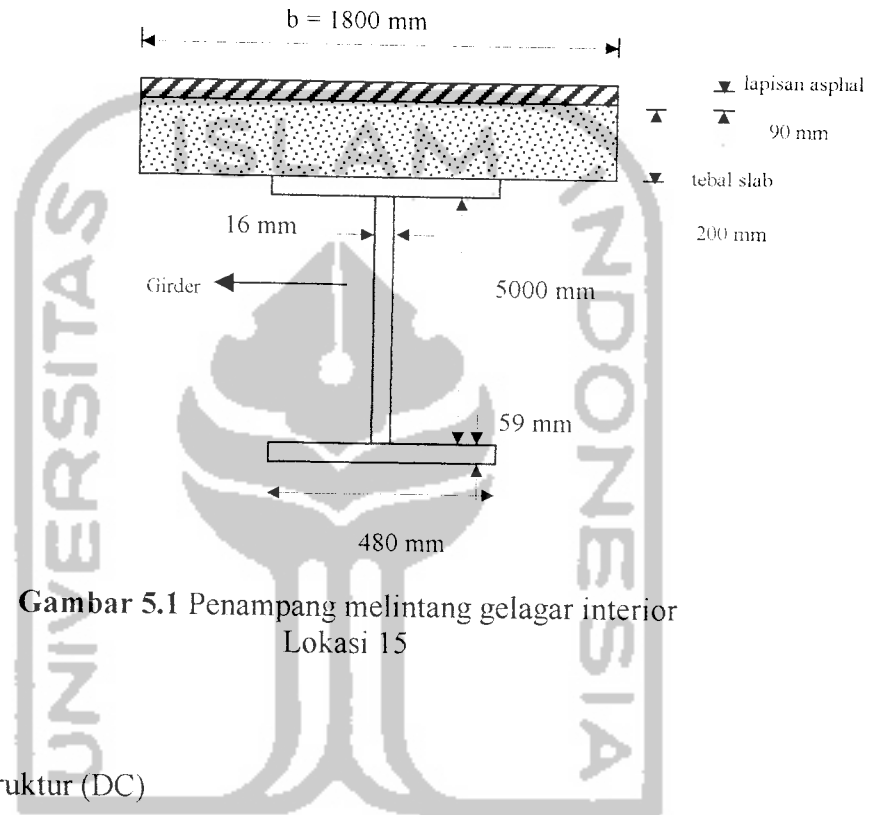


**BAB V**  
**DESAIN DAN PEMBAHASAN**

**5.1 Pembebanan**

Gelagar Interior



**Gambar 5.1** Penampang melintang gelagar interior Lokasi 15

Beban mati struktur (DC)

- Slab beton  $= 23,536 \times 0,2 \times 1,8 = 8,687 \text{ kN/m}$
- Berat girder (asumsi)  $= 9,876 \text{ kN/m}$

Beban mati merata total ( $W_{DC}$ )  $= 18,563 \text{ kN/m}$

Beban mati akibat asphal (DW)

- Perkerasan asphal  $= 22,072 \times 0,09 \times 1,8 = 3,5757 \text{ kN/m}$

## 5.2 Faktor distribusi (mg)

### 5.2.1 Faktor distribusi momen ( $mg_m$ )

Untuk  $L = 70$  m

- Satu pembebanan jalur rencana

$$mg_m = 0.06 + \left(\frac{S}{4300}\right)^{0.4} \left(\frac{S}{L}\right)^{0.3} \left(\frac{Kg}{Lt_s^3}\right)^{0.1}$$

untuk perencanaan awal  $Kg/Lt_s^3 = 1$  (asumsi)

$$mg_m^{si} = 0.06 + \left(\frac{1800}{4300}\right)^{0.4} \left(\frac{1800}{70.000}\right)^{0.3} (1)^{0.1} = 0.2954$$

- dua pembebanan jalur rencana

$$mg_m^{Mi} = 0.075 + \left(\frac{S}{2900}\right)^{0.6} \left(\frac{S}{L}\right)^{0.2} \left(\frac{Kg}{Lt_s^3}\right)^{0.1}$$

$$mg_m^{Mi} = 0.075 + \left(\frac{1800}{2900}\right)^{0.6} \left(\frac{1800}{70.000}\right)^{0.2} (1)^{0.1} = 0.4362$$

diambil yang terbesar  $mg_m = 0.4362$

Untuk  $L = 140$  m

- Satu pembebanan jalur rencana

$$mg_m = 0.06 + \left(\frac{S}{4300}\right)^{0.4} \left(\frac{S}{L}\right)^{0.3} \left(\frac{Kg}{Lt_s^3}\right)^{0.1}$$

untuk perencanaan awal  $Kg/Lt_s^3 = 1$  (asumsi)

$$mg_m^{si} = 0.06 + \left(\frac{1800}{4300}\right)^{0.4} \left(\frac{1800}{73000}\right)^{0.3} (1)^{0.1} = 0.2924$$

- dua pembebanan jalur rencana

$$mg_m^{Mi} = 0.075 + \left(\frac{S}{2900}\right)^{0.6} \left(\frac{S}{L}\right)^{0.2} \left(\frac{Kg}{Ls^3}\right)^{0.1}$$

$$mg_m^{Mi} = 0.075 + \left(\frac{1800}{2900}\right)^{0.6} \left(\frac{1800}{73000}\right)^{0.2} (1)^{0.1} = 0.433$$

diambil yang terbesar  $mg_m = 0.433$

### 5.2.2 Faktor distribusi geser ( $mg_v$ )

Untuk  $L = 70$  m

- Satu pembebanan jalur rencana

$$mg_v = 0.36 + \left(\frac{S}{7600}\right)$$

$$mg_v^{si} = 0.36 + \left(\frac{1800}{7600}\right) = 0.5968$$

- dua pembebanan jalur rencana

$$mg_v^{Mi} = 0.2 + \left(\frac{S}{3600}\right) - \left(\frac{S}{10700}\right)^2$$

$$mg_v^{Mi} = 0.2 + \left(\frac{1800}{3600}\right) - \left(\frac{1800}{10700}\right)^2 = 0.671$$

diambil yang terbesar  $mg_v = 0.671$

Untuk  $L = 140$  m

- Satu pembebanan jalur rencana

$$mg_v = 0.36 + \left(\frac{S}{7600}\right)$$

$$mg_v^{si} = 0.36 + \left( \frac{1800}{7600} \right) = 0.5968$$

- dua pembebanan jalur rencana

$$mg_v^{M1} = 0.2 + \left( \frac{S}{3600} \right) - \left( \frac{S}{10700} \right)^2$$

$$mg_v^{M1} = 0.2 + \left( \frac{1800}{3600} \right) - \left( \frac{1800}{10700} \right)^2 = 0.671$$

diambil yang terbesar  $mg_v = 0.671$

### 5.3 Pembebanan pada gelagar menerus

#### 5.3.1 beban mati

Perhitungan momen dan gaya geser akibat beban mati dilakukan dengan menggunakan program SAP 2000 dan dapat dilihat pada Tabel 5.1 dan Tabel 5.2

#### 5.3.2 beban hidup

1. Menghitung momen dan gaya geser akibat beban hidup terpusat

Untuk mendapatkan momen dan gaya geser akibat beban hidup terpusat dengan cara mengalikan beban terpusat dengan ordinat garis pengaruh. Tiap bentang pada gelagar dibagi menjadi beberapa segmen yang tiap segmennya sebesar 5 meter mulai dari lokasi 1 sampai dengan 57. Untuk lebih jelasnya dapat dilihat pada Gambar 5.2.

Perhitungan momen dan gaya geser di lokasi 2 (lihat garis pengaruh momen dan gaya geser di lampiran 1)

Perhitungan momen :

- Beban tandem rencana

Daerah positif

$$C1 : M_2^{Ta} = 110(4,58) + 110(4,479) = 996,490 \text{ kNm}$$

$$C2 : M_2^{Ta} = 110(3,481) + 110(4,58) = 886,710 \text{ kNm}$$

Daerah negatif

$$C1 : M_2^{Ta} = 110(-1,03) + 110(1,028) = -226,380 \text{ kNm}$$

$$C2 : M_2^{Ta} = 110(-1,025) + 110(-1,03) = -226,05 \text{ kNm}$$

- Beban truk rencana

Daerah positif

$$C1 : M_2^{Tr} = 145(4,58) + 145(4,219) + 35(3,858) + 145(2,639) + 145(2,3106) + 35(1,987) = 2198,035 \text{ kNm}$$

$$C2 : M_2^{Tr} = 145(0,641) + 145(4,580) + 35(4,219) + 145(2,977) + 145(2,639) + 35(2,310) = 1799,880 \text{ kNm}$$

Untuk perhitungan momen di lokasi selanjutnya dapat dilihat pada Tabel 5.1

Perhitungan gaya geser :

- Beban tandem rencana

Daerah positif

$$C1 : V_2^{Ta} = 110(0,205) + 110(0,20476) = 45,074 \text{ kN}$$

$$C2 : V_2^{Ta} = 110(0,20428) + 110(0,205) = 45,021 \text{ kN}$$

Daerah negatif

$$C1 : V_2^{Ta} = 110(-0,915) + 110(-0,895) = -199,100 \text{ kN}$$

$$C2 : V_2^{Ta} = 110(0,065) + 110(-0,915) = -93,500 \text{ kN}$$

- Beban truk rencana

Daerah positif

$$C1 : V_2^{Tr} = 145(0,2024) + 145(0,205) + 35(0,2041) + 145(0,188) + 145(0,181) + 35(0,171) = 125,711 \text{ kN}$$

$$C2 : V_2^{Tr} = 145(0,205) + 145(0,2041) + 35(0,202) + 145(0,181) + 145(0,171) + 35(0,160) = 123,030 \text{ kN}$$

Daerah negatif

$$C1 : V_2^{Tr} = 145(-0,915) + 145(-0,843) + 35(-0,771) + 145(-0,528) + 145(-0,462) - 35(-0,397) = -439,340 \text{ kN}$$

$$C2 : V_2^{Tr} = 145(0,012) + 145(-0,915) + 35(-0,843) + 145(-0,595) + 145(-0,528) + 35(-0,462) = -339,445 \text{ kN}$$

Untuk perhitungan gaya geser di lokasi selanjutnya dapat dilihat pada Tabel 5.2

2. Menghitung momen dan gaya geser akibat beban merata

Untuk mendapatkan momen dan gaya geser akibat beban merata dengan cara mengalikan beban merata dengan luasan bidang momen dan gesernya.

Perhitungan momen dan gaya geser di lokasi 2 ( lihat garis pengaruh momen dan gaya geser di lampiran 1)

**Momen gelagar jembatan akibat beban jalur rencana  $q = 9,3 \text{ kN/m}^1$  pada garis pengaruh dilokasi 2**

Interval	Lebar luasan ( m )	Nilai		Luasan grafik ( m <sup>2</sup> )	Momen ( kN/m )
		Batas atas	Batas bawah		
1-2	5	4.580	0.000	11.450	106.485
2-3	5	4.576	4.155	21.828	202.996
3-4	5	4.155	3.737	19.730	183.489
4-5	5	3.737	3.326	17.658	164.215
5-6	5	3.326	2.922	15.620	145.266

6-7	5	2.922	2.529	13.628	126.736
7-8	5	2.529	2.149	11.695	108.764
8-9	5	2.149	1.782	9.828	91.396
9-10	5	1.782	1.432	8.035	74.726
10-11	5	1.432	1.101	6.333	58.892
11-12	5	1.101	0.790	4.728	43.966
12-13	5	0.790	0.501	3.228	30.016
13-14	5	0.501	0.237	1.845	17.159
14-15	5	0.237	0.000	0.593	5.510
<b>Momen positif dilokasi 2 pada saat q terletak dibentang 1</b>				<b>146.195</b>	<b>1359.614</b>
15-16	5	-0.209	0.000	-0.523	-4.859
16-17	5	-0.391	-0.209	-1.500	-13.950
17-18	5	-0.546	-0.391	-2.343	-21.785
18-19	5	-0.677	-0.546	-3.058	-28.435
19-20	5	-0.785	-0.677	-3.655	-33.992
20-21	5	-0.871	-0.785	-4.140	-38.502
21-22	5	-0.937	-0.871	-4.520	-42.036
22-23	5	-0.984	-0.937	-4.803	-44.663
23-24	5	-1.012	-0.984	-4.990	-46.407
24-25	5	-1.025	-1.012	-5.093	-47.360
25-26	5	-1.030	-1.022	-5.130	-47.709
26-27	5	-1.022	-1.005	-5.068	-47.128
27-28	5	-1.005	-0.977	-4.955	-46.082
28-29	5	-0.977	-0.937	-4.785	-44.501
29-30	5	-0.937	-0.888	-4.563	-42.431
30-31	5	-0.888	-0.831	-4.298	-39.967
31-32	5	-0.831	-0.767	-3.995	-37.154
32-33	5	-0.767	-0.697	-3.660	-34.038
33-34	5	-0.697	-0.623	-3.300	-30.690
34-35	5	-0.623	-0.547	-2.925	-27.203
35-36	5	-0.547	-0.469	-2.540	-23.622
36-37	5	-0.469	-0.391	-2.150	-19.995
37-38	5	-0.391	-0.314	-1.763	-16.391
38-39	5	-0.314	-0.241	-1.388	-12.904
39-40	5	-0.241	-0.171	-1.030	-9.579
40-41	5	-0.171	-0.107	-0.695	-6.464
41-42	5	-0.107	-0.049	-0.391	-3.633
42-43	5	-0.049	0.000	-0.123	-1.145
<b>Momen negatif dilokasi 2 pada saat q terletak dibentang 2</b>				<b>-87.379</b>	<b>-812.622</b>

Untuk perhitungan lokasi selanjutnya dapat dilihat pada Tabel 5.1

**Gaya geser gelagar jembatan akibat beban jalur rencana  $q = 9,3 \text{ kN/m}^1$   
pada garis pengaruh dilokasi 2**

Interval	Lebar luasan ( m )	Nilai		Luasan grafik ( m <sup>2</sup> )	Gaya geser ( kN )
		Batas atas	Batas bawah		
2-3	5	-0.915	-0.831	-4.365	-40.595
3-4	5	-0.831	-0.747	-3.945	-36.689
4-5	5	-0.747	-0.665	-3.530	-32.829
5-6	5	-0.665	-0.584	-3.123	-29.039
6-7	5	-0.584	-0.506	-2.725	-25.343
7-8	5	-0.506	-0.430	-2.340	-21.762
8-9	5	-0.430	-0.356	-1.965	-18.275
9-10	5	-0.356	-0.286	-1.605	-14.927
10-11	5	-0.286	-0.220	-1.265	-11.765
11-12	5	-0.220	-0.158	-0.945	-8.789
12-13	5	-0.158	-0.100	-0.645	-5.999
13-14	5	-0.100	-0.047	-0.369	-3.428
14-15	5	-0.047	0.000	-0.119	-1.103
Gaya geser negatif dilokasi 2 pada saat q terletak dibentang 1				-26.940	-250.540
15-16	5	0.042	0.000	0.105	0.972
16-17	5	0.078	0.042	0.300	2.788
17-18	5	0.109	0.078	0.468	4.351
18-19	5	0.135	0.109	0.610	5.673
19-20	5	0.157	0.135	0.730	6.789
20-21	5	0.174	0.157	0.828	7.696
21-22	5	0.187	0.174	0.903	8.393
22-23	5	0.197	0.187	0.960	8.928
23-24	5	0.202	0.197	0.998	9.277
24-25	5	0.205	0.202	1.018	9.463
25-26	5	0.205	0.204	1.023	9.509
26-27	5	0.204	0.201	1.013	9.416
27-28	5	0.201	0.195	0.990	9.207
28-29	5	0.195	0.187	0.955	8.882
29-30	5	0.187	0.178	0.913	8.486
30-31	5	0.178	0.166	0.860	7.998
31-32	5	0.166	0.153	0.798	7.417
32-33	5	0.153	0.139	0.730	6.789
33-34	5	0.139	0.125	0.660	6.138
34-35	5	0.125	0.109	0.585	5.441
35-36	5	0.109	0.094	0.507	4.714
36-37	5	0.094	0.078	0.430	3.998
37-38	5	0.078	0.063	0.353	3.280
38-39	5	0.063	0.048	0.278	2.581
39-40	5	0.048	0.034	0.206	1.914
40-41	5	0.034	0.021	0.139	1.291
41-42	5	0.021	0.010	0.078	0.725



42-43	5	0.010	0.000	0.025	0.229
Gaya geser positif dilokasi 2 pada saat q terletak dibentang 2				17.456	162.344

Untuk perhitungan lokasi selanjutnya dapat dilihat pada Tabel 5.2

## 5.4 Perhitungan momen dan geser terfaktor

### 5.4.1 Momen terfaktor

distribusi momen akibat beban hidup :

$$M_{LL+IM} = mg \left[ (M_{lr} \text{ or } M_{lu}) \left( 1 + \frac{IM}{100} \right) + M_{ln} \right]$$

dengan  $IM = 33$  ( all other ) ,  $IM = 15$  ( fatigue )

$$M_{LL+IM}^{lokasi2} = 0,436 \left[ 2196,519 \left( 1 + \frac{33}{100} \right) + 846,045 \right] = 1643,347 kNm$$

$$M_{LL+IM}^{lokasi2} = 0,436 \left[ 2196,519 \left( 1 + \frac{15}{100} \right) + 846,045 \right] = 1470,885 kNm$$

- Strength 1:  $\eta = 0,95$

$$Mu = \eta(1,25DC + 1,50DW + 1,75(LL + IM))$$

$$Mu^{lokasi2} = 0,95(1,25 \times 1189,577 + 1,50 \times 229,142 + 1,75 \times 1643,347) = 4471,214 kNm$$

- Service 1:  $\eta = 1,0$

$$Mu = \eta(DC + DW + (LL + IM))$$

$$Mu^{lokasi2} = 1,0(1189,577 + 229,142 + 1643,347) = 3062,066 kNm$$

- Service 2:  $\eta = 1,0$

$$Mu = \eta(DC + DW + 1,3(LL + IM))$$

$$Mu^{lokasi2} = 1,0(1189,577 + 229,142 + 1,3 \times (1643,347)) = 3555,070 kNm$$

- Fatigue:  $\eta = 1,0$

$$Mu = \eta(0,75x(LL + IM))$$

$$Mu^{lokasi2} = 1,0(0,75x1470,885) = 1103,163kNm$$

$$Mu_{(pakai)} = 4471,214 \text{ kNm}$$

untuk perhitungan lokasi selanjutnya dapat dilihat pada Tabel 5.3 dan Tabel 5.4

#### 5.4.2 Geser terfaktor

distribusi geser akibat beban hidup :

$$V_{LL+IM} = mg \left[ (V_w \text{ or } V_{ta}) \left( 1 + \frac{IM}{100} \right) + V_{ln} \right]$$

dengan IM = 33 ( all other ) , IM = 15 ( fatigue )

$$V_{LL+IM}^{lokasi2} = 0,671 \left[ 127,62 \left( 1 + \frac{33}{100} \right) + 98,669 \right] = 180,099kN$$

$$V_{LL+IM}^{lokasi2} = 0,671 \left[ 127,62 \left( 1 + \frac{55}{100} \right) + 98,669 \right] = 164,685kN$$

- Strength 1:  $\eta = 0,95$

$$Vu = \eta(1,25DC + 1,50DW + 1,75(LL + IM))$$

$$Vu^{lokasi2} = 0,95(1,25x - 191,508 + 1,50x - 36,889 + 1,75x180,099) = 19,431kN$$

- Service 1:  $\eta = 1,0$

$$Vu = \eta(DC + DW + (LL + IM))$$

$$Vu^{lokasi2} = 1,0(-191,508 + -36,889 + 180,099) = -48,298kN$$

- Service 2:  $\eta = 1,0$

$$Vu = \eta(DC + DW + 1,3(LL + IM))$$

$$Vu^{lokasi2} = 1,0(-191,508 + -36,889 + 1,3x(180,099)) = 5,731kN$$

- Fatigue:  $\eta = 1,0$

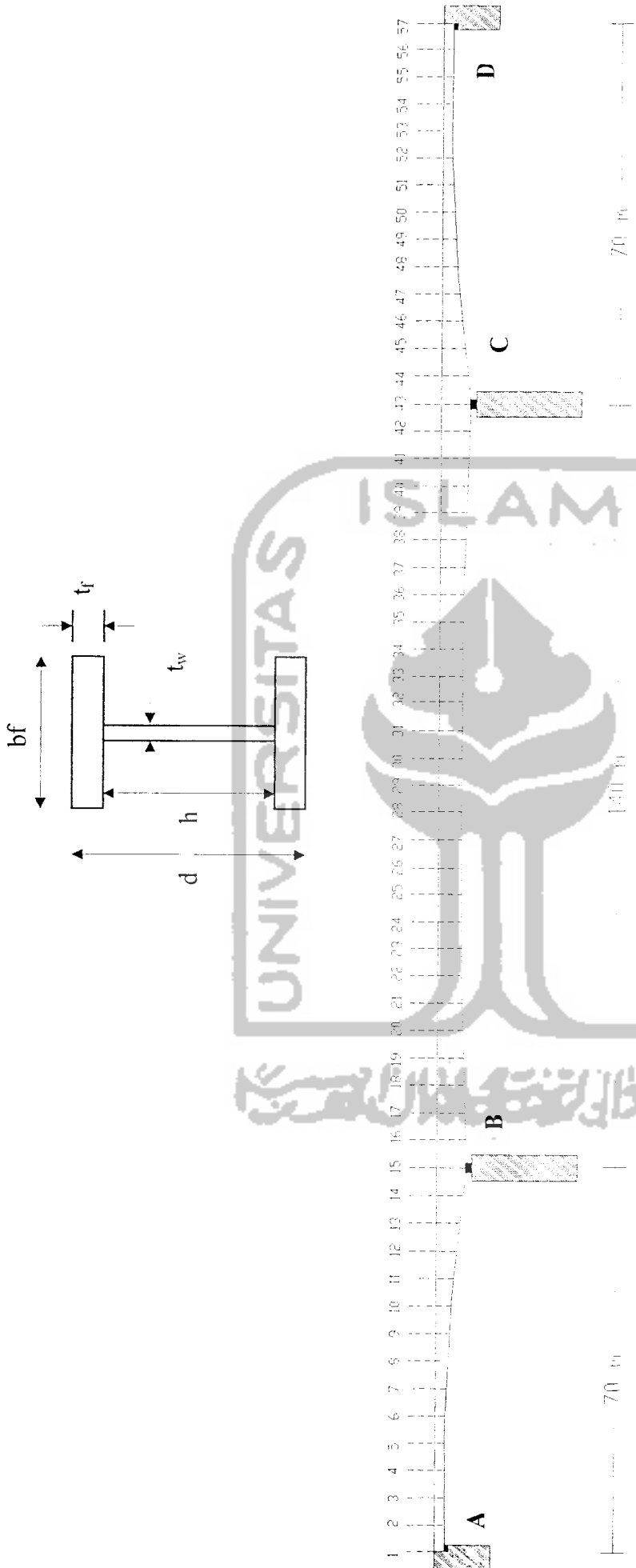
$$Vu = \eta(0,75x(LL + IM))$$

$$V_u^{lokasi2} = 1,0(0,75 \times 164,685) = 123,514 \text{ kN}$$

$$V_u_{(pakai)} = 123,514 \text{ kN}$$

untuk perhitungan lokasi selanjutnya dapat dilihat pada Tabel 5.5 dan Tabel 5.6





Gambar 5.2 Gambar memanjang Gelagar Jembatan

**TABEL 5.1 MOMEN GELAGAR JEMBATAN HASIL PERHITUNGAN SAP 2000  
BERDASARKAN PEMBEBANAN AASTHO 1994  
(BERAT SENDIRI GELAGAR  $W_{gelagar} = 9,876 \text{ kN/m}$ )**

Bentang	Lokasi	Momen (kN m)										
		DC	DW	Tandem		Truck		lane				
				max positif	max negatif	max positif	max negatif	max positif	max negatif			
1	1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
	2	1189.577	229.142	995.658	-225.288	2196.519	-638.101	846.045	-487.433			
	3	1915.079	368.892	1806.011	-450.577	3876.064	-1276.202	1552.589	-974.866			
	4	2176.506	419.250	2433.924	-675.865	5115.327	-1914.303	2119.634	-1462.300			
	5	1973.857	380.215	2884.064	-901.153	5981.540	-2552.404	2547.217	-1949.732			
	6	1307.134	251.787	3162.899	-1126.442	6449.945	-3190.506	2835.272	-2437.165			
	7	176.336	33.967	3278.699	-1351.730	6507.677	-3828.607	2983.826	-2924.599			
	8	-1418.537	-273.246	3247.591	-1577.018	6319.725	-4466.708	2992.880	-3412.031			
	9	-3477.485	-669.851	3082.575	-1802.306	6187.151	-5104.809	2862.434	-3899.465			
	10	-6000.508	-1155.849	2787.551	-2027.595	5629.187	-5742.910	2592.488	-4386.898			
	11	-8987.606	-1731.239	2377.672	-2252.883	4715.953	-6381.011	2183.043	-4874.331			
	12	-12438.780	-2396.021	1869.893	-2478.171	3458.890	-7019.112	1634.097	-5361.764			
	13	-16354.030	-3150.197	1282.971	-2703.460	1936.989	-7657.213	958.316	-5861.863			
	14	-20733.350	-3993.764	637.463	-2928.748	876.801	-8295.314	526.814	-6745.740			
	15	-25576.750	-4926.724	368.497	-3154.036	944.247	-8933.415	423.857	-8097.660			
	2	15	-25576.750	-4926.724	368.497	-3154.036	944.247	-8933.415	423.857	-8097.660		
		16	-19311.740	-3719.926	382.641	-2450.560	809.193	-6907.961	411.299	-6201.852		
		17	-13510.800	-2602.519	843.743	-1809.009	982.204	-5055.651	510.531	-4557.337		
		18	-8173.937	-1574.505	1327.770	-1235.849	1693.259	-3411.930	750.476	-3193.048		
		19	-3301.149	-635.884	1820.485	-896.430	2709.884	-2297.039	1158.414	-2136.219		
20		1107.563	213.345	2303.560	-843.725	4170.023	-2161.985	1752.637	-1405.208			

