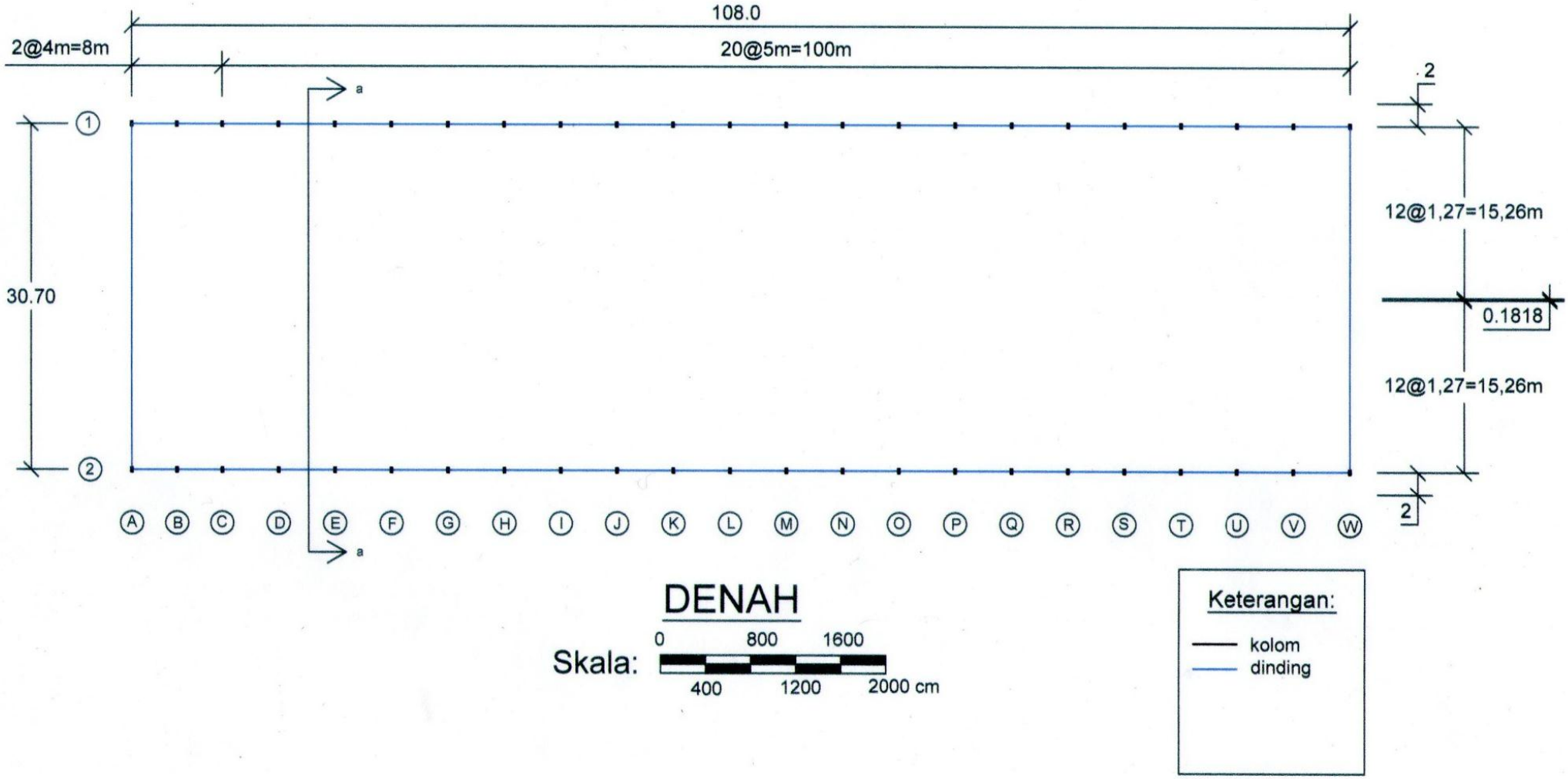
