	3	4	5	6	7	8	9	10	11	12
n	Asi	d	a	700	510	500	400	350	300	250	200	150	100	50	10	
8	3925	64,50	fsi1	600	535,5	522,6	503,25	489,4286	471	445,2	406,5	342	213	-174	-3270	
2	981,25	146,07	fsi2	600	453,9286	424,7143	380,8929	349,5918	307,857	249,4286	161,7857	15,71429	-276,429	-1152,86	-8164,286	
2	981,25	227,64	fsi3	600	372,3571	326,8286	258,5357	209,7551	144,714	53,65714	-82,9286	-310,571	-765,857	-2131,71	-13058,57	
2	981,25	309,21	fsi4	600	290,7857	228,9429	136,1786	69,91837	-18,429	-142,114	-327,643	-636,857	-1255,29	-3110,57	-17952,86	
2	981,25	390,79	fsi5	600	209,2143	131,0571	13,82143	-69,9184	-181,57	-337,886	-572,357	-963,143	-1744,71	-4089,43	-22847,14	
2	981,25	472,36	fsi6	600	127,6429	33,17143	-108,536	-209,755	-344,71	-533,657	-817,071	-1289,43	-2234,14	-5068,29	-27741,43	
2	981,25	553,93	fsi7	600	46,07143	-64,7143	-230,893	-349,592	-507,86	-729,429	-1061,79	-1615,71	-2723,57	-6047,14	-32635,71	
8	3925	635,50	fsi8	600	-35,5	-162,6	-353,25	-489,429	-671	-925,2	-1306,5	-1942	-3213	-7026	-37530	
8	3925	64,50	Cs1	1570000	1570000	1570000	1570000	1570000	1570000	1570000	1570000	1342350	836025	-682950	-1570000	
2	981,25	146,07	Cs2	392500	392500	392500	373751,1	343037	302085	244751,8	158752,2	15419,64	-271246	-392500	-392500	
2	981,25	227,64	Cs3	392500	365375,4	320700,5	253688,2	205822,2	142001	52651,07	-81373,7	-304748	-392500	-392500	-392500	
2	981,25	309,21	Cs4	392500	285333,5	224650,2	133625,2	68607,4	-18083	-139450	-321500	-392500	-392500	-392500	-392500	
2	981,25	390,79	Cs5	392500	205291,5	128599,8	13562,28	-68607,4	-178167	-178167	-392500	-392500	-392500	-392500	-392500	
2	981,25	472,36	Cs6	392500	125249,6	32549,46	-106501	-205822	-338251	-392500	-392500	-392500	-392500	-392500	-392500	
2	981,25	553,93	Cs7	392500	45207,59	-63500,9	-226564	-343037	-392500	-392500	-392500	-392500	-392500	-392500	-392500	
8	3925	635,50	Cs8	1570000	-139338	-638205	-1386506	-1570000	-2E+06	-1570000	-1570000	-1570000	-1570000	-1570000	-1570000	
Cc				10412500	7586250	6321875	5057500	4425313	3793125	3160938	2528750	1896563	1264375	632187,5	126437,5	
0,65Pn				10339,875	6783,316	5387,96	3693,662	2876,453	2151,64	1531,22	719,6339	-123,77	-1107,17	-2584,25	-3489,566	
0,65Mn				0	852,9158	1060,713	1251,785	1288,91	1265,8	1204,417	1117,98	954,3888	715,2878	299,7049	28,415248	
Tulangan: 32D25				Kondisi												
$\rho = 0,0032$				c	1	2	3	4	5	6	7	8	9	10	11	12
n	Asi	d	a	700	510	500	400	350	300	250	200	150	100	50	10	
9	4415,63	64,50	fsi1	600	535,5	522,6	503,25	489,4286	471	445,2	406,5	342	213	-174	-3270	
2	981,25	135,88	fsi2	600	464,125	436,95	396,1875	367,0714	328,25	273,9	192,375	56,5	-215,25	-1030,5	-7552,5	
2	981,25	207,25	fsi3	600	392,75	351,3	289,125	244,7143	185,5	102,6	-21,75	-229	-643,5	-1887	-11835	
2	981,25	278,63	fsi4	600	321,375	265,65	182,0625	122,3571	42,75	-68,7	-235,875	-514,5	-1071,75	-2743,5	-16117,5	
2	981,25	350,00	fsi5	600	250	180	75	0	-100	-240	-450	-800	-1500	-3600	-20400	
2	981,25	421,38	fsi6	600	178,625	94,35	-32,0625	-122,357	-242,75	-411,3	-664,125	-1085,5	-1928,25	-4456,5	-24682,5	
2	981,25	492,75	fsi7	600	107,25	8,7	-139,125	-244,714	-385,5	-582,6	-878,25	-1371	-2356,5	-5313	-28965	
2	981,25	564,13	fsi8	600	35,875	-76,95	-246,188	-367,071	-528,25	-753,9	-1092,38	-1656,5	-2784,75	-6169,5	-33247,5	
9	4415,63	635,50	fsi9	600	-35,5	-162,6	-353,25	-489,429	-671	-925,2	-1306,5	-1942	-3213	-7026	-37530	
9	4415,63	64,50	Cs1	1766250	1766250	1766250	1766250	1766250	1766250	1766250	1766250	1510144	940528,1	-768319	-1766250	
2	981,25	135,88	Cs2	392500	392500	392500	388759	360188,8	322095	268764,4	188768	55440,63	-211214	-392500	-392500	
2	981,25	207,25	Cs3	392500	385385,9	344713,1	283703,9	240125,9	182022	100676,3	-21342,2	-224706	-392500	-392500	-392500	
2	981,25	278,63	Cs4	392500	315349,2	260669,1	178648,8	120062,9	41948,4	-67411,9	-231452	-392500	-392500	-392500	-392500	
2	981,25	350,00	Cs5	392500	245312,5	176625	73593,75	0	-98125	-98125	-392500	-392500	-392500	-392500	-392500	
2	981,25	421,38	Cs6	392500	175275,8	92580,94	-31461,3	-120063	-238198	-392500	-392500	-392500	-392500	-392500	-392500	
2	981,25	492,75	Cs7	392500	105239,1	8536,875	-136516	-240126	-378272	-392500	-392500	-392500	-392500	-392500	-392500	
2	981,25	564,13	Cs8	392500	35202,34	-75507,2	-241571	-360189	-392500	-392500	-392500	-392500	-392500	-392500	-392500	
9	4415,63	635,50	Cs9	1766250	-156755	-717981	-1559820	-1766250	-2E+06	-1766250	-1766250	-1766250	-1766250	-1766250	-1766250	
Cc				10412500	7586250	6321875	5057500	4425313	3793125	3160938	2528750	1896563	1264375	632187,5	126437,5	
0,65Pn				10850,125	7052,507	5570,67	3756,406	2876,453	2100,86	1421,772	581,5702	-319,351	-1382,91	-3022,42	-3999,816	
0,65Mn				0	907,5343	1130,158	1345,432	1390,395	1368,57	1309,233	1213,933	1038,81	780,2589	320,2817	28,415248	

Keterangan Tabel 7.11:

$\rho = As / Ag$

$n =$ jumlah tulangan tiap lapis/sisi

$Asi = n \cdot As$ (luas tulangan tiap lapis, satuan mm²)

$di = ds + \{(i - 1)(h - 2ds)\} / (N - 1)$ dengan $i =$ nomor lapis tulangan, $N =$ banyaknya garis tulangan, $ds = 64,5$ mm (satuan mm)

Kondisi : $c =$ daerah desak, $a = 0,85 \cdot c$ (daerah desak beton)

$fsi = 600 \cdot [(c - di) / c]$ bila $fsi > fy$ maka $fsi = fy = 400$ MPa, bila $fsi < fy$ maka $fsi = fsi$, bila $fsi < -fy$ maka $fsi = -fy = -400$ MPa

$Csi = fsi \cdot Asi$ (gaya oleh baja tulangan, satuan N)

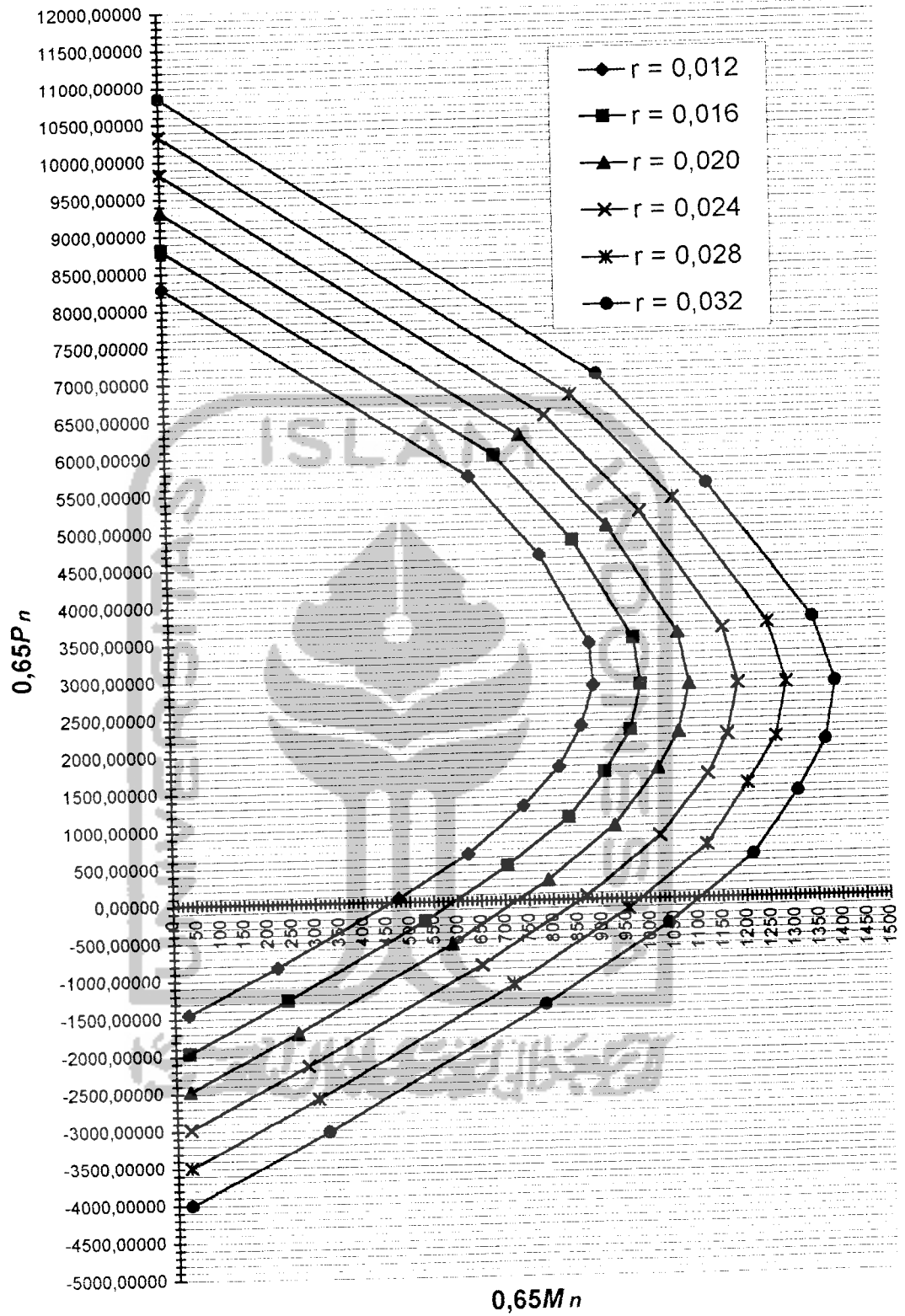
$Cc = 0,85 \cdot fc' \cdot b \cdot a$ (gaya oleh beton, satuan N)

$0,65Pn = 0,65 (0,85 \cdot fc' \cdot a \cdot b + \sum fsi \cdot Asi)$ (gaya desak beton, satuan kNm)

$0,65Mn = 0,65 [Cc (0,5h - 0,5a) + \sum fsi \cdot Asi \cdot (0,5h - di)]$ (momen beton, satuan kNm)

bila $di < a$, maka $fsi = fsi - 0,85fc'$

$di > a$, maka $fsi = fsi$



Gambar 7.7 Diagram Interaksi Kolom Ukuran 700 mm x 700 mm

Tabel 7.12 Perhitungan Diagram Interaksi Kolom Ukuran 250 mm x 700 mm

Tulangan:16D22				Kondisi	1	2	3	4	5	6	7	8	9	10	11	12
$\rho = 0,0035$				c	-	600	500	400	350	300	250	200	150	100	50	10
n	Asi	d	a		700	510	425	340	297,5	255	212,5	170	127,5	85	42,5	8,5
3	1139,8	63,00	fsi1	600	537	524,4	505,5	492	474	448,8	411	348	222	-156	-3180	
3	1139,8	103,00	fsi2	600	497	476,4	445,5	423,42857	394	352,8	291	188	-18	-636	-5580	
2	759,88	267,67	fsi3	600	332,3333	278,8	198,5	141,14286	64,66667	-42,4	-203	-470,6667	-1006	-2612	-15460	
2	759,88	432,33	fsi4	600	167,6667	81,2	-48,5	-141,1429	-264,667	-437,6	-697	-1129,333	-1994	-4588	-25340	
3	1139,8	597,00	fsi5	600	3	-116,4	-295,5	-423,4286	-594	-832,8	-1191	-1788	-2982	-6564	-35220	
3	1139,8	637,00	fsi6	600	-37	-164,4	-355,5	-492	-674	-928,8	-1311	-1948	-3222	-7044	-37620	
3	1139,8	63,00	Cs1	455928	455928	455928	455928	455928	455928	455928	455928	396657,36	253040,04	-177811,9	-455928	
3	1139,8	103,00	Cs2	455928	455928	455928	455928	455928	449089,1	402128,5	331687,6	214286,16	-20516,76	-455928	-455928	
2	759,88	267,67	Cs3	303952	252533,5	211854,54	150836,2	107251,63	49138,91	150836,18	-154255,6	-303952	-303952	-303952	-303952	
2	759,88	432,33	Cs4	303952	127406,5	61702,256	-36854,18	-107251,6	-201115	-303952	-303952	-303952	-303952	-303952	-303952	
3	1139,8	597,00	Cs5	455928	3419,46	-132675	-336816,8	-455928	-455928	-455928	-455928	-455928	-455928	-455928	-455928	
3	1139,8	637,00	Cs6	455928	-42173,34	-187386,4	-405206	-455928	-455928	-455928	-455928	-455928	-455928	-455928	-455928	
			Cc	3718750	2709375	2257812,5	1806250	1580468,8	1354688	1128906,3	903125	677343,75	451562,5	225781,3	45156,25	
			0,65Pn	3997,7379	2575,571	2030,0565	1358,542	1027,3047	777,3172	599,2941	208,44	-150,4573	-543,1882	-1253,017	-1551,2	
			0,65Mn	0	315,5425	393,28682	467,7105	486,91896	476,6639	461,97823	419,413	360,09514	271,24962	100,1292	10,1483	

Tulangan:18D22				Kondisi	1	2	3	4	5	6	7	8	9	10	11	12
$\rho = 0,0039$				c	-	600	500	400	350	300	250	200	150	100	50	10
n	Asi	d	a		700	510	425	340	297,5	255	212,5	170	127,5	85	42,5	8,5
3	1139,8	63,00	fsi1	600	537	524,4	505,5	492	474	448,8	411	348	222	-156	-3180	
3	1139,8	103,00	fsi2	600	497	476,4	445,5	423,42857	394	352,8	291	188	-18	-636	-5580	
2	759,88	226,50	fsi3	600	373,5	328,2	260,25	211,71429	147	56,4	-79,5	-306	-759	-2118	-12990	
2	759,88	350,00	fsi4	600	250	180	75	0	-100	-240	-450	-800	-1500	-3600	-20400	
2	759,88	473,50	fsi5	600	126,5	31,8	-110,25	-211,7143	-347	-536,4	-820,5	-1294	-2241	-5082	-27810	
3	1139,8	597,00	fsi6	600	3	-116,4	-295,5	-423,4286	-594	-832,8	-1191	-1788	-2982	-6564	-35220	
3	1139,8	637,00	fsi7	600	-37	-164,4	-355,5	-492	-674	-928,8	-1311	-1948	-3222	-7044	-37620	
3	1139,8	63,00	Cs1	455928	455928	455928	455928	455928	455928	455928	455928	396657,36	253040,04	-177811,9	-455928	
3	1139,8	103,00	Cs2	455928	455928	455928	455928	455928	449089,1	402128,5	331687,6	214286,16	-20516,76	-455928	-455928	
2	759,88	226,50	Cs3	303952	283815,2	249392,62	197758,8	160877,45	111702,4	197758,77	-60410,46	-232523,3	-303952	-303952	-303952	
2	759,88	350,00	Cs4	303952	189970	136778,4	56991	0	-75988	-182371,2	-303952	-303952	-303952	-303952	-303952	
2	759,88	473,50	Cs5	303952	96124,82	24164,184	-83776,77	-160877,5	-263678	-303952	-303952	-303952	-303952	-303952	-303952	
3	1139,8	597,00	Cs6	455928	3419,46	-132675	-336816,8	-455928	-455928	-455928	-455928	-455928	-455928	-455928	-455928	
3	1139,8	637,00	Cs7	455928	-42173,34	-187386,4	-405206	-455928	-455928	-455928	-455928	-455928	-455928	-455928	-455928	
			Cc	3718750	2709375	2257812,5	1806250	1580468,8	1354688	1128906,3	903125	677343,75	451562,5	225781,3	45156,25	
			0,65Pn	4195,307	2699,052	2118,9625	1395,587	1027,3047	727,925	511,25251	71,8706	-301,5974	-740,757	-1450,586	-1748,77	
			0,65Mn	0	328,1729	409,01035	488,0736	510,26409	501,9248	486,8795	438,7674	372,87205	276,66469	100,1292	10,1483	

Tulangan:20D22				Kondisi	1	2	3	4	5	6	7	8	9	10	11	12
$\rho = 0,0043$				c	-	600	500	400	350	300	250	200	150	100	50	10
n	Asi	d	a		700	510	425	340	297,5	255	212,5	170	127,5	85	42,5	8,5
3	1139,8	63,00	fsi1	600	537	524,4	505,5	492	474	448,8	411	348	222	-156	-3180	
3	1139,8	103,00	fsi2	600	497	476,4	445,5	423,42857	394	352,8	291	188	-18	-636	-5580	
2	759,88	201,80	fsi3	600	398,2	357,84	297,3	254,05714	196,4	115,68	-5,4	-207,2	-610,8	-1821,6	-11508	
2	759,88	300,60	fsi4	600	299,4	239,28	149,1	84,685714	-1,2	-121,44	-301,8	-602,4	-1203,6	-3007,2	-17436	
2	759,88	399,40	fsi5	600	200,6	120,72	0,9	-84,68571	-198,8	-358,56	-598,2	-997,6	-1796,4	-4192,8	-23364	
2	759,88	498,20	fsi6	600	101,8	2,16	-147,3	-254,0571	-396,4	-595,68	-894,6	-1392,8	-2389,2	-5378,4	-29292	
3	1139,8	597,00	fsi7	600	3	-116,4	-295,5	-423,4286	-594	-832,8	-1191	-1788	-2982	-6564	-35220	
3	1139,8	637,00	fsi8	600	-37	-164,4	-355,5	-492	-674	-928,8	-1311	-1948	-3222	-7044	-37620	
3	1139,8	63,00	Cs1	455928	455928	455928	455928	455928	455928	455928	455928	396657,36	253040,04	-177811,9	-455928	
3	1139,8	103,00	Cs2	455928	455928	455928	455928	455928	449089,1	402128,5	331687,6	214286,16	-20516,76	-455928	-455928	
2	759,88	201,80	Cs3	303952	302584,2	271915,46	225912,3	193052,94	149240,4	87902,918	-4103,352	-157447,1	-303952	-303952	-303952	
2	759,88	300,60	Cs4	303952	227508,1	181824,09	113298,1	64350,981	-911,856	-92279,83	-229331,8	-303952	-303952	-303952	-303952	
2	759,88	399,40	Cs5	303952	152431,9	91732,714	683,892	-64350,98	-151064	-151064,1	-303952	-303952	-303952	-303952	-303952	
2	759,88	498,20	Cs6	303952	77355,78	1641,3408	-111930,3	-193052,9	-301216	-303952	-303952	-303952	-303952	-303952	-303952	
3	1139,8	597,00	Cs7	455928	3419,46	-132675	-336816,8	-455928	-455928	-455928	-455928	-455928	-455928	-455928	-455928	
3	1139,8	637,00	Cs8	455928	-42173,34	-187386,4	-405206	-455928	-455928	-455928	-455928	-455928	-455928	-455928	-455928	
			Cc	3718750	2709375	2257812,5	1806250	1580468,8	1354688	1128906,3	903125	677343,75	451562,5	225781,3	45156,25	
			0,65Pn	4392,876	2822,532	2207,8684	1432,631	1027,3047	678,5328	400,2139	-40,59544	-450,3667	-938,3258	-1648,155	-1946,34	
			0,65Mn	0	340,5293	424,243	507,6207	532,65569	526,6375	496,19925	456,5813	386,09717	280,53259	100,1292	10,1483	

Keterangan Tabel 7.12.

$\rho = As/Ag$

n = jumlah tulangan tiap lapis/sisi

Asi = n . Asi (luas tulangan tiap lapis, satuan mm²)

di = ds + [(i - 1)(h - 2ds)] / (N - 1) dengan i = nomor lapis tulangan, N = banyaknya garis tulangan, ds = 64,5 mm (satuan mm)

Kondisi : c = daerah desak, a = 0,85 . c (daerah desak beton)

fsi = 600 [(c - di)/c] bila fsi > fy maka fsi = fy = 400 MPa, bila fsi < fy maka fsi = fsi, bila fsi < -fy maka fsi = -fy = -400 MPa

Csi = fsi . Asi (gaya oleh baja tulangan, satuan N)

Cc = 0,85 . fc' . b . a (gaya oleh beton, satuan N)

0,65Pn = 0,65 . (0,85 . fc' . a . b + ∑ fsi . Asi) (gaya desak beton, satuan kNm)

0,65Mn = 0,65 [Cc (0,5h - 0,5a) + ∑ fsi . Asi (0,5h - di)] (momen beton, satuan kNm)

bila : di < a, maka fsi = fsi - 0,85fc'

di > a, maka fsi = fsi

Tabel 7.12 Lanjutan

Tulangan:22D22			Kondisi												
$\rho = 0,0048$				1	2	3	4	5	6	7	8	9	10	11	12
n	Asi	d	c	700	510	425	340	297,5	255	212,5	170	127,5	85	42,5	10
3	1139,8	63,00	fsi1	600	537	524,4	505,5	492	474	448,8	411	348	222	-156	-3180
3	1139,8	103,00	fsi2	600	497	476,4	445,5	423,42857	394	352,8	291	188	-18	-636	-5580
2	759,88	185,33	fsi3	600	414,6667	377,6	322	282,28571	229,33333	155,2	44	-141,33333	-512	-1624	-10520
2	759,88	267,67	fsi4	600	332,33333	278,8	198,5	141,14286	64,66667	-42,4	-203	-470,6667	-1006	-2612	-15460
2	759,88	350,00	fsi5	600	250	180	75	0	-100	-240	-697	-1129,333	-1994	-4588	-25340
2	759,88	432,33	fsi6	600	167,6667	81,2	-48,5	-141,1429	-254,667	-437,6	-697	-1129,333	-1994	-4588	-25340
2	759,88	514,67	fsi7	600	85,33333	-17,6	-172	-282,2857	-429,333	-635,2	-944	-1458,667	-2488	-5576	-30280
3	1139,8	597,00	fsi8	600	3	-116,4	-295,5	-423,4286	-594	-832,8	-1191	-1788	-2982	-6564	-35220
3	1139,8	637,00	fsi9	600	-37	-164,4	-355,5	-492	-674	-928,8	-1311	-1948	-3222	-7044	-37620
3	1139,8	63,00	Cs1	455928	455928	455928	455928	455928	455928	455928	455928	396657,36	253040,04	-177811,9	-455928
3	1139,8	103,00	Cs2	455928	455928	455928	455928	455928	449089,1	402128,5	331687,6	214286,16	-20516,76	-455928	-455928
2	759,88	185,33	Cs3	303952	315096,9	286930,69	244681,4	214503,27	174265,8	117933,38	33434,72	-107396,4	-303952	-303952	-303952
2	759,88	267,67	Cs4	303952	252533,5	211854,54	150836,2	107251,63	49138,91	-32218,91	-154255,6	-303952	-303952	-303952	-303952
2	759,88	350,00	Cs5	303952	189970	136778,4	56991	0	-75988	-75988	-303952	-303952	-303952	-303952	-303952
2	759,88	432,33	Cs6	303952	127406,5	61702,256	-36854,18	-107251,6	-201115	-303952	-303952	-303952	-303952	-303952	-303952
2	759,88	514,67	Cs7	303952	64843,09	-13373,89	-130899,4	-214503,3	-326242	-303952	-303952	-303952	-303952	-303952	-303952
3	1139,8	597,00	Cs8	455928	3419,46	-132675	-336816,8	-455928	-455928	-455928	-455928	-455928	-455928	-455928	-455928
3	1139,8	637,00	Cs9	455928	-42173,34	-187386,4	-405206	-455928	-455928	-455928	-455928	-455928	-455928	-455928	-455928
			Cc	3718750	2709375	2257812,5	1806250	1580468,8	1354688	1128906,3	903125	677343,75	451562,5	225781,3	45156,25
			0,65Pn	4590,444	2946,013	2296,7744	1469,675	1027,3047	629,1406	310,00399	-164,965	-615,4025	-1135,895	-1845,724	-2143,91
			0,65Mn	0	352,7143	439,16886	526,6578	554,45134	551,0077	521,04496	474,3185	397,18314	283,43352	100,1292	10,1483

Keterangan Tabel 7.12:

$\rho = As / Ag$

n = jumlah tulangan tiap lapis/sisi

$As_i = n \cdot As$ (luas tulangan tiap lapis, satuan mm²)

$d_i = ds + [(i - 1)(h - 2ds)] / (N - 1)$ dengan i = nomor lapis tulangan, N = banyaknya garis tulangan, ds = 34,5 mm (satuan mm)

Kondisi : c = daerah desak, $a = 0,85 \cdot c$ (daerah desak beton)

$f_{si} = 600 \cdot [(c - d_i) / c]$ bila $f_{si} > f_y$ maka $f_{si} = f_y = 400$ MPa, bila $f_{si} < f_y$ maka $f_{si} = f_{si}$, bila $f_{si} < -f_y$ maka $f_{si} = -f_y = -400$ MPa

$C_{si} = f_{si} \cdot As_i$ (gaya oleh baja tulangan, satuan N)

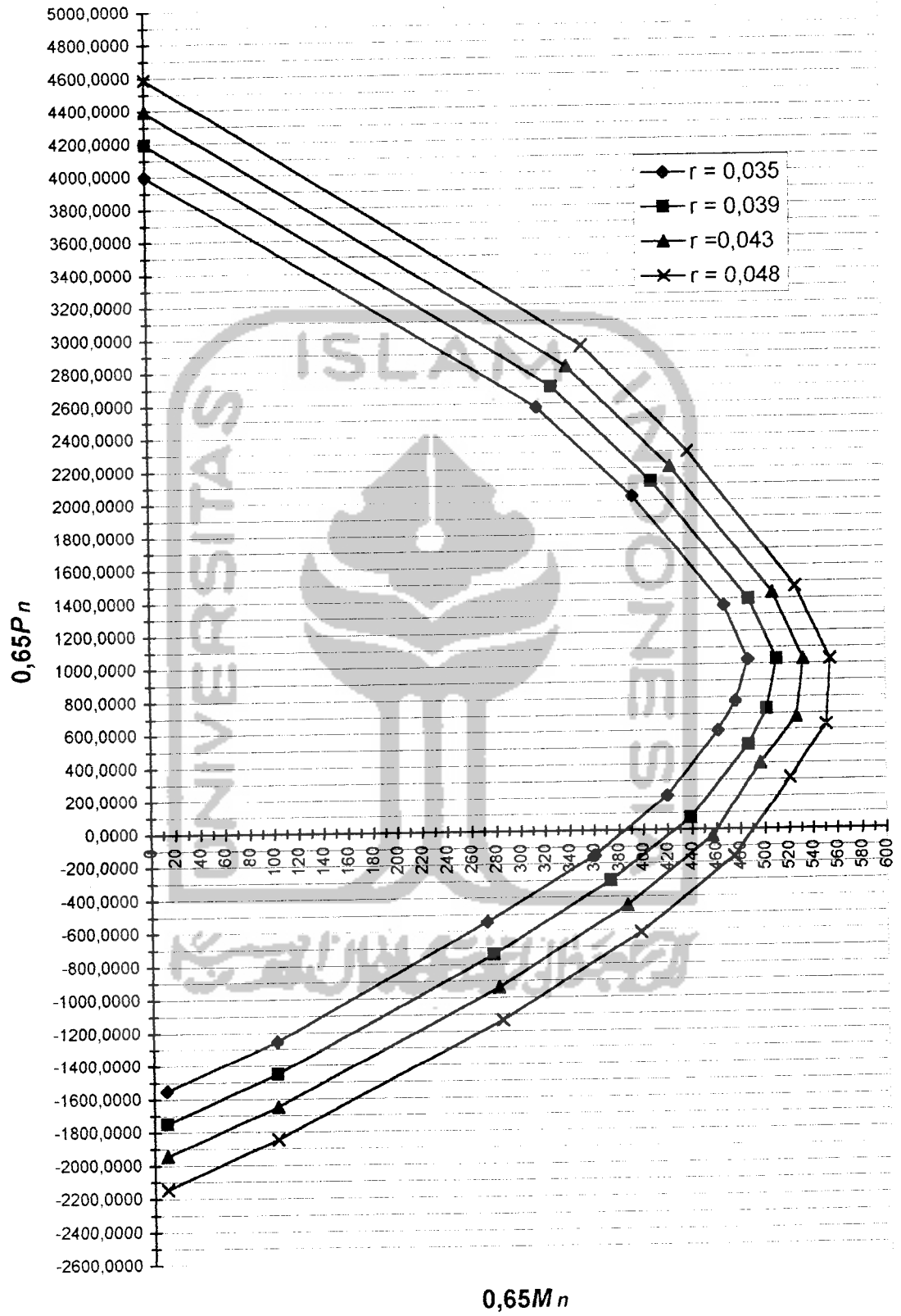
$C_c = 0,85 \cdot f_c' \cdot b \cdot a$ (gaya oleh beton, satuan N)

$0,65P_n = 0,65 (0,85 \cdot f_c' \cdot a \cdot b + \sum f_{si} \cdot As_i)$ (gaya desak beton, satuan kNm)

$0,65M_n = 0,65 [C_c \cdot (0,5h - 0,5a) + \sum f_{si} \cdot As_i \cdot (0,5h - d_i)]$ (momen beton, satuan kNm)

bila: $d_i < a$, maka $f_{si} = f_{si} - 0,85f_c'$

$d_i > a$, maka $f_{si} = f_{si}$



Gambar 7.8 Diagram Interaksi Kolom Ukuran 250 mm x 700 mm

Tabel 7.13 Perhitungan Diagram Interaksi Kolom Ukuran 700 mm x 250 mm

Tulangan: 16D22				Kondisi										
$\rho = 0,0035$				c	1	2	3	4	5	6	7	8	9	10
n	Asi	d	a	-	250	212,5	170	127,5	106,25	85	63,75	42,5	25	10
6	2279,64	63,00	fsi1	600	448,8	411	348	297,6	222	96	-156	-912	-3180	
4	1519,76	125,00	fsi2	600	300	225	100	0	-150	-400	-900	-2400	-6900	
6	2279,64	187,00	fsi3	600	151,2	39	-148	-297,6	-522	-896	-1644	-3888	-10620	
6	2279,64	63,00	Cs1	911856	911856	911856	793314,72	678420,86	506080,08	218845,44	-355623,8	-911856	-911856	
4	1519,76	125,00	Cs2	607904	455928	341946	151976	0	-227964	-607904	-607904	-607904	-607904	
6	2279,64	187,00	Cs3	911856	344681,57	88905,96	-337386,7	-678420,86	-911856	-911856	-911856	-911856	-911856	
				Cc	3718750	3160937,5	2528750	1896562,5	1580468,8	1264375	948281,25	632187,5	316093,75	126437,5
				0,65Pn	3997,7379	3167,7120	2516,4477	1627,9032	1027,3047	409,9126	-229,2117	-808,0776	-1375,0895	-1498,3660
				0,65Mn	0,0000	61,3811	98,9124	121,0742	128,5182	124,9449	102,9679	65,0493	23,4996	9,9238

Tulangan: 18D22				Kondisi										
$\rho = 0,0039$				c	1	2	3	4	5	6	7	8	9	10
n	Asi	d	a	-	250	212,5	170	127,5	106,25	85	63,75	42,5	25	10
7	2659,58	63,00	fsi1	600	448,8	411	348	297,6	222	96	-156	-912	-3180	
4	1519,76	125,00	fsi2	600	300	225	100	0	-150	-400	-900	-2400	-6900	
7	2659,58	187,00	fsi3	600	151,2	39	-148	-297,6	-522	-896	-1644	-3888	-10620	
7	2659,58	63,00	Cs1	1063832	1063832	1063832	925533,84	791491,01	590426,76	255319,68	-414894,5	-1063832	-1063832	
4	1519,76	125,00	Cs2	607904	455928	341946	151976	0	-227964	-607904	-607904	-607904	-607904	
7	2659,58	187,00	Cs3	1063832	402128,5	103723,62	-393617,8	-791491,01	-1063832	-1063832	-1063832	-1063832	-1063832	
				Cc	3718750	3160937,5	2528750	1896562,5	1580468,8	1264375	948281,25	632187,5	316093,75	126437,5
				0,65Pn	4195,3067	3303,8369	2624,8636	1677,2954	1027,3047	365,9537	-304,2878	-845,3879	-1572,6583	-1695,9348
				0,65Mn	0,0000	65,1906	104,4399	128,6667	137,6317	134,4687	110,5625	68,7853	23,4996	9,9238

Tulangan: 20D22				Kondisi										
$\rho = 0,0043$				c	1	2	3	4	5	6	7	8	9	10
n	Asi	d	a	-	250	212,5	170	127,5	106,25	85	63,75	42,5	25	10
8	3039,52	63,00	fsi1	600	448,8	411	348	297,6	222	96	-156	-912	-3180	
4	1519,76	125,00	fsi2	600	300	225	100	0	-150	-400	-900	-2400	-6900	
8	3039,52	187,00	fsi3	600	151,2	39	-148	-297,6	-522	-896	-1644	-3888	-10620	
8	3039,52	63,00	Cs1	1215808	1215808	1215808	1057753	904561,15	674773,44	291793,92	-474165,1	-1215808	-1215808	
4	1519,76	125,00	Cs2	607904	455928	341946	151976	0	-227964	-607904	-607904	-607904	-607904	
8	3039,52	187,00	Cs3	1215808	459575,42	118541,28	-449849	-904561,15	-1215808	-1215808	-1215808	-1215808	-1215808	
				Cc	3718750	3160937,5	2528750	1896562,5	1580468,8	1264375	948281,25	632187,5	316093,75	126437,5
				0,65Pn	4392,8755	3439,9618	2733,2794	1726,6876	1027,3047	321,9947	-379,3639	-1082,6983	-1770,2271	-1893,5036
				0,65Mn	0,0000	69,0001	109,9673	136,2633	146,7452	143,9925	118,1570	72,5214	23,4996	9,9238

Tulangan: 22D22				Kondisi										
$\rho = 0,0048$				c	1	2	3	4	5	6	7	8	9	10
n	Asi	d	a	-	250	212,5	170	127,5	106,25	85	63,75	42,5	25	10
9	3419,46	63,00	fsi1	600	448,8	411	348	297,6	222	96	-156	-912	-3180	
4	1519,76	125,00	fsi2	600	300	225	100	0	-150	-400	-900	-2400	-6900	
9	3419,46	187,00	fsi3	600	151,2	39	-148	-297,6	-522	-896	-1644	-3888	-10620	
9	3419,46	63,00	Cs1	1367784	1367784	1367784	1189972,1	1017631,3	759120,12	328268,16	-533435,8	-1367784	-1367784	
4	1519,76	125,00	Cs2	607904	455928	341946	151976	0	-227964	-607904	-607904	-607904	-607904	
9	3419,46	187,00	Cs3	1367784	517022,35	133358,94	-506080,1	-1017631,3	-1367784	-1367784	-1367784	-1367784	-1367784	
				Cc	3718750	3160937,5	2528750	1896562,5	1580468,8	1264375	948281,25	632187,5	316093,75	126437,5
				0,65Pn	4590,4443	3576,0867	2841,6953	1776,0798	1027,3047	278,0356	-454,4401	-1220,0086	-1967,7959	-2091,0724
				0,65Mn	0,0000	72,8096	115,4948	143,8578	155,8586	153,5183	125,7516	76,2574	23,4996	9,9238

Keterangan Tabel 7.13:

$\rho = As/Ag$

n = jumlah tulangan tiap lapis/sisi

Asi = n . Asi (luas tulangan tiap lapis, satuan mm²)

di = ds + [(i - 1)(h - 2ds)] / (N - 1) dengan i = nomor lapis tulangan, N = banyaknya garis tulangan, ds = 64,5 mm (satuan mm)

Kondisi : c = daerah desak, a = 0,85 c (daerah desak beton)

fsi = 600 [(c - di) / c] bila fsi > fy maka fsi = fy = 400 MPa, bila fsi < fy maka fsi = fsi, bila fsi < -fy maka fsi = -fy = -400 MPa

Csi = fsi Asi (gaya oleh baja tulangan, satuan N)

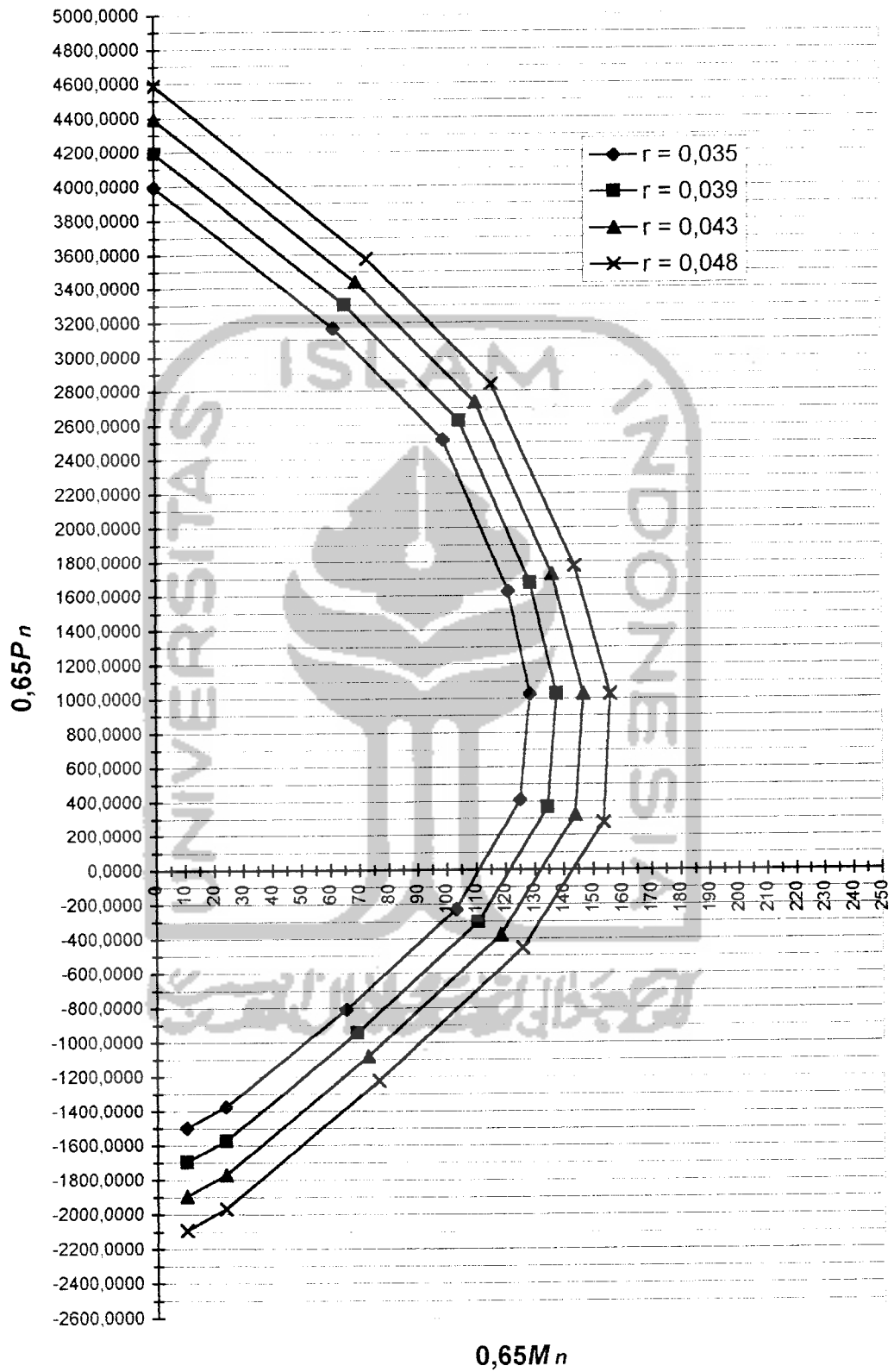
Cc = 0,85 . fc' . b . a (gaya oleh beton, satuan N)

0,65Pn = 0,65 . (0,85 . fc' . a . b + \sum fsi . Asi) (gaya desak beton, satuan kNm)

0,65Mn = 0,65 [Cc . (0,5h - 0,5a) + \sum fsi . Asi . (0,5h - di)] (momen beton, satuan kNm)

bila: di < a, maka fsi = fsi - 0,85fc'

di > a, maka fsi = fsi



Gambar 7.9 Diagram Interaksi Kolom Ukuran 700 mm x 250 mm

7.2.4 Perhitungan Kelangsingan Kolom dan Faktor Pembesaran Momen

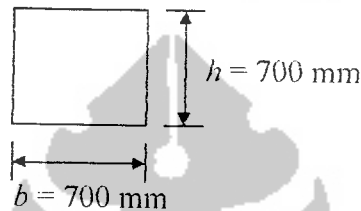
Sebagai contoh perhitungan kelangsingan kolom dan pembesaran momen ditinjau pada kolom K2 lantai 1 sejajar sumbu x.

- Cek kelangsingan kolom

$$\beta_d = \frac{1,05.M_{D,k}}{1,05.(M_{D,k} + M_{L,k} + 4/k.M_{E,k})}$$

$$= \frac{1,05.111,7600}{1,05.(111,7600 + 32,3400 - 4/1.182,5300)} = 0,11$$

- Ukuran kolom: $b = 700 \text{ mm}$, $h = 700 \text{ mm}$



Gambar 7.10 Penampang melintang kolom ukuran 700 mm x 700 mm

$$E_c = 4700 \cdot \sqrt{f'_c} = 4700 \cdot \sqrt{25} = 23500 \text{ MPa}$$

$$I_k = 1/12 \cdot b \cdot h^3 = 1/12 \cdot 700 \cdot 700^3 = 2 \cdot E10 \text{ mm}^4$$

$$EI_k = \frac{\left(\frac{E_c \cdot I_k}{2,5} \right)}{1 + \beta_d} = \frac{\left(\frac{23500 \cdot 2E10}{2,5} \right)}{1 + 0,11} = 1,7 \cdot E14 \text{ Nmm}^2$$

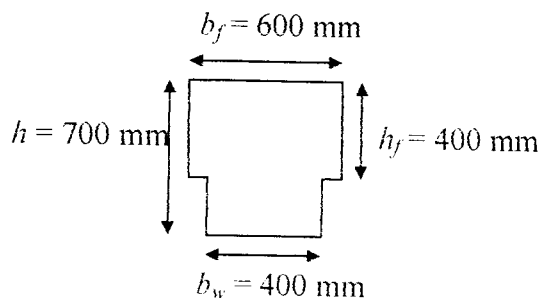
$$l_k = 5400 \text{ mm (panjang kolom lantai 1)}$$

$$l_{u,k} = 5400 - 700 - 600 = 4100 \text{ mm (panjang bersih kolom lantai 1)}$$

$$l_k = 3800 \text{ mm (panjang kolom lantai 2)}$$

$$l_{u,k} = 3800 - 700 = 3100 \text{ mm (panjang bersih kolom lantai 2)}$$

- Ukuran balok lantai 1: $b_f = 600 \text{ mm}$, $h_f = 400 \text{ mm}$, $b_w = 400 \text{ mm}$, $h = 700 \text{ mm}$



Gambar 7.11 Penampang melintang balok T

$$E_c = 4700 \cdot \sqrt{f_c} = 4700 \cdot \sqrt{25} = 23500 \text{ MPa}$$

$$I_b = 1/12 \cdot b \cdot h^3 = 1/12 \cdot 600 \cdot 400^3 + 1/12 \cdot 400 \cdot 300^3 = 4,1 \cdot E9 \text{ mm}^4$$

$$EI_{b,a} = \frac{\left(\frac{E_c \cdot I_b}{5} \right)}{1 + \beta_d} = \frac{\left(\frac{23500 \cdot 4,1E9}{5} \right)}{1 + 0,11} = 1,742 \cdot E13 \text{ Nmm}^2$$

$l_b = 9600 \text{ mm}$ (panjang balok sebelah kiri kolom)

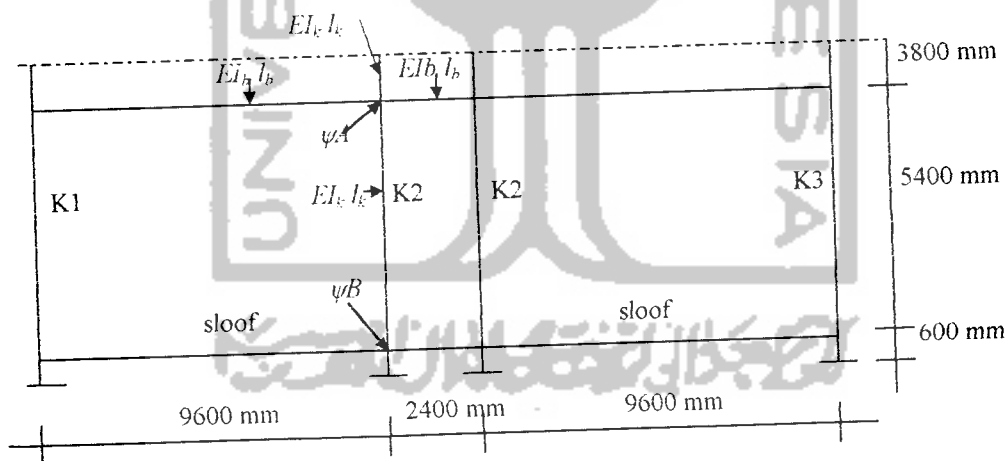
$l_{n,b} = 9600 - 700 = 8900 \text{ mm}$ (panjang bersih balok sebelah kiri kolom)

$l_b = 2400 \text{ mm}$ (panjang balok sebelah kanan kolom)

$l_{n,b} = 2400 - 700 = 1700 \text{ mm}$ (panjang balok bersih sebelah kanan kolom)

Kekakuan relatif kolom bagian atas

$$\varphi_A = \frac{\sum \left(\frac{EI_k}{l_{n,k}} \right)}{\sum \left(\frac{EI_b}{l_{n,b}} \right)} = \frac{\frac{1,7E14}{3700} + \frac{1,7E14}{5400}}{\frac{1,7E13}{8900} + \frac{1,7E13}{1700}} = 6,31$$



Gambar 7.12 Kekakuan relatif kolom K2 sejajar sumbu x (portal as C dan D)

Kekakuan relatif kolom bagian bawah

$$\psi_B = 0 \text{ (dianggap dukungan jepit)}$$

$$\psi_m = (\psi_A + \psi_B)/2 = (6,31 + 0)/2 = 3,155$$

Nilai k diambil dengan rumus Furlong (Wang dan Salmon, 1987):

$$\psi_m > 2,0$$

$$k = 0,9 \cdot (1 + \psi m)^{1/2} = 0,9 \cdot (1 + 3,155)^{1/2} = 1,835$$

Cek kelangsingan kolom K2 portal bergoyang

$$A = 700 \times 700 = 4,9E5 \text{ mm}^2$$

$$r = \sqrt{I/A} = \sqrt{(2E10/4,9E5)} = 202,03$$

$L = 4100 \text{ mm}$ (panjang bersih kolom lantai 1)

$$(kL)/r = (1,835 \cdot 4100)/202,03 = 37 > 22 \text{ (kolom langsing)}$$

$$P_{c,k2} = \frac{\pi^2 EI_k}{(kL)^2} = \frac{3,14^2 \cdot 1,7E14 \cdot 10^{-3}}{(1,835 \cdot 4100)^2} = 29652,9384 \text{ kN}$$

$$P_{u,k2} = N_{u,k,k2} = 3860,1750 \text{ kN}$$

Dengan cara yang sama dapat dihitung kelangsingan dan gaya tekuk Euler untuk kolom K1 dalam satu tingkat yang sama dan dalam satu portal arah x yang sama (disajikan dalam Tabel 7.14)

$$P_{u,k1} = N_{u,k,k1} = 3345,5556 \text{ kN}$$

$$P_{c,k1} = 8127,5293 \text{ kN}$$

$$\Sigma P_u = 2 \cdot 3345,5556 + 2 \cdot 3860,175 = 14499,0000 \text{ kN}$$

$$\Sigma P_c = 2 \cdot 8127,5293 + 2 \cdot 29652,9384 = 75560,9355 \text{ kN}$$

Faktor pembesaran momen

$$\delta_s = \frac{1}{1 - \frac{\Sigma P_u}{\phi \Sigma P_c}} = \frac{1}{1 - \frac{14499,0000}{0,65 \cdot 75560,9355}} = 1,4189 > 1$$

Dengan cara yang sama didapat perhitungan kolom dan faktor kelangsingan kolom-kolom yang lain, disajikan pada Tabel 7.14.