21	5052.201	973.181	2765.698	-791.020	5536.349	-2026.932	2528.518	-995.342
22	8532.764	1643.625	3196.799	-738.314	6783.471	-1891.878	3429.145	-849.457
23	11549.250	2224.676	3587.967	-685.609	7889.548	-1756.824	4335.935	-849.701
24	14101.660	2716.334	3931.505	-632.904	8836.286	-1621.771	5103.185	-849.702
25	16190.000	3118.601	4220.917	-580.198	9608.940	-1486.717	5730.935	-849.740
26	17814.260	3431.475	4450.909	-527.493	10196.310	-1351.664	6219.186	-849.740
27	18974.450	3654.956	4617.385	-474.788	10590.750	-1216.610	6567.936	-849.740
28	19670.560	3789.044	4717.451	-422.083	10788.150	-1081.557	6777.186	-849.740
29	19902.600	3833.741	4749.416	-369.377	10787.950	-946.503	6846.936	-849.740
30	19670.560	3789.044	4717.451	-422.083	10788.150	-1081.557	6777.186	-849.740
31	18974.450	3654.956	4617.385	-474.788	10590.750	-1216.610	6567.936	-849.740
32	17814.260	3431.475	4450.909	-527.493	10196.310	-1351.664	6219.186	-849.740
33	16190.000	3118.601	4220.917	-580.198	9608.940	-1486.717	5730.935	-849.740
34	14101.660	2716.334	3931.505	-632.904	8836.286	-1621.771	5103.185	-849.702
35	11549.250	2224.676	3587.967	-685.609	7889.548	-1756.824	4335.935	-849.721
36	8532.764	1643.625	3196.799	-738.314	6783.471	-1891.878	3429.145	-849.457
37	5052.201	973.181	2765.698	-791.020	5536.349	-2026.932	2528.518	-995.342
38	1107.563	213.345	2303.560	-843.725	4170.023	-2161.985	1752.637	-1405.208
39	-3301.149	-635.884	1820.485	-896.430	2709.884	-2297.039	1158.414	-2136.219
40	-8173.937	-1574.505	1327.770	-1235.849	1693.259	-3411.930	750.476	-3193.048
41	-13510.800	-2602.519	843.743	-1809.009	982.204	-5055.651	510.531	-4557.337
42	-19311.740	-3719.926	382.641	-2450.560	809.193	-6907.961	411.299	-6201.852
43	-25576.750	-4926.724	368.497	-3154.036	944.247	-8933.415	423.857	-8097.660
43	-25576.750	-4926.724	368.497	-3154.036	944.247	-8933.415	423.857	-8097.660
44	-20733.350	-3993.764	637.463	-2928.748	876.801	-8295.314	526.814	-6745.740
45	-16354.030	-3150.197	1282.971	-2703.460	1936.989	-7657.213	958.316	-5861.863
46	-12438.780	-2396.021	1869.893	-2478.171	3458.890	-7019.112	1634.097	-5361.764
47	-8987.606	-1731.239	2377.672	-2252.883	4715.953	-6381.011	2183.043	-4874.331
48	-6000.508	-1155.849	2787.551	-2027.595	5629.187	-5742.910	2592.488	-4386.898
3								

49	-3477.485	-669.851	3082.575	-1802.306	6187.151	-5104.809	2862.434	-3899.465
50	-1418.537	-273.246	3247.591	-1577.018	6319.725	-4466.708	2992.880	-3412.031
51	176.336	33.967	3278.699	-1351.730	6507.677	-3828.607	2983.826	-2924.599
52	1307.134	251.787	3162.899	-1126.442	6449.945	-3190.506	2835.272	-2437.165
53	1973.857	380.215	2884.064	-901.153	5981.540	-2552.404	2547.217	-1949.732
54	2176.506	419.250	2433.924	-675.865	5115.327	-1914.303	2119.634	-1462.300
55	1915.079	368.892	1806.011	-450.577	3876.064	-1276.202	1552.589	-974.866
56	1189.577	229.142	995.658	-225.288	2196.519	-638.101	846.045	-487.433
57	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000



**TABEL 5.2 GAYA GESER GELAGAR JEMBATAN HASIL PERHITUNGAN SAP 2000  
BERDASARKAN PEMBEBANAN AASTHO 1994  
(BERAT SENDIRI GELAGAR  $W_{gelagar} = 9,876 \text{ kN/m}$ )**

Bentang	Lokasi	Gaya geser (kN)									
		DC	DW	Tandem		Truck		lane			
				max positif	max negatif	max positif	max negatif	max positif	max negatif		
1	1	-284.323	-54.768	45.058	-217.763	127.620	-492.047	97.487	-183.159		
	2	-191.508	-36.889	45.058	-199.132	127.620	-439.304	98.669	-156.441		
	3	-98.693	-19.011	45.058	-180.601	127.620	-387.606	102.209	-132.082		
	4	-5.878	-1.132	53.362	-162.262	127.620	-337.221	108.091	-110.063		
	5	86.937	16.746	71.496	-144.203	127.620	-288.414	116.286	-90.360		
	6	179.752	34.625	89.280	-126.516	127.620	-241.451	126.753	-72.928		
	7	272.567	52.503	106.625	-109.290	166.867	-196.598	139.442	-57.716		
	8	365.382	70.382	123.440	-92.615	218.173	-154.122	154.289	-44.663		
	9	458.197	88.260	139.636	-76.582	269.700	-114.932	171.221	-33.695		
	10	551.012	106.139	155.121	-61.280	319.877	-82.884	190.151	-24.723		
	11	643.827	124.017	169.807	-46.800	368.439	-60.173	210.982	-17.654		
	12	736.642	141.896	183.602	-33.232	415.118	-40.797	233.607	-12.379		
	13	829.457	159.774	196.417	-20.665	459.649	-22.960	257.904	-8.776		
	14	922.272	177.653	208.162	-9.191	501.766	-13.489	283.743	-6.715		
	15	1015.087	195.531	218.747	-5.264	541.201	-13.489	310.981	-6.053		
	2	15	-1299.410	-250.299	10.541	-219.479	27.011	-600.125	12.125	-402.725	
		16	-1206.595	-232.421	10.541	-215.040	27.011	-581.570	12.400	-375.100	
		17	-1113.780	-214.542	10.541	-209.828	27.011	-561.230	13.276	-348.076	
		18	-1020.965	-196.664	14.615	-203.903	27.011	-539.280	14.848	-321.748	
		19	-928.150	-178.785	21.042	-197.324	27.011	-515.899	17.203	-296.203	
20		-835.335	-160.907	28.077	-190.153	37.635	-491.263	20.421	-271.521		





49	-458.197	-88.260	76.582	-139.636	114.932	-269.700	33.695	-171.221
50	-365.382	-70.382	92.615	-123.440	154.122	-218.173	44.663	-154.289
51	-272.567	-52.503	109.290	-106.625	196.598	-166.867	57.716	-139.442
52	-179.752	-34.625	126.516	-89.280	241.451	-127.620	72.928	-126.753
53	-86.937	-16.746	144.203	-71.496	288.414	-127.620	90.360	-116.286
54	5.878	1.132	162.262	-53.362	337.221	-127.620	110.063	-108.091
55	98.693	19.011	180.601	-45.058	387.606	-127.620	132.082	-102.209
56	191.508	36.889	199.132	-45.058	439.304	-127.620	156.441	-98.669
57	284.323	54.768	217.763	-45.058	492.047	-127.620	183.159	-97.487



**TABEL 5.3 MOMEN TERFAKTOR AKIBAT BEBAN HIDUP MAX POSITIF  
PADA GELAGAR INTERIOR**  
(BERAT SENDIRI GELAGAR  $w_{\text{gelagar}} = 9,876 \text{ kN/m}$ )

Bentang	Lokasi	Momen (kN m)				Mgm	$M_{LL+M}$ (all other)	$M_{LL+M}$ (fatigue)	Kombinasi Mu				Mu (kN m)	
		DC	DW	Truck/tandem max positif	lane max positif				I Strength	II Service 1	III Service 2	IV Fatigue		
1	1	0.000	0.000	0.000	0.000	0.436	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	2	1189.577	229.142	2196.519	846.045	0.436	1643.347	1470.885	4471.214	3062.066	3555.070	1103.163	4471.214	
	3	1915.079	368.892	3876.064	1552.589	0.436	2925.922	2621.589	7664.174	5209.894	6087.670	1966.192	7664.174	
	4	2176.506	419.250	5115.327	2119.634	0.436	3892.221	3490.586	9652.849	6487.976	7655.643	2617.939	9652.849	
	5	1973.857	380.215	5981.540	2547.217	0.436	4581.263	4111.616	10502.110	6935.334	8309.713	3083.712	10502.110	
	6	1307.134	251.787	6449.945	2835.272	0.436	4978.655	4472.232	10188.033	6537.576	8031.173	3354.174	10188.033	
	7	176.336	33.967	6507.677	2983.826	0.436	5076.948	4565.991	8698.227	5287.251	6810.335	3424.493	8698.227	
	8	-1418.537	-273.246	6319.725	2992.880	0.436	4971.857	4475.658	6191.825	3280.075	4771.632	3356.743	6191.825	
	9	-3477.485	-669.851	6187.151	2862.434	0.436	4838.045	4352.254	2959.198	690.709	2142.122	3264.191	3264.191	
	10	-6000.508	-1155.849	5629.187	2592.488	0.436	4396.594	3954.612	-1463.351	-2759.763	-1440.785	2965.959	2965.959	
	11	-8987.606	-1731.239	4715.953	2183.043	0.436	3688.185	3317.907	-7008.191	-7030.660	-5924.205	2488.430	-7030.660	
	12	-12438.780	-2396.021	3458.890	1634.097	0.436	2719.454	2447.876	-13664.288	-12115.347	-11299.510	1835.907	-13664.288	
	13	-16354.030	-3150.197	1936.989	958.316	0.436	1541.754	1389.669	-21346.276	-17902.473	-17499.947	1042.252	-21346.276	
	14	-20733.350	-3993.764	876.801	526.814	0.436	738.469	669.626	-29084.262	-23988.645	-23767.104	502.219	-29084.262	
	15	-25576.750	-4926.724	944.247	423.857	0.436	732.688	658.549	-36174.879	-29770.786	-29550.980	493.912	-36174.879	
	15	-25576.750	-4926.724	944.247	423.857	0.433	727.312	653.718	-36183.815	-29776.162	-29557.968	490.288	-36183.815	
	16	-19311.740	-3719.926	809.193	411.299	0.433	644.099	581.030	-27162.772	-22387.567	-22194.338	435.773	-27162.772	
	17	-13510.800	-2602.519	982.204	510.531	0.433	786.701	710.148	-18444.774	-15326.618	-15090.607	532.611	-18444.774	
	18	-8173.937	-1574.505	1693.259	750.476	0.433	1300.087	1168.114	-9788.825	-8448.355	-8058.329	876.086	-9788.825	
19	-3301.149	-635.884	2709.884	1158.414	0.433	2062.188	1850.980	-1397.861	-1874.845	-1256.188	1388.235	-1874.845		



48	-6000.508	-1155.849	5629.187	2592.488	0.436	4396.594	3954.612	-1463.351	-2759.763	-1440.785	2965.959	2965.959
49	-3477.485	-669.851	6187.151	2862.434	0.436	4838.045	4352.254	2959.198	690.709	2142.122	3264.191	3264.191
50	-1418.537	-273.246	6319.725	2992.880	0.436	4971.857	4475.658	6191.825	3280.075	4771.632	3356.743	6191.825
51	176.336	33.967	6507.677	2983.826	0.436	5076.948	4565.991	8698.227	5287.251	6810.335	3424.493	8698.227
52	1307.134	251.787	6449.945	2835.272	0.436	4978.655	4472.232	10188.033	6537.576	8031.173	3354.174	10188.033
53	1973.857	380.215	5981.540	2547.217	0.436	4581.263	4111.616	10502.110	6935.334	8309.713	3083.712	10502.110
54	2176.506	419.250	5115.327	2119.634	0.436	3892.221	3490.586	9652.849	6487.976	7655.643	2617.939	9652.849
55	1915.079	368.892	3876.064	1552.589	0.436	2925.922	2621.589	7664.174	5209.894	6087.670	1966.192	7664.174
56	1189.577	229.142	2196.519	846.045	0.436	1643.347	1470.885	4471.214	3062.066	3555.070	1103.163	4471.214
57	0.000	0.000	0.000	0.000	0.436	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Catatan :

Kombinasi I :  $\mu = \eta (1,25 DC + 1,5 DW + 1,75 (LL+IM))$

Kombinasi II :  $\mu = \eta (DC + DW + (LL+IM))$

Kombinasi III :  $\mu = \eta (DC + DW + 1,3 (LL+IM))$

Kombinasi IV :  $\mu = \eta (0,75 (LL+IM))$

**TABEL 5.4 MOMEN TERFAKTOR AKIBAT BEBAN HIDUP MAX NEGATIF  
PADA GELAGAR INTERIOR  
(BERAT SENDIRI GELAGAR  $w_{gelagar} = 9,876 \text{ kN/m}$ )**

Bentang	Lokasi	Momen (kN m)				Mgm	$M_{LL+IM}$		Kombinasi Mu				Mu (kN m)	
		DC	DW	Truck/tande m	lane max negatif		(all other)	fatigue)	I Strength	II Service 1	III Service 2	IV Fatigue		
														max negatif
1	1	0.000	0.000	0.000	0.000	0.436	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	2	1189.577	229.142	-638.101	-487.433	0.436	-582.810	-532.709	770.229	835.909	661.066	-399.532	835.909	
	3	1915.079	368.892	-1276.202	-974.866	0.436	-1165.620	-1065.418	861.984	1118.351	768.665	-799.063	1118.351	
	4	2176.506	419.250	-1914.303	-1462.300	0.436	-1748.430	-1598.127	275.266	847.325	322.796	-1198.595	-1198.595	
	5	1973.857	380.215	-2552.404	-1949.732	0.436	-2331.240	-2130.836	-989.926	22.831	-676.541	-1598.127	-1598.127	
	6	1307.134	251.787	-3190.506	-2437.165	0.436	-2914.051	-2663.545	-2933.591	-1355.130	-2229.345	-1997.659	-2933.591	
	7	176.336	33.967	-3828.607	-2924.599	0.436	-3496.861	-3196.254	-5555.730	-3286.558	-4335.617	-2397.191	-5555.730	
	8	-1418.537	-273.246	-4466.708	-3412.031	0.436	-4079.671	-3728.963	-8856.340	-5771.454	-6995.355	-2796.722	-8856.340	
	9	-3477.485	-669.851	-5104.809	-3899.465	0.436	-4662.481	-4261.672	-12835.426	-8809.817	-10208.562	-3196.254	-12835.426	
	10	-6000.508	-1155.849	-5742.910	-4386.898	0.436	-5245.291	-4794.381	-17492.985	-12401.648	-13975.236	-3595.786	-17492.985	
	11	-8987.606	-1731.239	-6381.011	-4874.331	0.436	-5828.101	-5327.090	-22829.016	-16546.946	-18295.377	-3995.317	-22829.016	
	12	-12438.780	-2396.021	-7019.112	-5361.764	0.436	-6410.911	-5859.799	-28843.521	-21245.712	-23168.986	-4394.849	-28843.521	
	13	-16354.030	-3150.197	-7657.213	-5861.863	0.436	-6999.246	-6398.032	-35545.688	-26503.473	-28603.247	-4798.524	-35545.688	
	14	-20733.350	-3993.764	-8295.314	-6745.740	0.436	-7754.985	-7103.670	-43204.629	-32482.099	-34808.595	-5327.753	-43204.629	
	15	-25576.750	-4926.724	-8933.415	-8097.660	0.436	-8714.884	-8013.468	-51881.467	-39218.358	-41832.824	-6010.101	-51881.467	
	16	-25576.750	-4926.724	-8933.415	-8097.660	0.433	-8650.951	-7954.681	-51775.179	-39154.425	-41749.710	-5966.011	-51775.179	
	17	-19311.740	-3719.926	-6907.961	-6201.852	0.433	-6663.628	-6125.221	-39311.867	-29695.294	-31694.382	-4593.916	-39311.867	
	18	-13510.800	-2602.519	-5055.651	-4557.337	0.433	-4884.826	-4490.788	-27873.687	-20998.145	-22463.593	-3368.091	-27873.687	
	19	-8173.937	-1574.505	-3411.930	-3193.048	0.433	-3347.486	-3081.560	-17515.416	-13095.928	-14100.174	-2311.170	-17515.416	
		-3301.149	-635.884	-2297.039	-2136.219	0.433	-2247.825	-2068.793	-8563.258	-6184.858	-6859.205	-1551.595	-8563.258	



48	-6000.508	-1155.849	-5742.910	-4386.898	0.436	-5245.291	-4794.381	-17492.985	-12401.648	-13975.236	-3595.786	-17492.985
49	-3477.485	-669.851	-5104.809	-3899.465	0.436	-4662.481	-4261.672	-12835.426	-8809.817	-10208.562	-3196.254	-12835.426
50	-1418.537	-273.246	-4466.708	-3412.031	0.436	-4079.671	-3728.963	-8856.340	-5771.454	-6995.355	-2796.722	-8856.340
51	176.336	33.967	-3828.607	-2924.599	0.436	-3496.861	-3196.254	-5555.730	-3286.558	-4335.617	-2397.191	-5555.730
52	1307.134	251.787	-3190.506	-2437.165	0.436	-2914.051	-2663.545	-2933.591	-1355.130	-2229.345	-1997.659	-2933.591
53	1973.857	380.215	-2552.404	-1949.732	0.436	-2331.240	-2130.836	-989.926	22.831	-676.541	-1598.127	-1598.127
54	2176.506	419.250	-1914.303	-1462.300	0.436	-1748.430	-1598.127	275.266	847.325	322.796	-1198.595	-1198.595
55	1915.079	368.892	-1276.202	-974.866	0.436	-1165.620	-1065.418	861.984	1118.351	768.665	-799.063	1118.351
56	1189.577	229.142	-638.101	-487.433	0.436	-582.810	-532.709	770.229	835.909	661.066	-399.532	835.909
57	0.000	0.000	0.000	0.000	0.436	0.000	0.000	-0.000	0.000	0.000	0.000	0.000

Catatan :

Kombinasi I :  $\mu = \eta (1,25 DC + 1,5 DW + 1,75 (LL+IM))$

Kombinasi II :  $\mu = \eta (DC + DW + (LL+IM))$

Kombinasi III :  $\mu = \eta (DC + DW + 1,3 (LL+IM))$

Kombinasi IV :  $\mu = \eta (0,75 (LL+IM))$





**TABEL 5.5 GAYA GESER TERFAKTOR AKIBAT BEBAN HIDUP MAX POSITIF  
PADA GELAGAR INTERIOR  
(BERAT SENDIRI GELAGAR  $W_{gelagar} = 9,876 \text{ kN/m}$ )**

Bentang	Lokasi	Gaya geser (kN)				Mgy	$V_{LL+IM}$ (all other)	$V_{LL+IM}$ (fatigue)	Kombinasi Vu				Vu (kN)	
		DC	DW	Truck/tandem					I Strength	II Service 1	III Service 2	IV Fatigue		
				max positif	lane max positif									
1	1	-284.323	-54.768	127.620	97.487	0.671	179.306	163.892	-117.582	-159.785	-105.993	122.919	-159.785	
	2	-191.508	-36.889	127.620	98.669	0.671	180.099	164.685	19.431	-48.298	5.731	123.514	123.514	
	3	-98.693	-19.011	127.620	102.209	0.671	182.474	167.060	159.075	64.771	119.513	125.295	159.075	
	4	-5.878	-1.132	127.620	108.091	0.671	186.421	171.007	301.331	179.411	235.337	128.255	301.331	
	5	86.937	16.746	127.620	116.286	0.671	191.920	176.506	446.168	295.603	353.179	132.379	446.168	
	6	179.752	34.625	127.620	126.753	0.671	198.943	183.529	593.539	413.320	473.003	137.647	593.539	
	7	272.567	52.503	166.867	139.442	0.671	242.483	222.329	801.618	567.553	640.298	166.746	801.618	
	8	365.382	70.382	218.173	154.289	0.671	298.232	271.881	1029.996	733.996	823.466	203.911	1029.996	
	9	458.197	88.260	269.700	171.221	0.671	355.578	323.003	1261.028	902.035	1008.708	242.252	1261.028	
	10	551.012	106.139	319.877	190.151	0.671	413.059	374.424	1492.285	1070.210	1194.128	280.818	1492.285	
	11	643.827	124.017	368.439	210.982	0.671	470.375	425.875	1723.268	1238.219	1379.332	319.406	1723.268	
	12	736.642	141.896	415.118	233.607	0.671	527.214	477.076	1953.457	1405.752	1563.916	357.807	1953.457	
	13	829.457	159.774	459.649	257.904	0.671	583.258	527.742	2182.325	1572.490	1747.467	395.806	2182.325	
	14	922.272	177.653	501.766	283.743	0.671	638.183	577.579	2409.332	1738.108	1929.562	433.184	2409.332	
	15	1015.087	195.531	541.201	310.981	0.671	691.652	626.286	2633.920	1902.271	2109.766	469.715	2633.920	
	2	15	-1299.410	-250.299	27.011	12.125	0.671	32.241	28.979	-1846.124	-1517.468	-1507.795	21.734	-1846.124
	16	-1206.595	-232.421	27.011	12.400	0.671	32.426	29.163	-1710.123	-1406.590	-1396.862	21.873	-1710.123	
	17	-1113.780	-214.542	27.011	13.276	0.671	33.014	29.751	-1573.451	-1295.308	-1285.404	22.313	-1573.451	
	18	-1020.965	-196.664	27.011	14.848	0.671	34.068	30.806	-1436.003	-1183.560	-1173.340	23.105	-1436.003	
19	-928.150	-178.785	27.011	17.203	0.671	35.649	32.386	-1297.681	-1071.286	-1060.592	24.290	-1297.681		



48	-551.012	-106.139	82.884	24.723	0.671	90.557	80.547	-655.023	-539.426	60.410	-655.023
49	-458.197	-88.260	114.932	33.695	0.671	125.178	111.297	-461.771	-383.726	83.472	-461.771
50	-365.382	-70.382	154.122	44.663	0.671	167.512	148.897	-255.697	-217.998	111.673	-268.252
51	-272.567	-52.503	196.598	57.716	0.671	214.177	190.432	-42.421	-46.640	142.824	142.824
52	-179.752	-34.625	241.451	72.928	0.671	264.413	235.250	176.790	129.360	176.438	176.790
53	-86.937	-16.746	288.414	90.360	0.671	318.021	283.186	401.608	309.744	212.390	401.608
54	5.878	1.132	337.221	110.063	0.671	374.798	334.069	631.696	494.248	250.552	631.696
55	98.693	19.011	387.606	132.082	0.671	434.538	387.723	866.708	682.603	290.792	866.708
56	191.508	36.889	439.304	156.441	0.671	497.020	443.961	1106.279	874.523	332.971	1106.279
57	284.323	54.768	492.047	183.159	0.671	562.017	502.588	1350.031	1069.713	376.941	1350.031

Catatan :

Kombinasi I :  $V_u = \eta (1,25 DC + 1,5 DW + 1,75 (LL+IM))$

Kombinasi II :  $V_u = \eta (DC + DW + (LL+IM))$

Kombinasi III :  $V_u = \eta (DC + DW + 1,3 (LL+IM))$

Kombinasi IV :  $V_u = \eta (0,75 (LL+IM))$



**TABEL 5.6 GAYA GESER TERFAKTOR AKIBAT BEBAN HIDUP MAX NEGATIF  
PADA GELAGAR INTERIOR  
(BERAT SENDIRI GELAGAR  $W_{gelagar} = 9,876 \text{ kN/m}$ )**

Bentang	Lokasi	Gaya geser (kN)			Mgv	$V_{LL+M}$ (all other)	$V_{LL+M}$ (fatigue)	Kombinasi $V_u$				$V_u$ (kN)	
		DC	DW	Truck/tandem max negatif				lane Max negatif	I Strength	II Service 1	III Service 2		IV Fatigue
1	1	-284.323	-54.768	-492.047	-183.159	0.671	-562.017	-502.588	-1350.031	-901.108	-1069.713	-376.941	-1350.031
	2	-191.508	-36.889	-439.304	-156.441	0.671	-497.020	-443.961	-1106.279	-725.417	-874.523	-332.971	-1106.279
	3	-98.693	-19.011	-387.606	-132.082	0.671	-434.538	-387.723	-866.708	-552.242	-682.603	-290.792	-866.708
	4	-5.878	-1.132	-337.221	-110.063	0.671	-374.798	-334.069	-631.696	-381.809	-494.248	-250.552	-631.696
	5	86.937	16.746	-288.414	-90.360	0.671	-318.021	-283.186	-401.608	-214.337	-309.744	-212.390	-401.608
	6	179.752	34.625	-241.451	-72.928	0.671	-264.413	-235.250	-176.790	-50.036	-129.360	-176.438	-176.790
	7	272.567	52.503	-196.598	-57.716	0.671	-214.177	-190.432	42.421	110.893	46.640	-142.824	-142.824
	8	365.382	70.382	-154.122	-44.663	0.671	-167.512	-148.897	255.697	268.252	217.998	-111.673	268.252
	9	458.197	88.260	-114.932	-33.695	0.671	-125.178	-111.297	461.771	421.279	383.726	-83.472	461.771
	10	551.012	106.139	-82.884	-24.723	0.671	-90.557	-80.547	655.023	566.594	539.426	-60.410	655.023
	11	643.827	124.017	-60.173	-17.654	0.671	-65.546	-58.278	832.299	702.298	682.635	-43.709	832.299
	12	736.642	141.896	-40.797	-12.379	0.671	-44.715	-39.787	1002.626	833.823	820.409	-29.840	1002.626
	13	829.457	159.774	-22.960	-8.776	0.671	-26.379	-23.606	1168.804	962.853	954.939	-17.704	1168.804
	14	922.272	177.653	-13.489	-6.715	0.671	-16.544	-14.915	1320.849	1083.381	1078.418	-11.186	1320.849
	15	1015.087	195.531	-13.489	-6.053	0.671	-16.100	-14.470	1457.282	1194.519	1189.689	-10.853	1457.282
	16	-1299.410	-250.299	-600.125	-402.725	0.671	-805.798	-733.315	-3239.365	-2355.507	-2597.246	-549.986	-3239.365
	17	-1206.595	-232.421	-581.570	-375.100	0.671	-770.703	-700.461	-3045.324	-2209.718	-2440.929	-525.345	-3045.324
	18	-1113.780	-214.542	-561.230	-348.076	0.671	-734.417	-666.632	-2849.305	-2062.739	-2283.065	-499.974	-2849.305
	19	-1020.965	-196.664	-539.280	-321.748	0.671	-697.163	-632.028	-2651.674	-1914.791	-2123.940	-474.021	-2651.674
		-928.150	-178.785	-515.899	-296.203	0.671	-659.156	-596.846	-2452.794	-1766.091	-1963.838	-447.634	-2452.794