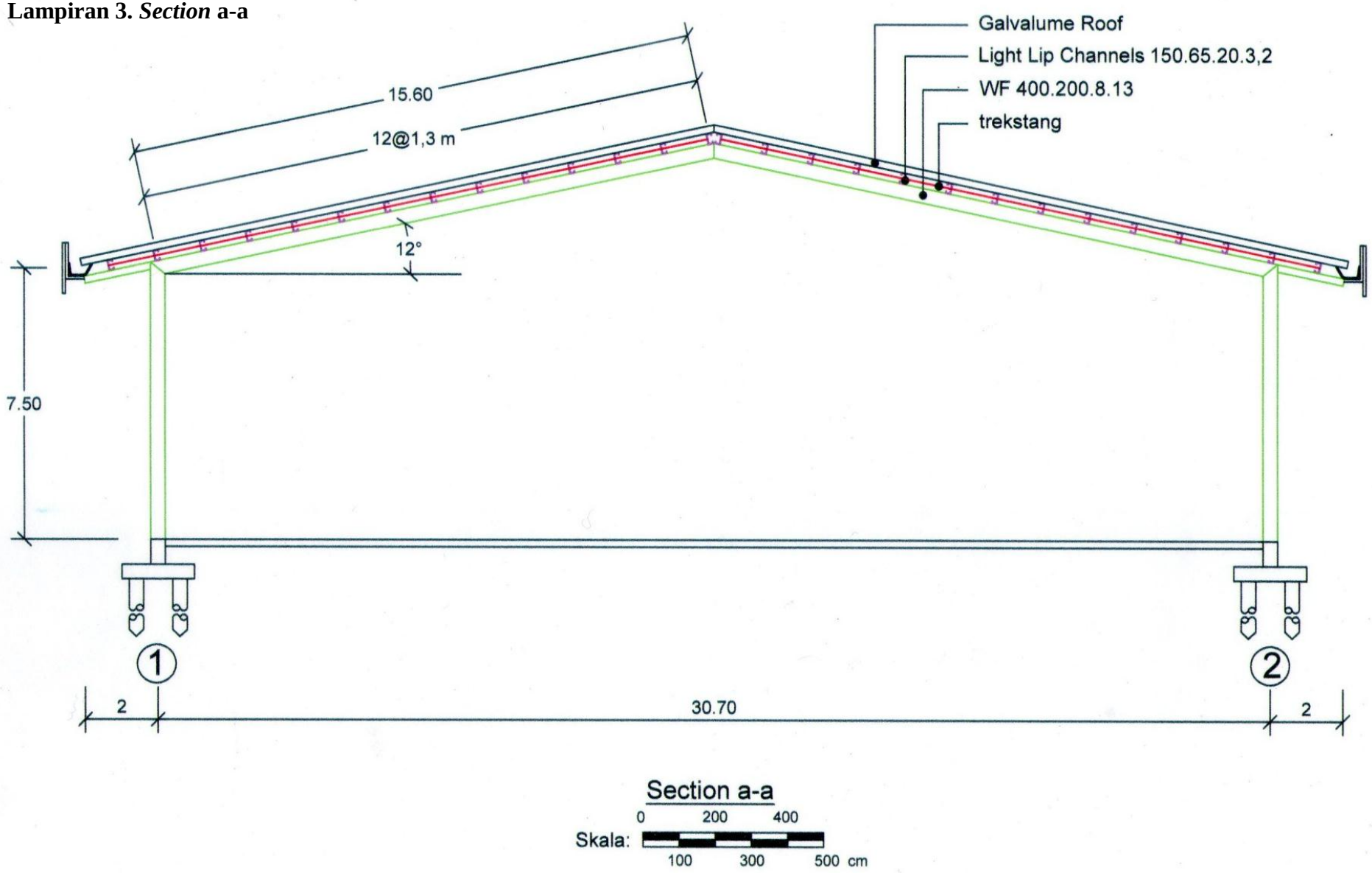
Lampiran 1. Denah