Tabel 7.14 Perhitungan Kelangsingan dan Faktor Pembesaran Momen Kolom Daktilitas Penuh

Ko- lom	Lt	Arah	l _{b,a} (mm ⁴)	l _{b,b} (mm ⁴)	l _k (mm ⁴)	β _d	El _{ba} (Nmm ²)	El _{bb} (Nmm ²)	El _k (Nmm ²)	ψ _A	ψ _B	k	kL _r	P _u (kN)	P _c (kN)	ΣP _u (kN)	ΣP _c (kN)	δ _s
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]
K1	1	Sb-x	4,10E+09	7,20E+09	2,00E+10	0,26	1,53E+13	0,00E+00	1,49E+14	24,60	0,00	3,28	66,6	3345,5556	8127,5293	14499,0000	75560,9355	1,4189
		Sb-y	4,10E+09	7,20E+09	2,00E+10	0,001	1,93E+13	0,00E+00	1,88E+14	17,97	0,00	2,84	57,7	3345,5556	13644,4168	9612,5600	38370,9956	1,6271
	2	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,319	1,46E+13	1,46E+13	1,43E+14	21,02	21,02	4,22	64,78	2636,9428	8214,5895	11591,7600	70642,2335	1,3377
		Sb-y	4,10E+09	4,10E+09	2,00E+10	0,001	1,92E+13	1,92E+13	1,88E+14	15,35	15,35	3,64	55,83	2636,9428	14568,5827	7662,5400	39892,7757	1,4195
	3	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,38	1,40E+13	1,40E+13	1,36E+14	21,02	21,02	4,22	64,78	1901,2156	7853,0159	8121,0400	65842,7517	1,2342
K2	1	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,006	1,92E+13	1,92E+13	1,87E+14	15,35	15,35	3,64	55,83	1901,2156	14504,5259	5930,2400	39122,1672	1,2844
		Sb-y	4,10E+09	4,10E+09	2,00E+10	0,42	1,36E+13	1,36E+13	1,33E+14	21,02	21,02	4,22	64,78	1083,6756	7648,9566	3867,3200	72820,6191	1,0890
	2	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,002	1,92E+13	1,92E+13	1,88E+14	15,35	15,35	3,64	55,83	1083,6756	14557,4463	3432,9800	38942,9248	1,1569
		Sb-y	4,10E+09	4,10E+09	2,00E+10	0,42	1,36E+13	1,36E+13	1,33E+14	11,21	22,42	3,8	58,27	643,7353	9453,8430	1287,4800	18907,6860	1,1170
	3	Sb-x	9,00E+09	9,00E+09	2,00E+10	0,027	4,12E+13	4,12E+13	1,83E+14	3,73	7,46	2,31	35,45	643,7353	35215,2009	1771,5400	95169,9227	1,0295
K3	1	Sb-x	4,10E+09	7,20E+09	2,00E+10	0,11	1,74E+13	0,00E+00	1,70E+14	6,31	0,00	1,83	37	3860,1750	29652,9384	14499,0000	75560,9355	1,4189
		Sb-y	4,10E+09	7,20E+09	2,00E+10	0,002	1,92E+13	0,00E+00	1,88E+14	14,38	0,00	2,58	51,93	3860,1750	16621,0317	16226,8800	117841,5967	1,2688
	2	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,13	1,70E+13	1,70E+13	1,66E+14	7,19	6,31	2,51	38,44	3119,4851	27106,5273	11591,7600	70642,2335	1,3377
		Sb-y	4,10E+09	4,10E+09	2,00E+10	0,004	1,92E+13	1,92E+13	1,87E+14	16,37	14,38	3,64	55,87	3119,4851	14507,1892	12928,1100	115801,2444	1,2074
	3	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,16	1,66E+13	1,66E+13	1,62E+14	7,19	7,19	2,58	39,51	2159,3019	25068,3599	8121,0400	65842,7517	1,2342
K4	1	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,002	1,92E+13	1,92E+13	1,88E+14	16,37	16,37	3,75	57,55	2159,3019	13700,5886	8567,8800	108383,2755	1,1385
		Sb-y	4,10E+09	4,10E+09	2,00E+10	0,30	1,49E+13	1,49E+13	1,45E+14	3,60	7,19	2,28	34,91	849,9796	28761,3529	3867,3200	72820,6191	1,0890
	2	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,010	1,91E+13	1,91E+13	1,86E+14	8,19	16,37	3,28	50,31	849,9796	17773,7662	4220,8300	114294,3202	1,0602
		Sb-y	4,10E+09	7,20E+09	2,00E+10	0,37	1,80E+13	0,00E+00	1,75E+14	22,67	0,00	3,16	64,13	1460,7144	10302,3977	11402,3000	121989,5477	1,1680
	3	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,297	1,49E+13	0,00E+00	1,45E+14	35,94	0,00	3,92	79,53	1460,7144	5541,0810	9612,5600	38370,9956	1,6271
K4	1	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,096	1,76E+13	1,76E+13	1,72E+14	25,82	22,67	4,52	69,37	1194,3294	8625,5710	9401,1600	109130,9435	1,1528
		Sb-y	4,10E+09	4,10E+09	2,00E+10	0,124	1,71E+13	1,71E+13	1,67E+14	40,93	35,94	5,65	86,7	1194,3294	5377,8052	7662,5400	39892,7757	1,4195
	2	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,11	1,74E+13	1,74E+13	1,70E+14	25,82	25,82	4,66	71,5	913,8965	8015,7151	6766,1800	102348,2733	1,1132
		Sb-y	4,10E+09	4,10E+09	2,00E+10	0,125	1,71E+13	1,71E+13	1,67E+14	40,93	40,93	5,83	89,4	913,8965	5056,5577	5930,2400	39122,1672	1,2844
	3	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,15	1,68E+13	1,68E+13	1,64E+14	25,82	25,82	4,66	71,5	632,8115	7753,8062	4214,9000	100550,5503	1,0689
K4	1	Sb-x	9,00E+09	9,00E+09	2,00E+10	0,157	1,68E+13	1,68E+13	1,63E+14	40,93	40,93	5,83	89,4	632,8115	4914,0161	3432,9800	38942,9248	1,1569
		Sb-y	9,00E+09	9,00E+09	2,00E+10	0,50	2,82E+13	2,82E+13	1,25E+14	5,88	11,76	2,82	43,27	242,0313	16168,1805	1746,6000	230138,4860	1,0118
	2	Sb-x	9,00E+09	9,00E+09	2,00E+10	0,287	3,29E+13	3,29E+13	1,46E+14	9,32	18,65	3,48	53,45	242,0313	12369,7605	1771,5400	95169,9227	1,0295
		Sb-y	4,10E+09	7,20E+09	2,00E+10	0,01	1,90E+13	0,00E+00	1,86E+14	11,33	0,00	2,32	47,15	1811,6971	20203,9092	11402,3000	121989,5477	1,1680
	3	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,067	2,52E+13	0,00E+00	1,76E+14	12,39	0,00	2,41	48,98	1811,6971	17749,5947	3867,9200	48439,4073	1,1470
K4	1	Sb-x	5,72E+09	4,10E+09	2,00E+10	0,016	1,90E+13	1,90E+13	1,85E+14	12,91	11,33	3,26	50,01	1491,3316	17890,4746	9401,1600	109130,9435	1,1528
		Sb-y	5,72E+09	5,72E+09	2,00E+10	0,041	2,58E+13	2,58E+13	1,81E+14	14,11	12,39	3,4	52,12	1491,3316	16078,9615	3166,6800	50928,2671	1,1058
	2	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,02	1,89E+13	1,89E+13	1,84E+14	12,91	12,91	3,36	51,49	1178,3476	16788,0369	6766,1800	102348,2733	1,1132
		Sb-y	5,72E+09	5,72E+09	2,00E+10	0,042	2,58E+13	2,58E+13	1,81E+14	14,11	14,11	3,5	53,67	1178,3476	15148,5240	2512,3000	48473,1635	1,0866
	3	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,03	1,87E+13	1,87E+13	1,83E+14	12,91	12,91	3,36	51,49	737,3205	16663,2968	4214,9000	100550,5503	1,0689
K4	1	Sb-x	5,72E+09	5,72E+09	2,00E+10	0,048	2,56E+13	2,56E+13	1,79E+14	14,11	14,11	3,5	53,67	737,3205	15051,2733	1578,9200	47840,3718	1,0535

Tabel 7.14. Lanjutan

Ko- lom	Arah	lb,a (mm ⁴)	lb,b (mm ⁴)	lk (mm ⁴)	βd	Elba (Nmm ²)	Elbb (Nmm ²)	Elk (Nmm ²)	ψ/A	ψ/B	k	kL/r	Pu (kN)	Pc (kN)	ΣPu (kN)	ΣPc (kN)	δs	
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]
K4	Sb-x	9,00E+09	9,00E+09	2,00E+10	0,06	3,98E+13	3,98E+13	1,77E+14	2,94	5,88	2,09	32,12	275,8245	41474,7802	1746,6000	230138,4860	1,0118	
	Sb-y	5,72E+09	5,72E+09	2,00E+10	0,155	2,33E+13	2,33E+13	1,63E+14	7,06	14,11	3,06	46,99	275,8245	17820,7061	604,4000	56048,1812	1,0169	
K5	Sb-x	4,10E+09	7,20E+09	2,00E+10	0,03	1,86E+13	0,00E+00	1,82E+14	6,64	0,00	1,87	37,96	2428,7337	30488,4670	11402,3000	121989,5477	1,1680	
	Sb-y	5,72E+09	7,20E+09	2,00E+10	0,070	2,51E+13	0,00E+00	1,76E+14	8,37	0,00	2,05	41,58	2428,7347	24572,6757	16226,8800	117841,5967	1,2698	
	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,049	1,84E+13	1,84E+13	1,79E+14	7,57	6,64	2,56	39,31	2014,9164	28049,4261	9401,1600	109130,9435	1,1528	
	Sb-y	5,72E+09	5,72E+09	2,00E+10	0,094	2,46E+13	2,46E+13	1,72E+14	9,53	8,37	2,84	43,55	2014,9164	21901,3702	12928,1100	115801,2444	1,2074	
	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,06	1,83E+13	1,83E+13	1,78E+14	7,57	7,57	2,63	40,41	1290,8406	26370,3847	6766,1800	102348,2733	1,1132	
	Sb-y	5,72E+09	5,72E+09	2,00E+10	0,120	2,40E+13	2,40E+13	1,68E+14	9,53	9,53	2,92	44,81	1290,8406	20212,4227	8567,8800	108383,2755	1,1385	
	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,08	1,79E+13	1,79E+13	1,75E+14	7,57	7,57	2,63	40,41	737,3205	25858,1721	4214,9000	100550,5503	1,0689	
	Sb-y	5,72E+09	5,72E+09	2,00E+10	0,144	2,35E+13	2,35E+13	1,64E+14	9,53	9,53	2,92	44,81	737,3205	19789,6459	4220,8300	114294,3202	1,0602	
K6	Sb-x	9,00E+09	9,00E+09	2,00E+10	0,16	3,65E+13	3,65E+13	1,62E+14	1,72	3,45	1,7	26,14	355,4523	57426,2823	1746,6000	230138,4860	1,0118	
	Sb-y	5,72E+09	5,72E+09	2,00E+10	0,058	2,54E+13	2,54E+13	1,78E+14	4,77	9,53	2,57	39,41	355,4523	27672,2299	1234,7800	98381,4618	1,0197	
K7	Sb-x	5,72E+09	7,20E+09	9,11E+08	0,11	2,43E+13	0,00E+00	7,74E+12	0,74	0,00	1,15	65,27	1344,0609	5161,3547	5609,9400	23595,1446	1,3402	
	Sb-y	5,72E+09	7,20E+09	7,15E+09	0,002	2,68E+13	0,00E+00	6,71E+13	2,29	0,00	1,38	28,01	1344,0609	20654,9336	3867,9200	46439,4073	1,1470	
	Sb-x	5,72E+09	5,72E+09	9,11E+08	0,111	2,42E+13	2,42E+13	7,71E+12	0,84	0,74	1,29	55,23	914,2791	4791,8266	4225,8200	23636,5518	1,3794	
	Sb-y	5,72E+09	5,72E+09	7,15E+09	0,001	2,68E+13	2,68E+13	6,71E+13	2,61	2,29	1,67	25,64	914,2791	24867,8589	3166,6800	50928,2671	1,1058	
	Sb-x	5,72E+09	5,72E+09	9,11E+08	0,11	2,43E+13	2,43E+13	7,75E+12	0,84	0,84	1,3	55,86	631,5561	4703,1443	3026,8000	23286,0139	1,2500	
	Sb-y	5,72E+09	5,72E+09	7,15E+09	0,003	2,68E+13	2,68E+13	6,69E+13	2,61	2,61	1,71	26,22	631,5561	23525,1367	2512,3000	48473,1635	1,0866	
	Sb-x	5,72E+09	5,72E+09	9,11E+08	0,13	2,39E+13	2,39E+13	7,61E+12	0,84	0,84	1,3	55,86	375,6522	4622,1187	1805,6200	22757,5535	1,1390	
	Sb-y	5,72E+09	5,72E+09	7,15E+09	0,008	2,67E+13	2,67E+13	6,67E+13	2,61	2,61	1,71	26,22	375,6522	23430,5676	1578,9200	47840,3718	1,0535	
	Sb-x	5,72E+09	5,72E+09	9,11E+08	0,24	2,17E+13	2,17E+13	6,92E+12	0,42	0,84	1,24	53,15	157,1283	4640,8992	741,9600	22557,9043	1,0533	
	Sb-y	5,72E+09	5,72E+09	7,15E+09	0,017	2,64E+13	2,64E+13	6,61E+13	1,30	2,61	1,55	23,8	157,1283	28198,4647	604,4000	56048,1812	1,0169	
K8	Sb-x	5,72E+09	7,20E+09	9,11E+08	0,04	2,59E+13	0,00E+00	8,26E+12	0,22	0,00	1,05	59,49	1400,8958	6636,2176	5609,9400	23595,1446	1,3402	
	Sb-y	5,72E+09	7,20E+09	7,15E+09	0,055	2,58E+13	0,00E+00	6,37E+13	2,32	0,00	1,38	28,1	1400,8958	19490,2055	16226,8800	117841,5967	1,2698	
	Sb-x	5,72E+09	5,72E+09	9,11E+08	0,040	2,58E+13	2,58E+13	8,24E+12	0,25	0,22	1,1	47,13	992,5062	7026,4493	4225,8200	23636,5518	1,3794	
	Sb-y	5,72E+09	5,72E+09	7,15E+09	0,073	2,50E+13	2,50E+13	6,26E+13	2,61	2,29	1,67	25,64	992,5062	23006,3117	12928,1100	115801,2444	1,2074	
	Sb-x	5,72E+09	5,72E+09	9,11E+08	0,04	2,58E+13	2,58E+13	8,22E+12	0,25	0,25	1,1	47,38	633,2403	6939,8627	3026,8000	23286,0139	1,2500	
	Sb-y	5,72E+09	5,72E+09	7,15E+09	0,096	2,45E+13	2,45E+13	6,13E+13	2,61	2,61	1,71	26,22	633,2403	21543,1816	8567,8800	108383,2755	1,1385	
	Sb-x	5,72E+09	5,72E+09	9,11E+08	0,07	2,51E+13	2,51E+13	8,00E+12	0,25	0,25	1,1	47,38	377,5065	6756,6580	1805,6200	22757,5535	1,1390	
	Sb-y	5,72E+09	5,72E+09	7,15E+09	0,137	2,36E+13	2,36E+13	5,91E+13	2,61	2,61	1,71	26,22	377,5065	20769,3450	4220,8300	114294,3202	1,0602	
	Sb-x	5,72E+09	5,72E+09	9,11E+08	0,14	2,36E+13	2,36E+13	7,52E+12	0,12	0,25	1,08	46,33	174,6003	6638,0530	741,9600	22557,9043	1,0533	
	Sb-y	5,72E+09	5,72E+09	7,15E+09	0,338	2,01E+13	2,01E+13	5,02E+13	1,30	2,61	1,55	23,8	174,6003	21422,1466	1234,7800	98381,4618	1,0197	
K8	Sb-x	5,72E+09	7,20E+09	7,15E+09	0,08	2,49E+13	0,00E+00	6,21E+13	5,81	0,00	1,78	36,08	651,2499	11840,9566	3464,0400	51479,6191	1,1155	
	Sb-y	5,72E+09	7,20E+09	2,60E+09	0,048	2,56E+13	0,00E+00	2,34E+13	1,73	0,00	1,31	37,11	651,2499	8034,8791	3867,9200	46439,4073	1,1470	
	Sb-x	5,72E+09	5,72E+09	7,15E+09	0,097	2,45E+13	2,45E+13	6,12E+13	6,61	5,81	2,42	37,07	554,9544	10769,0617	2597,7800	80026,5388	1,0547	
	Sb-y	5,72E+09	5,72E+09	2,60E+09	0,052	2,55E+13	2,55E+13	2,33E+13	1,97	1,73	1,53	32,9	554,9544	10181,4467	3166,6800	50928,2671	1,1058	

Tabel 7.14. Lanjutan

Ko- lom	Lt	Arah	l _{b,a} (mm ⁴)	l _{b,b} (mm ⁴)	l _k (mm ⁴)	βd	E _{lba} (Nmm ²)	E _{lbb} (Nmm ²)	E _{l_k} (Nmm ²)	ψ _A	ψ _B	k	kL/r	P _u (kN)	P _c (kN)	ΣP _u (kN)	ΣP _c (kN)	δs
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]
K8	3	Sb-x	5,72E+09	5,72E+09	7,15E+09	0,10	2,43E+13	2,43E+13	6,08E+13	6,61	6,61	2,48	38,1	453,7869	10129,4796	1941,9400	76423,1123	1,0407
		Sb-y	5,72E+09	5,72E+09	2,60E+09	0,063	2,53E+13	2,53E+13	2,30E+13	1,97	1,97	1,55	33,36	453,7869	9799,5028	2512,3000	48473,1635	1,0866
		Sb-x	5,72E+09	5,72E+09	7,15E+09	0,16	2,32E+13	2,32E+13	5,79E+13	6,61	6,61	2,48	38,1	316,2957	9644,5064	1301,3200	74646,0823	1,0276
		Sb-y	5,72E+09	5,72E+09	2,60E+09	0,113	2,41E+13	2,41E+13	2,20E+13	1,97	1,97	1,55	33,36	316,2957	9358,5310	1578,9200	47840,3718	1,0535
K9	1	Sb-x	5,72E+09	5,72E+09	7,15E+09	0,26	2,13E+13	2,13E+13	5,33E+13	3,31	6,61	2,2	33,71	132,2013	11335,8048	613,6800	81964,4382	1,0117
		Sb-y	5,72E+09	5,72E+09	2,60E+09	0,180	2,28E+13	2,28E+13	2,07E+13	0,98	1,97	1,46	31,31	132,2013	10029,0104	604,4000	56048,1812	1,0169
		Sb-x	5,72E+09	5,72E+09	7,15E+09	0,03	2,62E+13	0,00E+00	6,54E+13	4,68	0,00	1,64	33,37	1080,7654	14198,8529	3464,0400	51479,6191	1,1155
		Sb-y	5,72E+09	5,72E+09	2,60E+09	0,055	2,55E+13	0,00E+00	2,32E+13	1,73	0,00	1,31	37,11	1080,7654	7981,9882	16226,8800	117841,5967	1,2688
K9	2	Sb-x	5,72E+09	5,72E+09	7,15E+09	0,033	2,60E+13	2,60E+13	6,50E+13	1,94	1,70	1,51	23,19	793,9407	29244,2077	2697,7800	80026,5388	1,0547
		Sb-y	5,72E+09	5,72E+09	2,60E+09	0,073	2,51E+13	2,51E+13	2,28E+13	1,97	1,73	1,53	32,9	793,9407	9988,9069	12928,1100	115801,2444	1,2074
		Sb-x	5,72E+09	5,72E+09	7,15E+09	0,03	2,60E+13	2,60E+13	6,51E+13	1,94	1,94	1,54	23,67	517,1817	28082,0765	1941,9400	76423,1123	1,0407
		Sb-y	5,72E+09	5,72E+09	2,60E+09	0,096	2,45E+13	2,45E+13	2,23E+13	1,97	1,97	1,55	33,36	517,1817	9507,0357	8567,8800	108383,2755	1,1385
K9	3	Sb-x	5,72E+09	5,72E+09	7,15E+09	0,05	2,57E+13	2,57E+13	6,41E+13	1,94	1,94	1,54	23,67	334,3578	27678,5348	1301,3200	74646,0823	1,0276
		Sb-y	5,72E+09	5,72E+09	2,60E+09	0,132	2,37E+13	2,37E+13	2,16E+13	1,97	1,97	1,55	33,36	334,3578	9199,0755	4220,8300	114294,3202	1,0602
		Sb-x	5,72E+09	5,72E+09	7,15E+09	0,17	2,29E+13	2,29E+13	5,74E+13	0,97	1,94	1,41	21,63	174,6381	29646,4143	613,6800	81964,4382	1,0117
		Sb-y	5,72E+09	5,72E+09	2,60E+09	0,095	2,45E+13	2,45E+13	2,24E+13	0,98	1,97	1,46	31,31	174,6381	10807,4276	4156,2200	109463,6237	1,0620

Keterangan Tabel 7.14:

- [1] Kolom yang ditinjau
- [2] Lantai kolom yang ditinjau
- [3] Arah bekerjanya momen sejajar sb-x dan sb-y
- [4] l_{b,a} = Inersia balok atas; l = 1/12 . b . h³
- [5] l_{b,b} = Inersia balok bawah
- [6] l_k = Inersia kolom
- [7] βd = 1,05MD / (1,05(MD + ML + 4ME))
- [8] E_{lba} = [(E_c . l_{b,a}) / (2,5)] / [1 + βd]
- [9] E_{lbb} = [(E_c . l_{b,b}) / (2,5)] / [1 + βd]
- [10] E_{l_k} = [(E_c . k) / 5] / [1 + βd]
- [11] ψ_A = Σ[E_{l_k} / I_k] / Σ[E_{l_b} / I_{b,a}]
- [12] ψ_B = Σ[E_{l_k} / I_k] / Σ[E_{l_b} / I_{b,b}]
- [13] k = 0,9 . (1 + ψ_m)^{0,5} untuk ψ_m = (y_A + y_B) / 2 > 2,0
k = (20 - ψ_m) / 20 . (1 + ψ_m)^{0,5} untuk ψ_m < 2,0
- [14] kL/r > 22 kolom langsing r = (I/A)^{0,5}
- [15] P_u = N_u . k = Gaya aksial rencana terpacai kolom
- [16] P_c = [3, 14² . E_{l_k}] / [(k . l)²]
- [17] ΣP_u = jumlah gaya-gaya aksial dalam lantai dan portal yang sama
- [18] ΣP_c = jumlah gaya-gaya tekuk Euler dalam lantai dan portal yang sama
- [19] δs = 1 / [1 - (ΣP_u / 0,65ΣP_c)] > 1 (faktor pembesaran momen)

7.2.5 Penulangan kombinasi Lentur dan Aksial Kolom

Sebagai contoh perhitungan penulangan kombinasi lentur dan aksial kolom adalah Kolom K2 Lantai 1.

Diketahui dari perhitungan sebelumnya:

$$P_u = N_{u,k} = 3860,1750 \text{ kN}$$

$$M_{u,k,x} = 530,6030 \text{ kNm} ; \delta_{s,x} = 1,4189$$

$$M_{c,x} = \delta_{s,x} \cdot M_{u,k,x} = 1,4189 \cdot 530,6030 = 752,8726 \text{ kNm}$$

$$M_{u,k,y} = 394,0670 \text{ kNm} ; \delta_{s,y} = 1,2688$$

$$M_{c,y} = \delta_{s,y} \cdot M_{u,k,y} = 1,2688 \cdot 394,0670 = 499,9922 \text{ kNm}$$

Eksentrisitasnya adalah:

$$e_x = M_{c,x}/P_u = 752,8726/3860,1750 = 0,195 \text{ m} = 195 \text{ mm}$$

$$e_y = M_{c,y}/P_u = 499,9922/3860,1750 = 0,130 \text{ m} = 130 \text{ mm}$$

Untuk menentukan harga-harga dari P_x dan P_y , diperlukan Gambar 7.7 Diagram Interaksi Kolom Ukuran 700 mm x 700 mm, dalam lentur uniaxial masing-masing terhadap sumbu x dan sumbu y, oleh karena sifat simetris dalam hal ini hanya diperlukan diagram tunggal yang telah dibuat sebelumnya. Dari Diagram Interaksi Kolom 700 mm x 700 mm, diambil penulangan 24D25 dengan $A_{st} = 11780,97 \text{ mm}^2$, jadi $\rho_g = A_{st}/A_g = 11780,97/490000 = 0,024$, ditentukan P_x dan P_y (cara penentuan P_x dan P_y lihat Gambar 7.13)

$$\text{untuk } e_x = 195 \text{ mm} \text{ didapat } \phi P_{n,x} = 5175,0000 \text{ kN}$$

$$\text{untuk } e_y = 130 \text{ mm} \text{ didapat } \phi P_{n,y} = 6375,0000 \text{ kN}$$

$$\text{dan } \phi P_o = 9829,6250 \text{ kN}$$

Kemudian dengan menggunakan persamaan *Bresler* didapat ϕP_n (Wang dan Salmon, 1993):

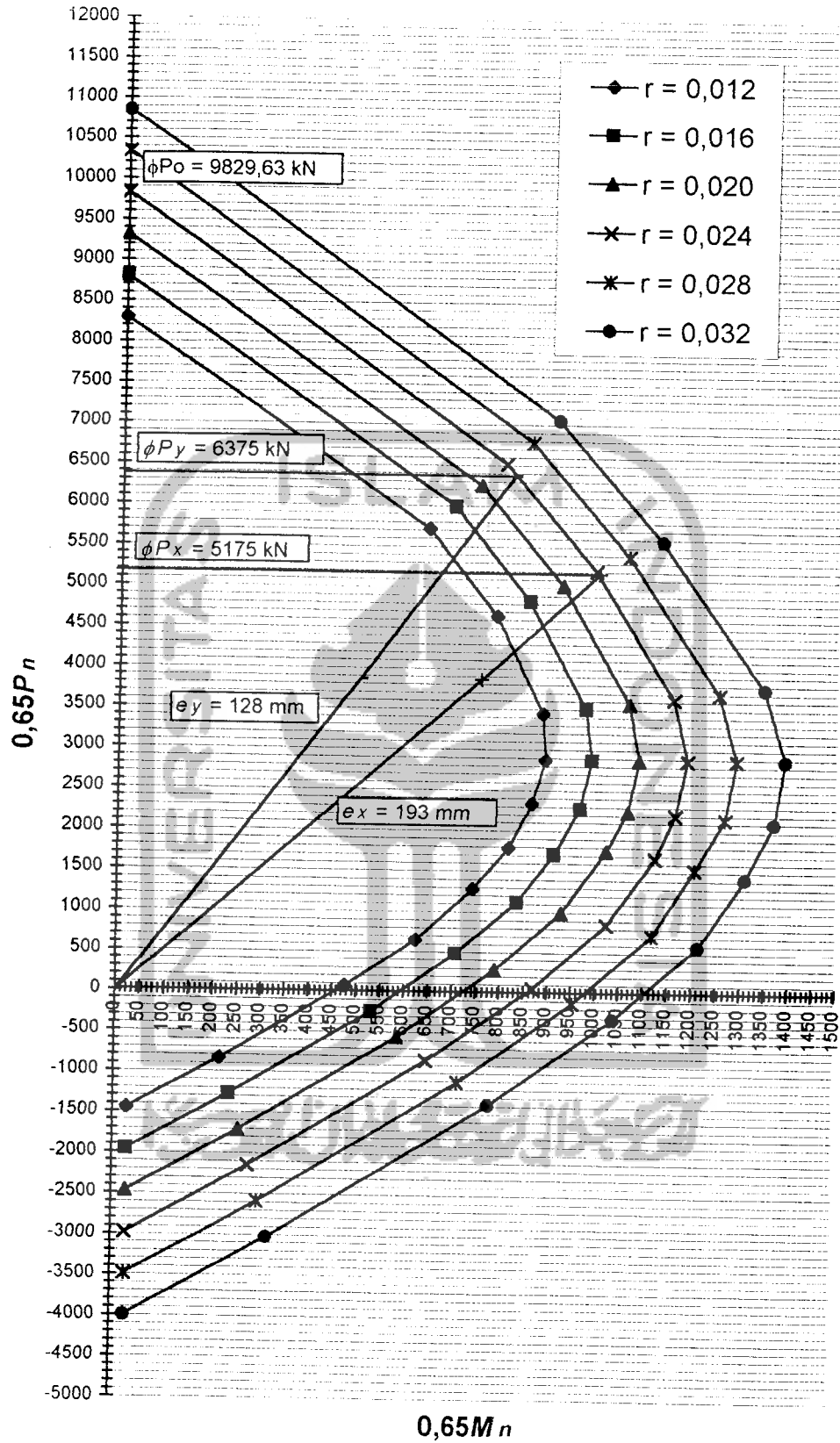
$$1/\phi P_n = (1/\phi P_{n,x}) + (1/\phi P_{n,y}) - (1/\phi P_o)$$

$$1/\phi P_n = (1/5175,0000) + (1/6375,0000) - (1/9829,6250)$$

$$\text{didapat, } \phi P_n = 4026,3131 \text{ kN} \geq (P_u = 3860,1750 \text{ kN}) \quad \text{- aman -}$$

Jadi tulangan kolom 24D25, dengan penempatan tulangan 7D25 pada masing-masing sisi dapat dipergunakan pada kolom K2 Lantai 1.

Dengan cara yang sama dapat dihitung penulangan lentur dan aksial kolom-kolom yang lain, disajikan pada Tabel 7.15.



Gambar 7.13 Menentukan harga-harga ϕP_o , ϕP_x , dan ϕP_y pada Kolom K2 Lantai 1

Tabel 7.15 Penulangan Kombinasi Lentur dan Aksial Kolom Daktilitas Penuh

Kolom	Lt	Arah	Ukuran b x h (mm)	δ_s	$M_{u,k}$ (kNm)	M_c (kNm)	$P_u/N_{u,k}$ (kN)	e (mm)	Tul. total	Tul. tiap sisi	ρ total	Diagram interaksi Kolom			
												ϕP (kN)	ϕP_o (kN)	$\phi P_n \geq P_u$ (kN)	ϕM_n (kNm)
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]
K1	1	Sb-x	700x700	1,4189	440,2161	624,6226	3345,5556	187	24D25	7D25	0,024	5250,0000	9829,6250	3558,0781	664,3010
		Sb-y	700x700	1,6271	402,9811	655,6905		196	7D25	7D25		5200,0000			697,3425
	2	Sb-x	700x700	1,3377	527,4319	705,5457	2636,9428	268	24D25	7D25	0,024	4125,0000	9829,6250	2792,6544	747,2081
		Sb-y	700x700	1,4195	425,7166	604,3047		229	7D25	7D25		4600,0000			639,9889
	3	Sb-x	700x700	1,2342	580,0603	715,9104	1901,2156	377	24D25	7D25	0,024	3500,0000	9829,6250	2219,0284	835,5841
		Sb-y	700x700	1,2844	431,1416	553,7583		291	7D25	7D25		3750,0000			646,3261
4	Sb-x	700x700	1,0890	596,9231	650,0493	1083,6756	600	24D25	7D25	0,024	1750,0000	9829,6250	1093,9247	656,1972	
	Sb-y	700x700	1,1569	489,6239	566,4459		523	7D25	7D25		2250,0000			571,8032	
5	Sb-x	700x700	1,1170	634,1018	708,2917	643,7353	1100	24D25	7D25	0,024	950,0000	9829,6250	649,7162	714,8724	
	Sb-y	700x700	1,0295	389,5501	401,0418		623	7D25	7D25		1700,0000			404,7679	
K2	1	Sb-x	700x700	1,4189	530,6030	752,8726	3860,1750	195	24D25	7D25	0,024	5175,0000	9829,6250	4026,3131	785,2755
		Sb-y	700x700	1,2688	394,0670	499,9922		130	7D25	7D25		6375,0000			521,5114
	2	Sb-x	700x700	1,3377	694,5736	929,1311	3119,4851	298	24D25	7D25	0,024	4750,0000	9829,6250	3341,4729	995,2496
		Sb-y	700x700	1,2074	487,0952	588,1187		189	7D25	7D25		5250,0000			629,9703
	3	Sb-x	700x700	1,2342	699,6499	863,5079	2159,3019	400	24D25	7D25	0,024	3050,0000	9829,6250	2180,1040	871,8267
		Sb-y	700x700	1,1385	481,4479	548,1284		254	7D25	7D25		4300,0000			553,4090
	4	Sb-x	700x700	1,0890	230,2347	250,7256	849,9796	295	24D25	7D25	0,024	1250,0000	9829,6300	851,4571	251,1614
		Sb-y	700x700	1,0602	547,0954	580,0305		682	7D25	7D25		2100,0000			581,0388
K3	1	Sb-x	700x700	1,1680	270,7508	316,2369	1460,7144	216	12D25	4D25	0,012	3900,0000	8298,8750	2131,0814	461,3678
		Sb-y	700x700	1,6271	280,5154	456,4266		312	4D25	4D25		3000,0000			665,8949
	2	Sb-x	700x700	1,1528	310,0298	357,4024	1194,3294	299	12D25	4D25	0,012	2900,0000	8298,8750	1282,2405	383,7097
		Sb-y	700x700	1,4195	359,3998	510,1680		427	4D25	4D25		1800,0000			547,7200
	3	Sb-x	700x700	1,1132	325,9595	362,8581	913,8965	397	12D25	4D25	0,012	2000,0000	8298,8750	955,8690	379,5231
		Sb-y	700x700	1,2844	363,4159	466,7714		511	4D25	4D25		1500,0000			488,2088
	4	Sb-x	700x700	1,0689	329,4157	352,1124	632,8115	556	12D25	4D25	0,012	1300,0000	8298,8750	641,9213	357,1814
		Sb-y	700x700	1,1569	356,3726	412,2875		652	4D25	4D25		1100,0000			418,2226
	5	Sb-x	700x700	1,0118	206,3563	208,7913	242,0313	863	12D25	4D25	0,012	500,0000	8298,8750	257,7651	222,3642
		Sb-y	700x700	1,0295	200,2979	206,2067		852	4D25	4D25		500,0000			219,6116
K4	1	Sb-x	700x700	1,1680	358,3781	418,5856	1811,6971	231	12D25	4D25	0,012	3700,0000	8298,8750	2758,3318	637,3019
		Sb-y	700x700	1,1528	239,2430	275,7993		152	4D25	4D25		4700,0000			419,9080
	2	Sb-x	700x700	1,1528	399,9445	461,0560	1491,3316	309	12D25	4D25	0,012	2900,0000	8298,8750	2162,5149	668,5572
		Sb-y	700x700	1,1058	260,7742	288,3641		193	4D25	4D25		4200,0000			418,1442
	3	Sb-x	700x700	1,1132	442,0256	492,0629	1178,3476	418	12D25	4D25	0,012	2000,0000	8298,8750	1345,6449	561,9241
		Sb-y	700x700	1,0866	346,3618	376,3567		319	4D25	4D25		2750,0000			429,7904
	4	Sb-x	700x700	1,0689	510,8872	546,0873	737,3205	741	12D25	4D25	0,012	1200,0000	8298,8750	871,3703	645,3697
		Sb-y	700x700	1,0535	326,6980	344,1763		467	4D25	4D25		2300,0000			406,7499
	5	Sb-x	700x700	1,0118	362,4073	366,6837	275,8245	1329	12D25	4D25	0,012	600,0000	8298,8750	336,1639	446,8994
		Sb-y	700x700	1,0169	213,7965	217,4097		788	4D25	4D25		700,0000			264,9702
K5	1	Sb-x	700x700	1,1680	397,7632	464,5874	2428,7337	191	12D25	4D25	0,012	4200,0000	8298,8750	2578,2017	493,1788
		Sb-y	700x700	1,2688	430,5694	546,3065		225	4D25	4D25		3700,0000			579,9270
	2	Sb-x	700x700	1,1528	424,2382	489,0618	2014,9164	243	12D25	4D25	0,012	3300,0000	8298,8750	2020,0713	490,3130
		Sb-y	700x700	1,2074	481,4663	581,3224		289	4D25	4D25		3200,0000			582,8096
	3	Sb-x	700x700	1,1132	436,4932	485,9042	1290,8406	376	12D25	4D25	0,012	2600,0000	8298,8750	1308,6999	492,6269
		Sb-y	700x700	1,1385	503,1892	572,8809		444	4D25	4D25		2000,0000			580,8069
	4	Sb-x	700x700	1,0689	520,6833	556,5584	737,3205	755	12D25	4D25	0,012	1100,0000	8298,8750	804,4159	607,2046
		Sb-y	700x700	1,0602	353,7112	375,0046		509	4D25	4D25		2200,0000			409,1296
	5	Sb-x	700x700	1,0118	319,3733	323,1419	355,4523	909	12D25	4D25	0,012	650,0000	8298,8750	363,4650	330,4262
		Sb-y	700x700	1,0197	287,3348	292,9953		824	4D25	4D25		750,0000			299,6001
K6	1	Sb-x	250x700	1,3402	111,9496	150,0349	1344,0609	112	16D22	6D22	0,035	2350,0000	3997,7379	1396,7827	155,9201
		Sb-y	700x250	1,1470	73,9201	84,7864		63	6D22	6D22		1850,0000			88,1122
	2	Sb-x	250x700	1,3794	94,2106	129,9541	914,2791	142	16D22	6D22	0,035	2500,0000	3997,7379	1088,0335	154,6513
		Sb-y	700x250	1,1058	89,1704	98,6046		108	6D22	6D22		1300,0000			117,3440
	3	Sb-x	250x700	1,2500	101,2991	126,6239	631,5561	200	16D22	6D22	0,035	2200,0000	3997,7379	898,0733	180,0592
		Sb-y	700x250	1,0866	87,1390	94,6852		150	6D22	6D22		1100,0000			134,6425
	4	Sb-x	250x700	1,1390	135,9795	154,8807	375,6522	412	16D22	6D22	0,035	1000,0000	3997,7379	389,4020	160,5497
		Sb-y	700x250	1,0535	77,8390	82,0034		218	6D22	6D22		550,0000			85,0049
	5	Sb-x	250x700	1,0533	143,9650	151,6383	157,1283	965	16D22	6D22	0,035	550,0000	3997,7379	179,5964	173,3214
		Sb-y	700x250	1,0169	78,4227	79,7480		508	6D22	6D22		250,0000			91,1514
K7	1	Sb-x	250x700	1,3402	141,9911	190,2965	1400,6958	136	16D22	6D22	0,035	2400,0000	3997,7379	1443,3326	196,0890
		Sb-y	700x250	1,2688	71,1766	90,3089		64	6D22	6D22		1900,0000			93,0578
	2	Sb-x	250x700	1,3794	130,4349	179,9219	992,5062	181	16D22	6D22	0,035	2100,0000	3997,7379	1004,7426	182,1401
		Sb-y	700x250	1,2074	78,5191	94,8040		96	6D22	6D22		1300,0000			95,9728

Tabel 7.15. Lanjutan

Ko-lom	Lt	Arah	Ukuran b x h (mm)	δ_s	M _{u,k} (kNm)	M _c (kNm)	P _u /N _{u,k} (kN)	e (mm)	Tul total	Tul tiap sisi	ρ total	Diagram Interaksi Kolom			ϕM_n (kNm)
												ϕP (kN)	ϕP_o (kN)	$\phi P_n \geq P_u$ (kN)	
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]
K7	3	Sb-x	250x700	1,2500	132,5338	165,6673	633,2403	262	16D22	6D22	0,035	1600,0000	3997,7379	644,6085	168,6414
		Sb-y	700x250	1,1385	83,3292	94,8703		150		6D22			850,0000		96,5735
	4	Sb-x	250x700	1,1390	144,1921	164,2348	377,5065	435	16D22	6D22	0,035	1100,0000	3997,7379	429,9936	187,0694
		Sb-y	700x250	1,0602	75,4796	80,0235		212		6D22			600,0000		91,1496
5	Sb-x	250x700	1,0533	133,3723	140,4810	174,6003	805	16D22	6D22	0,035	600,0000	3997,7379	184,6202	148,5429	
	Sb-y	700x250	1,0197	83,4121	85,0553		487		6D22			250,0000		89,9364	
K8	1	Sb-x	250x700	1,1155	109,3404	121,9692	651,2499	187	16D22	6D22	0,035	2000,0000	3997,7379	701,1005	131,3055
		Sb-y	700x250	1,1470	93,3374	107,0580		164		6D22			850,0000		115,2529
	2	Sb-x	250x700	1,0547	110,2083	116,2367	554,9544	209	16D22	6D22	0,035	1900,0000	3997,7379	586,5977	122,8645
		Sb-y	700x250	1,1058	116,0553	128,3340		231		6D22			700,0000		135,6515
	3	Sb-x	250x700	1,0407	112,3995	116,9742	453,7869	258	16D22	6D22	0,035	1850,0000	3997,7379	474,2526	122,2497
		Sb-y	700x250	1,0866	95,4678	103,7353		229		6D22			550,0000		108,4138
	4	Sb-x	250x700	1,0276	114,1995	117,3514	316,2957	371	16D22	6D22	0,035	1200,0000	3997,7379	324,3392	120,3357
		Sb-y	700x250	1,0535	89,6000	94,3936		298		6D22			400,0000		96,7941
	5	Sb-x	250x700	1,0117	105,7626	107,0000	132,2013	809	16D22	6D22	0,035	550,0000	3997,7379	152,2524	123,2288
		Sb-y	700x250	1,0169	78,7307	80,0612		606		6D22			200,0000		92,2042
K9	1	Sb-x	250x700	1,1155	132,0508	147,3027	1080,7654	136	16D22	6D22	0,035	2300,0000	3997,7379	1293,8679	176,3474
		Sb-y	700x250	1,2688	63,1824	80,1658		74		6D22			1700,0000		95,9727
	2	Sb-x	250x700	1,0547	121,3087	127,9443	793,9407	161	16D22	6D22	0,035	2200,0000	3997,7379	1088,5068	175,4139
		Sb-y	700x250	1,2074	73,0306	88,1771		111		6D22			1400,0000		120,8924
	3	Sb-x	250x700	1,0407	123,2591	128,2757	517,1817	248	16D22	6D22	0,035	1600,0000	3997,7379	778,8469	193,1761
		Sb-y	700x250	1,1385	77,5051	88,2396		171		6D22			1100,0000		132,8839
	4	Sb-x	250x700	1,0276	134,1056	137,8069	334,3578	412	16D22	6D22	0,035	1050,0000	3997,7379	469,3049	193,4259
		Sb-y	700x250	1,0602	70,2035	74,4298		223		6D22			700,0000		104,4697
	5	Sb-x	250x700	1,0117	124,0281	125,4792	174,6381	719	16D22	6D22	0,035	550,0000	3997,7379	179,5964	129,0418
		Sb-y	700x250	1,0620	78,0842	82,9254		475		6D22			250,0000		85,2798

Keterangan Tabel 7.15.

- [1] Kolom yang ditinjau
- [2] Lantai kolom yang ditinjau
- [3] Arah momen yang bekerja sejajar sb-x dan sb-y
- [4] Ukuran kolom
- [5] δ_s = faktor pembesaran momen
- [6] $M_{u,k}$ = momen rencana kolom terpakai
- [7] $M_c = \delta_s \cdot M_{u,k}$ (Momen rencana yang telah diperbesar)
- [8] $P_u = N_{u,k}$ = gaya aksial rencana kolom terpakai
- [9] $e = M_c / P_u$ (eksentrisitas)
- [10] Tulangan terpasang
- [11] Tulangan terpasang pada tiap-tiap sisi
- [12] ρ = rasio tulangan terpasang
- [13] ϕP_x dan ϕP_y (dilihat pada diagram interaksi kolom)
- [14] ϕP_o (dilihat pada diagram interaksi kolom)
- [15] ϕP_n = hasil dari persamaan Bresler $1/\phi P_n = 1/\phi P_x + 1/\phi P_y - 1/\phi P_o$
 $\phi P_n \geq P_u$ (tulangan terpasang aman digunakan)
- [16] $\phi M_n = \phi P_n \cdot e$ (Momen nominal kolom) dengan $\phi = 0,65$

7.2.6. Gaya Geser Rencana Kolom

Gaya geser rencana kolom diperoleh dengan menentukan nilai terkecil dari persamaan berikut (Andriono dan Takim, 1993)

$$V_{u,k} = (M_{u,k \text{ atas}} + M_{u,k \text{ bawah}})/h_n$$

tetapi tidak perlu lebih besar dari.

$$V_{u,k \text{ maks}} = 1,05.(V_{D,k,x} + V_{L,k,x} + 4/K.(V_{E,k,x} + 0,3.V_{E,k,y}))$$

dengan harga $K=1$

Akan tetapi pada lantai dasar dan lantai paling atas yang memperbolehkan terjadinya sendi plastis pada kolom, gaya geser rencana kolom dihitung berdasarkan momen kapasitas dari kolom

$$V_{u,k \text{ lantai } 1} = (M_{u,k \text{ atas lt } 1} + M_{kap,k \text{ lt } 1})/h_n$$

$$V_{u,k \text{ lantai } 5} = (2..M_{kap,k \text{ lt } 5})/h_n$$

Sebagai contoh perhitungan ditinjau pada kolom K2 lantai 1 :

$$M_{u,k \text{ atas-x}} = 530,6030 \text{ kNm} ; M_{u,k \text{ atas-y}} = 394,0670 \text{ kNm}$$

Menentukan momen kapasitas kolom:

$$\phi P_n = 4026,3131 \text{ kN (hasil perhitungan sebelumnya, tulangan pokok kolom 24D25)}$$

$$e_x = 195 \text{ mm}$$

$$M_{kap,k,x} = 1,25. \phi P_n . e_x = 1,25.4026,3131.0,195 = 981,4138 \text{ kNm}$$

$$e_y = 130 \text{ mm}$$

$$M_{kap,k,y} = 1,25. \phi P_n . e_y = 1,25.4026,3131.0,130 = 654,2759 \text{ kNm}$$

Perhitungan gaya geser kolom ditambah 30% gaya geser tegak lurus yang ditinjau.

$$V_{u,k,x} = (M_{u,k \text{ atas-x}} + M_{kap,k,x})/h_n + 0,3. (M_{u,k \text{ atas-y}} + M_{kap,k,y})/h_n$$

$$= (530,6030 + 981,4138)/4,1 + 0,3.(394,0670 + 654,2759)/4,1 = 430,0553 \text{ kN}$$

Dengan cara yang sama didapat gaya geser kolom rencana lainnya yang disajikan pada Tabel 7.16

Tetapi gaya geser rencana kolom tidak perlu lebih besar dari:

$$V_{u,k \text{ maks}} = 1,05.(V_{D,k} + V_{L,k} + 4/K.(V_{E,k,x} + 0,3.V_{E,k,y}))$$

$$= 1,05.(56,3700 + 15,400 + 4/1.(177,4500 + 0,3.118,5200) = 758,1598 \text{ kN}$$

dipakai $V_{u,k} = 430,0553 \text{ kN}$

Dengan cara yang sama didapat gaya geser maksimum kolom lainnya yang disajikan pada Tabel 7.17, dan gaya geser kolom terpakai disajikan pada Tabel 7.18.

Tabel 7.16 Gaya Geser Rencana Kolom Daktilitas Penuh (Satuan: kN)

Kolom	Lantai	Arah Portal	$M_{u,ka}$ (kNm)	$M_{u,kb}$ (kN)	h_n (m)	$V_{u,k}$ (kN)
[1]	[2]	[3]	[4]	[5]	[6]	[7]
K1	1	Sejajar sb-x	440,2161	830,3763	4,1	403,1683
		Sejajar sb-y	402,9811	871,6781	4,1	403,8627
	2	Sejajar sb-x	527,4319	401,6068	3,1	381,5909
		Sejajar sb-y	425,7166	420,5932	3,1	362,9101
	3	Sejajar sb-x	580,0603	236,1914	3,1	332,5470
		Sejajar sb-y	431,1416	284,3381	3,1	309,7920
	4	Sejajar sb-x	596,9231	119,7832	3,1	302,4022
		Sejajar sb-y	489,6239	246,1781	3,1	306,7142
	5	Sejajar sb-x	893,5905	893,5905	3,2	653,3615
		Sejajar sb-y	505,9599	505,9599	3,2	483,7732
K2	1	Sejajar sb-x	530,6030	981,5944	4,1	430,0553
		Sejajar sb-y	394,0670	651,8893	4,1	343,6302
	2	Sejajar sb-x	694,5736	602,0597	3,1	407,0144
		Sejajar sb-y	487,0952	448,0625	3,1	402,0483
	3	Sejajar sb-x	699,6499	459,8639	3,1	430,2468
		Sejajar sb-y	481,4479	325,2713	3,1	341,0239
	4	Sejajar sb-x	313,9518	313,9518	3,1	315,0087
		Sejajar sb-y	726,2985	726,2985	3,1	517,1916
K3	1	Sejajar sb-x	270,7508	576,7098	4,1	271,8421
		Sejajar sb-y	280,5154	832,3686	4,1	321,0426
	2	Sejajar sb-x	310,0298	239,1085	3,1	243,7068
		Sejajar sb-y	359,3998	328,4428	3,1	275,0271
	3	Sejajar sb-x	325,9595	205,4427	3,1	231,3029
		Sejajar sb-y	363,4159	255,3735	3,1	251,0355
	4	Sejajar sb-x	329,4157	147,3558	3,1	202,0547
		Sejajar sb-y	356,3726	142,2879	3,1	206,9974
	5	Sejajar sb-x	277,9553	277,9553	3,2	225,1935
		Sejajar sb-y	274,5145	274,5145	3,2	223,6882
K4	1	Sejajar sb-x	345,6983	796,6274	4,1	326,1014
		Sejajar sb-y	124,0823	524,8850	4,1	241,8695
	2	Sejajar sb-x	399,9455	353,5155	3,1	293,2173
		Sejajar sb-y	257,6013	260,7742	3,1	240,1335
	3	Sejajar sb-x	442,0256	306,4363	3,1	287,5222
		Sejajar sb-y	346,3618	129,8276	3,1	226,0413
	4	Sejajar sb-x	510,8872	264,3551	3,1	285,6683
		Sejajar sb-y	326,6980	41,0672	3,1	193,6574
	5	Sejajar sb-x	558,6243	558,6243	3,2	386,4016
		Sejajar sb-y	331,2128	331,2128	3,2	311,7501
K5	1	Sejajar sb-x	397,7632	616,4735	4,1	305,7124
		Sejajar sb-y	430,5694	724,9088	4,1	333,0305
	2	Sejajar sb-x	424,2382	393,6819	3,1	314,5909
		Sejajar sb-y	481,4663	407,3001	3,1	332,6079
	3	Sejajar sb-x	436,4932	320,0300	3,1	298,1071
		Sejajar sb-y	503,1892	306,5145	3,1	311,7110
	4	Sejajar sb-x	520,6833	250,0878	3,1	301,4903
		Sejajar sb-y	353,7112	192,4514	3,1	250,7722
	5	Sejajar sb-x	413,0328	413,0328	3,2	328,3643
		Sejajar sb-y	374,5001	374,5001	3,2	311,5062

Tabel 7.16. Lanjutan

Kolom	Lantai	Arah Portal	$M_{u,k a}$ (kNm)	$M_{u,k b}$ (kN)	h_n (m)	$V_{u,k}$ (kN)
[1]	[2]	[3]	[4]	[5]	[6]	[7]
K6	1	Sejajar sb-x	53,9462	194,9001	4,1	71,4875
		Sejajar sb-y	37,3680	110,1403	4,1	54,1859
	2	Sejajar sb-x	94,2106	84,0785	3,1	72,2856
		Sejajar sb-y	89,1704	63,4843	3,1	66,4972
	3	Sejajar sb-x	101,2991	73,0542	3,1	72,1600
		Sejajar sb-y	87,1390	77,3367	3,1	69,9296
	4	Sejajar sb-x	135,9795	69,8721	3,1	78,6854
		Sejajar sb-y	77,8390	49,0719	3,1	60,8601
	5	Sejajar sb-x	216,6518	216,6518	3,1	161,8281
		Sejajar sb-y	113,9393	113,9393	3,1	115,4418
K7	1	Sejajar sb-x	101,5743	245,1113	4,1	98,2769
		Sejajar sb-y	71,1766	116,3223	4,1	71,0987
	2	Sejajar sb-x	130,4349	128,1713	3,1	98,1083
		Sejajar sb-y	78,5191	73,2457	3,1	73,9828
	3	Sejajar sb-x	132,5338	99,8960	3,1	89,3571
		Sejajar sb-y	83,3292	65,2619	3,1	70,4258
	4	Sejajar sb-x	144,1921	71,3723	3,1	83,0901
		Sejajar sb-y	75,4796	64,5702	3,1	66,0384
	5	Sejajar sb-x	185,6786	185,6786	3,1	141,5515
		Sejajar sb-y	112,4205	112,4205	3,1	108,4671
K8	1	Sejajar sb-x	91,6445	164,1319	4,1	79,7039
		Sejajar sb-y	92,6323	144,0661	4,1	76,4467
	2	Sejajar sb-x	110,2083	103,4343	3,1	89,2649
		Sejajar sb-y	116,0553	94,2069	3,1	88,5016
	3	Sejajar sb-x	112,3995	77,3499	3,1	79,3822
		Sejajar sb-y	95,4678	92,3172	3,1	78,9387
	4	Sejajar sb-x	114,1995	90,5648	3,1	83,2345
		Sejajar sb-y	89,6000	87,9421	3,1	77,0875
	5	Sejajar sb-x	154,0360	154,0360	3,1	121,6855
		Sejajar sb-y	115,2553	115,2553	3,1	104,1717
K9	1	Sejajar sb-x	107,4625	220,4343	4,1	93,3759
		Sejajar sb-y	63,1824	119,9659	4,1	68,6628
	2	Sejajar sb-x	121,3087	120,2189	3,1	90,8859
		Sejajar sb-y	73,0306	61,0312	3,1	66,6194
	3	Sejajar sb-x	123,2591	102,4230	3,1	87,2243
		Sejajar sb-y	77,5051	71,5388	3,1	69,9189
	4	Sejajar sb-x	134,1056	104,0294	3,1	89,8142
		Sejajar sb-y	70,2035	64,0934	3,1	66,3669
	5	Sejajar sb-x	161,3023	161,3023	3,1	124,6982
		Sejajar sb-y	106,5998	106,5998	3,1	99,9939

Keterangan Tabel 7.16:

- [1] Kolom yang ditinjau
 [2] Tingkat lantai pada kolom yang ditinjau
 [3] Arah portal: Sejajar sumbu x dan sejajar sumbu y
 [4] $M_{u,k atas}$ = momen rencana kolom atas
 [5] $M_{u,k bawah}$ = momen rencana kolom bawah
 [6] h_n = tinggi bersih kolom
 [7] $V_{u,k,x} = (M_{u,k,x atas} + M_{u,k,x bawah})/h_n$
 $+ 0,3.(M_{u,k,y atas} + M_{u,k,y bawah})/h_n$
 $V_{u,k,y} = (M_{u,k,y atas} + M_{u,k,y bawah})/h_n$
 $+ 0,3.(M_{u,k,x atas} + M_{u,k,x bawah})/h_n$
 (Gaya geser rencana kolom)

Tabel 7.17. Lanjutan

Kolom	Lantai	Sejajar Sumbu x			Sejajar Sumbu y			Akibat Gempa Kiri		Akibat Gempa Kanan			
		$V_{D,k-x}$	$V_{L,k-x}$	$V_{Eki,k-x}$	$V_{D,k-y}$	$V_{L,k-y}$	$V_{Eki,k-y}$	$V_{Eka,k-y}$	$V_{u,k-x1}$	$V_{u,k-y1}$	$V_{u,k-x2}$	$V_{u,k-y2}$	
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]
K7	1	4,9300	1,4400	51,6900	-51,6100	-0,4000	-0,0600	18,5700	-19,0400	247,1847	142,6404	-234,0639	-145,4796
	2	8,1800	2,8300	49,1800	-49,1500	-0,8200	-0,1600	18,3700	-18,6200	241,2627	138,0918	-218,3307	-141,1620
	3	7,4500	2,5600	39,9900	-39,9600	-0,5400	-0,0600	15,1200	-15,0700	197,5197	113,2614	-176,3097	-114,2736
	4	7,1000	2,6200	26,9400	-26,9100	-0,9100	-0,1600	9,8800	-10,6000	135,8028	74,3169	-116,1720	-79,5501
	5	8,5800	2,3500	10,1800	-10,1400	-1,5600	-0,4800	3,0100	-12,6400	58,0251	23,3268	-47,0379	-68,0064
K8	1	-6,1700	-1,1500	25,8500	-25,5800	-2,5600	-0,3300	21,0700	-21,0300	127,4322	118,0305	-141,6198	-123,5913
	2	-9,8900	-2,2500	23,2600	-23,1900	-3,8300	-0,6400	23,1800	-23,1800	114,1518	121,9701	-139,3518	-131,2689
	3	-9,9800	-2,1600	19,8700	-19,7800	-3,6800	-0,6000	20,0200	-20,0100	95,9322	104,6262	-121,0356	-113,4588
	4	-9,9200	-2,2500	14,6400	-14,4500	-3,7800	-0,6200	14,3700	-14,3500	66,8157	74,1804	-91,5495	-83,0970
	5	-13,4800	-1,9400	7,8600	-8,0700	-3,2800	-0,5000	9,0500	-9,0700	28,2240	43,9446	-61,5132	-52,2312
K9	1	3,8300	0,8400	51,9500	-51,8200	2,4300	0,4500	13,2100	-13,8900	239,7381	123,9630	-230,2419	-120,6072
	2	6,0200	1,6800	47,1500	-47,0900	4,0500	0,8400	12,6400	-13,0800	222,0414	117,6315	-206,1738	-109,1349
	3	5,1100	1,4300	38,2000	-38,1400	4,5800	0,9500	10,5000	-10,8700	180,5370	98,0385	-167,0172	-87,9039
	4	4,3500	1,4400	26,0300	-25,9500	4,7800	0,9800	7,1000	-7,6200	124,3515	68,6658	-112,5117	-58,6530
	5	6,3300	0,9900	9,9600	-10,0600	4,0000	0,5300	2,1000	-9,0700	52,1640	26,1261	-45,9942	-46,0131

Keterangan Tabel 7.17:

- [1] Kolom yang ditinjau
- [2] Tingkat lantai pada kolom yang ditinjau
- [3] $V_{D,k-x}$ = Gaya geser kolom akibat beban mati sejajar sb-x
- [4] $V_{L,k-x}$ = Gaya geser kolom akibat beban hidup sejajar sb-x
- [5] $V_{Eki,k-x}$ = Gaya geser kolom akibat beban gempa kiri sejajar sb-x
- [6] $V_{Eka,k-x}$ = Gaya geser kolom akibat beban gempa kanan sejajar sb-x
- [7] $V_{D,k-y}$ = Gaya geser kolom akibat beban mati sejajar sb-y
- [8] $V_{L,k-y}$ = Gaya geser kolom akibat beban hidup sejajar sb-y
- [9] $V_{Eki,k-y}$ = Gaya geser kolom akibat beban gempa kiri sejajar sb-y
- [10] $V_{Eka,k-y}$ = Gaya geser kolom akibat beban gempa kanan sejajar sb-y
- [11] $V_{u,k-x1} = 1,05(N_{D,k-x} + N_{L,k-x} + 4/k(N_{Eki,k-x} + 0,3N_{Eka,k-x}))$ dengan $k=1$
(Gaya geser maksimum atas akibat gempa kiri sejajar sb-x)
- [12] $V_{u,k-y1} = 1,05(N_{D,k-y} + N_{L,k-y} + 4/k(N_{Eki,k-y} + 0,3N_{Eka,k-y}))$ dengan $k=1$
(Gaya geser maksimum atas akibat gempa kiri sejajar sb-y)
- [13] $V_{u,k-x2} = 1,05(N_{D,k-x} + N_{L,k-x} + 4/k(N_{Eka,k-x} + 0,3N_{Eki,k-x}))$ dengan $k=1$
(Gaya geser maksimum atas akibat gempa kanan sejajar sb-x)
- [14] $V_{u,k-y2} = 1,05(N_{D,k-y} + N_{L,k-y} + 4/k(N_{Eka,k-y} + 0,3N_{Eki,k-y}))$ dengan $k=1$
(Gaya geser maksimum atas akibat gempa kanan sejajar sb-y)

Tabel 7.18 Gaya Geser Terpakai Kolom Daktilitas Penuh (Satuan kN)

Kolom	Lantai	$V_{u,k}$ rencana (kN)	$V_{u,k}$ maksimum (kN)	$V_{u,k}$ terpakai (kN)
[1]	[2]	[3]	[4]	[5]
K1	1	403,8627	621,1758	403,8627
	2	381,5909	603,6387	381,5909
	3	332,547	511,2765	332,547
	4	306,7142	470,7465	306,7142
	5	653,3615	428,6121	428,6121
K2	1	430,0553	758,1598	430,0553
	2	407,0144	784,0615	407,0144
	3	430,2468	592,2795	430,2468
	4	517,1916	433,7752	433,7752
K3	1	321,0426	425,1639	321,0426
	2	275,0271	374,4426	275,0271
	3	251,0355	319,4877	251,0355
	4	206,9974	251,0613	206,9974
	5	225,1935	115,6554	115,6554
K4	1	326,1014	429,0447	326,1014
	2	293,2173	404,6175	293,2173
	3	287,5222	338,478	287,5222
	4	285,6683	245,9373	245,9373
	5	386,4016	129,2298	129,2298
K5	1	333,0305	598,8948	333,0305
	2	332,6079	529,6284	332,6079
	3	311,711	433,7046	311,711
	4	301,4903	323,9376	301,4903
	5	328,3643	278,1324	278,1324
K6	1	71,4875	162,8319	71,4875
	2	72,2856	151,8027	72,2856
	3	72,1600	129,8787	72,1600
	4	78,6854	98,0700	78,6854
	5	161,8281	61,9815	61,9815
K7	1	98,2769	247,1847	98,2769
	2	98,1083	241,2627	98,1083
	3	89,3571	197,5197	89,3571
	4	83,0901	135,8028	83,09
	5	141,5515	68,0064	68,0064
K8	1	79,7039	141,6198	79,7039
	2	89,2649	139,3518	89,2649
	3	79,3822	121,0356	79,38
	4	83,2345	91,5495	83,24
	5	121,6855	61,5132	61,5132
K9	1	93,3759	239,7381	93,3759
	2	90,8859	222,0414	90,8859
	3	87,2243	180,5370	87,2243
	4	89,8142	124,3515	89,8142
	5	124,6982	52,1640	52,1640

Keterangan **Tabel 7.18**:

[1] Kolom yang ditinjau

[4] $V_{u,k}$ maks dari Tabel 7.17

[2] Lantai yang ditinjau

[5] $V_{u,k}$ terpakai pilih yang terkecil[3] $V_{u,k}$ terpakai dari Tabel 7.16

7.2.7 Penulangan Geser Kolom

Sebagai contoh perhitungan penulangan geser kolom ditinjau pada kolom K2 lantai 1, adalah sebagai berikut ini (Kusuma dan Andriono, 1993).