20	-835.335	-160.907	-491.263	-271.521	0.671	-620.608	-561.274	-2253.014	-1616.850	-1803.032	-420.955	-2253.014
21	-742.520	-143.028	-465.550	-247.775	0.671	-581.728	-525.499	-2052.680	-1467.276	-1641.794	-394.124	-2052.680
22	-649.705	-125.150	-438.938	-225.029	0.671	-542.716	-489.701	-1852.128	-1317.570	-1480.385	-367.276	-1852.128
23	-556.890	-107.271	-411.604	-203.340	0.671	-503.769	-454.055	-1651.684	-1167.930	-1319.061	-340.542	-1651.684
24	-464.075	-89.393	-383.725	-182.758	0.671	-465.078	-418.732	-1451.666	-1018.546	-1158.069	-314.049	-1451.666
25	-371.260	-71.514	-355.479	-163.325	0.671	-426.831	-383.896	-1252.386	-869.605	-997.655	-287.922	-1252.386
26	-278.445	-53.636	-327.043	-145.075	0.671	-389.208	-349.708	-1054.143	-721.289	-838.051	-262.281	-1054.143
27	-185.630	-35.757	-298.594	-128.034	0.671	-352.385	-316.321	-857.230	-573.772	-679.488	-237.241	-857.230
28	-92.815	-17.879	-270.310	-112.222	0.671	-316.534	-283.886	-661.932	-427.227	-522.187	-212.914	-661.932
29	0.000	0.000	-242.368	-97.650	0.671	-281.820	-252.546	-468.525	-281.820	-366.366	-189.410	-468.525
30	92.815	17.879	-214.946	-84.322	0.671	-248.404	-222.443	-277.278	-137.711	-212.232	-166.832	-277.278
31	185.630	35.757	-188.220	-72.234	0.671	-216.442	-193.709	-88.446	4.945	-59.988	-145.282	-145.282
32	278.445	53.636	-162.369	-61.375	0.671	-186.086	-166.475	97.717	145.995	90.169	-124.856	145.995
33	371.260	71.514	-137.570	-51.725	0.671	-157.479	-140.863	280.970	285.295	238.051	-105.648	285.295
34	464.075	89.393	-113.999	-43.258	0.671	-130.762	-116.993	461.081	422.705	383.477	-87.745	461.081
35	556.890	107.271	-91.835	-35.940	0.671	-106.072	-94.980	637.823	558.089	526.267	-71.235	637.823
36	649.705	125.150	-71.255	-29.729	0.671	-83.538	-74.932	810.980	691.316	666.255	-56.199	810.980
37	742.520	143.028	-52.681	-24.575	0.671	-63.504	-57.141	979.982	822.044	802.993	-42.856	979.982
38	835.335	160.907	-37.635	-20.421	0.671	-47.289	-42.744	1142.634	948.952	934.766	-32.058	1142.634
39	928.150	178.785	-27.011	-17.203	0.671	-35.649	-32.386	1297.681	1071.286	1060.592	-24.290	1297.681
40	1020.965	196.664	-27.011	-14.848	0.671	-34.068	-30.806	1436.003	1183.560	1173.340	-23.105	1436.003
41	1113.780	214.542	-27.011	-13.276	0.671	-33.014	-29.751	1573.451	1295.308	1285.404	-22.313	1573.451
42	1206.595	232.421	-27.011	-12.400	0.671	-32.426	-29.163	1710.123	1406.590	1396.862	-21.873	1710.123
43	1299.410	250.299	-27.011	-12.125	0.671	-32.241	-28.979	1846.124	1517.468	1507.795	-21.734	1846.124
43	-1015.087	-195.531	-541.201	-310.981	0.671	-691.652	-626.286	-2633.920	-1902.271	-2109.766	-469.715	-2633.920
44	-922.272	-177.653	-501.766	-283.743	0.671	-638.183	-577.579	-2409.332	-1738.108	-1929.562	-433.184	-2409.332
45	-829.457	-159.774	-459.649	-257.904	0.671	-583.258	-527.742	-2182.325	-1572.490	-1747.467	-395.806	-2182.325
46	-736.642	-141.896	-415.118	-233.607	0.671	-527.214	-477.076	-1953.457	-1405.752	-1563.916	-357.807	-1953.457
47	-643.827	-124.017	-368.439	-210.982	0.671	-470.375	-425.875	-1723.268	-1238.219	-1379.332	-319.406	-1723.268
3												

48	-551.012	-106.139	-319.877	-190.151	0.671	-413.059	-374.424	-1492.285	-1070.210	-1194.128	-280.818	-1492.285
49	-458.197	-88.260	-269.700	-171.221	0.671	-355.578	-323.003	-1261.028	-902.035	-1008.708	-242.252	-1261.028
50	-365.382	-70.382	-218.173	-154.289	0.671	-298.232	-271.881	-1029.996	-733.996	-823.466	-203.911	-1029.996
51	-272.567	-52.503	-166.867	-139.442	0.671	-242.483	-222.329	-801.618	-567.553	-640.298	-166.746	-801.618
52	-179.752	-34.625	-127.620	-126.753	0.671	-198.943	-183.529	-593.539	-413.320	-473.003	-137.647	-593.539
53	-86.937	-16.746	-127.620	-116.286	0.671	-191.920	-176.506	-446.168	-295.603	-353.179	-132.379	-446.168
54	5.878	1.132	-127.620	-108.091	0.671	-186.421	-171.007	-301.331	-179.411	-235.337	-128.255	-301.331
55	98.693	19.011	-127.620	-102.209	0.671	-182.474	-167.060	-159.075	-64.771	-119.513	-125.295	-159.075
56	191.508	36.889	-127.620	-98.669	0.671	-180.099	-164.685	-19.431	48.298	-5.731	-123.514	-123.514
57	284.323	54.768	-127.620	-97.487	0.671	-179.306	-163.892	117.582	159.785	105.993	-122.919	159.785

Catatan :

Kombinasi I :  $V_u = \eta (1,25 DC + 1,5 DW + 1,75 (LL+IM))$

Kombinasi II :  $V_u = \eta (DC + DW + (LL+IM))$

Kombinasi III :  $V_u = \eta (DC + DW + 1,3 (LL+IM))$

Kombinasi IV :  $V_u = \eta (0,75 (LL+IM))$



## 5.5 Perhitungan Momen dan Gaya Geser Saat Pelaksanaan Tiap Segmen Tumpuan A - D

Pada saat pelaksanaan momen dan gaya geser yang bekerja diakibatkan oleh beban berat sendiri dari gelagar dan *voorhouw wagen* yaitu alat yang digunakan sebagai tempat penyetelan gelagar pelat dari tiap-tiap segmen dari jembatan tanpa menggunakan perancah. Alat ini dibuat dari rangka baja yang dilengkapi dengan roda-roda dan ditaksir mempunyai berat sebesar 40 ton.

Pada perencanaan gelagar jembatan dalam tugas akhir ini, pelaksanaan pembuatan gelagar bentang B – C digunakan alat *voorhouw wagen*, sedangkan pelaksanaan pembuatan gelagar untuk bentang A – B dan C – D menggunakan perancah. Pada saat pelaksanaan gelagar bentang B – C dianggap sebagai batang kantilever dengan peninjauan tiap segmen dari tumpuan B atau C. Untuk menghitung momen dan gaya geser yang terjadi pada tiap segmen ( 5 m) menggunakan program SAP 2000. Setelah diperoleh momen dan gaya geser akibat berat sendiri dan beban titik, kemudian dikalikan dengan faktor beban sebesar 1,25. Hasil perhitungan momen dan gaya geser saat pelaksanaan dapat dilihat pada Tabel 5.7 dan 5.8 sebagai berikut :

**TABEL 5.7 MOMEN SAAT PELAKSANAAN TIAP SEGMENT**  
**( $W_{gelagar} = 9,876 \text{ kN/m}$ )**

Bentang	Lokasi	Momen (kN m)		
		Akibat Berat Sendiri	Akibat Berat Alat	Mu
1	1	0.000	0.000	0.000
	2	-123.450	-2000.000	-2654.313
	3	-493.800	-4000.000	-5617.250
	4	-1111.050	-6000.000	-8888.813
	5	-1975.200	-8000.000	-12469.000
	6	-3086.250	-10000.000	-16357.813
	7	-4444.200	-12000.000	-20555.250
	8	-6049.050	-14000.000	-25061.313
	9	-7900.800	-16000.000	-29876.000
	10	-9999.450	-18000.000	-34999.313
	11	-12345.000	-20000.000	-40431.250
	12	-14937.450	-22000.000	-46171.813
	13	-17776.800	-24000.000	-52221.000
	14	-20863.050	-26000.000	-58578.813
	15	-24196.200	-28000.000	-65245.250
2	15	-24196.200	-28000.000	-65245.250
	16	-20863.050	-26000.000	-58578.813
	17	-17776.800	-24000.000	-52221.000
	18	-14937.450	-22000.000	-46171.813
	19	-12345.000	-20000.000	-40431.250
	20	-9999.450	-18000.000	-34999.313
	21	-7900.800	-16000.000	-29876.000
	22	-6049.050	-14000.000	-25061.313
	23	-4444.200	-12000.000	-20555.250
	24	-3086.250	-10000.000	-16357.813
	25	-1975.200	-8000.000	-12469.000
	26	-1111.050	-6000.000	-8888.813
	27	-493.800	-4000.000	-5617.250
	28	-123.450	-2000.000	-2654.313
	29	0.000	0.000	0.000

$$M_u = 1,25 (M_{titik} + M_{merata})$$



**TABEL 5.8 GAYA GESER SAAT PELAKSANAAN TIAP SEGMENT**  
 ( $W_{gelagar} = 9,876 \text{ kN/m}$ )

Bentang	Lokasi	Gaya Geser (kN)		
		Akibat Berat Sendiri	Akibat Berat Alat	Vu
1	1	0.000	400.000	500.000
	2	49.380	400.000	561.725
	3	98.760	400.000	623.450
	4	148.140	400.000	685.175
	5	197.520	400.000	746.900
	6	246.900	400.000	808.625
	7	296.280	400.000	870.350
	8	345.660	400.000	932.075
	9	395.040	400.000	993.800
	10	444.420	400.000	1055.525
	11	493.800	400.000	1117.250
	12	543.180	400.000	1178.975
	13	592.560	400.000	1240.700
	14	641.940	400.000	1302.425
	15	691.320	400.000	1364.150
2	15	-691.320	-400.000	-1364.150
	16	-641.940	-400.000	-1302.425
	17	-592.560	-400.000	-1240.700
	18	-543.180	-400.000	-1178.975
	19	-493.800	-400.000	-1117.250
	20	-444.420	-400.000	-1055.525
	21	-395.040	-400.000	-993.800
	22	-345.660	-400.000	-932.075
	23	-296.280	-400.000	-870.350
	24	-246.900	-400.000	-808.625
	25	-197.520	-400.000	-746.900
	26	-148.140	-400.000	-685.175
	27	-98.760	-400.000	-623.450
	28	-49.380	-400.000	-561.725
	29	0.000	-400.000	-500.000

$$V_u = 1,25 (V_{titik} + V_{merata})$$

### 5.6 Perhitungan Momen dan Gaya Geser Rencana Tiap Segmen

Setelah momen saat pelaksanaan dan saat service didapatkan, kemudian dibandingkan dan dipilih yang terbesar sebagai momen dalam perencanaan selanjutnya. Hasil perhitungan momen rencana dapat dilihat pada tabel 5.9 dan 5.10 sebagai berikut :



TABEL 5.9 MOMEN RENCANA TIAP SEGMENT

Bentang	Lokasi	Momen Pelaksanaan (kN m)	Momen Service (kN m)		Momen Rencana (kN m)	
			Max Positif	Max Negatif	Positif	Negatif
1	1	0.000	0.000	0.000	0.000	0.000
	2	-2654.313	4471.214	835.909	4471.214	-2654.313
	3	-5617.250	7664.174	1118.351	7664.174	-5617.250
	4	-8888.813	9652.849	-1198.595	9652.849	-8888.813
	5	-12469.000	10502.110	-1598.127	10502.110	-12469.000
	6	-16357.813	10188.033	-2933.591	10188.033	-16357.813
	7	-20555.250	8698.227	-5555.730	8698.227	-20555.250
	8	-25061.313	6191.825	-8856.340	6191.825	-25061.313
	9	-29876.000	3264.191	-12835.426	3264.191	-29876.000
	10	-34999.313	2965.959	-17492.985	2965.959	-34999.313
	11	-40431.250	-7030.660	-22829.016		-40431.250
	12	-46171.813	-13664.288	-28843.521		-46171.813
	13	-52221.000	-21346.276	-35545.688		-52221.000
	14	-58578.813	-29084.262	-43204.629		-58578.813
2	15	-65245.250	-36174.879	-51881.467		-65245.250
	16	-58578.813	-27162.772	-39311.867		-58578.813
	17	-52221.000	-18444.774	-27873.687		-52221.000
	18	-46171.813	-9788.825	-17515.416		-46171.813
	19	-40431.250	-1874.845	-8563.258		-40431.250
	20	-34999.313	6873.356	-1462.231	6873.356	-34999.313
	21	-29876.000	14507.052	4729.143	14507.052	-29876.000
	22	-25061.313	21437.947	10052.014	21437.947	-25061.313
	23	-20555.250	27559.763	14591.216	27559.763	-20555.250
	24	-16357.813	32750.100	18452.117	32750.100	-16357.813
	25	-12469.000	36994.880	21634.527	36994.880	-12469.000
	26	-8888.813	40283.366	24138.483	40283.366	-8888.813
	27	-5617.250	42608.248	25963.972	42608.248	-5617.250
	28	-2654.313	43965.579	27110.981	43965.579	-2654.313
	29	0.000	44354.839	27579.524	44354.839	0.000

TABEL 5.10 GAYA GESER RENCANA TIAP SEGMENT

Bentang	Lokasi	Gaya Geser Pelaksanaan (kN)	Gaya Geser Service (kN)		Gaya Geser Rencana (kN)	
			Max Positif	Max Negatif	Positif	Negatif
1	1	500.000	-159.785	-1350.031	500.000	-1350.031
	2	561.725	123.514	-1106.279	561.725	-1106.279
	3	623.450	159.075	-866.708	623.450	-866.708
	4	685.175	301.331	-631.696	685.175	-631.696
	5	746.900	446.168	-401.608	746.900	-401.608
	6	808.625	593.539	-176.790	808.625	-176.790
	7	870.350	801.618	-142.824	870.350	-142.824
	8	932.075	1029.996	268.252	1029.996	
	9	993.800	1261.028	461.771	1261.028	
	10	1055.525	1492.285	655.023	1492.285	
	11	1117.250	1723.268	832.299	1723.268	
	12	1178.975	1953.457	1002.626	1953.457	
	13	1240.700	2182.325	1168.804	2182.325	
	14	1302.425	2409.332	1320.849	2409.332	
	15	1364.150	2633.920	1457.282	2633.920	
2	15	-1364.150	-1846.124	-3239.365		-3239.365
	16	-1302.425	-1710.123	-3045.324		-3045.324
	17	-1240.700	-1573.451	-2849.305		-2849.305
	18	-1178.975	-1436.003	-2651.674		-2651.674
	19	-1117.250	-1297.681	-2452.794		-2452.794
	20	-1055.525	-1142.634	-2253.014		-2253.014
	21	-993.800	-979.982	-2052.680		-2052.680
	22	-932.075	-810.980	-1852.128		-1852.128
	23	-870.350	-637.823	-1651.684		-1651.684
	24	-808.625	-461.081	-1451.666		-1451.666
	25	-746.900	-285.295	-1252.386		-1252.386
	26	-685.175	-145.995	-1054.143		-1054.143
	27	-623.450	145.282	-857.230	145.282	-857.230
	28	-561.725	277.278	-661.932	277.278	-661.932
29	-500.000	468.525	-468.525	468.525	-500.000	

### 5.7 Perencanaan Gelagar Pelat dengan Metode LRFD

a)  $M_u = -65245,250 \text{ kNm}$  (lihat tabel 5.4 pada lokasi 15)

Mutu baja yang digunakan A36 =  $248 \text{ N/mm}^2$  (untuk badan)

A50 =  $345 \text{ N/mm}^2$  (untuk sayap)

- Perencanaan ukuran pelat badan

Untuk evaluasi nilai optimum,  $h/t_w$  dipakai 320 ( $\beta_w$ )

Rumus pendekatan dari tinggi pelat badan :

$$h = \sqrt[3]{\frac{3Mn\beta_w}{2f}} = \sqrt[3]{\frac{3 \times (65245,250 \times 10^6 / 0,9) \times 320}{2 \times 345}} = 4654,891 \text{ mm}$$

$$\frac{h}{t_w} = \beta_w \quad t_w = \frac{4654,891}{320} = 14,547 \text{ mm}$$

diambil  $h = 5500 \text{ mm}$  ;  $t_w = 18 \text{ mm}$

$$A_w = 5500 \times 18 = 99000 \text{ mm}^2$$

- Perencanaan Ukuran Pelat Sayap

$$A_f = \frac{M}{f \cdot h} - \frac{A_w}{6} = \frac{65245,250 \times 10^6 / 0,9}{345 \times 5500} - \frac{99000}{6}$$

$$= 21705,387 \text{ mm}^2$$

dicoba flens  $t_f = 80 \text{ mm}$  ;  $b_f = 460 \text{ mm}$

$$A_f = 80 \times 460 = 36800 \text{ mm}^2$$

- Cek lokal buckling:

$$\lambda = \frac{b_f}{2t_f} \leq \frac{171}{\sqrt{F_y}} \Rightarrow \frac{460}{2 \times 80} = 2,875 \leq 9,206 \rightarrow \text{ok}$$

- cek  $F_{cr}$  untuk tekuk puntir lateral:

$$r_T = \sqrt{\frac{I_{yflens}}{A_f + A_w/6}} = \sqrt{\frac{(1/12) \times 80 \times 460^3}{36800 + (99000/6)}}$$

$$= 110,339 \text{ mm}$$

$$\lambda_p = \frac{790}{\sqrt{F_{yf}}} = \frac{790}{\sqrt{345}} = 42,532$$

$$\lambda_r = \frac{1985}{\sqrt{F_{yf}}} = \frac{1985}{\sqrt{345}} = 106,869$$

$$\lambda = \frac{I_{tb}}{r_T} = \frac{5000}{110,339} = 45,315$$

karena  $\lambda > \lambda_p$ , maka  $F_{cr} = C_b \cdot F_{yf} \left[ 1 - \frac{1}{2} \left( \frac{\lambda - \lambda_p}{\lambda_r - \lambda_p} \right) \right]$

$$C_b = 1,75 + 1,05 \frac{M_1}{M_2} + 0,3 \left( \frac{M_1}{M_2} \right)^2 \leq 2,3$$

$$C_b = 1,75 + 1,05 \left( -\frac{58578,813}{65245,250} \right) + 0,3 \left( -\frac{58578,813}{65245,250} \right)^2 = 1,049$$

$$F_{cr} = 1,049 \times 345 \times \left[ 1 - \frac{1}{2} \left( \frac{45,315 - 42,532}{106,869 - 42,532} \right) \right] = 354,078 \text{ MPa}$$

karena  $F_{cr} > F_{yf}$ , maka  $F_{cr} = F_{yf} = 345 \text{ N/mm}^2$

cek  $F_{cr}$  untuk tekuk lokal flens:

$$\lambda = \frac{b_f}{2t_f} = \frac{460}{2 \times 80} = 2,875$$

$$\lambda_p = \frac{170}{\sqrt{F_{yf}}} = \frac{170}{\sqrt{345}} = 9,152$$

$$\lambda_r = \frac{390}{\sqrt{F_{yf}}} = \frac{390}{\sqrt{345}} = 20,997$$

karena  $\lambda < \lambda_p$ , maka  $F_{cr} = F_{yf} = 345 \text{ N/mm}^2$

- Reduksi kekuatan dari keadaan batas tekuk lentur bila  $h/t_w > \frac{2550}{\sqrt{F_{cr}}}$  adalah

sebagai berikut :

$$\alpha_r = \frac{A_w}{A_f} = \frac{99000}{36800} = 2,690$$

$$R_{PG} = 1 - 0,0005\alpha_r \left( \frac{h_c}{t_w} - \frac{2550}{\sqrt{F_{cr}}} \right) \leq 1$$

$$= 1 - 0,0005 \times 2,69 \times \left( \frac{5500}{18} - \frac{2550}{\sqrt{345}} \right) = 0,774 \leq 1$$

- momen inersia penampang :

$$I_w = 1/12 \times 18 \times 5500^2 = 0,24956 \cdot 10^{12} \text{ mm}^4$$

$$I_f = (2 \times 1/12 \times 460 \times 80^3) + (2 \times 460 \times 80 \times 2790^2) = 0,57295 \cdot 10^{12} \text{ mm}^4$$

$$I_g = I_w + I_f = 0,24956 \cdot 10^{12} + 0,57295 \cdot 10^{12} = 0,82251 \cdot 10^{12} \text{ mm}^4$$

$$S_x = \frac{I_g}{(h/2) + t_f} = \frac{0,82251 \cdot 10^{12}}{(5500/2) + 80} = 0,2906 \cdot 10^9 \text{ mm}^3$$

$$R_e = 1 - 0,1(1,3 + \beta)(0,81 - \alpha)$$

$$= 1 - 0,1(1,3 + 2,69)(0,81 - (248/345)) = 0,964$$

- Kekuatan momen nominal (Mn):

$$M_n = F_{cr} \times S_x \times R_{PG} \times R_e$$

$$= 345 \cdot 10^3 \times 0,2906 \times 0,774 \times 0,964 = 74753,857 \text{ kNm}$$

$$\phi M_n = 0,9 \times 74753,857 = 67278,47 \text{ kNm} \geq M_u \dots \dots \text{ok}$$

2.  $M_u^- = +44354,839 \text{ kNm}$  ( lihat tabel 5.3 pada lokasi 29)

Mutu baja yang digunakan A36 =  $248 \text{ N/mm}^2$  (untuk badan)

$$A50 = 345 \text{ N/mm}^2 \text{ (untuk sayap)}$$

Untuk evaluasi nilai optimum,  $h/t_w$  dipakai 320 ( $\beta_w$ )

- Perencanaan ukuran pelat badan

Rumus pendekatan dari tinggi pelat badan :

$$h = \sqrt[3]{\frac{3Mn\beta_w}{2f}} = \sqrt[3]{\frac{3 \times (44354,839 \times 10^6 / 0,9) \times 320}{2 \times 345}} = 4092,986 \text{ mm}$$

$$\frac{h}{t_w} = \beta_w \quad t_w = \frac{4092,986}{320} = 12,791 \text{ mm}$$

diambil  $h = 4000 \text{ mm}$  ;  $t_w = 18 \text{ mm}$

$$A_w = 4000 \times 18 = 720000 \text{ mm}^2$$

- Perencanaan Ukuran Pelat Sayap

$$A_f = \frac{M}{f \cdot h} - \frac{A_w}{6} = \frac{44354,839 \times 10^6 / 0,9}{345 \times 4000} - \frac{720000}{6}$$

$$= 23712,431 \text{ mm}^2$$

dicoba flens  $t_f = 80 \text{ mm}$  ;  $b_f = 460 \text{ mm}$

$$A_f = 80 \times 460 = 36800 \text{ mm}^2$$

- Cek lokal buckling:

$$\lambda = \frac{b_f}{2t_f} \leq \frac{171}{\sqrt{F_y}} \Rightarrow \frac{460}{2 \times 80} = 2,875 \leq 9,206 \rightarrow \text{ok}$$

- cek  $F_{cr}$  untuk tekuk puntir lateral:

$$r_T = \sqrt{\frac{I_y \text{flens}}{A_f + A_w/6}} = \sqrt{\frac{(1/12) \times 80 \times 460^3}{36800 + (720000/6)}}$$



$$= 115,314 \text{ mm}$$

$$\lambda_p = \frac{790}{\sqrt{F_{yf}}} = \frac{790}{\sqrt{345}} = 42,532$$

$$\lambda_r = \frac{1985}{\sqrt{F_{yf}}} = \frac{1985}{\sqrt{345}} = 106,869$$

$$\lambda = \frac{L_b}{r_i} = \frac{5000}{115,314} = 43,360$$

karena  $\lambda > \lambda_p$ , maka  $F_{cr} = C_b F_{yf} \left[ 1 - \frac{1}{2} \left( \frac{\lambda - \lambda_p}{\lambda_r - \lambda_p} \right) \right]$

$$C_b = 1,75 + 1,05 \frac{M_1}{M_2} + 0,3 \left( \frac{M_1}{M_2} \right)^2 \leq 2,3$$

$$C_b = 1,75 + 1,05 \left( -\frac{43965,579}{44354,839} \right) + 0,3 \left( -\frac{43965,579}{44354,839} \right)^2 = 1,004$$

$$F_{cr} = 1,004 \times 345 \times \left[ 1 - \frac{1}{2} \left( \frac{43,360 - 42,532}{106,869 - 42,532} \right) \right] = 344,151 \text{ MPa}$$

karena  $F_{cr} < F_{yf}$ , maka  $F_{cr} = 344,151 \text{ N/mm}^2$

- cek  $F_{cr}$  untuk tekuk lokal flens:

$$\lambda = \frac{b_f}{2t_f} = \frac{460}{2 \times 80} = 2,875$$

$$\lambda_p = \frac{170}{\sqrt{F_{yf}}} = \frac{170}{\sqrt{345}} = 9,152$$

$$\lambda_r = \frac{390}{\sqrt{F_{yf}}} = \frac{390}{\sqrt{345}} = 20,997$$

karena  $\lambda < \lambda_p$ , maka  $F_{cr} = F_{yf} = 345 \text{ N/mm}^2$

- Reduksi kekuatan dari keadaan batas tekuk lentur bila  $h/t_w > \frac{2550}{\sqrt{F_{cr}}}$  adalah

sebagai berikut :

$$a_r = \frac{A_w}{A_f} = \frac{72000}{36800} = 1,957$$

$$R_{PG} = 1 - 0,0005\alpha_r \left( \frac{h_c}{t_w} - \frac{2550}{\sqrt{F_{cr}}} \right) \leq 1$$

$$= 1 - 0,0005 \times 1,957 \times \left( \frac{4000}{18} - \frac{2550}{\sqrt{345}} \right) = 0,917 \leq 1$$

- momen inersia penampang :

$$I_w = 1/12 \times 18 \times 4000^3 = 0,096000 \cdot 10^{12} \text{ mm}^4$$

$$I_f = (2 \times 1/12 \times 460 \times 80^3) + (2 \times 460 \times 80 \times 2040^2) = 0,30633 \cdot 10^{12} \text{ mm}^4$$

$$I_g = I_w + I_f = 0,096000 \cdot 10^{12} + 0,30633 \cdot 10^{12} = 0,40233 \cdot 10^{12} \text{ mm}^4$$

$$S_x = \frac{I_g}{(h/2) + t_f} = \frac{0,40233 \cdot 10^{12}}{(4000/2) + 80} = 0,1934 \cdot 10^9 \text{ mm}^3$$

$$R_e = 1 - 0,1(1,3 + \beta)(0,81 - \alpha)$$

$$= 1 - 0,1(1,3 + 1,957)(0,81 - (248/345)) = 0,970$$

- Kekuatan momen nominal (Mn):

$$M_n = F_{cr} \times S_x \times R_{PG} \times R_e$$

$$= 344,151 \cdot 10^3 \times 0,1934 \times 0,917 \times 0,970 = 59225,847 \text{ kNm}$$

$$\phi M_n = 0,9 \times 59225,847 = 53303,26 \text{ kNm} \geq M_u \dots \dots \dots \text{ ok}$$