Lampiran 2. ***Roof Plan***

Lampiran 3. ***Section*** **a-a**



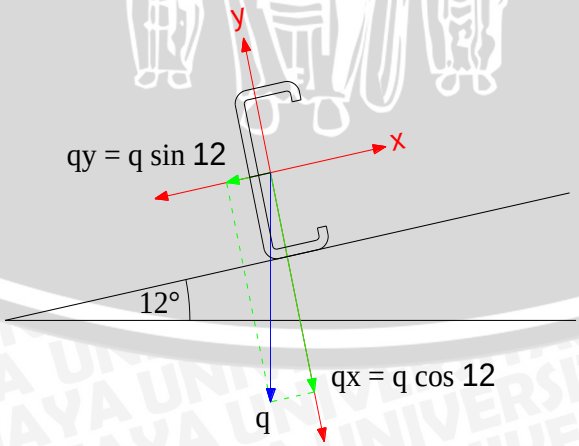
Lampiran 4. Perencanaan Gording

A. Perencanaan Gording

A.1 Data perencanaan & spesifikasi profil gording

Data-data yang diperlukan untuk merencanakan sebuah gording antara lain:

- Jarak antar gording = 1,3 m
- Jarak antar kuda-kuda = 5 m
- Sudut kemiringan atap = 12°
- Berat penutup atap = 11 kg/m^2
- Tekanan angin = 25 kg/m^2
- Profil yang dipakai: Light Lip Channels 150.65.20.3,2
- A = 150 mm
- B = 65 mm
- t = 3.2 mm
- Luas penampang = 9,567 cm^2
- Berat = 7,51 kg/m
- Ix = 332 cm^4
- Iy = 53,8 cm^4
- Zx = 44,3 cm^3
- Zy = 12,2 cm^3
- ix = 5,89 cm
- iy = 2,37 cm



Penguraian Beban

A.2 Pembebanan Gording

A.2.1 Beban Pada Gording

a) Beban Mati (D)

- Berat sendiri gording = 7,51
- Berat penutup atap = 11 x 1,3 = 14,30 +

21,81

- Berat alat sambung = 10% x 21,81 = 2,18 +

Total beban mati = 24,0 kg/m

Penguraian beban

qx = Total beban mati x cos 12°
= 24,0 x 0,978
= 23 kg/m

Vx = 0,5 . qx . L
= 0,5 x 23 x 5
= 59 kg

Mx = qx . L^2 / 8
= 23 x 25 / 8
= 73 kgm

qy = Total beban mati x sin 12°
= 24,0 x 0,208
= 5 kg/m

Vy = 0,5 . qy . L
= 0,5 x 5 x 1,67
= 4 kg

My = qy . L^2 / 8
= 5 x 2,78 / 8
= 2 kgm

b) Beban Hidup akibat Pekerja (La)

Beban hidup pada atap dan atau pada bagian atap serta pada struktur tudung (canopi) yang dapat dipakai dan dibebani oleh orang harus diambil minimum sebesar 100 kg bidang datar

Penguraian beban

Px = beban pekerja x cos 12°
= 100 x 0,978
= 98 kg

Vx = 0,5 . Px
= 0,5 x 98
= 49 kg

Mx = Px . L / 4
= 98 x 5 / 4
= 122 kgm
Py = beban pekerja x sin 12°
= 100 x 0,208
= 21 kg
Vy = 0,5 . Py
= 1 x 21
= 10 kg
My = Py . L / 4
= 21 x 1,67 / 4
= 9 kgm

c) Beban Angin (W)

c_1 = koef. Angin tekan
= 0,02 x α - 0,4
= 0,02 x 12 - 0,4
= -0,16

c_2 = koef. Angin hisap
= -0,4

Beban angin pada atap

q tekan = c_1 x 25 x jarak antar kuda-kuda x cos α
= **-20** kg/m

q hisap = c_2 x 25 x jarak antar kuda-kuda x cos α
= -49 kg/m

Vx = 0,5 . qx . L
= -49 kg

Mx = qx . L^2 / 8
= -61 kgm

d) Beban air hujan (H)

Beban terbagi rata per m^2 bidang datar berasal dari beban air hujan sebesar (40-0,8α) kg/m^2 ***(PPIUG 1983 pasal 3.2.2.a)***

Wa = 40 - 0,8 x α
= 40 - 0,8 x 12
= 30 kg/m^2

(tidak perlu diambil lebih besar dari 20 kg/m^2)

Wa pakai = **20** kg/m^2

q_H = Wa x jarak gording
= 20 x 1,3
= 26 kg/m

Penguraian beban

qx = Beban air hujan x cos 12°
= 26 x 0,978
= 25 kg/m

Vx = 0,5 . qx . L
= 0,5 x 25 x 5
= 64 kg

Mx = qx . L^2 / 8
= 25 x 25 / 8
= 79 kgm

qy = Beban air hujan x sin 12°
= 26 x 0,208
= 5 kg/m

Vy = 0,5 . qy . L
= 0,5 x 5 x 1,67
= 5 kg

My = qy . L^2 / 8
= 5 x 2,78 / 8
= 2 kgm

A.2.2 Kombinasi Pembebanan Groding

Kombinasi pembebanan untuk struktur baja bangunan gedung berdasarkan SNI 03-1729-2002, antara lain:

1. 1,4D
2. 1,2D + 1,6L + 0,5(L_a atau H)
3. 1,2D + 1,6(L_a atau H) + ($\gamma_L L$ atau 0,8W)
4. 1,2D + 1,3W + $\gamma_L L$ + 0,5(L_a atau H)
5. 1,2D ± 1,0E + $\gamma_L L$
6. 0,9D ± (1,3W atau 1,0E)

Keterangan:

D adalah beban mati yang diakibatkan oleh berat konstruksi permanen, termasuk dinding, lantai, atap, plafon, partisi tetap, tangga, dan peralatan layan tetap

L adalah beban hidup yang ditimbulkan oleh penggunaan gedung, termasuk kejut, tetapi tidak termasuk beban lingkungan seperti angin, hujan, dan lain-lain

L_a adalah beban hidup di atap yang ditimbulkan selama perawatan oleh pekerja, peralatan, dan material, atau selama penggunaan biasa oleh orang dan benda bergerak

H adalah beban hujan, tidak termasuk yang diakibatkan genangan air

W adalah beban angin

E adalah beban gempa, yang ditentukan menurut SNI 03–1726–1989, atau penggantinya

Beban-beban dalam perencanaan gording pada bangunan ini adalah beban mati (*D*), beban hidup akibat pekerja (L_a), beban air hujan (*H*) dan beban angin (*W*). Nilai beban hidup akibat pekerja terhadap sumbu-*x* dan sumbu-*y* lebih besar dari nilai beban air hujan (*H*) sehingga yang dipakai untuk perhitungan kombinasi beban ini adalah beban hidup akibat pekerja (L_a). Berdasarkan perhitungan beban angin pada butir A.2.1(c), nilai beban angin yang didapatkan pada perhitungan angin tekan dan angin hisap memiliki nilai negatif, maka beban angin ini dapat diabaikan karena dapat memperingan struktur.

Kombinasi terhadap Sumbu-*x*

Kombinasi	M.D			M.La			M_x (kgm)
1	1,4	73				=	103
2	1,2	73	+	0,5	122	=	149
3	1,2	73	+	1,6	122	=	284
4	1,2	73	+	0,5	122	=	149
5	1,2	73				=	88
6	0,9	73				=	66
				M_x MAX		=	**284**

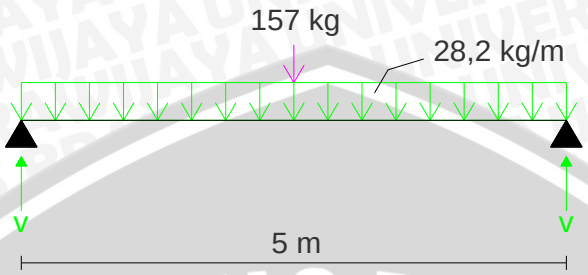
Kombinasi terhadap Sumbu-*y*

Kombinasi	M.D			M.La			M_y (kgm)
1	1,4	2				=	2
2	1,2	2		0,5	9	=	6
3	1,2	2	+	1,6	9	=	16
4	1,2	2	+	0,5	9	=	6
5	1,2	2				=	2
6	0,9	2				=	2
				M_y MAX		=	**16**

Berdasarkan perhitungan di atas, kombinasi pembebanan yang dipakai untuk mendesain gording adalah kombinasi 3, yaitu 1,2 D + 1,6 La.

1,2 D = 1,2 x 24 = 28,2 kg/m

1,6 La = 1,6 x 98 = 157 kg



Reaksi beban (V) berdasarkan pembebanan di atas dapat dihitung melalui,

V = 0,5 x (157+ 28,2 . 5)