- Penulangan geser sepanjang l_o

Syarat panjang l_o dari muka balok (SK-SNI T-15-1991-03) :

$$- l_o \geq h = 700 \text{ mm, bila } N_{u,k} \leq 0,3 \cdot A_g \cdot f_c'$$

$$- l_o \geq 1,5 \cdot h = 1,5 \cdot 700 = 1050 \text{ mm, bila } N_{u,k} > 0,3 \cdot A_g \cdot f_c'$$

$$- l_o \geq 1/6 \text{ bentang bersih kolom} = 1/6 \cdot 4100 = 683 \text{ mm}$$

$$- l_o \geq 450 \text{ mm}$$

$$(N_{u,k} = 3860,1750 \text{ kN}) > (0,3 \cdot 700 \cdot 700 \cdot 25 = 3675 \text{ kN}), \text{ dipakai } l_o = 1050 \text{ mm}$$

$$V_{s,k} = V_{u,k} / 0,6 - V_c = 430,0553 / 0,6 - 0 = 716,7588 \text{ kN}$$

$$S = (A_v \cdot f_y \cdot d) / V_{s,k} = (4,0,25 \cdot \pi \cdot 12^2 \cdot 240 \cdot 642,5) / 716758,8 = 101,80 \text{ mm}$$

Jarak maksimum tulangan geser pada daerah l_o (SK-SNI T-15-1991-03):

$$- 1/4 \cdot b = 1/4 \cdot 700 = 175 \text{ mm}$$

$$- 8 \text{ kali diameter tulangan longitudinal} = 8 \cdot 25 = 200 \text{ mm}$$

$$- 100 \text{ mm}$$

dipakai **4P12-100**

Cek tulangan geser,

$$V_{s,k} = (A_v \cdot f_y \cdot d) / S = (4,0,25 \cdot \pi \cdot 12^2 \cdot 240 \cdot 642,5 / 100) \cdot 10^{-3} = 729,63 \text{ kN}$$

$$(0,6 V_{s,k} = 0,6 \cdot 729,63 = 437,7784 \text{ kN}) \geq (V_{u,k} = 430,0553 \text{ kN}) \quad \text{- aman -}$$

- Penulangan geser daerah diluar l_o

$$V_c = \left[1 + \frac{N_{u,k}}{14 \cdot A_g} \right] \cdot \frac{1}{6} \sqrt{f_c'} \cdot b \cdot d = \left[1 + \frac{3860,1750}{14 \cdot 700 \cdot 700} \right] \cdot \frac{1}{6} \sqrt{25} \cdot 700 \cdot 64,5 = 583,4109 \text{ kN}$$

$$V_{s,k} = V_{u,k} / 0,6 - V_c = 430,0553 / 0,6 - 583,4109 = 133,3479 \text{ kN}$$

$$S = (A_v \cdot f_y \cdot d) / V_{s,k} = (2,0,25 \cdot \pi \cdot 12^2 \cdot 240 \cdot 642,5) / 133347,9 = 273,58 \text{ mm}$$

dipakai **2P12-200**

Cek tulangan geser kolom,

$$V_{s,k} = (A_v \cdot f_y \cdot d) / S = (2,0,25 \cdot \pi \cdot 12^2 \cdot 240 \cdot 635,5 / 200) \cdot 10^{-3} = 182,4113 \text{ kN}$$

$$(0,6(V_{s,k} + V_c) = 0,6(182,4113 + 583,4109) = 459,4911 \text{ kN}) \geq (V_{u,k} = 430,0553 \text{ kN})$$

- aman-

Dengan cara yang sama didapat penulangan geser kolom lainnya yang disajikan dalam Tabel 7.19.

Tabel 7.19 Penulangan Geser Kolom Daktilitas Penuh

Ko- lom	Lan- tai	l (m)	l_n (m)	b (mm)	h (mm)	$N_{u,k}$ (kN)	0,3 $A_g f_c$ (kN)	Lokasi	Jarak (mm)	$V_{u,k}$ (kN)	V_c (kN)	V_s (kN)	S (mm)	S_{max} (mm)	Tul.ges terpakai	$V_{u,k} \leq$ $0,6(V_s + V_c)$ (kN)
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]
K1	1	5,4	4,1	700	700	3345,5556	3675,0000	Pada lo	0-1050	403,8627	0,0000	673,1045	108,40	100	4P12- 100	437,7784
								Luar lo	sisa	403,8227	555,4044	117,6334	310,13	200	2P12- 200	442,6872
	2	3,8	3,1	700	700	2636,9428	3675,0000	Pada lo	0-700	381,5909	0,0000	635,9848	114,72	100	4P12- 100	437,7784
								Luar lo	sisa	381,5909	516,8404	119,1444	306,20	200	2P12- 200	419,5489
	3	3,8	3,1	700	700	1901,2156	3675,0000	Pada lo	0-700	332,5470	0,0000	554,2450	131,64	100	4P12- 100	437,7784
								Luar lo	sisa	332,5470	495,8729	58,3721	624,98	200	2P12- 200	406,9683
	4	3,8	3,1	700	700	1083,6756	3675,0000	Pada lo	0-700	306,7142	0,0000	511,1903	142,73	100	4P12- 100	437,7784
								Luar lo	sisa	306,7142	475,5398	35,6506	1023,31	200	2P12- 200	394,7685
	5	3,8	3,1	700	700	643,7353	3675,0000	Pada lo	0-700	428,6121	0,0000	714,3535	102,14	100	4P12- 100	437,7784
								Luar lo	sisa	428,6121	473,7052	185,1141	206,46	200	2P12- 200	430,1493
K2	1	5,4	4,1	700	700	3860,1750	3675,0000	Pada lo	0-1050	430,0553	0,0000	716,7588	101,80	100	4P12- 100	437,7784
								Luar lo	sisa	430,0553	583,4109	133,3479	273,58	200	2P12- 200	459,4911
	2	3,8	3,1	700	700	3119,4851	3675,0000	Pada lo	0-700	407,0144	0,0000	678,3573	107,56	100	4P12- 100	437,7784
								Luar lo	sisa	407,0144	559,3943	118,9631	306,66	200	2P12- 200	445,0812
	3	3,8	3,1	700	700	2159,3019	3675,0000	Pada lo	0-700	430,2468	0,0000	717,0780	101,75	100	4P12- 100	437,7784
								Luar lo	sisa	430,2480	555,6381	161,4419	225,97	200	2P12- 200	442,8275
	4	3,8	3,1	700	700	849,9796	3675,0000	Pada lo	0-700	433,7752	0,0000	722,9587	100,92	100	4P12- 100	437,7784
								Luar lo	sisa	433,7752	482,5293	184,9456	206,65	200	2P12- 200	435,4437
K3	1	5,4	4,1	700	700	1460,7144	3675,0000	Pada lo	0-700	321,0426	0,0000	535,0710	102,27	100	3P12- 100	333,5455
								Luar lo	sisa	321,0426	452,8280	82,2430	443,58	200	2P12- 200	381,1414
	2	3,8	3,1	700	700	1194,3294	3675,0000	Pada lo	0-700	275,0271	0,0000	458,3785	119,38	100	3P12- 100	333,5455
								Luar lo	sisa	275,0271	438,3309	20,0476	1819,74	200	2P12- 200	372,4431
	3	3,8	3,1	700	700	913,8965	3675,0000	Pada lo	0-700	251,0355	0,0000	418,3925	130,79	100	3P12- 100	333,5455
								Luar lo	sisa	251,0355	423,0692	-4,6767	-7800,71	200	2P12- 200	363,2861
	4	3,8	3,1	700	700	632,8115	3675,0000	Pada lo	0-700	206,9974	0,0000	344,9957	105,74	100	3P12- 100	333,5455
								Luar lo	sisa	206,9974	407,7721	-62,7764	-581,13	200	2P12- 200	354,1078
	5	3,8	3,1	700	700	242,0313	3675,0000	Pada lo	0-700	115,6554	0,0000	192,7590	189,26	100	3P12- 100	333,5455
								Luar lo	sisa	115,6554	386,5051	-193,7461	-188,30	200	2P12- 200	341,3477
K4	1	5,4	4,1	700	700	1811,6971	3675,0000	Pada lo	0-700	326,1014	0,0000	543,5023	103,88	100	3P12- 100	333,5455
								Luar lo	sisa	326,1014	471,9291	71,5732	509,71	200	2P12- 200	392,6021
	2	3,8	3,1	700	700	1491,3316	3675,0000	Pada lo	0-700	293,2173	0,0000	488,6955	111,98	100	3P12- 100	333,5455
								Luar lo	sisa	293,2173	454,4942	34,2013	1066,67	200	2P12- 200	382,1412
	3	3,8	3,1	700	700	1178,3476	3675,0000	Pada lo	0-700	287,5222	0,0000	479,2037	114,19	100	3P12- 100	333,5455
								Luar lo	sisa	287,5222	437,4611	41,7426	873,96	200	2P12- 200	371,9213
	4	3,8	3,1	700	700	737,3205	3675,0000	Pada lo	0-700	245,9373	0,0000	409,8955	133,50	100	3P12- 100	333,5455
								Luar lo	sisa	245,9373	413,4596	-3,5641	-10235,78	200	2P12- 200	357,5204
	5	3,8	3,1	700	700	275,8245	3675,0000	Pada lo	0-700	129,2298	0,0000	215,3830	169,38	100	3P12- 100	333,5455
								Luar lo	sisa	129,2298	388,3442	-172,9612	-210,92	200	2P12- 200	342,4511
K5	1	5,4	4,1	700	700	2428,7337	3675,0000	Pada lo	0-700	333,0305	0,0000	523,6329	107,99	100	3P12- 100	333,5455
								Luar lo	sisa	333,0305	505,5093	49,5415	736,38	200	2P12- 200	412,7502
	2	3,8	3,1	700	700	2014,9164	3675,0000	Pada lo	0-700	332,6079	0,0000	518,0808	110,32	100	3P12- 100	333,5455
								Luar lo	sisa	332,6079	482,9886	71,3579	511,25	200	2P12- 200	399,2378
	3	3,8	3,1	700	700	1290,8406	3675,0000	Pada lo	0-700	311,7110	0,0000	519,5183	110,01	100	3P12- 100	333,5455
								Luar lo	sisa	311,7110	443,5832	75,9352	480,43	200	2P12- 200	375,5945
	4	3,8	3,1	700	700	737,3205	3675,0000	Pada lo	0-700	301,4903	0,0000	502,4838	108,90	100	3P12- 100	333,5455
								Luar lo	sisa	301,4903	413,4596	89,0242	624,45	200	2P12- 200	414,8485
	5	3,8	3,1	700	700	355,4523	3675,0000	Pada lo	0-700	278,1324	0,0000	463,5540	118,05	100	3P12- 100	333,5455
								Luar lo	sisa	278,1324	392,6777	70,8763	514,72	200	2P12- 200	345,0512
K6	1	5,4	4,1	250	700	1344,0609	1312,5000	Pada lo	0-1050	71,4875	0,0000	119,1458	202,50	100	2P10- 100	144,7649
								Luar lo	sisa	71,4875	206,4795	-87,3337	-276,27	150	2P10- 150	220,3977
	2	3,8	3,1	250	700	914,2791	1312,5000	Pada lo	0-700	72,2856	0,0000	120,4760	200,27	100	2P10- 100	144,7649
								Luar lo	sisa	72,2856	183,0900	-62,6140	-385,34	150	2P10- 150	206,3640
	3	3,8	3,1	250	700	631,5561	1312,5000	Pada lo	0-700	72,1600	0,0000	120,2667	200,62	100	2P10- 100	144,7649
								Luar lo	sisa	72,1600	167,7037	-47,4371	-508,62	150	2P10- 150	197,1322
	4	3,8	3,1	250	700	375,6522	1312,5000	Pada lo	0-700	78,6854	0,0000	131,1423	183,98	100	2P10- 100	144,7649
								Luar lo	sisa	78,6854	153,7770	-22,6347	-1065,95	150	2P10- 150	188,7761
	5	3,8	3,1	250	700	157,1283	1312,5000	Pada lo	0-700	61,9815	0,0000	103,3025	233,56	100	2P10- 100	144,7649
								Luar lo	sisa	61,9815	141,8845	-38,5820	-625,36	150	2P10- 150	181,6407

Tabel 7.19. Lanjutan

Ko- lom	Lan- tai	<i>l</i> (m)	<i>l_n</i> (m)	<i>b</i> (mm)	<i>h</i> (mm)	<i>N_{u,k}</i> (kN)	0,3 <i>A_g.f_c</i> (kN)	Lokasi	Jarak (mm)	<i>V_{u,k}</i> (kN)	<i>V_c</i> (kN)	<i>V_s</i> (kN)	<i>S</i> (mm)	<i>S_{max}</i> (mm)	Tul.ges terpakai	<i>V_{u,k}</i> ≤ 0,6(<i>V_s</i> + <i>V_c</i>) (kN)
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]
K7	1	5,4	4,1	250	700	1400,6958	1312,5000	Pada lo	0-1050	98,2769	0,0000	163,7948	147,30	100	2P10- 100	144,7649
								Luar lo	sisa	98,2769	209,5617	-45,7668	-527,18	150	2P10- 150	222,2470
	2	3,8	3,1	250	700	992,5062	1312,5000	Pada lo	0-700	98,1083	0,0000	163,5138	147,56	100	2P10- 100	144,7649
								Luar lo	sisa	98,1083	187,3473	-23,8334	-1012,34	150	2P10- 150	208,9183
	3	3,8	3,1	250	700	633,2403	1312,5000	Pada lo	0-700	89,3571	0,0000	148,9285	162,01	100	2P10- 100	144,7649
							Luar lo	sisa	89,3571	167,7954	-18,8669	-1278,83	150	2P10- 150	197,1872	
	4	3,8	3,1	250	700	377,5065	1312,5000	Pada lo	0-700	83,0900	0,0000	138,4833	174,23	100	2P10- 100	144,7649
							Luar lo	sisa	83,0900	153,8779	-15,3946	-1567,27	150	2P10- 150	188,8367	
	5	3,8	3,1	250	700	174,6003	1312,5000	Pada lo	0-700	68,0064	0,0000	113,3440	212,87	100	2P10- 100	144,7649
							Luar lo	sisa	68,0064	142,8354	-29,4914	-818,12	150	2P10- 150	182,2112	
K8	1	5,4	4,1	250	700	651,2499	1312,5000	Pada lo	0-700	79,7039	0,0000	132,8398	181,63	100	2P10- 100	144,7649
								Luar lo	sisa	79,7039	168,7755	-35,9357	-671,41	150	2P10- 150	197,7753
	2	3,8	3,1	250	700	554,9544	1312,5000	Pada lo	0-700	89,2649	0,0000	148,7748	162,17	100	2P10- 100	144,7649
								Luar lo	sisa	89,2649	163,5349	-14,7601	-1634,64	150	2P10- 150	194,6309
	3	3,8	3,1	250	700	453,7869	1312,5000	Pada lo	0-700	79,3800	0,0000	132,3000	182,37	100	2P10- 100	144,7649
							Luar lo	sisa	79,3800	158,0292	-25,7292	-937,75	150	2P10- 150	191,3275	
	4	3,8	3,1	250	700	316,2957	1312,5000	Pada lo	0-700	83,2400	0,0000	138,7333	173,91	100	2P10- 100	144,7649
							Luar lo	sisa	83,2400	150,5467	-11,8134	-2042,39	150	2P10- 150	186,8380	
	5	3,8	3,1	250	700	132,2013	1312,5000	Pada lo	0-700	61,5132	0,0000	102,5220	235,34	100	2P10- 100	144,7649
							Luar lo	sisa	61,5132	140,5280	-38,0060	-634,83	150	2P10- 150	180,8267	
K9	1	5,4	4,1	250	700	1080,7654	1312,5000	Pada lo	0-700	93,3756	0,0000	155,6260	155,04	100	2P10- 100	144,7649
								Luar lo	sisa	93,3756	192,1505	-36,5245	-660,58	150	2P10- 150	211,8003
	2	3,8	3,1	250	700	793,9407	1312,5000	Pada lo	0-700	90,8859	0,0000	151,4765	159,28	100	2P10- 100	144,7649
								Luar lo	sisa	90,8859	176,5410	-25,0645	-962,62	150	2P10- 150	202,4345
	3	3,8	3,1	250	700	517,1817	1312,5000	Pada lo	0-700	87,2243	0,0000	145,3738	165,97	100	2P10- 100	144,7649
							Luar lo	sisa	87,2243	161,4793	-16,1054	-1498,10	150	2P10- 150	193,3975	
	4	3,8	3,1	250	700	334,3578	1312,5000	Pada lo	0-700	89,8142	0,0000	149,6903	161,18	100	2P10- 100	144,7649
							Luar lo	sisa	89,8142	151,5297	-1,8393	-13117,45	150	2P10- 150	187,4278	
	5	3,8	3,1	250	700	174,6381	1312,5000	Pada lo	0-700	52,1640	0,0000	86,9400	277,52	100	2P10- 100	144,7649
							Luar lo	sisa	52,1640	142,8374	-55,8974	-431,64	150	2P10- 150	182,2124	

Keterangan Tabel 7.19:

- [1] Kolom yang ditinjau
 [2] Lantai kolom yang ditinjau
 [3] *l* = panjang kolom
 [4] *l_n* = panjang bersih kolom
 [5] *b* = lebar penampang kolom
 [6] *h* = tinggi penampang kolom
 [7] *N_{u,k}* = gaya aksial terpakai kolom (Tabel 7.10)
 [8] 0,3 *A_g.f_c* dengan *A_g*=*b.h*, *f_c*'=25 MPa
 [9] Daerah penulangan geser
 [10] Jarak penulangan geser dari muka kolom
l_o=*h*=700 mm untuk *N_{u,k}*<0,3 *A_g.f_c*
l_o=1,5*h*=1050 mm untuk *N_{u,k}*>0,3 *A_g.f_c*
 [11] *V_{u,k}* = gaya geser rencana kolom (Tabel 7.18)
 [12] *V_c* = $[1 + N_{u,k}/(14 A_g)] \cdot (1/6) \cdot (f_c)^{0,5} \cdot b \cdot d$
 (gaya geser beton)
 [13] *V_s* = *V_{u,k}*/0,6 - *V_c*
 [14] *S* = (*A_v.f_y.d*)/*V_s* dengan:
 diameter sengkang = 12 mm (untuk kolom K1 s/d K5),
 diameter sengkang = 10 mm (untuk kolom K6 s.d K9)
f_y=240 MPa *d*=640 mm
 [15] *S_{max}* = 8 *d* tul. pokok
 [16] Tulangan geser kolom terpasang
 [17] *V_{u,k}* ≤ 0,6(*V_s*+*V_c*) tulangan geser aman

7.3 Desain Pertemuan Balok Kolom

Perencanaan pertemuan balok kolom (joint) didasarkan dengan memperhitungkan kebutuhan penulangan geser arah horisontal dan vertikal. Sebagai contoh hitungan ditinjau pada pertemuan balok kolom K2 lantai 1 (Andriono dan Kusuma, 1993)

1. Penulangan Geser Horizontal

Diketahui:

$$- M_{nak,b,ki,x} = 1100,2186 \text{ kNm}$$

$$M_{nak,b,ka,x} = 578,1163 \text{ kNm}$$

$$- M_{nak,b,ki,y} = 673,1497 \text{ kNm}$$

$$M_{nak,b,ka,y} = 358,9232 \text{ kNm}$$

Tinjauan sejajar sumbu-x (Portal as C) yang paling menentukan.

Dihitung 100 % dalam satu arah sumbu x dan 30 % dalam arah tegak lurus yaitu sumbu y.

$$V_{kol-x} = \frac{0,7 \cdot 1,25 \left[\left(\frac{I_{ki,x}}{I_{ka,x}} M_{nak,b,ki,x} + \frac{I_{ka,x}}{I_{ka,x}} M_{nak,b,ka,x} \right) + 0,3 \left(\frac{I_{ki,y}}{I_{ka,y}} M_{nak,b,ki,y} + \frac{I_{ka,y}}{I_{ka,y}} M_{nak,b,ka,y} \right) \right]}{\frac{1}{2} (h_{k,a} + h_{k,b})}$$

$$= \frac{0,7 \cdot 1,25 \left[\left(\frac{4,8}{4,1} \cdot 1100,2186 + \frac{2,4}{1,7} \cdot 578,1163 \right) + 0,3 \left(\frac{7,2}{6,5} \cdot 673,1497 + \frac{7,2}{6,5} \cdot 358,9232 \right) \right]}{\frac{1}{2} (3,8 + 5,4)}$$

$$= 464,8381 \text{ kN}$$

$$C_{ki,x} = 0,7 \cdot 1,25 \cdot (M_{nak,b,ki,x} + 0,3 \cdot M_{nak,b,ki,y}) / z_{ki}$$

$$= 0,7 \cdot (1100,2186 + 0,3 \cdot 673,1497) / 0,6275 = 1361,8244 \text{ kN}$$

$$T_{ka,x} = 0,7 \cdot 1,25 \cdot (M_{kap,b,ka,x} + 0,3 \cdot M_{kap,b,ka,y}) / z_{ka}$$

$$= 0,7 \cdot (578,1163 + 0,3 \cdot 358,9232) / 0,6275 = 717,2141 \text{ kN}$$

$$V_{j,h,x} = C_{ki} + T_{ka} - V_{kol}$$

$$= 1361,8244 + 717,2141 - 464,8381 = 1614,2004 \text{ kN}$$

Kontrol tegangan geser horizontal minimal

$$V_{j,h,x} = V_{j,h,x}/(b_j \cdot h_c) < 1,5 \sqrt{f_c}$$

$$V_{j,h,x} = 1614,2004 / (0,7 \cdot 0,7) \cdot 10^{-3} < 1,5 \sqrt{25}$$

$$3,4348 \text{ N/mm}^2 < 7,5 \text{ N/mm}^2$$

Penulangan geser horizontal

$$N_{u,k} = 3860,1750 \text{ kN}$$

$$\begin{aligned} V_{c,h} &= 2/3 \cdot \sqrt{[(N_{u,k}/A_g) - 0,1f_c] \cdot b_j \cdot h_c} \\ &= 2/3 \cdot \sqrt{[(3860,1750 \cdot 10^3 / (700 \cdot 700)) - 0,1 \cdot 25] \cdot 700 \cdot 700} \\ &= 606,0403 \text{ kN} \end{aligned}$$

$$V_{s,h} + V_{c,h} = V_{j,h}$$

$$V_{s,h} = 1614,2004 - 606,0403 = 1008,1601 \text{ kN}$$

$$A_{j,h} = V_{s,h}/f_y = 1008,1601 \cdot 10^3 / 240 = 4200,67 \text{ mm}^2$$

digunakan sengkang rangkap 4P13

$$\text{luas yang tersedia} = 4 \cdot 0,25 \cdot 13^2 \cdot \pi = 530,92 \text{ mm}^2$$

$$\text{jumlah lapis sengkang} = 4200,67 / 530,92 = 7,9120 = 8 \text{ lapis}$$

2. Penulangan Geser Vertikal

$$\begin{aligned} V_{c,v} &= \frac{A_s'}{A_s} V_{j,h} \left(0,6 + \frac{N_{u,k}}{A_g f_c'} \right) \\ &= 1614,2004 \cdot 10^3 \left(0,6 + \frac{3860,1750 \cdot 10^3}{700 \cdot 700 \cdot 25} \right) \\ &= 14771811 \text{ N} = 1477,1811 \text{ kN} \end{aligned}$$

$$V_{s,v} = V_{j,h} - V_{c,v}$$

$$= 1614,2004 - 1477,1811 = 137,0193 \text{ kN}$$

$$A_{j,v} = V_{s,v}/f_y = 137,0193 \cdot 10^3 / 240 = 570,91 \text{ mm}^2$$

$$\text{Tulangan kolom terpasang} = 10\text{D}25 = 4906,25 \text{ mm}^2 > (A_{j,v} = 570,91 \text{ mm}^2)$$

Tulangan pokok kolom dapat menahan geser vertikal

Dengan cara yang sama didapat penulangan geser horizontal dan vertikal pada pertemuan balok kolom, yang disajikan pada Tabel 7.20.

Tabel 7.20 Penulangan Geser Pertemuan Balok Kolom Daktilitas Penuh

Ko- lom	Lan- tai	h (m)	Kiri		Kanan		V _{kol} (kNm)	C _{kr} (kN)	T _{ka} (kN)	V _{jh} (kN)	N _{uk} (kN)	Penulangan Geser Vertikal				Penulangan Geser Horizontal						
			M _{nak,b} (kNm)	I _{ki} (m)	I _{nki} (m)	M _{nak,b} (kNm)						I _{kn} (m)	I _{nkn} (m)	V _{cv} (kN)	V _{sv} (kN)	A _{iv} (mm ²)	A _{s≥A_{iv}} (mm ²)	V _{ch} (kN)	V _{sh} (kN)	A _{jh} (mm ²)	n	
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]	[21]	[22]	[23]
K1	1 sb-x	5.4	0,0000	0,0	0,0	1100,2200	9,6	8,9	203,3538	150,1472	1543,4026	1490,1960	1301,1000	189,0961	787,90	4906,25	509,6745	980,5215	4085,51	8		
	sb-y	5.4	358,9232	7,2	6,5	673,1497	7,2	6,5	375,1673	500,4905	1119,1251	1244,4483	1086,5360	157,9123	657,97	4906,25	509,6745	734,7739	3061,56	5		
	2 sb-x	3.8	0,0000	0,0	0,0	1100,2200	9,6	8,9	295,3981	150,1472	1543,4026	1398,1517	1139,8580	258,2937	1076,22	4906,25	415,8882	982,2635	4092,76	8		
	sb-y	3.8	358,9232	7,2	6,5	673,1497	7,2	6,5	544,9794	500,4905	1119,1251	1074,6362	876,1086	198,5276	827,20	4906,25	415,8882	658,7480	2744,78	5		
	3 sb-x	3.8	0,0000	0,0	0,0	1100,2186	9,6	8,9	253,7829	135,0948	1416,8985	1298,2103	980,4101	317,8002	1324,17	4906,25	287,8132	1010,3972	4209,99	8		
sb-y	3.8	358,9232	7,2	6,5	566,4322	7,2	6,5	544,9487	500,3511	1062,5820	1017,9844	788,7831	249,2013	1038,34	4906,25	287,8132	730,1713	3042,38	5			
4 sb-x	3.8	0,0000	0,0	0,0	1100,2186	9,6	8,9	253,7817	90,0598	1151,2300	987,5081	679,8631	307,6450	1281,85	4906,25	0,0000	987,5081	4114,62	8			
sb-y	3.8	358,9097	7,2	6,5	566,4322	7,2	6,5	544,9445	300,1994	937,5724	965,5763	476,9861	215,8411	899,34	4906,25	0,0000	692,8272	2886,78	5			
5 sb-x	3.8	0,0000	0,0	0,0	1100,2186	9,6	8,9	88,6822	75,2774	978,9611	965,5763	643,7353	630,0866	335,4897	1397,87	4906,25	0,0000	965,5763	4023,23	8		
sb-y	3.8	179,9488	7,2	6,5	232,9100	7,2	6,5	272,9381	250,9246	667,2719	645,2584	421,0633	224,1951	934,15	4906,25	0,0000	645,2584	2698,58	5			
K2	1 sb-x	5.4	1100,2186	9,6	8,9	378,1163	2,4	1,7	464,8381	1361,8244	717,2141	1614,2004	1477,1811	137,0193	570,91	4906,25	606,0403	1008,1601	4200,67	8		
	sb-y	5.4	673,1497	7,2	6,5	358,9232	7,2	6,5	453,5299	1049,1793	586,7480	1152,3985	1054,5786	97,8198	407,58	4906,25	606,0403	546,3582	2276,49	5		
	2 sb-x	3.8	1100,2186	9,6	8,9	578,1163	2,4	1,7	608,5903	1361,8244	717,2141	1469,4482	3119,4851	1255,8686	213,5816	889,92	4906,25	513,8571	955,5911	3981,63	8	
	sb-y	3.8	673,1497	7,2	6,5	358,9232	7,2	6,5	549,0098	1189,0699	519,6324	1159,6925	991,1333	168,5592	702,33	4906,25	513,8571	645,8354	2690,98	5		
	3 sb-x	3.8	1100,2186	9,6	8,9	578,1163	2,4	1,7	552,8450	1328,3423	717,1785	1492,6757	2159,3019	1158,7187	333,9570	1391,49	4906,25	428,5229	1064,1529	4433,97	8	
sb-y	3.8	566,4322	7,2	6,5	358,8097	7,2	6,5	516,3472	1000,0772	519,5216	1083,2516	778,7937	284,4579	935,24	4906,25	428,5229	574,2817	2394,70	5			
4 sb-x	3.8	1100,2186	9,6	8,9	578,1186	2,4	1,7	598,9155	1062,6738	621,5567	1085,3151	849,9796	726,4949	368,8203	1495,08	4906,25	0,0000	823,3628	4522,10	8		
sb-y	3.8	566,4322	7,2	6,5	358,8097	7,2	6,5	446,2174	750,0579	519,5223	823,3628	551,1476	272,2152	1134,23	4906,25	0,0000	1083,3628	3430,68	5			
K3	1 sb-x	5.4	0,0000	0,0	0,0	348,9900	4,8	4,1	192,4563	0,0000	691,4123	498,9560	1460,7144	358,8701	140,0859	1962,50	169,9265	-329,0295	-1370,96	4		
	sb-y	5.4	0,0000	0,0	0,0	673,1497	7,2	6,5	96,8484	0,0000	976,1821	879,3338	632,4538	246,8800	1028,67	1962,50	169,9265	709,4073	2955,86	6		
	2 sb-x	3.8	0,0000	0,0	0,0	348,9900	4,8	4,1	186,3789	0,0000	640,7251	454,3462	1194,3294	316,9048	137,4414	572,67	1962,50	0,0000	454,3462	1893,11	4	
	sb-y	3.8	0,0000	0,0	0,0	538,5200	7,2	6,5	117,2375	0,0000	852,0703	734,8328	512,5432	222,2897	926,21	1962,50	0,0000	734,8328	3061,80	6		
	3 sb-x	3.8	0,0000	0,0	0,0	348,9900	4,8	4,1	196,0391	0,0000	651,2338	455,1947	913,8965	307,0761	148,1186	617,16	1962,50	0,0000	455,1947	1896,64	4	
sb-y	3.8	0,0000	0,0	0,0	566,4322	7,2	6,5	117,2375	0,0000	842,2538	725,0163	489,0987	235,9176	982,99	1962,50	0,0000	725,0163	3020,90	6			
4 sb-x	3.8	0,0000	0,0	0,0	348,9900	4,8	4,1	196,0391	0,0000	651,2338	455,1947	632,8115	296,6313	156,5634	660,68	1962,50	0,0000	455,1947	1896,64	4		
sb-y	3.8	0,0000	0,0	0,0	566,4322	7,2	6,5	74,0174	0,0000	795,4619	721,4445	470,1951	251,3093	1047,12	1962,50	0,0000	721,4445	3006,02	6			
5 sb-x	3.8	0,0000	0,0	0,0	179,5400	4,8	4,1	66,5900	0,0000	521,6806	455,0906	242,0313	282,0459	173,0447	721,02	1962,50	0,0000	455,0906	1896,21	4		
sb-y	3.8	0,0000	0,0	0,0	232,9100	7,2	6,5	68,4222	0,0000	739,7804	671,3582	416,0794	255,2788	1063,66	1962,50	0,0000	671,3582	2797,33	6			
K4	1 sb-x	5.4	358,4400	4,8	4,1	348,9900	4,8	4,1	96,0528	565,8795	462,3075	932,1341	1811,6971	697,1372	234,9969	979,15	1962,50	268,0865	664,0476	2766,86	6	
	sb-y	5.4	229,1173	3,6	2,9	0,0000	0,0	0,0	101,3639	445,9597	138,6922	483,2880	361,4480	121,8400	507,87	1962,50	268,0865	715,2015	896,67	4		
	2 sb-x	3.8	358,4400	4,8	4,1	348,9900	4,8	4,1	116,2745	565,8795	462,3075	911,9125	1491,3316	658,1649	253,7475	1057,28	180,6256	731,2868	3047,03	6		
	sb-y	3.8	229,1173	3,6	2,9	0,0000	0,0	0,0	122,7037	445,9597	138,6922	461,9483	333,4072	128,5411	535,59	1962,50	180,6256	281,3226	1172,18	4		
	3 sb-x	3.8	358,4400	4,8	4,1	348,9900	4,8	4,1	116,2745	565,8795	462,3075	911,9125	1178,3476	634,8658	277,0466	1154,36	1962,50	0,0000	911,9125	3799,64	6	
sb-y	3.8	229,1173	3,6	2,9	0,0000	0,0	0,0	122,7037	445,9597	138,6922	461,9483	321,6045	140,3437	584,77	1962,50	0,0000	461,9483	1924,78	4			
4 sb-x	3.8	358,4400	4,8	4,1	348,9900	4,8	4,1	116,2745	565,8795	462,3075	911,9125	737,3205	602,0350	309,8775	1291,16	1962,50	0,0000	911,9125	3799,64	6		
sb-y	3.8	229,1173	3,6	2,9	0,0000	0,0	0,0	122,7037	445,9597	138,6922	461,9483	304,9734	156,9749	654,06	1962,50	0,0000	461,9483	1924,78	4			
5 sb-x	3.8	179,5400	4,8	4,1	179,5400	4,8	4,1	120,3240	369,2809	300,4255	549,3823	275,8245	341,9995	207,3829	864,10	1962,50	0,0000	549,3823	2289,09	6		
sb-y	3.8	137,1643	3,6	2,9	0,0000	0,0	0,0	136,4949	319,6456	90,1276	273,2784	170,1203	103,1581	429,83	1962,50	0,0000	273,2784	1138,66	4			

Tabel 7.20. Lanjutan

Ko- lom	Lan- tai	Arah	h (m)	Kiri				Kanan				V _{kol} (kNm)	C _{ki} (kN)	T _{ke} (kN)	V _{jh} (kN)	N _{u,k} (kN)	Penulangan Geser Vertikal				Penulangan Geser Horizontal			
				M _{nak,b} (kNm)	I _{ki} (m)	I _{nk} (m)	I _{nk} (m)	M _{nak,b} (kNm)	I _{ki} (m)	I _{nk} (m)	I _{nk} (m)						V _{cv} (kN)	V _{sv} (kN)	A _v (mm ²)	A _{s2-A₁v} (mm ²)	V _{ch} (kN)	V _{sh} (kN)	A _{j/h} (mm ²)	n
K5	1	sb-x	4	358,4362	4,8	4,1	348,9900	2,4	1,7	326,7361	584,9627	691,4123	949,6390	2428,7337	758,0626	191,5764	798,23	1962,50	384,0018	585,6372	2356,82	5		
			5	358,9232	3,6	3,1	673,1497	2,2	6,5	224,6706	585,3906	978,1821	1336,9021	1087,2008	269,7013	1123,76	1962,50	384,0018	952,9003	3970,42	6			
	2	sb-x	3	358,4362	4,8	4,1	348,9900	2,4	1,7	395,5226	584,9627	691,4123	880,8524	2014,9164	673,3967	207,4557	864,40	1962,50	311,0703	569,7821	2374,09	5		
			4	358,9232	3,6	3,1	673,1497	2,2	6,5	296,6942	585,3906	978,1821	1264,8785	966,9781	297,9004	1241,25	1962,50	311,0703	953,8081	3974,20	6			
	3	sb-x	sb-y	3	358,4362	4,8	4,1	348,9900	2,4	1,7	352,6563	552,4244	615,0542	814,8223	1290,8406	574,7551	240,0672	1000,28	1962,50	0,0000	814,8223	3395,09	5	
				4	358,9232	3,6	3,1	673,1497	2,2	6,5	296,6581	552,7343	795,4619	1051,5382	741,7285	309,8097	1290,87	1962,50	0,0000	1051,5382	4381,41	6		
4	sb-x	sb-y	3	358,4362	4,8	4,1	348,9900	2,4	1,7	352,6563	552,4244	615,0542	814,8223	737,3205	537,9371	276,8852	1153,69	1962,50	0,0000	814,8223	3395,09	5		
			4	358,9232	3,6	3,1	673,1497	2,2	6,5	244,7940	552,7343	795,4619	1103,4022	728,4545	374,9477	1562,28	1962,50	0,0000	1103,4022	4597,51	6			
5	sb-x	sb-y	3	179,5400	4,8	4,1	179,5400	2,4	1,7	115,7283	400,0695	434,8430	719,1841	355,4523	452,3787	266,8054	1111,69	1962,50	0,0000	719,1841	2996,60	5		
			4	137,1922	3,6	3,1	201,1347	2,2	6,5	104,7975	346,3333	462,2450	703,7608	442,6898	261,0911	1087,88	1962,50	0,0000	703,7608	2932,42	6			
K6	1	sb-x	4	0,0000	0,0	0,0	229,1173	4,8	4,1	81,2684	109,5382	385,6656	413,9354	1344,0608	375,5279	38,4074	160,03	3799,40	199,1533	214,7821	894,93	6		
			5	229,1173	3,6	3,1	229,1173	3,6	3,1	342,1928	296,6658	385,6656	340,1386	308,5785	31,5601	131,50	1519,76	199,1533	140,9853	587,44	4			
	2	sb-x	sb-y	3	0,0000	0,0	0,0	229,1173	4,8	4,1	98,3775	109,5382	385,6656	336,8262	914,2791	321,0237	75,8025	315,84	3799,40	144,4267	252,3995	1051,66	4	
				4	229,1173	3,6	3,1	229,1173	3,6	3,1	344,4945	296,6658	385,6656	337,8369	631,5561	273,3028	64,5342	268,89	1519,76	144,4267	193,4101	805,88	4	
	3	sb-x	sb-y	3	0,0000	0,0	0,0	229,1173	4,8	4,1	98,3775	109,5382	385,6656	396,8262	375,6522	295,3789	101,4464	422,69	3799,40	92,1409	304,6853	1269,52	6	
				4	229,1173	3,6	3,1	229,1173	3,6	3,1	344,4945	296,6658	385,6656	337,8369	375,6522	272,1686	124,6577	519,41	3799,40	0,0000	396,8262	1653,44	6	
4	sb-x	sb-y	3	0,0000	0,0	0,0	229,1173	4,8	4,1	98,3775	109,5382	385,6656	404,0430	157,1283	272,1686	126,9247	528,85	3799,40	0,0000	404,0430	1515,16	4		
			4	229,1173	3,6	3,1	229,1173	3,6	3,1	278,2884	296,6658	385,6656	357,3999	388,5223	247,0672	141,4551	569,40	3799,40	0,0000	388,5223	1618,84	6		
5	sb-x	sb-y	3	0,0000	0,0	0,0	137,1600	3,6	3,1	137,1600	273,2271	355,2064	357,3999	1400,6958	227,2569	130,1130	542,14	1519,76	0,0000	357,3999	1489,04	4		
			4	229,1200	4,8	4,1	229,1200	2,4	1,7	259,4741	302,5632	305,1328	278,5775	992,5062	256,3356	22,2419	92,67	3799,40	205,2798	73,2977	305,41	4		
6	sb-y	sb-x	4	348,9900	3,6	3,1	358,4400	3,6	3,4	212,0512	378,6162	387,1814	442,9972	1400,6958	407,6278	35,3693	147,37	1519,76	205,2798	237,7173	990,49	6		
			5	229,1200	4,8	4,1	229,1200	2,4	1,7	314,1002	302,5632	305,1328	234,8767	992,5062	194,2098	40,6669	169,45	3799,40	155,8253	79,0514	329,38	4		
7	sb-y	sb-x	3	348,9900	3,6	3,1	358,4400	3,6	3,4	256,6935	378,6162	387,1814	407,2833	633,2403	336,7657	70,5176	293,82	3799,40	155,8253	251,4560	1047,74	6		
			4	229,1200	4,8	4,1	229,1200	2,4	1,7	314,1002	302,5632	305,1328	234,8767	633,2403	174,9222	59,9545	249,81	3799,40	92,5399	142,3367	539,07	4		
8	sb-y	sb-x	3	348,9900	3,6	3,1	358,4400	3,6	3,4	256,6935	378,6162	387,1814	407,2833	633,2403	303,3204	103,9629	433,18	1519,76	92,5399	314,7433	1311,43	6		
			4	229,1200	4,8	4,1	229,1200	2,4	1,7	314,1002	302,5632	305,1328	234,8767	633,2403	161,1928	73,6838	307,02	3799,40	0,0000	234,8767	978,65	4		
9	sb-y	sb-x	3	348,9900	3,6	3,1	358,4400	3,6	3,4	225,9740	378,6162	387,1814	431,8589	174,6003	296,3792	135,4797	564,50	1519,76	0,0000	431,8589	1619,47	6		
			4	229,1200	4,8	4,1	229,1200	2,4	1,7	120,1785	179,0081	161,6220	176,3613	174,6003	112,8551	63,5082	264,61	3799,40	0,0000	176,3613	734,84	4		
10	sb-y	sb-x	3	201,1300	3,6	3,1	137,1900	3,6	3,4	150,0149	270,2703	198,9428	255,3586	132,2013	163,4062	91,9524	383,14	1519,76	0,0000	255,3586	1063,99	6		
			4	0,0000	0,0	0,0	229,1200	4,8	4,1	67,2543	0,0000	385,6701	318,4158	651,2499	238,4479	79,9679	333,20	3799,40	128,9379	189,4779	789,49	5		
11	sb-y	sb-x	4	0,0000	0,0	0,0	229,1200	3,6	2,9	69,4096	0,0000	385,6701	316,2605	651,2499	236,8339	79,4266	330,94	3799,40	128,9379	187,3226	780,51	6		
			5	229,1200	4,8	4,1	229,1200	3,6	2,9	81,4131	0,0000	385,6701	304,2570	554,9544	221,1482	83,1088	346,29	3799,40	95,5790	208,6780	869,49	5		
12	sb-y	sb-x	3	0,0000	0,0	0,0	229,1200	3,6	2,9	84,0222	0,0000	385,6701	301,8480	316,2957	219,2518	82,3991	343,32	1519,76	95,5790	206,0690	858,62	6		
			4	229,1200	4,8	4,1	229,1200	3,6	2,9	81,4131	0,0000	385,6701	304,2570	453,7869	214,1126	90,1444	375,60	3799,40	35,5916	268,6655	1119,44	5		
13	sb-y	sb-x	3	0,0000	0,0	0,0	229,1200	3,6	2,9	84,0222	0,0000	385,6701	301,8480	316,2957	220,4689	107,4853	447,77	1519,76	0,0000	327,9342	1366,39	6		
			4	229,1200	4,8	4,1	229,1200	3,6	2,9	81,4131	0,0000	385,6701	304,2570	453,7869	212,2765	89,3714	372,38	3799,40	35,5916	266,0564	1108,57	6		
14	sb-y	sb-x	3	0,0000	0,0	0,0	229,1200	3,6	2,9	84,0222	0,0000	385,6701	301,8480	316,2957	220,4689	107,4853	447,77	1519,76	0,0000	327,9342	1366,39	6		
			4	229,1200	4,8	4,1	229,1200	3,6	2,9	81,4131	0,0000	385,6701	304,2570	453,7869	212,2765	89,3714	372,38	3799,40	35,5916	266,0564	1108,57	6		
15	sb-y	sb-x	3	0,0000	0,0	0,0	137,1600	4,8	4,1	48,7370	0,0000	230,8769	182,1399	132,2013	114,7877	67,3522	280,63	3799,40	0,0000	182,1399	758,92	5		
			4	229,1200	4,8	4,1	229,1200	3,6	2,9	11,0925	0,0000	230,8769	219,7844	132,2013	114,7877	67,3522	280,63	3799,40	0,0000	182,1399	758,92	5		
16	sb-y	sb-x	3	0,0000	0,0	0,0	137,1600	3,6	2,9	11,0925	0,0000	230,8769	219,7844	132,2013	114,7877	67,3522	280,63	3799,40	0,0000	182,1399	758,92	5		
			4	229,1200	4,8	4,1	229,1200	3,6	2,9	11,0925	0,0000	230,8769	219,7844	132,2013	114,7877	67,3522	280,63	3799,40	0,0000	182,1399	758,92	5		

Tabel 7.20. Lanjutan

Ko- lom	Lan-Arah tai	h (m)	Kiri		Kanan		V kol (kNm)	C ki (kN)	T ka (kN)	V jh (kN)	N u,k (kN)	Penulangan Geser Vertikal		Penulangan Geser Horizontal								
			M nak,b (kNm)	I ki (m)	M nak,b (kNm)	I ki (m)						V cv (kN)	A jv (mm²)	V ch (kN)	A jh (mm²)							
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]	[21]	[22]	[23]
K9	1	sb-x	5,4	229,1200	4,8	4,1	229,1200	4,8	4,1	206,3161	296,6693	435,9040	421,0058	1080,7654	356,6054	64,4004	268,33	3799,40	223,6778	197,3280	822,20	4
		sb-y	5,4	0,0000	0,0	0,0	358,4400	3,6	3,4	140,2432	89,0008	593,1163	401,4992		340,0827	61,4165	255,90	1519,76	223,6778	177,8214	740,92	6
	2	sb-x	3,8	229,1200	4,8	4,1	229,1200	4,8	4,1	249,7510	296,6693	435,9040	386,2578	793,9407	301,8497	84,4081	351,70	3799,40	166,5027	219,7551	915,65	4
		sb-y	3,8	0,0000	0,0	0,0	358,4400	3,6	3,4	169,7680	89,0008	553,1163	377,8793		295,3021	82,5771	344,07	1519,76	166,5027	211,3765	890,74	6
	3	sb-x	3,8	229,1200	4,8	4,1	229,1200	4,8	4,1	249,7510	296,6693	435,9040	386,2578	517,1817	277,4154	108,8424	453,51	3799,40	78,7240	307,5338	1153,25	4
		sb-y	3,8	0,0000	0,0	0,0	358,4400	3,6	3,4	169,7680	89,0008	553,1163	377,8793		271,3978	106,4815	443,67	1519,76	78,7240	299,1553	1246,48	6
	4	sb-x	3,8	229,1200	4,8	4,1	229,1200	4,8	4,1	249,7510	296,6693	435,9040	386,2578	334,3578	261,2743	124,9835	520,76	3799,40	0,0000	386,2578	1287,53	4
		sb-y	3,8	0,0000	0,0	0,0	358,4400	3,6	3,4	169,7680	89,0008	553,1163	377,8793		255,6069	122,2724	509,47	1519,76	0,0000	377,8793	1574,50	6
	5	sb-x	3,8	136,6200	4,8	4,1	137,1600	4,8	4,1	216,0877	190,5060	341,2040	252,4978	174,6381	161,5777	90,9201	378,83	3799,40	0,0000	252,4978	1032,07	4
		sb-y	3,8	0,0000	0,0	0,0	358,4400	3,6	3,4	149,6879	57,1518	557,1944	371,7266		237,8743	133,8523	557,72	1519,76	0,0000	371,7266	1548,86	6

Keterangan Tabel 7.20:

- [1] Kolom yang ditinjau
- [2] Lantai yang ditinjau
- [3] Arah sumbu x dan sumbu y
- [4] l = panjang kolom
- [5] $M_{nak,b,ki}$ = momen nominal aktual balok kiri
- [6] I_{ki} = panjang bentang balok kiri
- [7] $M_{nak,b,ka}$ = momen nominal aktual balok kanan
- [8] I_{ka} = panjang bentang balok kanan
- [9] I_{ka} = panjang bentang balok kanan
- [10] I_{nka} = panjang bentang bersih balok kanan
- [11] $V_{kol,x} = 0,7 \cdot 1,25 \cdot (I_{ll} \cdot n \cdot \sum M_{nak,b,x} + 0,3 \cdot I_{ll} \cdot n \cdot \sum M_{nak,b,y}) / (0,5 \cdot (h_a + h_b))$
 $V_{kol,y} = 0,7 \cdot 1,25 \cdot (I_{ll} \cdot n \cdot \sum M_{nak,b,y} + 0,3 \cdot I_{ll} \cdot n \cdot \sum M_{nak,b,x}) / (0,5 \cdot (h_a + h_b))$
- [12] $C_{ki,x} = 0,7 \cdot 1,25 \cdot (M_{nak,b,ki,x} + 0,3 \cdot M_{nak,b,ki,y}) / Z_{ki}$
 $C_{ki,y} = 0,7 \cdot 1,25 \cdot (M_{nak,b,ki,y} + 0,3 \cdot M_{nak,b,ki,x}) / Z_{ki}$
- [13] $T_{ka,x} = 0,7 \cdot 1,25 \cdot (M_{nak,b,ka,x} + 0,3 \cdot M_{nak,b,ka,y}) / Z_{ka}$
 $T_{ka,y} = 0,7 \cdot 1,25 \cdot (M_{nak,b,ka,y} + 0,3 \cdot M_{nak,b,ka,x}) / Z_{ka}$
- [14] $V_{jh} = C_{ki} + T_{ka} - V_{kol}$
- [15] $N_{u,k}$ = gaya aksial rencana kolom
- [16] $V_{cv} = A_s \cdot V_{jh} / A_s (0,6 + N_{u,k} / (A_g \cdot f_c))$
- [17] $V_{sv} = V_{jh} - V_{cv}$
- [18] $A_{jv} = V_{sv} / f_y$
- [19] $A_s =$ luas tul. pokok kolom $> A_{sv}$
- [20] $V_{ch} = 2/3 \cdot [(N_{u,k} / A_g) - 0,1 \cdot f_c] \cdot 0,5 \cdot b_j \cdot h_c$
- [21] $V_{sh} = V_{jh} - V_{ch}$
- [22] $A_{jh} = V_{sh} / f_y$
- [23] $n = A_{jh} / (4 \cdot 0,25 \cdot 3,14 \cdot 13^2)$ (jumlah lapis tul.geser)
 - Untuk kolom K1, K2, K3, K4, dan K5 digunakan tul. Geser 4P13
 - Untuk kolom K6, K7, K8 dan K9 digunakan tul. Geser 2P13

BAB VIII

PERENCANAAN STRUKTUR PORTAL BETON BERTULANG DENGAN DAKTILITAS TERBATAS

Pada bab ini merupakan kelanjutan dari bahasan analisa struktur sebelumnya. Untuk perencanaan daktilitas terbatas meliputi momen rencana balok, penulangan lentur balok, gaya geser rencana balok, penulangan geser balok, momen rencana kolom, penulangan lentur kolom, gaya geser rencana kolom, dan penulangan geser kolom. Struktur, pembebanan dan lain-lain diambil sama dengan perhitungan daktilitas penuh, sehingga gaya-gaya dalam yang dihasilkan analisa struktur tetap dapat dipakai. Khusus untuk gaya gempa diberi faktor pengali 2 ($K = 2,0$).

8.1 Desain Balok

8.1.1 Momen Rencana Balok

Momen rencana balok dihitung berdasarkan tipe-tipe pembebanan menurut SK SNI T-15-1991-03 adalah sebagai berikut.

$$M_{u1} = 1,2M_D + 1,6M_L$$

$$M_{u2} = 1,05 (M_D + 0,9M_L + M_{Gki})$$

$$M_{u3} = 1,05 (M_D + 0,9M_L + M_{Gka})$$

$$M_{u4} = 0,9 (M_D + M_{Gki})$$

$$M_{u5} = 0,9 (M_D + M_{Gka})$$

Contoh perhitungan diambil pada Balok lantai 1 tumpuan kiri:

Diketahui:

$$M_D = -130,9800 \text{ kN} ; M_L = -71,3500 \text{ kN}$$

$$M_{Gki} = 432,3000 \text{ kN} ; M_{Gka} = -428,8800 \text{ kN}$$

$$M_u = 1,05 (M_D + 0,9M_L + M_{Gka})$$

$$= 1,05 (-130,9800 + 0,9 \cdot (-71,3500) + (-428,8800)) = -655,2788 \text{ kN}$$

Hasil perhitungan momen rencana balok lainnya disajikan pada Tabel 8.1.