3.  $M_u = 4471,214 \text{ kNm}$  ( lihat tabel 5.3 pada lokasi 2)

Mutu baja yang digunakan A36 =  $248 \text{ N/mm}^2$  (untuk badan)

A50 =  $345 \text{ N/mm}^2$  (untuk sayap)

- Perencanaan ukuran pelat badan

Untuk evaluasi nilai optimum,  $h/t_w$  dipakai 320 ( $\beta_w$ )

Rumus pendekatan dari tinggi pelat badan :

$$h = \sqrt[3]{\frac{3Mn\beta_w}{2f}} = \sqrt[3]{\frac{3 \times (4471,214 \times 10^6 / 0,9) \times 320}{2 \times 345}} = 1904,883 \text{ mm}$$

$$\frac{h}{t_w} = \beta_w \quad t_w = \frac{1904,883}{320} = 5,953 \text{ mm}$$

diambil  $h = 2500 \text{ mm}$  ;  $t_w = 14 \text{ mm}$

$$A_w = 2500 \times 14 = 35000 \text{ mm}^2$$

- Perencanaan Ukuran Pelat Sayap

$$A_f = \frac{M}{f \cdot h} - \frac{A_w}{6} = \frac{4471,214 \times 10^6 / 0,9}{345 \times 2500} - \frac{35000}{6}$$

$$= -73,315 \text{ mm}^2$$

dicoba flens  $t_f = 58 \text{ mm}$  ;  $b_f = 420 \text{ mm}$

$$A_f = 58 \times 420 = 24360 \text{ mm}^2$$

- Cek lokal buckling:

$$\lambda = \frac{b_f}{2t_f} \leq \frac{171}{\sqrt{F_y}} \Rightarrow \frac{420}{2 \times 58} = 3,621 \leq 9,206 \rightarrow \text{ok}$$

- cek  $F_{cr}$  untuk tekuk puntir lateral:

$$r_T = \sqrt{\frac{I_y \text{flens}}{A_f + A_w/6}} = \sqrt{\frac{(1/12) \times 58 \times 420^3}{24360 + (35000/6)}}$$

$$= 108,903 \text{ mm}$$

$$\lambda_p = \frac{790}{\sqrt{F_{yf}}} = \frac{790}{\sqrt{345}} = 42,532$$

$$\lambda_r = \frac{1985}{\sqrt{F_{yf}}} = \frac{1985}{\sqrt{345}} = 106,869$$

$$\lambda = \frac{I_b}{r_t} = \frac{5000}{108,903} = 45,912$$

karena  $\lambda > \lambda_p$ , maka  $F_{cr} = C_b \cdot F_{yf} \left[ 1 - \frac{1}{2} \left( \frac{\lambda - \lambda_p}{\lambda_r - \lambda_p} \right) \right]$

$$C_b = 1,75 + 1,05 \frac{M_1}{M_2} + 0,3 \left( \frac{M_1}{M_2} \right)^2 \leq 2,3$$

$$C_b = 1,75 + 1,05 \left( -\frac{0}{4471,214} \right) + 0,3 \left( -\frac{0}{4471,214} \right)^2 = 1,75$$

$$F_{cr} = 1,75 \cdot 345 \cdot \left[ 1 - \frac{1}{2} \left( \frac{45,912 - 42,532}{106,869 - 42,532} \right) \right] = 587,890 \text{ MPa}$$

karena  $F_{cr} > F_{yf}$ , maka  $F_{cr} = F_{yf} = 345 \text{ N/mm}^2$

- cek  $F_{cr}$  untuk tekuk lokal flens:

$$\lambda = \frac{b_f}{2t_f} \leq \frac{171}{\sqrt{F_y}} \Rightarrow \frac{420}{2 \cdot 58} = 3,621 \leq 9,206 \rightarrow \text{ok}$$

$$\lambda_p = \frac{170}{\sqrt{F_{yf}}} = \frac{170}{\sqrt{345}} = 9,152$$

$$\lambda_r = \frac{390}{\sqrt{F_{yf}}} = \frac{390}{\sqrt{345}} = 20,997$$

karena  $\lambda < \lambda_p$ , maka  $F_{cr} = F_{yf} = 345 \text{ N/mm}^2$

- Reduksi kekuatan dari keadaan batas tekuk lentur bila  $h/t_w > \frac{2550}{\sqrt{F_{cr}}}$  adalah

sebagai berikut :

$$a_r = \frac{A_w}{A_f} = \frac{35000}{24360} = 1,437$$

$$R_{PG} = 1 - 0,0005 \alpha_r \left( \frac{h_c}{t_w} - \frac{2550}{\sqrt{F_{cr}}} \right) \leq 1$$

$$= 1 - 0,0005 \times 1,437 \times \left( \frac{2500}{14} - \frac{2550}{\sqrt{345}} \right) = 0,970 \leq 1$$

- momen inersia penampang :

$$I_w = 1/12 \times 14 \times 2500^3 = 0,01823 \cdot 10^{12} \text{ mm}^4$$

$$I_f = (2 \times 1/12 \times 420 \times 58^3) + (2 \times 420 \times 58 \times 1279^2) = 0,07971 \cdot 10^{12} \text{ mm}^4$$

$$I_g = I_w + I_f = 0,01823 \cdot 10^{12} + 0,07971 \cdot 10^{12} = 0,09794 \cdot 10^{12} \text{ mm}^4$$

$$S_x = \frac{I_g}{(h/2) + t_f} = \frac{0,09794 \cdot 10^{12}}{(2500/2) + 58} = 0,0749 \cdot 10^9 \text{ mm}^3$$

$$R_e = 1 - 0,1(1,3 + \beta)(0,81 - \alpha)$$

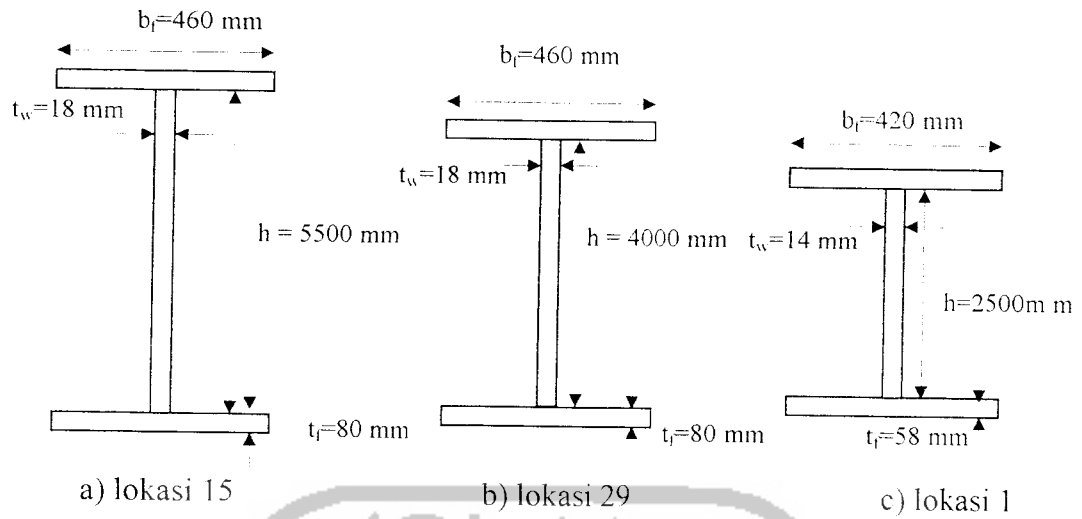
$$= 1 - 0,1(1,3 + 1,437)(0,81 - (248/345)) = 0,975$$

- Kekuatan momen nominal (Mn):

$$M_n = F_{cr} \times S_x \times R_{PG} \times R_e$$

$$= 345 \cdot 10^3 \times 0,0749 \times 0,970 \times 0,975 = 24441,525 \text{ kNm}$$

$$\phi M_n = 0,9 \times 24441,525 = 21997,370 \text{ kNm} \geq M_u \dots \dots \dots \text{ok}$$



Gambar 5.3 Gambar penampang gelagar



## 5.8 Perhitungan tinggi gelagar tiap segmen

### 5.8.1 Perhitungan jari-jari lingkaran

Mengacu pada persamaan lingkaran, maka nilai jari-jari ( R ) dapat diperoleh :

- Untuk bentang 70 m

$$R^2 = (R-(h_n-h_1))^2 + L_j^2$$

$$R^2 = (R-(5500 - 2500 ))^2 + 70000^2$$

$$R = 818166,667 \text{ mm}$$

- Untuk bentang 140 m (setengah bentang)

$$R^2 = (R-(h_n-h_1))^2 + L_1^2$$

$$R^2 = (R-(5500 - 4000 ))^2 + 70000^2$$

$$R = 1634083,333 \text{ mm}$$

### 5.8.2 Perhitungan tinggi gelagar

Dengan mengacu pada persamaan  $h_1 = (R + h_1) - \sqrt{R^2 - X^2}$  maka diperoleh :

- Untuk bentang 70 m

$$h_1 = 2500 \text{ mm}$$

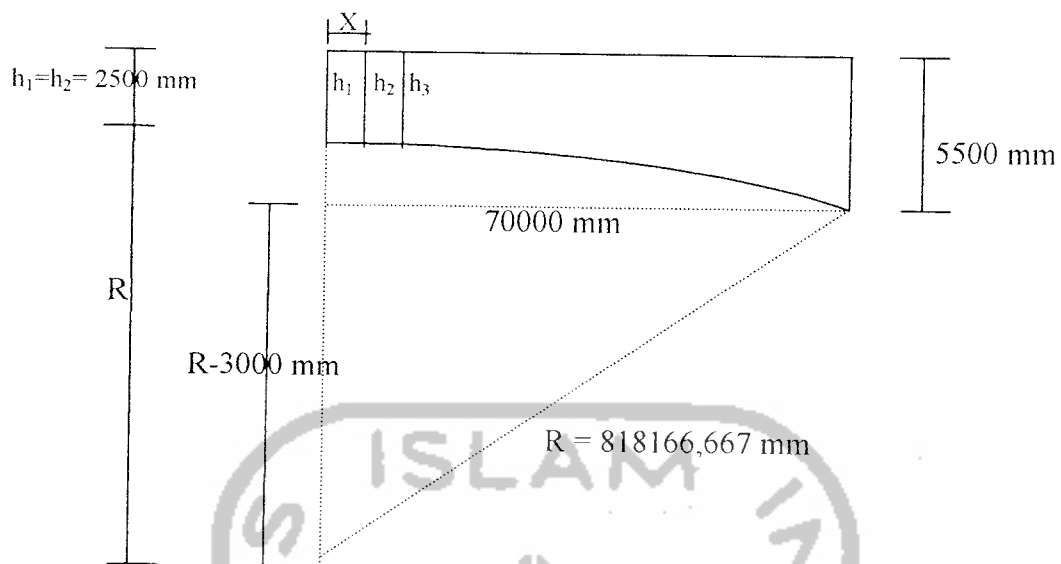
$$h_2 = (818166,667 + 2500) - \sqrt{818166,667^2 - 5000^2} = 2515,278 \text{ mm}$$

- Untuk bentang 140 m (setengah bentang)

$$H_{29} = 4000 \text{ mm}$$

$$H_{28} = (1634083,333 + 4000) - \sqrt{1634083,333^2 - 5000^2} = 4007,650 \text{ mm}$$

Untuk perhitungan h selanjutnya dapat dilihat pada Tabel 5.11



Gambar 5.4 Sket mencari tinggi gelagar





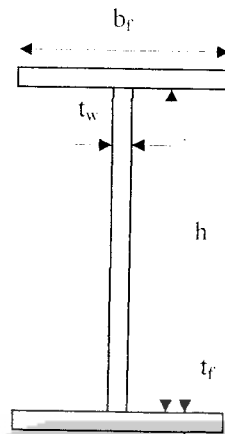
TABEL 5.11 TINGGI PENAMPANG GELAGAR TIAP SEGMENT

Lokasi	R (mm)	Jarak (mm)	h (mm)
1	818166.667	0	2500.000
2	818166.667	5000	2515.278
3	818166.667	10000	2561.115
4	818166.667	15000	2637.514
5	818166.667	20000	2744.485
6	818166.667	25000	2882.041
7	818166.667	30000	3050.195
8	818166.667	35000	3248.968
9	818166.667	40000	3478.381
10	818166.667	45000	3738.460
11	818166.667	50000	4029.235
12	818166.667	55000	4350.739
13	818166.667	60000	4703.007
14	818166.667	65000	5086.079
15	818166.667	70000	5500.000

Lokasi	R (mm)	Jarak (mm)	h (mm)
15	1634083.333	70000	5500.000
16	1634083.333	65000	5293.286
17	1634083.333	60000	5101.907
18	1634083.333	55000	4925.858
19	1634083.333	50000	4765.134
20	1634083.333	45000	4619.731
21	1634083.333	40000	4489.644
22	1634083.333	35000	4374.871
23	1634083.333	30000	4275.407
24	1634083.333	25000	4191.250
25	1634083.333	20000	4122.397
26	1634083.333	15000	4068.847
27	1634083.333	10000	4030.598
28	1634083.333	5000	4007.650
29	1634083.333	0	4000.000

### 5.9 Perhitungan Inersia penampang gelagar tiap segmen



Inersia penampang pada lokasi 15

$$h = 5500 \text{ mm}$$

$$t_w = 18 \text{ mm}$$

$$b_f = 460 \text{ mm}$$

$$t_f = 80 \text{ mm}$$

$$\text{Inersia badan} = 1/12 \cdot t_w \cdot h^3$$

$$= 1/12 \cdot 18 \cdot 5500^3 = 0,24956 \cdot 10^{12} \text{ mm}^4$$

$$\text{Inersia sayap} = (2 \cdot 1/12 \cdot b_f \cdot t_f^3) + (2 \cdot b_f \cdot t_f \cdot (h/2 + t_f/2)^2)$$

$$= (2 \cdot 1/12 \cdot 460 \cdot 80^3) + (2 \cdot 460 \cdot 80 \cdot 2790^2) = 0,57295 \cdot 10^{12} \text{ mm}^4$$

$$\text{Inersia total} = \text{Inersia badan} + \text{Inersia sayap}$$

$$= 0,24956 \cdot 10^{12} + 0,57295 \cdot 10^{12} = 0,82251 \cdot 10^{12} \text{ mm}^4$$

untuk perhitungan inersia selanjutnya dapat dilihat pada Tabel 5.12

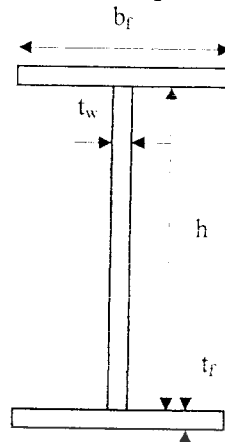
TABEL 5.12 PERHITUNGAN INERSIA PENAMPANG GELAGAR  
TIAP SEGMENT

Lokasi	h (mm)	tw (mm)	tf (mm)	bf (mm)	I badan $10^{12}(\text{mm}^4)$	I sayap $10^{12}(\text{mm}^4)$	I total $10^{12}(\text{mm}^4)$
1	2500.000	14	58	420	0.01823	0.07971	0.09794
2	2515.278	14	58	420	0.01857	0.08067	0.09923
3	2561.115	14	58	420	0.01960	0.08357	0.10316
4	2637.514	14	58	420	0.02141	0.08851	0.10992
5	2744.485	14	58	420	0.02412	0.09567	0.11979
6	2882.041	14	58	420	0.02793	0.10530	0.13322
7	3050.195	14	58	420	0.03311	0.11768	0.15079
8	3248.968	14	58	420	0.04001	0.13321	0.17323
9	3478.381	14	80	420	0.04910	0.21276	0.26186
10	3738.460	14	80	420	0.06096	0.24499	0.30595
11	4029.235	14	80	420	0.07632	0.28372	0.36003
12	4350.739	14	80	420	0.09608	0.32984	0.42592
13	4703.007	18	80	460	0.15603	0.42098	0.57701
14	5086.079	18	80	460	0.19735	0.49111	0.68846
15	5500.000	18	80	460	0.24956	0.57295	0.82251
15	5500.000	18	80	460	0.24956	0.57295	0.82251
16	5293.286	18	80	460	0.22247	0.53129	0.75376
17	5101.907	18	80	460	0.19920	0.49412	0.69332
18	4925.858	18	80	460	0.17928	0.46112	0.64040
19	4765.134	18	80	460	0.16230	0.43199	0.59428
20	4619.731	18	80	460	0.14789	0.40645	0.55434
21	4489.644	18	80	460	0.13575	0.38426	0.52001
22	4374.871	18	80	460	0.12560	0.36520	0.49080
23	4275.407	18	80	460	0.11723	0.34908	0.46631

24	4191.250	18	80	460	0.11044	0.33572	0.44616
25	4122.397	18	80	460	0.10509	0.32499	0.43007
26	4068.847	18	80	460	0.10104	0.31676	0.41780
27	4030.598	18	80	460	0.09822	0.31094	0.40916
28	4007.650	18	80	460	0.09655	0.30748	0.40403
29	4000.000	18	80	460	0.09600	0.30633	0.40233



### 5.10 Perhitungan berat sendiri penampang gelagar tiap segmen



Berat sendiri penampang pada lokasi 15

$$h = 5500 \text{ mm}$$

$$t_w = 18 \text{ mm}$$

$$b_f = 460 \text{ mm}$$

$$t_f = 80 \text{ mm}$$

$$\begin{aligned} A_w &= h \cdot t_w \\ &= 5500 \cdot 18 = 99000 \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} A_f &= 2 \cdot t_f \cdot b_f \\ &= 2 \cdot 80 \cdot 460 = 73600 \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} A_{\text{total}} &= A_w + A_f \\ &= 99000 + 73600 = 172600 \text{ mm}^2 \end{aligned}$$

Berat sendiri gelagar =  $A_{\text{total}} \cdot B_j \text{ baja}$

$$= 172600 \cdot 10^{-6} \cdot 78,5 = 13,549 \text{ kN/m}$$

untuk perhitungan berat sendiri selanjutnya dapat dilihat pada Tabel 5.13

TABEL 5.13 PERHITUNGAN BERAT SENDIRI GELAGAR TIAP SEGMENT

Lokasi	h (mm)	tw (mm)	Aw (mm <sup>2</sup> )	Tf (mm)	bf (mm)	Af (mm <sup>2</sup> )	A total (mm <sup>2</sup> )	Bj baja (kN/m <sup>3</sup> )	Berat (kN/m)
1	2500.000	14	35000.000	58	420	48720	83720.000	78.5	6.572
2	2515.278	14	35213.895	58	420	48720	83933.895	78.5	6.589
3	2561.115	14	35855.603	58	420	48720	84575.603	78.5	6.639
4	2637.514	14	36925.197	58	420	48720	85645.197	78.5	6.723
5	2744.485	14	38422.797	58	420	48720	87142.797	78.5	6.841
6	2882.041	14	40348.570	58	420	48720	89068.570	78.5	6.992
7	3050.195	14	42702.733	58	420	48720	91422.733	78.5	7.177
8	3248.968	14	45485.549	58	420	48720	94205.549	78.5	7.395
9	3478.381	14	48697.332	80	420	67200	115897.332	78.5	9.098
10	3738.460	14	52338.443	80	420	67200	119538.443	78.5	9.384
11	4029.235	14	56409.293	80	420	67200	123609.293	78.5	9.703
12	4350.739	14	60910.340	80	420	67200	128110.340	78.5	10.057
13	4703.007	18	84654.120	80	460	73600	158254.120	78.5	12.423
14	5086.079	18	91549.428	80	460	73600	165149.428	78.5	12.964
15	5500.000	18	99000.000	80	460	73600	172600.000	78.5	13.549
15	5500.000	18	99000.000	80	460	73600	172600.000	78.5	13.549
16	5293.286	18	95279.139	80	460	73600	168879.139	78.5	13.257
17	5101.907	18	91834.318	80	460	73600	165434.318	78.5	12.987
18	4925.858	18	88665.438	80	460	73600	162265.438	78.5	12.738
19	4765.134	18	85772.412	80	460	73600	159372.412	78.5	12.511
20	4619.731	18	83155.157	80	460	73600	156755.157	78.5	12.305
21	4489.644	18	80813.601	80	460	73600	154413.601	78.5	12.121
22	4374.871	18	78747.676	80	460	73600	152347.676	78.5	11.959
23	4275.407	18	76957.325	80	460	73600	150557.325	78.5	11.819

24	4191.250	18	75442.498	80	460	73600	149042.498	78.5	11.700
25	4122.397	18	74203.153	80	460	73600	147803.153	78.5	11.603
26	4068.847	18	73239.253	80	460	73600	146839.253	78.5	11.527
27	4030.598	18	72550.773	80	460	73600	146150.773	78.5	11.473
28	4007.650	18	72137.692	80	460	73600	145737.692	78.5	11.440
29	4000.000	18	72000.000	80	460	73600	145600.000	78.5	11.430
Jumlah									
									300.975
									10.378



### 5.11 Perhitungan Faktor Distribusi Momen Gelagar

Propertis jembatan pada lokasi 1

Spasi girder (s)	= 1800 mm
Panjang bentang 1 (L)	= 70000 mm
Tebal slub ( $t_s$ )	= 200 mm
Inersia ( $I_g$ )	= $0,09794 \cdot 10^{12}$ mm
Luas ( $A_g$ )	= 83720 mm
Modulus elastis beton ( $E_c$ )	= $4800 \sqrt{f'_c}$ ; $f'_c = 30$ Mpa
Modulus elastis girder ( $E_s$ )	= 200000 Mpa

rasio modulus

$$n = \frac{E_s}{E_c} = \frac{200000}{4800 \sqrt{30}} = 7,607 \approx 8$$

parameter pengaku

$$K_g = n (I_g + e_g^2 A_g); \text{ Untuk noncomposit } e_g = 0$$

$$K_g = 8 (0,09794 \cdot 10^{12} + 0) = 0,7835 \cdot 10^{12} \text{ mm}$$

- Satu pembebanan jalur rencana

$$mg_m = 0,06 + \left( \frac{S}{4300} \right)^{0,4} \left( \frac{S}{L} \right)^{0,3} \left( \frac{Kg}{Lt_s^3} \right)^{0,1}$$

$$mg_m^{si} = 0,06 + \left( \frac{1800}{4300} \right)^{0,4} \left( \frac{1800}{70000} \right)^{0,3} \left( \frac{0,7835 \cdot 10^{12}}{70000 \cdot 200^3} \right)^{0,1} = 0,3034$$

- dua pembebanan jalur rencana

$$mg_m^{Au} = 0,075 + \left( \frac{S}{2900} \right)^{0,6} \left( \frac{S}{L} \right)^{0,2} \left( \frac{Kg}{Lt_s^3} \right)^{0,1}$$



$$mg_m^{Mi} = 0,075 + \left(\frac{1800}{2900}\right)^{0,6} \left(\frac{1800}{70000}\right)^{0,2} \left(\frac{0,7835 \cdot 10^{12}}{70000 \cdot x 200^3}\right)^{0,1} = 0,4485$$

diambil yang terbesar  $mg_m = 0,4485.3$

untuk perhitungan faktor distribusi momen pada lokasi berikutnya dapat dilihat pada Tabel 5.14



TABEL 5.14 FAKTOR DISTRIBUSI MOMEN (mgm)

Bentang	Iokasi	A total (mm <sup>2</sup> )	I total 10 <sup>12</sup> (mm <sup>4</sup> )	S (mm)	ts (mm)	Kg 10 <sup>12</sup> (mm <sup>4</sup> )	Mg <sup>st</sup> Mg <sub>m</sub>	Mg <sup>mi</sup> Mg <sub>m</sub>	Mg <sup>mi</sup> Mg <sub>m</sub> pakai
1	1	83720.000	0.09794	1800	200	0.7835	0.3034	0.4485	0.4485
	2	83933.895	0.09923	1800	200	0.7939	0.3037	0.4490	0.4490
	3	84575.603	0.10316	1800	200	0.8253	0.3047	0.4505	0.4505
	4	85645.197	0.10992	1800	200	0.8793	0.3062	0.4529	0.4529
	5	87142.797	0.11979	1800	200	0.9583	0.3084	0.4561	0.4561
	6	89068.570	0.13322	1800	200	1.0658	0.3110	0.4602	0.4602
	7	91422.733	0.15079	1800	200	1.2063	0.3142	0.4650	0.4650
	8	94205.549	0.17323	1800	200	1.3858	0.3177	0.4705	0.4705
	9	115897.332	0.26186	1800	200	2.0949	0.3286	0.4872	0.4872
	10	119538.443	0.30595	1800	200	2.4476	0.3328	0.4936	0.4936
	11	123609.293	0.36003	1800	200	2.8803	0.3373	0.5005	0.5005
	12	128110.340	0.42592	1800	200	3.4074	0.3420	0.5077	0.5077
	13	158254.120	0.57701	1800	200	4.6161	0.3507	0.5210	0.5210
	14	165149.428	0.68846	1800	200	5.5077	0.3558	0.5290	0.5290
	15	172600.000	0.82251	1800	200	6.5801	0.3611	0.5371	0.5371
	15	172600.000	0.82251	1800	200	6.5801	0.3561	0.5313	0.5313
	16	168879.139	0.75376	1800	200	6.0300	0.3536	0.5274	0.5274
	17	165434.318	0.69332	1800	200	5.5465	0.3511	0.5236	0.5236
	18	162265.438	0.64040	1800	200	5.1232	0.3488	0.5201	0.5201
	19	159372.412	0.59428	1800	200	4.7543	0.3467	0.5168	0.5168
	20	156755.157	0.55434	1800	200	4.4347	0.3447	0.5137	0.5137
	21	154413.601	0.52001	1800	200	4.1601	0.3429	0.5109	0.5109
	22	152347.676	0.49080	1800	200	3.9264	0.3412	0.5084	0.5084
	23	150557.325	0.46631	1800	200	3.7304	0.3398	0.5062	0.5062
24	149042.498	0.44616	1800	200	3.5693	0.3386	0.5043	0.5043	

25	147803.153	0.43007	1800	200	3.4406	0.3375	0.5027	0.5027
26	146839.253	0.41780	1800	200	3.3424	0.3367	0.5015	0.5015
27	146150.773	0.40916	1800	200	3.2733	0.3362	0.5006	0.5006
28	145737.692	0.40403	1800	200	3.2323	0.3358	0.5000	0.5000
29	145600.000	0.40233	1800	200	3.2187	0.3357	0.4999	0.4999