= 149 kg

sedangkan momen pada ¼ bentang, ¾ bentang dan ½ bentang berturut-turut,

$M_{1/4L} = M_{3/4L}$ = V . 0,25 L – 0,5 . q . $(0,25\ L)^2$

= 149. 0,25 . 5 – 0,5 . 28,2 . $(0,25 . 5)^2$

= 164 kgm

$M_{max} = M_{1/2L}$ = V . 0,5 L – 0,5 . q . $(0,5\ L)^2$

= 149. 0,5 . 5 – 0,5 . 28,2 . $(0,5 . 5)^2$

= 284 kgm

A.3 Kontrol Desain

Lendutan terbesar untuk pembebanan gording tersebut,

$$EI = 2000000\ {}^{kg}/_{cm^2} \times 332 cm^4$$

$$= 664000000 kg cm^2$$

$$= 66400 kg m^2$$

$$\theta_{0,5L} = \frac{1}{EI}\int -M_{max}\, dx$$

$$= \frac{1}{EI}\int_0^{0,5L} -\left(V.x - \frac{1}{2}qx^2\right)dx$$

$$= \frac{1}{EI}\int_0^{2,5} -149.x + \frac{1}{2}28,2x^2\, dx$$

$$= \frac{1}{EI}\left| -\frac{149.x^2}{2} + \frac{1}{2}.\frac{1}{3}28{,}2x^3 + c_1 \right|_0^{2{,}5}$$

$$= \frac{1}{EI}\left(-\frac{149.2{,}5^2}{2} + \frac{1}{2}.\frac{1}{3}28{,}2.2{,}5^3 + c_1 \right)$$

$$0 = -391{,}2 + c_1$$

$$c_1 = 391{,}2$$

$$\Delta_{max} = \frac{1}{EI}\int \theta_{0,5L}\, dx$$

$$= \frac{1}{EI}\int_0^{2{,}5} -\frac{149.x^2}{2} + \frac{1}{2}.\frac{1}{3}28{,}2x^3 + c_1\, dx$$

$$= \frac{1}{EI}\left| -\frac{149.x^3}{2.3} + \frac{1}{6}.\frac{1}{4}28{,}2x^4 + c_1x + c_2 \right|_0^{2{,}5}$$

$$= \frac{1}{EI}\left| -\frac{149.x^3}{6} + \frac{1}{24}28{,}2x^4 + 391{,}2x + c_2 \right|_0^{2{,}5} \rightarrow c_2 = 0$$

$$= \frac{1}{EI}\left(-\frac{149.2{,}5^3}{6} + \frac{1}{24}28{,}2.2{,}5^4 + 391{,}2.2{,}5 \right)$$

$$\Delta_{max} = \frac{636{,}7}{EI}m$$

$$= \frac{509{,}4}{66400}m$$

$$= 0{,}00959\ m = 9{,}59\ mm$$

Batas-batas lendutan untuk keadaan kemampuan-layan batas harus sesuai dengan struktur, fungsi penggunaan, sifat pembebanan, serta elemen-elemen yang didukung oleh struktur tersebut (Anonymous, 2000:15). Batas lendutan untuk balok yang memikul lentur adalah L/240 = 5/240 = 0,02083 m = 20,83 mm, sehingga lendutan gording aman.

Kontrol kelangsingan profil

Untuk Sayap

$$\lambda = \frac{bf}{tf} = \frac{65}{3,2} = 20,3125$$

$$\lambda p = \frac{170}{fy^{\wedge 0.5}} = \frac{170}{240^{\wedge 0.5}} = 10,973453$$

Fr = 70 MPA untuk penampang di rol (SNI 2002, tabel 7.5-1)

$$\lambda r = \frac{370}{(fy-Fr)^{\wedge 0.5}} = \frac{370}{(240-70)^{\wedge 0.5}} = 28,377705$$

jika, $\lambda > \lambda p < \lambda r$ ..... **Penampang tidak kompak**

20,3125 10,97345 28,3777

Untuk Badan

$$\lambda = \frac{h}{tw} = \frac{150}{3,2} = 46,875$$

$$\lambda p = \frac{1680}{fy^{\wedge 0.5}} = \frac{1680}{240^{\wedge 0.5}} = 108,44353$$

$$\lambda r = \frac{2550}{(fy-Fr)^{\wedge 0.5}} = \frac{2550}{(240-70)^{\wedge 0.5}} = 195,57607$$

jika, $\lambda < \lambda p < \lambda r$ ..... **Penampang kompak**

46,875 108,4435 195,5761

Penampang kompak untuk badan, maka :

Mn = Mp = fy x 1,5 x Sx

= 2400 x 1,5 x 44,3

= 159480 kg.cm = 1594,8 kg.m

Penampang tidak kompak untuk sayap, maka :

$$M_n = M_p - (M_p - M_r)\frac{\lambda - \lambda_p}{\lambda_r - \lambda_p} = 1143,1 \text{ kg.m}$$