Tabel 8.1 Momen Rencana Balok Daktilitas Terbatas (Satuan kNm)

Port- tal	No. Elm Balok	Letak Momen	M mati	M hidup	M Gempa		Mu1	Mu2	Mu3	Mu4	Mu5	Balok
			MD	ML	M Gki	M Gka						
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]
As 1 dan As 6	25	Tump ki	-27,3300	-2,4300	162,4200	-161,3000	-36,6840	139,5482	-200,3579	121,5810	-169,7670	Sloof
		Lap	12,2700	1,6300	162,4200	158,5200	17,3320	184,9649	180,8699	157,2210	153,7110	
		Tump ka	-22,8500	1,6300	-159,3000	158,5200	-24,8120	-189,7172	143,9939	-163,9350	122,1030	
	26	Tump ki	-24,9300	-0,0300	157,5400	-157,3800	-29,9640	139,2122	-191,4539	119,3490	-164,0790	Balok Lantai 1
		Lap	12,3900	-0,0300	157,5400	157,5400	14,8200	178,3982	178,3982	152,9370	152,9370	
		Tump ka	-24,9300	-0,0300	-157,3800	157,5400	-29,9640	-191,4539	139,2122	-164,0790	119,3490	
	27	Tump ki	-22,8500	1,6300	158,5200	-159,3000	-24,8120	143,9939	-189,7172	122,1030	-163,9350	Balok Lantai 1
		Lap	12,2700	1,6300	158,5200	162,4200	17,3320	180,8699	184,9649	153,7110	157,2210	
		Tump ka	-23,3300	-2,4300	-161,3000	162,4200	-31,8840	-196,1579	143,7482	-166,1670	125,1810	
	28-30	Tump ki	-130,9800	-71,3500	432,3000	-428,8800	-271,3360	248,9603	-655,2788	271,1880	-503,8740	Balok Lantai 1
		Lap	77,8100	42,9700	432,3000	400,8400	162,1240	576,2222	543,1892	459,0990	430,7850	
		Tump ka	-145,7200	-80,6300	-403,0400	400,8400	-303,8720	-652,3934	191,6807	-493,8840	229,6080	
	31-33	Tump ki	-144,1700	-79,3600	382,7800	-382,3600	-299,9800	175,5453	-627,8517	214,7490	-473,8770	Balok Lantai 2
		Lap	71,8900	39,5500	382,7800	382,7800	149,5480	514,7783	514,7783	409,2030	409,2030	
		Tump ka	-144,1700	-79,3600	-382,3600	382,7800	-299,9800	-627,8517	175,5453	-473,8770	214,7490	
	34-36	Tump ki	-145,7200	-80,6300	400,8400	-403,0400	-303,8720	191,6807	-652,3934	229,6080	-493,8840	Balok Lantai 2
		Lap	77,8100	42,9700	400,8400	432,3000	162,1240	543,1892	576,2222	430,7850	459,0990	
		Tump ka	-130,9800	-71,3500	-428,8800	432,3000	-271,3360	-655,2788	248,9603	-503,8740	271,1880	
	37-39	Tump ki	-139,1000	-76,3000	401,2600	-398,8000	-289,0000	203,1645	-636,8985	235,9440	-484,1100	Balok Lantai 2
		Lap	76,4700	42,0700	401,2600	375,7200	159,0760	541,3727	514,5557	429,9570	406,9710	
		Tump ka	-140,0800	-77,3600	-377,2800	375,7200	-291,8720	-616,3332	174,3168	-465,6240	212,0760	
	40-42	Tump ki	-143,6600	-79,0700	365,9000	-365,5600	-298,9040	158,6309	-609,4022	200,0160	-458,2980	Balok Lantai 3
		Lap	72,4000	39,8400	365,9000	365,9000	150,6240	497,8638	497,8638	394,4700	394,4700	
		Tump ka	-143,6600	-79,0700	-365,5600	365,9000	-298,9040	-609,4022	158,6309	-458,2980	200,0160	
43-45	Tump ki	-140,0800	-77,3600	375,7200	-377,2800	-291,8720	174,3168	-616,3332	212,0760	-465,6240	Balok Lantai 3	
	Lap	76,4700	42,0700	375,7200	401,2600	159,0760	514,5557	541,3727	406,9710	429,9570		
	Tump ka	-139,1000	-71,3500	-398,8000	401,2600	-281,0800	-632,2208	207,8423	-484,1100	235,9440		
46-48	Tump ki	-142,1900	-77,8400	318,5400	-316,8200	-295,1720	111,6087	-555,5193	158,7150	-413,1090	Balok Lantai 3	
	Lap	76,5000	42,0800	318,5400	298,1800	159,1280	454,5576	433,1796	355,5360	337,2120		
	Tump ka	-136,9400	-75,8100	-299,3000	298,1800	-285,6240	-529,6925	97,6616	-392,6160	145,1160		
49-51	Tump ki	-143,5600	-79,0100	294,7000	-294,3600	-298,6880	84,0326	-534,4805	136,0260	-394,1280	Balok Lantai 4	
	Lap	72,5000	39,9000	294,7000	294,7000	150,8400	423,2655	423,2655	330,4800	330,4800		
	Tump ka	-143,5600	-79,0100	-294,3600	294,7000	-298,6880	-534,4805	84,0326	-394,1280	136,0260		
52-54	Tump ki	-136,9400	-75,8100	298,1800	-299,3000	-285,6240	97,6616	-529,6925	145,1160	-392,6160	Balok Lantai 4	
	Lap	76,5000	42,0800	298,1800	318,5400	159,1280	433,1796	454,5576	337,2120	355,5360		
	Tump ka	-142,1900	-77,8400	-316,8200	318,5400	-295,1720	-555,5193	111,6087	-413,1090	158,7150		
55-57	Tump ki	-140,1800	-75,7700	223,0000	-214,2000	-289,4480	15,3584	-443,7017	74,5380	-318,9420	Balok Lantai 4	
	Lap	77,4500	42,8400	223,0000	201,6800	161,4840	355,9563	333,5703	270,4050	251,2170		
	Tump ka	-137,0600	-76,3600	-207,4000	201,6800	-286,6480	-433,8432	-4,3092	-310,0140	58,1580		
58-60	Tump ki	-143,4000	-78,9700	206,5800	-205,4600	-298,4320	-8,2877	-440,9297	56,8620	-313,9740	Balok Ring	
	Lap	72,6600	39,9300	206,5800	206,5800	151,0800	330,9359	330,9359	251,3160	251,3160		
	Tump ka	-143,4000	-78,9700	-205,4600	206,5800	-298,4320	-440,9297	-8,2877	-313,9740	56,8620		
61-63	Tump ki	-137,0600	-76,3600	201,6800	-207,4000	-286,6480	-4,3092	-433,8432	58,1580	-310,0140	Balok Ring	
	Lap	77,4500	42,8400	201,6800	223,0000	161,4840	333,5703	355,9563	251,2170	270,4050		
	Tump ka	-140,1800	-75,7700	-214,2000	223,0000	-289,4480	-443,7017	15,3584	-318,9420	74,5380		
64-65	Tump ki	-55,7000	-18,6400	78,4600	-71,2000	-96,6640	6,2832	-150,8598	20,4840	-114,2100	Balok Ring	
	Lap	49,7200	16,4000	78,4600	68,2200	85,9040	150,0870	139,3350	115,3620	106,1460		
	Tump ka	-52,7900	-13,3500	-72,9600	68,2200	-84,7080	-144,6533	3,5857	-113,1750	13,8870		
66-67	Tump ki	-60,2300	-15,8800	73,2000	-72,3200	-97,6840	-1,3881	-154,1841	11,6730	-119,2950	Balok Lantai 3	
	Lap	54,9100	16,5200	73,2000	73,2000	92,3240	150,1269	150,1269	115,2990	115,2990		
	Tump ka	-60,2300	-15,8800	-72,3200	73,2000	-97,6840	-154,1841	-1,3881	-119,2950	11,6730		
68-69	Tump ki	-52,7900	-13,3500	68,2200	-72,9600	-84,7080	3,5857	-144,6533	13,8870	-113,1750	Balok Lantai 4	
	Lap	49,7200	16,4000	68,2200	78,4600	85,9040	139,3350	150,0870	106,1460	115,3620		
	Tump ka	-55,7000	-18,6400	-71,2000	78,4600	-96,6640	-150,8598	6,2832	-114,2100	20,4840		
As 2 dan As 5 (A-B)	13	Tump ki	-5,6300	-0,2400	107,3200	-107,2600	-7,1400	106,5477	-118,7613	91,5210	-101,6010	Balok Sloof
		Lap	3,7800	0,1200	107,3200	129,5200	4,7280	116,7684	140,0784	99,9900	119,9700	
		Tump ka	-5,4700	0,1200	-129,5000	129,5200	-6,3720	-141,6051	130,3659	-121,4730	111,6450	
	14	Tump ki	-12,9200	-2,0500	159,0400	-158,9200	-18,7840	151,4888	-182,3693	131,5080	-154,6560	Balok Lantai 1
		Lap	11,1700	1,8500	159,0400	198,5600	16,3640	180,4688	221,9648	153,1890	188,7570	
		Tump ka	-15,3500	-2,5400	-198,5000	198,5600	-22,4840	-226,9428	189,9702	-192,4650	164,8890	
	15	Tump ki	-14,0200	-2,3000	160,3600	-160,3000	-20,5040	151,4835	-185,2095	131,7060	-156,8880	Balok Lantai 2
		Lap	10,9800	1,7800	160,3600	198,1000	16,0240	181,5891	221,2161	154,2060	188,1720	
		Tump ka	-14,7800	-2,4200	-198,0200	198,1000	-21,6080	-225,7269	190,1991	-191,5200	164,9880	
	16	Tump ki	-14,0400	-2,3000	129,2800	-129,1800	-20,5280	118,8285	-152,5545	103,7160	-128,8980	Balok Lantai 3
		Lap	10,9200	1,7900	129,2800	159,5800	15,9680	148,9016	180,7166	126,1800	153,4500	
		Tump ka	-14,7100	-2,4100	-159,5200	159,5800	-21,5080	-185,2190	149,8361	-156,8070	130,3830	
17	Tump ki	-13,6900	-2,2100	91,0600	-87,0400	-19,9640	79,1501	-107,8550	69,6330	-90,6570	Balok Lantai 4	
	Lap	11,0400	1,8200	91,0600	105,5200	16,1600	108,9249	124,1079	91,8900	104,9040		
	Tump ka	-14,8100	-2,4400	-105,5000	105,5200	-21,6760	-128,6313	92,9397	-108,2790	81,6390		

Tabel 8.1 Lanjutan

Por- tal	No. Elm Balok	Letak Momen	M mati	M hidup	M Gempa		Mu1	Mu2	Mu3	Mu4	Mu5	Balok
			MD	ML	M Gki	M Gka						
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]
As 2, As 5 (A-B)	18	Tump ki	-5,8900	-0,8800	39,3600	-39,4200	-8,4760	34,3119	-48,4071	30,1230	-40,7790	Balok
		Lap	5,6700	0,7900	39,3600	56,4800	8,0680	48,0281	66,0041	40,5270	55,9350	Atap
		Tump ka	-5,6400	-0,7800	-56,7000	56,4800	-8,0160	-66,1941	52,6449	-56,1060	45,7560	
As 2 dan As 5 (E-G)	19	Tump ki	-8,86	-0,5600	160,8600	-160,6200	-11,5280	159,0708	-178,4832	136,8000	-152,5320	Balok
		Lap	3,69	0,6100	160,8600	62,2400	5,4040	173,3540	69,8030	148,0950	59,3370	Sloof
		Tump ka	-2,89	0,6100	-62,3400	62,2400	-2,4920	-67,9151	62,8940	-58,7070	53,4150	
	20	Tump ki	-2,48	0,6900	46,6800	-46,8200	-1,8720	47,0621	-51,1130	39,7800	-44,3700	
		Lap	3,99	0,6900	46,6800	124,2400	5,8920	53,8556	135,2936	45,6030	115,4070	
		Tump ka	-8,73	-0,7600	-123,9200	124,2400	-11,6920	-140,0007	120,5673	-119,3850	103,9590	
	21	Tump ki	-22,39	-3,8800	251,2000	-250,7600	-33,0760	236,5839	-290,4741	205,9290	-245,8350	Balok
		Lap	10,23	1,8400	251,2000	86,7800	15,2200	276,2403	103,5993	235,2870	87,3090	Lantai 1
		Tump ka	-10,87	-2,2300	-86,9400	86,7800	-16,6120	-104,8079	77,5982	-88,0290	68,3190	
	22	Tump ki	-10,2	-2,1200	61,4800	-61,7200	-15,6320	51,8406	-77,5194	46,1520	-64,7280	
		Lap	11,63	2,1100	61,4800	188,1400	17,3320	78,7595	211,7525	65,7990	179,7930	
		Tump ka	-20,11	-3,4200	-187,5400	188,1400	-29,6040	-221,2644	173,1996	-186,8850	151,2270	
23	Tump ki	-26,51	-4,5400	249,0000	-248,6600	-39,0760	229,3242	-293,2188	200,2410	-247,6530	Balok	
	Lap	11,17	1,9700	249,0000	87,0800	16,5560	275,0402	105,0242	234,1530	88,4250	Lantai 2	
	Tump ka	-6,19	-1,4900	-87,1800	87,0800	-9,8120	-99,4466	83,5265	-84,0330	72,8010		
24	Tump ki	-5,14	-1,3100	65,2600	-65,3800	-8,2640	61,8881	-75,2840	54,1080	-63,4680		
	Lap	12,43	2,1900	65,2600	190,1000	18,4200	83,6441	214,7261	69,9210	182,2770		
	Tump ka	-24,96	-4,2600	-189,7800	190,1000	-36,7680	-229,5027	169,3713	-193,2660	148,6260		
25	Tump ki	-29,22	-4,9200	197,3600	-197,0200	-42,9360	171,8976	-242,2014	151,3260	-203,6160	Balok	
	Lap	12,01	2,0700	197,3600	68,5000	17,7240	221,7947	86,4917	188,4330	72,4590	Lantai 3	
	Tump ka	-3,07	-1,0500	-68,6200	68,5000	-5,3640	-76,2668	67,7093	-64,5210	58,8870		
26	Tump ki	-1,72	-0,8500	54,3800	-54,5400	-3,4240	54,4898	-59,8763	47,3940	-50,6340		
	Lap	13,42	2,3000	54,3800	153,6600	19,7840	73,3635	177,6075	61,0200	150,3720		
	Tump ka	-27,72	-4,6400	-153,2000	153,6600	-40,6880	-194,3508	127,8522	-162,8280	113,3460		
27	Tump ki	-31,18	-5,0800	125,8800	-125,8800	-45,5440	94,6344	-169,7136	85,2300	-141,3540	Balok	
	Lap	12,82	2,1200	125,8800	43,2400	18,7760	147,6384	60,8664	124,8300	50,4540	Lantai 4	
	Tump ka	-0,67	-0,8500	-43,2000	43,2400	-2,1640	-46,8668	43,8953	-39,4830	38,3130		
28	Tump ki	1,17	-0,6200	39,1800	-39,1400	0,4120	41,7816	-40,4544	36,3150	-34,1730		
	Lap	13,91	2,3600	39,1800	103,3000	20,4680	57,9747	125,3007	47,7810	105,4890		
	Tump ka	-31,47	-4,8500	-103,3400	103,3000	-45,5240	-146,1338	70,8383	-121,3290	64,6470		
29	Tump ki	-26,36	-2,7900	70,1000	-70,4000	-36,0960	43,2905	-104,2346	39,3660	-87,0840	Balok	
	Lap	13,3	1,5000	70,1000	17,3800	18,3600	88,9875	33,6315	75,0600	27,6120	Atap	
	Tump ka	-2,76	1,2500	-17,2200	17,3800	-1,3120	-19,7978	16,5323	-17,9820	13,1580		
30	Tump ki	-1,78	1,3800	13,9800	-13,7800	0,0720	14,1141	-15,0339	10,9800	-14,0040		
	Lap	15,66	1,6600	13,9800	48,2800	21,4480	32,6907	68,7057	26,6760	57,5460		
	Tump ka	-21,92	-2,5200	-48,7000	48,2800	-30,3360	-76,5324	25,2966	-63,5580	23,7240		
As 3 dan As 4	41	Tump ki	-4,6300	-0,8500	107,8400	-106,5200	-6,9160	107,5673	-117,5108	92,8890	-100,0350	Balok
		Lap	5,1000	1,7900	107,8400	198,4600	8,9840	120,2786	215,4296	101,6460	183,2040	Sloof
		Tump ka	-3,8400	1,7900	-200,0400	198,4600	-1,7440	-212,3825	206,0426	-183,4920	175,1580	
	42	Tump ki	-26,7100	-0,8600	159,3000	-157,2400	-33,4280	138,4068	-193,9602	119,3310	-165,5550	
		Lap	12,2300	0,5500	159,3000	160,4800	15,5560	180,6263	181,8653	154,3770	155,4390	
		Tump ka	-23,5200	0,5500	-162,0600	160,4800	-27,3440	-194,3393	144,3278	-167,0220	123,2640	
	43	Tump ki	-24,8300	0,0200	164,5800	-164,0400	-29,7640	146,7564	-198,2946	125,7750	-169,9830	
		Lap	12,4000	0,0200	164,5800	164,2400	14,9120	185,8479	185,4909	159,2820	158,9760	
		Tump ka	-25,0300	-0,0500	-164,2800	164,2400	-30,1160	-198,8228	146,1233	-170,3790	125,2890	
	44	Tump ki	-23,2900	0,6300	160,6000	-161,6200	-26,9400	144,7709	-193,5602	123,5790	-166,4190	
		Lap	12,1800	0,6300	160,6000	158,9200	15,6240	182,0144	180,2504	155,5020	153,9900	
		Tump ka	-27,0500	-0,9700	-157,4200	158,9200	-34,0120	-194,6102	137,5469	-166,0230	118,6830	
45	Tump ki	-7,1100	0,7800	191,7600	-193,0800	-7,2840	194,6196	-209,4624	166,1850	-180,1710		
	Lap	3,8400	0,7800	191,7600	85,3600	5,8560	206,1171	94,3971	176,0400	80,2800		
	Tump ka	-4,0100	0,2000	-85,0200	85,3600	-4,4920	-93,2925	85,6065	-80,1270	73,2150		
46	Tump ki	-3,6600	0,5700	35,1400	-36,9000	-3,4800	33,5927	-42,0494	28,3320	-36,5040		
	Lap	4,6600	0,5700	35,1400	81,4600	6,5040	42,3287	90,9647	35,8200	77,5080		
	Tump ka	-5,7500	-0,8400	-78,9400	81,4600	-8,2440	-89,7183	78,7017	-76,2210	68,1390		
47	Tump ki	-8,3400	-1,6900	121,9000	-120,7000	-12,7120	117,6410	-137,0891	102,2040	-116,1360	Balok	
	Lap	16,7100	3,1000	121,9000	225,3600	25,0120	148,4700	257,1030	124,7490	217,8630	Lantai 1	
	Tump ka	-44,3200	-9,6200	-225,5400	225,3600	-68,5760	-292,4439	181,0011	-242,8740	162,9360		
48-50	Tump ki	-163,9700	-43,1100	432,9200	-426,0600	-265,7400	241,6586	-660,2705	242,0550	-531,0270		
	Lap	95,0200	25,3400	432,9200	411,3600	154,5680	578,2833	555,6453	475,1460	455,7420		
	Tump ka	-183,6900	-48,7700	-416,4400	411,3600	-298,4600	-676,2242	192,9659	-540,1170	204,9030		
51-53	Tump ki	-178,9600	-47,4200	401,3600	-399,8000	-290,6240	188,7081	-652,5099	200,1600	-520,8840		
	Lap	89,2800	23,6600	401,3600	400,5200	144,9920	537,5307	536,6487	441,5760	440,8200		
	Tump ka	-179,8700	-47,6800	-400,6800	400,5200	-292,1320	-654,6351	186,6249	-522,4950	198,5850		
54-56	Tump ki	-182,9500	-48,5500	412,3600	-415,5800	-297,2200	195,0008	-674,3363	206,4690	-538,6770		
	Lap	94,9000	25,3000	412,3600	432,4800	154,3600	556,5315	577,6575	456,5340	474,6420		
	Tump ka	-164,9000	-43,3900	-427,5800	432,4800	-267,3040	-663,1076	239,9555	-533,2320	240,8220		

Tabel 8.1 Lanjutan

Por-tal	No. Elm Balok	Letak Momen	M mati	M hidup	M Gempa		Mu1	Mu2	Mu3	Mu4	Mu5	Balok
			MD	ML	M Gki	M Gka						
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]
As 3 dan As 4	57	Tump ki	-47,9500	-10,6100	221,3000	-221,5600	-74,5160	171,9911	-293,0120	156,0150	-242,5590	Balok Lantai 1
		Lap	9,3200	1,7000	221,3000	94,7600	13,9040	243,7575	110,8905	207,5580	93,6720	
		Tump ka	-20,3100	-4,5100	-95,3800	94,7600	-31,5880	-125,7365	73,9106	-104,1210	67,0050	
	58	Tump ki	-22,9400	-5,0100	43,2000	-46,5200	-35,5440	16,5386	-77,6675	18,2340	-62,5140	Balok Lantai 2
		Lap	24,4100	5,1900	43,2000	99,2000	37,5960	75,8951	134,6951	60,8490	111,2490	
		Tump ka	-13,1700	-2,6900	-95,1600	99,2000	-20,1080	-116,2886	87,7895	-97,4970	77,4270	
	59	Tump ki	-10,4500	-2,3100	106,3200	-107,7600	-16,2360	98,4806	-126,3035	86,2830	-106,3890	Balok Lantai 2
		Lap	17,3400	3,3300	106,3200	197,4000	26,1360	132,9899	228,6239	111,2940	193,2660	
		Tump ka	-39,5900	-8,1200	-193,7200	197,4000	-60,5000	-252,6489	158,0271	-209,9790	142,0290	
	60-62	Tump ki	-168,8000	-44,7000	393,6000	-387,2200	-274,0800	193,7985	-626,0625	202,3200	-500,4180	Balok Lantai 2
		Lap	94,0400	25,0000	393,6000	376,8400	152,8480	535,6470	518,0490	438,8760	423,7920	
		Tump ka	-180,6200	-47,7600	-380,7000	376,8400	-293,1600	-634,5192	160,8978	-505,1880	176,5980	
	63-65	Tump ki	-178,2900	-47,2500	370,5800	-369,6800	-289,5480	157,2533	-620,0198	173,0610	-493,1730	Balok Lantai 2
		Lap	89,5700	20,9400	370,5800	369,6200	140,9880	502,9458	501,9378	414,1350	413,2710	
		Tump ka	-179,9500	-47,6800	-370,8200	369,6200	-292,2280	-623,3661	154,0959	-495,6930	170,7030	
	66-68	Tump ki	-178,7900	-47,3200	377,5800	-378,9800	-290,2600	164,0121	-630,3759	178,9110	-501,9930	Balok Lantai 2
		Lap	93,6000	24,8900	377,5800	391,5400	152,1440	518,2601	532,9181	424,0620	436,6260	
		Tump ka	-171,4400	-45,3300	-387,9400	391,5400	-278,2560	-630,1859	188,2682	-503,4420	198,0900	
	69	Tump ki	-49,3100	-10,3400	196,8400	-194,1400	-75,7160	145,1352	-265,3938	132,7770	-219,1050	Balok Lantai 2
		Lap	11,0400	2,1300	196,8400	82,0600	16,6560	220,2869	99,7679	187,0920	83,7900	
		Tump ka	-16,4400	-3,9700	-84,9400	82,0600	-26,0800	-110,2007	65,1494	-91,2420	59,0580	
	70	Tump ki	-18,9800	-4,3800	42,2400	-46,0200	-29,7840	20,2839	-72,3891	20,9340	-58,5000	Balok Lantai 2
		Lap	24,6500	5,1200	42,2400	90,5800	37,7720	75,0729	125,8299	60,2010	103,7070	
		Tump ka	-16,3900	-3,4000	-87,4600	90,5800	-25,1080	-112,2555	74,6865	-93,4650	66,7710	
	71	Tump ki	-10,7700	-2,4600	75,6200	-77,3400	-16,8600	65,7678	-94,8402	58,3650	-79,2990	Balok Lantai 3
		Lap	17,8600	3,4900	75,6200	141,9000	27,0160	101,4521	171,0461	84,1320	143,7840	
		Tump ka	-37,8700	-7,5100	-129,8200	141,9000	-57,4600	-183,1715	102,1346	-150,9210	93,6270	
	72-74	Tump ki	-170,1200	-45,1800	294,1000	-293,2600	-276,4320	87,4839	-529,2441	111,5820	-417,0420	Balok Lantai 3
		Lap	93,6100	24,8700	294,1000	284,4400	152,1240	430,5977	420,4547	348,9390	340,2450	
		Tump ka	-180,1300	-47,5300	-290,7600	284,4400	-292,2040	-539,3504	64,6097	-423,8010	93,8790	
	75-77	Tump ki	-177,1400	-46,9500	286,9000	-281,7600	-287,6880	70,8803	-526,2128	98,7840	-413,0100	Balok Lantai 3
		Lap	89,9700	23,8600	286,9000	284,2000	146,1400	418,2612	415,4262	339,1830	336,7530	
		Tump ka	-180,3100	-47,7400	-283,9600	284,2000	-292,7560	-532,5978	63,9702	-417,8430	93,5010	
	78-80	Tump ki	-177,0500	-46,8100	285,8600	-287,7400	-287,3560	70,0151	-532,2650	97,9290	-418,3110	Balok Lantai 3
		Lap	93,1900	24,7800	285,8600	291,9800	151,4760	421,4196	427,8456	341,1450	346,6530	
		Tump ka	-173,9500	-46,0500	-295,0400	291,9800	-282,4200	-535,9568	80,4143	-422,0910	106,2270	
	78-80	Tump ki	-177,0500	-46,8100	285,8600	-287,7400	-287,3560	70,0151	-532,2650	97,9290	-418,3110	Balok Lantai 3
		Lap	93,1900	24,7800	285,8600	291,9800	151,4760	421,4196	427,8456	341,1450	346,6530	
		Tump ka	-173,9500	-46,0500	-295,0400	291,9800	-282,4200	-535,9568	80,4143	-422,0910	106,2270	
	81	Tump ki	-51,6200	-10,5100	146,9000	-135,7800	-78,7600	90,1121	-206,7020	85,7520	-168,6600	Balok Lantai 3
		Lap	11,9200	2,3000	146,9000	56,5200	17,9840	168,9345	74,0355	142,9380	61,5960	
		Tump ka	-13,4700	-3,5500	-61,9200	56,5200	-21,8440	-82,5143	41,8478	-67,8510	38,7450	
	82	Tump ki	-16,1400	-3,9400	33,1800	-40,9000	-25,6720	14,1687	-63,6153	15,3360	-51,3360	Balok Lantai 3
		Lap	25,3800	5,2000	33,1800	70,8400	38,7760	66,4020	105,9450	52,7040	86,5980	
		Tump ka	-17,7500	-3,6500	-66,4200	70,8400	-27,1400	-91,8278	52,2953	-75,7530	47,7810	
	83	Tump ki	-7,1000	-1,1600	74,3000	-37,4200	-10,3760	69,4638	-47,8422	60,4800	-40,0680	Balok Lantai 4
		Lap	15,7500	2,9800	74,3000	62,8600	23,6680	97,3686	85,3566	81,0450	70,7490	
		Tump ka	-48,8300	-10,8800	-127,2600	62,8600	-76,0040	-195,1761	4,4499	-158,4810	12,6270	
	84-86	Tump ki	-155,5100	-40,7700	248,9400	-153,4800	-251,8440	59,5739	-362,9672	84,0870	-278,0910	Balok Lantai 4
		Lap	98,5200	26,4000	248,9400	150,6800	160,4640	389,7810	286,6080	312,7140	224,2800	
		Tump ka	-185,5800	-49,1800	-193,2800	150,6800	-301,3840	-444,2781	-83,1201	-340,9740	-31,4100	
	87-89	Tump ki	-178,4300	-47,3000	146,3400	-148,6800	-289,7960	-78,3930	-388,1640	-28,8810	-294,3990	Balok Lantai 4
		Lap	89,2400	23,6500	146,3400	145,5000	144,9280	269,7083	268,8263	212,0220	211,2660	
		Tump ka	-180,4700	-47,8200	-150,8600	145,5000	-293,0760	-393,0864	-81,9084	-298,1970	-31,4730	
	90-92	Tump ki	-181,5600	-48,2200	149,3800	-183,9200	-295,0240	-79,3569	-429,3219	-28,9620	-328,9320	Balok Lantai 4
		Lap	96,7600	25,9500	149,3800	230,1600	157,6320	282,9698	367,7888	221,5260	294,2280	
		Tump ka	-162,6000	-42,4600	-147,9400	230,1600	-263,0560	-366,1917	30,8133	-279,4860	60,8040	
	93	Tump ki	-62,7100	-13,6100	66,2000	-120,9600	-97,0280	-9,1970	-205,7150	3,1410	-165,3030	Balok Lantai 4
		Lap	10,9900	1,9000	66,2000	48,4800	16,2280	82,8450	64,2390	69,4710	53,5230	
		Tump ka	-8,6000	-2,3500	-27,4000	48,4800	-14,0800	-40,0208	39,6533	-32,4000	35,8920	
	94	Tump ki	-13,5800	-3,6400	21,3600	-38,7800	-22,1200	4,7292	-58,4178	7,0020	-47,1240	Balok Lantai 4
		Lap	27,0600	5,6700	21,3600	63,0600	41,5440	56,1992	99,9842	43,5780	81,1080	
		Tump ka	-16,9700	-3,0300	-35,2800	63,0600	-25,2120	-57,7259	45,5312	-47,0250	41,4810	
	95	Tump ki	-2,3800	0,0300	49,3000	-8,8600	-2,8080	49,2944	-11,7737	42,2280	-10,1160	Balok Atap
		Lap	15,3100	1,8000	49,3000	22,4200	21,2520	69,5415	41,3175	58,1490	33,9570	
		Tump ka	-20,5700	-3,5200	-166,4400	22,4200	-30,3160	-199,6869	-1,3839	-168,3090	1,6650	
	96	Tump ki	-29,0300	-5,1300	20,4400	-151,2400	-43,0440	-13,8674	-194,1314	-7,7310	-162,2430	Balok Atap
		Lap	11,6500	1,6700	20,4400	41,3800	16,6520	35,2727	57,2597	28,8810	47,7270	
		Tump ka	-2,9100	0,6100	-4,3000	41,3800	-2,5160	-6,9941	40,9700	-6,4890	34,6230	

Tabel 8.1 Lanjutan

Por-tal	No. Elm	Letak Momen	M mati	M hidup	M Gempa		Mu1	Mu2	Mu3	Mu4	Mu5	Balok
			MD	ML	M Gki	M Gka						
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]
As 3 dan As 4	97	Tump ki	-5,6600	-0,2400	7,2600	-7,6200	-7,1760	1,4532	-14,1708	1,4400	-11,9520	Balok
		Lap	19,4200	2,7400	7,2600	35,2000	27,6880	30,6033	59,9403	24,0120	49,1580	Atap
		Tump ka	-7,4800	-0,9200	-9,0200	35,2000	-10,4480	-18,1944	28,2366	-14,8500	24,9480	
As A dan As G	25	Tump ki	-11,5900	-0,6900	117,1000	-116,5400	-15,0120	110,1335	-135,1886	94,9590	-115,3170	Balok
		Lap	6,2400	0,2500	117,1000	108,6600	7,8880	129,7433	120,8813	111,0060	103,4100	Sloof
		Tump ka	-9,1400	0,2500	-108,9800	108,6600	-10,5680	-123,7898	104,7323	-106,3080	89,5680	
	26	Tump ki	-3,3900	0,2800	143,3800	-143,3000	-3,6200	147,2541	-153,7599	125,9910	-132,0210	
		Lap	0,8900	0,4000	143,3800	143,3800	1,7080	151,8615	151,8615	129,8430	129,8430	
		Tump ka	-3,1300	0,4000	-143,3000	143,3800	-3,1160	-153,3735	147,6405	-131,7870	126,2250	
	27	Tump ki	-9,0000	0,3200	108,6600	-108,9800	-10,2880	104,9454	-123,5766	89,6940	-106,1820	
		Lap	6,2600	0,3200	108,6600	117,1000	8,0240	120,9684	129,8304	103,4280	111,0240	
		Tump ka	-11,7100	-0,7400	-116,5400	117,1000	-15,2360	-135,3618	109,9602	-115,4250	94,8510	
	28-29	Tump ki	-33,6600	-7,4800	169,1200	-168,0800	-52,3600	135,1644	-218,8956	121,9140	-181,5660	Balok
		Lap	31,1000	8,7900	169,1200	159,5400	51,3840	218,5376	208,4786	180,1980	171,5760	Lantai 1
		Tump ka	-34,9600	-8,5600	-160,1000	159,5400	-55,6480	-212,9022	122,7198	-175,5540	112,1220	
30	Tump ki	-13,4900	-2,8300	189,8200	-189,7000	-20,7160	182,4722	-216,0239	158,6970	-182,8710		
	Lap	-2,6500	-1,2400	189,8200	189,8200	-5,1640	195,3567	195,3567	168,4530	168,4530		
	Tump ka	-12,8500	-2,5300	-189,7000	189,8200	-19,4680	-215,0684	183,4277	-182,2950	159,2730		
31-32	Tump ki	-34,6000	-8,3800	159,5400	-160,1000	-54,9280	123,2679	-212,3541	112,4460	-175,2300		
	Lap	31,1400	8,8100	159,5400	169,1200	51,4640	208,5395	218,5985	171,6120	180,2340		
	Tump ka	-33,9400	-7,6200	-168,0800	169,1200	-52,9200	-219,3219	134,7381	-181,8180	121,6620		
33-34	Tump ki	-37,2300	-8,2200	160,3800	-159,6600	-57,8280	121,5396	-214,5024	110,8350	-177,2010	Balok	
	Lap	30,4100	8,5500	160,3800	153,9600	50,1720	208,4093	201,6683	171,7110	165,9330	Lantai 2	
	Tump ka	-32,7600	-8,3000	-154,3400	153,9600	-52,5920	-204,2985	119,4165	-168,3900	109,0800		
35	Tump ki	-12,2100	-2,5500	163,7600	-163,6600	-18,7320	156,7178	-187,0733	136,3950	-158,2830		
	Lap	-1,0900	-0,8100	163,7600	163,7600	-2,6040	170,0381	170,0381	146,4030	146,4030		
	Tump ka	-11,0200	-1,9800	-163,6600	163,7600	-16,3920	-185,2851	158,5059	-157,2120	137,4660		
36-37	Tump ki	-32,0900	-7,9800	153,9600	-154,3400	-51,2760	120,4224	-203,2926	109,6830	-167,7870		
	Lap	30,4800	8,5800	153,9600	160,3800	50,3040	201,7701	208,5111	165,9960	171,7740		
	Tump ka	-37,7600	-8,4700	-159,6600	160,3800	-58,8640	-215,2952	120,7469	-177,6780	110,3580		
38-39	Tump ki	-38,4400	-8,3500	129,0000	-128,1600	-59,4880	87,1973	-182,8208	81,5040	-149,9400	Balok	
	Lap	30,6900	8,5800	129,0000	125,3800	50,5560	175,7826	171,9816	143,7210	140,4630	Lantai 3	
	Tump ka	-31,0000	-8,1100	-125,8200	125,3800	-50,1760	-172,3250	91,4351	-141,1380	84,9420		
40	Tump ki	-12,5100	-2,6800	114,7800	-114,6600	-19,3000	104,8509	-136,0611	92,0430	-114,4530		
	Lap	-1,1300	-0,8100	114,7800	114,7800	-2,6520	118,5671	118,5671	102,2850	102,2850		
	Tump ka	-10,8200	-1,8800	-114,6600	114,7800	-15,9920	-133,5306	107,3814	-112,9320	93,5640		
41-42	Tump ki	-29,9400	-7,6000	125,3800	-125,8200	-48,0880	93,0300	-170,7300	85,8960	-140,1840		
	Lap	30,8700	8,6600	125,3800	129,0000	50,9000	172,2462	176,0472	140,6250	143,8830		
	Tump ka	-39,1400	-8,6900	-128,1600	129,0000	-60,8720	-183,8771	86,1410	-150,5700	80,8740		
43-44	Tump ki	-40,9100	-8,2800	84,5800	-84,6000	-62,3400	38,0289	-139,6101	39,3030	-112,9590	Balok	
	Lap	29,9500	8,6400	84,5800	84,5400	49,7640	128,4213	128,3793	103,0770	103,0410	Lantai 4	
	Tump ka	-30,0200	-8,0700	-84,5200	84,5400	-48,9360	-127,8932	49,6199	-103,0860	49,0680		
45	Tump ki	-12,2000	-3,1800	53,5600	-53,5400	-19,7280	40,4229	-72,0321	37,2240	-59,1660		
	Lap	0,5400	-0,5700	53,5600	53,5600	-0,2640	56,2664	56,2664	48,6900	48,6900		
	Tump ka	-7,9700	-1,1800	-53,5400	53,5600	-11,4520	-65,7006	46,7544	-55,3590	41,0310		
46-47	Tump ki	-28,4900	-7,3400	84,5400	-84,5200	-45,9320	51,9162	-125,5968	50,4450	-101,7090		
	Lap	29,6800	8,5100	84,5400	84,5800	49,2320	127,9730	128,0150	102,7980	102,8340		
	Tump ka	-42,9600	-9,2500	-84,6000	84,5800	-66,3520	-142,6793	34,9598	-114,8040	37,4580		
48-49	Tump ki	-28,8000	-3,4200	38,2200	-38,8800	-40,0320	6,6591	-74,2959	8,4780	-60,9120	Balok	
	Lap	32,9400	3,7000	38,2200	45,3200	45,4480	78,2145	85,6695	64,0440	70,4340	Atap	
	Tump ka	-29,2500	-2,6200	-44,9600	45,3200	-39,2920	-80,3964	14,3976	-66,7890	14,4630		
50	Tump ki	-15,3200	-1,0500	2,0000	-2,0200	-20,0640	-14,9783	-19,1993	-11,9880	-15,6060		
	Lap	-6,5400	-1,0100	2,0000	2,0000	-9,4640	-5,7215	-5,7215	-4,0860	-4,0860		
	Tump ka	-18,9500	-2,7700	-2,0200	2,0000	-27,1720	-24,6362	-20,4152	-18,8730	-15,2550		
51-52	Tump ki	-39,2600	-7,3700	45,3200	-44,9600	-58,9040	-0,6017	-95,3957	5,4540	-75,7980		
	Lap	47,8600	10,7700	45,3200	38,2200	74,6640	108,0167	100,5617	83,8620	77,4720		
	Tump ka	-35,6000	-6,6400	-38,8800	38,2200	-53,3440	-84,4788	-3,5238	-67,0320	2,3580		
As B dan As E	37	Tump ki	-1,5000	-15,3200	143,0800	-140,8200	-26,3120	134,1816	-163,9134	127,4220	-128,0880	Balok
		Lap	1,4100	5,8000	143,0800	136,6200	10,9720	157,1955	150,4125	130,0410	124,2270	Sloof
		Tump ka	1,4100	-6,8100	-138,4200	136,6200	-9,2040	-150,2960	138,4961	-123,3090	124,2270	
	38	Tump ki	0,5000	-9,4400	136,9000	-135,8400	-14,5040	135,3492	-151,0278	123,6600	-121,8060	
		Lap	0,5000	5,4200	136,9000	133,0200	9,2720	149,3919	145,3179	123,6600	120,1680	
		Tump ka	-0,7400	-12,9900	-133,6600	133,0200	-21,6720	-153,3956	126,6185	-120,9600	119,0520	
	39	Tump ki	0,2600	-2,6600	202,6200	-202,4400	-3,9440	210,5103	-214,8027	182,5920	-181,9620	
		Lap	0,2600	1,4900	202,6200	202,6200	2,6960	214,4321	214,4321	182,5920	182,5920	
		Tump ka	0,2600	-2,6600	-202,4400	202,6200	-3,9440	-214,8027	210,5103	-181,9620	182,5920	
	40	Tump ki	-0,7400	-12,9900	133,0200	-133,6600	-21,6720	126,6185	-153,3956	119,0520	-120,9600	
		Lap	0,5000	5,4200	133,0200	136,9000	9,2720	145,3179	149,3919	120,1680	123,6600	
		Tump ka	0,5000	-9,4400	-135,8400	136,9000	-14,5040	-151,0278	135,3492	-121,8060	123,6600	

Tabel 8.1 Lanjutan

Por-tal	No. Elm Balok	Letak Momen	M mati	M hidup	M Gempa		Mu1	Mu2	Mu3	Mu4	Mu5	Balok
			MD	ML	M Gki	M Gka	[8]	[9]	[10]	[11]	[12]	[13]
			[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]
As B dan As E	41	Tump ki	1,4100	-6,8100	136,6200	-138,4200	-9,2040	138,4961	-150,2960	124,2270	-123,3090	Balok Stroof
		Tump ka	1,4100	5,8000	136,6200	143,0800	10,9720	150,4125	157,1955	124,2270	130,0410	
	42-43	Tump ki	-14,8200	-66,8700	339,5400	-333,4000	-124,7760	277,7639	-428,8232	292,2480	-313,3980	Balok Lantai 1
		Tump ka	-1,5000	-15,3200	-140,8200	143,0800	-26,3120	-163,9134	134,1816	-128,0880	127,4220	
	44-45	Tump ki	11,7100	47,5400	339,5400	302,1000	90,1160	413,7378	374,4258	316,1250	282,4290	
		Tump ka	-10,7600	-54,3700	-306,5000	302,1000	-99,9040	-384,5027	-254,5274	-285,5340	262,2060	
	46	Tump ki	-18,9200	-71,8300	301,8200	-299,4400	-137,6320	229,1657	-402,1574	254,6100	-286,5240	
		Tump ka	20,3200	64,1900	301,8200	294,3600	127,0880	398,9066	391,0736	289,9260	283,2120	
	47-48	Tump ki	-23,0700	-83,0400	294,3600	-295,7800	-160,5480	206,3817	-413,2653	206,3817	-286,9650	
		Tump ka	-6,1400	-25,2800	359,0600	-358,7000	-47,8160	346,6764	-406,9716	346,6764	320,2200	
	49-50	Tump ki	-3,2600	-8,4100	359,0600	359,0600	-17,3680	365,6426	365,6426	320,2200	320,2200	
		Tump ka	-6,1400	-25,2800	-358,7000	359,0600	-47,8160	-406,9716	-413,2653	244,1610	-286,9650	
	51-52	Tump ki	20,3200	64,1900	294,3600	301,8200	127,0880	391,0736	398,9066	289,9260	289,9260	
		Tump ka	-18,9200	-71,8300	-299,4400	301,8200	-137,6320	-402,1574	229,1657	-286,5240	254,6100	
	53-54	Tump ki	-10,7600	-54,3700	302,1000	-306,5000	-99,9040	254,5274	-384,5027	262,2060	-285,5340	
		Tump ka	11,7100	47,5400	302,1000	339,5400	90,1160	374,4258	413,7378	282,4290	316,1250	
	55	Tump ki	11,7100	47,5400	302,1000	339,5400	90,1160	374,4258	413,7378	282,4290	316,1250	
		Tump ka	-10,7600	-54,3700	-306,5000	302,1000	-99,9040	-92,9400	-400,9667	305,6204	-289,5210	
	56-57	Tump ki	-18,1800	-78,4000	301,1600	-296,4600	-147,2560	223,0410	-404,4600	254,6820	-283,1760	Balok Lantai 2
		Tump ka	11,7300	47,3700	301,1600	270,2200	89,8680	373,2992	340,8122	281,6010	253,7550	
	58-59	Tump ki	-7,3800	-43,1800	270,2200	-285,7800	-124,6040	222,9035	-379,4816	243,7830	-272,5470	
		Tump ka	-7,3800	-43,1800	-273,6800	270,2200	-147,2560	-77,9440	-335,8971	-252,9360	236,5560	
	60-61	Tump ki	-17,0500	-65,0900	287,9200	-283,2600	126,5960	383,9766	379,0836	277,2990	273,1050	
		Tump ka	20,1900	63,9800	287,9200	283,2600	-174,5480	-410,4345	185,7345	-278,7390	232,2630	
	62-63	Tump ki	-25,1900	-90,2000	283,2600	-284,5200	-174,5480	185,7345	-410,4345	265,1940	-275,2920	
		Tump ka	-5,7600	-24,3000	300,4200	-300,1200	-45,7920	305,3957	286,4295	305,3957	267,7860	
	64	Tump ki	-2,8800	-7,4300	300,4200	300,4200	-15,3440	305,3957	305,3957	267,7860	267,7860	
		Tump ka	-5,7600	-24,3000	-300,1200	300,4200	-45,7920	-344,1375	286,4295	-275,2920	265,1940	
	65-66	Tump ki	20,1900	63,9800	283,2600	287,9200	126,5960	379,0836	383,9766	277,2990	273,1050	
		Tump ka	-17,0500	-65,0900	-285,7800	287,9200	-124,6040	-379,4816	222,9035	-272,5470	243,7830	
	67-68	Tump ki	-7,3800	-43,1800	270,2200	-273,6800	-147,2560	223,0410	-404,4600	254,6820	-283,1760	
		Tump ka	11,7300	47,3700	270,2200	301,1600	89,8680	340,8122	373,2992	340,8122	253,7550	
	69-70	Tump ki	-18,1800	-78,4000	301,1600	-296,4600	-147,2560	223,0410	-404,4600	254,6820	-283,1760	
		Tump ka	-20,0300	-84,7500	233,7800	-228,9600	-159,6360	144,3488	-341,5283	192,3750	-224,0910	
	71-72	Tump ki	-20,0300	-84,7500	233,7800	-228,9600	-159,6360	144,3488	-341,5283	192,3750	-224,0910	Balok Lantai 3
		Tump ka	11,7800	47,5300	233,7800	207,1400	90,1840	302,7539	274,7819	221,0040	197,0280	
	73	Tump ki	-11,7800	-47,5300	207,1400	-207,1400	-44,2640	-243,1905	195,3735	-178,8840	192,9550	
		Tump ka	11,7800	-36,5000	-210,5400	207,1400	-44,2640	-243,1905	195,3735	-178,8840	192,9550	
	74-75	Tump ki	-15,8700	-61,0500	236,1600	-234,0800	-116,7240	173,6123	-320,1398	198,2610	-229,2750	
		Tump ka	20,2900	64,3300	236,1600	234,4600	127,2760	330,0644	328,2794	230,8050	187,4610	
	76-77	Tump ki	-26,1700	-93,5300	234,4600	-235,7000	-181,0520	130,3187	-363,3494	187,4610	-235,6830	
		Tump ka	-6,0100	-25,2200	208,0600	-207,7600	-47,5640	188,3196	-248,2914	207,2858	184,4370	
	78-79	Tump ki	-3,1300	-8,3500	208,0600	208,0600	-17,1160	207,2858	207,2858	184,4370	184,4370	
		Tump ka	-6,0100	-25,2200	-207,7600	208,0600	-47,5640	-248,2914	188,3196	-192,3930	181,8450	
	79-80	Tump ki	-26,1700	-93,5300	234,4600	-235,7000	-181,0520	130,3187	-363,3494	187,4610	-235,6830	
		Tump ka	20,2900	64,3300	234,4600	236,1600	127,2760	328,2794	328,2794	229,2750	230,8050	
	80-81	Tump ki	-15,8700	-61,0500	236,1600	-234,0800	-116,7240	173,6123	-320,1398	198,2610	-229,2750	
		Tump ka	20,2900	64,3300	236,1600	234,4600	127,2760	330,0644	328,2794	230,8050	187,4610	
	81-82	Tump ki	-26,1700	-93,5300	234,4600	-235,7000	-181,0520	130,3187	-363,3494	187,4610	-235,6830	
		Tump ka	-6,0100	-25,2200	208,0600	-207,7600	-47,5640	188,3196	-248,2914	207,2858	184,4370	
	82-83	Tump ki	-3,1300	-8,3500	208,0600	208,0600	-17,1160	207,2858	207,2858	184,4370	184,4370	
		Tump ka	-6,0100	-25,2200	-207,7600	208,0600	-47,5640	-248,2914	188,3196	-192,3930	181,8450	
	83-84	Tump ki	-26,1700	-93,5300	234,4600	-235,7000	-181,0520	130,3187	-363,3494	187,4610	-235,6830	
		Tump ka	20,2900	64,3300	234,4600	236,1600	127,2760	328,2794	328,2794	229,2750	230,8050	
	84-85	Tump ki	-15,8700	-61,0500	236,1600	-234,0800	-116,7240	173,6123	-320,1398	198,2610	-229,2750	
		Tump ka	20,2900	64,3300	236,1600	234,4600	127,2760	330,0644	328,2794	230,8050	187,4610	
	85-86	Tump ki	-26,1700	-93,5300	234,4600	-235,7000	-181,0520	130,3187	-363,3494	187,4610	-235,6830	
		Tump ka	-6,0100	-25,2200	208,0600	-207,7600	-47,5640	188,3196	-248,2914	207,2858	184,4370	
	86-87	Tump ki	-3,1300	-8,3500	208,0600	208,0600	-17,1160	207,2858	207,2858	184,4370	184,4370	
		Tump ka	-6,0100	-25,2200	-207,7600	208,0600	-47,5640	-248,2914	188,3196	-192,3930	181,8450	
	87-88	Tump ki	-26,1700	-93,5300	234,4600	-235,7000	-181,0520	130,3187	-363,3494	187,4610	-235,6830	
		Tump ka	20,2900	64,3300	234,4600	236,1600	127,2760	328,2794	328,2794	229,2750	230,8050	
	88-89	Tump ki	-15,8700	-61,0500	236,1600	-234,0800	-116,7240	173,6123	-320,1398	198,2610	-229,2750	
		Tump ka	20,2900	64,3300	236,1600	234,4600	127,2760	330,0644	328,2794	230,8050	187,4610	
	89-90	Tump ki	-26,1700	-93,5300	234,4600	-235,7000	-181,0520	130,3187	-363,3494	187,4610	-235,6830	
		Tump ka	-6,0100	-25,2200	208,0600	-207,7600	-47,5640	188,3196	-248,2914	207,2858	184,4370	
	90-91	Tump ki	-3,1300	-8,3500	208,0600	208,0600	-17,1160	207,2858	207,2858	184,4370	184,4370	
		Tump ka	-6,0100	-25,2200	-207,7600	208,0600	-47,5640	-248,2914	188,3196	-192,3930	181,8450	
	91-92	Tump ki	-26,1700	-93,5300	234,4600	-235,7000	-181,0520	130,3187	-363,3494	187,4610	-235,6830	
		Tump ka	20,2900	64,3300	234,4600	236,1600	127,2760	328,2794	328,2794	229,2750	230,8050	
	92-93	Tump ki	-15,8700	-61,0500	236,1600	-234,0800	-116,7240	173,6123	-320,1398	198,2610	-229,2750	
		Tump ka	20,2900	64,3300	236,1600	234,4600	127,2760	330,0644	328,2794	230,8050	187,4610	
	93-94	Tump ki	-26,1700	-93,5300	234,4600	-235,7000	-181,0520	130,3187	-363,3494	187,4610	-235,6830	
		Tump ka	-6,0100	-25,2200	208,0600	-207,7600	-47,5640	188,3196	-248,2914	207,2858	184,4370	
	94-95	Tump ki	-3,1300	-8,3500	208,0600	208,0600	-17,1160	207,2858	207,2858	184,4370	184,4370	
		Tump ka	-6,0100	-25,2200	-207,7600	208,0600	-47,5640	-248,2914	188,3196	-192,3930	181,8450	
	95-96	Tump ki	-26,1700	-93,5300	234,4600	-235,7000	-181,0520	130,3187	-363,3494	187,4610	-235,6830	
		Tump ka	20,2900	64,3300	234,4600	236,1600	127,2760	328,2794	328,2794	229,2750	230,8050	

Tabel 8.1 Lanjutan

Por-tal	No. Elm Balok	Letak Momen	M mati	M hidup	M Gempa		Mu1	Mu2	Mu3	Mu4	Mu5	Balok	
			MD	ML	M Gki	M Gka							
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	
As B dan As E	82-83	Tump ki	-8,100	-30,580	17,4000	-17,4000	-58,6480	-19,1331	-55,6731	8,3700	-22,9500	18,6120	Balok Atap
		Lap	3,280	7,890	17,4000	17,4000	16,5600	29,1701	29,1701	18,6120	18,6120	18,6120	
		Tump ka	-8,100	-30,580	-17,4000	17,4000	-58,6480	-55,6731	-19,1331	-22,9500	8,3700	8,3700	
	84-85	Tump ki	-17,530	-68,070	77,2200	-77,3200	-129,9480	-1,6517	-163,9187	53,7210	-85,3650	79,1370	
		Lap	14,650	53,200	77,2200	73,2800	102,7000	146,7375	142,6005	82,6830	57,1230	57,1230	
		Tump ka	-9,810	-41,750	-73,1000	73,2800	-78,5720	-126,5093	27,1898	-74,6190	40,1580	40,1580	
86-87	Tump ki	-5,650	-25,460	46,2800	-46,0200	-47,5160	18,6018	-78,3132	36,5670	-46,5030	57,4740		
	Lap	9,540	27,470	46,2800	54,3200	55,4000	84,5702	93,0122	50,2380	57,4740	57,4740		
	Tump ka	-9,700	-40,330	-54,6400	54,3200	-76,1680	-105,6689	8,7392	-57,9060	40,1580	40,1580		
As C dan As D	21	Tump ki	-48,8800	-1,8800	169,5200	-168,0000	-61,6640	124,8954	-229,5006	108,5760	-195,1920	163,0080	Balok Sloof
		Lap	20,4400	0,1300	169,5200	160,6800	24,7360	199,5809	190,2989	170,9640	163,0080	163,0080	
		Tump ka	-43,0200	0,1300	-161,5600	160,6800	-51,4160	-214,6862	123,6659	-184,1220	105,8940	105,8940	
	22	Tump ki	0,4100	2,1900	440,4200	-440,1400	3,9960	464,9411	-459,6470	396,7470	-395,7570	396,7470	
		Lap	4,5600	2,1900	440,4200	440,4200	8,9760	469,2986	469,2986	400,4820	400,4820	400,4820	
		Tump ka	0,4100	2,1900	-440,1400	440,4200	3,9960	-459,6470	464,9411	-395,7570	396,7470	396,7470	
	23	Tump ki	-43,0200	0,1300	160,6800	-161,5600	-51,4160	123,6659	-214,6862	105,8940	-184,1220	163,0080	
		Lap	20,4400	0,1300	160,6800	169,5200	24,7360	199,5809	199,5809	163,0080	170,9640	170,9640	
		Tump ka	-48,8800	-1,8800	-168,0000	169,5200	-61,6640	-229,5006	124,8954	-195,1920	108,5760	108,5760	
	24-27	Tump ki	-441,4100	-129,4600	476,9800	-471,9200	-736,8280	-84,9912	-1081,3362	32,0130	-821,9970	663,4710	Balok Lantai 1
		Lap	311,3300	95,3000	476,9800	425,8600	526,0760	917,7840	864,1080	709,4790	663,4710	663,4710	
		Tump ka	-460,1200	-135,3800	-428,5200	425,8600	-768,7520	-1061,0061	-163,9071	-799,7760	-30,8340	-30,8340	
	28	Tump ki	-100,9000	-29,0400	822,4400	-821,9800	-167,5440	730,1742	-996,4668	649,3860	-830,5920	649,3860	
		Lap	-84,0600	-26,1600	822,4400	822,4400	-142,7280	750,5778	750,5778	664,5420	664,5420	664,5420	
		Tump ka	-100,9000	-29,0400	-821,9800	822,4400	-167,5440	-996,4668	730,1742	-830,5920	649,3860	649,3860	
	29-32	Tump ki	-460,1200	-135,3800	425,8600	-428,5200	-768,7520	-163,9071	-1061,0061	-30,8340	-799,7760	709,4790	
		Lap	311,3300	95,3000	425,8600	476,9800	526,0760	864,1080	917,7840	663,4710	709,4790	709,4790	
		Tump ka	-441,4100	-129,4600	-471,9200	476,9800	-736,8280	-1081,3362	-84,9912	-821,9970	32,0130	32,0130	
	33-36	Tump ki	-452,4800	-133,0100	445,9600	-442,2200	-755,7920	-132,5405	-1065,1295	-5,8680	-805,2300	644,3010	Balok Lantai 2
		Lap	306,0300	93,5400	445,9600	409,8600	516,9000	877,9848	840,0798	676,7910	644,3010	644,3010	
		Tump ka	-459,6600	-135,3400	-411,8400	409,8600	-768,1360	-1042,9713	-180,1863	-784,3500	-44,8200	-44,8200	
	37	Tump ki	-86,5900	-24,2600	669,1800	-668,7000	-142,7240	588,7938	-815,9802	524,3310	-679,7610	539,4960	
		Lap	-69,7400	-21,3800	669,1800	669,1800	-117,8930	609,2079	609,2079	539,4960	539,4960	539,4960	
		Tump ka	-86,5900	-24,2600	-668,7000	669,1800	-142,7240	-815,9802	588,7938	-679,7610	524,3310	524,3310	
38-41	Tump ki	-459,6600	-135,3400	409,8600	-411,8400	-768,1360	-180,1863	-1042,9713	-44,8200	-784,3500	676,7910		
	Lap	306,0300	93,5400	409,8600	445,9600	516,9000	840,0798	877,9848	644,3010	676,7910	676,7910		
	Tump ka	-452,4800	-133,0100	-442,2200	445,9600	-755,7920	-1065,1295	-132,5405	-805,2300	-5,8680	-5,8680		
42-45	Tump ki	-459,3900	-134,9800	347,6600	-343,7400	-767,2360	-244,8726	-970,8426	-100,5570	-722,8170	564,6600	Balok Lantai 3	
	Lap	302,0600	92,3900	347,6600	325,3400	510,2960	769,5146	746,0786	584,7480	521,6600	521,6600		
	Tump ka	-460,6800	-135,6700	-327,4000	325,3400	-769,8880	-955,6922	-270,3152	-709,2720	-121,8060	-121,8060		
46	Tump ki	-74,0700	-20,6500	388,3800	-387,9000	-121,9240	310,5113	-504,5828	282,8790	-415,7730	298,0440		
	Lap	-57,2200	-17,7700	388,3800	388,3800	-97,0960	330,9254	330,9254	298,0440	298,0440	298,0440		
	Tump ka	-74,0700	-20,6500	-387,9000	388,3800	-121,9240	-504,5828	310,5113	-415,7730	282,8790	282,8790		
47-50	Tump ki	-460,6800	-135,6700	325,3400	-327,4000	-769,8880	-270,3152	-955,6922	-121,8060	-709,2720	584,7480		
	Lap	302,0600	92,3900	325,3400	347,6600	510,2960	746,0786	769,5146	564,6600	521,6600	521,6600		
	Tump ka	-459,3900	-134,9800	-343,7400	347,6600	-767,2360	-970,8426	-244,8726	-722,8170	-100,5570	-100,5570		
51-54	Tump ki	-400,5800	-117,7300	225,4200	-222,2000	-669,0640	-295,1729	-765,1739	-157,6440	-560,5020	496,5480	Balok Lantai 4	
	Lap	332,8400	101,4700	225,4200	218,8800	561,7600	682,0622	675,1952	502,4340	496,5480	496,5480		
	Tump ka	-457,9400	-134,7700	-220,4600	218,8800	-765,1600	-839,6777	-378,3707	-610,5600	-215,1540	-215,1540		
55	Tump ki	-158,8000	-45,8000	89,1200	-89,0200	-263,8400	-116,4450	-303,4920	-62,7120	-223,0380	109,3050		
	Lap	-141,9500	-42,9200	89,1200	89,1200	-239,0120	-96,0309	-96,0309	-47,5470	-47,5470	-47,5470		
	Tump ka	-158,8000	-45,8000	-89,0200	89,1200	-263,8400	-303,4920	-116,4450	-223,0380	-62,7120	-62,7120		
56-59	Tump ki	-457,9400	-134,7700	218,8800	-220,4600	-765,1600	-378,3707	-839,6777	-215,1540	-610,5600	502,4340		
	Lap	332,8400	101,4700	218,8800	225,4200	561,7600	675,1952	682,0622	496,5480	502,4340	502,4340		
	Tump ka	-400,5800	-117,7300	-222,2000	225,4200	-669,0640	-765,1739	-295,1729	-560,5020	-157,6440	-157,6440		
As F	25	Tump ki	-12,3900	-0,9700	132,8200	-132,4200	-16,4200	125,5349	-152,9672	108,3870	-130,3290	110,8080	Balok Sloof
		Lap	5,9200	0,4400	132,8200	117,2000	7,8080	146,0928	129,6918	124,8660	110,8080	110,8080	
		Tump ka	-9,0200	0,4400	-117,4200	117,2000	-10,1200	-132,3462	114,0048	-113,7960	97,3620	97,3620	
	26	Tump ki	-1,9500	1,0600	145,7600	-145,7200	-0,6440	152,0022	-154,0518	129,4290	-132,9030	132,0750	
		Lap	0,9900	1,0600	145,7600	145,7600	2,8840	155,0892	155,0892	132,0750	132,0750	132,0750	
		Tump ka	-4,5600	-0,2800	-145,7200	145,7600	-5,9200	-158,0586	147,9954	-135,2520	127,0800	127,0800	
	27	Tump ki	-9,8800	-0,0100	117,2000	-117,4200	-11,8720	112,6766	-133,6745	96,5880	-114,5700	124,9110	
		Lap	5,9700	-0,0100	117,2000	132,8200	7,1480	129,3191	145,7201	110,8530	109,3050	109,3050	
		Tump ka	-11,3700	-0,4400	-132,4200	132,8200	-14,3480	-151,3953	127,1067	-129,4110	124,9110	124,9110	
	28	Tump ki	-43,4500	-13,1200	170,8200	-170,2400	-73,1320	121,3401	-236,7729	114,6330	-192,3210	162,6030	Balok Lantai 1
		Lap	26,6100	8,2200	170,8200	154,0600	45,0840	215,0694	197,4714	177,6870	162,6030	162,6030	
		Tump ka	-41,1700	-12,5600	-154,3600	154,0600	-69,5000	-217,1757	106,6653	-175,9770	101,6010	101,6010	
29	Tump ki	-12,8800	-3,0800	192,9600	-192,8800	-20,3840	186,1734	-218,9586	162,0720	-185,1840	173,2320		
	Lap	-0,4800	-0,5700	192,9600	192,9600	-1,4880	201,5654	201,5654	173,2320	173,2320	173,2320		
	Tump ka	-14,1900	-3,8400	-192,8800	192,9600	-23,1720	-221,0523	184,0797	-186,3630	160,8930	160,8930		

Tabel 8.1 Lanjutan

Por-tal	No. Elm Balok	Letak Momen	M mati		M hidup		M Gempa		Mu1	Mu2	Mu3	Mu4	Mu5	Balok
			MD	ML	M Gki	M Gka								
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]		
As F	30-31	Tump ki	-33,4400	-8,8100	154,0600	-154,3600	-54,2240	118,3256	-205,5155	108,5580	-169,0200			Balok Lantai 1
		Lap	25,2500	8,1700	154,0600	170,8200	43,3720	195,9962	213,5942	161,3790	176,4630			
		Tump ka	-34,0600	-8,4600	-170,2400	170,8200	-54,4080	-222,5097	135,6033	-183,8700	123,0840			
	32	Tump ki	-46,0300	-13,9600	166,9600	-166,5800	-77,5720	113,7843	-236,4327	108,8370	-191,3490			Balok Lantai 2
		Lap	26,0500	8,0000	166,9600	152,7000	44,0600	210,2205	195,2475	173,7090	160,8750			
		Tump ka	-39,7700	-12,1800	-152,8800	152,7000	-67,2120	-213,7926	107,0664	-173,3850	101,6370			
	33	Tump ki	-10,6900	-2,1300	176,0800	-176,0200	-16,2360	171,6467	-198,0584	148,8510	-168,0390			
		Lap	0,6100	-0,1400	176,0800	176,0800	0,5080	185,3922	185,3922	159,0210	159,0210			
		Tump ka	-14,3200	-4,0700	-176,0200	176,0800	-23,6960	-203,7032	166,0019	-171,3060	145,5840			
	34-35	Tump ki	-32,7600	-8,8100	152,7000	-152,8800	-53,4080	117,6116	-203,2475	107,9460	-167,0760			
		Lap	24,7400	7,9800	152,7000	166,9600	42,4560	193,8531	208,8261	159,6960	172,5300			
		Tump ka	-35,7600	-8,8400	-166,5800	166,9600	-57,0560	-220,8108	129,4062	-182,1060	118,0800			
	36	Tump ki	-46,8100	-14,1800	133,6600	-133,2800	-78,8600	77,7924	-202,4946	78,1650	-162,0810			Balok Lantai 3
		Lap	26,2700	8,0500	133,6600	123,4200	44,4040	175,5338	164,7818	143,9370	134,7210			
		Tump ka	-38,6100	-11,8700	-123,6000	123,4200	-65,3240	-181,5377	77,8334	-145,9890	76,3290			
	37	Tump ki	-10,4400	-1,9600	125,8400	-125,7800	-15,6640	119,3178	-144,8832	103,8600	-122,5980			
		Lap	0,4900	-0,1300	125,8400	125,8400	0,3800	132,5237	132,5237	113,6970	113,6970			
		Tump ka	-14,8600	-4,3100	-125,7800	125,8400	-24,7280	-151,7450	112,4561	-126,5760	99,8820			
	38-39	Tump ki	-32,0300	-8,7200	123,4200	-123,6000	-52,3880	87,7191	-171,6519	82,2510	-140,0670			
		Lap	24,9000	8,0100	123,4200	133,6600	42,6960	163,3055	174,0575	133,4880	142,7040			
		Tump ka	-36,1800	-8,8700	-133,2800	133,6600	-57,6080	-186,3152	93,9719	-152,5140	87,7320			
	40	Tump ki	-48,1300	-14,3100	85,7000	-85,3200	-80,6520	25,9256	-153,6455	33,8130	-120,1050			Balok Lantai 4
		Lap	25,9000	8,0700	85,7000	80,4400	43,9920	124,8062	119,2832	100,4400	95,7060			
		Tump ka	-38,0900	-11,7100	-80,6400	80,4400	-64,4440	-135,7325	33,4016	-106,8570	38,1150			
41	Tump ki	-9,9800	-2,0500	60,9200	-60,8600	-15,2560	51,5498	-76,3193	45,8460	-63,7560				
	Lap	1,1900	-0,1300	60,9200	60,9200	1,2200	65,0927	65,0927	55,8990	55,8990				
	Tump ka	-13,8700	-4,1600	-60,8600	60,9200	-23,3000	-82,3977	45,4713	-67,2570	42,3450				
42-43	Tump ki	-31,6400	-8,6300	80,4400	-80,6400	-51,7760	43,0847	-126,0494	43,9200	-101,0520				
	Lap	24,3800	7,9700	80,4400	85,7000	42,0080	117,5927	123,1157	94,3380	99,0720				
	Tump ka	-37,6000	-9,0500	-85,3200	85,7000	-59,6000	-137,6183	41,9528	-110,6280	43,2900				
44-45	Tump ki	-33,2500	-7,3600	49,4200	-49,1000	-51,6760	10,0233	-93,4227	14,5530	-74,1150			Balok Atap	
	Lap	35,8100	7,3400	49,4200	51,3400	54,7160	96,4278	98,4438	76,7070	78,4350				
	Tump ka	-27,3500	-4,8400	-51,4600	51,3400	-40,5640	-87,3243	20,6157	-70,9290	21,5910				
46	Tump ki	-9,6500	-0,5300	0,9000	-0,8600	-12,4280	-9,6884	-11,5364	-7,8750	-9,4590				
	Lap	-6,0900	-0,4800	0,9000	0,9000	-8,0760	-5,9031	-5,9031	-4,6710	-4,6710				
	Tump ka	-16,6400	-4,1500	-0,8600	0,9000	-26,6080	-22,2968	-20,4488	-15,7500	-14,1660				
47-48	Tump ki	-31,0500	-6,7700	51,3400	-51,4600	-48,0920	14,9069	-93,0332	18,2610	-74,2590				
	Lap	35,3900	7,1200	51,3400	49,4200	53,8600	97,7949	95,7789	78,0570	76,3290				
	Tump ka	-30,3900	-5,8800	-49,1000	49,4200	-45,8760	-89,0211	14,4249	-71,5410	17,1270				

Keterangan Tabel 8.1:

- [1] Portal yang ditinjau
- [2] Nomor elemen balok
- [3] Letak momen: Tumpuan kiri, Tumpuan kanan, dan Lapangan
- [4] MD = Momen akibat beban mati
- [5] ML = Momen akibat beban hidup
- [6] M Gki = Momen akibat beban gempa kiri
- [7] M Gka = Momen akibat beban gempa kanan
- [8] Mu1 = 1,2MD + 1,6ML
- [9] Mu2 = 1,05 (MD + 0,9ML + M Gki)
- [10] Mu3 = 1,05 (MD + 0,9ML + M Gka)
- [11] Mu4 = 0,9 (MD + M Gki)
- [12] Mu5 = 0,9 (MD + M Gka)
- [13] Keterangan Balok: sloof, lantai 1 s/d 4, dan atap.