**TABEL 5.15 MOMEN GELAGAR JEMBATAN HASIL PERHITUNGAN SAP 2000  
BERDASARKAN PEMBEBANAN AASTHO 1994  
(BERAT SENDIRI GELAGAR  $w_{gelagar} = 10,378 \text{ kN/m}$ )**

Bentang	Lokasi	Momen (kN m)											
		DC		DW		Tandem		Truck		lane			
		max	min	max	min	max	min	max	min	max	min		
1	1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	2	1221.824	229.157	995.658	-225.288	2196.519	-638.101	846.045	-487.433				
	3	1967.023	368.921	1806.011	-450.577	3876.064	-1276.202	1552.589	-974.866				
	4	2235.597	419.293	2433.924	-675.865	5115.327	-1914.303	2119.634	-1462.300				
	5	2027.546	380.273	2884.064	-901.153	5981.540	-2552.404	2547.217	-1949.732				
	6	1342.870	251.859	3162.899	-1126.442	6449.945	-3190.506	2835.272	-2437.165				
	7	181.569	34.054	3278.699	-1351.730	6507.677	-3828.607	2983.826	-2924.599				
	8	-1456.357	-273.144	3247.591	-1577.018	6319.725	-4466.708	2992.880	-3412.031				
	9	-3570.908	-669.735	3082.575	-1802.306	6187.151	-5104.809	2862.434	-3899.465				
	10	-6162.084	-1155.718	2787.551	-2027.595	5629.187	-5742.910	2592.488	-4386.898				
	11	-9229.886	-1731.094	2377.672	-2252.883	4715.953	-6381.011	2183.043	-4874.331				
	12	-12774.310	-2395.862	1869.893	-2478.171	3458.890	-7019.112	1634.097	-5361.764				
	13	-16795.360	-3150.022	1282.971	-2703.460	1936.989	-7657.213	958.316	-5861.863				
	14	-21293.040	-3993.575	637.463	-2928.748	876.801	-8295.314	526.814	-6745.740				
	15	-26267.340	-4926.521	368.497	-3154.036	944.247	-8933.415	423.857	-8097.660				
	15	-26267.340	-4926.521	368.497	-3154.036	944.247	-8933.415	423.857	-8097.660				
	16	-19832.900	-3719.722	382.641	-2450.560	809.193	-6907.961	411.299	-6201.852				
	17	-13875.090	-2602.316	843.743	-1809.009	982.204	-5055.651	510.531	-4557.337				
	18	-8393.902	-1574.302	1327.770	-1235.849	1693.259	-3411.930	750.476	-3193.048				
	19	-3389.339	-635.681	1820.485	-896.430	2709.884	-2297.039	1158.414	-2136.219				
20	1138.598	213.548	2303.560	-843.725	4170.023	-2161.985	1752.637	-1405.208					
2													

21	5189.911	973.384	2765.698	-791.020	5536.349	-2026.932	2528.518	-995.342
22	8764.598	1643.828	3196.799	-738.314	6783.471	-1891.878	3429.145	-849.457
23	11862.660	2224.879	3587.967	-685.609	7889.548	-1756.824	4335.935	-849.701
24	14484.100	2716.538	3931.505	-632.904	8836.286	-1621.771	5103.185	-849.702
25	16628.910	3118.804	4220.917	-580.198	9608.940	-1486.717	5730.935	-849.740
26	18297.100	3431.678	4450.909	-527.493	10196.310	-1351.664	6219.186	-849.740
27	19488.660	3655.159	4617.385	-474.788	10590.750	-1216.610	6567.936	-849.740
28	20203.600	3789.248	4717.451	-422.083	10788.150	-1081.557	6777.186	-849.740
29	20441.910	3833.944	4749.416	-369.377	10787.950	-946.503	6846.936	-849.740
30	20203.600	3789.248	4717.451	-422.083	10788.150	-1081.557	6777.186	-849.740
31	19488.660	3655.159	4617.385	-474.788	10590.750	-1216.610	6567.936	-849.740
32	18297.100	3431.678	4450.909	-527.493	10196.310	-1351.664	6219.186	-849.740
33	16628.910	3118.804	4220.917	-580.198	9608.940	-1486.717	5730.935	-849.740
34	14484.100	2716.538	3931.505	-632.904	8836.286	-1621.771	5103.185	-849.702
35	11862.660	2224.879	3587.967	-685.609	7889.548	-1756.824	4335.935	-849.721
36	8764.598	1643.828	3196.799	-738.314	6783.471	-1891.878	3429.145	-849.457
37	5189.911	973.384	2765.698	-791.020	5536.349	-2026.932	2528.518	-995.342
38	1138.598	213.548	2303.560	-843.725	4170.023	-2161.985	1752.637	-1405.208
39	-3389.339	-635.681	1820.485	-896.430	2709.884	-2297.039	1158.414	-2136.219
40	-8393.902	-1574.302	1327.770	-1235.849	1693.259	-3411.930	750.476	-3193.048
41	-13875.090	-2602.316	843.743	-1809.009	982.204	-5055.651	510.531	-4557.337
42	-19832.900	-3719.722	382.641	-2450.560	809.193	-6907.961	411.299	-6201.852
43	-26267.340	-4926.521	368.497	-3154.036	944.247	-8933.415	423.857	-8097.660
43	-26267.340	-4926.521	368.497	-3154.036	944.247	-8933.415	423.857	-8097.660
44	-21293.040	-3993.575	637.463	-2928.748	876.801	-8295.314	526.814	-6745.740
45	-16795.360	-3150.022	1282.971	-2703.400	1936.989	-7657.213	958.316	-5861.863
46	-12774.310	-2395.862	1869.893	-2478.171	3458.890	-7019.112	1634.097	-5361.764
47	-9229.886	-1731.094	2377.672	-2252.883	4715.953	-6381.011	2183.043	-4874.331
48	-6162.084	-1155.718	2787.551	-2027.595	5629.187	-5742.910	2592.488	-4386.898
3								

49	-3570.908	-669.735	3082.575	-1802.306	6187.151	-5104.809	2862.434	-3899.465
50	-1456.357	-273.144	3247.591	-1577.018	6319.725	-4466.708	2992.880	-3412.031
51	181.569	34.054	3278.699	-1351.730	6507.677	-3828.607	2983.826	-2924.599
52	1342.870	251.859	3162.899	-1126.442	6449.945	-3190.506	2835.272	-2437.165
53	2027.546	380.273	2884.064	-901.153	5981.540	-2552.404	2547.217	-1949.732
54	2235.597	419.293	2433.924	-675.865	5115.327	-1914.303	2119.634	-1462.300
55	1967.023	368.921	1806.011	-450.577	3876.064	-1276.202	1552.589	-974.866
56	1221.824	229.157	995.658	-225.288	2196.519	-638.101	846.045	-487.433
57	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000



**TABEL 5.16 GAYA GESER GELAGAR JEMBATAN HASIL PERHITUNGAN SAP 2000  
BERDASARKAN PEMBEBANAN AASTHO 1994  
(BERAT SENDIRI GELAGAR  $w_{gelagar} = 10,378$  kN/m)**

Bentang	Lokasi	Gaya geser (kN)									
		DC	DW	Tandem		Truck		lane			
				Max	min	Max	min	max	Min		
1	1	-292.027	-54.771	45.058	-217.763	127.620	-492.047	97.487	-183.159		
	2	-196.702	-36.892	45.058	-199.132	127.620	-439.304	98.669	-156.441		
	3	-101.377	-19.014	45.058	-180.601	127.620	-387.606	102.209	-132.082		
	4	-6.052	-1.135	53.362	-162.262	127.620	-337.221	108.091	-110.063		
	5	89.273	16.743	71.496	-144.203	127.620	-288.414	116.286	-90.360		
	6	184.598	34.622	89.280	-126.516	127.620	-241.451	126.753	-72.928		
	7	279.923	52.500	106.625	-109.290	166.867	-196.598	139.442	-57.716		
	8	375.248	70.379	123.440	-92.615	218.173	-154.122	154.289	-44.663		
	9	470.573	88.257	139.636	-76.582	269.700	-114.932	171.221	-33.695		
	10	565.898	106.136	155.121	-61.280	319.877	-82.884	190.151	-24.723		
	11	661.223	124.014	169.807	-46.800	368.439	-60.173	210.982	-17.654		
	12	756.548	141.893	183.602	-33.232	415.118	-40.797	233.607	-12.379		
	13	851.873	159.771	196.417	-20.665	459.649	-22.960	257.904	-8.776		
	14	947.198	177.650	208.162	-9.191	501.766	-13.489	283.743	-6.715		
	15	1042.523	195.528	218.747	-5.264	541.201	-13.489	310.981	-6.053		
	2	15	-1334.550	-250.299	10.541	-219.479	27.011	-600.125	12.125	-402.725	
		16	-1239.225	-232.421	10.541	-215.040	27.011	-581.570	12.400	-375.100	
		17	-1143.900	-214.542	10.541	-209.828	27.011	-561.230	13.276	-348.076	
		18	-1048.575	-196.664	14.615	-203.903	27.011	-539.280	14.848	-321.748	
		19	-953.250	-178.785	21.042	-197.324	27.011	-515.899	17.203	-296.203	
	20	-857.925	-160.907	28.077	-190.153	37.635	-491.263	20.421	-271.521		





49	-470.573	-88.257	76.582	-139.636	114.932	-269.700	33.695	-171.221
50	-375.248	-70.379	92.615	-123.440	154.122	-218.173	44.663	-154.289
51	-279.923	-52.500	109.290	-106.625	196.598	-166.867	57.716	-139.442
52	-184.598	-34.622	126.516	-89.280	241.451	-127.620	72.928	-126.753
53	-89.273	-16.743	144.203	-71.496	288.414	-127.620	90.360	-116.286
54	6.052	1.135	162.262	-53.362	337.221	-127.620	110.063	-108.091
55	101.377	19.014	180.601	-45.058	387.606	-127.620	132.082	-102.209
56	196.702	36.892	199.132	-45.058	439.304	-127.620	156.441	-98.669
57	292.027	54.771	217.763	-45.058	492.047	-127.620	183.159	-97.487



**TABEL 5.17 MOMEN TERFAKTOR AKIBAT BEBAN HIDUP MAX POSITIF  
PADA GELAGAR INTERIOR  
(BERAT SENDIRI GELAGAR  $w_{gelagar} = 10,378$  kN/m)**

Bentang	Lokasi	Momen (kN m)						M <sub>LJ+M</sub> (all other)	M <sub>FL+M</sub> (fatigue)	Kombinasi Mu				Mu (kN m)
		DC	DW	Truck/tandem		Mgm	I			II	III	IV		
				max positif	lane max positif								Strength	
1	1	0.000	0.000	0.000	0.000	0.449	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	2	1221.824	229.157	2196.519	846.045	0.449	1691.569	1514.047	4589.699	3142.550	3650.021	1135.535	4589.699	
	3	1967.023	368.921	3876.064	1552.589	0.451	3021.843	2707.533	7885.367	5357.788	6264.341	2030.650	7885.367	
	4	2235.597	419.293	5115.327	2119.634	0.453	4041.235	3624.224	9970.818	6696.125	7908.496	2718.168	9970.818	
	5	2027.546	380.273	5981.540	2547.217	0.456	4790.266	4299.193	10913.416	7198.084	8635.164	3224.395	10913.416	
	6	1342.870	251.859	6449.945	2835.272	0.460	5252.584	4718.297	10685.979	6847.314	8423.089	3538.722	10685.979	
	7	181.569	34.054	6507.677	2983.826	0.465	5412.152	4867.459	9261.842	5627.775	7251.420	3650.595	9261.842	
	8	-1456.357	-273.144	6319.725	2992.880	0.471	5362.813	4827.595	6797.022	3633.311	5242.155	3620.696	6797.022	
	9	-3570.908	-669.735	6187.151	2862.434	0.487	5403.703	4861.115	3788.831	1163.060	2784.171	3645.836	3645.836	
	10	-6162.084	-1155.718	5629.187	2592.488	0.494	4975.146	4475.004	-693.193	-2342.656	-850.112	3356.253	3356.253	
	11	-9229.886	-1731.094	4715.953	2183.043	0.501	4231.858	3806.998	-6391.835	-6729.122	-5459.565	2855.248	-6729.122	
	12	-12774.310	-2395.862	3458.890	1634.097	0.508	3165.215	2849.121	-13321.426	-12004.957	-11055.392	2136.841	-13321.426	
	13	-16795.360	-3150.022	1936.989	958.316	0.521	1841.480	1659.830	-21371.810	-18103.902	-17551.457	1244.872	-21371.810	
	14	-21293.040	-3993.575	876.801	526.814	0.529	895.575	812.086	-29487.435	-24391.040	-24122.367	609.065	-29487.435	
	15	-26267.340	-4926.521	944.247	423.857	0.537	902.170	810.882	-36712.901	-30291.691	-30021.040	608.161	-36712.901	
	2	15	-26267.340	-4926.521	944.247	423.857	0.531	892.428	802.125	-36729.098	-30301.433	-30033.705	601.594	-36729.098
		16	-19832.900	-3719.722	809.193	411.299	0.527	784.521	707.703	-27547.906	-22768.101	-22532.745	530.777	-27547.906
		17	-13875.090	-2602.316	982.204	510.531	0.524	951.309	858.738	-18603.418	-15526.097	-15240.704	644.054	-18603.418
		18	-8393.902	-1574.302	1693.259	750.476	0.520	1561.606	1403.086	-9614.970	-8406.598	-7938.117	1052.315	-9614.970
	19	-3389.339	-635.681	2709.884	1158.414	0.517	2461.291	2209.207	-838.790	-1563.729	-825.342	1656.905	-1563.729	

20	1138.598	213.548	4170.023	1752.637	0.514	3749.377	3363.792	7889.730	5101.523	6226.336	2522.844	7889.730
21	5189.911	973.384	5536.349	2528.518	0.511	5053.752	4544.619	15951.955	11217.047	12733.173	3408.464	15951.955
22	8764.598	1643.828	6783.471	3429.145	0.508	6330.170	5709.401	23274.323	16738.596	18637.648	4282.051	23274.323
23	11862.660	2224.879	7889.548	4335.935	0.506	7506.457	6787.593	29736.846	21593.996	23845.933	5090.695	29736.846
24	14484.100	2716.538	8836.286	5103.185	0.504	8500.201	7698.096	35202.520	25700.839	28250.899	5773.572	35202.520
25	16628.910	3118.804	9608.940	5730.935	0.503	9305.392	8435.917	39661.340	29053.106	31844.723	6326.938	39661.340
26	18297.100	3431.678	10196.310	6219.186	0.502	9919.810	8999.389	43109.631	31648.588	34624.530	6749.541	43109.631
27	19488.660	3655.159	10590.750	6567.936	0.501	10339.209	9384.898	45540.320	33483.028	36584.791	7038.673	45540.320
28	20203.600	3789.248	10788.150	6777.186	0.500	10562.713	9591.779	46951.963	34555.561	37724.375	7193.834	46951.963
29	20441.910	3833.944	10787.950	6846.936	0.500	10595.335	9624.614	47352.883	34871.189	38049.790	7218.460	47352.883
30	20203.600	3789.248	10788.150	6777.186	0.500	10562.713	9591.779	46951.963	34555.561	37724.375	7193.834	46951.963
31	19488.660	3655.159	10590.750	6567.936	0.501	10339.209	9384.898	45540.320	33483.028	36584.791	7038.673	45540.320
32	18297.100	3431.678	10196.310	6219.186	0.502	9919.810	8999.389	43109.631	31648.588	34624.530	6749.541	43109.631
33	16628.910	3118.804	9608.940	5730.935	0.503	9305.392	8435.917	39661.340	29053.106	31844.723	6326.938	39661.340
34	14484.100	2716.538	8836.286	5103.185	0.504	8500.201	7698.096	35202.520	25700.839	28250.899	5773.572	35202.520
35	11862.660	2224.879	7889.548	4335.935	0.506	7506.457	6787.593	29736.846	21593.996	23845.933	5090.695	29736.846
36	8764.598	1643.828	6783.471	3429.145	0.508	6330.170	5709.401	23274.323	16738.596	18637.648	4282.051	23274.323
37	5189.911	973.384	5536.349	2528.518	0.511	5053.752	4544.619	15951.955	11217.047	12733.173	3408.464	15951.955
38	1138.598	213.548	4170.023	1752.637	0.514	3749.377	3363.792	7889.730	5101.523	6226.336	2522.844	7889.730
39	-3389.339	-635.681	2709.884	1158.414	0.517	2461.291	2209.207	-838.790	-1563.729	-825.342	1656.905	-1563.729
40	-8393.902	-1574.302	1693.259	750.476	0.520	1561.606	1403.086	-9614.970	-8406.598	-7938.117	1052.315	-9614.970
41	-13875.090	-2602.316	982.204	510.531	0.524	951.309	858.738	-18603.418	-15526.097	-15240.704	644.054	-18603.418
42	-19832.900	-3719.722	809.193	411.299	0.527	784.521	707.703	-27547.906	-22768.101	-22532.745	530.777	-27547.906
43	-26267.340	-4926.521	944.247	423.857	0.531	892.428	802.125	-36729.098	-30301.433	-30033.705	601.594	-36729.098
44	-26267.340	-4926.521	944.247	423.857	0.537	902.170	810.882	-36712.901	-30291.691	-30021.040	608.161	-36712.901
45	-21293.040	-3993.575	876.801	526.814	0.529	895.575	812.086	-29487.435	-24391.040	-24122.367	609.065	-29487.435
46	-16795.360	-3150.022	1936.989	958.316	0.521	1841.480	1659.830	-21371.810	-18103.902	-17551.457	1244.872	-21371.810
47	-12774.310	-2395.862	3458.890	1634.097	0.508	3165.215	2849.121	-13321.426	-12004.957	-11055.392	2136.841	-13321.426
3	-9229.886	-1731.094	4715.953	2183.043	0.501	4231.858	3806.998	-6391.835	-6729.122	-5459.565	2855.248	-6729.122

48	-6162.084	-1155.718	5629.187	2592.488	0.494	4975.146	4475.004	-693.193	-2342.656	-850.112	3356.253	3356.253
49	-3570.908	-669.735	6187.151	2862.434	0.487	5403.703	4861.115	3788.831	1163.060	2784.171	3645.836	3645.836
50	-1456.357	-273.144	6319.725	2992.880	0.471	5362.813	4827.595	6797.022	3633.311	5242.155	3620.696	6797.022
51	181.569	34.054	6507.677	2983.826	0.465	5412.152	4867.459	9261.842	5627.775	7251.420	3650.595	9261.842
52	1342.870	251.859	6449.945	2835.272	0.460	5252.584	4718.297	10685.979	6847.314	8423.089	3538.722	10685.979
53	2027.546	380.273	5981.540	2547.217	0.456	4790.266	4299.193	10913.416	7198.084	8635.164	3224.395	10913.416
54	2235.597	419.293	5115.327	2119.634	0.453	4041.235	3624.224	9970.818	6696.125	7908.496	2718.168	9970.818
55	1967.023	368.921	3876.064	1552.589	0.451	3021.843	2707.533	7885.367	5357.788	6264.341	2030.650	7885.367
56	1221.824	229.157	2196.519	846.045	0.449	1691.569	1514.047	4589.699	3142.550	3650.021	1135.535	4589.699
57	0.000	0.000	0.000	0.000	0.449	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Catatan :

Kombinasi I :  $\mu = \eta (1,25 DC + 1,5 DW + 1,75 (LL+IM))$

Kombinasi II :  $\mu = \eta (DC + DW + (LL+IM))$

Kombinasi III :  $\mu = \eta (DC + DW + 1,3 (LL+IM))$

Kombinasi IV :  $\mu = \eta (0,75 (LL+IM))$





20	1138.598	213.548	-2161.985	-1405.208	0.514	-2198.969	-1999.059	-1999.395	-846.823	-1506.514	-1499.294	-1999.395
21	5189.911	973.384	-2026.932	-995.342	0.511	-1885.814	-1699.414	4414.925	4277.480	3711.736	-1274.560	4414.925
22	8764.598	1643.828	-1891.878	-849.457	0.508	-1711.099	-1537.969	9905.713	8697.327	8183.997	-1153.477	9905.713
23	11862.660	2224.879	-1756.824	-849.701	0.506	-1612.893	-1452.819	14575.926	12474.646	11990.778	-1089.614	14575.926
24	14484.100	2716.538	-1621.771	-849.702	0.504	-1516.257	-1369.043	18550.158	15684.381	15229.503	-1026.782	18550.158
25	16628.910	3118.804	-1486.717	-849.740	0.503	-1421.170	-1286.643	21828.431	18326.544	17900.193	-964.982	21828.431
26	18297.100	3431.678	-1351.664	-849.740	0.502	-1327.698	-1205.683	24410.650	20401.080	20002.771	-904.262	24410.650
27	19488.660	3655.159	-1216.610	-849.740	0.501	-1235.396	-1125.770	26297.539	21908.423	21537.804	-844.328	26297.539
28	20203.600	3789.248	-1081.557	-849.740	0.500	-1144.105	-1046.765	27489.378	22848.743	22505.511	-785.074	27489.378
29	20441.910	3833.944	-946.503	-849.740	0.500	-1054.084	-968.915	27985.724	23221.770	22905.545	-726.687	27985.724
30	20203.600	3789.248	-1081.557	-849.740	0.500	-1144.105	-1046.765	27489.378	22848.743	22505.511	-785.074	27489.378
31	19488.660	3655.159	-1216.610	-849.740	0.501	-1235.396	-1125.770	26297.539	21908.423	21537.804	-844.328	26297.539
32	18297.100	3431.678	-1351.664	-849.740	0.502	-1327.698	-1205.683	24410.650	20401.080	20002.771	-904.262	24410.650
33	16628.910	3118.804	-1486.717	-849.740	0.503	-1421.170	-1286.643	21828.431	18326.544	17900.193	-964.982	21828.431
34	14484.100	2716.538	-1621.771	-849.702	0.504	-1516.257	-1369.043	18550.158	15684.381	15229.503	-1026.782	18550.158
35	11862.660	2224.879	-1756.824	-849.721	0.506	-1612.904	-1452.829	14575.909	12474.635	11990.764	-1089.622	14575.909
36	8764.598	1643.828	-1891.878	-849.457	0.508	-1711.099	-1537.969	9905.713	8697.327	8183.997	-1153.477	9905.713
37	5189.911	973.384	-2026.932	-995.342	0.511	-1885.814	-1699.414	4414.925	4277.480	3711.736	-1274.560	4414.925
38	1138.598	213.548	-2161.985	-1405.208	0.514	-2198.969	-1999.059	-1999.395	-846.823	-1506.514	-1499.294	-1999.395
39	-3389.339	-635.681	-2297.039	-2136.219	0.517	-2682.854	-2469.174	-9390.930	-6707.874	-7512.730	-1851.881	-9390.930
40	-8393.902	-1574.302	-3411.930	-3193.048	0.520	-4020.849	-3701.431	-18895.800	-13989.053	-15195.307	-2776.073	-18895.800
41	-13875.090	-2602.316	-5055.651	-4557.337	0.524	-5906.916	-5430.431	-30005.218	-22384.322	-24156.397	-4072.824	-30005.218
42	-19832.900	-3719.722	-6907.961	-6201.852	0.527	-8116.391	-7460.604	-42345.672	-31669.013	-34103.930	-5595.453	-42345.672
43	-26267.340	-4926.521	-8933.415	-8097.660	0.531	-10614.897	-9760.559	-55860.025	-41808.758	-44993.227	-7320.419	-55860.025
43	-26267.340	-4926.521	-8933.415	-8097.660	0.537	-10730.776	-9867.111	-56052.673	-41924.637	-45143.869	-7400.333	-56052.673
44	-21293.040	-3993.575	-8295.314	-6745.740	0.529	-9404.831	-8614.951	-46611.860	-34691.446	-37512.895	-6461.213	-46611.860
45	-16795.360	-3150.022	-7657.213	-5861.863	0.521	-8359.943	-7641.850	-38331.677	-28305.325	-30813.308	-5731.387	-38331.677
46	-12774.310	-2395.862	-7019.112	-5361.764	0.508	-7461.760	-6820.311	-30988.772	-22631.932	-24870.460	-5115.233	-30988.772
47	-9229.886	-1731.094	-6381.011	-4874.331	0.501	-6687.218	-6112.353	-24544.799	-17648.198	-19654.364	-4584.265	-24544.799
3												

48	-6162.084	-1155.718	-5742.910	-4386.898	0.494	-5935.524	-5425.278	-18832.182	-13253.326	-15033.984	-4068.959	-18832.182
49	-3570.908	-669.735	-5104.809	-3899.465	0.487	-5207.613	-4759.942	-13852.482	-9448.256	-11010.540	-3569.956	-13852.482
50	-1456.357	-273.144	-4466.708	-3412.031	0.471	-4400.470	-4022.185	-9434.436	-6129.971	-7450.112	-3016.638	-9434.436
51	181.569	34.054	-3828.607	-2924.599	0.465	-3727.741	-3407.286	-5933.229	-3512.118	-4630.440	-2555.465	-5933.229
52	1342.870	251.859	-3190.506	-2437.165	0.460	-3074.384	-2810.095	-3157.605	-1479.654	-2401.969	-2107.571	-3157.605
53	2027.546	380.273	-2552.404	-1949.732	0.456	-2437.594	-2228.047	-1102.901	-29.776	-761.054	-1671.035	-1671.035
54	2235.597	419.293	-1914.303	-1462.300	0.453	-1815.369	-1659.312	234.212	839.521	294.910	-1244.484	-1244.484
55	1967.023	368.921	-1276.202	-974.866	0.451	-1203.833	-1100.345	860.181	1132.112	770.962	-825.259	1132.112
56	1221.824	229.157	-638.101	-487.433	0.449	-599.912	-548.341	780.111	851.069	671.095	-411.256	851.069
57	0.000	0.000	0.000	0.000	0.449	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Catatan :

Kombinasi I :  $\mu = \eta (1,25 DC + 1,5 DW + 1,75 (LL+IM))$

Kombinasi II :  $\mu = \eta (DC + DW + (LL+IM))$

Kombinasi III :  $\mu = \eta (DC + DW + 1,3 (LL+IM))$

Kombinasi IV :  $\mu = \eta (0,75 (LL+IM))$



**TABEL 5.19 GAYA GESER TERFAKTOR AKIBAT BEBAN HIDUP MAX POSITIF  
PADA GELAGAR INTERIOR  
(BERAT SENDIRI GELAGAR  $W_{gelagar} = 10,378 \text{ kN/m}$ )**