Kontrol Momen **(*SNI 03-1729-2002, pasal 8.2 - 1.a)***

ϕ Mn ≥ Mu

0,9 1143,1 ≥ 284

1028,8 ≥ 284 (kg.m) **Ok**

Kuat Nominal Lentur

Kuat Nominal Lentur Penampang dengan pengaruh tekuk lateral (*SNI 03-1729-2002 pasal 8.3.1)*

J = 1/3 . (∑(panjang tebal)^3 = 1/3 ∑ (b.t^3) J = konstanta puntir torsi (mm^4)

J = 1/3 (2 . 6,5 . 0,32^3 + 15 . 0,32^3 + 0,32 . 2^3)

J = 361,8 cm^4

X1 = $\frac{\pi}{Sx}\sqrt{\frac{E.G.J.A}{2}} = \frac{\pi}{115}\sqrt{\frac{2.10^6.8.10^5.192812523,71}{2}}$ = 3732008 kg/cm^2

Iw = $\frac{Iy.h^2}{4}$ = $\frac{53,8 \quad 15^{\ 2}}{4}$ = 3026,25 cm^6

X2 = $4.(\frac{Sx}{G.J})^2 \frac{Iw}{Iy}$ = $4 \left(\frac{44,3}{8,00E+05 \quad 361,8487}\right)^2 \frac{3026,25}{53,8}$

= 5,26934E-12 cm^2/kg

Lp = $1,76 .ry.\sqrt{\frac{E}{fy}}$ = $1,76 \quad 2,37 \left(\frac{2000000}{2400}\right)^{0,5}$

= 120,412 cm **(*SNI 03-1729-2002, tabel 8.3 - 2)***

L = 5 m = 500 cm

Lr = $\frac{ry.X_1}{fy-Fr}\sqrt{1+\sqrt{1+X_2(fy-Fr)^2}}$ ***(SNI 03-1729-2002, tabel 8.3 - 2)***

= $\frac{7,28x1719294}{3200-700}\sqrt{1+\sqrt{1+7,999710^{-7}(3200-700)^2}}$

= 7357,9539 cm

(SNI 03-1729-2002, pasal. 8.3.4)

Lp < L < Lr ..... **Bentang Menengah**

$$Cb = \frac{12,5\,M\ \max}{2,5\ M\ \max + 3Ma + 4Mb + 3Mc}$$

Ma = 163,81496

Mc = 163,81496

Cb = 1,25

Mp = fy x Zx (Zx = 1,5 Sx)

= 2400 x 1,5 x 44,3

= 159480 kg.cm

= 1594,8 kg.m

Mr = (fy - fr) Sx

= 1700 44,3

= 75310 kg.cm

= 753,1 kg.m

Mn = $Cb\left[Mr + (Mp - Mr)\frac{Lr - Lb}{Lr - Lp} \right] \leq Mp$ ***(SNI 03-1729-2002, pasal. 8.3.-1)***

= 1,25 (753,1 + 841,7 $\frac{6857,954}{7237,54}$)

= 1945 kgm > 1595 **dipakai Mp**

Sehingga di pake Mp = 1595 kg.m

ϕ	Mn	≥	Mu		
0,9	1595	≥	284		
	1435	≥	284	(kg.m)	**Ok**

Profil kuat menahan momen terhadap tekuk lateral

Lampiran 5. Perencanaan Trekstang

B. Perencanaan Trekstang

B.1 Data perencanaan

Trekstang digunakan untuk mengurangi lendutan gording searah sumbu-*x*. Trekstang direncanakan sebagai batang tarik karena penampangnya memiliki inersia kecil. Data-data yang dipergunakan dalam perhitungan trekstang ini adalah:

- Mutu baja tulangan

  f_y = 240 MPa

  f_u = 370 MPa
- Profil gording yang dipakai Light Lip Channels 150.65.20.3,2

  berat profil = 7,51 kg/m

  jumlah gording pada 1 sisi atap = 14 buah
- Jarak antar gording = 1,3 m
- Jarak trekstang = jarak antar kuda-kuda / 3

  = 5 / 3

  = 1,67 m
- berat air hujan = 20 kg/m^2
- berat sendiri penutup atap = 11 kg/m^2

B.2 Beban pada Trekstang

Beban pada trekstang antara lain:

a) Beban mati (P_D)

Beban mati ini terdiri atas berat sendiri gording dan berat penutup atap.