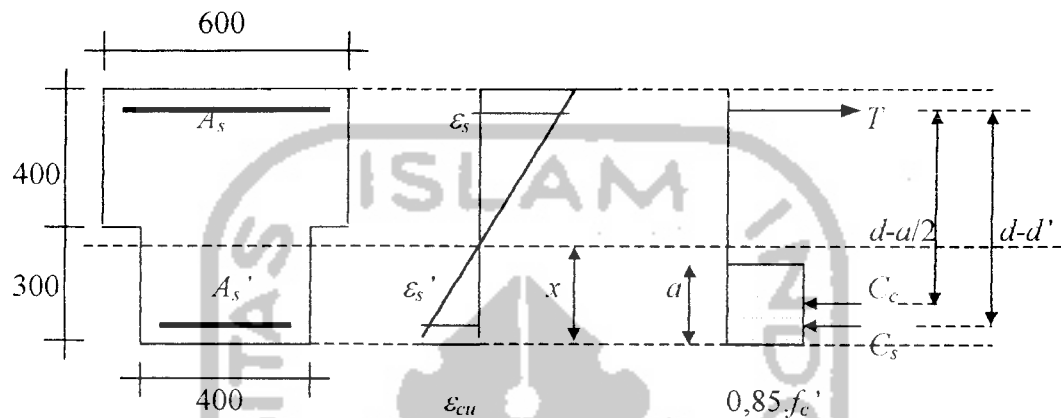
Angka yang dicetak tebal adalah Mu terbesar

8.1.2 Penulangan Lentur Balok

Sebagai contoh perhitungan penulangan lentur balok ditinjau pada Portal as 1 dan as 6, untuk balok lantai 1 adalah sebagai berikut (Dipohusodo,1996):

1. Tulangan tumpuan balok Lantai 1

- Untuk momen negatif ($M_u = - 655,2788$ kNm)



Gambar 8.1 Analisis balok bertulangan rangkap tumpuan untuk momen negatif

$$\rho_b = \frac{0,85 \cdot f_c'}{f_y} \beta_1 \left(\frac{600}{600 + f_y} \right) = \frac{0,85 \cdot 25}{400} \cdot 0,85 \left(\frac{600}{600 + 400} \right) = 0,02709$$

$$\rho_{min} = 1,4/f_y = 1,4/400 = 0,0035 ; \rho_{maks} = 0,75 \cdot \rho_b = 0,75 \cdot 0,02709 = 0,02032$$

$$\rho_{min} < \rho \leq \rho_{maks} \text{ diambil } \rho = (0,0035 + 0,02709)/4 = 0,007146$$

$$d' = p(\text{selimut beton}) + \varnothing_{\text{tul. sengkang}} + \frac{1}{2} \cdot \varnothing_{\text{tul. lentur}} = 50 + 10 + \frac{1}{2} \cdot 25 = 72,5 \text{ mm}$$

$$d = h - d' = 700 - 72,5 = 627,5 \text{ mm}$$

$$x = [600/(600 + f_y)] \cdot d = [600/(600 + 400)] \cdot 627,5 = 376,5 \text{ mm}$$

$$a = \beta_1 \cdot x = 0,85 \cdot 376,5 = 320,025 \text{ mm}$$

$$\text{Luas tulangan tarik : } A_{s1} = \rho \cdot b \cdot d = 0,007146 \cdot 400 \cdot 627,5 = 1793,646 \text{ mm}^2$$

$$T_1 = A_{s1} \cdot f_y = 1793,646 \cdot 400 = 717458,4 \text{ kN}$$

$$M_{n1} = T_1 \cdot (d - a/2) = 717458,4 \cdot (627,5 - 320,025/2)$$

$$= 335.4028 \text{ kNm} < M_n = M_u/0,8 = 819,0985 \text{ kNm}$$

$$M_{n2} = M_n - M_{n1} = 819,0985 - 335,4028 = 483,6957 \text{ kNm}$$

$$M_{n2} = C_s \cdot (d - d') \text{ atau } M_{n2} = T_2 \cdot (d - d')$$

$$T_2 = C_s = M_{n2} / (d - d') = 483,6957 / (627,5 - 72,5) = 871523,78 \text{ N}$$

Periksa regangan tulangan tekan:

$$\varepsilon_s' = [(x-d')/x] \cdot \varepsilon_{cu} = [(376,5 - 72,5)/376,5] \cdot 0,003 = 0,0024$$

$$\varepsilon_y = f_y/E_s = 400/200000 = 0,002$$

$$\varepsilon_s' > \varepsilon_y$$

dianggap baja tekan telah leleh saat beton tekan mencapai regangan hancur 0,003

dan $f_s' = f_y = 400$ MPa

$$\text{Luas tulangan tekan: } A_s' = C_c/f_s' = 871523,78/400 = 2178,81 \text{ mm}^2$$

$$\text{Tambahan luas tulangan tarik: } A_{s2} = T_2/f_y = 871523,78/400 = 2178,81 \text{ mm}^2$$

$$\text{Luas tulangan tarik: } A_s = A_{s1} + A_{s2} = 1793,646 + 2178,81 = 3872,46 \text{ mm}^2$$

$$\text{Dipakai tulangan: - tulangan tarik/atas: } \mathbf{8D25} = 3926,991 \text{ mm}^2 > A_s = 3872,46 \text{ mm}^2$$

$$\text{- tulangan tekan/bawah: } \mathbf{4D25} = 1963,50 \text{ mm}^2 > A_s' = 2178,81 \text{ mm}^2$$

Periksa kapasitas penampang (lihat Gambar 8.1)

Anggap tulangan tarik dan tulangan tekan telah leleh :

$$C_c = 0,85 \cdot f_c' \cdot b \cdot a = 0,85 \cdot 25 \cdot 400 \cdot a = 8500 \cdot a$$

$$C_s = A_s' \cdot (f_y - 0,85 \cdot f_c') = 1963,50 \cdot (400 - 0,85 \cdot 25) = 929592,64 \text{ N}$$

$$T = A_s \cdot f_y = 3926,991 \cdot 400 = 1570796,4 \text{ N}$$

Keseimbangan gaya-gaya dalam:

$$T = C_c + C_s$$

$$1570796,4 = 8500 \cdot a + 929592,64, \text{ didapat } a = 75,44 \text{ mm}$$

$$x = a/\beta_1 = 75,44/0,85 = 88,75 \text{ mm}$$

$$\varepsilon_s' = [(x-d')/x] \cdot \varepsilon_{cu} = [(88,75-72,5)/88,75]0,003 = 0,00055 < (\varepsilon_y = 0,002)$$

$$\varepsilon_s = [(d-x)/x] \cdot \varepsilon_{cu} = [(627,5-88,75)/88,75]0,003 = 0,0182 > (\varepsilon_y = 0,002)$$

Anggapan tidak benar, tulangan tekan belum leleh dicari garis netral terlebih dahulu:

untuk mendapatkan nilai x digunakan persamaan sebagai berikut:

$$(0,85 \cdot f_c' \cdot b \cdot \beta_1)x^2 + (600 \cdot A_s' - A_s \cdot f_y)x - 600 \cdot d' \cdot A_s' = 0$$

$$(0,85 \cdot 25 \cdot 400 \cdot 0,85)x^2 + (600 \cdot 1963,50 - 3926,991 \cdot 400)x - 600 \cdot 72,5 \cdot 2454,369 = 0$$

$$7225 \cdot x^2 - 98175 \cdot x - 106765051,5 = 0$$

dari persamaan diatas didapat $x = 139,25$ mm

$$f_s' = [(x-d')/x]600 = [(139,25-72,5)/139,25]600 = 287,61 \text{ MPa} < f_y = 400 \text{ MPa}$$

Periksa rasio tulangan

$$\rho = A_{s1}/(bd) = [A_s - (A_s' \cdot f_s')/f_y]/(b \cdot d)$$

$$= [3926,991 - (1963,50.261,60)/400]/(400.627,5) = 0,01$$

$\rho_{min} = 0,0035 < \rho = 0,01 < \rho_{maks} = 0,0203$, memenuhi syarat

$$a = 0,85 \cdot x = 0,85 \cdot 139,25 = 118,36 \text{ mm}$$

Hitung momen nominal aktual negatif tumpuan.

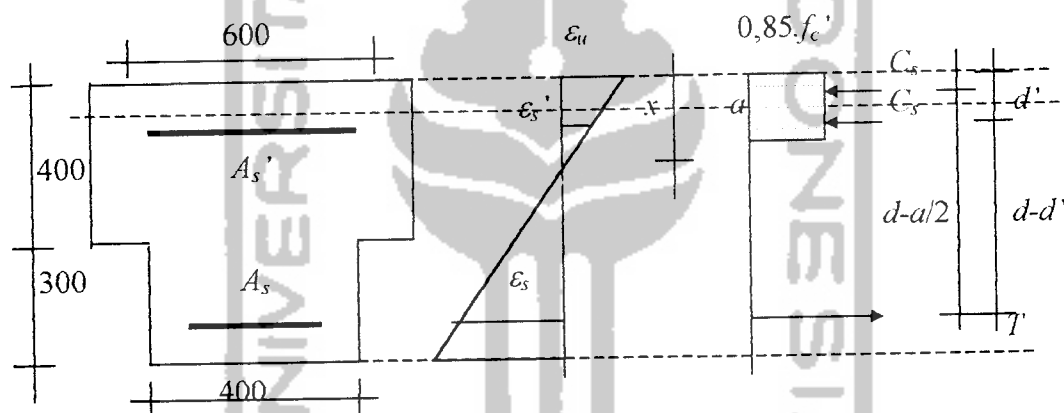
$$C_c = 0,85 \cdot f_c' \cdot b \cdot a = 0,85 \cdot 25 \cdot 400 \cdot 118,36 \cdot 10^{-3} = 1006,0749 \text{ kN}$$

$$C_s = A_s' \cdot f_s' = 1963,50 \cdot 287,61 = 564,7214 \text{ kN}$$

$$\begin{aligned} M_{nak} &= C_c \cdot [d - (a/2)] + C_s \cdot (d - d') \\ &= 1006,0749 \cdot [627,5 - (118,46/2)] + 654,7214 \cdot (627,5 - 72,5) \\ &= 885,1920 \text{ kN.m} \quad \text{- aman -} \end{aligned}$$

$$(0,8 \cdot M_{nak} = 0,8 \cdot 885,1920 = 708,1536 \text{ kNm}) > (M_u = 655,2788 \text{ kN}) \quad \text{- aman -}$$

- Untuk momen tumpuan positif ($M_u = 271,1880 \text{ kN.m}$)



Gambar 8.2 Analisis balok bertulangan rangkap tumpuan untuk momen positif

Periksa kapasitas penampang (lihat Gambar 8.2):

Anggap tulangan tarik dan tulangan tekan telah leleh :

$$C_c = 0,85 \cdot f_c' \cdot b \cdot a = 0,85 \cdot 25 \cdot 600 \cdot a = 12750 \cdot a$$

$$C_s = A_s' \cdot (f_y - 0,85 \cdot f_c') = 3926,991 \cdot (400 - 0,85 \cdot 25) = 1487347,84 \text{ N}$$

$$T = A_s \cdot f_y = 1963,50 \cdot 400 = 981747,6 \text{ N}$$

Keseimbangan gaya-gaya dalam:

$$T = C_c + C_s$$

$$981747,6 = 12750 \cdot a + 1487347,84, \text{ didapat } a = -39,65 \text{ mm}$$

$$x = a/\beta_1 = -39,65/0,85 = -46,65 \text{ mm}$$

$$\epsilon_s' = [(x-d')/x] \cdot \epsilon_{cu} = [(46,65-72,5)/46,65]0,003 = -0,00166 < \epsilon_y = 0,002$$

$$\epsilon_s = [(d-x)/x] \cdot \epsilon_{cu} = [(627,5-46,65)/46,65]0,003 = 0,0373 > \epsilon_y = 0,002$$

Anggapan tidak benar, tulangan tekan belum leleh dicari garis netral terlebih dahulu:
 untuk mendapatkan nilai x digunakan persamaan sebagai berikut:

$$(0,85 \cdot f_c' \cdot b \cdot \beta_1)x^2 + (600 \cdot A_s' - A_s \cdot f_y)x - 600 \cdot d' \cdot A_s' = 0$$

$$(0,85 \cdot 25 \cdot 600 \cdot 0,85) \cdot x^2 + (600 \cdot 3926,991 - 2454,369 \cdot 400)x - 600 \cdot 72,5 \cdot 3926,991 = 0$$

$$10837,5 \cdot x^2 + 1374447 \cdot x - 170824108,5 = 0$$

dari persamaan diatas didapat $x = 77,24$ mm

$$f_s' = [(x-d')/x]600 = [(77,25-72,5)/77,25]600 = 36,83 \text{ MPa} < f_y = 400 \text{ MPa}$$

Periksa rasio tulangan

$$\rho = A_{s1}/(bd) = [A_s - (A_s' \cdot f_s')/f_y]/(b \cdot d)$$

$$= [2454,369 - (3926,991 \cdot 36,83)/400]/(600 \cdot 627,5) = 0,0055$$

$$\rho_{min} = 0,0035 < \rho = 0,0055 < \rho_{maks} = 0,0203, \text{ memenuhi syarat}$$

$$a = 0,85 \cdot x = 0,85 \cdot 77,25 = 65,66 \text{ mm}$$

Hitung momen nominal aktual balok positif tumpuan.

$$C_c = 0,85 \cdot f_c' \cdot b \cdot a = 0,85 \cdot 25 \cdot 600 \cdot 65,66 \cdot 10^{-3} = 837,1067 \text{ kN}$$

$$C_s = A_s' \cdot f_s' = 3926,991 \cdot 36,83 \cdot 10^{-3} = 144,6410 \text{ kN}$$

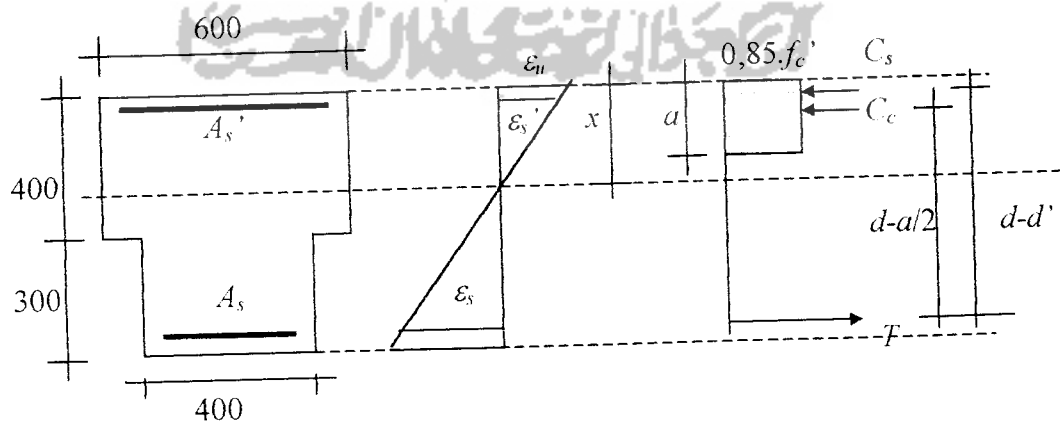
$$M_{nak} = C_c \cdot [d - (a/2)] + C_s \cdot (d - d')$$

$$= 837,1067 \cdot [627,5 - (65,66/2)] - 144,6410 \cdot (627,5 - 72,5)$$

$$= 578,0799 \text{ kNm}$$

$$(0,8 \cdot M_{nak} = 0,8 \cdot 578,0799 = 462,4639 \text{ kNm}) > (M_u = 271,1880 \text{ kNm}) - \text{aman}$$

2. Tulangan lapangan balok Lantai 1 ($M_u = 576,2222$ kNm)



Gambar 8.3 Analisis balok bertulangan rangkap untuk momen lapangan

$$\rho_b = \frac{0,85 \cdot f_c'}{f_y} \beta_1 \left(\frac{600}{600 + f_y} \right) = \frac{0,85 \cdot 25}{400} \cdot 0,85 \left(\frac{600}{600 + 400} \right) = 0,02709$$

$$\rho_{min} = 1,4/f_y = 1,4/400 = 0,0035 ; \rho_{maks} = 0,75 \cdot \rho_b = 0,75 \cdot 0,02709 = 0,02032$$

$$\rho_{min} < \rho \leq \rho_{maks} \text{ diambil } \rho = 0,004866$$

$$d' = p_{(selimut beton)} + \varnothing_{tul.sengkang} + \frac{1}{2} \cdot \varnothing_{tul.lentur} = 50 + 10 + \frac{1}{2} \cdot 25 = 72,5 \text{ mm}$$

$$d = h - d' = 700 - 72,5 = 627,5 \text{ mm}$$

$$x = [600/(600+f_y)] \cdot d = [600/(600+400)] \cdot 627,5 = 376,5 \text{ mm}$$

$$a = \beta_1 \cdot x = 0,85 \cdot 376,5 = 320,025 \text{ mm}$$

$$\text{Luas tulangan tarik: } A_{s1} = \rho \cdot b \cdot d = 0,004866 \cdot 600 \cdot 627,5 = 1832,049 \text{ mm}^2$$

$$T_1 = A_{s1} \cdot f_y = 1832,049 \cdot 400 = 732819,6 \text{ N}$$

$$M_{n1} = T_1 \cdot (d - a/2) = 732819,6 \cdot (627,5 - 320,025/2)$$

$$= 342584002,755 \text{ Nmm}$$

$$= 342,5840 \text{ kNm} < M_n = M_u/0,8 = 720,2778 \text{ kNm}$$

$$M_{n2} = M_n - M_{n1} = 720,2778 - 342,5840 = 377,6938 \text{ kNm}$$

$$M_{n2} = C_s \cdot (d - d') \text{ atau } M_{n2} = T_2 \cdot (d - d')$$

$$T_2 = C_s = M_{n2}/(d - d') = 377,6938 \cdot 10^6 / (627,5 - 72,5) = 680529,37 \text{ N}$$

Periksa regangan tulangan tekan:

$$\varepsilon_s' = [(x-d')/x] \cdot \varepsilon_{cu} = [(376,5 - 72,5)/376,5] \cdot 0,003 = 0,0024$$

$$\varepsilon_y = f_y/E_s = 400/200000 = 0,002$$

$$\varepsilon_s' > \varepsilon_y$$

dianggap baja tekan telah leleh saat beton tekan mencapai regangan hancur 0,003

dan $f_s' = f_y = 400 \text{ MPa}$

$$\text{Luas tulangan tekan: } A_{s2}' = C_s/f_s' = 680529,37/400 = 1701,32 \text{ mm}^2$$

$$\text{Tambahan luas tulangan tarik: } A_{s2} = T_2/f_y = 680529,37/400 = 1701,32 \text{ mm}^2$$

$$\text{Luas tulangan tarik: } A_s = A_{s1} + A_{s2} = 1832,049 + 1701,32 = 3433,36 \text{ mm}^2$$

$$\text{Dipakai tulangan: - tulangan tarik/bawah: } \mathbf{7D25} = 3436,117 \text{ mm}^2 > A_s = 3433,36 \text{ mm}^2$$

$$\text{- tulangan tekan/atas: } \mathbf{4D25} = 1963,50 \text{ mm}^2 > A_{s2}' = 1701,31 \text{ mm}^2$$

Periksa kapasitas penampang:

Anggap tulangan tarik dan tulangan tekan telah leleh :

$$C_c = 0,85 \cdot f_c' \cdot b \cdot a = 0,85 \cdot 25 \cdot 600 \cdot a = 12750 \cdot a$$

$$C_s = A_s' \cdot (f_y - 0,85 \cdot f_c') = 1963,50 \cdot (400 - 0,85 \cdot 25) = 929592,26 \text{ N}$$

$$T = A_s \cdot f_y = 3436,117 \cdot 400 = 1374446,8 \text{ N}$$

Keseimbangan gaya-gaya dalam:

$$T = C_c + C_s$$

$$1374446,8 = 12750 \cdot a + 929592,26, \text{ didapat } a = 34,89 \text{ mm}$$

$$x = a/\beta_1 = 34,89/0,85 = 41,05 \text{ mm}$$

$$\varepsilon_s' = [(x-d')/x] \cdot \varepsilon_{cu} = [(41,05-72,5)/41,05]0,003 = -0,0022 < \varepsilon_y = 0,002$$

$$\varepsilon_s = [(d-x)/x] \cdot \varepsilon_{cu} = [(627,5-41,05)/41,05]0,003 = 0,043 > \varepsilon_y = 0,002$$

Anggapan tidak benar, berarti tulangan tekan belum leleh diperlukan mencari garis netral terlebih dahulu:

untuk mendapatkan nilai x digunakan persamaan sebagai berikut:

$$(0,85 \cdot f_c' \cdot b \cdot \beta_1) x^2 + (600 \cdot A_s' - A_s \cdot f_y) x - 600 \cdot d' \cdot A_s' = 0$$

$$(0,85 \cdot 25 \cdot 600 \cdot 0,85) x^2 + (600 \cdot 2454,369 - 4346,117 \cdot 400) x - 600 \cdot 72,5 \cdot 2454,369 = 0$$

$$10837,5 \cdot x^2 - 265825,4 \cdot x - 106765051,5 = 0$$

dari persamaan diatas didapat $x = 98,30 \text{ mm}$

$$f_s' = [(x-d')/x]600 = [(98,30-72,5)/98,30]600 = 157,46 \text{ MPa} < f_y = 400 \text{ MPa}$$

Periksa rasio tulangan

$$\rho = A_s/(bd) = [A_s - (A_s' \cdot f_s')/f_y]/(b \cdot d)$$

$$= [3436,117 - (1963,50 \cdot 157,46)/400]/(600 \cdot 627,5) = 0,0066$$

$$\rho_{min} = 0,0035 < \rho = 0,0066 < \rho_{maks} = 0,0203$$

$$a = 0,85 \cdot x = 0,85 \cdot 98,30 = 83,55 \text{ mm} - \text{memenuhi syarat}$$

Hitung momen nominal aktual balok lapangan

$$C_c = 0,85 \cdot f_c' \cdot b \cdot a = 0,85 \cdot 25 \cdot 600 \cdot 80,60 \cdot 10^{-3} = 1065,2794 \text{ kN}$$

$$C_s = A_s' \cdot f_s' = 1963,50 \cdot (157,46) \cdot 10^{-3} = 564,7214 \text{ kN}$$

$$M_{nak} = C_c \cdot [d - (a/2)] + C_s \cdot (d - d')$$

$$= 1065,2794 \cdot [627,5 - (83,55/2)] + 564,7214 \cdot (627,5 - 72,5)$$

$$= 795,5480 \text{ kNm}$$

$$(0,8 \cdot M_{nak} = 0,8 \cdot 795,5480 = 636,4384 \text{ kNm}) > (M_u = 576,2222 \text{ kNm}) - \text{aman}$$

Dengan cara yang sama didapat penulangan lentur semua balok, disajikan dalam lampiran Tabel 8.2.

Tabel 8.2 Penulangan Lentur Balok Daktililitas Terbatas

Por-tal	Balok	Ukuran [mm]	l [m]	Letak Tulangan	Tulangan terpakai	As (mm ²)	ρ	Analisis	Mu (kNm)	b (mm)	d' (mm)	d (mm)	x (mm)	a (mm)	fs' (MPa)	Cc (kN)	Cs (kN)	Mnek (kN.m)	$\phi Mnek$ (kNm)
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]
As 1	Sloof	b = 400 h = 600	7,2	Tump.	Atas	1134,11	0,0056	M.tump. -	200,3579	400	69,5	530,5	66,25	56,31	-29,42	478,6684	-25,0225	233,4988	186,7990
					Bawah	850,59	0,0052	M.tump. +	143,9939	400	69,5	530,5	60,72	51,61	-86,80	438,6757	-98,4412	181,2968	145,0374
					Atas	850,59	0,0056	M.lap.	184,9649	400	69,5	530,5	66,25	56,31	-29,42	478,6684	-25,0225	233,4988	186,7990
As 6					Bawah	1134,11	0,0100	M.tump. -	655,2788	400	72,5	627,5	139,25	118,36	287,61	1006,0749	564,7214	885,1920	708,1536
					Atas	3926,99	0,0052	M.tump. +	271,1880	600	72,5	627,5	72,49	61,62	-0,06	785,6386	-0,2404	468,6498	374,9198
					Bawah	1963,50	0,0071	M.lap.	576,2222	600	72,5	627,5	98,30	83,55	157,46	1065,2794	309,1674	795,5480	636,4384
					Atas	1963,50	0,0056	M.lap.	184,9649	400	69,5	530,5	66,25	56,31	-29,42	478,6684	-25,0225	233,4988	186,7990
					Bawah	3436,12	0,0100	M.tump. -	636,8985	400	72,5	627,5	139,25	118,36	287,61	1006,0749	564,7214	885,1920	708,1536
					Atas	3926,99	0,0052	M.tump. +	235,9440	600	72,5	627,5	72,49	61,62	-0,06	785,6386	-0,2404	468,6498	374,9198
					Bawah	1963,50	0,0071	M.lap.	541,3727	600	72,5	627,5	98,30	83,55	157,46	1065,2794	309,1674	795,5480	636,4384
					Atas	1963,50	0,0056	M.lap.	184,9649	400	69,5	530,5	66,25	56,31	-29,42	478,6684	-25,0225	233,4988	186,7990
					Bawah	3436,12	0,0089	M.tump. -	555,5193	400	72,5	627,5	123,16	104,69	246,81	889,8441	484,6027	780,7539	624,6031
					Atas	3436,12	0,0052	M.tump. +	158,7150	600	72,5	627,5	72,49	61,62	-0,07	785,6303	-0,2321	468,6497	374,9197
					Bawah	1963,50	0,0066	M.lap.	454,5576	800	72,5	627,5	91,66	77,91	125,43	993,3862	184,7110	687,1658	549,7326
					Atas	1472,62	0,0056	M.lap.	184,9649	400	69,5	530,5	66,25	56,31	-29,42	478,6684	-25,0225	233,4988	186,7990
					Bawah	2945,24	0,0089	M.tump. -	443,7017	400	72,5	627,5	123,16	104,69	246,81	889,8441	484,6027	780,7539	624,6031
					Atas	3436,12	0,0052	M.tump. +	74,5380	600	72,5	627,5	72,49	61,62	-0,07	785,6303	-0,2321	468,6497	374,9197
					Bawah	1963,50	0,0066	M.lap.	355,9563	600	72,5	627,5	91,66	77,91	125,43	993,3862	184,7110	687,1658	549,7326
					Atas	1472,62	0,0056	M.lap.	184,9649	400	69,5	530,5	66,25	56,31	-29,42	478,6684	-25,0225	233,4988	186,7990
					Bawah	2945,24	0,0089	M.tump. -	150,8598	500	69,5	530,5	65,89	56,00	-32,90	595,0427	-27,9852	286,1066	228,8853
					Atas	1417,64	0,0049	M.tump. +	20,4840	500	69,5	530,5	57,44	48,83	-125,94	518,7775	-178,5430	180,2382	144,1905
					Bawah	850,59	0,0051	M.lap.	150,1269	500	69,5	530,5	59,61	50,67	-99,57	538,3369	-84,6909	232,9072	186,3258
					Atas	850,59	0,0051	M.lap.	150,1269	500	69,5	530,5	59,61	50,67	-99,57	538,3369	-84,6909	232,9072	186,3258
					Bawah	1134,11	0,0050	M.tump. -	-141,6051	400	69,5	530,5	59,28	50,38	-103,49	428,2656	-88,0311	198,6807	158,9446
					Atas	850,59	0,0050	M.tump. +	130,3659	400	69,5	530,5	59,28	50,38	-103,49	428,2656	-88,0311	198,6807	158,9446
					Bawah	850,59	0,0050	M.lap.	140,0784	400	69,5	530,5	59,28	50,38	-103,49	428,2656	-88,0311	198,6807	158,9446
					Atas	850,59	0,0071	M.tump. -	-226,9428	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590
					Bawah	1472,62	0,0071	M.tump. +	189,9702	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590
					Atas	1472,62	0,0071	M.lap.	221,9600	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590
					Bawah	1472,62	0,0071	M.tump. -	-225,7269	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590
					Atas	1472,62	0,0071	M.tump. +	190,1991	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590
					Bawah	1472,62	0,0071	M.lap.	221,2161	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590
					Atas	1472,62	0,0071	M.tump. -	-185,2190	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590
					Bawah	1472,62	0,0071	M.tump. +	149,8361	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590
					Atas	1472,62	0,0071	M.lap.	180,7166	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590
					Bawah	1472,62	0,0071	M.tump. -	-128,6300	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590
					Atas	1472,62	0,0071	M.tump. +	92,9400	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590
					Bawah	1472,62	0,0071	M.lap.	124,1100	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590
					Atas	1472,62	0,0071	M.tump. -	-128,6300	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590
					Bawah	1472,62	0,0071	M.tump. +	92,9400	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590
					Atas	1472,62	0,0071	M.lap.	124,1100	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590
					Bawah	1472,62	0,0071	M.tump. -	-128,6300	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590
					Atas	1472,62	0,0071	M.tump. +	92,9400	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590
					Bawah	1472,62	0,0071	M.lap.	124,1100	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590

Tabel 8.2 Lanjutan

Por-tal	Baok	Ukuran	/	Letak	Tulangan	Tulangan	As	ρ	Analisis	M_u	b	d'	d	x	a	f_s'	C_c	C_s	M_{nek}	ϕM_{nek}
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]	[21]
As 2	Atap	b = 200 h = 700	3,6	Tump.	Atas	3 D 19	850,59	0,0056	M.tump.	-66,1900	200	69,5	630,5	78,30	66,56	67,45	282,8657	57,3687	201,1174	160,8939
As 5	Bawah	b = 200 h = 700	3,6	Tump.	Bawah	3 D 19	850,59	0,0056	M.tump. +	52,6400	200	69,5	630,5	78,30	66,56	67,45	282,8657	57,3687	201,1174	160,8939
(A-B)	Atas	b = 200 h = 700	3,6	Lap	Atas	3 D 19	850,59	0,0056	M.lap.	66,0000	200	69,5	630,5	78,30	66,56	67,45	282,8657	57,3687	201,1174	160,8939
(A-B)	Bawah	b = 200 h = 700	3,6	Lap	Bawah	3 D 19	850,59	0,0056	M.lap.	66,0000	200	69,5	630,5	78,30	66,56	67,45	282,8657	57,3687	201,1174	160,8939
As 2	Sloof	b = 400 h = 600	3,6	Tump.	Atas	4 D 19	1134,11	0,0056	M.tump.	-178,4800	400	69,5	530,5	66,25	56,31	-29,42	478,6684	-25,0225	258,6800	206,9440
dan	Bawah	b = 400 h = 600	3,6	Tump.	Bawah	3 D 19	850,59	0,0062	M.tump. +	159,0700	400	69,5	530,5	60,72	51,61	-86,80	438,6757	-98,4412	198,8984	159,1187
As 5	Atas	b = 400 h = 600	3,6	Lap	Atas	3 D 19	850,59	0,0056	M.lap.	173,3500	400	69,5	530,5	66,25	56,31	-29,42	478,6684	-25,0225	258,6800	206,9440
(E-G)	Bawah	b = 400 h = 600	3,6	Lap	Bawah	4 D 19	1134,11	0,0087	M.tump.	290,4700	200	72,5	627,5	120,27	102,23	238,31	434,4649	350,9332	445,1876	356,1501
Lantai 1	Atas	b = 200 h = 700	3,6	Tump.	Atas	4 D 25	1963,50	0,0087	M.tump.	-293,2200	200	72,5	627,5	120,27	102,23	238,31	434,4649	350,9332	445,1876	356,1501
Lantai 2	Bawah	b = 200 h = 700	3,6	Tump.	Bawah	3 D 25	1472,62	0,0067	M.tump. +	229,3200	200	72,5	627,5	92,51	78,64	129,79	334,2011	254,8475	338,0115	270,4092
Lantai 3	Atas	b = 200 h = 700	3,6	Lap	Atas	3 D 25	1472,62	0,0087	M.lap.	276,2400	200	72,5	627,5	120,27	102,23	238,31	434,4649	350,9332	445,1876	356,1501
Lantai 4	Bawah	b = 200 h = 700	3,6	Lap	Bawah	4 D 25	1963,50	0,0087	M.lap.	276,2400	200	72,5	627,5	120,27	102,23	238,31	434,4649	350,9332	445,1876	356,1501
Lantai 3	Atas	b = 200 h = 700	3,6	Tump.	Atas	3 D 25	1472,62	0,0071	M.tump.	-242,2000	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590
Lantai 4	Bawah	b = 200 h = 700	3,6	Lap	Bawah	3 D 25	1472,62	0,0071	M.tump. +	171,9000	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590
Lantai 4	Atas	b = 200 h = 700	3,6	Tump.	Atas	3 D 25	1472,62	0,0071	M.tump.	221,7900	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590
Lantai 4	Bawah	b = 200 h = 700	3,6	Lap	Bawah	3 D 25	1472,62	0,0071	M.lap.	147,6400	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590
Atap	Atas	b = 200 h = 700	3,6	Tump.	Atas	3 D 25	1472,62	0,0056	M.tump.	-104,2300	200	69,5	630,5	78,30	66,56	67,45	282,8657	57,3687	201,1174	160,8939
Atap	Bawah	b = 200 h = 700	3,6	Tump.	Bawah	3 D 19	850,59	0,0056	M.tump. +	43,2900	200	69,5	630,5	78,30	66,56	67,45	282,8657	57,3687	201,1174	160,8939
Atap	Atas	b = 200 h = 700	3,6	Lap	Atas	3 D 19	850,59	0,0056	M.lap.	88,9900	200	69,5	630,5	78,30	66,56	67,45	282,8657	57,3687	201,1174	160,8939
Atap	Bawah	b = 200 h = 700	3,6	Lap	Bawah	3 D 19	850,59	0,0056	M.lap.	88,9900	200	69,5	630,5	78,30	66,56	67,45	282,8657	57,3687	201,1174	160,8939
As 3	Sloof	b = 400 h = 600	7,2	Tump.	Atas	5 D 19	1417,64	0,0063	M.tump.	-198,9200	400	69,5	530,5	74,10	62,99	37,25	535,3742	31,6833	287,3969	229,9175
dan	Bawah	b = 400 h = 600	7,2	Tump.	Bawah	3 D 19	850,59	0,0053	M.tump. +	146,1200	400	69,5	530,5	61,79	52,52	-74,90	446,4123	-106,1778	183,1972	146,5578
As 4	Atas	b = 400 h = 600	3,6	Lap	Atas	3 D 19	850,59	0,0063	M.lap.	185,8500	400	69,5	530,5	74,10	62,99	37,25	535,3742	31,6833	287,3969	229,9175
As 4	Bawah	b = 400 h = 600	3,6	Lap	Bawah	5 D 19	1417,64	0,0056	M.tump.	169,9060	400	69,5	530,5	66,25	56,31	-29,42	478,6684	-25,0225	233,4988	186,7990
As 4	Atas	b = 400 h = 600	3,6	Tump.	Atas	4 D 19	1134,11	0,0052	M.tump. +	145,3467	400	69,5	530,5	60,72	51,61	-86,80	438,6757	-98,4412	176,0163	149,2618
As 4	Bawah	b = 400 h = 600	3,6	Lap	Bawah	3 D 19	850,59	0,0056	M.lap.	172,3436	400	69,5	530,5	66,25	56,31	-29,42	478,6684	-25,0225	233,4988	186,7990
Lantai 1	Atas	bf = 600 bw = 400 hf = 400 h = 700	7,2	Tump.	Atas	8 D 25	3926,99	0,0093	M.tump.	-676,2200	400	72,5	627,5	128,55	109,26	261,60	928,7391	642,0572	888,3869	710,7095
Lantai 1	Bawah	bf = 600 bw = 400 hf = 400 h = 700	7,2	Tump.	Bawah	5 D 25	2454,37	0,0056	M.tump. +	242,0600	600	72,5	627,5	77,24	65,66	36,83	837,1067	144,6410	578,0799	462,4639
Lantai 1	Atas	bf = 600 bw = 400 hf = 400 h = 700	3,6	Lap	Atas	5 D 25	2454,37	0,0068	M.lap.	578,2800	600	72,5	627,5	94,83	80,60	141,28	1027,7023	346,7445	795,9079	636,7263
Lantai 1	Bawah	bf = 600 bw = 400 hf = 400 h = 700	3,6	Lap	Bawah	7 D 25	3436,12	0,0063	M.tump.	-292,4400	400	72,5	627,5	87,61	74,47	103,49	632,9948	152,4033	458,2185	366,5748
Lantai 1	Atas	bf = 600 bw = 400 hf = 400 h = 700	3,6	Tump.	Atas	4 D 25	1963,50	0,0047	M.tump. +	181,0000	600	72,5	627,5	65,67	55,82	-62,44	711,6554	-122,6068	358,6561	286,9249
Lantai 1	Bawah	bf = 600 bw = 400 hf = 400 h = 700	3,6	Lap	Bawah	3 D 25	1472,62	0,0052	M.lap.	257,1000	600	72,5	627,5	72,49	61,61	-0,12	785,5679	-0,1697	468,6490	374,9192

Tabel 8.2 Lanjutan

Por- tal	Balok	Ukuran [mm]	l [m]	Letak Tulangan	Tulangan terpakai	As (mm ²)	ρ	Analisis	Mu (kNm)	b (mm)	d' (mm)	d (mm)	x (mm)	a (mm)	f _{s'} (MPa)	C _c (kN)	C _s (kN)	M _{nak} (kN.m)	ϕ M _{nak} (kNm)	
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]	
As 3 dan As 4	Lantai 2	bf = 600 bw = 400 hf = 400 h = 700	7,2	Tump	Atas	8 D 25	3926,99	0,0093	M.tump. -	-634,5200	400	72,5	627,5	128,55	109,26	261,60	928,7391	642,0572	888,3869	710,7095
				Lap	Bawah	5 D 25	2454,37	0,0056	M.tump. +	202,3200	600	72,5	627,5	77,24	65,66	36,83	837,1067	144,6410	578,0799	462,4639
				Lap	Atas	5 D 25	2454,37	0,0056	M.lap.	535,6500	600	72,5	627,5	94,83	80,60	141,28	1027,7023	346,7445	795,9079	636,7263
				Lap	Bawah	7 D 25	3436,12	0,0063	M.tump. -	-285,3900	400	72,5	627,5	87,61	74,47	103,49	632,9948	152,4033	458,2185	366,5748
	Lantai 3	bf = 600 bw = 400 hf = 400 h = 700	7,2	Tump	Atas	7 D 25	3436,12	0,0089	M.tump. -	-535,9600	400	72,5	627,5	123,16	104,69	246,81	889,8441	484,6027	780,7539	624,6031
				Lap	Bawah	4 D 25	1963,50	0,0052	M.tump. +	111,5800	600	72,5	627,5	72,49	61,62	-0,07	785,6303	-0,2321	468,6497	374,9197
				Lap	Atas	4 D 25	1963,50	0,0064	M.lap.	430,6000	600	72,5	627,5	88,78	75,46	110,00	982,1087	215,9886	687,2967	549,8374
				Lap	Bawah	6 D 25	2945,24	0,0063	M.tump. -	-206,7000	400	72,5	627,5	87,61	74,47	103,49	632,9948	152,4033	458,2185	366,5748
	Lantai 4	bf = 600 bw = 400 hf = 400 h = 700	7,2	Tump	Atas	7 D 25	3436,12	0,0089	M.tump. -	-444,2800	400	72,5	627,5	123,16	104,69	246,81	889,8441	484,6027	780,7539	624,6031
				Lap	Bawah	4 D 25	1963,50	0,0052	M.tump. +	84,0900	600	72,5	627,5	72,49	61,62	-0,07	785,6303	-0,2321	468,6497	374,9197
				Lap	Atas	4 D 25	1963,50	0,0064	M.lap.	389,7800	600	72,5	627,5	88,78	75,46	110,00	982,1087	215,9886	687,2967	549,8374
				Lap	Bawah	6 D 25	2945,24	0,0063	M.tump. -	-205,7100	400	72,5	627,5	87,61	74,47	103,49	632,9948	152,4033	458,2185	366,5748
Atap	b = 200 h = 700	3,6	Tump	Atas	4 D 19	1134,11	0,0066	M.tump. -	-199,6900	200	69,5	630,5	91,55	77,82	144,51	330,7255	122,9205	264,6127	211,6901	
			Lap	Bawah	3 D 19	850,59	0,0055	M.tump. +	49,2900	200	69,5	630,5	76,64	65,14	55,88	276,8552	63,3793	201,0955	160,8764	
			Lap	Atas	3 D 19	850,59	0,0066	M.lap.	69,5400	200	69,5	630,5	91,55	77,82	144,51	330,7255	122,9205	264,6127	211,6901	
			Lap	Bawah	4 D 19	1134,11	0,0050	M.tump. -	-153,7600	400	69,5	630,5	59,28	50,38	-103,49	428,2656	-88,0311	198,6807	158,9446	
Lantai 1	b = 200 h = 700	4,8	Tump	Atas	3 D 19	850,59	0,0050	M.tump. -	-147,6400	400	69,5	630,5	59,28	50,38	-103,49	428,2656	-88,0311	198,6807	158,9446	
			Lap	Bawah	3 D 19	850,59	0,0050	M.lap.	151,8600	400	69,5	630,5	59,28	50,38	-103,49	428,2656	-88,0311	198,6807	158,9446	
			Lap	Atas	3 D 19	850,59	0,0071	M.tump. -	-219,3200	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590	
			Lap	Bawah	3 D 25	1472,62	0,0071	M.tump. +	183,4300	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590	
Lantai 2	b = 200 h = 700	4,8	Tump	Atas	3 D 25	1472,62	0,0071	M.tump. -	-215,3000	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590	
			Lap	Bawah	3 D 25	1472,62	0,0071	M.tump. +	158,5100	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590	
			Lap	Atas	3 D 25	1472,62	0,0071	M.lap.	208,5100	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590	
			Lap	Bawah	3 D 25	1472,62	0,0071	M.tump. -	-183,8800	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590	
Lantai 3	b = 200 h = 700	4,8	Tump	Atas	3 D 25	1472,62	0,0071	M.tump. -	-107,3800	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590	
			Lap	Bawah	3 D 25	1472,62	0,0071	M.tump. +	176,0500	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590	
			Lap	Atas	3 D 25	1472,62	0,0071	M.lap.	176,0500	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590	
			Lap	Bawah	3 D 25	1472,62	0,0071	M.tump. -	-183,8800	200	72,5	627,5	98,50	83,72	158,37	355,8277	233,2209	337,8238	270,2590	

Tabel 8.2 Lanjutan

Por-tal	Balok	Ukuran [mm]	l [m]	/ Tulangan	Tulangan terpakai	As (mm ²)	ρ	Analisis	Mu (kNm)	b (mm)	d' (mm)	d (mm)	x (mm)	a (mm)	f _{s'} (MPa)	C _c (kN)	C _s (kN)	M _{nek} (kN.m)	φ M _{nek} (kNm)
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]
As A dan As G	Lantai 4	b = 200 h = 700	4,8	Tump. Lap.	3 D 25 3 D 25 3 D 25	1472,62 1472,62 1472,62	0,0071 0,0071 0,0071	M.tump. M.tump. M.lap.	-142,6800 51,9200 128,4200	200 200 200	72,5 72,5 72,5	627,5 627,5 627,5	98,50 98,50 98,50	83,72 83,72 83,72	158,37 158,37 158,37	355,8277 355,8277 355,8277	233,2209 233,2209 233,2209	337,8238 337,8238 337,8238	270,2590 270,2590 270,2590
As B dan As E	Atap	b = 200 h = 700	4,8	Tump. Lap.	3 D 19 3 D 19 3 D 19	850,59 850,59 850,59	0,0056 0,0056 0,0056	M.tump. M.tump. M.lap.	-95,4000 14,4600 108,0200	200 200 200	69,5 69,5 69,5	630,5 630,5 630,5	78,30 78,30 78,30	66,56 66,56 66,56	67,45 67,45 67,45	282,8657 282,8657 282,8657	57,3687 57,3687 57,3687	201,1174 201,1174 201,1174	160,8939 160,8939 160,8939
	Sloof	b = 400 h = 600	4,8	Tump. Lap.	4 D 19 3 D 19 3 D 19	1134,11 850,586 850,586	0,0056 0,0052 0,0056	M.tump. M.tump. M.lap.	-163,9100 138,5000 157,2000	400 400 400	69,5 69,5 69,5	530,5 530,5 530,5	66,25 60,72 66,25	56,31 51,61 56,31	-29,42 -86,80 -29,42	478,6684 438,6757 478,6684	-25,0225 -98,4412 -25,0225	228,9204 198,8984 228,9204	183,1363 159,1187 183,1363
	Lantai 1	bf = 600 bw = 400 hf = 400 h = 700	4,8	Tump. Lap.	5 D 25 4 D 25 4 D 25	2454,37 1963,5 1963,5	0,0069 0,0052 0,0058	M.tump. M.tump. M.lap.	-428,8200 292,2500 413,7400	400 600 600	72,5 72,5 72,5	627,5 627,5 627,5	95,99 72,49 80,18	81,59 61,62 68,15	146,81 -0,09 57,46	693,4946 785,6072 868,9299	288,2531 -0,2091 112,8178	566,8580 468,6494 578,2580	453,4864 374,9195 462,6064
	Lantai 2	bf = 600 bw = 400 hf = 400 h = 700	4,8	Tump. Lap.	5 D 25 4 D 25 4 D 25	2454,37 1963,5 1963,5	0,0069 0,0052 0,0058	M.tump. M.tump. M.lap.	-410,4300 254,6800 383,9800	400 600 600	72,5 72,5 72,5	627,5 627,5 627,5	95,99 72,49 80,18	81,59 61,62 68,15	146,81 -0,09 57,46	693,4946 785,6072 868,9299	288,2531 -0,2091 112,8178	566,8580 468,6494 578,2580	453,4864 374,9195 462,6064
	Lantai 3	bf = 600 bw = 400 hf = 400 h = 700	4,8	Tump. Lap.	5 D 25 4 D 25 4 D 25	2454,37 1963,5 1963,5	0,0069 0,0052 0,0058	M.tump. M.tump. M.lap.	-344,1400 286,4300 305,4000	400 600 600	72,5 72,5 72,5	627,5 627,5 627,5	84,90 72,49 72,49	72,16 61,61 61,61	87,61 -0,10 -0,10	613,3758 785,5905 785,5905	172,0223 -0,1923 -0,1923	458,2345 468,6492 468,6492	366,5876 374,9194 374,9194
	Lantai 4	bf = 600 bw = 400 hf = 400 h = 700	4,8	Tump. Lap.	5 D 25 4 D 25 4 D 25	2454,37 1963,5 1963,5	0,0069 0,0052 0,0058	M.tump. M.tump. M.lap.	-248,2900 188,3200 207,2900	400 600 600	72,5 72,5 72,5	627,5 627,5 627,5	84,90 72,49 72,49	72,16 61,61 61,61	87,61 -0,10 -0,10	613,3758 785,5905 785,5905	172,0223 -0,1923 -0,1923	458,2345 468,6492 468,6492	366,5876 374,9194 374,9194

Tabel 8.2 Lanjutan

Por-tal	Balok	Ukuran [mm]	l [m]	Letak Tulangan	Tulangan terpakai	As (mm ²)	ρ	Analisis	Mu (kNm)	b (mm)	d' (mm)	d (mm)	x (mm)	a (mm)	f _s ' (MPa)	C _c (kN)	C _s (kN)	M _{nek} (kN.m)	ϕ M _{nek} (kNm)							
As B dan As E	Lantai 4	bf = 600 bw = 400 hf = 400 h = 700	2,4	Tump.	Atas	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]				
						Bawah	4 D 25	1963,5	0,0061	M.tump.	-135,2300	400	72,5	627,5	84,90	72,16	87,61	613,3758	172,0223	458,2345	366,5876					
						Bawah	4 D 25	1963,5	0,0052	M.tump.	84,4900	600	72,5	627,5	72,49	61,61	-0,10	785,5905	-0,1923	468,6492	374,9194					
						Bawah	4 D 25	1963,5	0,0052	M.lap.	93,7400	600	72,5	627,5	72,49	61,61	-0,10	785,5905	-0,1923	468,6492	374,9194					
						Bawah	4 D 25	1963,5																		
						Bawah	4 D 25	1963,5																		
	Ring	bf = 600 bw = 400 hf = 400 h = 700	4,8	Tump.	Atas	5 D 19	1417,64	0,0056	M.tump.	-163,9200	500	69,5	530,5	66,36	56,40	-28,42	599,2872	-32,2298	286,1630	228,9304						
						Bawah	4 D 19	1134,11	0,0053	M.tump.	57,1200	500	69,5	530,5	61,86	52,58	-74,09	558,6821	-105,0361	233,2709	186,6167					
						Bawah	4 D 19	1134,11	0,0056	M.lap.	146,7400	500	69,5	530,5	66,36	56,40	-28,42	599,2872	-32,2298	286,1630	228,9304					
						Bawah	5 D 19	1417,64																		
						Bawah	4 D 19	1134,11	0,0052	M.tump.	-58,6500	500	69,5	530,5	60,89	51,75	-84,87	549,8934	-96,2474	233,1186	186,4949					
						Bawah	4 D 19	1134,11	0,0052	M.tump.	8,3700	500	69,5	530,5	60,89	51,75	-84,87	549,8934	-96,2474	233,1186	186,4949					
As C dan As D	Lantai 1	bf = 600 bw = 400 hf = 400 h = 700	9,6	Tump	Atas	5 D 19	1417,64	0,0063	M.tump.	-229,5000	400	69,5	530,5	74,10	62,99	37,25	535,3742	-106,1778	192,0048	153,6038						
						Bawah	3 D 19	850,59	0,0053	M.tump.	124,9000	400	69,5	530,5	61,79	52,52	-74,90	446,4123	-106,1778	192,0048	153,6038					
						Bawah	3 D 19	850,59	0,0063	M.lap.	199,5800	400	69,5	530,5	74,10	62,99	37,25	535,3742	-106,1778	192,0048	153,6038					
						Bawah	5 D 19	1417,64																		
						Bawah	5 D 19	1417,64	0,0063	M.tump.	-229,5000	400	69,5	530,5	74,10	62,99	37,25	535,3742	-106,1778	192,0048	153,6038					
						Bawah	3 D 19	850,59	0,0053	M.tump.	124,9000	400	69,5	530,5	61,79	52,52	-74,90	446,4123	-106,1778	192,0048	153,6038					
	Lantai 2	bf = 600 bw = 400 hf = 400 h = 700	9,6	Tump	Atas	13 D 25	6381,36	0,0131	M.tump.	-1081,3400	400	72,5	627,5	181,76	154,50	360,67	1313,2234	1239,3206	1410,4262	1128,3409						
						Bawah	7 D 25	3436,12	0,0060	M.tump.	32,0100	600	72,5	627,5	82,82	70,39	74,74	897,5164	476,9303	796,2983	637,0386					
						Bawah	6 D 25	2945,24	0,0092	M.lap.	917,7800	600	72,5	627,5	128,34	109,09	261,07	1390,9343	768,9106	1223,6861	978,9489					
						Bawah	11 D 25	5399,61																		
						Bawah	10 D 25	4908,74	0,0099	M.tump.	-996,4700	400	72,5	627,5	137,20	116,62	282,94	991,2674	972,2279	1214,1868	971,3494					
						Bawah	7 D 25	3436,12	0,0062	M.tump.	730,1700	600	72,5	627,5	85,50	72,68	91,23	926,6132	447,8335	796,3264	637,0611					
Lantai 3	bf = 600 bw = 400 hf = 400 h = 700	9,6	Tump	Atas	13 D 25	6381,36	0,0131	M.tump.	-1065,1300	400	72,5	627,5	181,76	154,50	360,67	1313,2234	1239,3206	1410,4262	1128,3409							
					Bawah	7 D 25	3436,12	0,0060	M.tump.	0,0000	600	72,5	627,5	82,82	70,39	74,74	897,5164	476,9303	796,2983	637,0386						
					Bawah	6 D 25	2945,24	0,0092	M.lap.	877,9800	600	72,5	627,5	128,34	109,09	261,07	1390,9343	768,9106	1223,6861	978,9489						
					Bawah	11 D 25	5399,61																			
					Bawah	10 D 25	4908,74	0,0099	M.tump.	-970,8400	400	72,5	627,5	137,20	116,62	282,94	991,2674	972,2279	1214,1868	971,3494						
					Bawah	7 D 25	3436,12	0,0062	M.tump.	588,7900	600	72,5	627,5	85,50	72,68	91,23	926,6132	447,8335	796,3264	637,0611						

Tabel 8.2 Lanjutan

Por-tal	Balok	Ukuran [mm]	l [m]	Letak Tulangan	Tulangan terpakai	As (mm ²)	ρ	Analisis	Mu (kNm)	b (mm)	d' (mm)	d (mm)	x (mm)	a (mm)	f's (MPa)	Cc (kN)	Cs (kN)	M _{nek} (kN.m)	φ M _{nek} (kNm)
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]
As C dan As D	Lantai 4	bf = 600 bw = 400 hf = 400 h = 700	9,6	Tump Atas Bawah Lap	12 D 25 7 D 25 6 D 25	5990,49 3436,12 2945,24	0,0119 0,0060 0,0078	M.tump. - M.tump. + M.lap.	-839,6800 0,0000 682,0600	400 600 600	72,5 72,5 72,5	627,5 627,5 627,5	165,65 83,58 108,73	140,80 71,05 92,42	337,40 79,56 199,92	1196,8405 905,8247 1178,3377	1159,3539 468,6221 588,8082	1310,1984 796,3131 1011,7452	1048,1587 637,0504 809,3662
AS F	Sloof	b = 400 h = 600	4,8	Tump Atas Bawah Lap	3 D 19 3 D 19 3 D 19	850,59 850,59 850,59	0,0050 0,0050 0,0050	M.tump. - M.tump. + M.lap.	-158,0600 148,0000 155,0900	400 400 400	69,5 69,5 69,5	530,5 530,5 530,5	59,28 59,28 59,28	50,38 50,38 50,38	-103,49 -103,49 -103,49	428,2656 428,2656 428,2656	-88,0311 -88,0311 -88,0311	198,6807 198,6807 198,6807	158,9446 158,9446 158,9446
	Lantai 1	b = 200 h = 700	4,8	Tump Atas Bawah Lap	3 D 25 3 D 25 3 D 25	1472,62 1472,62 1472,62	0,0071 0,0071 0,0071	M.tump. - M.tump. + M.lap.	-236,7700 186,1700 215,0700	200 200 200	72,5 72,5 72,5	627,5 627,5 627,5	98,50 98,50 98,50	83,72 83,72 83,72	158,37 158,37 158,37	355,8277 355,8277 355,8277	233,2209 233,2209 233,2209	337,8238 337,8238 337,8238	270,2590 270,2590 270,2590
	Lantai 2	b = 200 h = 700	4,8	Tump Atas Bawah Lap	3 D 25 3 D 25 3 D 25	1472,62 1472,62 1472,62	0,0071 0,0071 0,0071	M.tump. - M.tump. + M.lap.	-236,4300 166,0000 210,2200	200 200 200	72,5 72,5 72,5	627,5 627,5 627,5	98,50 98,50 98,50	83,72 83,72 83,72	158,37 158,37 158,37	355,8277 355,8277 355,8277	233,2209 233,2209 233,2209	337,8238 337,8238 337,8238	270,2590 270,2590 270,2590
	Lantai 3	b = 200 h = 700	4,8	Tump Atas Bawah Lap	3 D 25 3 D 25 3 D 25	1472,62 1472,62 1472,62	0,0071 0,0071 0,0071	M.tump. - M.tump. + M.lap.	-202,4946 119,3178 175,9338	200 200 200	72,5 72,5 72,5	627,5 627,5 627,5	98,50 98,50 98,50	83,72 83,72 83,72	158,37 158,37 158,37	355,8277 355,8277 355,8277	233,2209 233,2209 233,2209	337,8238 337,8238 337,8238	270,2590 270,2590 270,2590
	Lantai 4	b = 200 h = 700	4,8	Tump Atas Bawah Lap	3 D 25 3 D 25 3 D 25	1472,62 1472,62 1472,62	0,0071 0,0071 0,0071	M.tump. - M.tump. + M.lap.	-153,6455 51,5498 124,8062	200 200 200	72,5 72,5 72,5	627,5 627,5 627,5	98,50 98,50 98,50	83,72 83,72 83,72	158,37 158,37 158,37	355,8277 355,8277 355,8277	233,2209 233,2209 233,2209	337,8238 337,8238 337,8238	270,2590 270,2590 270,2590
	Atap	b = 200 h = 700	4,8	Tump Atas Bawah Lap	3 D 19 3 D 19 3 D 19	850,59 850,59 850,59	0,0056 0,0058 0,0058	M.tump. - M.tump. + M.lap.	-93,4227 21,5910 98,4438	200 200 200	69,5 72,5 72,5	630,5 627,5 627,5	78,30 80,36 80,36	66,56 68,31 68,31	57,45 58,70 58,70	282,8657 290,3069 290,3069	57,3687 49,9276 49,9276	201,1174 199,9623 199,9623	160,8939 159,9699 159,9699

Keterangan Tabel 8.2.