Bentang	Lokasi	Gaya geser (kN)				Mgv	$V_{LL+M}$ (all other)	$V_{LL+M}$ (fatigue)	Kombinasi Vu				Vu (kN)
		DC	DW	Truck/tandem max positif	lane max positif				I Strength	II Service 1	III Service 2	IV Fatigue	
1	1	-292.027	-54.771	127.620	97.487	0.671	179.306	163.892	-126.735	-167.492	-113.701	122.919	-167.492
	2	-196.702	-36.892	127.620	98.669	0.671	180.099	164.685	13.259	-53.496	0.534	123.514	123.514
	3	-101.377	-19.014	127.620	102.209	0.671	182.474	167.060	155.883	62.083	116.825	125.295	155.883
	4	-6.052	-1.135	127.620	108.091	0.671	186.421	171.007	301.120	179.234	235.160	128.255	301.120
	5	89.273	16.743	127.620	116.286	0.671	191.920	176.506	448.937	297.936	355.512	132.379	448.937
	6	184.598	34.622	127.620	126.753	0.671	198.943	183.529	599.289	418.163	477.846	137.647	599.289
	7	279.923	52.500	166.867	139.442	0.671	242.483	222.329	810.349	574.906	647.651	166.746	810.349
	8	375.248	70.379	218.173	154.289	0.671	298.232	271.881	1041.707	743.859	833.328	203.911	1041.707
	9	470.573	88.257	269.700	171.221	0.671	355.578	323.003	1275.720	914.408	1021.081	242.252	1275.720
	10	565.898	106.136	319.877	190.151	0.671	413.059	374.424	1509.958	1085.093	1209.010	280.818	1509.958
	11	661.223	124.014	368.439	210.982	0.671	470.375	425.875	1743.921	1255.612	1396.725	319.406	1743.921
	12	756.548	141.893	415.118	233.607	0.671	527.214	477.076	1977.091	1425.655	1583.819	357.807	1977.091
	13	851.873	159.771	459.649	257.904	0.671	583.258	527.742	2208.940	1594.902	1769.880	395.806	2208.940
	14	947.198	177.650	501.766	283.743	0.671	638.183	577.579	2438.927	1763.030	1954.485	433.184	2438.927
	15	1042.523	195.528	541.201	310.981	0.671	691.652	626.286	2666.496	1929.704	2137.199	469.715	2666.496
	16	-1334.550	-250.299	27.011	12.125	0.671	32.241	28.979	-1887.853	-1552.608	-1542.935	21.734	-1887.853
	17	-1239.225	-232.421	27.011	12.400	0.671	32.426	29.163	-1748.871	-1439.220	-1429.492	21.873	-1748.871
	18	-1143.900	-214.542	27.011	13.276	0.671	33.014	29.751	-1609.218	-1325.428	-1315.524	22.313	-1609.218
	19	-1048.575	-196.664	27.011	14.848	0.671	34.068	30.806	-1468.790	-1211.170	-1200.950	23.105	-1468.790
2		-953.250	-178.785	27.011	17.203	0.671	35.649	32.386	-1327.487	-1096.386	-1085.692	24.290	-1327.487



20	-857.925	-160.907	37.635	20.421	0.671	47.289	42.744	-1169.460	-971.542	-957.356	32.058	-1169.460
21	-762.600	-143.028	52.681	24.575	0.671	63.504	57.141	-1003.827	-842.124	-823.073	42.856	-1003.827
22	-667.275	-125.150	71.255	29.729	0.671	83.538	74.932	-831.845	-708.886	-683.825	56.199	-831.845
23	-571.950	-107.271	91.835	35.940	0.671	106.072	94.980	-655.707	-573.149	-541.327	71.235	-655.707
24	-476.625	-89.393	113.999	43.258	0.671	130.762	116.993	-475.984	-435.255	-396.027	87.745	-475.984
25	-381.300	-71.514	137.570	51.725	0.671	157.479	140.863	-292.892	-295.335	-248.091	105.648	-295.335
26	-285.975	-53.636	162.369	61.375	0.671	186.086	166.475	-106.659	-153.525	-97.699	124.856	-153.525
27	-190.650	-35.757	188.220	72.234	0.671	216.442	193.709	82.485	-9.965	54.908	145.282	145.282
28	-95.325	-17.879	214.946	84.322	0.671	248.404	222.443	274.297	135.201	209.722	166.832	274.297
29	0.000	0.000	242.368	97.650	0.671	281.820	252.546	468.525	281.820	366.366	189.410	468.525
30	95.325	17.879	270.310	112.222	0.671	316.534	283.886	664.913	429.737	524.697	212.914	664.913
31	190.650	35.757	298.594	128.034	0.671	352.385	316.321	863.191	578.792	684.508	237.241	863.191
32	285.975	53.636	327.043	145.075	0.671	389.208	349.708	1063.085	728.819	845.581	262.281	1063.085
33	381.300	71.514	355.479	163.325	0.671	426.831	383.896	1264.308	879.645	1007.695	287.922	1264.308
34	476.625	89.393	383.725	182.758	0.671	465.078	418.732	1466.569	1031.096	1170.619	314.049	1466.569
35	571.950	107.271	411.604	203.340	0.671	503.769	454.055	1669.568	1182.990	1334.121	340.542	1669.568
36	667.275	125.150	438.938	225.029	0.671	542.716	489.701	1872.992	1335.140	1497.955	367.276	1872.992
37	762.600	143.028	465.550	247.775	0.671	581.728	525.499	2076.525	1487.356	1661.874	394.124	2076.525
38	857.925	160.907	491.263	271.521	0.671	620.608	561.274	2279.839	1639.440	1825.622	420.955	2279.839
39	953.250	178.785	515.899	296.203	0.671	659.156	596.846	2482.600	1791.191	1988.938	447.634	2482.600
40	1048.575	196.664	539.280	321.748	0.671	697.163	632.028	2684.461	1942.401	2151.550	474.021	2684.461
41	1143.900	214.542	561.230	348.076	0.671	734.417	666.632	2885.073	2092.859	2313.185	499.974	2885.073
42	1239.225	232.421	581.570	375.100	0.671	770.703	700.461	3084.072	2242.348	2473.559	525.345	3084.072
43	1334.550	250.299	600.125	402.725	0.671	805.798	733.315	3281.093	2390.647	2632.386	549.986	3281.093
44	-1042.523	-195.528	13.489	6.053	0.671	16.100	14.470	-1489.859	-1221.952	-1217.122	10.853	-1489.859
45	-947.198	-177.650	13.489	6.715	0.671	16.544	14.915	-1350.444	-1108.304	-1103.341	11.186	-1350.444
46	-851.873	-159.771	22.960	8.776	0.671	26.379	23.606	-1195.418	-985.265	-977.352	17.704	-1195.418
47	-756.548	-141.893	40.797	12.379	0.671	44.715	39.787	-1026.259	-853.726	-840.311	29.840	-1026.259
3	-661.223	-124.014	60.173	17.654	0.671	65.546	58.278	-852.952	-719.691	-700.027	43.709	-852.952

48	-565.898	-106.136	82.884	24.723	0.671	90.557	80.547	-672.696	-581.476	-554.309	60.410	-672.696
49	-470.573	-88.257	114.932	33.695	0.671	125.178	111.297	-476.463	-433.652	-396.099	83.472	-476.463
50	-375.248	-70.379	154.122	44.663	0.671	167.512	148.897	-267.408	-278.115	-227.861	111.673	-278.115
51	-279.923	-52.500	196.598	57.716	0.671	214.177	190.432	-51.151	-118.246	-53.992	142.824	142.824
52	-184.598	-34.622	241.451	72.928	0.671	264.413	235.250	171.040	45.193	124.517	176.438	171.040
53	-89.273	-16.743	288.414	90.360	0.671	318.021	283.186	398.839	212.005	307.411	212.390	398.839
54	6.052	1.135	337.221	110.063	0.671	374.798	334.069	631.907	381.986	494.425	250.552	631.907
55	101.377	19.014	387.606	132.082	0.671	434.538	387.723	869.900	554.929	685.291	290.792	869.900
56	196.702	36.892	439.304	156.441	0.671	497.020	443.961	1112.451	730.614	879.720	332.971	1112.451
57	292.027	54.771	492.047	183.159	0.671	562.017	502.588	1359.184	908.815	1077.420	376.941	1359.184

Catatan :

Kombinasi I :  $V_u = \eta (1,25 DC + 1,5 DW + 1,75 (LL+IM))$

Kombinasi II :  $V_u = \eta ( DC + DW + (LL+IM))$

Kombinasi III :  $V_u = \eta ( DC + DW + 1,3 (LL+IM))$

Kombinasi IV :  $V_u = \eta ( 0,75 (LL+IM))$



**TABEL 5.20 GAYA GESER TERFAKTOR AKIBAT BEBAN HIDUP MAX NEGATIF  
PADA GELAGAR INTERIOR  
(BERAT SENDIRI GELAGAR  $w_{gelagar} = 10,378$  kN/m)**

Bentang	Lokasi	Gaya geser (kN)					Mgv	$V_{L+IM}$ (all other)	$V_{L+IM}$ (fatigue)	Kombinasi Vu				Vu (kN)
		DC	DW	Truck/tandem max negatif	lane max negatif	I Strength				II Service 1	III Service 2	IV Fatigue		
1	1	-292.027	-54.771	-492.047	-183.159	0.671	-562.017	-502.588	-1359.184	-908.815	-1077.420	-376.941	-1359.184	
	2	-196.702	-36.892	-439.304	-156.441	0.671	-497.020	-443.961	-1112.451	-730.614	-879.720	-332.971	-1112.451	
	3	-101.377	-19.014	-387.606	-132.082	0.671	-434.538	-387.723	-869.900	-554.929	-685.291	-290.792	-869.900	
	4	-6.052	-1.135	-337.221	-110.063	0.671	-374.798	-334.069	-631.907	-381.986	-494.425	-250.552	-631.907	
	5	89.273	16.743	-288.414	-90.360	0.671	-318.021	-283.186	-398.839	-212.005	-307.411	-212.390	-398.839	
	6	184.598	34.622	-241.451	-72.928	0.671	-264.413	-235.250	-171.040	-45.193	-124.517	-176.438	-171.040	
	7	279.923	52.500	-196.598	-57.716	0.671	-214.177	-190.432	51.151	118.246	53.992	-142.824	-142.824	
	8	375.248	70.379	-154.122	-44.663	0.671	-167.512	-148.897	267.408	278.115	227.861	-111.673	278.115	
	9	470.573	88.257	-114.932	-33.695	0.671	-125.178	-111.297	476.463	433.652	396.099	-83.472	476.463	
	10	565.898	106.136	-82.884	-24.723	0.671	-90.557	-80.547	672.696	581.476	554.309	-60.410	672.696	
	11	661.223	124.014	-60.173	-17.654	0.671	-65.546	-58.278	852.952	719.691	700.027	-43.709	852.952	
	12	756.548	141.893	-40.797	-12.379	0.671	-44.715	-39.787	1026.259	853.726	840.311	-29.840	1026.259	
	13	851.873	159.771	-22.960	-8.776	0.671	-26.379	-23.606	1195.418	985.265	977.352	-17.704	1195.418	
	14	947.198	177.650	-13.489	-6.715	0.671	-16.544	-14.915	1350.444	1108.304	1103.341	-11.186	1350.444	
	15	1042.523	195.528	-13.489	-6.053	0.671	-16.100	-14.470	1489.859	1221.952	1217.122	-10.853	1489.859	
	16	-1334.550	-250.299	-600.125	-402.725	0.671	-805.798	-733.315	-3281.093	-2390.647	-2632.386	-549.986	-3281.093	
	17	-1239.225	-232.421	-581.570	-375.100	0.671	-770.703	-700.461	-3084.072	-2242.348	-2473.559	-525.345	-3084.072	
	18	-1143.900	-214.542	-561.230	-348.076	0.671	-734.417	-666.632	-2885.073	-2092.859	-2313.185	-499.974	-2885.073	
	19	-1048.575	-196.664	-539.280	-321.748	0.671	-697.163	-632.028	-2684.461	-1942.401	-2151.550	-474.021	-2684.461	
20	-953.250	-178.785	-515.899	-296.203	0.671	-659.156	-596.846	-2482.600	-1791.191	-1988.938	-447.634	-2482.600		



48	-565.898	-106.136	-319.877	-190.151	0.671	-413.059	-374.424	-1509.958	-1085.093	-1209.010	-280.818	-1509.958
49	-470.573	-88.257	-269.700	-171.221	0.671	-355.578	-323.003	-1275.720	-914.408	-1021.081	-242.252	-1275.720
50	-375.248	-70.379	-218.173	-154.289	0.671	-298.232	-271.881	-1041.707	-743.859	-833.328	-203.911	-1041.707
51	-279.923	-52.500	-166.867	-139.442	0.671	-242.483	-222.329	-810.349	-574.906	-647.651	-166.746	-810.349
52	-184.598	-34.622	-127.620	-126.753	0.671	-198.943	-183.529	-599.289	-418.163	-477.846	-137.647	-599.289
53	-89.273	-16.743	-127.620	-116.286	0.671	-191.920	-176.506	-448.937	-297.936	-355.512	-132.379	-448.937
54	6.052	1.135	-127.620	-108.091	0.671	-186.421	-171.007	-301.120	-179.234	-235.160	-128.255	-301.120
55	101.377	19.014	-127.620	-102.209	0.671	-182.474	-167.060	-155.883	-62.083	-116.825	-125.295	-155.883
56	196.702	36.892	-127.620	-98.669	0.671	-180.099	-164.685	-13.259	53.496	-0.534	-123.514	-123.514
57	292.027	54.771	-127.620	-97.487	0.671	-179.306	-163.892	126.735	167.492	113.701	-122.919	167.492

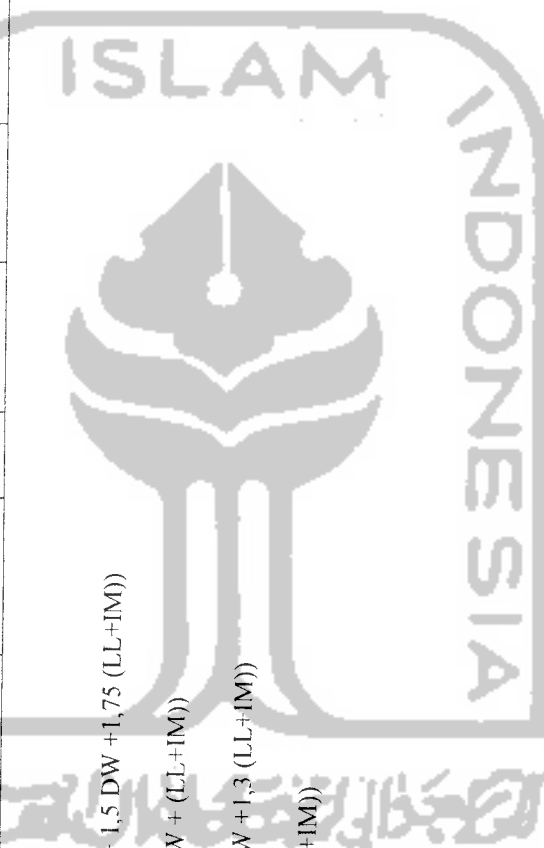
Catatan :

Kombinasi I :  $Vu = \eta (1,25 DC + 1,5 DW + 1,75 (LL+IM))$

Kombinasi II :  $Vu = \eta (DC + DW + (LL+IM))$

Kombinasi III :  $Vu = \eta (DC + DW + 1,3 (LL+IM))$

Kombinasi IV :  $Vu = \eta (0,75 (LL+IM))$



**TABEL 5.21 MOMEN SAAT PELAKSANAAN TIAP SEGMENT**  
 ( $W_{gelagar} = 10,378 \text{ kN/m}$ )

Bentang	Lokasi	Momen (kN m)		
		Akibat Berat Sendiri	Akibat Berat Alat	Mu
1	1	0.000	0.000	0.000
	2	-129.725	-2000.000	-2662.156
	3	-518.900	-4000.000	-5648.625
	4	-1167.525	-6000.000	-8959.406
	5	-2075.600	-8000.000	-12594.500
	6	-3243.125	-10000.000	-16553.906
	7	-4670.100	-12000.000	-20837.625
	8	-6356.525	-14000.000	-25445.656
	9	-8302.400	-16000.000	-30378.000
	10	-10507.720	-18000.000	-35634.650
	11	-12972.500	-20000.000	-41215.625
	12	-15696.720	-22000.000	-47120.900
	13	-18680.400	-24000.000	-53350.500
	14	-21923.530	-26000.000	-59904.413
	15	-25426.100	-28000.000	-66782.625
2	15	-25426.100	-28000.000	-66782.625
	16	-21923.530	-26000.000	-59904.413
	17	-18680.400	-24000.000	-53350.500
	18	-15696.720	-22000.000	-47120.900
	19	-12972.500	-20000.000	-41215.625
	20	-10507.720	-18000.000	-35634.650
	21	-8302.400	-16000.000	-30378.000
	22	-6356.525	-14000.000	-25445.656
	23	-4670.100	-12000.000	-20837.625
	24	-3243.125	-10000.000	-16553.906
	25	-2075.600	-8000.000	-12594.500
	26	-1167.525	-6000.000	-8959.406
	27	-518.900	-4000.000	-5648.625
	28	-129.725	-2000.000	-2662.156
29	0.000	0.000	0.000	

$$Mu = 1,25(M_{titik} + M_{merata})$$

**TABEL 5.22 GAYA GESER SAAT PELAKSANAAN TIAP SEGMENT**  
**( $W_{gelagar} = 10,378 \text{ kN/m}$ )**

Bentang	Lokasi	Gaya Geser (kN)		
		Akibat Berat Sendiri	Akibat Berat Alat	Vu
1	1	0.000	400.000	500.000
	2	51.890	400.000	564.863
	3	103.780	400.000	629.725
	4	155.670	400.000	694.588
	5	207.560	400.000	759.450
	6	259.450	400.000	824.313
	7	311.340	400.000	889.175
	8	363.230	400.000	954.038
	9	415.120	400.000	1018.900
	10	467.010	400.000	1083.763
	11	518.900	400.000	1148.625
	12	570.790	400.000	1213.488
	13	622.680	400.000	1278.350
	14	674.570	400.000	1343.213
	15	726.460	400.000	1408.075
2	15	-726.460	-400.000	-1408.075
	16	-674.570	-400.000	-1343.213
	17	-622.680	-400.000	-1278.350
	18	-570.790	-400.000	-1213.488
	19	-518.900	-400.000	-1148.625
	20	-467.010	-400.000	-1083.763
	21	-415.120	-400.000	-1018.900
	22	-363.230	-400.000	-954.038
	23	-311.340	-400.000	-889.175
	24	-259.450	-400.000	-824.313
	25	-207.560	-400.000	-759.450
	26	-155.670	-400.000	-694.588
	27	-103.780	-400.000	-629.725
	28	-51.890	-400.000	-564.863
	29	0.000	-400.000	-500.000

$$V_u = 1,25(V_{\text{utik}} + V_{\text{merata}})$$

TABEL 5.23 MOMEN RENCANA TIAP SEGMENT

Bentang	Lokasi	Momen Pelaksanaan (kN m)	Momen Service (kN m)		Momen Rencana (kN m)	
			Max Positif	Max Negatif	Positif	Negatif
1	1	0.000	0.000	0.000	0.000	0.000
	2	-2662.156	4589.699	851.069	4589.699	-2662.156
	3	-5648.625	7885.367	1132.112	7885.367	-5648.625
	4	-8959.406	9970.818	-1244.484	9970.818	-8959.406
	5	-12594.500	10913.416	-1671.035	10913.416	-12594.500
	6	-16553.906	10685.979	-3157.605	10685.979	-16553.906
	7	-20837.625	9261.842	-5933.229	9261.842	-20837.625
	8	-25445.656	6797.022	-9434.436	6797.022	-25445.656
	9	-30378.000	3645.836	-13852.482	3645.836	-30378.000
	10	-35634.650	3356.253	-18832.182	3356.253	-35634.650
	11	-41215.625	-6729.122	-24544.799		-41215.625
	12	-47120.900	-13321.426	-30988.772		-47120.900
	13	-53350.500	-21371.810	-38331.677		-53350.500
	14	-59904.413	-29487.435	-46611.860		-59904.413
2	15	-66782.625	-36712.901	-56052.673		-66782.625
	16	-66782.625	-36729.098	-55860.025		-66782.625
	17	-59904.413	-27547.906	-42345.672		-59904.413
	18	-53350.500	-18603.418	-30005.218		-53350.500
	19	-47120.900	-9614.970	-18895.800		-47120.900
	20	-41215.625	-1563.729	-9390.930		-41215.625
	21	-35634.650	7889.730	-1999.395	7889.730	-35634.650
	22	-30378.000	15951.955	4414.925	15951.955	-30378.000
	23	-25445.656	23274.323	9905.713	23274.323	-25445.656
	24	-20837.625	29736.846	14575.926	29736.846	-20837.625
	25	-16553.906	35202.520	18550.158	35202.520	-16553.906
	26	-12594.500	39661.340	21828.431	39661.340	-12594.500
	27	-8959.406	43109.631	24410.650	43109.631	-8959.406
	28	-5648.625	45540.320	26297.539	45540.320	-5648.625
	29	-2662.156	46951.963	27489.378	46951.963	-2662.156
		0.000	47352.883	27985.724	47352.883	0.000



TABEL 5.24 GAYA GESER RENCANA TIAP SEGMENT

Bentang	Lokasi	Gaya Geser Pelaksanaan (kN)	Gaya Geser Service (kN)		Gaya Geser Rencana (kN)	
			Max Positif	Max Negatif	Positif	Negatif
1	1	500.000	-167.492	-1359.184	500.000	-1359.184
	2	564.863	123.514	-1112.451	564.863	-1112.451
	3	629.725	155.883	-869.900	629.725	-869.900
	4	694.588	301.120	-631.907	694.588	-631.907
	5	759.450	448.937	-398.839	759.450	-398.839
	6	824.313	599.289	-171.040	824.313	-171.040
	7	889.175	810.349	-142.824	889.175	-142.824
	8	954.038	1041.707	278.115	1041.707	
	9	1018.900	1275.720	476.463	1275.720	
	10	1083.763	1509.958	672.696	1509.958	
	11	1148.625	1743.921	852.952	1743.921	
	12	1213.488	1977.091	1026.259	1977.091	
	13	1278.350	2208.940	1195.418	2208.940	
	14	1343.213	2438.927	1350.444	2438.927	
	15	1408.075	2666.496	1489.859	2666.496	
2	15	-1408.075	-1887.853	-3281.093		-3281.093
	16	-1343.213	-1748.871	-3084.072		-3084.072
	17	-1278.350	-1609.218	-2885.073		-2885.073
	18	-1213.488	-1468.790	-2684.461		-2684.461
	19	-1148.625	-1327.487	-2482.600		-2482.600
	20	-1083.763	-1169.460	-2279.839		-2279.839
	21	-1018.900	-1003.827	-2076.525		-2076.525
	22	-954.038	-831.845	-1872.992		-1872.992
	23	-889.175	-655.707	-1669.568		-1669.568
	24	-824.313	-475.984	-1466.569		-1466.569
	25	-759.450	-295.335	-1264.308		-1264.308
	26	-694.588	-153.525	-1063.085		-1063.085
	27	-629.725	145.282	-863.191	145.282	-863.191
	28	-564.863	274.297	-664.913	274.297	-664.913
29	-500.000	468.525	-468.525	468.525	-500.000	

TABEL 5.25 KAPASITAS MOMEN TIAP SEGMIEN

Lokasi	h (mm)	d (mm)	tw (mm)	h/tw	Aw (mm <sup>2</sup> )	Tf (mm)	bf (mm)	Af (mm <sup>2</sup> )	fr (mm)	Fcr (MPa)	Fer pakai (MPa)	ar	Rpg	Inersia 10 <sup>12</sup> (mm <sup>4</sup> )	Sx 10 <sup>9</sup> (mm <sup>3</sup> )	Re	Mn (kNm)	φ Mn (kNm)
1	2500.000	2616.000	14	178.571	35000.000	58	420	24360	108.903	587.890	345.000	1.437	0.970	0.09794	0.0749	0.975	24441.525	21997.37
2	2515.278	2631.278	14	179.663	35213.895	58	420	24360	108.839	416.808	345.000	1.446	0.969	0.09923	0.0754	0.975	24593.312	22133.98
3	2561.115	2677.115	14	182.937	35855.603	58	420	24360	108.647	371.561	345.000	1.472	0.966	0.10316	0.0771	0.975	25047.040	22542.33
4	2637.514	2753.514	14	188.394	36925.197	58	420	24360	108.329	371.155	345.000	1.516	0.961	0.10992	0.0798	0.974	25797.419	23217.67
5	2744.485	2860.485	14	196.035	38422.797	58	420	24360	107.889	376.627	345.000	1.577	0.954	0.11979	0.0838	0.974	26834.345	24150.91
6	2882.041	2998.041	14	205.860	40348.570	58	420	24360	107.331	369.217	345.000	1.656	0.943	0.13322	0.0889	0.973	28140.897	25326.80
7	3050.195	3166.195	14	217.871	42702.733	58	420	24360	106.660	363.682	345.000	1.753	0.929	0.15079	0.0953	0.972	29690.433	26721.38
8	3248.968	3364.968	14	232.069	45485.549	58	420	24360	105.882	359.351	345.000	1.867	0.912	0.17323	0.1030	0.971	31442.652	28298.38
9	3478.381	3638.381	14	248.456	48697.332	80	420	33600	108.812	360.349	345.000	1.449	0.919	0.26186	0.1439	0.975	44515.124	40063.61
10	3738.460	3898.460	14	267.033	52338.443	80	420	33600	108.029	357.046	345.000	1.558	0.899	0.30595	0.1570	0.974	47410.485	42669.43
11	4029.235	4189.235	14	287.803	56409.293	80	420	33600	107.173	354.321	345.000	1.679	0.874	0.36003	0.1719	0.973	50401.120	45361.00
12	4350.739	4510.739	14	310.767	60910.340	80	420	33600	106.250	351.836	345.000	1.813	0.843	0.42592	0.1888	0.972	53350.069	48015.06
13	4703.007	4863.007	18	261.278	84654.120	80	460	36800	112.900	358.330	345.000	2.300	0.857	0.57701	0.2373	0.967	67891.142	61102.02
14	5086.079	5246.079	18	282.560	91549.428	80	460	36800	111.647	355.910	345.000	2.488	0.819	0.68846	0.2625	0.965	71626.298	64463.66
15	5500.000	5660.000	18	305.556	99000.000	80	460	36800	110.339	354.415	345.000	2.690	0.774	0.82251	0.2906	0.964	74753.857	67278.47
15	5500.000	5660.000	18	305.556	99000.000	80	460	36800	110.339	354.415	345.000	2.690	0.774	0.82251	0.2906	0.964	74753.857	67278.47
16	5293.286	5453.286	18	294.071	95279.139	80	460	36800	110.986	355.159	345.000	2.589	0.797	0.75376	0.2764	0.965	73319.927	65987.93
17	5101.907	5261.907	18	283.439	91834.318	80	460	36800	111.596	358.225	345.000	2.495	0.818	0.69332	0.2635	0.965	71764.231	64587.80
18	4925.858	5085.858	18	273.659	88665.438	80	460	36800	112.166	360.228	345.000	2.409	0.836	0.64040	0.2518	0.966	70154.312	63138.88
19	4765.134	4925.134	18	264.730	85772.412	80	460	36800	112.694	362.522	345.000	2.331	0.851	0.59428	0.2413	0.967	68546.087	61691.47
20	4619.731	4779.731	18	256.652	83155.157	80	460	36800	113.178	365.449	345.000	2.260	0.865	0.55434	0.2320	0.968	66985.544	60286.98
21	4489.644	4649.644	18	249.425	80813.601	80	460	36800	113.616	368.668	345.000	2.196	0.877	0.52001	0.2237	0.968	65510.237	58959.21
22	4374.871	4534.871	18	243.048	78747.676	80	460	36800	114.008	375.331	345.000	2.140	0.887	0.49080	0.2165	0.969	64150.585	57735.52
23	4275.407	4435.407	18	237.523	76957.325	80	460	36800	114.350	368.119	345.000	2.091	0.895	0.46631	0.2103	0.969	62930.987	56637.88