- Berat gording = berat sendiri profil x jarak trekstang

  = 7,51 x 1,67

  = 12,52 kg
- Berat penutup atap = berat sendiri x jarak trekstang x jarak gording

  = 11 x 1,67 x 1,3

  = 23,83 kg
- Total beban mati = P_D = berat gording + berat penutup atap

= 12,52 + 23,83

= 36,35 kg

b) Beban pekerja (P_{La}) = 100 kg

c) Beban air hujan (P_H) = berat air hujan x jarak trekstang x jarak gording

= 20 x 1,67 x 1,3

= 43,33 kg

D			La			P_u (kg)
1,4	36,35				=	51
1,2	36,35	+	0,5	100	=	94
1,2	36,35	+	1,6	100	=	204
1,2	36,35	+	0,5	100	=	94
1,2	36,35				=	44
0,9	36,35				=	33
				P MAX	=	**204**

Berdasarkan tabel di atas, kombinasi beban terbesar adalah 204 kg, maka gaya tarik searah trekstang yang terjadi adalah

P = P_u x sin 12°

= 204 x sin 12°

= 42,33 kg

B.3 Kontrol Desain

Komponen struktur yang memikul gaya tarik aksial terfaktor N_u harus memenuhi $N_u \leq \phi N_n$ (Anonymus, 2000: 70) dengan ϕ = 0,9 untuk keruntuhan leleh dan ϕ = 0,75 untuk keruntuhan tarik. Berdasarkan keruntuhan leleh, diameter tulangan trekstang yang dibutuhkan adalah

N_u = jumlah gording 1 sisi x P

= 14 x 42,33

= 592,69 kg

$N_u \leq \phi f_y A_g$

592,69 $\leq$ 0,9 x 2400 x 0,25 π d^2

0,349 $\leq d^2$

0,591 $\leq$ d

berdasarkan keruntuhan tarik,

$N_u \leq \phi f_u A_e$

$592{,}69 \leq 0{,}75 \times 3700 \times 0{,}25\ \pi\ d^2$

$0{,}272 \leq d^2$

$0{,}521 \leq d$

agar memenuhi seluruh kebutuhan tulangan berdasarkan keruntuhan tarik dan keruntuhan leleh, maka digunakan baja tulangan dengan diameter 6 mm.

Lampiran 6. Perencanaan Struktur Portal

C.1 Data perencanaan & spesifikasi profil portal

Data-data yang digunakan untuk merencanakan struktur portal ini antara lain:

- E = 200000Mpa
- f_r = 70 Mpa
- f_y = 240 Mpa
- G = 80000 MPa
- Profil yang dipakai: WF 400.200.8.13
- d = 400 mm
- b = 200 mm
- Luas penampang = 8412 mm^2
- Berat = 66 kg/m
- t_f = 13 mm
- t_w = 8 mm
- I_y = 53,8 cm^4
- r =16 mm
- S_x = 44,3 cm^3
- r_x = 5,89 cm
- r_y = 2,37 cm

C.2 Beban Portal

Kombinasi pembebanan untuk struktur baja bangunan gedung berdasarkan SNI 03-1729-2002, antara lain:

1. 1,4D
2. 1,2D + 1,6L + 0,5(L_a atau H)
3. 1,2D + 1,6(L_a atau H) + ($\gamma_L L$ atau 0,8W)
4. 1,2D + 1,3W + $\gamma_L L$ + 0,5(L_a atau H)
5. 1,2D ± 1,0E + $\gamma_L L$
6. 0,9D ± (1,3W atau 1,0E)

Keterangan:

D adalah beban mati yang diakibatkan oleh berat konstruksi permanen, termasuk dinding, lantai, atap, plafon, partisi tetap, tangga, dan peralatan layan tetap

L adalah beban hidup yang ditimbulkan oleh penggunaan gedung, termasuk kejut, tetapi tidak termasuk beban lingkungan seperti angin, hujan, dan lain-lain

L_a adalah beban hidup di atap yang ditimbulkan selama perawatan oleh pekerja, peralatan, dan material, atau selama penggunaan biasa oleh orang dan benda bergerak

H adalah beban hujan, tidak termasuk yang diakibatkan genangan air

W adalah beban angin

E adalah beban gempa, yang ditentukan menurut SNI 03–1726–1989, atau penggantinya