- [1] Portal yang ditinjau
- [2] Balok: Sloof, Lantai 1 s/d 4, dan Atap
- [3] Ukuran Balok: bf = lebar sayap, bw = lebar badan, hf = tinggi sayap h = tinggi balok
- [4] l = bentang balok
- [5] Letak tulangan: Tumpuan & lapangan, Atas & bawah
- [6] Tulangan yang dipakai
- [7] Luas tulangan
- [8] $\rho = (A_s - A_s') / (f_y \cdot b \cdot d)$ (rasio penulangan)
- [9] Analisis: Momen tumpuan: -, negatif; positif dan lapangan
- [10] Mu = momen rencana balok (dari Tabel 8.1)
- [11] b = lebar balok daerah desak
- [12] d' = D/2 + 10 + 50
- [13] d = h - d' (tinggi efektif)
- [14] x: didapat dari persamaan $(0,85 \cdot f_c' \cdot b \cdot 0,85) x^2 + (600 A_s - A_s') x - 600 d' A_s = 0$
- [15] a = x · 0,85
- [16] fs' = (x - d') / x · f600
- [17] Cc = 0,85 · fc' · b · a
- [18] Cs = As · fs'
- [19] Mnak = Cc(d - a/2) + Cs(d - d')
- [20] 0,8 · Mnak ≥ Mu

8.1.3 Gaya Geser Rencana Balok

Gaya geser rencana balok dapat dihitung dengan rumus (Kusuma dan Andriono, 1993):

$$V_{u,b} = 1,05.(V_{D,b} + V_{L,b} + 4/k . V_{E,b})$$

Sebagai contoh perhitungan adalah gaya geser rencana balok Portal as 1 dan as 6, lantai 1, sebagai berikut ini.

Diketahui:

$$V_{D,b} = 100,9757 \text{ kN}$$

$$V_{L,b} = 57,3986 \text{ kN}$$

$$V_{E,b} = 58,0100 \text{ kN}$$

$$k = 2$$

$$V_{u,b} = 1,05.(100,9757 + 57,3986 + 4/2.58,0100) = 288,1140 \text{ kN}$$

Dengan cara yang sama didapat gaya geser rencana dari semua balok, disajikan pada Tabel 8.3.



Tabel 8.3 Gaya Geser Rencana Balok Daktilitas Terbatas

Por-tal	Balok	ln (m)	U-jung	V_D (kN)	V_L (kN)	V_E (kN)	$V_{u,b}$ (kN)
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
As 1- dan As 6	Sloof	6.5	1	19.3104	0.5146	22.3400	67.7303
			2	19.3104	0.5146	22.3400	-26.0978
	Lantai 1	6.5	1	100.9757	57.3986	58.0100	288.1140
			2	100.9757	57.3986	58.0100	44.4720
	Lantai 2	6.5	1	99.2063	56.3604	54.0700	276.8920
			2	99.2063	56.3604	54.0700	49.7980
	Lantai 3	6.5	1	100.0819	56.4688	42.9000	254.4682
			2	100.0819	56.4688	42.9000	74.2882
	Lantai 4	6.5	1	99.7750	56.1347	29.8900	226.4742
			2	99.7750	56.1347	29.8900	100.9362
	Ring	6.5	1	44.0736	8.8021	10.5100	77.5905
			2	44.0736	8.8021	10.5100	33.4485
As 2 dan As 5 (A-B)	Sloof	3.1	1	8.9642	0.0861	32.8900	78.5718
			2	8.9642	0.0861	32.8900	-59.5662
	Lantai 1	3.1	1	24.7742	4.0817	49.6500	134.5636
			2	24.7742	4.0817	49.6500	-73.9664
	Lantai 2	3.1	1	24.3781	3.9956	49.7800	134.3303
			2	24.3781	3.9956	49.7800	-74.7457
	Lantai 3	3.1	1	24.3522	3.9869	40.1000	113.9661
			2	24.3522	3.9869	40.1000	-54.4539
	Lantai 4	3.1	1	24.4642	4.0128	26.7400	86.0548
			2	24.4642	4.0128	26.7400	-26.2532
	Ring	3.1	1	11.0050	1.5758	13.3200	41.1819
			2	11.0050	1.5758	13.3200	-14.7621
As 2 dan As 5 (E-G)	Sloof	3.1	1	10.4281	0.3444	31.0000	76.4111
			2	10.4281	0.3444	31.0000	-53.7889
	Lantai 1	3.1	1	28.1583	5.0461	46.9600	133.4807
			2	28.1583	5.0461	46.9600	-63.7513
	Lantai 2	3.1	1	30.2681	5.3819	46.6900	135.4815
			2	30.2681	5.3819	46.6900	-60.6165
	Lantai 3	3.1	1	31.6631	5.5714	36.9400	116.6702
			2	31.6631	5.5714	36.9400	-38.4778
	Lantai 4	3.1	1	33.2131	5.6661	23.4900	90.1521
			2	33.2131	5.6661	23.4900	-8.5059
	Ring	3.1	1	30.2250	2.5144	12.1900	59.9754
			2	30.2250	2.5144	12.1900	8.7774
As 3 dan As 4	Sloof	6.5	1	19.6444	0.1986	22.8400	68.7992
			2	19.6444	0.1986	22.8400	-27.1288
		3.1	1	9.7483	0.6337	42.7600	100.6970
			2	9.7483	0.6337	42.7600	-78.8950
	Lantai 1	6.5	1	122.5521	30.7486	58.8900	284.6347
			2	122.5521	30.7486	58.8900	37.2967
		3.1	1	47.4826	10.1563	48.0600	161.4468
			2	47.4826	10.1563	48.0600	-40.4052
	Lantai 2	6.5	1	119.8708	29.9813	53.5100	269.7157
			2	119.8708	29.9813	53.5100	44.9737
		3.1	1	48.7413	10.2170	42.3800	150.9043
			2	48.7413	10.2170	42.3800	-27.0918
Lantai 3	6.5	1	121.3333	30.3333	40.6200	244.5520	
		2	121.3333	30.3333	40.6200	73.9480	
	3.1	1	50.0174	10.3559	30.4500	127.3369	
		2	50.0174	10.3559	11.9300	38.3389	
Lantai 4	6.5	1	124.3396	31.0917	30.7100	227.6938	
		2	124.3396	31.0917	30.7100	98.7118	

Tabel 8.3 Lanjutan

Porta l	Balok	ln (m)	U- jung	V _D (kN)	V _L (kN)	V _E (kN)	V _{u,b} (kN)
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
As 3 dan As 4	Lantai 4	3.1	1	53.8628	11.3976	28.0000	127.3234
			2	53.8628	11.3976	28.0000	9.7234
As 4	Atap	3.1	1	31.3628	4.5747	29.9600	100.6504
			2	31.3628	4.5747	29.9600	-25.1816
As A dan As G	Sloof	4.1	1	12.2915	0.1879	23.5500	62.5583
			2	12.2915	0.1879	23.5500	-36.3517
		1.7	1	4.9725	0.0354	39.8133	88.8663
			2	4.9725	0.0354	39.8133	-78.3497
	Lantai 1	4.1	1	38.3777	8.1658	34.2900	120.8797
			2	38.3777	8.1658	34.2900	-23.1383
		1.7	1	12.6083	1.7921	52.7067	125.8044
			2	12.6083	1.7921	52.7067	-95.5636
	Lantai 2	4.1	1	39.2660	8.1231	32.7800	118.5966
			2	39.2660	8.1231	32.7800	-19.0794
		1.7	1	12.7783	1.8700	45.4733	110.8748
			2	12.7783	1.8700	45.4733	-80.1133
	Lantai 3	4.1	1	39.8981	8.2256	26.5400	106.2639
			2	39.8981	8.2256	26.5400	-5.2041
		1.7	1	12.9200	1.9408	31.8667	82.5239
			2	12.9200	1.9408	31.8667	-51.3161
	Lantai 4	4.1	1	40.8377	8.3708	17.6200	88.6710
			2	40.8377	8.3708	17.6200	14.6670
		1.7	1	13.6708	2.2950	14.8733	47.9981
			2	13.6708	2.2950	14.8733	-14.4699
	Atap	4.1	1	45.9883	7.2775	8.7700	74.3461
			2	45.9883	7.2775	8.7700	37.5121
		1.7	1	13.4938	1.1900	0.5600	16.5939
			2	13.4938	1.1900	0.5600	14.2419
As B dan As E	Sloof	4.1	1	12.4367	0.2221	29.3200	59.8910
			2	12.4367	0.2221	29.3100	-38.6075
		1.7	1	4.8946	0.0000	33.7560	60.8215
			2	4.8946	0.0000	33.7560	-52.5986
	Lantai 1	4.1	1	75.4138	19.5433	67.3000	193.6680
			2	76.4138	19.5433	67.3000	-32.4601
		1.7	1	19.9183	3.4000	59.8160	120.0783
			2	19.9183	3.4000	59.8160	-80.9035
	Lantai 2	4.1	1	78.8908	20.2523	59.8800	183.8786
			2	78.8908	20.2523	59.8800	-17.3182
		1.7	1	19.9183	3.4000	50.0440	103.6613
			2	19.9183	3.4000	50.0440	-64.4865
	Lantai 3	4.1	1	80.1977	20.6367	49.1500	167.2729
			2	80.1977	20.6367	49.1500	2.1289
		1.7	1	19.9183	3.4000	34.6520	77.8028
			2	19.9183	3.4000	34.6520	-38.6280
	Lantai 4	4.1	1	80.9750	20.8758	34.7900	144.0019
			2	80.9750	20.8758	34.7900	27.1075
		1.7	1	19.9183	3.4000	16.6680	47.5896
			2	19.9183	3.4000	16.6680	-8.4148
	Ring	4.1	1	53.6160	12.2744	15.6900	81.7072
			2	53.6160	12.2744	15.6900	28.9888
		1.7	1	27.0442	3.4000	2.9000	30.4451
			2	27.0442	3.4000	2.9000	20.7011
As C dan As D	Sloof	8.9	1	26.1994	0.1947	17.2400	51.1342
			2	26.1994	0.1947	17.2400	-6.7922
		1.7	1	4.8946	0.0000	52.4143	92.1675
			2	4.8946	0.0000	52.4143	-83.9446

Tabel 8.3 Lanjutan

Por-tal	Balok	ln (m)	U-ujung	V_D (kN)	V_L (kN)	V_E (kN)	$V_{u,b}$ (kN)	
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	
As C dan As D	Lantai 1	8.9	1	240.3185	67.9367	46.7600	337.4912	
			2	240.3185	67.9367	46.7600	180.3776	
			1.7	1	19.8900	3.4000	97.8829	184.0068
				2	19.8900	3.4000	97.8829	-144.8796
	Lantai 2	8.9	1	239.2060	67.5844	44.6800	332.7664	
			2	239.2060	67.5844	44.6800	182.6416	
			1.7	1	19.8900	3.4000	79.6371	153.3540
				2	19.8900	3.4000	79.6371	-114.2268
	Lantai 3	8.9		1	238.6405	67.4268	34.8500	315.6445
				2	238.6405	67.4268	34.8500	198.5485
			1.7	1	19.8900	3.4000	46.2057	97.1892
				2	19.8900	3.4000	46.2057	-58.0620
	Lantai 4	8.9		1	244.0547	69.0121	23.2200	301.9857
				2	244.0547	69.0121	23.2200	223.9665
			1.7	1	19.8900	3.4000	24.7400	61.1268
				2	19.8900	3.4000	24.7400	-21.9996
As F	Sloof	4.1	1	12.4110	0.2477	26.0700	68.0387	
			2	12.4110	0.2477	26.0700	-41.4553	
			1.7	1	5.6667	0.3967	40.4800	91.3745
				2	5.6667	0.3967	40.4800	-78.6415
	Lantai 1	4.1		1	49.4563	15.0931	33.8700	138.9038
				2	49.4563	15.0931	33.8700	-3.3502
			1.7	1	15.7888	3.6267	53.5867	132.9182
				2	15.7888	3.6267	53.5867	-92.1458
	Lantai 2	4.1		1	50.1652	15.3067	33.3200	138.7175
				2	50.1652	15.3067	33.3200	-1.2265
			1.7	1	16.4688	12.6933	48.9000	133.3102
				2	16.4688	12.6933	48.9000	-72.0698
	Lantai 3	4.1		1	50.5154	15.4006	26.8000	125.4918
				2	50.5154	15.4006	26.8000	12.9318
			1.7	1	16.7025	4.0942	34.9467	95.2245
				2	16.7025	4.0942	34.9467	-51.5515
	Lantai 4	4.1		1	50.8400	15.4519	17.3300	105.9995
				2	51.1817	15.4519	17.3300	33.5722
			1.7	1	16.5538	4.0233	16.9133	57.1239
				2	16.5538	4.0233	16.9133	-13.9121
	Atap	4.1		1	33.9617	6.8760	10.5100	64.9506
				2	33.9617	6.8760	10.5100	20.8086
			1.7	1	9.8388	2.4296	0.4867	13.9038
				2	9.8388	2.4296	0.4867	11.8598

Keterangan Tabel 8.3:

- [1] Portal yang ditinjau
 [2] Balok yang ditinjau
 [3] ln = bentang bersih balok
 [4] Ujung: 1 = ujung balok, 2 = ujung balok yang lain
 [5] V_D = gaya geser balok akibat beban mati
 [6] V_L = gaya geser balok akibat beban hidup
 [7] V_E = gaya geser balok akibat beban gempa
 [8] Untuk ujung 1. $V_{u,b} = 1.05(V_D + V_L + 2.V_E)$
 Untuk ujung 2. $V_{u,b} = 1.05(V_D + V_L - 2.V_E)$

8.1.4 Penulangan Geser Balok

Sebagai contoh perhitungan adalah penulangan geser balok ditinjau pada portal as 1 dan as 6, lantai 1, sebagai berikut ini. (Kusuma, dan Andriano, 1993)

a. Sepanjang dalam daerah d

Tulangan geser dalam daerah $d = 0,6275 \text{ m} \approx 0,6 \text{ m}$ dari muka kolom ke tengah bentang.

$$V_{u,b1} = 288,1140 \text{ kN (pada ujung komponen)}$$

$$V_{u,b2} = 44,4720 \text{ kN (pada ujung komponen yang lain)}$$

$$d = 0,6275 \text{ m}$$

$$\begin{aligned} V_{u,b \text{ terpakai}} &= [(V_{u,b1} + V_{u,b2})/(l_n - d)/l_n] - V_{u,b2} \quad (\text{lihat Gambar 8.4}) \\ &= [(288,1140 + 44,4720) \cdot (6,5 - 0,6275)/6,5] - 44,4720 \\ &= 256,0067 \text{ kN} \end{aligned}$$

$$\frac{1}{2} \cdot V_c = \frac{1}{2} \cdot (1/6 \cdot \sqrt{f_c} \cdot b_w \cdot d) = \frac{1}{2} \cdot (1/6 \cdot \sqrt{24.400} \cdot 627,5) \cdot 10^{-3} = 104,5833 \text{ kN}$$

$$V_s = V_{u,b}/\phi - \frac{1}{2} \cdot V_c = 256,0067/0,6 - 104,5833 = 322,0944 \text{ kN}$$

dipakai sengkang diameter 10 mm, mutu baja $f_y = 240 \text{ MPa}$

$$A_v = \frac{1}{4} \cdot \pi \cdot d^2 = \frac{1}{4} \cdot 3,14 \cdot 10^2 = 78,54 \text{ mm}^2$$

$$S = A_v \cdot f_y \cdot d / V_s$$

$$S = (3 \cdot 78,54 \cdot 240 \cdot 627,5) / (322,0944 \cdot 10^3) = 110,17 \text{ mm}$$

$$S_{\text{terpakai}} = 110 \text{ mm} \leq S_{\text{maks}} \quad d/4 = 156,88 \text{ mm} \quad (\text{SK-SNI,1991})$$

digunakan sengkang **3P-110**

kontrol kuat geser

$$V_{u,b} \leq 0,6 \cdot (1/2 \cdot V_c + V_s)$$

$$256,0067 \text{ kN} \leq 0,6 \cdot (104,5833 + (3 \cdot 78,54 \cdot 240 \cdot 627,5) / 110 \cdot 10^3) = 256,2025 \text{ kN} \text{ --aman--}$$

b. Di luar jarak d

Untuk menghemat tulangan sengkang pada jarak di luar d , dibagi menjadi dua daerah tulangan geser.

Tulangan geser dalam daerah (0,6 m - 2 m) dari muka kolom ke tengah bentang.

$$V_{u,b \text{ terpakai}} = 256,0067 \text{ kN}$$

$$V_c = 1/6 \cdot \sqrt{f_c} \cdot b_w \cdot d = 1/6 \cdot \sqrt{24.400} \cdot 627,5 = 209,1667 \text{ kN}$$

$$V_s = V_{u,b}/\phi - V_c = 256,0067/0,6 - 209,1667 = 217,5111 \text{ kN}$$

$$S = (2 \cdot 78,54 \cdot 240 \cdot 627,5) / (217,5111 \cdot 10^3) = 108,76 \text{ mm}$$

$$S_{\text{terpakai}} = 100 \text{ mm} \leq S_{\text{maks}} = d/2 = 313,75 \text{ kN} \quad (\text{SK-SNI,1991})$$

dipakai sengkang **2P-100**

kontrol kuat geser

$$V_{u,b} \leq 0,6 \cdot (V_c + V_s)$$

$$256,0067 \text{ kN} \leq 0,6 \cdot (209,1667 + (2,78,54 \cdot 240 \cdot 627,5) / 100 \cdot 10^{-3}) = 267,3652 \text{ kN} \text{ --aman--}$$

Tulangan geser dalam daerah (2 m - tengah bentang)/sisa

$$V_{u,b \text{ terpakai}} = [(V_{u,b1} + V_{u,b2}) / (l_n - 2) / l_n] - V_{u,b2} \quad (\text{lihat Gambar 8.4})$$

$$= [(288,1140 + 44,4720) \cdot (6,5 - 2) / 6,5] - 44,4720$$

$$= 185,7798 \text{ kN}$$

$$V_c = 1/6 \cdot \sqrt{f_c} \cdot b_w \cdot d = 1/6 \cdot \sqrt{25} \cdot 400 \cdot 627,5 = 209,1667 \text{ kN}$$

$$V_s = V_{u,b} / \phi - V_c = 185,7798 / 0,6 - 209,1667 = 100,4664 \text{ kN}$$

$$S = (2,78,54 \cdot 240 \cdot 627,5) / (100,4664 \cdot 10^3) = 235,46 \text{ mm}$$

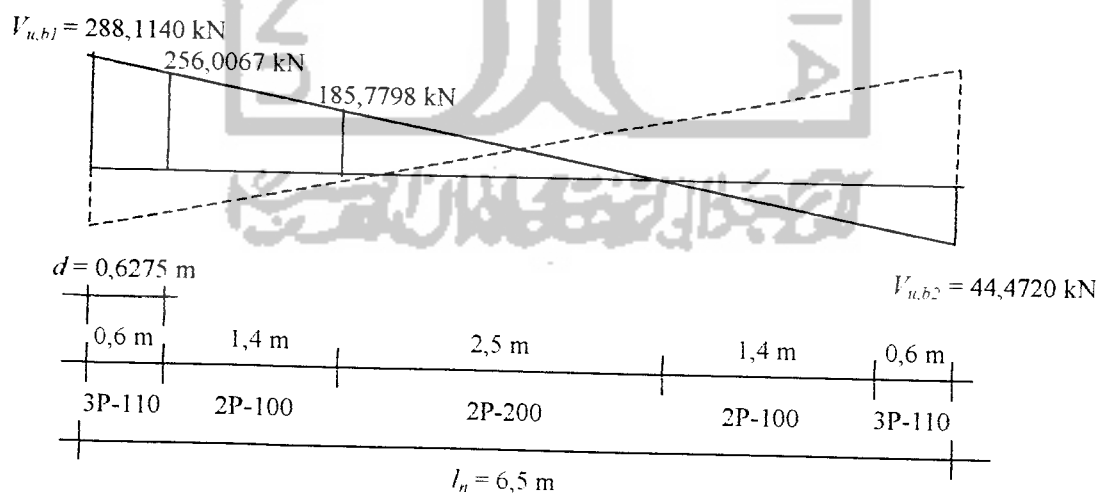
$$S_{\text{terpakai}} = 200 \leq S_{\text{maks}} = d/2 = 313,75 \text{ kN} \quad (\text{SK-SNI,1991})$$

dipakai sengkang **2P-200**

kontrol kuat geser

$$V_{u,b} \leq 0,6 \cdot (V_c + V_s)$$

$$185,7798 \text{ kN} \leq 0,6 \cdot (209,1667 + (2,78,54 \cdot 240 \cdot 627,5) / 200 \cdot 10^{-3}) = 196,4326 \text{ kN} \text{ --aman--}$$



Gambar 8.4 Distribusi gaya dan tulangan geser balok

Dengan cara yang sama didapat penulangan geser balok dari semua balok, disajikan pada Tabel 8.4.

Tabel 8.4. Lanjutan

Portai	Balok	In	Ujung	V _{u,b}	Lokasi	Jarak	V _{u,b'}	d	bw	V _c	V _s	S	S _{max}	Tul.ges terpakai	0,6(V _s +V _c) ≥ V _{u,b'}
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]
As 3 dan As 4	Lt.4	3,1	1	127,3234	Dalam d	0-0,6	90,1114	627,5	400	104,5833	45,6023	518,49	156,88	2P10- 150	157,3268
			2	9,7234	Luar d	sisa	90,1114	627,5	400	209,1667	-58,9810	-400,88	313,75	2P10- 200	196,4326
As 4	A.	3,4	1	100,6504	Dalam d	0-0,6	85,3741	627,5	200	52,2917	89,9984	262,72	156,88	2P10- 150	125,9518
			2	-25,1816	Luar d	sisa	85,3741	627,5	200	104,5833	37,7068	627,05	313,75	2P10- 200	133,6826
As A dan As G	S.	4,1	1	62,5583	Dalam d	0-0,6	59,1674	530,5	400	88,4167	10,1957	1960,56	132,63	2P10- 130	145,3080
			2	-36,3517	Luar d	Sisa	59,1674	530,5	400	176,8333	-78,2210	-255,55	265,25	2P10- 250	139,6819
	1,7	1	88,8663	Dalam d	0-0,6	85,5845	530,5	400	88,4167	54,2242	368,64	132,63	2P10- 130	145,3080	
		2	-78,3497	Luar d	sisa	85,5845	530,5	400	176,8333	-34,1925	-584,61	265,25	2P10- 250	139,6819	
	Lt.1	4,1	1	120,8797	Dalam d	0-0,6	105,9205	627,5	200	52,2917	124,2425	190,31	156,88	2P10- 150	125,9518
			2	-23,1383	Luar d	Sisa	105,9205	627,5	200	104,5833	71,9508	328,62	313,75	2P10- 200	112,4028
	1,7	1	125,8044	Dalam d	0-0,6	114,6420	627,5	200	52,2917	138,7783	170,37	156,88	2P10- 150	125,9518	
		2	-95,5636	Luar d	sisa	114,6420	627,5	200	104,5833	86,4866	273,39	313,75	2P10- 200	112,4028	
	Lt.2	4,1	1	118,5966	Dalam d	0-0,6	103,3656	627,5	200	52,2917	119,9844	197,06	156,88	2P10- 150	125,9518
			2	-19,0794	Luar d	Sisa	103,3656	627,5	200	104,5833	67,6927	349,29	313,75	2P10- 200	112,4028
	1,7	1	110,8748	Dalam d	0-0,6	99,5202	627,5	200	52,2917	113,5753	208,18	156,88	2P10- 150	125,9518	
		2	-80,1133	Luar d	sisa	99,5202	627,5	200	104,5833	61,2836	385,82	313,75	2P10- 200	112,4028	
	Lt.3	4,1	1	106,2639	Dalam d	0-0,6	90,7968	627,5	200	52,2917	99,0364	238,74	156,88	2P10- 150	125,9518
			2	-5,2041	Luar d	Sisa	90,7968	627,5	200	104,5833	46,7447	505,82	313,75	2P10- 200	112,4028
	1,7	1	82,5239	Dalam d	0-0,6	71,0046	627,5	200	52,2917	66,0493	357,98	156,88	2P10- 150	125,9518	
		2	-51,3161	Luar d	sisa	71,0046	627,5	200	104,5833	13,7576	1718,63	313,75	2P10- 200	112,4028	
	Lt.4	4,1	1	88,6710	Dalam d	0-0,6	72,8552	627,5	200	52,2917	69,1337	342,01	156,88	2P10- 150	125,9518
			2	14,6670	Luar d	Sisa	72,8552	627,5	200	104,5833	16,8421	1403,88	313,75	2P10- 200	112,4028
	1,7	1	47,9981	Dalam d	0-0,6	35,6222	627,5	200	52,2917	7,0787	3340,17	156,88	2P10- 150	125,9518	
		2	-14,4699	Luar d	sisa	35,6222	627,5	200	104,5833	-45,2129	-522,95	313,75	2P10- 200	112,4028	
	A.	4,1	1	74,3461	Dalam d	0-0,6	57,1445	630,5	200	52,5417	42,6992	556,39	157,63	2P10- 150	126,5540
			2	37,5121	Luar d	Sisa	57,1445	630,5	200	105,0833	-9,8425	-1689,62	315,25	2P10- 200	134,3217
	1,7	1	16,5939	Dalam d	0-0,6	5,1574	630,5	200	52,5417	-43,9459	-540,60	157,63	2P10- 150	126,5540	
		2	14,2419	Luar d	sisa	5,1574	630,5	200	105,0833	-96,4876	-172,35	315,25	2P10- 200	134,3217	
As B dan As E	S.	4,1	1	59,8910	Dalam d	0-1,2	57,1371	530,5	500	110,5208	-15,2923	-1307,14	132,63	2P10- 130	158,5705
			2	-38,6075	Luar d	sisa	57,1371	530,5	500	221,0417	-125,8131	-158,88	265,25	2P10- 250	180,5992
	1,7	1	60,8215	Dalam d	0-1	58,2555	530,5	500	110,5208	-13,4284	-1488,58	132,63	2P10- 130	158,5705	
		2	-52,5986	Luar d	sisa	58,2555	530,5	500	221,0417	-123,9492	-161,27	265,25	2P10- 250	180,5992	
	Lt.1	4,1	1	193,6680	Dalam d	0-0,6	168,9953	627,5	400	104,5833	177,0755	150,02	156,88	2P10- 150	157,3268
			2	-32,4601	Luar d	Sisa	168,9953	627,5	400	209,1667	72,4922	326,16	313,75	2P10- 200	196,4326
	1,7	1	120,0783	Dalam d	0-0,6	105,6182	627,5	400	104,5833	71,4470	330,93	156,88	2P10- 150	157,3268	
		2	-80,9035	Luar d	sisa	105,6182	627,5	400	209,1667	-33,1364	-713,54	313,75	2P10- 200	196,4326	
	Lt.2	4,1	1	183,8786	Dalam d	0-0,6	158,3867	627,5	400	104,5833	159,3946	155,75	156,88	2P10- 150	157,3268
			2	-17,3182	Luar d	Sisa	158,3867	627,5	400	209,1667	54,8112	431,38	313,75	2P10- 200	196,4326
	1,7	1	103,6613	Dalam d	0-0,6	89,2012	627,5	400	104,5833	44,0853	536,33	156,88	2P10- 150	157,3268	
		2	-64,4865	Luar d	sisa	89,2012	627,5	400	209,1667	-60,4980	-390,83	313,75	2P10- 200	196,4326	
	Lt.3	4,1	1	167,2729	Dalam d	0-0,6	141,3462	627,5	400	104,5833	130,9936	180,50	156,88	2P10- 150	157,3268
			2	2,1289	Luar d	Sisa	141,3462	627,5	400	209,1667	26,4103	895,27	313,75	2P10- 200	196,4326
	1,7	1	77,8028	Dalam d	0-0,6	63,3427	627,5	400	104,5833	0,9878	23935,82	156,88	2P10- 150	157,3268	
		2	-38,6280	Luar d	sisa	63,3427	627,5	400	209,1667	-103,5955	-228,24	313,75	2P10- 200	196,4326	
	Lt.4	4,1	1	144,0019	Dalam d	0-0,6	117,8138	627,5	400	104,5833	91,7730	257,64	156,88	2P10- 150	157,3268
			2	27,1075	Luar d	Sisa	117,8138	627,5	400	209,1667	-12,8103	-1845,72	313,75	2P10- 200	196,4326
	1,7	1	47,5896	Dalam d	0-0,6	33,1295	627,5	400	104,5833	-49,3675	-478,94	156,88	2P10- 150	157,3268	
		2	-8,4148	Luar d	sisa	33,1295	627,5	400	209,1667	-153,9509	-153,58	313,75	2P10- 200	196,4326	
	R.	4,1	1	81,7072	Dalam d	0-0,6	64,7653	530,5	500	110,5208	-2,5786	-7751,83	132,63	2P10- 130	145,3080
			2	28,9888	Luar d	Sisa	64,7653	530,5	500	221,0417	-113,0995	-176,74	265,25	2P10- 250	180,5992
	1,7	1	30,4451	Dalam d	0-0,6	11,5661	530,5	500	110,5208	-91,2439	-219,07	132,63	2P10- 130	145,3080	
		2	20,7011	Luar d	sisa	11,5661	530,5	500	221,0417	-201,7648	-99,07	265,25	2P10- 200	192,5927	
As C dan As D	S.	8,9	1	51,1342	Dalam d	0-0,6	48,0078	530,5	400	88,4167	-8,4036	-2378,65	132,63	2P10- 130	145,3080
			2	-6,7922	Luar d	Sisa	48,0078	530,5	400	176,8333	-96,8203	-206,46	265,25	2P10- 250	154,0742
1,7	1	92,1675	Dalam d	0-0,6	89,1323	530,5	400	88,4167	60,1371	332,39	132,63	2P10- 130	145,3080		
	2	-83,9446	Luar d	Sisa	89,1323	530,5	400	176,8333	-28,2795	-706,84	265,25	2P10- 250	154,0742		
Lt.1	8,9	1	337,4912	Dalam d	0-0,6	300,9785	627,5	400	104,5833	397,0476	119,10	156,88	4P10- 110	320,6867	
		2	180,3776	Luar d	Sisa	300,9785	627,5	400	209,1667	292,4642	121,27	313,75	3P10- 120	302,8315	
1,7	1	184,0068	Dalam d	0-0,6	166,9659	627,5	400	104,5833	173,6931	153,14	156,88	2P10- 150	169,1489		
	2	-144,8796	Luar d	Sisa	166,9659	627,5	400	209,1667	73,4404	321,95	313,75	2P10- 200	196,4326		

Tabel 8.4 Lanjutan

Por-tal	Ba-lok	l_n	U- jung	$V_{u,b}$	Lokasi	Jarak	$V_{u,b}'$	d	bw	V_c	V_s	S	S_{max}	Tul.ges terpakai	$0,6(V_s+V_c)$ $\geq V_{u,b}'$	
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	
As C dan As D	Lt.2	8,9	1	332,7664	Dalam d	0-0,6	296,4272	627,5	400	104,5833	389,4621	121,42	156,88	4P10- 110	320,6867	
			2	182,6416	Luar d	0,6-2,7	296,4272	627,5	400	209,1667	284,8787	124,50	313,75	3P10- 120	302,8315	
		1,7	1	153,3540	Dalam d	0-0,6	136,3131	627,5	400	104,5833	122,6051	216,95	156,88	2P10- 150	169,1489	
			2	-114,2268	Luar d	Sisa	138,9115	627,5	400	209,1667	22,3524	1057,79	313,75	2P10- 200	196,4326	
		Lt.3	8,9	1	315,6445	Dalam d	0-0,6	279,3910	627,5	400	104,5833	361,0683	130,97	156,88	4P10- 130	281,0042
				2	198,5485	Luar d	0,6-2,7	279,3910	627,5	400	209,1667	256,4850	138,28	313,75	3P10- 130	289,1906
	1,7	1	97,1892	Dalam d	0-0,6	80,1483	627,5	400	104,5833	28,9971	917,32	156,88	2P10- 150	169,1489		
		2	-58,0620	Luar d	Sisa	82,7467	627,5	400	209,1667	-71,2556	-331,82	313,75	2P10- 200	196,4326		
	Lt.4	8,9	1	Dalam d	0-0,6	264,9058	627,5	400	104,5833	336,9263	140,35	156,88	4P10- 130	281,0042		
				Luar d	0,6-2,7	264,9058	627,5	400	209,1667	232,3429	152,65	313,75	3P10- 130	289,1906		
	1,7	1	Dalam d	0-0,6	44,0859	627,5	400	104,5833	-31,1069	-855,11	156,88	2P10- 150	169,1489			
			Luar d	Sisa	46,6843	627,5	400	209,1667	-131,3596	-180,00	313,75	2P10- 200	196,4326			
As F	S	4,1	1	68,0387	Dalam d	0-0,6	51,2808	530,5	200	44,2083	41,2596	484,47	132,63	2P10- 130	118,7830	
			2	-41,4553	Luar d	sisa	51,2808	530,5	200	88,4167	-2,9487	-6778,99	265,25	2P10- 250	101,0242	
		1,7	1	91,3745	Dalam d	0-0,6	28,6186	530,5	200	44,2083	3,4893	5728,69	132,63	2P10- 130	118,7830	
			2	-78,6415	Luar d	sisa	28,6186	530,5	200	88,4167	-40,7190	-490,91	265,25	2P10- 250	101,0242	
		Lt.1	4,1	1	138,9038	Dalam d	0-0,6	117,1320	627,5	200	52,2917	142,9283	165,43	156,88	2P10- 150	125,9518
				2	-3,3502	Luar d	sisa	117,1320	627,5	200	104,5833	90,6367	260,87	313,75	2P10- 200	133,6826
	1,7	1	Dalam d	0-0,6	49,8431	627,5	200	52,2917	30,7802	768,16	156,88	2P10- 150	125,9518			
			Luar d	sisa	49,8431	627,5	200	104,5833	-21,5115	-1099,14	313,75	2P10- 200	133,6826			
	Lt.2	4,1	1	Dalam d	0-0,6	117,2992	627,5	200	52,2917	143,2071	165,10	156,88	2P10- 150	125,9518		
				Luar d	sisa	117,2992	627,5	200	104,5833	90,9154	260,07	313,75	2P10- 200	133,6826		
	1,7	1	Dalam d	0-0,6	57,5008	627,5	200	52,2917	43,5430	543,01	156,88	2P10- 150	125,9518			
			Luar d	sisa	57,5008	627,5	200	104,5833	-8,7486	-2702,62	313,75	2P10- 200	133,6826			
	Lt.3	4,1	1	Dalam d	0-0,6	108,2646	627,5	200	52,2917	128,1494	184,50	156,88	2P10- 150	125,9518		
				Luar d	sisa	108,2646	627,5	200	104,5833	75,8577	311,69	313,75	2P10- 200	133,6826		
	1,7	1	Dalam d	0-0,6	41,0469	627,5	200	52,2917	16,1198	1466,78	156,88	2P10- 150	125,9518			
			Luar d	sisa	41,0469	627,5	200	104,5833	-36,1719	-653,66	313,75	2P10- 200	133,6826			
	Lt.4	4,1	1	Dalam d	0-0,6	94,9146	627,5	200	52,2917	105,8993	223,27	156,88	2P10- 150	125,9518		
				Luar d	sisa	94,9146	627,5	200	104,5833	53,6077	441,06	313,75	2P10- 200	133,6826		
	1,7	1	Dalam d	0-0,6	30,9033	627,5	200	52,2917	-0,7862	-30073	156,88	2P10- 150	125,9518			
			Luar d	sisa	30,9033	627,5	200	104,5833	-53,0779	-445,46	313,75	2P10- 200	133,6826			
	A	4,1	1	Dalam d	0-0,6	58,1947	627,5	200	52,2917	44,6995	528,96	156,88	2P10- 150	125,9518		
				Luar d	sisa	58,1947	627,5	200	104,5833	-7,5921	-3114,30	313,75	2P10- 200	133,6826		
	1,7	1	Dalam d	0-0,6	13,1493	627,5	200	52,2917	-30,3761	-778,38	156,88	2P10- 150	125,9518			
			Luar d	sisa	13,1493	627,5	200	104,5833	-82,6678	-286,01	313,75	2P10- 200	133,6826			

Keterangan Tabel 8.4:

- [1] Portal yang ditinjau
 [2] Balok: Sloof, Lantai 1 s/d 4, dan Atap/Ring
 [3] l_n = jarak bentang bersih balok
 [4] Ujung: 1 = ujung balok, 2 = ujung balok yang lain
 [5] $V_{u,b}$ = gaya geser rencana balok dari Tabel 8.3
 [6] Lokasi tulangan geser: Dalam d atau Luar d
 [7] Jarak penulangan dari ujung ke tengah bentang balok
 [8] $V_{u,b}'$ = gaya geser terpakai disesuaikan lokasi tulangan
 [9] d = tinggi efektif balok
 [10] bw = lebar badan balok
 [11] $V_c = 1/2(1/6 \cdot f_c^{0,5} \cdot d \cdot bw)$ (untuk dalam d)
 $V_c = 1/6 \cdot f_c^{0,5} \cdot d \cdot bw$ (untuk luar d)
 [12] $V_s = V_{u,b}'/0,6 - V_c$
 [13] $S = (A_v \cdot f_y \cdot d)/V_s$, diameter: 10 mm (P10)
 jika $S > S_{max}$ dipakai S_{max}
 [14] $S_{max} = d/4$ (pada dalam d)
 $= d/2$ (luar d)
 [15] Tulangan geser terpakai
 [16] $0,6(V_c+V_s) \geq V_{u,b}$
 $V_s = (A_v \cdot f_y \cdot d)/S_{terpakai}$
 $f_y = 240 \text{ MPa}$, $f_c' = 25 \text{ MPa}$

8.2 Desain Kolom

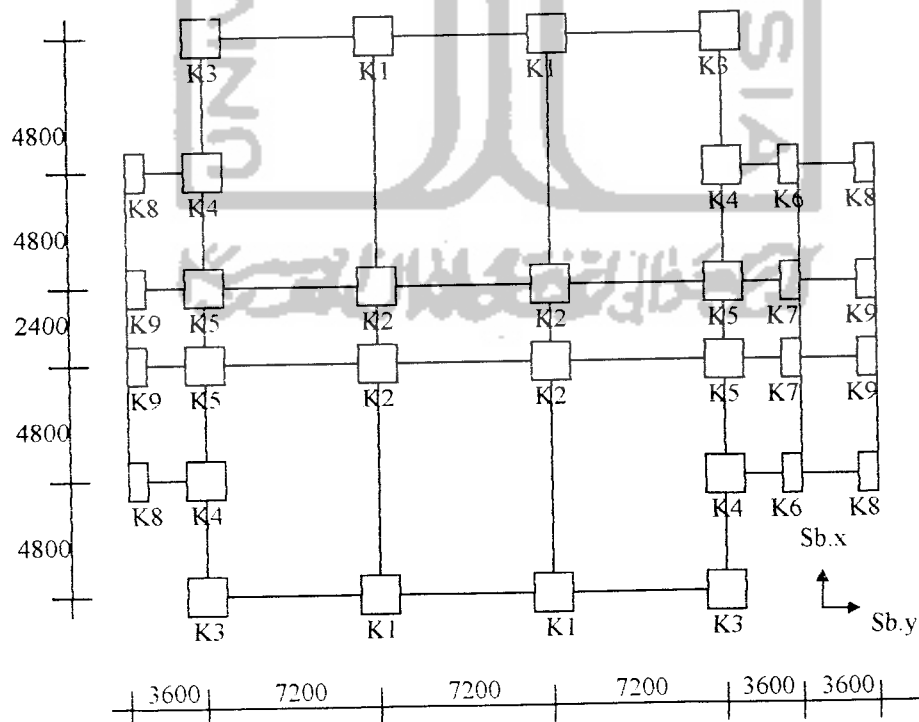
Kolom yang akan didesain telah ditentukan terlebih dahulu letak pada denah portal dan ukuran dimensinya. Kolom-kolom yang didesain adalah sebagai berikut ini:

- K1, K2, K3, K4, K5, dan, K6 dengan dimensi 700 mm x 700 mm
- K7, K8, dan K9 dengan dimensi 250 mm x 700 mm

Letak kolom-kolom yang dimaksud diatas dapat dilihat pada Gambar 8.5

Desain kolom pada pembahasan ini meliputi.

1. Momen rencana kolom
2. Gaya aksial rencana kolom
3. Perhitungan diagram interaksi kolom
4. Cek kelangsingan kolom dan faktor pembesaran momen
5. Penulangan lentur dan aksial kolom
6. Gaya geser rencana kolom
7. Penulangan geser kolom



Gambar 8.5 Denah rencana kolom lantai 1 s/d lantai 5 (Skala 1 : 280)

8.2.1 Momen Rencana Kolom

Momen rencana kolom dengan daktilitas terbatas yang ditentukan dengan rumus sebagai berikut (Kusuma dan Andriono, 1993):

$$M_{u,k \max} = 1,05 \cdot [M_{D,k,x} + M_{L,x} + \omega_d \cdot K \cdot (M_{E,k,x} + 0,3M_{E,k,y})]$$

Sebagai contoh perhitungan ditinjau pada momen kolom atas K2 lantai 1 (sejajar sumbu x)

diketahui:

$\omega_d = 1$ untuk kolom lantai 1 dan lantai paling atas

$\omega_d = 1,3$ untuk kolom lantai 2,3,4

$M_{D,k-x \text{ atas}} = 111,7600 \text{ kNm}$

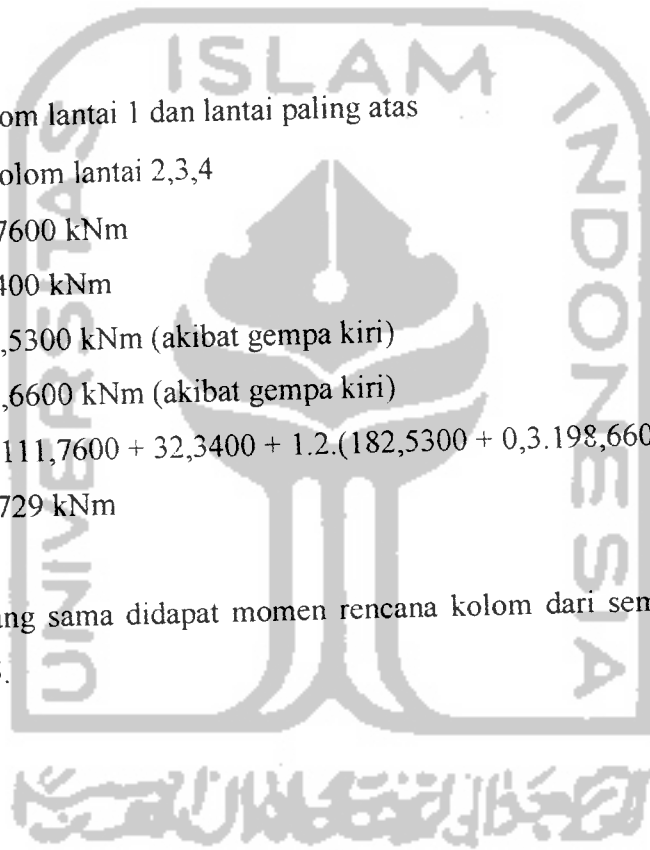
$M_{L,k-x \text{ atas}} = 32,3400 \text{ kNm}$

$M_{Eki,k-x \text{ atas}} = 182,5300 \text{ kNm}$ (akibat gempa kiri)

$M_{Eki,k-y \text{ atas}} = 198,6600 \text{ kNm}$ (akibat gempa kiri)

$M_{u,k \text{ atas}} = 1,05 [111,7600 + 32,3400 + 1,2 \cdot (182,5300 + 0,3 \cdot 198,6600)]$
 $= 593,6729 \text{ kNm}$

Dengan cara yang sama didapat momen rencana kolom dari semua kolom disajikan pada Tabel .8.5.