24	4191.250	4351.250	18	232.847	75442.498	80	460	36800	114.642	360.572	345.000	2.050	0.902	0.44616	0.2051	0.969	61870.775	55683.69
25	4122.397	4282.397	18	229.022	74203.153	80	460	36800	114.882	355.353	345.000	2.016	0.908	0.43007	0.2009	0.970	60985.018	54886.51
26	4068.847	4228.847	18	226.047	73239.253	80	460	36800	115.071	351.098	345.000	1.990	0.912	0.41780	0.1976	0.970	60285.180	54256.66
27	4030.598	4190.598	18	223.922	72550.773	80	460	36800	115.205	347.468	345.000	1.971	0.915	0.40916	0.1953	0.970	59779.645	53801.68
28	4007.650	4167.650	18	222.647	72137.692	80	460	36800	115.287	344.124	344.124	1.960	0.916	0.40403	0.1939	0.970	59323.069	53390.76
29	4000.000	4160.000	18	222.222	72000.000	80	460	36800	115.314	344.151	344.151	1.957	0.917	0.40233	0.1934	0.970	59225.847	53303.26



## 5.12 Perencanaan pengaku

### 5.12.1 Pengaku antara (*intermediate stiffeners*)

a) Pengaku antara eksterior

- Perhitungan jarak

Pelat badan 14 mm x 2500 mm ;  $A_w = 35000 \text{ mm}^2$  ;  $F_{yw} = 248 \text{ Mpa}$

Ujung eksterior :  $V_u = 1359,184 \text{ kN}$  (Tabel 5.24)

Pada kekuatan paska tekuk panel ujung (yakni aksi medan tarik) tidak diperkenankan untuk digunakan. Persamaan 3.44 menggambarkan kekuatan geser nominal  $V_n$  dari panel ujung semacam ini,

$$V_n = C_v \cdot (0,6 \cdot F_{yw}) \cdot A_w \quad (3.50)$$

$$C_{v_{\text{perlu}}} = \frac{V_u / \phi_v}{0,6 \cdot F_{yw} \cdot A_w} = \frac{1359,184 \times 10^3 / 0,9}{0,6 \times 248 \times 35000} = 0,29$$

asumsi  $C_v < 0,8$

$$C_v = \frac{303000k}{\left(\frac{h}{t_w}\right)^2 F_{yw}} \quad (3.32)$$

$$C_v = \frac{303000 \cdot k}{178,571^2 \cdot 248} = \frac{k}{26,1} < 0,8 \dots \dots \text{ok}$$

$$k_{\text{perlu}} = 0,290 \times 26,1 = 7,569$$

$$k = 5 + \frac{5}{\left(\frac{a}{h}\right)^2} \quad (3.30)$$

$$a/h \text{ maks} = 1,395 ; a \text{ maks} = 3487,731 \text{ mm}$$

diambil  $a = 3200 \text{ mm}$

- Desain pengaku antara eksterior

Pada jarak 3200 mm

$$A_{st} = \frac{F_{ywr}}{F_{ywt}} \left( 0,15 \cdot D \cdot A_w (1 - C_v) \frac{V_u}{\phi V_n} - 18 t_w^2 \right) \quad (3.56)$$

Dimana :

$$h = 2509,78 \text{ mm}$$

$$t_w = 14 \text{ mm}$$

$$D = 1$$

$$V_u = 1359,184 - \frac{1359,184 - 1112,451}{5000} \cdot 3200 = 1201,275 \text{ kN}$$

$$V_u \leq \phi V_n \quad (3.37)$$

$$V_u = \phi V_n = 1201,275 \text{ kN}$$

$$k = 5 + \frac{5}{\left(\frac{a}{h}\right)^2} \quad (3.30)$$

$$k = 5 + \frac{5}{\left(\frac{3200}{2509,78}\right)^2} = 8,076$$

asumsi  $C_v < 0,8$

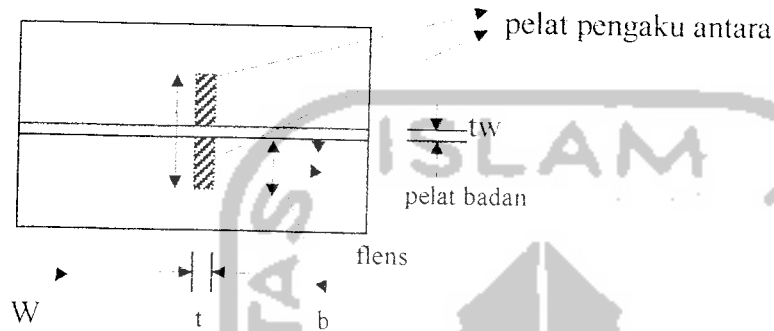
$$C_v = \frac{303000k}{\left(\frac{h}{t_w}\right)^2 F_{yw}} \quad (3.32)$$

$$C_v = \frac{303000 \cdot 8,076}{179,27^2 \cdot 248} = 0,307 < 0,8 \dots \dots \text{ok}$$

$$A_{st} = \frac{248}{248} \left( 0,15 \times 1 \times 35136,92 \times (1 - 0,307) \frac{1201,275}{1201,275} - 18 \times 14^2 \right) = 124,483 \text{ mm}^2$$

Kriteria tekuk lokal

$$\lambda = b/t \leq \lambda_{cr} = \frac{250}{\sqrt{I_{cr}}} = \frac{250}{\sqrt{248}} = 15,875$$



**Gambar 5.4** Penampang lintang pelat pengaku intermediate eksterior

Persyaratan kekakuan

$$I_{st} \geq J a_w^3$$

$$J = \frac{2,5}{\left(\frac{a}{h}\right)^2} - 2 \geq 0,5$$

$$J = \frac{2,5}{\left(\frac{3200}{2509,78}\right)^2} - 2 = -0,462 \approx 0,5$$

(3.54)

$$I_{st} \geq 0,5 \times 3200 \times 14^3 = 4390400 \text{ mm}^4$$

Untuk mendapatkan lebar pengaku yang layak maka :

$$r^2 \text{ perlu} = \frac{I_{st}}{A_{st}} = \frac{4390400}{124,483} = 35269,073 \text{ mm}^2$$

$$r^2 \text{ tersedia} = \frac{t.W^3}{12.t.W} = \frac{W^2}{12}$$

$$W \text{ perlu} = \sqrt{12 \times 35269,073} = 650,56 \text{ mm}$$

$$b = 0,5.(W - t_w) = 0,5 \times (650,56 - 14) \\ = 318,28 \text{ mm}$$

b diambil 193 mm

$$t = \frac{b}{\lambda_r} = \frac{193}{15,875} = 12,157 \text{ mm}$$

t diambil = 14 mm

cek kekakuan :

$$I_{st} = \frac{t.W^3}{12} = \frac{14 \times 400^3}{12} = 74666666,67 \text{ mm}^4 > J.a.t_w^3 = 4390400 \text{ mm}^4 \dots \dots \text{ok}$$

digunakan pengaku antara 2PLS-14 mm x 193 mm

a) Pengaku antara interior

- Perhitungan jarak

Pelat badan 18 mm x 5500 mm ;  $A_w = 99000 \text{ mm}^2$  ;  $F_{yw} = 248 \text{ Mpa}$

Ujung interior :  $V_u = 3281,093 \text{ kN}$

$$\frac{\phi_v V_{u-perlu}}{A_w} = \frac{V_u}{A_w} = \frac{3281,093 \cdot 10^3}{99000} = 33,142 \text{ MPa} = 4,807 \text{ Ksi}$$

$$\frac{h}{t_w} = \frac{5500}{18} = 305,556$$

dengan menggunakan LRFD " Numerical Values Table 10" yang berisi nilai  $\frac{\phi_v V_u}{A_w}$

sebagai fungsi dari  $h/t_w$  dan  $a/h$ . Untuk kasus ini tidak ditemukan nilai tabulasi untuk 4,807 Ksi dan  $h/t_w = 305,556$  ini berarti persamaan 3.47 mengendalikan.

$$a/h \text{ maks} = \left( \frac{260}{\frac{h}{t_w}} \right)^2 = \left( \frac{260}{305,556} \right)^2 = 0,724 < 3,0 \quad (3.53)$$

kriteria interaksi badan gelagar untuk geser yang dikombinasikan dengan tarik dari lentur.

$$\frac{Mu}{\phi Mn} \leq 0,75 \quad (3.37)$$

$$\frac{66782,625}{67278,47} = 0,993 > 0,75$$

Persyaratan interaksi akan mengendalikan panel ini

$$\frac{Mu}{\phi Mn} + 0,625 \left( \frac{Vu}{\phi Vn} \right) \leq 1,375 \quad (3.38)$$

$$\frac{Vu}{\phi Vn} \text{ perlu} = \frac{1,375 - 0,993}{0,625} = 0,6112$$

$$\phi Vn \text{ perlu} = \frac{Vu}{0,71} = \frac{3281,093}{0,6112} = 5368,280 \text{ kN}$$

$$\frac{\phi Vn \text{ perlu}}{Aw} = \frac{5368,280 \cdot 10^3}{99000} = 54,225 \text{ N/mm}^2 = 7,863 \text{ Ksi}$$

coba  $a/h = 0,7$

$$k = 5 + \frac{5}{\left( \frac{a}{h} \right)^2} \quad (3.30)$$

$$k = 5 + \frac{5}{0,7^2} = 15,204$$



asumsi  $C_v < 0,8$

$$C_v = \frac{303000k}{\left(\frac{h}{t_w}\right)^2 I_{yw}} \quad (3.32)$$

$$C_v = \frac{303000 \times 15,204}{305,556^2 \times 248} = 0,199 < 0,8 \dots\dots \text{ok}$$

$$V_n = 0,6 \cdot I_{yw} \cdot A_w \cdot \left( C_v + \frac{1 - C_v}{1,15 \sqrt{1 + (a/h)^2}} \right) \quad (3.35)$$

$$V_n = 0,6 \times 248 \times 99000 \cdot \left( 0,199 + \frac{1 - 0,199}{1,15 \sqrt{1 + (0,7)^2}} \right) = 11337320,7 N = 11337,321 kN$$

$$\phi V_n = 0,9 \times 11337,321 = 10203,589 \text{ kN} > \phi V_{n \text{ perlu}} = 5368,280 \text{ kN} \dots\dots \text{ok}$$

jarak maksimum ke pengaku intermediate pertama adalah :

$$a \text{ maks} = 0,7 \times 5500 = 3850 \text{ mm}$$

- Interior pada bentang 140 m

Panel 2 : Asumsi bahwa diagram geser linier sehingga pada jarak 3850mm dari tumpuan interior :

$$V_{u2} = 3281,693 - \frac{3281,093 - 3084,072}{5000} \times 3850 = 3129,387 kN$$

$$\frac{h}{t_w} = \frac{5340,83}{18} = 296,713$$

$$\frac{\phi V_{n \text{ perlu}}}{A_w} = \frac{V_{u2}}{A_w} = \frac{3129,387 \cdot 10^3}{96134,94} = 32,552 \text{ MPa} = 4,72 \text{ Ksi}$$

asumsi bahwa diagram momen adalah variasi linier pada jarak 3850mm momen terfaktor adalah 61486,402 kNm.

$$\frac{Mu}{\phi Mn} \leq 0,75 \quad (3.37)$$

$$\frac{61486,402}{66284,754} = 0,928 > 0,75$$

Persyaratan interaksi akan mengendalikan panel ini,

$$\frac{Mu}{\phi Mn} + 0,625 \left( \frac{Vu}{\phi Vn} \right) \leq 1,375 \quad (3.38)$$

$$\frac{Vu}{\phi Vn} \text{ perlu} = \frac{1,375 - 0,928}{0,625} = 0,715$$

$$\phi Vn \text{ perlu} = \frac{Vu}{0,715} = \frac{3129,387}{0,715} = 4376,765 \text{ kN}$$

$$\frac{\phi Vn \text{ perlu}}{Aw} = \frac{4376,765 \cdot 10^3}{96134,94} = 45,527 \text{ N/mm}^2 = 6,601 \text{ Ksi}$$

$$a/h \text{ maks} = \left( \frac{260}{h} \right)^2 = \left( \frac{260}{296,713} \right)^2 = 0,768 < 3,0 \quad (3.53)$$

$$a \text{ maks} = 0,768 \times 5340,83 = 4100,93 \text{ mm}$$

digunakan spasi pengaku sebagai berikut dimulai dari tumpuan interior : 1(3700 mm) dan 17(3900 mm).

- Desain pengaku antara

Pada jarak 3700 mm

$$Ast = \frac{F_{vw}}{F_{yst}} \left( 0,15 \cdot D \cdot A_w (1 - C_v) \frac{Vu}{\phi Vn} - 18l_w^2 \right) \quad (3.56)$$

Dimana :

$$h = 5347,032 \text{ mm}$$

$$t_w = 18 \text{ mm}$$

$$D = 1$$

$$V_u = 3281,093 - \frac{3281,093 - 3084,072}{5000} \cdot 3700 = 3135,297 \text{ kN}$$

$$\frac{M_u}{\phi M_n} \leq 0,75 \quad (3.37)$$

$$\frac{61692,748}{66323,470} = 0,930 > 0,75$$

$$\frac{M_u}{\phi M_n} + 0,625 \left( \frac{V_u}{\phi V_n} \right) \leq 1,375 \quad (3.38)$$

$$\frac{V_u}{\phi V_n} \text{ perlu} = \frac{1,375 - 0,930}{0,625} = 0,712$$

$$\phi V_{n \text{ perlu}} = \frac{V_u}{0,862} = \frac{3135,297}{0,712} = 4403,507 \text{ kN}$$

$$k = 5 + \frac{5}{\left( \frac{a}{h} \right)^2} \quad (3.30)$$

$$k = 5 + \frac{5}{\left( \frac{3700}{5347,032} \right)^2} = 15,442$$

asumsi  $C_v < 0,8$

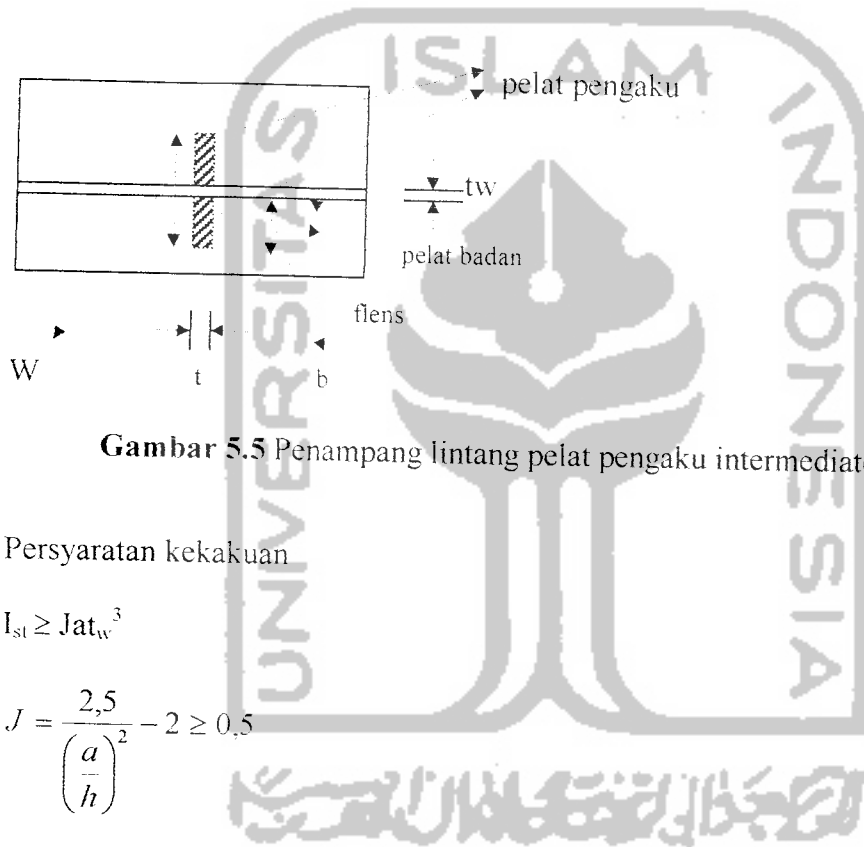
$$C_v = \frac{303000k}{\left( \frac{h}{t_w} \right)^2 F_{yv}} \quad (3.32)$$

$$C_v = \frac{303000 \times 15,442}{297,057^2 \times 248} = 0,214 < 0,8 \dots \dots \text{ok}$$

$$A_{st} = \frac{248}{248} \left( 0,15 \times 1 \times 96246,576 \times (1 - 0,214) \frac{3135,297}{4403,507} - 18 \times 18^2 \right) = 2247,4 \text{ mm}^2$$

Kriteria tekuk lokal

$$\lambda = b/t \leq \lambda_r = \frac{250}{\sqrt{f_{st}}} = \frac{250}{\sqrt{248}} = 15,875$$



**Gambar 5.5** Penampang lintang pelat pengaku intermediate interior

Persyaratan kekakuan

$$I_{st} \geq J a t_w^3$$

$$J = \frac{2,5}{\left(\frac{a}{h}\right)^2} - 2 \geq 0,5 \quad (3.54)$$

$$J = \frac{2,5}{\left(\frac{3700}{5347,032}\right)^2} - 2 = 3,221$$

$$I_{st} \geq 3,221 \times 3700 \times 18^3 = 69506214,22 \text{ mm}^4$$

Untuk mendapatkan lebar pengaku yang layak maka :

$$r^2 \text{ perlu} = \frac{I_{st}}{A_{st}} = \frac{69506214,22}{2247,4} = 30927,389 \text{ mm}^2$$

$$r^2 \text{ tersedia} = \frac{tW^3}{12.tW} = \frac{W^2}{12}$$

$$W \text{ perlu} = \sqrt{12 \times 30927,389} = 609,203 \text{ mm}$$

$$b = 0,5.(W - t_w) = 0,5 \times (609,203 - 18)$$

$$= 295,602 \text{ mm}$$

b diambil 210 mm

$$t = \frac{b}{\lambda_r} = \frac{210}{15,875} = 13,228 \text{ mm}$$

t diambil = 14 mm

cek kekakuan :

$$I_{st} = \frac{tW^3}{12} = \frac{14 \times 438^3}{12} = 98032284 \text{ mm}^4 > J.a.t_w^3 = 69506214,22 \text{ mm}^4 \dots\dots\dots \text{ok}$$

digunakan pengaku antara 2PLS-14 mm x 210 mm

- Interior pada bentang 70 m

Panel 2 : Asumsi bahwa diagram geser linier sehingga pada jarak 3850 dari tumpuan interior:

$$V_u = 3281,093 - \frac{3281,093 - 2438,927}{5000} \times 3850 = 2632,625 \text{ kN}$$

$$\frac{h}{t_w} = \frac{5181,281}{18} = 287,849$$

$$\frac{\phi_v V_{n-perlu}}{A_w} = \frac{V_u}{A_w} = \frac{2632,625 \cdot 10^3}{93263,058} = 28,228 \text{ MPa} = 4,093 \text{ Ksi}$$

asumsi bahwa diagram momen adalah variasi linier pada jarak 3850mm momen terfaktor adalah 61486,402 kNm.

$$\frac{Mu}{\phi Mn} \leq 0,75 \quad (3.37)$$

$$\frac{61486,402}{65111,066} = 0,944 > 0,75$$

Persyaratan interaksi akan mengendalikan panel ini

$$\frac{Mu}{\phi Mn} + 0,625 \left( \frac{Vu}{\phi Vn} \right) \leq 1,375 \quad (3.38)$$

$$\frac{Vu}{\phi Vn} \text{ perlu} = \frac{1,375 - 0,944}{0,625} = 0,690$$

$$\phi Vn \text{ perlu} = \frac{Vu}{0,690} = \frac{2632,625}{0,690} = 3817,612 \text{ kN}$$

$$\frac{\phi Vn \text{ perlu}}{Aw} = \frac{3817,612 \cdot 10^3}{93263,058} = 40,934 \text{ N/mm}^2 = 5,935 \text{ Ksi}$$

$$a/h \text{ maks} = \left( \frac{260}{\frac{h}{t_w}} \right)^2 = \left( \frac{260}{287,849} \right)^2 = 0,816 < 3,0 \quad (3.53)$$

$$a \text{ maks} = 0,816 \times 5181,281 = 4227,216 \text{ mm}$$

digunakan spasi pengaku sebagai berikut dimulai dari tumpuan interior : 1(3800 mm) dan 15(4200 mm).

- Desain pengaku antara

Pada jarak 3800 mm

$$A_{st} = \frac{F_{vw}}{F_{yst}} \left( 0,15 \cdot D \cdot A_w (1 - C_v) \frac{V_u}{\phi V_n} - 18 t_w^2 \right) \quad (3.56)$$

Dimana :

$$h = 5185,42 \text{ mm}$$

$$t_w = 18 \text{ mm}$$

$$D = 1$$

$$V_u = 3281,093 - \frac{3281,093 - 2438,927}{5000} \times 3800 = 2641,047 \text{ kN}$$

$$\frac{M_u}{\phi M_n} \leq 0,75 \quad (3.37)$$

$$\frac{61555,184}{65139,214} = 0,945 > 0,75$$

$$\frac{M_u}{\phi M_n} + 0,625 \left( \frac{V_u}{\phi V_n} \right) \leq 1,375 \quad (3.38)$$

$$\frac{V_u}{\phi V_n} \text{ perlu} = \frac{1,375 - 0,945}{0,625} = 0,688$$

$$\phi V_{n \text{ perlu}} = \frac{V_u}{0,688} = \frac{2641,047}{0,688} = 3838,543 \text{ kN}$$

$$k = 5 + \frac{5}{\left( \frac{a}{h} \right)^2} \quad (3.30)$$

$$k = 5 + \frac{5}{\left( \frac{3800}{5185,42} \right)^2} = 14,311$$

asumsi  $C_v < 0,8$

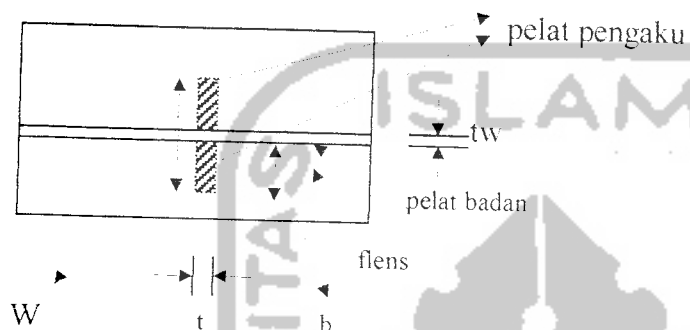
$$C_v = \frac{303000k}{\left( \frac{h}{t_w} \right)^2 F_{yw}} \quad (3.32)$$

$$C_v = \frac{303000 \times 14,311}{288,079^2 \times 248} = 0,211 < 0,8 \dots \dots \text{ok}$$

$$A_{st} = \frac{248}{248} \left( 0,15 \times 1 \times 93337,56 (1 - 0,211) \frac{2641,047}{3838,543} - 18 \times 18^2 \right) = 1768,365 \text{ mm}^2$$

Kriteria tekuk lokals

$$\lambda = b/t \leq \lambda_r = \frac{250}{\sqrt{F_{y,st}}} = \frac{250}{\sqrt{248}} = 15,875$$



Gambar 5.6 Penampang lintang pelat pengaku intermediate interior

Persyaratan kekakuan

$$I_{st} \geq J a t_w^3$$

$$J = \frac{2,5}{\left(\frac{a}{h}\right)^2} - 2 \geq 0,5 \quad (3.54)$$

$$J = \frac{2,5}{\left(\frac{3800}{5185,42}\right)^2} - 2 = 2,655$$

$$I_{st} \geq 2,655 \times 3800 \times 18^3 = 58844038,11 \text{ mm}^4$$

Untuk mendapatkan lebar pengaku yang layak maka :



$$r^2 \text{ perlu} = \frac{I_{st}}{A_{st}} = \frac{58844038,11}{1768,365} = 33275,957 \text{ mm}^2$$

$$r^2 \text{ tersedia} = \frac{tW^3}{12.tW} = \frac{W^2}{12}$$

$$W \text{ perlu} = \sqrt{12 \times 33275,957} = 631,911 \text{ mm}$$

$$b = 0,5.(W - t_w) = 0,5 \times (631,911 - 18) \\ = 306,955 \text{ mm}$$

b diambil 190 mm

$$t = \frac{b}{\lambda_r} = \frac{190}{15,875} = 11,969 \text{ mm}$$

t diambil = 12 mm

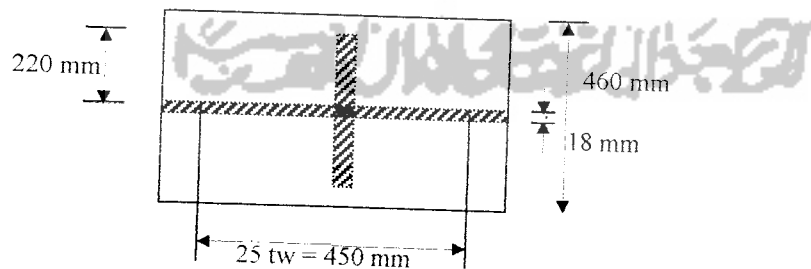
cek kekakuan :

$$I_{st} = \frac{tW^3}{12} = \frac{12 \times 398^3}{12} = 63044792 \text{ mm}^4 > J.a.t_w^3 = 58844038,11 \text{ mm}^4 \dots\dots\text{ok}$$

digunakan pengaku antara 2PLS-12 mm x 190 mm

### 5.12.2 Pengaku Tumpu (*Bearing Stiffeners*)

a) Desain pengaku tumpu interior



**Gambar 5.7** Penampang lintang pengaku tumpu pada tumpuan interior

$$W = \frac{460 - 18}{2} = 221 \text{ mm} ; \text{ diambil } 220 \text{ mm}$$

- kriteria stabilitas kolom :

$$\frac{K.L}{r} = 0,75 \cdot \frac{h}{r} \quad (3.44)$$

$$r \approx 0,25 \times 458 = 114,5 \text{ mm}$$

$$\frac{K.L}{r} \approx \frac{0,75 \times 5500}{114,5} = 36,026$$

dengan menggunakan LRFD tabel 3-36 "Numerical Values" ditemukan,

$$\phi_c F_{cr} = 28,577 \text{ Ksi} = 197,038 \text{ Mpa (untuk baja A36)}$$

$$A_e_{perlu} = \frac{Pu}{\phi_c F_{cr}} = \frac{3281,093 \cdot 10^3}{197,038} = 16652,082 \quad (3.46)$$

$$t_{perlu} = \frac{16652,082 - 450 \times 18}{2 \times 220} = 19,437 \text{ mm}$$