Tabel 8.5 Momen Rencana Kolom Daktilitas Terbatas (Satuan: kNm)

Ko- lom	Letak Momen	Sejajar Sumbu x					Sejajar Sumbu y					Akibat Gempa kiri			Akibat Gempa kanan		
		MD,k-x	ML,k-x	MEki,k-x	MEta,k-x	MD,k-y	ML,k-y	MEki,k-y	MEta,k-y	Mu,k-x1	[12]	[13]	Mu,k-x2	[14]	[15]		
K1	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]			
	1	Atas	-139,8500	-40,1100	72,9200	-71,1800	-0,5200	-0,4800	187,0200	-186,1700	81,9966	437,6316	-455,7231	-436,8504			
		Bawah	42,6500	8,5700	-139,9100	136,9500	0,4700	0,3900	-225,8100	224,8200	-382,2903	-533,3241	493,7434	531,3835			
	2	Atas	-172,0400	-50,6500	88,2100	-87,7300	-0,4800	-0,0300	213,9600	-213,4000	86,2113	554,8416	-536,5658	-503,9454			
		Bawah	191,2100	56,9900	-70,1700	70,4000	1,0100	0,8300	-205,8900	205,4400	-16,4577	-474,6441	537,8772	477,7080			
K2	3	Atas	-154,2200	-45,3100	87,3400	-86,8000	-4,3400	-1,9100	191,0300	-190,6300	94,2564	495,2434	-527,0022	-461,5695			
		Bawah	167,3300	49,1200	-45,5800	44,9400	3,2300	1,7400	-157,6300	157,2400	32,2476	-354,5199	420,7077	363,7347			
	4	Atas	-300,4400	-88,3000	67,6300	-66,6600	-1,1800	-1,3900	146,8800	-147,6300	-173,6196	348,3564	-547,9727	-381,1187			
		Bawah	190,3200	55,9300	-16,9600	16,3100	1,1100	1,3000	-105,9600	105,6400	156,1917	-230,6703	359,3667	234,6498			
	5	Atas	-300,4400	-88,3000	-67,6300	-66,6600	-7,8700	-2,5700	73,0800	-70,2700	-504,1596	99,8991	-555,5819	-210,0029			
	Bawah	190,3200	55,9300	-16,9600	16,6600	5,7800	1,2200	-60,1100	55,9400	185,0772	-129,5658	328,7907	135,3198				
K3	1	Atas	111,7600	32,3400	182,5300	-181,9900	1,4100	0,4200	198,6600	-197,1400	593,6729	355,3600	-291,7751	-460,6452			
		Bawah	-44,6700	-10,4000	-212,4700	211,9600	-1,0900	-0,3400	-239,8500	237,9200	-580,4710	-503,4646	462,8064	552,5195			
	2	Atas	147,8900	44,1500	195,1300	-194,7400	2,1900	0,6200	225,2400	-222,3600	584,6278	524,3944	-278,7687	-512,9864			
		Bawah	-157,6500	-47,4200	-192,7600	192,3700	-3,3200	-0,9300	-210,2300	208,4400	-587,3415	-497,0191	253,0589	484,5900			
	3	Atas	123,3800	36,7000	155,4800	-155,4800	1,6400	0,5900	188,2700	-193,3000	557,5623	329,8369	-224,1671	-438,5556			
	Bawah	-131,9100	-39,1600	-128,8300	128,8300	-0,1400	-0,1000	-150,4000	150,9000	-499,2566	-347,6295	140,2853	348,0443				
K4	4	Atas	224,3600	66,7300	-92,3600	-92,3600	7,1500	1,8800	169,8200	-149,6800	229,5463	205,6653	53,4219	-316,4690			
		Bawah	-166,5800	-49,5800	58,4900	58,4900	-4,6300	-1,1700	-100,5600	89,8000	-174,9263	-158,6264	-69,9904	191,1601			
	1	Atas	-28,2900	-6,0400	91,0200	-88,5300	-57,4300	-29,8200	107,7700	-106,1100	211,8411	182,4447	-274,3684	-351,7065			
		Bawah	11,9200	1,8000	-124,3000	120,8600	22,5100	6,9100	-179,0600	176,4700	-341,4602	-402,2718	360,4187	453,7388			
	2	Atas	-38,0500	-8,7200	90,5600	-89,4300	-70,9800	-38,6300	108,3800	-123,0400	272,5393	242,2078	-374,3211	-465,5453			
	Bawah	38,5700	8,7700	-78,7500	78,1700	76,3500	42,4900	-123,6200	108,3300	-253,1990	-263,3370	334,2417	460,3169				
K5	3	Atas	-41,4000	-9,7900	81,8400	-80,7400	-71,5500	-38,9100	116,8800	-115,7800	252,1285	256,6200	-350,5438	-442,4165			
		Bawah	40,3500	9,4600	-60,0100	58,8000	71,1300	38,7000	-77,0100	76,3600	-165,8681	-136,8608	261,5952	353,3444			
	4	Atas	-45,5400	-10,7600	65,8100	-63,4600	-77,7400	-44,3000	88,2700	-92,9900	183,1975	158,3968	-293,0936	-412,2795			
		Bawah	43,3500	10,2400	-35,0500	33,7400	73,5300	-39,9700	-42,3900	42,6400	-70,4277	-103,7330	174,1368	170,3143			
	5	Atas	-40,3300	-9,7000	27,1600	-27,3200	-70,2400	-18,7000	39,2300	-35,6000	27,7584	5,8015	-125,7149	-176,0907			
	Bawah	41,3000	9,8800	-6,5300	7,7800	66,8400	32,4700	-23,2400	14,1000	24,1156	48,7897	75,0120	131,8476				
K6	1	Atas	-7,3600	-3,3600	151,9400	-149,8500	-11,9500	-2,0100	41,0600	-40,8600	333,6648	167,2902	-351,7038	-194,8695			
		Bawah	2,2800	1,0300	-162,7800	160,5300	2,8400	0,1700	-173,1700	172,7000	-447,4596	-463,0479	449,3895	466,9644			
	2	Atas	-10,2200	-4,6700	158,9800	-157,5600	-14,1000	-2,4000	82,7800	-82,6900	447,5768	338,8690	-475,1993	-372,1103			
		Bawah	10,1100	4,7700	-152,2200	150,9200	10,4400	1,8700	-84,5400	84,5200	-431,8826	-342,5369	459,8395	367,2686			
	3	Atas	-12,1500	-5,1300	139,7700	-138,3900	-15,4200	-2,5400	88,2200	-88,1200	400,7707	336,4542	-433,5055	-327,7670			
	Bawah	11,6900	5,0000	-121,8100	120,4500	12,4200	2,1400	-41,7200	41,6400	-320,9770	-198,3700	352,5383	372,6138				
K7	4	Atas	-12,6900	-5,6400	106,8500	-105,0800	-15,7700	-2,6300	77,3300	-76,9300	308,4770	279,3011	-342,2072	-315,3994			
		Bawah	12,4100	5,3300	-83,5900	82,2200	13,8000	-2,3800	-10,4600	10,3900	-199,9276	-80,0270	233,6762	112,6919			
	5	Atas	-16,2900	-4,1600	59,6400	-59,6900	-26,3600	-2,7900	35,0500	-35,2000	125,8530	80,5707	-124,6455	5,7078			
		Bawah	12,7300	4,7300	-40,9600	41,4000	15,4100	2,4500	-14,4000	13,9800	-76,7550	-37,2918	114,0804	74,1930			

Tabel 8.5 Lanjutan

Ko- lom	Lan- tai	Letak Momen	Sejajar Sumbu x					Sejajar Sumbu y					Akibat Gempa kiri			Akibat Gempa kanan		
			MD,k-x	ML,k-x	MEk,k-x	MEk,k-x	MD,k-y	ML,k-y	MEk,k-y	MEk,k-y	Mu,k-x1	Mu,k-y1	Mu,k-x2	Mu,k-y2	[14]	[15]		
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]				
K5	1	Atas	23,8700	6,8100	165,0600	-164,5500	-51,3400	-13,9700	169,6900	-166,6200	437,1702	352,5852	-376,4804	-469,9296				
		Bawah	-10,5800	-2,3900	-176,1000	175,5900	19,4600	3,8400	-241,4700	236,7900	-481,9991	-534,2085	453,8684	569,1111				
	2	Atas	32,9900	9,7700	166,7100	-166,3100	-64,6500	-19,5300	179,4300	-178,9100	498,9088	397,4619	-416,9365	-524,3853				
		Bawah	-33,8800	-10,1200	-162,3700	161,9800	68,3200	18,3100	-159,5400	159,0900	-478,6523	-351,0885	394,4009	513,6404				
	3	Atas	33,7700	9,9000	141,0600	-140,6700	-64,0800	-18,1200	165,1400	-157,9200	461,8369	353,6262	-349,6795	-510,1882				
	Bawah	-32,9200	-9,6700	-125,7600	125,3800	64,5600	18,3100	-114,2300	113,4000	-372,9478	-237,6085	291,1451	392,2703					
	4	Atas	34,5100	10,4400	101,6900	-101,2500	-90,6000	-26,3600	44,7300	-127,7500	297,4443	45,8905	-247,6987	-439,2691				
		Bawah	-34,5400	-10,2600	-80,8200	80,4400	68,1600	19,5400	-46,8200	59,6600	-239,5624	-64,8697	162,1087	257,0801				
	5	Atas	37,4900	9,4300	47,3600	-47,3100	-20,5700	-3,5200	83,2200	-11,2100	191,0931	170,3391	-57,1473	-78,6408				
		Bawah	-35,9500	-10,0700	-32,4000	32,4100	16,0800	3,5400	-143,3800	19,5800	-206,6904	-300,9090	32,0754	82,1373				
K6	1	Atas	-18,6200	-5,3300	37,6500	-37,3200	-0,0600	-0,0300	33,5800	-33,5800	75,0729	75,3144	-124,6749	-75,2993				
		Bawah	9,7400	1,9800	-77,7600	77,2200	0,2100	0,0600	-32,9200	32,9200	-171,7296	-94,2698	187,3993	92,0900				
	2	Atas	-22,9800	-6,9800	49,6100	-49,6100	-0,1800	-0,0700	40,3700	-40,3700	98,3031	92,6503	-161,0721	-93,0350				
		Bawah	24,8300	7,8000	-47,7600	47,8000	0,3500	0,0800	-40,6400	40,6400	-91,6377	-91,9850	160,2447	92,7276				
	3	Atas	-23,3700	-6,9700	47,4200	-47,3200	-0,4100	-0,0900	35,4700	-35,4700	90,0711	83,0893	-153,5751	-83,8569				
	Bawah	23,0500	6,8000	-33,8000	33,6800	0,5000	0,1000	-35,8500	35,8500	-62,2230	-76,7592	124,6560	77,7067					
	4	Atas	-22,2200	-7,1600	38,9900	-38,9000	-0,7700	-0,1100	25,5900	-25,5900	67,1517	61,9030	-128,6607	-63,3360				
		Bawah	23,4400	7,2100	-19,4100	19,3100	0,7900	0,1100	-26,0300	26,0300	-24,9774	-52,7570	89,1324	54,2186				
	5	Atas	-33,2500	-7,3600	24,7100	-24,5500	-0,9800	-0,1300	15,6100	-15,6100	19,0848	37,7462	-104,0298	-39,5304				
		Bawah	25,9100	7,1500	-3,8700	3,7700	1,0700	0,1300	-15,6100	15,6100	16,7517	-27,1673	52,4643	29,1329				
K7	1	Atas	12,4000	4,0300	79,8700	-79,7400	-1,0300	-0,1800	34,3300	-35,1800	196,2761	84,7984	-172,3659	-94,0385				
		Bawah	-5,8300	-1,3100	-111,3700	111,2100	0,4600	0,0300	-34,3700	35,2700	-189,3795	-99,2779	248,2641	98,3578				
	2	Atas	15,1800	5,2900	93,1000	-93,0400	-1,5000	-0,2800	34,8300	-35,3000	172,0414	90,9489	-196,1295	-94,2299				
		Bawah	-15,8900	-5,4600	-93,8000	93,7400	1,6000	0,3300	-34,9600	35,4600	-176,2383	-91,3385	196,7763	97,5951				
	3	Atas	14,4200	4,9800	80,5900	-80,5300	-1,0200	-0,1100	28,7100	-28,5500	166,1570	76,9133	-166,7295	-87,2628				
	Bawah	-13,9100	-4,7600	-71,3800	71,3200	1,0400	0,1300	-28,7500	28,7300	-187,6140	-72,8811	148,2684	74,5452					
	4	Atas	13,2200	5,0300	58,2600	-58,2000	-1,8000	-0,3200	18,7100	-20,1200	153,2958	51,6382	-115,7331	-56,8008				
		Bawah	-13,7600	-4,9300	-44,1300	44,0700	1,6400	0,2800	-18,8400	20,1700	-124,1667	-45,7449	85,6296	72,1371				
	5	Atas	17,6900	4,3000	26,1800	-26,1000	-2,7500	-0,8400	5,7800	-24,5100	93,9652	39,7790	-47,1618	-64,5152				
		Bawah	-14,8900	-4,6300	-12,5200	12,4500	3,1800	0,9700	-5,6700	23,5100	-60,4321	-24,6994	20,4603	61,5720				
K8	1	Atas	-14,6300	-3,1000	41,2400	-40,8100	-8,1900	-1,3200	40,2600	-40,5300	93,3513	65,3521	-129,8514	-72,4853				
		Bawah	8,1900	1,1700	-54,4100	53,8300	6,0700	0,7800	-59,9800	60,3100	-142,2204	-99,4785	160,8663	95,6211				
	2	Atas	-18,5600	-4,1700	45,0800	-44,9100	-11,7000	-2,0300	52,8500	-52,9200	104,0970	81,2298	-151,5171	-92,3051				
		Bawah	19,0300	4,3800	-43,3200	43,2300	11,9200	2,1000	-53,5100	53,5400	-100,1028	-81,2120	149,0937	92,6339				
	3	Atas	-19,2500	-4,1400	40,3900	-40,2400	-13,3700	-2,2400	49,0800	-49,1500	91,1799	72,8801	-140,0280	-94,2219				
		Bawah	18,6800	4,0500	-35,1100	34,9200	13,2600	2,2300	-42,0400	42,1300	-76,3497	-61,1902	123,7404	82,3791				
	4	Atas	-18,5000	-4,3400	31,5200	-31,0600	-13,6600	-2,3900	37,3700	-37,6400	65,7531	52,9634	-112,9212	-75,0518				
		Bawah	19,1900	4,2200	-24,1100	23,8500	14,3500	2,4000	-27,5100	27,6800	-43,3818	-35,9923	92,1039	58,9817				

Tabel 8.5 Lanjutan

Ko- lom	Lan- tai	Sejajar Sumbu x			Sejajar Sumbu y			Akibat Gempa kiri		Akibat Gempa kanan			
		MD,k-x	MEki,k-x	MEka,k-x	MD,k-y	MEki,k-y	MEka,k-y	Mu,k-x1	Mu,k-y1	Mu,k-x2	Mu,k-y2		
[1]	[2]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]
K8	5 Atas	-28,8000	-3,4200	19,1100	-19,4400	-21,9200	-2,5200	24,3500	-24,1400	21,6405	31,8855	-89,8632	-70,8826
	Bawah	22,4100	3,9300	-10,7600	11,2400	17,8100	2,4600	-14,3000	14,0100	-3,9480	-16,3016	63,0917	60,6750
K9	1 Atas	-9,5600	-2,4300	85,7100	-85,7100	5,5900	1,1100	23,7500	-24,9700	140,4203	75,4170	-160,3999	-67,5915
	Bawah	4,7800	0,7700	-106,4900	106,4900	-3,3800	-0,5600	-25,1300	26,4000	-179,8977	-84,3191	189,4881	80,5064
	2 Atas	-11,0700	-3,1400	89,9300	-89,9300	7,8000	1,6100	24,2100	-25,0800	145,6723	79,8166	-169,0719	-67,6215
	Bawah	12,1800	3,4200	-89,2400	89,2400	-7,5800	-1,5800	-23,8300	24,6300	-143,2484	-78,7999	168,8617	66,8618
	3 Atas	-10,2100	-2,9500	76,0500	-76,0500	8,8300	1,8300	20,3800	-21,1200	122,2193	69,2937	-143,8580	-55,1279
	Bawah	10,0100	2,8600	-69,1200	69,1200	-8,5900	1,7900	-19,5100	20,2000	-110,8259	-62,3265	131,9715	53,6014
	4 Atas	-7,5500	-2,6400	54,6700	-54,6700	9,2600	1,9200	14,1500	-14,6800	113,0220	56,9221	-134,7549	-40,1483
	Bawah	8,9100	2,7800	-44,2500	44,2500	-8,9200	-1,8200	-12,8300	14,3000	-88,7334	-52,2170	114,2085	36,8381
	5 Atas	-20,3000	-4,6000	23,4900	-23,4900	7,4800	0,9200	4,5100	-17,6000	32,5316	49,6346	-103,8744	-42,9387
	Bawah	12,9700	3,5200	-14,3600	14,3600	-7,7100	-1,1100	-3,4900	16,8500	-21,0563	-38,4552	81,3204	38,6879

Keterangan Tabel 8.5:

- [1] Kolom yang ditinjau
- [2] Tingkat lantai tiap kolom yang ditinjau
- [3] Letak momen pada bagian atas dan bawah kolom
- [4] $M_{D,k-x}$ = Momen kolom akibat beban mati sejajar sb-x
- [5] $M_{L,k-x}$ = Momen kolom akibat beban hidup sejajar sb-x
- [6] $M_{Eki,k-x}$ = Momen kolom akibat beban gempa kiri sejajar sb-x
- [7] $M_{Eka,k-x}$ = Momen kolom akibat beban gempa kanan sejajar sb-x
- [8] $M_{D,k-y}$ = Momen kolom akibat beban mati sejajar sb-y
- [9] $M_{L,k-y}$ = Momen kolom akibat beban hidup sejajar sb-y
- [10] $M_{Eki,k-y}$ = Momen kolom akibat beban gempa kiri sejajar sb-y
- [11] $M_{Eka,k-y}$ = Momen kolom akibat beban gempa kanan sejajar sb-y
- [12] $M_{u,k-x1} = 1,05(M_{D,k-x} + M_{L,k-x} + \omega_d \cdot k)(M_{Eki,k-x} - 0,3M_{Eka,k-x})$
(Momen maksimum kolom sejajar sb-x, akibat gempa kiri) dengan $k = 1$
- [13] $M_{u,k-y1} = 1,05(M_{D,k-y} + M_{L,k-y} + \omega_d \cdot k)(M_{Eki,k-y} - 0,3M_{Eka,k-y})$
(Momen maksimum kolom sejajar sb-y, akibat gempa kiri) dengan $k = 1$
- [14] $M_{u,k-x2} = 1,05(M_{D,k-x} + M_{L,k-x} + \omega_d \cdot k)(M_{Eka,k-x} - 0,3M_{Eki,k-x})$
(Momen maksimum kolom sejajar sb-x, akibat gempa kanan) dengan $k = 1$
- [15] $M_{u,k-y2} = 1,05(M_{D,k-y} + M_{L,k-y} + \omega_d \cdot k)(M_{Eka,k-y} - 0,3M_{Eki,k-y})$
(Momen maksimum kolom sejajar sb-y, akibat gempa kanan) dengan $k = 1$
dengan $k = 2, \omega_d = 1$ (untuk lantai 1 dan 5), $\omega_d = 1,3$ (untuk lantai 2,3, dan 4)

8.2.2. Gaya Aksial Rencana Kolom

Gaya aksial rencana $N_{u,k}$ yang bekerja pada kolom portal dengan daktilitas penuh dihitung dengan rumus sebagai berikut, untuk gaya gravitasi dijumlah dengan arah tegak lurus nya, namun untuk gaya gempa arah tegak lurus nya hanya diambil 30 % saja. (Kusuma dan Andriono, 1993)

$$N_{u,k,maks} = 1,05 (N_{g,k,x} + N_{g,k,y} + \omega_d K.(N_{E,k,x} + N_{E,k,y}))$$

dengan:

$$N_{g,k} = N_{D,k} + N_{L,k} \text{ (sesuai arah } x \text{ dan arah } y \text{)}$$

Sebagai contoh perhitungan ditinjau pada kolom K2 lantai 1

diketahui:

$\omega_d = 1$ untuk kolom lantai 1 dan lantai paling atas

$\omega_d = 1,3$ untuk kolom lantai 2,3,4

Gaya aksial

Berat kolom = 197,57 kN

$$N_{D,k,x} = 1150,2200 \text{ kN}, N_{L,k,x} = 312,5500 \text{ kN}$$

$$N_{g,k,x} = 1150,2200 + 312,5500 = 1462,7700 \text{ kN}$$

$$N_{D,k,y} = 1072,9700 \text{ kN}, N_{L,k,y} = 268,5900 \text{ kN}$$

$$N_{g,k,y} = 1072,9700 + 268,5900 = 1341,5600 \text{ kN}$$

$$N_{Eka,k,x} = 671,1900 \text{ kN}$$

$$N_{Eka,k,y} = 5,8100 \text{ kN}$$

$$\begin{aligned} N_{u,k,x} &= 1,05.(\text{Berat kolom} + N_{g,k,x} + N_{g,k,y} + \omega_d K.(N_{E,k,x} + 0,3.N_{E,k,y})) \\ &= 1,05.[1462,7700 + 1341,5600 + 1,2.(671,1900 + 0,3.5,8100)] \\ &= 4557,8337 \text{ kN} \end{aligned}$$

Dengan cara yang sama didapat gaya aksial rencana kolom dari semua kolom, yang disajikan pada Tabel 8.6.

Tabel 8.6 Gaya Aksial Rencana Kolom Daktilitas Terbatas (Satuan kN)

Ko- lom	Lantai	Berat Kolom	Sejajar Sumbu x					Sejajar Sumbu y					Akibat Gempa Kiri			Akibat Gempa Kanan		
			N _{D,k-x}	N _{L,k-x}	N _{Eki,k-x}	N _{Eka,k-x}	N _{D,k-y}	N _{L,k-y}	N _{Eki,k-y}	N _{Eka,k-y}	N _{u,k-x1}	N _{u,k-y1}	N _{u,k-x2}	N _{u,k-y2}				
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]				
K1	1	-242,2600	-1020,3000	-287,9400	150,2200	-148,9600	-1028,4300	-534,7300	-11,8300	9,1200	-2961,3339	-3199,5474	-3576,4134	-3344,0358				
	2	-178,7500	-764,9700	-215,8900	103,0600	-102,2000	-806,8000	-408,8700	-6,9500	4,6300	-2218,3823	-2428,6114	-2769,2580	-2565,1059				
	3	-143,0600	-508,4400	-143,4700	58,3800	-57,8200	-587,1600	-284,1600	-3,6800	1,6400	-1593,2410	-1711,8377	-1906,1099	-1792,4819				
	4	-89,3800	-251,3000	-70,8900	23,2200	-22,9700	-368,5400	-159,8900	-1,6800	-0,1600	-924,9853	-972,5692	-1049,8391	-1006,2492				
	5	-44,6900	-251,3000	-70,8900	23,2200	-22,9700	-149,7800	-35,2500	-0,4100	-0,4200	-531,0018	-565,7379	-628,0071	-594,8586				
K2	1	-197,5700	-1150,2200	-312,5500	669,9300	-671,1900	-1072,9700	-268,5900	-16,6200	5,8100	-1755,6128	-2764,8411	-4557,8337	-3562,6437				
	2	-134,0600	-862,9200	-234,4700	374,5000	-375,3600	-804,3300	-201,3000	-13,3300	3,2300	-1337,4663	-2078,6094	-3371,0214	-2847,5359				
	3	-89,3800	-576,8200	-156,7700	140,4500	-141,0100	-536,8900	-134,3900	-11,0400	1,5100	-1194,5758	-1484,0732	-1952,6831	-1680,3274				
	4	-44,6900	-291,3300	-79,2400	13,8900	-14,1400	-269,9200	-67,6400	-10,0700	0,6900	-760,7888	-806,5762	-828,4981	-800,1580				
K3	1	-242,2600	-352,9900	-69,2400	212,4900	-209,3600	-501,6400	-261,5600	195,3800	-192,6800	-929,7561	-954,9078	-2060,1189	-2035,5993				
	2	-178,7500	-281,4300	-55,7900	145,1900	-143,1700	-393,9100	-200,6000	137,3700	-135,0600	-657,1293	-672,0733	-1667,4722	-1651,9740				
	3	-143,0600	-205,1300	-40,9300	85,3200	-84,1300	-284,2200	-138,4800	83,3100	-81,2700	-551,2565	-555,0976	-1148,6460	-1143,1806				
	4	-89,3800	-126,1200	-25,2700	39,0300	-38,7100	-173,7400	-75,9300	40,4000	-38,5600	-375,3225	-372,7044	-652,2209	-651,9343				
	5	-44,6900	-46,0200	-9,3400	10,4500	-10,5100	-63,0500	-13,7500	10,5100	-9,6800	-157,1262	-157,0380	-213,8619	-212,6418				
K4	1	-242,2600	-912,4900	-234,6000	9,0200	-10,8300	-178,6500	-28,1200	166,2100	-166,0700	-1552,2717	-1321,2024	-1803,2931	-2031,4959				
	2	-178,7500	-701,0800	-179,4600	14,0700	-15,1800	-145,9500	-22,2600	119,2400	-119,1900	-1152,8063	-951,8265	-1427,9330	-1626,6961				
	3	-143,0600	-497,2900	-126,5700	14,3100	-14,9300	-110,8000	-16,0100	72,5500	-72,5600	-839,9318	-728,6351	-1038,6020	-1148,7330				
	4	-89,3800	-297,7600	-74,9100	11,4500	-11,5500	-74,0400	-9,5400	35,6100	-35,6800	-512,4884	-466,3187	-633,6649	-679,7774				
	5	-44,6900	-100,2300	-23,8100	5,2300	-5,1500	-36,0600	-2,9600	12,1300	-12,1900	-199,5126	-189,3696	-236,6322	-246,9810				
K5	1	-242,2600	-583,9300	-138,7100	188,6900	-190,0000	-775,7400	-179,7600	7,6600	-33,2800	-1615,3452	-1881,4593	-2436,3864	-2206,0080				
	2	-178,7500	-466,3500	-111,0300	101,4000	-102,3200	-589,8500	-135,8800	-3,0700	-23,1900	-1281,6453	-1481,2875	-1854,2792	-1703,0618				
	3	-143,0600	-345,8800	-82,5200	35,9100	-36,4800	-404,7600	-92,2200	-15,1700	-12,5100	-1036,2519	-1133,8658	-1231,6981	-1185,8914				
	4	-89,3800	-223,8700	-53,5700	-1,5600	1,3400	-219,9800	-48,6700	-27,2500	-2,8500	-693,8201	-742,9136	-665,9195	-673,9265				
	5	-44,6900	-100,9500	-24,3300	-8,4300	8,4100	-33,9300	-4,6700	-29,9600	4,3500	-255,5763	-287,2254	-198,5970	-204,5652				
K6	1	-86,5200	-289,5800	-80,0500	147,8900	-147,5100	-251,0700	-37,7100	46,1700	45,7600	-500,6946	-785,9628	-1063,1187	-779,0118				
	2	-63,8400	-217,1500	-62,0900	87,9500	-87,7300	-180,6800	-27,7300	26,4900	26,3900	-360,6563	-579,3512	-796,9540	-578,8707				
	3	-47,8800	-158,4200	-44,1700	54,6300	-54,4700	-132,8300	-18,5900	15,2200	15,2400	-285,3098	-418,7931	-558,2060	-424,9902				
	4	-31,9200	-99,2800	-26,1400	27,8400	-27,7300	-88,3200	-9,9200	-7,1100	7,2800	-198,1789	-284,9683	-338,0396	-271,1955				
	5	-15,9600	-39,7600	-8,0500	10,5100	-10,4600	-46,8500	-1,4700	-3,4200	3,5700	-97,7781	-118,2552	-137,4114	-116,7873				

Tabel 8.6. Lanjutan

Ko- lom	Lantai	Berat Kolom	Sejajar Sumbu x			Sejajar Sumbu y			Akibat Gempa Kiri		Akibat Gempa Kanan			
			$N_{D,k-x}$	$N_{L,k-x}$	$N_{Eka,k-x}$	$N_{D,k-y}$	$N_{L,k-y}$	$N_{Eki,k-y}$	$N_{u,k-x1}$	$N_{u,k-y1}$	$N_{u,k-x2}$	$N_{u,k-y2}$		
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]
K7	1	-86,5200	-350,9500	-92,3100	110,0700	-110,3900	-385,7900	-78,2300	-67,3700	84,4700	-854,7861	-1115,6229	-1222,0929	-935,6487
	2	-63,8400	-272,8000	-70,3900	63,5600	-63,7900	-296,7100	-59,2800	-42,6000	60,7800	-662,5416	-865,4134	-925,5389	-687,4856
	3	-47,8800	-196,4500	-49,2200	23,5200	-23,6900	-211,0700	-40,7700	-21,4800	41,3800	-526,0420	-612,0370	-603,4430	-479,0942
	4	-31,9200	-120,8200	-28,3400	-2,1000	2,0000	-128,0700	-22,6200	-6,3100	30,1900	-359,2594	-367,3047	-318,1729	-264,3018
	5	-15,9600	-45,3700	-7,4100	-10,1400	10,0900	-49,9900	-5,5800	-1,1800	20,8000	-152,5629	-139,3917	-96,2325	-80,4888
K8	1	-86,5200	-226,9100	-41,3900	119,9000	-119,5900	-177,6600	-27,9300	-127,3400	127,5100	-416,8647	-780,3075	-759,2382	-396,0012
	2	-63,8400	-182,3900	-32,2100	85,6100	-85,4700	-145,4000	-22,1700	-92,7500	92,8000	-310,5575	-651,4034	-625,6404	-284,9664
	3	-47,8800	-136,6600	-22,8300	52,8200	-52,8000	-110,3900	-15,9500	-57,3300	57,3200	-253,1502	-463,6468	-447,5944	-237,1551
	4	-31,9200	-90,3200	-13,3700	26,2800	-26,3900	-73,6600	-9,5000	-28,5000	28,4000	-181,3056	-285,9902	-278,4936	-173,7899
	5	-15,9600	-43,2600	-3,9300	8,6700	-8,7700	-35,1000	-2,9200	-8,7100	8,6200	-93,5088	-119,0574	-119,2149	-93,6516
K9	1	-86,5200	-333,0500	-55,3100	134,5000	-134,9000	-226,3800	-43,3000	-77,0300	91,2600	-547,8669	-858,8160	-1007,5842	-675,1290
	2	-63,8400	-250,7800	-43,4700	53,5600	-53,6900	-215,4300	-33,3500	-41,9700	54,5800	-525,3681	-707,9260	-739,0862	-532,1822
	3	-47,8800	-190,1400	-32,0100	18,1300	-18,1500	-124,8200	-23,6200	-23,9600	35,6100	-409,5218	-489,9558	-459,7784	-357,0431
	4	-31,9200	-130,4300	-20,7600	-3,1300	3,2400	-77,3500	-13,7000	-10,1300	20,0900	-304,7094	-318,0864	-262,5691	-230,3687
	5	-15,9600	-72,8900	-10,1900	-7,8300	7,9300	-29,3800	-3,8700	-2,2600	5,9500	-156,7713	-148,5834	-118,5030	-121,4136

Keterangan Tabel 8.6:

- [1] Kolom yang ditinjau
- [2] Tingkat lantai pada kolom yang ditinjau
- [3] Berat sendiri kolom
- [4] $N_{D,k-x}$ = Gaya aksial kolom akibat beban mati sejajar sb-x
- [5] $N_{L,k-x}$ = Gaya aksial kolom akibat beban hidup sejajar sb-x
- [6] $N_{Eka,k-x}$ = Gaya aksial kolom akibat beban gempa kiri sejajar sb-x
- [7] $N_{Eki,k-x}$ = Gaya aksial kolom akibat beban gempa kanan sejajar sb-x
- [8] $N_{D,k-y}$ = Gaya aksial kolom akibat beban mati sejajar sb-y
- [9] $N_{L,k-y}$ = Gaya aksial kolom akibat beban hidup sejajar sb-y
- [10] $N_{Eki,k-y}$ = Gaya aksial kolom akibat beban gempa kiri sejajar sb-y
- [11] $N_{Eka,k-y}$ = Gaya aksial kolom akibat beban gempa kanan sejajar sb-y
- [12] $N_{u,k-x1} = 1,05(N_{D,k-x} + N_{L,k-x} + N_{D,k-y} + N_{L,k-y} + \omega d.k.(N_{Eki,k-x} + 0,3.N_{Eki,k-y}))$ dengan $k=1$
(Gaya aksial rencana kolom akibat gempa kiri sejajar sb-x)
- [13] $N_{u,k-x1} = 1,05(N_{D,k-x} + N_{L,k-x} + N_{D,k-y} + N_{L,k-y} + \omega d.k.(N_{Eki,k-y} + 0,3.N_{Eki,k-x}))$ dengan $k=1$
(Gaya aksial rencana kolom akibat gempa kiri sejajar sb-y)
- [14] $N_{u,k-x1} = 1,05(N_{D,k-x} + N_{L,k-x} + N_{D,k-y} + N_{L,k-y} + \omega d.k.(N_{Eka,k-x} + 0,3.N_{Eka,k-y}))$
(Gaya aksial rencana kolom akibat gempa kanan sejajar sb-x)
- [15] $N_{u,k-x1} = 1,05(N_{D,k-x} + N_{L,k-x} + N_{D,k-y} + N_{L,k-y} + \omega d.k.(N_{Eka,k-y} + 0,3.N_{Eka,k-x}))$
(Gaya aksial rencana kolom akibat gempa kanan sejajar sb-y)
dengan $k = 2$, $\omega d = 1$ (untuk lantai 1 dan 5), $\omega d = 1,3$ (untuk lantai 2, 3, dan 4)

8.2.3 Perhitungan Kelangsingan Kolom dan Pembesaran Momen

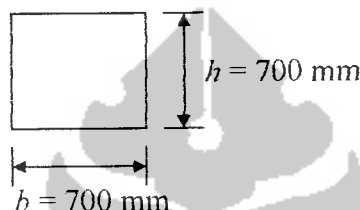
Sebagai contoh perhitungan kelangsingan kolom dan pembesaran momen ditinjau pada kolom K2 lantai 1 sejajar sumbu x .

- Cek kelangsingan kolom

$$\beta_d = \frac{1,05 \cdot M_{D,k}}{1,05(M_{D,k} + M_{L,k} + k \cdot M_{E,k})}$$

$$= \frac{1,05 \cdot 111,7600}{1,05 \cdot (111,7600 + 32,3400 - 2.182,5300)} = 0,19$$

- Ukuran kolom: $b = 700$ mm, $h = 700$ mm



Gambar 8.6 Penampang melintang kolom ukuran 700 mm x 700 mm

$$E_c = 4700 \cdot \sqrt{f_c} = 4700 \cdot \sqrt{25} = 23500 \text{ MPa}$$

$$I_k = 1/12 \cdot b \cdot h^3 = 1/12 \cdot 700 \cdot 700^3 = 2 \cdot E10 \text{ mm}^4$$

$$EI_k = \frac{\left(\frac{E_c \cdot I_k}{2,5} \right)}{1 + \beta_d} = \frac{\left(\frac{23500 \cdot 2 \cdot E10}{2,5} \right)}{1 + 0,19} = 1,59 \cdot E14 \text{ Nmm}^2$$

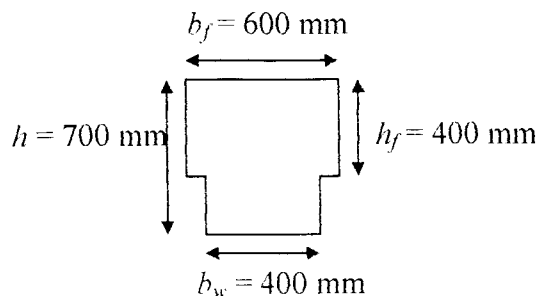
$$l_k = 5400 \text{ mm (panjang kolom lantai 1)}$$

$$l_{u,k} = 5400 - 700 - 600 = 4100 \text{ mm (panjang bersih kolom lantai 1)}$$

$$l_k = 3800 \text{ mm (panjang kolom lantai 2)}$$

$$l_{u,k} = 3800 - 700 = 3100 \text{ mm (panjang bersih kolom lantai 2)}$$

- Ukuran balok lantai 1: $b_f = 600$ mm, $h_f = 400$ mm, $b_w = 400$ mm, $h = 700$ mm



Gambar 8.7 Penampang melintang balok T

$$E_c = 4700 \cdot \sqrt{f_c'} = 4700 \cdot \sqrt{25} = 23500 \text{ MPa}$$

$$I_b = 1/12 \cdot b \cdot h^3 = 1/12 \cdot 600 \cdot 400^3 + 1/12 \cdot 400 \cdot 300^3 = 4,1 \cdot 10^9 \text{ mm}^4$$

$$EI_{b,a} = \frac{\left(\frac{E_c \cdot I_b}{5} \right)}{1 + \beta_d} = \frac{\left(\frac{23500 \cdot 4,1 \cdot 10^9}{5} \right)}{1 + 0,19} = 1,62 \cdot 10^{13} \text{ Nmm}^2$$

$l_b = 9600 \text{ mm}$ (panjang balok sebelah kiri kolom)

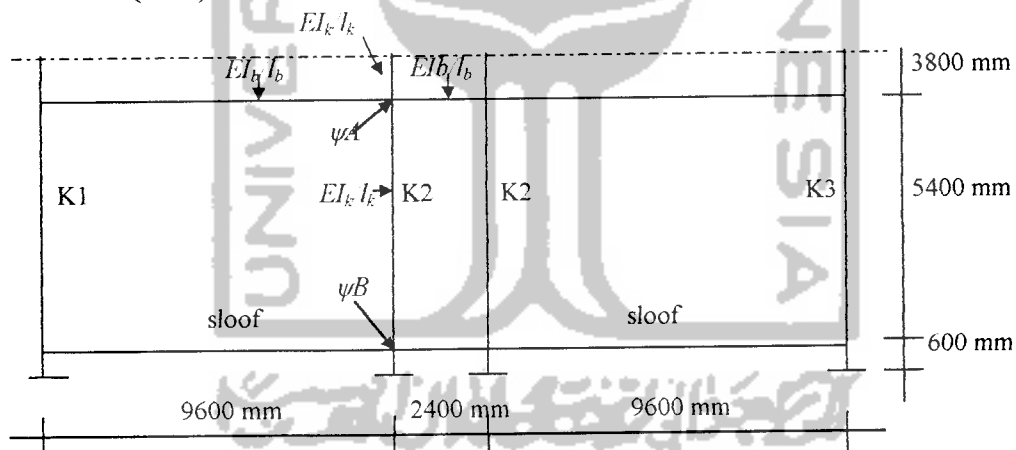
$l_{n,b} = 9600 - 700 = 8900 \text{ mm}$ (panjang bersih balok sebelah kiri kolom)

$l_b = 2400 \text{ mm}$ (panjang balok sebelah kanan kolom)

$l_{n,b} = 2400 - 700 = 1700 \text{ mm}$ (panjang balok bersih sebelah kanan kolom)

Kekakuan relatif kolom bagian atas

$$\varphi_A = \frac{\sum \left(\frac{EI_k}{l_{n,k}} \right)}{\sum \left(\frac{EI_b}{l_{n,b}} \right)} = \frac{\frac{1,59 \cdot 10^{14}}{3700} + \frac{1,59 \cdot 10^{14}}{5400}}{\frac{1,62 \cdot 10^{13}}{8900} + \frac{1,62 \cdot 10^{13}}{1700}} = 6,31$$



Gambar 8.8 Kekakuan relatif kolom K2 sejajar sumbu x (portal as C dan D)

Kekakuan relatif kolom bagian bawah

$\psi_B = 0$ (dianggap dukungan jepit)

$$\psi_m = (\psi_A + \psi_B)/2 = (6,31 + 0)/2 = 3,155$$

Nilai k diambil dengan rumus Furlong (Wang dan Salmon, 1987):

$$\psi_m > 2,0$$

$$k = 0,9 \cdot (1 + \psi_m)^{1/2} = 0,9 \cdot (1 + 3,155)^{1/2} = 1,835$$

Cek kelangsingan kolom K2 portal bergoyang

$$A = 700 \times 700 = 4,9E5 \text{ mm}^2$$

$$r = \sqrt{(I/A)} = \sqrt{(2E10/4,9E5)} = 202,03$$

$$L = 4100 \text{ mm (panjang bersih kolom lantai 1)}$$

$$(k.L)/r = (1,835.4100)/202,03 = 37 > 22 \text{ (kolom langsing)}$$

$$P_{c,K2} = \frac{\pi^2 EI_k}{(kL)^2} = \frac{3,14^2 1,59E14.10^{-3}}{(1,835.4100)^2} = 27640,5546 \text{ kN}$$

$$P_{u,K2} = N_{u,k,K2} = 4557,8337 \text{ kN}$$

Dengan cara yang sama dapat dihitung kelangsingan dan gaya tekuk Euler untuk kolom K1 dalam satu tingkat yang sama dan dalam satu portal arah x yang sama (disajikan pada Tabel 8.7)

$$P_{u,K1} = N_{u,k,K1} = 3576,4134 \text{ kN}$$

$$P_{c,K1} = 7369,2149 \text{ kN}$$

$$\Sigma P_u = 2.3576,4134 + 2.4557,8337 = 16268,4942 \text{ kN}$$

$$\Sigma P_c = 2.7369,2149 + 2.27640,5546 = 70019,5390 \text{ kN}$$

Faktor pembesaran momen

$$\delta_s = \frac{1}{1 - \frac{\Sigma P_u}{\phi \Sigma P_c}} = \frac{1}{1 - \frac{16268,4942}{0,65 \cdot 70019,5390}} = 1,4474 > 1$$

Dengan cara yang sama didapat perhitungan kolom dan faktor kelangsingan kolom-kolom yang lain, disajikan pada Tabel 8.7.

Tabel 8.7 Perhitungan Kelangsingan dan Faktor Pembesaran Momen Kolom Daktililitas Terbatas

Ko- lom	Arah	l _{b,a} (mm ⁴)	l _{b,b} (mm ⁴)	l _k (mm ⁴)	l/d	E _{lba} (Nmm ²)	E _{lbb} (Nmm ²)	E _{l_k} (Nmm ²)	ψ _A	ψ _B	k	kL/r	P _u (kN)	P _u (kN)	ΔP _u (kN)	ΔP _c (kN)	δ's	
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]
K1	1	Sb-x	4,10E+09	7,20E+09	2,00E+10	0,39	1,39E+13	0,00E+00	1,35E+14	24,60	0,00	3,28	66,6	3576,4134	7369,2149	16268,4942	70019,5390	1,4629
		Sb-y	4,10E+09	7,20E+09	2,00E+10	0,001	1,92E+13	0,00E+00	1,88E+14	17,97	0,00	2,84	57,7	3576,4134	13634,9834	11273,0646	39330,7315	1,6027
	2	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,45	1,33E+13	1,33E+13	1,30E+14	21,02	21,02	4,22	64,78	2769,2580	7466,1538	12280,5588	64973,4495	1,3818
		Sb-y	4,10E+09	4,10E+09	2,00E+10	0,002	1,92E+13	1,92E+13	1,88E+14	15,35	15,35	3,64	55,83	2769,2580	14550,8784	8873,4604	39109,1440	1,4902
	3	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,51	1,28E+13	1,28E+13	1,25E+14	21,02	21,02	4,22	64,78	1906,1099	7178,4771	7717,5860	60316,9679	1,2451
K2	4	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,11	1,91E+13	1,91E+13	1,86E+14	15,35	15,35	3,64	55,83	1906,1099	14424,8553	6109,6900	38256,4838	1,3257
		Sb-y	4,10E+09	4,10E+09	2,00E+10	0,54	1,25E+13	1,25E+13	1,22E+14	21,02	21,02	4,22	64,78	1049,8391	7029,2015	3756,6744	66275,6898	1,0955
	5	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,004	1,92E+13	1,92E+13	1,87E+14	15,35	15,35	3,64	55,83	1049,8391	14528,8463	3404,1200	38140,0780	1,1592
		Sb-y	9,00E+09	9,00E+09	2,00E+10	0,54	1,26E+13	1,26E+13	1,22E+14	11,21	22,42	3,8	58,27	628,0071	8687,8473	1256,0142	17375,6947	1,1251
	1	Sb-x	4,10E+09	7,20E+09	2,00E+10	0,052	4,02E+13	4,02E+13	1,79E+14	3,73	7,46	2,31	35,45	628,0071	34374,0977	1683,7380	91420,2520	1,0292
K3	2	Sb-x	4,10E+09	7,20E+09	2,00E+10	0,19	1,62E+13	0,00E+00	1,59E+14	6,31	0,00	1,83	37	4557,8337	27640,5546	16268,4942	70019,5390	1,4474
		Sb-y	4,10E+09	7,20E+09	2,00E+10	0,004	1,92E+13	0,00E+00	1,87E+14	14,38	0,00	2,58	51,93	4557,8337	16591,8453	17225,7015	113681,1444	1,3040
	3	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,23	1,57E+13	1,57E+13	1,53E+14	7,19	6,31	2,51	38,44	3371,0214	25020,5710	12280,5588	64973,4495	1,4100
		Sb-y	4,10E+09	4,10E+09	2,00E+10	0,008	1,91E+13	1,91E+13	1,87E+14	16,37	14,38	3,64	55,87	3371,0214	14451,2099	12854,3125	110598,8225	1,2177
	4	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,27	1,52E+13	1,52E+13	1,48E+14	7,19	7,19	2,58	39,51	1952,6831	22980,0088	7717,5860	60316,9679	1,2451
K4		Sb-y	4,10E+09	4,10E+09	2,00E+10	0,43	1,35E+13	1,35E+13	1,32E+14	3,60	7,19	2,28	34,91	828,4981	13674,1828	7960,7110	102753,9011	1,1353
	1	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,021	1,89E+13	1,89E+13	1,84E+14	8,19	16,37	3,28	50,31	828,4981	17597,5321	4146,3009	107706,6173	1,0630
		Sb-y	4,10E+09	7,20E+09	2,00E+10	0,13	1,70E+13	0,00E+00	1,66E+14	22,67	0,00	3,16	64,13	2060,1189	9748,1233	13056,0024	118613,4313	1,2039
	2	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,192	1,62E+13	0,00E+00	1,58E+14	35,94	0,00	3,92	79,53	2060,1189	6030,3824	11273,0646	39330,7315	1,6099
		Sb-y	4,10E+09	4,10E+09	2,00E+10	0,17	1,65E+13	1,65E+13	1,61E+14	25,82	22,67	4,52	69,37	1667,4722	8070,7377	10296,8950	105285,9449	1,1771
K4	3	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,209	1,59E+13	1,59E+13	1,56E+14	40,93	35,94	5,65	86,7	1667,4722	5003,6936	8873,4604	39109,1440	1,4594
		Sb-y	4,10E+09	4,10E+09	2,00E+10	0,19	1,62E+13	1,62E+13	1,58E+14	25,82	25,82	4,86	71,5	1148,6460	7455,8064	7058,1542	98283,6961	1,1242
	4	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,209	1,59E+13	1,59E+13	1,56E+14	40,93	40,93	5,63	89,4	1148,6460	4703,3866	6109,6900	38256,4838	1,3257
		Sb-y	4,10E+09	4,10E+09	2,00E+10	0,25	1,54E+13	1,54E+13	1,51E+14	25,82	25,82	4,86	71,5	652,2209	7122,1218	4149,8238	95604,3195	1,0716
	5	Sb-x	9,00E+09	9,00E+09	2,00E+10	0,62	2,61E+13	2,61E+13	1,16E+14	5,88	11,76	2,82	43,27	213,8619	14999,6599	1496,1366	214265,8324	1,0192
K4		Sb-y	9,00E+09	9,00E+09	2,00E+10	0,404	3,01E+13	3,01E+13	1,34E+14	9,32	18,65	3,48	53,45	213,8619	11336,0283	1683,7380	91420,2520	1,0292
	1	Sb-x	4,10E+09	7,20E+09	2,00E+10	0,02	1,88E+13	0,00E+00	1,84E+14	11,33	0,00	2,32	47,15	2031,4959	19974,0740	13056,0024	118613,4313	1,2039
		Sb-y	5,72E+09	7,20E+09	2,00E+10	0,125	2,39E+13	0,00E+00	1,67E+14	12,39	0,00	2,41	48,98	2031,4959	16841,7789	3874,9221	45182,6451	1,1520
	2	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,03	1,87E+13	1,87E+13	1,82E+14	12,91	11,33	3,26	50,01	1626,6961	17628,0927	10296,8950	105285,9449	1,1771
		Sb-y	5,72E+09	5,72E+09	2,00E+10	0,078	2,49E+13	2,49E+13	1,75E+14	14,11	12,39	3,4	52,12	1626,6961	15528,0351	3075,0535	49921,7666	1,1047
K4	3	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,04	1,85E+13	1,85E+13	1,81E+14	12,91	12,91	3,36	51,49	1148,7330	16465,0557	7058,1542	98283,6961	1,1242
		Sb-y	5,72E+09	5,72E+09	2,00E+10	0,079	2,49E+13	2,49E+13	1,74E+14	14,11	14,11	3,5	53,67	1148,7330	14618,3621	2170,5858	47385,2469	1,0758
	4	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,06	1,83E+13	1,83E+13	1,78E+14	12,91	12,91	3,36	51,49	679,7774	16243,2350	4149,8238	95604,3195	1,0716
		Sb-y	5,72E+09	5,72E+09	2,00E+10	0,092	2,46E+13	2,46E+13	1,72E+14	14,11	14,11	3,5	53,67	679,7774	14455,7125	1296,3706	46397,4071	1,0449

Tabel 8.7 Lanjutan

Ko- lom	Arah	lb, a (mm ⁴)	lb, b (mm ⁴)	Ik (mm ⁴)	β/d	Eiba (Nmm ²)	Eibb (Nmm ²)	Elk (Nmm ²)	ψA	ψB	k	kL/r	Pu (kN)	Pu (kN)	ΣPu (kN)	ΣPc (kN)	δs
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[17]	[18]	[19]
K5	Sb-x	9,00E+09	9,00E+09	2,00E+10	0,12	3,79E+13	3,79E+13	1,69E+14	2,94	5,88	2,09	32,12	246,9810	39493,2999	1496,1366	214265,8324	1,0109
	Sb-y	5,72E+09	5,72E+09	2,00E+10	0,265	2,12E+13	2,12E+13	1,49E+14	7,06	14,11	3,06	46,99	246,9810	16275,2325	503,6073	53136,3762	1,0148
	Sb-x	4,10E+09	7,20E+09	2,00E+10	0,07	1,81E+13	0,00E+00	1,76E+14	6,64	0,00	1,87	37,96	2436,3864	29584,5183	13056,0024	118613,4313	1,2039
	Sb-y	5,72E+09	7,20E+09	2,00E+10	0,129	2,38E+13	0,00E+00	1,67E+14	8,37	0,00	2,05	41,58	2436,3864	23295,7294	17225,7015	113681,1444	1,3040
	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,09	1,76E+13	1,76E+13	1,72E+14	7,57	6,64	2,56	39,31	1854,2792	26944,1421	10296,8950	105285,9449	1,1771
K6	Sb-y	5,72E+09	5,72E+09	2,00E+10	0,168	2,30E+13	2,30E+13	1,61E+14	9,53	8,37	2,84	43,55	1854,2792	20515,4807	12854,3125	110598,8225	1,2177
	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,10	1,75E+13	1,75E+13	1,70E+14	7,57	7,57	2,63	40,41	1231,6981	25220,9859	7058,1542	98283,6961	1,1242
	Sb-y	5,72E+09	5,72E+09	2,00E+10	0,208	2,22E+13	2,22E+13	1,56E+14	9,53	9,53	2,92	44,81	1231,6981	18738,2753	7960,7110	102753,9011	1,1353
	Sb-x	4,10E+09	4,10E+09	2,00E+10	0,14	1,69E+13	1,69E+13	1,65E+14	7,57	7,57	2,63	40,41	742,9136	24436,8029	4149,8238	95604,3195	1,0716
	Sb-y	5,72E+09	5,72E+09	2,00E+10	0,243	2,16E+13	2,16E+13	1,51E+14	9,53	9,53	2,92	44,81	742,9136	18214,2567	4146,3009	107706,6173	1,0630
K7	Sb-x	9,00E+09	9,00E+09	2,00E+10	0,26	3,35E+13	3,35E+13	1,49E+14	1,72	3,45	1,7	26,14	287,2254	52639,9564	1496,1366	214265,8324	1,0109
	Sb-y	5,72E+09	5,72E+09	2,00E+10	0,108	2,43E+13	2,43E+13	1,70E+14	4,77	9,53	2,57	39,41	287,2254	26415,1852	1040,5563	92300,8544	1,0177
	Sb-x	5,72E+09	7,20E+09	9,11E+08	0,19	2,26E+13	0,00E+00	7,21E+12	0,74	0,00	1,15	65,27	1063,1187	4808,0681	4570,4232	22473,5308	1,2370
	Sb-y	5,72E+09	7,20E+09	7,15E+09	0,003	2,68E+13	0,00E+00	6,70E+13	2,29	0,00	1,38	28,01	1063,1187	20622,2989	3874,9221	45182,6451	1,1520
	Sb-x	5,72E+09	5,72E+09	9,11E+08	0,19	2,25E+13	2,25E+13	7,18E+12	0,84	0,74	1,29	55,29	796,9540	4459,8132	3444,9858	22499,9311	1,3081
K8	Sb-y	5,72E+09	5,72E+09	7,15E+09	0,002	2,68E+13	2,68E+13	6,70E+13	2,61	2,29	1,67	25,64	796,9540	24640,6169	3075,0535	49921,7666	1,1047
	Sb-x	5,72E+09	5,72E+09	9,11E+08	0,19	2,26E+13	2,26E+13	7,22E+12	0,84	0,84	1,3	55,86	558,2060	4384,2081	2340,4860	22164,0791	1,1940
	Sb-y	5,72E+09	5,72E+09	7,15E+09	0,007	2,67E+13	2,67E+13	6,67E+13	2,61	2,61	1,71	26,22	558,2060	23444,8664	2170,5858	47385,2469	1,0758
	Sb-x	5,72E+09	5,72E+09	9,11E+08	0,22	2,21E+13	2,21E+13	7,05E+12	0,84	0,84	1,3	55,86	338,0996	4279,3171	1410,8086	21376,4186	1,1130
	Sb-y	5,72E+09	5,72E+09	7,15E+09	0,015	2,65E+13	2,65E+13	6,62E+13	2,61	2,61	1,71	26,22	338,0996	23259,8558	1296,3706	46397,4071	1,0449
K9	Sb-x	5,72E+09	5,72E+09	9,11E+08	0,37	1,96E+13	1,96E+13	6,26E+12	0,42	0,84	1,24	53,15	137,4114	4197,3054	579,9486	20622,8002	1,0452
	Sb-y	5,72E+09	5,72E+09	7,15E+09	0,033	2,60E+13	2,60E+13	6,50E+13	1,30	2,61	1,55	23,8	137,4114	27756,4906	503,6073	53136,3762	1,0148
	Sb-x	5,72E+09	7,20E+09	9,11E+08	0,07	2,51E+13	0,00E+00	8,00E+12	0,22	0,00	1,05	59,49	1222,0929	6428,6973	4570,4232	22473,5308	1,2370
	Sb-y	5,72E+09	7,20E+09	7,15E+09	0,103	2,44E+13	0,00E+00	6,09E+13	2,32	0,00	1,38	28,1	1222,0929	18639,1216	17225,7015	113681,1444	1,3040
	Sb-x	5,72E+09	5,72E+09	9,11E+08	0,08	2,50E+13	2,50E+13	7,98E+12	0,25	0,22	1,1	47,13	925,5389	6790,1524	3444,9858	22499,9311	1,3081
K10	Sb-y	5,72E+09	5,72E+09	7,15E+09	0,135	2,37E+13	2,37E+13	5,92E+13	2,61	2,29	1,67	25,64	925,5389	21760,2629	12854,3125	110598,8225	1,2177
	Sb-x	5,72E+09	5,72E+09	9,11E+08	0,08	2,49E+13	2,49E+13	7,93E+12	0,25	0,25	1,1	47,38	612,0370	6697,8314	2340,4860	22164,0791	1,1940
	Sb-y	5,72E+09	5,72E+09	7,15E+09	0,172	2,29E+13	2,29E+13	5,73E+13	2,61	2,61	1,71	26,22	612,0370	20147,0995	7960,7110	102753,9011	1,1353
	Sb-x	5,72E+09	5,72E+09	9,11E+08	0,13	2,38E+13	2,38E+13	7,59E+12	0,25	0,25	1,1	47,38	367,3047	6408,8922	1410,8086	21376,4186	1,1130
	Sb-y	5,72E+09	5,72E+09	7,15E+09	0,235	2,18E+13	2,18E+13	5,44E+13	2,61	2,61	1,71	26,22	367,3047	19121,8158	4146,3009	107706,6173	1,0630
K11	Sb-x	5,72E+09	5,72E+09	9,11E+08	0,24	2,17E+13	2,17E+13	6,93E+12	0,12	0,25	1,08	46,33	152,5629	6114,0947	579,9486	20622,8002	1,0452
	Sb-y	5,72E+09	5,72E+09	7,15E+09	0,488	1,81E+13	1,81E+13	4,51E+13	1,30	2,61	1,55	23,8	152,5629	19259,5313	1040,5563	92300,8544	1,0177
	Sb-x	5,72E+09	7,20E+09	7,15E+09	0,15	2,34E+13	0,00E+00	5,85E+13	5,81	0,00	1,78	36,08	780,3075	10872,8474	3575,7834	49463,7393	1,1251
	Sb-y	5,72E+09	7,20E+09	2,60E+09	0,091	2,48E+13	0,00E+00	2,24E+13	1,73	0,00	1,31	37,11	780,3075	7718,5673	3874,9221	45182,6451	1,1520
	Sb-x	5,72E+09	5,72E+09	7,15E+09	0,17	2,29E+13	2,29E+13	5,73E+13	6,61	5,81	2,42	37,07	651,4034	10068,9098	2780,9792	76971,6256	1,0589
K12	Sb-y	5,72E+09	5,72E+09	2,60E+09	0,098	2,45E+13	2,45E+13	2,23E+13	1,97	1,73	1,53	32,9	651,4034	9753,1146	3075,0535	49921,7666	1,1047

Tabel 8.7 Lanjutan

Ko- lom	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]
Arah	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	
Lt	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	
3	Sb-x	5,72E+09	5,72E+09	5,72E+09	7,15E+09	0,19	2,27E+13	2,27E+13	5,67E+13	6,61	6,61	2,48	38,1	463,6468	9438,0721	1907,2052	73474,0544	1,0416	
	Sb-y	5,72E+09	5,72E+09	5,72E+09	2,60E+09	0,118	2,40E+13	2,40E+13	2,19E+13	1,97	1,97	1,55	33,36	463,6468	9322,1985	2170,5858	47385,2469	1,0758	
4	Sb-x	5,72E+09	5,72E+09	5,72E+09	7,15E+09	0,27	2,12E+13	2,12E+13	5,30E+13	6,61	6,61	2,48	38,1	278,4936	8826,5040	1193,1600	70889,6646	1,0266	
	Sb-y	5,72E+09	5,72E+09	5,72E+09	2,60E+09	0,200	2,24E+13	2,24E+13	2,04E+13	1,97	1,97	1,55	33,36	278,4936	8681,8388	1296,3706	46397,4071	1,0449	
5	Sb-x	5,72E+09	5,72E+09	5,72E+09	7,15E+09	0,40	1,92E+13	1,92E+13	4,78E+13	3,31	6,61	2,2	33,71	119,2149	10191,6859	551,9724	74515,1418	1,0115	
	Sb-y	5,72E+09	5,72E+09	5,72E+09	2,60E+09	0,300	2,07E+13	2,07E+13	1,88E+13	0,98	1,97	1,46	31,31	119,2149	9104,6531	503,6073	53136,3762	1,0148	
K9	Sb-x	5,72E+09	7,20E+09	7,20E+09	7,15E+09	0,05	2,55E+13	0,00E+00	6,38E+13	4,68	0,00	1,64	33,37	1007,5842	13859,0223	3575,7834	49463,7393	1,1251	
	Sb-y	5,72E+09	7,20E+09	7,20E+09	2,60E+09	0,103	2,44E+13	0,00E+00	2,22E+13	1,73	0,00	1,31	37,11	1007,5842	7633,4367	17225,7015	113681,1444	1,3040	
2	Sb-x	5,72E+09	5,72E+09	5,72E+09	7,15E+09	0,06	2,58E+13	2,53E+13	6,32E+13	1,94	1,70	1,51	23,19	739,0862	28416,9030	2780,9792	76971,6256	1,0589	
	Sb-y	5,72E+09	5,72E+09	5,72E+09	2,60E+09	0,133	2,37E+13	2,37E+13	2,18E+13	1,97	1,73	1,53	32,9	739,0862	9452,5892	12854,3125	110598,8225	1,2177	
3	Sb-x	5,72E+09	5,72E+09	5,72E+09	7,15E+09	0,06	2,53E+13	2,53E+13	6,33E+13	1,94	1,94	1,54	23,67	489,9558	27298,9551	1907,2052	73474,0544	1,0416	
	Sb-y	5,72E+09	5,72E+09	5,72E+09	2,60E+09	0,172	2,29E+13	2,29E+13	2,09E+13	1,97	1,97	1,55	33,36	489,9558	8890,9428	7960,7110	102753,9011	1,1353	
4	Sb-x	5,72E+09	5,72E+09	5,72E+09	7,15E+09	0,09	2,47E+13	2,47E+13	6,17E+13	1,94	1,94	1,54	23,67	318,0864	26618,3283	1193,1600	70889,6646	1,0266	
	Sb-y	5,72E+09	5,72E+09	5,72E+09	2,60E+09	0,228	2,19E+13	2,19E+13	1,99E+13	1,97	1,97	1,55	33,36	318,0864	8480,6120	4146,3009	107706,6173	1,0630	
5	Sb-x	5,72E+09	5,72E+09	5,72E+09	7,15E+09	0,28	2,10E+13	2,10E+13	5,24E+13	0,97	1,94	1,41	21,63	156,7713	27065,8850	551,9724	74515,1418	1,0115	
	Sb-y	5,72E+09	5,72E+09	5,72E+09	2,60E+09	0,172	2,29E+13	2,29E+13	2,09E+13	0,98	1,97	1,46	31,31	156,7713	10100,4763	5160,7941	104361,6191	1,0823	

Keterangan Tabel 8.7:

- [1] Kolom yang ditinjau
- [2] Lantai kolom yang ditinjau
- [3] Arah bekerjanya momen sejajar sb-x dan sb-y
- [4] l_b, a = inersia balok atas; $l = 1/12 \cdot b \cdot h^3$
- [5] l_b, b = inersia balok bawah
- [6] l_k = inersia kolom
- [7] $\beta d = 1,05MD / (1,05(MD + ML + 2ME))$
- [8] $EI_b, a = [(Ec \cdot l_b, a) / 2,5] / [1 + \beta d]$
- [9] $EI_b, b = [(Ec \cdot l_b, b) / 2,5] / [1 + \beta d]$
- [10] $EIk = [(Ec \cdot k) / 5] / [1 + \beta d]$
- [11] $\psi A = \Sigma [EI / Ik] / \Sigma [EI / Ib, a]$
- [12] $\psi B = \Sigma [EI / Ik] / \Sigma [EI / Ib, b]$
- [13] $k = 0,9 \cdot (1 + \psi m)^{0,5}$ untuk $\psi m = (yA + yB) / 2 > 2,0$
 $k = (20 - \psi m) / 20 \cdot (1 + \psi m)^{0,5}$ untuk $\psi m < 2,0$
- [14] $kL / r > 22$ kolom langsing $r = (I/A)^{0,5}$
- [15] $P_u = Nu, k =$ Gaya aksial rencana tercapai kolom
- [16] $P_c = [3,14 \cdot 2 \cdot EIk] / [(k \cdot l)^2]$
- [17] $\Sigma P_u =$ jumlah gaya-gaya aksial dalam lantai dan portal yang sama
- [18] $\Sigma P_c =$ jumlah gaya-gaya tekuk Euler dalam lantai dan portal yang sama
- [19] $\delta s = 1 / [1 - (\Sigma P_u / 0,65 \Sigma P_c)] > 1$ (faktor pembesaran momen)

8.2.4 Penulangan Kombinasi Lentur dan Aksial Kolom

Sebagai contoh perhitungan penulangan kombinasi lentur dan aksial kolom adalah Kolom K2 Lantai 1.

Diketahui dari perhitungan sebelumnya:

$$P_u = N_{u,k} = 4557,8337 \text{ kN}$$

$$M_{u,k,x} = 593,6729 \text{ kNm} ; \delta_{s,x} = 1,4474$$

$$M_{c,x} = \delta_{s,x} \cdot M_{u,k,x} = 1,4474 \cdot 593,6729 = 859,2822 \text{ kNm}$$

$$M_{u,k,y} = 503,4646 \text{ kNm} ; \delta_{s,y} = 1,3040$$

$$M_{c,y} = \delta_{s,y} \cdot M_{u,k,y} = 1,3040 \cdot 503,4646 = 656,5178 \text{ kNm}$$

Eksentrisitasnya adalah:

$$e_x = M_{c,x}/P_u = 859,2822/4557,8337 = 0,189 \text{ m} = 189 \text{ mm}$$

$$e_y = M_{c,y}/P_u = 656,5178/4557,8337 = 0,144 \text{ m} = 144 \text{ mm}$$

Untuk menentukan harga-harga dari P_x dan P_y diperlukan Gambar 7.7 Diagram Interaksi Kolom Ukuran 700 mm x 700 mm, dalam lentur uniaksial masing-masing terhadap sumbu x dan sumbu y , oleh karena sifat simetris dalam hal ini, hanya diperlukan diagram tunggal yang telah dibuat sebelumnya. Dari Diagram Interaksi Kolom 700 mm x 700 mm, diambil penulangan 32D25 dengan $A_{st} = 15707,96 \text{ mm}^2$, jadi $\rho_g = A_{st}/A_g = 15707,96/490000 = 0,032$, ditentukan P_x dan P_y (cara penentuan P_x dan P_y lihat Gambar 8.9)

untuk $e_x = 189 \text{ mm}$ didapat $\phi P_{n,x} = 5800,0000 \text{ kN}$

untuk $e_y = 144 \text{ mm}$ didapat $\phi P_{n,y} = 6700,0000 \text{ kN}$

dan $\phi P_o = 10850,1300 \text{ kN}$

Kemudian dengan menggunakan persamaan *Bresler* didapat ϕP_n (Wang dan Salmon, 1993):

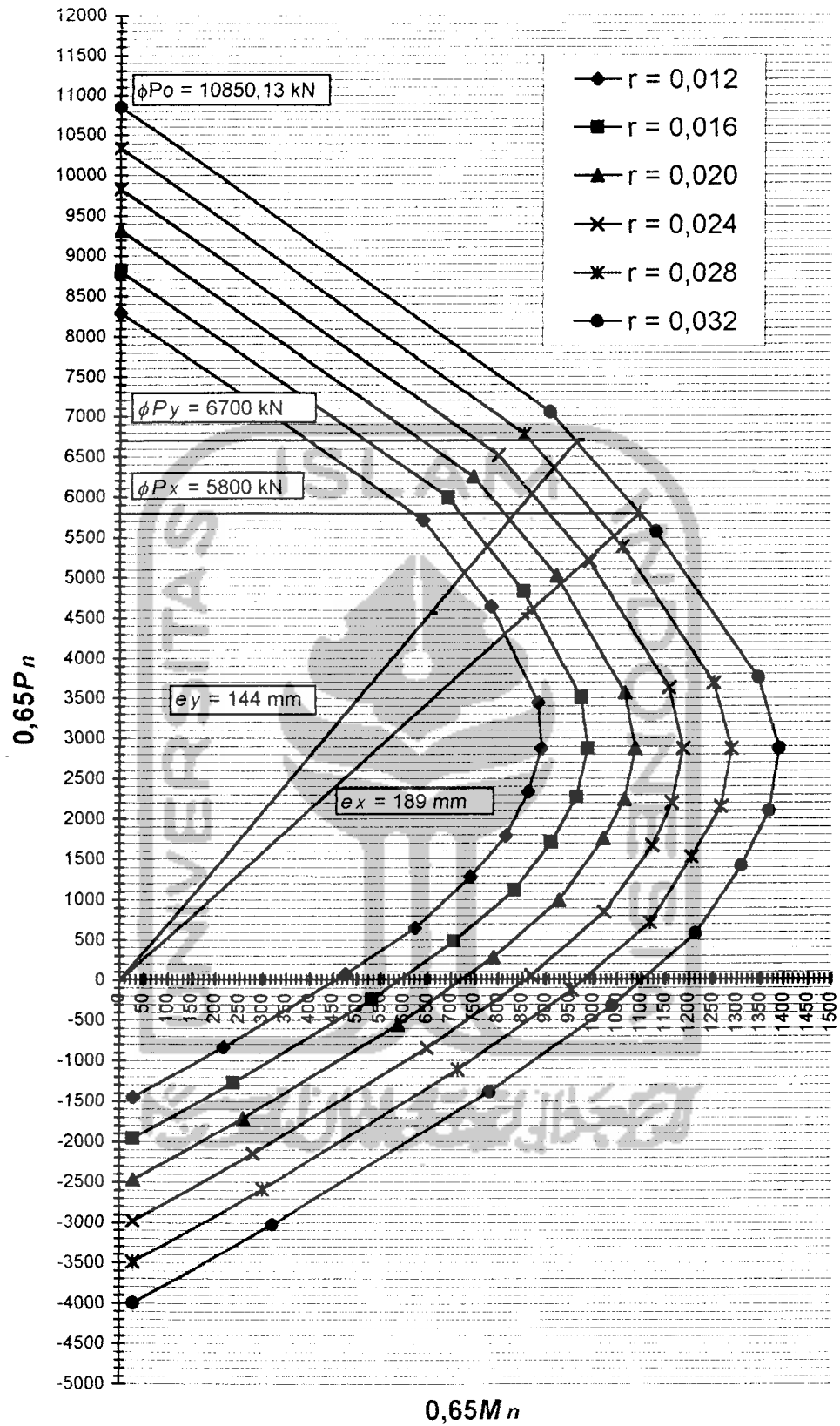
$$1/\phi P_n = (1/\phi P_{n,x}) + (1/\phi P_{n,y}) - (1/\phi P_o)$$

$$1/\phi P_n = (1/5800,0000) + (1/6700,0000) - (1/10850,1300)$$

didapat, $\phi P_n = 4562,0732 \text{ kN} \geq (P_u = 4557,8337 \text{ kN})$ - aman -

Jadi tulangan kolom 32D25, dengan penempatan tulangan 9D25 pada masing-masing sisi dapat dipergunakan pada kolom K2 Lantai 1.

Dengan cara yang sama dapat dihitung penulangan lentur dan aksial kolom-kolom yang lain, disajikan pada Tabel 8.8.



Gambar 8.9 Menentukan harga-harga ϕP_o , ϕP_x , dan ϕP_y pada Kolom K2 Lantai 1

Tabel 8.8 Penulangan Kombinasi Lentur dan Aksial Kolom Daktilitas Terbatas

Ko- lom	Lt.	Arah	Ukuran b x h (mm)	δ_s	$M_{u,k}$ (kNm)	M_c (kNm)	$P_u/N_{u,k}$ (kN)	e (mm)	Tul. total	Tul. tiap sisi	ρ total	Diagram Interaksi Kolom			
												ϕP (kN)	ϕP_o (kN)	$\phi P_n \geq P_u$ (kN)	ϕM_n (kNm)
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]
K1	1	Sb-x	700x700	1,4629	493,7434	722,2972	3576,4134	202	32D25	9D25	0,032	5600,0000	10850,1300	3631,2008	733,3622
		Sb-y	700x700	1,6027	533,3241	854,7585		239		9D25			5000,0000		867,8527
	2	Sb-x	700x700	1,3818	537,8772	743,2387	2769,2580	268	32D25	9D25	0,032	4500,0000	10850,1300	2781,0471	746,4028
		Sb-y	700x700	1,4902	554,8416	826,8250		299		9D25			4100,0000		830,3449
	3	Sb-x	700x700	1,2451	527,0022	656,1704	1906,1099	344	32D25	9D25	0,032	3500,0000	10850,1300	2169,9950	747,0118
		Sb-y	700x700	1,3257	495,2434	656,5442		344		9D25			3500,0000		747,4373
	4	Sb-x	700x700	1,0955	547,9727	600,3041	1049,8391	572	32D25	9D25	0,032	2700,0000	10850,1300	1533,4583	876,8404
		Sb-y	700x700	1,1592	381,1187	441,7928		421		9D25			2500,0000		645,3092
	5	Sb-x	700x700	1,1251	555,5819	625,0852	628,0071	995	32D25	9D25	0,032	2000,0000	10850,1300	712,1011	708,7879
		Sb-y	700x700	1,0292	210,0029			344		9D25			950,0000		245,0768
K2	1	Sb-x	700x700	1,4474	593,6729	859,2822	4557,8337	189	32D25	9D25	0,032	5800,0000	10850,1300	4562,0372	860,0746
		Sb-y	700x700	1,3040	503,4646	656,5178		144		9D25			6700,0000		657,1233
	2	Sb-x	700x700	1,4100	587,3415	828,1515	3371,0214	246	32D25	9D25	0,032	4800,0000	10850,1300	3411,1102	838,0000
		Sb-y	700x700	1,2177	524,3944	638,5551		189		9D25			5650,0000		646,1489
	3	Sb-x	700x700	1,2451	557,5623	694,2208	1952,6831	356	32D25	9D25	0,032	3050,0000	10850,1300	2135,5557	759,2360
		Sb-y	700x700	1,1353	438,5556	497,8922		255		9D25			4300,0000		544,5207
	4	Sb-x	700x700	1,0955	229,5463	251,4680	828,4981	304	32D25	9D25	0,032	1500,0000	10850,1300	860,0396	261,0415
		Sb-y	700x700	1,0630	316,4690	336,4065		406		9D25			1700,0000		349,2138
K3	1	Sb-x	700x700	1,2039	360,4187	433,9081	2060,1189	211	16D25	5D25	0,016	4300,0000	8809,1250	2071,7838	436,3650
		Sb-y	700x700	1,6099	453,7388	730,4741		355		5D25			2750,0000		734,6102
	2	Sb-x	700x700	1,1771	374,3211	440,6134	1667,4722	264	16D25	5D25	0,016	3600,0000	8809,1250	1669,3328	441,1050
		Sb-y	700x700	1,4594	465,5453	679,4168		407		5D25			2300,0000		680,1749
	3	Sb-x	700x700	1,1242	350,5438	394,0813	1148,6460	343	16D25	5D25	0,016	2400,0000	8809,1250	1245,1005	427,1733
		Sb-y	700x700	1,3257	442,4165	586,5116		511		5D25			2000,0000		635,7623
	4	Sb-x	700x700	1,0716	293,0936	314,0791	652,2209	482	16D25	5D25	0,016	1500,0000	8809,1250	683,8828	329,3260
		Sb-y	700x700	1,1592	412,2795	477,9144		733		5D25			1100,0000		501,1146
	5	Sb-x	700x700	1,0109	125,7149	127,0852	213,8619	594	16D25	5D25	0,016	1000,0000	8809,1250	468,0593	278,1393
		Sb-y	700x700	1,0292	176,0907	181,2325		847		5D25			800,0000		396,6465
K4	1	Sb-x	700x700	1,2039	449,3895	541,0200	2031,4959	266	16D25	5D25	0,016	3500,0000	8809,1250	2183,8356	581,5905
		Sb-y	700x700	1,1520	466,9644	537,9430		265		5D25			3500,0000		578,2828
	2	Sb-x	700x700	1,1771	475,1993	559,3571	1626,6961	344	16D25	5D25	0,016	2800,0000	8809,1250	1945,9248	669,1273
		Sb-y	700x700	1,1047	372,1103	411,0702		253		5D25			3700,0000		491,7402
	3	Sb-x	700x700	1,1242	433,5055	487,3469	1148,7330	424	16D25	5D25	0,016	2000,0000	8809,1250	1333,1241	565,5743
		Sb-y	700x700	1,0758	372,7670	401,0227		349		5D25			2750,0000		465,3937
	4	Sb-x	700x700	1,0716	342,2072	366,7092	679,7774	539	16D25	5D25	0,016	1200,0000	8809,1250	866,1028	467,2234
		Sb-y	700x700	1,0449	315,3994	329,5608		485		5D25			2300,0000		419,8927
	5	Sb-x	700x700	1,0109	125,8530	127,2248	246,9810	515	16D25	5D25	0,016	500,0000	8809,1250	281,4406	144,9756
		Sb-y	700x700	1,0148	80,5707	81,7631		331		5D25			600,0000		93,1710
K5	1	Sb-x	700x700	1,2039	481,9991	580,2787	2436,3864	238	16D25	5D25	0,016	3900,0000	8298,8800	2461,9485	586,3669
		Sb-y	700x700	1,3040	569,1111	742,1209		305		5D25			3700,0000		749,9071
	2	Sb-x	700x700	1,1771	498,9088	587,2655	1854,2792	317	16D25	5D25	0,016	3100,0000	8298,8800	1867,7073	591,5183
		Sb-y	700x700	1,2177	524,3853	638,5440		344		5D25			3000,0000		643,1681
	3	Sb-x	700x700	1,1242	461,8369	519,1970	1231,6981	422	16D25	5D25	0,016	2400,0000	8298,8800	1256,0156	529,4476
		Sb-y	700x700	1,1353	510,1882	579,2167		470		5D25			2000,0000		590,6522
	4	Sb-x	700x700	1,0716	297,4443	318,7413	742,9136	429	16D25	5D25	0,016	1000,0000	8298,8800	749,5986	321,6095
		Sb-y	700x700	1,0630	439,2691	466,9431		629		5D25			2200,0000		471,1448
	5	Sb-x	700x700	1,0109	206,6904	208,9433	287,2254	727	16D25	5D25	0,016	750,0000	8298,8800	347,2823	252,6320
		Sb-y	700x700	1,0177	300,9090	306,2351		1066		5D25			600,0000		370,2668
K6	1	Sb-x	250x700	1,2370	187,3993	231,8129	1063,1187	218	20D22	8D22	0,043	2100,0000	4392,8800	1092,6382	238,2497
		Sb-y	700x250	1,1520	92,0900	106,0877		100		6D22			1500,0000		109,0334
	2	Sb-x	250x700	1,3081	161,0721	210,6984	796,9540	264	20D22	8D22	0,043	2000,0000	4392,8800	932,5236	246,5403
		Sb-y	700x250	1,1047	93,0350	102,7758		129		6D22			1250,0000		120,2589
	3	Sb-x	250x700	1,1940	153,5751	183,3687	558,2060	328	20D22	8D22	0,043	1500,0000	4392,8800	645,1044	211,9145
		Sb-y	700x250	1,0758	83,8589	90,2154		162		6D22			900,0000		104,2596
	4	Sb-x	250x700	1,1130	128,6607	143,1994	338,0996	424	20D22	8D22	0,043	1200,0000	4392,8800	515,7230	218,4303
		Sb-y	700x250	1,0449	63,3360	66,1798		196		6D22			750,0000		100,9479
	5	Sb-x	250x700	1,0452	104,0298	108,7319	137,4114	791	20D22	8D22	0,043	950,0000	4392,8800	353,9835	280,1028
		Sb-y	700x250	1,0148	39,5304	40,1154		292		6D22			500,0000		103,3408

Tabel 8.8. Lanjutan

Ko- lom	Lt	Arah	Ukuran b x h (mm)	δ_s	Mu,k (kNm)	Mc (kNm)	$Pu/Nu,k$ (kN)	e (mm)	Tul total	Tul tiap sisi	ρ total	Diagram Interaksi Kolom			ϕMn (kNm)
												ϕP (kN)	ϕPo (kN)	$\phi Pn > Pu$ (kN)	
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]
K7	1	Sb-x	250x700	1,2370	189,3795	234,2624	1222,0929	192	20D22	8D22	0,043	2500,0000	4392,8800	1223,2114	234,4768
		Sb-y	700x250	1,3040	98,3578	128,2586		105		6D22			1550,0000		128,3760
	2	Sb-x	250x700	1,3081	176,2383	230,5373	925,5389	249	20D22	8D22	0,043	2050,0000	4392,8800	943,2505	234,9490
		Sb-y	700x250	1,2177	97,5951	118,8416		128		6D22			1250,0000		121,1158
	3	Sb-x	250x700	1,1940	166,1570	198,3915	612,0370	324	20D22	8D22	0,043	1550,0000	4392,8800	599,6929	194,3901
		Sb-y	700x250	1,1353	87,2628	99,0695		162		6D22			800,0000		97,0713
	4	Sb-x	250x700	1,1130	153,2958	170,6182	367,3047	465	20D22	8D22	0,043	1000,0000	4392,8800	386,0198	179,3117
		Sb-y	700x250	1,0630	72,1371	76,6817		209		6D22			550,0000		80,5889
5	Sb-x	250x700	1,0452	93,9652	98,2124	152,5629	644	20D22	8D22	0,043	700,0000	4392,8800	220,5430	141,9746	
	Sb-y	700x250	1,0177	64,5152	65,6571		430		6D22			300,0000		94,9131	
K8	1	Sb-x	250x700	1,1251	160,8663	180,9907	780,3075	232	20D22	8D22	0,043	2100,0000	4392,8800	924,3146	214,3928
		Sb-y	700x250	1,1520	95,6211	110,1555		141		6D22			1200,0000		130,4849
	2	Sb-x	250x700	1,0589	151,5171	160,4415	651,4034	246	20D22	8D22	0,043	2000,0000	4392,8800	656,8753	161,7892
		Sb-y	700x250	1,1047	92,6339	102,3327		157		6D22			800,0000		103,1923
	3	Sb-x	250x700	1,0416	140,0280	145,8532	463,6468	315	20D22	8D22	0,043	1900,0000	4392,8800	472,3986	148,6063
		Sb-y	700x250	1,0758	94,2219	101,3639		219		6D22			550,0000		103,2773
	4	Sb-x	250x700	1,0266	112,9212	115,9249	278,4936	416	20D22	8D22	0,043	1100,0000	4392,8800	282,5982	117,6335
		Sb-y	700x250	1,0449	75,0518	78,4216		282		6D22			350,0000		79,5775
	5	Sb-x	250x700	1,0115	89,8632	90,8966	119,2149	762	20D22	8D22	0,043	700,0000	4392,8800	192,2733	146,6007
		Sb-y	700x250	1,0148	70,8826	71,9317		603		6D22			250,0000		116,0135
K9	1	Sb-x	250x700	1,1251	189,4881	213,1931	1007,5842	212	20D22	8D22	0,043	2100,0000	4392,8800	1038,5994	219,7555
		Sb-y	700x250	1,3040	84,3191	109,9521		109		6D22			1400,0000		113,3366
	2	Sb-x	250x700	1,0589	169,0719	179,0302	739,0862	242	20D22	8D22	0,043	1900,0000	4392,8800	883,3860	213,9842
		Sb-y	700x250	1,2177	79,8166	97,1927		132		6D22			1200,0000		116,1686
	3	Sb-x	250x700	1,0416	143,8580	149,8425	489,9558	306	20D22	8D22	0,043	1400,0000	4392,8800	625,8779	191,4114
		Sb-y	700x250	1,1353	69,2937	78,6691		161		6D22			900,0000		100,4933
K9	4	Sb-x	250x700	1,0266	134,7549	138,3394	318,0864	435	20D22	8D22	0,043	1200,0000	4392,8800	561,1160	244,0357
		Sb-y	700x250	1,0630	56,9221	60,5082		190		6D22			850,0000		106,7386
	5	Sb-x	250x700	1,0115	103,8744	105,0690	156,7713	670	20D22	8D22	0,043	600,0000	4392,8800	209,5400	140,4348
		Sb-y	700x250	1,0823	42,9387	46,4726		296		6D22			300,0000		62,1151

Keterangan Tabel 8.8.

- | | |
|--|---|
| [1] Kolom yang ditinjau | [10] Tulangan terpasang |
| [2] Lantai kolom yang ditinjau | [11] Tulangan terpasang pada tiap-tiap sisi |
| [3] Arah momen yang bekerja sejajar sb-x dan sb-y | [12] ρ = rasio tulangan terpasang |
| [4] Ukuran kolom | [13] ϕPx dan ϕPy (dilihat pada diagram interaksi kolom) |
| [5] δ_s = faktor pembesaran momen (Tabel 8.7) | [14] ϕPo (dilihat pada diagram interaksi kolom) |
| [6] Mu,k = momen rencana kolom terpakai | [15] ϕPn = hasil dari persamaan Bresler $1/\phi Pn = 1/\phi Px + 1/\phi Py - 1/\phi Po$ |
| [7] $Mc = \delta_s \cdot Mu,k$ (Momen rencana yang telah diperbesar) | $\phi Pn \geq Pu$ (tulangan terpasang aman digunakan) |
| [8] $Pu = Nu,k$ = gaya aksial rencana kolom terpakai | [16] $\phi Mn = \phi Pn \cdot e$ (Momen nominal kolom) |
| [9] $e = Mc/Pu$ (eksentrisitas) | dengan $\phi = 0,65$ |

8.2.5 Gaya Geser Rencana Kolom

Gaya geser rencana kolom diperoleh dengan persamaan berikut (Andriono dan Takim, 1993)

$$V_{u,k} = 1,05.(V_{D,k,x} + V_{L,k,x} + \omega_d K.(V_{E,k,x} + 0,3.V_{E,k,y}))$$

dengan:

$$\omega_d = 1 \text{ (untuk lantai 1 dan 5)}$$

$$\omega_d = 1,3 \text{ (untuk lantai 2,3, dan 4)}$$

$$K = 2$$

Sebagai contoh perhitungan ditinjau pada kolom K2 lantai 1.

Diketahui:

$$V_{D,k,x} = 56,3700 \text{ kN}$$

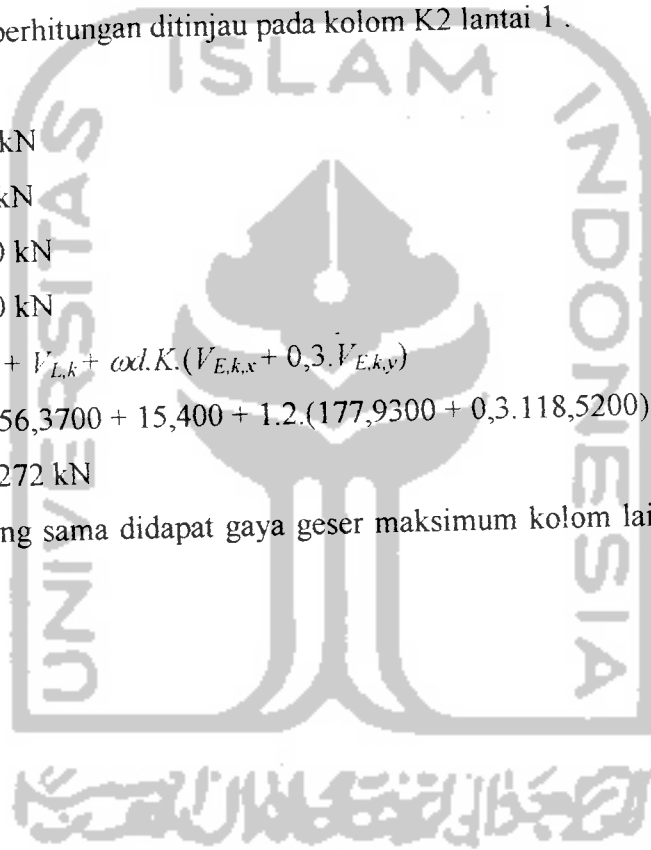
$$V_{L,k,x} = 15,4000 \text{ kN}$$

$$V_{E,k,x} = 177,9300 \text{ kN}$$

$$V_{E,k,y} = 118,5200 \text{ kN}$$

$$\begin{aligned} V_{u,k} &= 1,05.(V_{D,k} + V_{L,k} + \omega_d K.(V_{E,k,x} + 0,3.V_{E,k,y})) \\ &= 1,05.(56,3700 + 15,400 + 1,2.(177,9300 + 0,3.118,5200)) \\ &= 445,1272 \text{ kN} \end{aligned}$$

Dengan cara yang sama didapat gaya geser maksimum kolom lainnya disajikan pada Tabel 8.9.



Tabel 8.9 Gaya Geser Rencana Kolom Daktililitas Terbatas (Satuan kN)

Kolom	Lantai	Sejajar Sumbu x					Sejajar Sumbu y					Akibat Gempa Kiri		Akibat Gempa Kanan	
		$V_{D,k-x}$	$V_{L,k-x}$	$V_{Eki,k-x}$	$V_{Eka,k-x}$	$V_{D,k-y}$	$V_{L,k-y}$	$V_{Eki,k-y}$	$V_{Eka,k-y}$	$V_{u,k-x1}$	$V_{u,k-y1}$	$V_{u,k-x2}$	$V_{u,k-y2}$		
K1	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]		
	1	-65,7600	-17,5400	95,8700	-93,7500	0,2700	0,2300	111,5800	-111,0800	184,1574	295,2411	-304,7155	-291,8055		
	2	-127,4600	-37,7700	69,4600	-69,3500	0,1400	0,2300	110,4900	-110,2200	106,6256	358,9139	-362,4697	-357,3098		
	3	-112,8200	-33,1300	58,3000	-57,7800	-1,9900	-0,9600	91,7500	-91,5500	81,0548	295,1277	-308,7731	-300,3508		
	4	-172,1900	-50,6000	37,1000	-36,3900	-0,6400	-0,7100	66,5400	-66,6500	-78,1502	210,6216	-310,2884	-213,1754		
K2	5	-172,1900	-50,6000	37,1000	-36,3900	-3,4000	-0,9900	35,0500	-33,2100	-133,9380	92,3685	-265,0166	-97,2762		
	1	56,3700	15,4000	177,9300	-177,4500	0,6800	0,2100	118,5200	-117,5800	445,1272	361,9224	-371,3619	-357,7770		
	2	107,2100	32,1300	170,1200	-169,7800	1,4500	0,4100	114,6000	-113,3700	457,9848	454,1393	-410,0424	-446,5969		
	3	89,5700	26,6200	125,0100	-124,7000	-0,4000	-1,1800	89,1200	-90,5800	429,0129	344,0218	-292,6165	-351,0717		
	4	137,1700	40,8100	66,5700	-66,1600	3,1000	0,8000	71,1500	-63,0200	334,3505	195,4491	8,2404	-169,9278		
K3	1	-10,8700	-2,1200	58,2000	-56,5900	-21,6000	-9,9300	77,5200	-76,3700	157,4181	166,3515	-180,5916	-229,1352		
	2	-20,1600	-4,6000	44,5600	-44,1100	-38,7700	-21,3500	61,0500	-60,8900	145,6508	140,0351	-196,2872	-246,8981		
	3	-21,5100	-5,0700	37,3300	-36,7200	-37,5500	-20,4200	51,0200	-50,5600	115,7873	108,9894	-169,5632	-228,9710		
	4	-23,3900	-5,5300	26,5400	-25,5800	-43,4700	-22,1800	34,3800	-35,6900	70,2454	46,6612	-129,4295	-187,3162		
	5	-21,4800	-5,1500	8,8700	-9,2400	-33,2700	-13,4700	16,4400	-13,0800	1,0227	-8,9649	-55,6059	-82,3662		
K4	1	-2,6000	-1,1900	85,0600	-83,8900	-4,0000	-0,5900	57,9000	-57,7200	211,1235	170,3583	-216,5121	-178,8822		
	2	-5,3500	-2,4800	81,9000	-81,1800	-6,4600	-1,1200	44,0300	-44,0000	251,4261	179,3190	-247,2674	-194,5654		
	3	-6,2700	-2,6700	68,8400	-68,1100	-7,3200	-1,2300	34,1900	-34,1500	206,5478	140,7412	-223,2962	-157,9891		
	4	-6,6000	-2,8900	50,1100	-49,2900	-7,7800	-1,3200	23,1100	-22,9800	145,7629	94,5754	-163,3468	-112,6589		
	5	-7,6400	-2,3400	26,4700	-26,6000	-10,9900	-1,3800	5,4400	-5,5800	48,5352	15,1116	-69,8544	-41,4645		
K5	1	9,3100	2,4900	92,2100	-91,9300	-19,1300	-4,8100	111,1300	-109,0300	276,0429	266,3283	-249,3519	-312,0159		
	2	17,6000	5,2300	86,6000	-86,3900	-34,9900	-9,9500	89,2000	-88,9500	300,0999	267,2544	-284,7233	-360,7739		
	3	17,5500	5,1500	70,2200	-70,0100	-33,8500	-9,5900	73,5200	-71,4000	275,7485	212,6078	-225,7689	-297,8722		
	4	18,1700	5,4500	48,0300	-47,8100	-41,7800	-12,0800	24,0900	-49,3200	175,6526	48,5493	-146,1134	-230,3530		
	5	19,3300	5,1300	20,9900	-20,9800	1,1800	0,0000	59,6300	2,2000	107,3289	139,6857	-16,9890	-7,3584		
K6	1	-7,6700	-1,9800	31,1900	-30,9600	-0,1600	0,0300	17,9700	-17,9900	66,6876	57,2502	-86,4822	-57,4203		
	2	-12,5800	-3,8900	25,6400	-25,6300	-0,1400	0,0200	21,3200	-21,3200	70,1648	79,0768	-104,7245	-79,3206		
	3	-12,2200	-3,6700	21,3700	-21,3200	-0,2400	0,0400	18,7700	-18,7700	57,0282	68,5341	-90,2607	-68,9132		
	4	-12,0200	-3,7800	15,3700	-15,3200	-0,3200	0,0500	13,5800	-13,6000	36,4921	49,3779	-69,5520	-49,9586		
	5	-15,5700	-3,8200	7,5200	-7,4500	-0,4100	0,0600	8,2100	-8,2000	0,6048	21,6111	-41,1705	-22,2810		

Tabel 8.9. lanjutan

Kolom	Lantai	Sejajar Sumbu x				Sejajar Sumbu y				Akibat Gempa Kiri		Akibat Gempa Kanan	
		$V_{D,k-x}$	$V_{L,k-x}$	$V_{Eki,k-x}$	$V_{Eka,k-x}$	$V_{D,k-y}$	$V_{L,k-y}$	$V_{Eki,k-y}$	$V_{Eka,k-y}$	$V_{u,k-x1}$	$V_{u,k-y1}$	$V_{u,k-x2}$	$V_{u,k-y2}$
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]
K7	1	4,9300	1,4400	51,6900	-51,6100	-0,4000	-0,0600	18,5700	-19,0400	126,9366	71,0787	-113,6877	-72,9813
	2	8,1800	2,8300	49,1800	-49,1500	-0,8200	-0,1600	18,3700	-18,6200	160,8669	89,3995	-137,8688	-92,1155
	3	7,4500	2,5600	39,9900	-39,9600	-0,5400	-0,0600	15,1200	-15,0700	132,0665	73,3994	-110,9226	-74,4983
	4	7,1000	2,6200	26,9400	-26,9100	-0,9100	-0,1600	9,8800	-10,6000	91,8439	47,9128	-71,9397	-52,1008
	5	8,5800	2,3500	10,1800	-10,1400	-1,5600	-0,4800	3,0100	-12,6400	34,7508	10,5924	-17,7807	-35,0742
K8	1	-6,1700	-1,1500	25,8500	-25,5800	-2,5600	-0,3300	21,0700	-21,0300	59,8731	57,4980	-74,6529	-63,3129
	2	-9,8900	-2,2500	23,2600	-23,1900	-3,8300	-0,6400	23,1800	-23,1800	69,7372	77,6378	-95,0401	-86,9675
	3	-9,9800	-2,1600	19,8700	-19,7800	-3,6800	-0,6000	20,0200	-20,0100	57,8945	66,4341	-83,1346	-75,3211
	4	-9,9200	-2,2500	14,6400	-14,4500	-3,7800	-0,6200	14,3700	-14,3500	38,9577	46,6003	-63,9797	-55,6301
	5	-13,4800	-1,9400	7,8600	-8,0700	-3,2800	-0,5000	9,0500	-9,0700	6,0165	19,9878	-38,8521	-28,1001
K9	1	3,8300	0,8400	51,9500	-51,8200	2,4300	0,4500	13,2100	-13,8900	122,3208	63,4935	-112,6692	-58,7916
	2	6,0200	1,6800	47,1500	-47,0900	4,0500	0,8400	12,6400	-13,0800	147,1567	78,2576	-131,1832	-69,1406
	3	5,1100	1,4300	38,2000	-38,1400	4,5800	0,9500	10,5000	-10,8700	119,7525	65,7573	-106,1577	-55,1053
	4	4,3500	1,4400	26,0300	-25,9500	4,7800	0,9800	7,1000	-7,6200	82,9563	46,7496	-71,0048	-36,0077
	5	6,3300	0,9900	9,9600	-10,0600	4,0000	0,5300	2,1000	-9,0700	29,9250	15,4413	-19,1541	-20,6283

Keterangan Tabel 8.9:

- [1] Kolom yang ditinjau
 [2] Tingkat lantai pada kolom yang ditinjau
 [3] $V_{D,k-x}$ = Gaya geser kolom akibat beban mati sejajar sb-x
 [4] $V_{L,k-x}$ = Gaya geser kolom akibat beban hidup sejajar sb-x
 [5] $V_{Eki,k-x}$ = Gaya geser kolom akibat beban gempa kiri sejajar sb-x
 [6] $V_{Eka,k-x}$ = Gaya geser kolom akibat beban gempa kanan sejajar sb-x
 [7] $V_{D,k-y}$ = Gaya geser kolom akibat beban mati sejajar sb-y
 [8] $V_{L,k-y}$ = Gaya geser kolom akibat beban hidup sejajar sb-y
 [9] $V_{Eki,k-y}$ = Gaya geser kolom akibat beban gempa kiri sejajar sb-y
 [10] $V_{Eka,k-y}$ = Gaya geser kolom akibat beban gempa kanan sejajar sb-y
 [11] $V_{u,k-x1} = 1,05(N_{D,k-x} + N_{L,k-x} + \omega d \cdot k(N_{Eka,k-x} + 0,3N_{Eki,k-x}))$
 (Gaya geser rencana kolom akibat gempa kiri sejajar sb-x)
 [12] $V_{u,k-y1} = 1,05(N_{D,k-y} + N_{L,k-y} + \omega d \cdot k(N_{Eka,k-y} + 0,3N_{Eki,k-y}))$
 (Gaya geser rencana kolom akibat gempa kiri sejajar sb-y)
 [13] $V_{u,k-x2} = 1,05(N_{D,k-x} + N_{L,k-x} + \omega d \cdot k(N_{Eka,k-x} + 0,3N_{Eki,k-x}))$
 (Gaya geser rencana kolom akibat gempa kanan sejajar sb-x)
 [14] $V_{u,k-y2} = 1,05(N_{D,k-y} + N_{L,k-y} + \omega d \cdot k(N_{Eka,k-y} + 0,3N_{Eki,k-y}))$
 (Gaya geser rencana kolom akibat gempa kanan sejajar sb-y)
 dengan: $k = 2,$
 $\omega d = 1$ (untuk lantai 1 dan 5)
 $\omega d = 1,3$ (untuk lantai 2,3, dan 4)

8.2.6 Penulangan Geser Kolom

Sebagai contoh perhitungan penulangan geser kolom ditinjau pada kolom K2 lantai 1, adalah sebagai berikut ini. (Kusuma, dan Andriono, 1993)

- Penulangan geser sepanjang l_o

Syarat panjang l_o dari muka balok (SK-SNI T-15-1991-03):

$$l_o \geq h = 700 \text{ mm, bila } N_{u,k} \leq 0,3 \cdot A_g \cdot f_c'$$

$$l_o \geq 1,5 h = 1,5 \cdot 700 = 1050 \text{ mm, bila } N_{u,k} > 0,3 \cdot A_g \cdot f_c'$$

$$(N_{u,k} = 4557,8337 \text{ kN}) > (0,3 \cdot 700 \cdot 700 \cdot 25 = 3675 \text{ kN}), \text{ dipakai } l_o = 1050 \text{ mm}$$

$$0,5 \cdot V_c = 0,5 \cdot \left[1 + \frac{N_{u,k}}{14 \cdot A_g} \right] \cdot \frac{1}{6} \sqrt{f_c'} \cdot b \cdot d = 0,5 \cdot \left[1 + \frac{4557,8337}{14 \cdot 700 \cdot 700} \right] \cdot \frac{1}{6} \sqrt{25} \cdot 700 \cdot 635,5 = 313,7962 \text{ kN}$$

$$V_{s,k} = V_{u,k} / 0,6 - 0,5 \cdot V_c = 445,1272 / 0,6 - 313,7962 = 428,0824 \text{ kN}$$

$$S = (A_v \cdot f_y \cdot d) / V_{s,k} = 3,0 \cdot 25 \cdot \pi \cdot 12^2 \cdot 240 \cdot 635,5 / 4280824 = 127,83 \text{ mm}$$

Jarak maksimum tulangan geser pada daerah l_o (SK-SNI T-15-1991-03):

$$- 1/2 \cdot b = 1/2 \cdot 700 = 350 \text{ mm}$$

$$- 10 \text{ kali diameter tulangan longitudinal} = 10 \cdot 25 = 250 \text{ mm}$$

$$- 200 \text{ mm}$$

dipakai **3P12-120**

Cek tulangan geser,

$$V_{s,k} = (A_v \cdot f_y \cdot d) / S = (3,0 \cdot 25 \cdot \pi \cdot 12^2 \cdot 240 \cdot 635,5 / 120) \cdot 10^{-3} = 331,7313 \text{ kN}$$

$$0,6(V_{s,k} + V_c) = 461,8893 \text{ kN} \geq V_{u,k} = 445,1272 \text{ kN} \quad \text{- aman -}$$

- Penulangan geser daerah diluar l_o

$$V_c = \left[1 + \frac{N_{u,k}}{14 \cdot A_g} \right] \cdot \frac{1}{6} \sqrt{f_c'} \cdot b \cdot d = \left[1 + \frac{4557,8337}{14 \cdot 700 \cdot 700} \right] \cdot \frac{1}{6} \sqrt{25} \cdot 700 \cdot 635,5 = 627,5925 \text{ kN}$$

$$V_{s,k} = V_{u,k} / 0,6 - V_c = 445,1272 / 0,6 - 627,5925 = 114,2862 \text{ kN}$$

$$S = (A_v \cdot f_y \cdot d) / V_{s,k} = 2,0 \cdot 25 \cdot \pi \cdot 12^2 \cdot 240 \cdot 635,5 / 1142862 = 319,2019 \text{ mm}$$

dipakai **2P12-250**

Cek tulangan geser kolom,

$$V_{s,k} = (A_v \cdot f_y \cdot d) / S = (2,0 \cdot 25 \cdot \pi \cdot 12^2 \cdot 240 \cdot 635,5 / 250) \cdot 10^{-3} = 145,9323 \text{ kN}$$

$$0,6(V_{s,k} + V_c) = 464,1112 \text{ kN} \geq V_{u,k} = 445,1272 \text{ kN} \quad \text{- aman -}$$

Dengan cara yang sama didapat dimensi dan jarak sengkang geser kolom lainnya yang disajikan pada Tabel 8.10.

Tabel 8.10 Penulangan Geser Kolom Daktilitas Terbatas

Ko- lom	Lan- tai	<i>l</i> (m)	<i>l_n</i> (m)	<i>b</i> (mm)	<i>h</i> (mm)	<i>N_{u,k}</i> (kN)	0,3 <i>A_gf_c</i> (kN)	Lokasi	Jarak (mm)	<i>V_{u,k}</i> (kN)	<i>V_c</i> (kN)	<i>V_s</i> (kN)	<i>S</i> (mm)	<i>S_{max}</i> (mm)	Tul.ges terpakai	<i>V_{u,k} ≤</i> 0,6(<i>V_s+V_c</i>) (kN)
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]
K1	1	5,4	4,1	700	700	3576,4134	3675,0000	Pada lo	0-700	304,7155	283,9840	325,4470	112,10	200	2P12- 100	389,2796
								Luar lo	sisa	304,7155	567,9681	-60,1089	-606,92	400	2P12- 300	413,7439
	2	3,8	3,1	700	700	2769,2580	3675,0000	Pada lo	0-700	362,4697	262,0206	342,0955	106,64	200	2P12- 100	376,1016
								Luar lo	sisa	362,4697	524,0413	80,0749	455,59	400	2P12- 300	387,3878
	3	3,8	3,1	700	700	1906,1099	3675,0000	Pada lo	0-700	308,7731	238,5336	276,0882	132,14	200	2P12- 100	362,0094
								Luar lo	sisa	308,7731	477,0672	37,5546	971,43	400	2P12- 300	359,2034
	4	3,8	3,1	700	700	1049,8391	3675,0000	Pada lo	0-700	310,2884	215,2337	301,9136	120,83	200	2P12- 100	348,0294
								Luar lo	sisa	310,2884	430,4674	86,6799	420,88	400	2P12- 300	331,2435
	5	3,8	3,1	700	700	628,0071	3675,0000	Pada lo	0-700	265,0166	203,7553	326,2779	111,81	200	2P12- 100	341,1424
								Luar lo	sisa	265,0166	407,5106	34,1837	1067,22	400	2P12- 300	317,4694
K2	1	5,4	4,1	700	700	4557,8337	3675,0000	Pada lo	0-1050	445,1272	313,7962	428,0824	127,83	200	3P12- 100	500,9766
								Luar lo	sisa	445,1272	627,5925	114,2862	319,21	400	2P12- 250	464,1112
	2	3,8	3,1	700	700	3371,0214	3675,0000	Pada lo	0-700	457,9848	300,6668	462,6412	118,28	200	3P12- 100	508,7339
								Luar lo	sisa	457,9848	601,3335	147,2495	259,55	400	2P12- 250	465,0331
	3	3,8	3,1	700	700	1952,6831	3675,0000	Pada lo	0-700	429,0129	271,4546	443,5689	123,38	200	3P12- 100	491,2066
								Luar lo	sisa	429,0129	542,9092	152,5818	250,48	400	2P12- 250	429,9785
	4	3,8	3,1	700	700	828,4981	3675,0000	Pada lo	0-700	334,3505	209,2108	348,0400	154,73	200	3P12- 100	344,4157
								Luar lo	sisa	334,3505	418,4217	138,8292	262,78	400	2P12- 250	338,6087
K3	1	5,4	4,1	700	700	2060,1189	3675,0000	Pada lo	0-700	229,1352	242,7243	139,1677	262,14	200	2P12- 200	255,0792
								Luar lo	sisa	229,1352	485,4486	-103,5566	-352,29	400	2P12- 300	364,2323
	2	3,8	3,1	700	700	1667,4722	3675,0000	Pada lo	0-700	246,8981	232,0401	179,4568	203,29	200	2P12- 200	248,6686
								Luar lo	sisa	246,8981	464,0801	-52,5833	-693,79	400	2P12- 300	351,4111
	3	3,8	3,1	700	700	1148,6460	3675,0000	Pada lo	0-700	228,9710	217,9223	163,6960	222,86	200	2P12- 200	240,1980
								Luar lo	sisa	228,9710	435,8447	-54,2263	-672,76	400	2P12- 300	334,4699
	4	3,8	3,1	700	700	652,2209	3675,0000	Pada lo	0-700	187,3162	204,4142	107,7795	338,48	200	2P12- 200	232,0931
								Luar lo	sisa	187,3162	408,8283	-96,6347	-377,52	400	2P12- 300	318,2601
	5	3,8	3,1	700	700	213,8619	3675,0000	Pada lo	0-700	82,3662	192,4860	-55,2090	-660,79	200	2P12- 200	224,9362
								Luar lo	sisa	82,3662	384,9721	-247,6951	-147,28	400	2P12- 300	303,9463
K4	1	5,4	4,1	700	700	2031,4959	3675,0000	Pada lo	0-700	216,5121	241,9455	118,9080	306,80	200	2P12- 200	254,6119
								Luar lo	sisa	216,5121	483,8909	-123,0374	-296,51	400	2P12- 300	363,2976
	2	3,8	3,1	700	700	1626,6961	3675,0000	Pada lo	0-700	247,2674	230,9305	181,1818	201,35	200	2P12- 200	248,0029
								Luar lo	sisa	247,2674	461,8610	-49,7487	-733,32	400	2P12- 300	350,0797
	3	3,8	3,1	700	700	1148,7330	3675,0000	Pada lo	0-700	223,2962	217,9247	154,2356	236,53	200	2P12- 200	240,1994
								Luar lo	sisa	223,2962	435,8494	-63,6891	-572,81	400	2P12- 300	334,4727
	4	3,8	3,1	700	700	679,7774	3675,0000	Pada lo	0-700	163,3468	205,1640	67,0807	543,85	200	2P12- 200	232,5430
								Luar lo	sisa	163,3468	410,3280	-138,0834	-264,20	400	2P12- 300	319,1599
	5	3,8	3,1	700	700	246,3810	3675,0000	Pada lo	0-700	69,8544	193,3872	-75,9632	-474,01	200	2P12- 200	225,4770
								Luar lo	sisa	69,8544	386,7745	-270,3505	-134,94	400	2P12- 300	305,0278
K5	1	5,4	4,1	700	700	2436,3864	3675,0000	Pada lo	0-700	276,0429	278,2592	181,8123	200,65	200	2P12- 200	276,4001
								Luar lo	sisa	276,0429	556,5184	-96,4469	-378,26	400	2P12- 300	406,8741
	2	3,8	3,1	700	700	1854,2792	3675,0000	Pada lo	0-700	300,0999	260,8356	177,2822	205,78	200	2P12- 200	307,6391
								Luar lo	sisa	300,0999	521,6711	-21,5046	-1696,45	400	2P12- 300	385,9658
	3	3,8	3,1	700	700	1231,6981	3675,0000	Pada lo	0-700	275,7485	220,1823	177,3323	205,72	200	2P12- 200	283,2471
								Luar lo	sisa	275,7485	440,3645	19,2163	1898,47	400	2P12- 300	337,1818
	4	3,8	3,1	700	700	742,9136	3675,0000	Pada lo	0-700	175,6526	206,8820	85,8723	424,83	200	2P12- 200	233,5738
								Luar lo	sisa	175,6526	413,7640	-121,0097	-301,48	400	2P12- 300	321,2215
	5	3,8	3,1	700	700	287,2254	3675,0000	Pada lo	0-700	139,6857	194,4823	38,3272	951,85	200	2P12- 200	226,1340
								Luar lo	sisa	139,6857	388,9646	-156,1551	-233,62	400	2P12- 300	306,3419
K6	1	5,4	4,1	250	700	1063,1187	1312,5000	Pada lo	0-700	86,4822	95,5951	48,5419	497,04	200	2P10- 150	153,8670
								Luar lo	sisa	86,4822	191,1901	-47,0531	-512,77	400	2P10- 250	172,6201
	2	3,8	3,1	250	700	796,9540	1312,5000	Pada lo	0-700	104,7245	88,3525	86,1883	279,94	200	2P10- 150	149,5214
								Luar lo	sisa	104,7245	176,7050	-2,1641	-11148,7	400	2P10- 250	163,9290
	3	3,8	3,1	250	700	558,2060	1312,5000	Pada lo	0-700	90,2607	81,8559	68,5786	351,82	200	2P10- 150	145,6235
								Luar lo	sisa	90,2607	163,7119	-13,2774	-1817,19	400	2P10- 250	156,1331
	4	3,8	3,1	250	700	338,0996	1312,5000	Pada lo	0-700	69,5520	75,8667	40,0533	602,38	200	2P10- 150	142,0299
								Luar lo	sisa	69,5520	151,7333	-35,8133	-673,70	400	2P10- 250	148,9460
	5	3,8	3,1	250	700	137,4114	1312,5000	Pada lo	0-700	41,1705	70,4058	-1,7883	-13492,2	200	2P10- 150	138,7534
								Luar lo	sisa	41,1705	140,8115	-72,1940	-334,20	400	2P10- 250	142,3929

Tabel 8.10. lanjutan

Ko- lom	Lan- tai	<i>l</i>	<i>l_n</i>	<i>b</i>	<i>h</i>	<i>N_{u,k}</i>	$0,3$ <i>A_g f_c</i>	Lokasi	Jarak	<i>V_{u,k}</i>	<i>V_c</i>	<i>V_s</i>	<i>S</i>	<i>S_{max}</i>	Tul.ges terpakai	$V_{u,k} \leq$ $0,6(V_s + V_c)$
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]
K7	1	5,4	4,1	250	700	1222,0929	1312,5000	Pada lo	0-700	126,9366	119,9051	91,6559	263,24	200	2P10- 150	168,4530
								Luar lo	0-700	126,9366	239,8101	-28,2491	-854,10	400	2P10- 250	201,7921
	2	3,8	3,1	250	700	925,5389	1312,5000	Pada lo	0-700	160,8669	110,2217	157,8898	152,81	200	2P10- 150	162,6430
								Luar lo	0-700	160,8669	220,4434	47,6681	506,16	400	2P10- 250	190,1720
	3	3,8	3,1	250	700	612,0370	1312,5000	Pada lo	0-700	132,0665	83,3207	136,7901	176,38	200	2P10- 150	146,5024
							Luar lo	0-700	132,0665	166,6415	53,4694	451,24	400	2P10- 250	157,8909	
	4	3,8	3,1	250	700	367,3047	1312,5000	Pada lo	0-700	91,8439	76,6614	76,4118	315,76	200	2P10- 150	142,5068
							Luar lo	0-700	91,8439	153,3227	-0,2495	-96688,60	400	2P10- 250	149,8996	
	5	3,8	3,1	250	700	152,5629	1312,5000	Pada lo	0-700	35,0742	70,8180	-12,3610	-1951,90	200	2P10- 150	139,0008
							Luar lo	0-700	35,0742	141,6361	-83,1791	-290,07	400	2P10- 250	142,8876	
K8	1	5,4	4,1	250	700	780,3075	1312,5000	Pada lo	0-700	74,6529	87,8995	36,5220	660,63	200	2P10- 150	149,2497
								Luar lo	0-700	74,6529	175,7990	-51,3775	-469,61	400	2P10- 250	163,3854
	2	3,8	3,1	250	700	651,4034	1312,5000	Pada lo	0-700	95,0401	84,3919	74,0082	326,01	200	2P10- 150	147,1451
								Luar lo	0-700	95,0401	168,7839	-10,3837	-2323,59	400	2P10- 250	159,1763
	3	3,8	3,1	250	700	463,6468	1312,5000	Pada lo	0-700	83,1346	79,2829	59,2748	407,04	200	2P10- 150	144,0797
							Luar lo	0-700	83,1346	158,5658	-20,0081	-1205,88	400	2P10- 250	153,0455	
	4	3,8	3,1	250	700	278,4936	1312,5000	Pada lo	0-700	63,9797	74,2447	32,3881	744,95	200	2P10- 150	141,0568
							Luar lo	0-700	63,9797	148,4894	-41,8566	-576,43	400	2P10- 250	146,9996	
	5	3,8	3,1	250	700	119,2149	1312,5000	Pada lo	0-700	38,8521	69,9106	-5,1571	-4678,49	200	2P10- 150	138,4563
							Luar lo	0-700	38,8521	139,8212	-75,0677	-321,41	400	2P10- 250	141,7987	
K9	1	5,4	4,1	250	700	1007,5842	1312,5000	Pada lo	0-700	122,3208	94,0839	109,7841	219,77	200	2P10- 150	152,9603
								Luar lo	0-700	122,3208	188,1678	15,7002	1536,77	400	2P10- 250	170,8067
	2	3,8	3,1	250	700	739,0862	1312,5000	Pada lo	0-700	147,1567	86,7779	158,4833	152,24	200	2P10- 150	148,5767
								Luar lo	0-700	147,1567	173,5557	71,7055	336,48	400	2P10- 250	162,0394
	3	3,8	3,1	250	700	489,9558	1312,5000	Pada lo	0-700	119,7525	79,9988	119,5987	201,75	200	2P10- 150	144,5092
							Luar lo	0-700	119,7525	159,9976	39,5899	609,44	400	2P10- 250	153,9045	
	4	3,8	3,1	250	700	318,0864	1312,5000	Pada lo	0-700	82,9563	75,3221	62,9384	383,35	200	2P10- 150	141,7032
							Luar lo	0-700	82,9563	150,6442	-12,3837	-1948,33	400	2P10- 250	146,2925	
	5	3,8	3,1	250	700	156,7713	1312,5000	Pada lo	0-700	29,9250	70,9326	-21,0576	-1145,79	200	2P10- 150	139,0695
							Luar lo	0-700	29,9250	141,8651	-91,9901	-262,28	400	2P10- 250	143,0250	

Keterangan Tabel 8.10:

- [1] Kolom yang ditinjau
 [2] Lantai kolom yang ditinjau
 [3] *l* = panjang kolom
 [4] *l_n* = panjang bersih kolom
 [5] *b* = lebar penampang kolom
 [6] *h* = tinggi penampang kolom
 [7] *N_{u,k}* = gaya aksial terpakai kolom (Tabel 8.6)
 [8] $0,3 A_g f_c$ dengan $A_g = b \cdot h$, $f_c = 25$ MPa
 [9] Daerah penulangan geser
 [10] Jarak penulangan geser dari muka kolom
 $l_o = h = 700$ mm untuk $N_{u,k} < 0,3 A_g f_c'$
 $l_o = 1,5h = 1050$ mm untuk $N_{u,k} > 0,3 A_g f_c'$
 $l_o = 1,5h = 1050$ mm untuk $N_{u,k} > 0,3 A_g f_c'$
- [11] *V_{u,k}* = gaya geser rencana kolom (Tabel 8.9)
 [12] $V_c = [1 + N_{u,k} / (14 A_g)] \cdot (1/6) \cdot (f_c \cdot 0,5 \cdot b \cdot d)$
 (gaya geser beton)
 [13] $V_s = V_{u,k} / 0,6 - V_c$
 [14] $S = (A_v \cdot f_y \cdot d) / V_s$ dengan:
 diameter sengkang = 12 mm (untuk kolom K1 s/d K5),
 diameter sengkang = 10 mm (untuk kolom K6 s.d K9)
 $f_y = 240$ MPa $d = 640$ mm
 [15] $S_{maks} = 8 \cdot d$ tul. pokok
 [16] Tulangan geser kolom terpasang
 [17] $V_{u,k} \leq 0,6(V_s + V_c)$ tulangan geser aman

BAB IX

PEMBAHASAN

Pada bab ini akan dibahas mengenai perbandingan tulangan balok dan kolom, yang dihasilkan dari dua perencanaan yaitu daktilitas penuh dan terbatas. Dari perbandingan tersebut dapat dilihat perbedaan penulangan dari dua cara perencanaan antara daktilitas penuh dan terbatas.

9.1 Perbandingan Tulangan Antara Daktilitas Penuh dan Terbatas

Dari Bab VII dan Bab VIII sebelumnya telah dihasilkan tulangan lentur dan geser balok, dan tulangan kombinasi lentur-aksial, dan geser kolom, dari daktilitas penuh dan terbatas.

Perbandingan tulangan antara daktilitas penuh dan daktilitas terbatas untuk lebih jelasnya disajikan dalam:

Tabel 9.1 Perbandingan Tulangan Lentur Balok Daktilitas Penuh dan Terbatas

Tabel 9.2 Perbandingan Tulangan Geser Balok Daktilitas Penuh dan Terbatas

Tabel 9.3 Perbandingan Tulangan Kombinasi Lentur-Aksial Kolom Daktilitas Penuh dan Terbatas

Tabel 9.4 Perbandingan Tulangan Geser Kolom Daktilitas Penuh dan Terbatas

dan disajikan pula dalam Gambar 9.1 s/d Gambar 9.8 untuk Portal As1 dan As6 adalah sebagai berikut ini.