- kriteria tekuk lokal :

$$t_{\min} = \frac{W}{250 \sqrt{F_{yr}}} \quad (3.47)$$

$$t_{\min} = \frac{220}{250 \sqrt{248}} = 13,858 \text{ mm}$$

- kriteria tekuk lokal dengan menggunakan luas bidang kontak ( $A_{pb}$ )

$$\phi R_n \geq Pu \quad (3.48)$$

$$R_n = 2 \cdot F_y \cdot A_{pb}$$

$$A_{pb-perlu} = \frac{Pu}{\phi \cdot 2 \cdot F_y} = \frac{3281,093 \times 10^3}{0,75 \times 2 \times 248} = 8820,142 \text{ mm}^2$$

estimasi untuk memperhitungkan las fillet = 12,7 mm

$$A_{pb} = 2 \times (220 - 12,7) \times t$$

$$t_{perlu} = \frac{8820,142}{2 \times 207,3} = 21,274$$

kriteria tekuk lokal dengan menggunakan luas bidang kontak mengendalikan,

t dipakai = 22 mm

- cek rasio lebar terhadap tebal

$$\frac{W}{t} \leq \frac{250}{\sqrt{F_y}} \quad (3.47)$$

$$\frac{220}{22} = 10 < 15,875$$

- cek kekuatan :

$$\phi P_n \geq P_u \quad (3.45)$$

$$I = 1/12 \times 22 \times 458^3 = 176131838,7 \text{ mm}^4$$

$$A_{eff} = 2 \times 220 \times 22 + 25 \times 18^2 = 17780 \text{ mm}^2$$

$$r = \sqrt{\frac{I}{A_{eff}}} = \sqrt{\frac{176131838,7}{17780}} = 99,530$$

$$K.L = 0,75.h = 0,75 \times 5500 = 4125 \text{ mm}$$

$$\frac{K.L}{r} = \frac{4125}{99,530} = 41,445$$

$\phi F_{cr}$  dari tabel 3-36 LRFD didapat 27,957 Ksi = 192,761 Mpa

$$\phi P_n = \phi F_{cr} A_{eff} = 192,761 \times 10^3 \times 17780 = 3427,286 \text{ kN} > 3281,093 \text{ kN} \dots \text{ok}$$

- cek kriteria tumpu :

$$\phi R_n \geq P_u \quad (3.48)$$

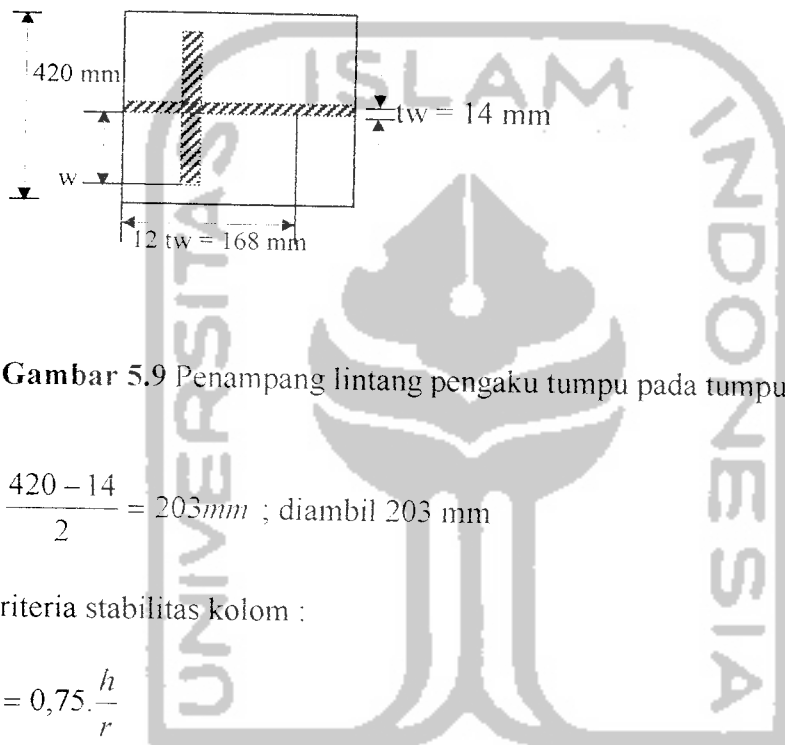
$$\phi R_n = 0,75 \cdot 2 \cdot F_y \cdot A_{pb}$$

$$A_{pb} = 2 \times (220 - 12,7) \times 22 = 9121,2 \text{ mm}^2$$

$$\phi R_n = 0,75 \times 2 \times 248 \times 10^{-3} \times 9121,2 = 3393,086 \text{ kN} > 3281,093 \text{ kN} \dots \text{ok}$$

digunakan pengaku tumpu interior 2PLS-22 mm x 220 mm

b) Desain pengaku tumpu eksterior



**Gambar 5.9** Penampang lintang pengaku tumpu pada tumpuan eksterior

$$W = \frac{420 - 14}{2} = 203 \text{ mm} ; \text{diambil } 203 \text{ mm}$$

- kriteria stabilitas kolom :

$$\frac{K.L}{r} = 0,75 \cdot \frac{h}{r} \quad (3.44)$$

$$r \approx 0,25 \times 420 = 105 \text{ mm}$$

$$\frac{K.L}{r} \approx \frac{0,75 \times 2500}{105} = 17,857$$

dengan menggunakan LRFD tabel 3-36 "Numerical Values" ditemukan,

$$\phi_c F_{cr} = 30,089 \text{ Ksi} = 207,461 \text{ Mpa} \text{ (untuk baja A36)}$$

$$Ae_{perlu} = \frac{Pu}{\phi_c F_{cr}} = \frac{1359,184 \cdot 10^3}{207,461} = 6551,523 \quad (3.46)$$

$$t_{\text{perlu}} = \frac{6551,523 - 168 \times 14}{2 \times 203} = 10,344 \text{ mm}$$

- kriteria tekuk lokal :

$$l_{\text{min}} = \frac{W}{250 \sqrt{F_{yw}}} \quad (3.47)$$

$$l_{\text{min}} = \frac{203}{250 \sqrt{248}} = 12,787 \text{ mm}$$

- kriteria tekuk lokal dengan menggunakan luas bidang kontak ( $A_{pb}$ )

$$\phi R_n \geq P_u \quad (3.48)$$

$$R_n = 2 \cdot F_y \cdot A_{pb}$$

$$A_{pb-\text{perlu}} = \frac{P_u}{\phi \cdot 2 \cdot F_y} = \frac{1359,184 \times 10^3}{0,75 \times 2 \times 248} = 3653,720 \text{ mm}^2$$

estimasi untuk memperhitungkan las fillet = 12,7 mm

$$A_{pb} = 2 \times (203 - 12,7) \times t$$

$$t_{\text{perlu}} = \frac{3653,720}{2 \times 190,3} = 9,6 \text{ mm}$$

kriteria tekuk lokal mengendalikan, t dipakai = 13 mm

- cek rasio lebar terhadap tebal

$$\frac{W}{t} \leq \frac{250}{\sqrt{F_y}} \quad (3.47)$$

$$\frac{203}{13} = 15,615 < 15,875$$

- cek kekuatan :

$$\phi P_n \geq P_u \quad (3.45)$$

$$I = 1/12 \times 13 \times 420^3 = 80262000 \text{ mm}^4$$

$$A_{eff} = 2 \times 203 \times 13 + 12 \times 14^2 = 7630 \text{ mm}^2$$

$$r = \sqrt{\frac{I}{A_{eff}}} = \sqrt{\frac{80262000}{7630}} = 102,562 \text{ mm}$$

$$K.L = 0,75.h = 0,75 \times 2500 = 1875 \text{ mm}$$

$$\frac{K.L}{r} = \frac{1875}{102,563} = 18,281$$

$\phi F_{cr}$  dari tabel 3-36 LRFD didapat 30,063 Ksi = 207,285 Mpa

$$\phi P_n = \phi F_{cr} A_{eff} = 207,285 \times 10^{-3} \times 7630 = 1581,587 \text{ kN} > 1359,184 \text{ kN} \dots \text{ok}$$

• cek kriteria tumpu :

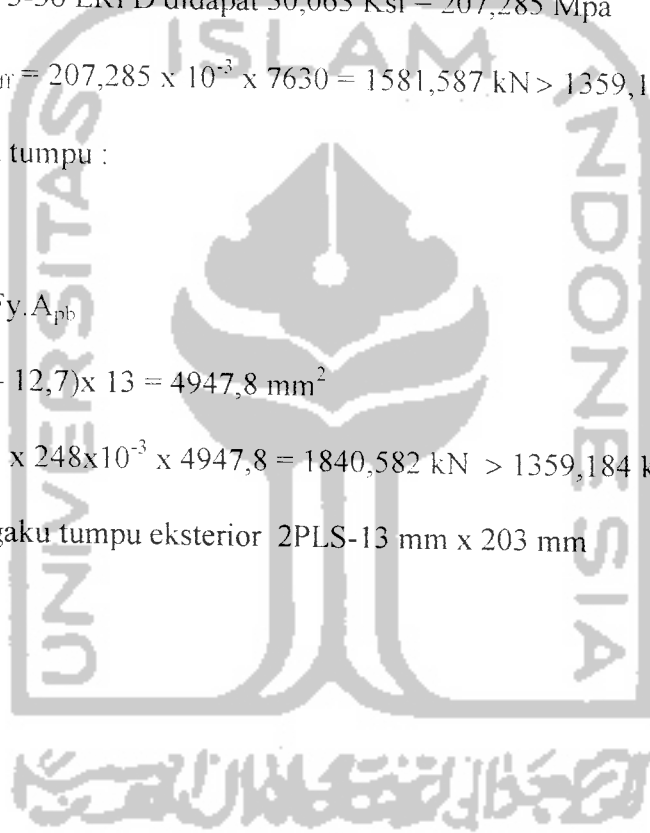
$$\phi R_n \geq P_u \tag{3.48}$$

$$\phi R_n = 0,75 \cdot 2 \cdot F_y \cdot A_{pb}$$

$$A_{pb} = 2 \times (203 - 12,7) \times 13 = 4947,8 \text{ mm}^2$$

$$\phi R_n = 0,75 \times 2 \times 248 \times 10^{-3} \times 4947,8 = 1840,582 \text{ kN} > 1359,184 \text{ kN} \dots \text{ok}$$

digunakan pengaku tumpu eksterior 2PLS-13 mm x 203 mm



### 5.13 Perhitungan las

a) Sambungan Flens kepelat badan

Ukuran las min  $a = 5/16 \text{ in} = 8 \text{ mm}$  (SMAW)

$$a_{\text{max efektif}} = 0,707 \frac{F_u t_1}{F_{EXX}}$$

$$= 0,707 \frac{400 \times 14}{482,65} = 8,203 \text{ mm}$$

Untuk E 70 (482,65 MPa) aliran geser  $\frac{V_u Q}{I_x}$

$$Q = A_f \left( \frac{h}{2} + \frac{t_f}{2} \right)$$

$$= 36800 \times \left( \frac{5500}{2} + \frac{80}{2} \right) = 102672000 \text{ mm}^3$$

$$V_u = 3281,093 \cdot 10^3 \text{ N}$$

$$I_x = 0,82251 \cdot 10^{12} \text{ mm}^4$$

$$\frac{V_u Q}{I_x} = \frac{3281,093 \cdot 10^3 \times 102672000}{0,82251 \cdot 10^{12}} = 409,571 \text{ N/mm}$$

samakan kekuatan dua las fillet dengan  $\frac{V_u Q}{I_x}$  :

$$R_{nW} = a \cdot 0,707 \cdot 0,6 \cdot F_{EXX}$$

$$2 \times a \times 0,707 \times 0,6 \times 482,65 = 409,57$$

$$a_{\text{perlu}} = 1 \text{ mm} < 8,203 \text{ mm}$$

gunakan las 5/16, E 70 menerus pada kedua sisi pelat badan. Kekuatan desain

$\phi R_{nW}$  untuk las menerus pada kedua sisi pelat badan adalah :

$$\phi R_{nW} = 0,75 \times 2 \times 0,707 \times 8,203 \times 0,6 \times 482,65$$

$$= 2519,225 \text{ N/mm}$$

b) Sambungan pengaku kepelat badan

Data :

$$h = 5500 \text{ (tabel 5.25)}$$

$$F_y = 248 \text{ Mpa ; } E = 200000 \text{ Mpa}$$

$$F_u = 400 \text{ Mpa}$$

$$F_{EXX} = 70 \text{ Ksi} = 482,65 \text{ Mpa}$$

$$t_1 = 18 \text{ mm}$$

$$f_w = 0,045 \cdot h \sqrt{\frac{F_y^3}{E}}$$

$$= 0,045 \cdot 5500 \sqrt{\frac{248^3}{200000}} = 2161,413 \text{ N/mm}$$

ukuran las minimum  $a = 3/16 \text{ in} = 5 \text{ mm}$

$$a_{\text{max efektif}} = 0,707 \frac{F_u \cdot t_1}{F_{EXX}} = 0,707 \frac{400 \cdot 18}{482,65} = 10,547 \text{ mm}$$

kekuatan las nominal :

$$R_{nw} = a \cdot 0,707 \cdot 0,6 \cdot F_{EXX}$$

$$= 5 \times 0,707 \times 0,6 \times 482,65 = 1023,701 \text{ N/mm}$$

$$\% \text{ las kontinu } 3/16 = \frac{2161,413/4}{1023,701} \times 100 = 52,784\%$$

untuk las terputus-putus, segmen minimal 38 mm

$$\text{pitch max} = \frac{38 \times 1023,701}{2161,413/4} = 71,99 \approx 71 \text{ mm}$$

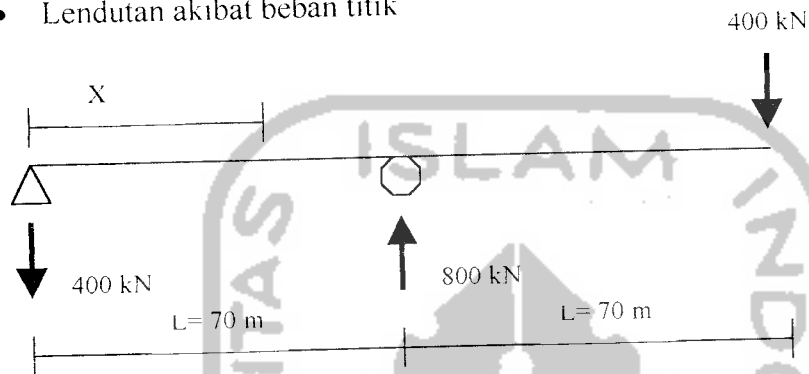
gunakan segmen 5mm-38mm dengan pitch @ 71mm, elektroda E70 (282,65 Mpa)



### 5.14 Kontrol Lendutan

Pada saat pelaksanaan momen lentur yang terjadi diakibatkan oleh berat sendiri gelagar dan beban titik (akibat berat alat). Lendutan yang terjadi dihitung berdasarkan pengintegrasian persamaan momen lentur. Adapun langkah-langkahnya sebagai berikut.

- Lendutan akibat beban titik



Persamaan momen :

$$M(x) = -400 \cdot x + 800 \cdot (x-L) \quad \text{kN-mm}$$

Persamaan kemiringan :

$$\frac{dy(x)}{dx} = \frac{1}{EI} \int M(x) dx + C1$$

$$\begin{aligned} \frac{dy(x)}{dx} &= \frac{1}{EI} \int M(x) dx + C1 = \frac{1}{EI} \int \{-400 \cdot x + 800 \cdot (x-L)\} dx + C1 \\ &= \frac{1}{EI} \{-200x^2 + 400(x-L)^2\} + C1 \end{aligned}$$

Persamaan lendutan :

$$\begin{aligned} y(x) &= \frac{1}{EI} \iint M(x) dx dx + C1x + C2 = \frac{1}{EI} \int \frac{dy(x)}{dx} dx + C2 \\ &= \frac{1}{EI} \int \{-200x^2 + 400(x-L)^2 + C1\} dx + C2 \end{aligned}$$

$$= \frac{1}{EI} \left\{ -\frac{200x^3}{3} + \frac{400(x-L)^3}{3} \right\} + C_1x + C_2$$

kondisi batas :

pada titik A (dukungan sendi)  $x = 0$  mm dan  $y = 0$  mm, diperoleh :

$$y(A) = \frac{1}{EI} \left\{ -\frac{200 \cdot 0^3}{3} + \frac{400(0 - 70000)^3}{3} \right\} + C_1 \cdot 0 + C_2$$

$$0 = \frac{1}{EI} \{-0 + 0\} + 0 + C_2 \longrightarrow C_2 = 0$$

pada titik B (dukungan rol)  $x = 70000$  mm dan  $y = 0$  mm, diperoleh :

$$y(B) = \frac{1}{EI} \left\{ -\frac{200 \cdot 70000^3}{3} + \frac{400(70000 - 70000)^3}{3} \right\} + C_1 \cdot 70000 + 0$$

$$0 = \frac{1}{3EI} \{-200 \cdot 70000^3 + 0\} + C_1 \cdot 70000 + 0 \longrightarrow C_1 = \frac{200 \cdot 70000^2}{3EI}$$

dengan nilai  $C_1$  dan  $C_2$  tersebut persamaan umum lendutan menjadi :

$$y(x) = \frac{1}{EI} \left\{ -\frac{200x^3}{3} + \frac{400(x-L)^3}{3} + \frac{200 \cdot L^2 \cdot x}{3} \right\}$$

lendutan pada titik  $x = 5000$  mm:

$$y_{(s)} = \frac{1}{200 \cdot 0,099232 \cdot 10^{12}} \left\{ -\frac{200 \cdot 5000^3}{3} + \frac{400(5000 - 70000)^3}{3} + \frac{200 \cdot 70000^2 \cdot 5000}{3} \right\}$$

$$= 81,879 \text{ mm}$$

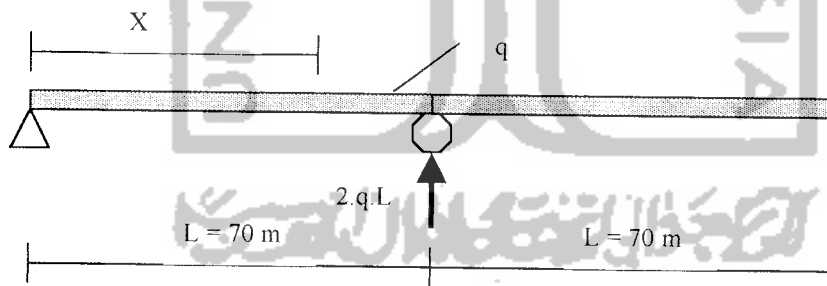
untuk titik yang lainnya dapat dilihat pada tabel 5.26

Tabel 5.26 perhitungan lendutan akibat beban titik

Lokasi	X (mm)	Inersia (mm <sup>4</sup> )	Lendutan (mm)
1	0	97940998026.67	0.000
2	5000	99232127291.30	81.879
3	10000	103164539897.06	155.092

4	15000	109916841601.46	212.661
5	20000	119791815467.96	250.434
6	25000	133224090454.03	267.407
7	30000	150790894229.45	265.268
8	35000	173225907070.70	247.509
9	40000	261858316844.05	168.030
10	45000	305947780612.73	140.955
11	50000	360033350004.24	111.101
12	55000	425924716661.52	80.707
13	60000	577012432403.35	45.060
14	65000	688456962600.81	21.243
15	70000	822511513333.33	0.000
16	75000	753755510403.29	-23.936
17	80000	693318644540.63	-56.732
18	85000	640399760301.09	-99.352
19	90000	594284492325.93	-152.564
20	95000	554339573864.15	-216.850
21	100000	520007647578.27	-292.303
22	105000	490802576692.44	-378.547
23	110000	466305254637.53	-474.653
24	115000	446159911544.54	-579.109
25	120000	430070916133.77	-689.809
26	125000	417800071742.97	-804.113
27	130000	409164405432.81	-918.946
28	135000	404034449301.43	-1030.956
29	140000	402333013333.33	-1136.703

- Lentutan akibat beban merata



Persamaan momen :

$$M(x) = (-\frac{1}{2} q \cdot x^2 + 2q \cdot L(x-L))$$

Persamaan kemiringan :

$$\frac{dy(x)}{dx} = \frac{1}{EI} \int M(x) dx + C1$$

$$\begin{aligned}\frac{dy(x)}{dx} &= \frac{1}{EI} \int M(x) dx + C1 = \frac{1}{EI} \int \left\{ -1/2 \cdot q \cdot x^2 + 2 \cdot q \cdot L \cdot (x - L) \right\} dx + C1 \\ &= \frac{1}{EI} \left\{ -\frac{q \cdot x^3}{6} + q \cdot L \cdot (x - L)^2 \right\} + C1\end{aligned}$$

Persamaan lendutan :

$$\begin{aligned}y(x) &= \frac{1}{EI} \iint M(x) dx dx + C1x + C2 = \frac{1}{EI} \int \frac{dy(x)}{dx} dx + C2 \\ &= \frac{1}{EI} \int \left\{ -\frac{q \cdot x^3}{6} + q \cdot L \cdot (x - L)^2 + C1 \right\} dx + C2 \\ &= \frac{1}{EI} \left\{ -\frac{q \cdot x^4}{24} + \frac{q \cdot L \cdot (x - L)^3}{3} \right\} + C1x + C2\end{aligned}$$

kondisi batas :

pada titik A (dukungan sendi)  $x = 0$  mm dan  $y = 0$  mm, diperoleh :

$$y(A) = \frac{1}{EI} \left\{ -\frac{q \cdot 0^4}{24} + \frac{q \cdot L \cdot (0 - L)^3}{3} \right\} + C1 \cdot 0 + C2$$

$$0 = \frac{1}{EI} \{ -0 + 0 \} + 0 + C2 \quad \longrightarrow \quad C2 = 0$$

pada titik B (dukungan rol)  $x = L$  mm dan  $y = 0$  mm, diperoleh :

$$y(B) = \frac{1}{EI} \left\{ -\frac{q \cdot L^4}{24} + \frac{q \cdot L \cdot (L - L)^3}{3} \right\} + C1 \cdot L + C2$$

$$0 = \frac{1}{EI} \left\{ -\frac{q \cdot L^4}{24} \right\} + C1 \cdot L + 0 \quad \longrightarrow \quad C1 = \frac{q \cdot L^3}{24EI}$$

dengan nilai C1 dan C2 tersebut persamaan umum lendutan menjadi :

$$y(x) = \frac{1}{EI} \left\{ -\frac{q \cdot x^4}{24} + \frac{q \cdot L \cdot (x - L)^3}{3} + \frac{q \cdot L^3 \cdot x}{24} \right\}$$

lendutan pada titik  $x = 5000$  mm :

$y(x) =$

$$\frac{1}{200.0,099232 \cdot 10^{12}} \left\{ \frac{10,378 \cdot 10^{-3} \cdot 5000^4}{24} + \frac{10,378 \cdot 10^{-3} \cdot 70000(5000 - 70000)^3}{3} + \frac{10,378 \cdot 10^{-3} \cdot 70000^3 \cdot 5000}{24} \right\}$$

$= 37,353$  mm

untuk titik yang lainnya dapat dilihat pada tabel 5.27

Tabel 5.27 perhitungan lendutan akibat beban merata (berat sendiri)

Lokasi	x (mm)	Inersia (mm <sup>4</sup> )	Lendutan (mm)
1	0	97940998026.67	0.000
2	5000	99232127291.30	37.353
3	10000	103164539897.06	71.675
4	15000	109916841601.46	100.207
5	20000	119791815467.96	120.926
6	25000	133224090454.03	132.824
7	30000	150790894229.45	135.927
8	35000	173225907070.70	131.108
9	40000	261858316844.05	92.145
10	45000	305947780612.73	80.098
11	50000	360033350004.24	65.457
12	55000	425924716661.52	49.312
13	60000	577012432403.35	28.552
14	65000	688456962600.81	13.957
15	70000	822511513333.33	0.000
16	75000	753755510403.29	-16.768
17	80000	693318644540.63	-40.415
18	85000	640399760301.09	-71.424
19	90000	594284492325.93	-110.090
20	95000	554339573864.15	-156.462
21	100000	520007647578.27	-210.301
22	105000	490802576692.44	-271.033
23	110000	466305254637.53	-337.732
24	115000	446159911544.54	-409.125
25	120000	430070916133.77	-483.624
26	125000	417800071742.97	-559.387
27	130000	409164405432.81	-634.414
28	135000	404034449301.43	-706.661
29	140000	402333013333.33	-774.159

Tabel 5.28 Perhitungan lendutan total

Lokasi	Lendutan akibat beban titik (mm)	Lendutan akibat beban merata (mm)	Lendutan total (mm)
1	0.000	0.000	0.000
2	81.879	37.353	119.232
3	155.092	71.675	226.767
4	212.661	100.207	312.868
5	250.434	120.926	371.361
6	267.407	132.824	400.230
7	265.268	135.927	401.195
8	247.509	131.108	378.617
9	168.030	92.145	260.174
10	140.955	80.098	221.054
11	111.101	65.457	176.558
12	80.707	49.312	130.019
13	45.060	28.552	73.612
14	21.243	13.957	35.201
15	0.000	0.000	0.000
16	-23.936	-16.768	-40.703
17	-56.732	-40.415	-97.147
18	-99.352	-71.424	-170.776
19	-152.564	-110.090	-262.654
20	-216.850	-156.462	-373.312
21	-292.303	-210.301	-502.604
22	-378.547	-271.033	-649.579
23	-474.653	-337.732	-812.385
24	-579.109	-409.125	-988.234
25	-689.809	-483.624	-1173.432
26	-804.113	-559.387	-1363.499
27	-918.946	-634.414	-1553.360
28	-1030.956	-706.661	-1737.617
29	-1136.703	-774.159	-1910.862