Beban yang terdapat dalam perencanaan struktur bangunan ini adalah beban mati (*D*), beban hidup akibat pekerja (L_a), beban air hujan (*H*) dan beban angin (*W*). Kombinasi pembebanan 1 dan 5, 4 dan 6 identik, sehingga diambil yang terbesar sehingga diambil kombinasi pembebanan 1 dan 4.

a) <u>Beban Mati (D)</u>

- Berat sendiri kuda-kuda + alat sambung (10% berat profil kuda-kuda)
  = 66 + 6,6
  = 73 kg/m
- Berat penutup atap
  = Berat sendiri penutup atap x jarak antar kuda-kuda x jarak antar gording
  = 11 x 5 x 1,3
  = 72 kg
- Berat gording
  = Berat gording x jarak antar kuda-kuda
  = 7,51 x 5
  = 38 kg
- Berat sendiri kolom
  = Berat kolom x panjang kolom
  = 66 x 7,5
  = 495 kg
- Beban mati terpusat total = **604** kg

b) <u>Beban hidup akibat pekerja (La)</u>

Beban hidup pada atap dan atau pada bagian atap serta pada struktur tudung (canopi) yang dapat dipakai dan dibebani oleh orang harus diambil minimum sebesar 100 kg bidang datar ***(PPIUG 1983 pasal 3.2.1)***.

P_{La} = 100 kg

c) Beban air hujan (H)

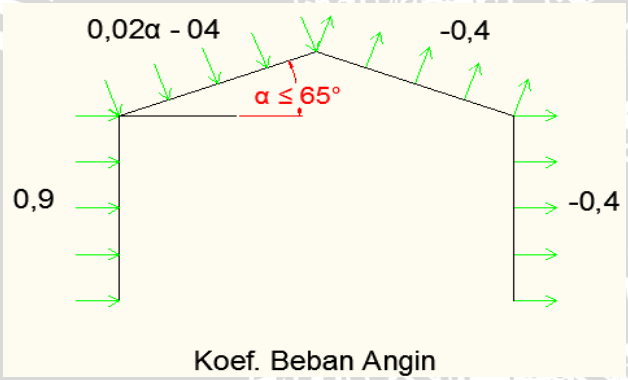
Beban terbagi rata per m^2 bidang datar berasal dari beban air hujan sebesar (40-0,8α) kg/m^2 ***(PPIUG 1983 pasal 3.2.2.a)***.

Wa = 40 - 0,8 x α
= 40 - 0,8 x 12
= 30,4 kg/m^2 (tidak perlu diambil lebih besar dari 20 kg/m^2)

Wa pakai = **20** kg/m^2
H = Wa x jarak antar kuda-kuda x jarak gording
= 20 x 5 x 1,3
= 130 kg

Beban hidup akibat pekerja (L_a) dan beban air hujan (H) dipakai yang terbesar yaitu beban air hujan (H) sebesar 130 kg.

d) Beban Angin (W)



Koef. Beban Angin

Sumber: PPIUG 1983 pasal 4.3

Tekanan angin minimum 25 kg/m^2 untuk daerah yang jauh dari tepi pantai

c_1 = koef. Angin tekan atap
= 0,02 x α - 0,4
= 0,02 x 12 - 0,4
= -0,16

c_2 = koef. Angin hisap atap
= -0,4

c_3 = koef. Angin tekan dinding
= 0,9

c_4 = koef. Angin hisap dinding
= -0,4

- Beban angin pada atap

  q tekan = c_1 x 25 x jarak antar kuda-kuda x cos α

  = **-20** kg/m

  q hisap = c_2 x 25 x jarak antar kuda-kuda x cos α

  = -49 kg/m

- Beban angin pada dinding

  q tekan = c_3 x 25 x jarak antar kuda-kuda

  = **113** kg/m

  q hisap = c_4 x 25 x jarak antar kuda-kuda

  = -50 kg/m

- **Kombinasi Pembebanan Portal**

- <u>Beban-beban pada portal</u>

a) q_D = 73 kg/m

b) P_D:

Penutup atap	=	72	
gording	=	38	+
		109	kg

Penutup atap	=	72	
2 x gording	=	75	+
		147	kg

Penutup atap	=	72	
gording	=	38	
kolom	=	495	+
		604	kg

c) La = 100 kg

d) H = 130 kg

e) W

pada atap = -20 kg/m (diabaikan karena memperingan struktur)

pada kolom = 113 kg/m

TABEL DATA BATANG

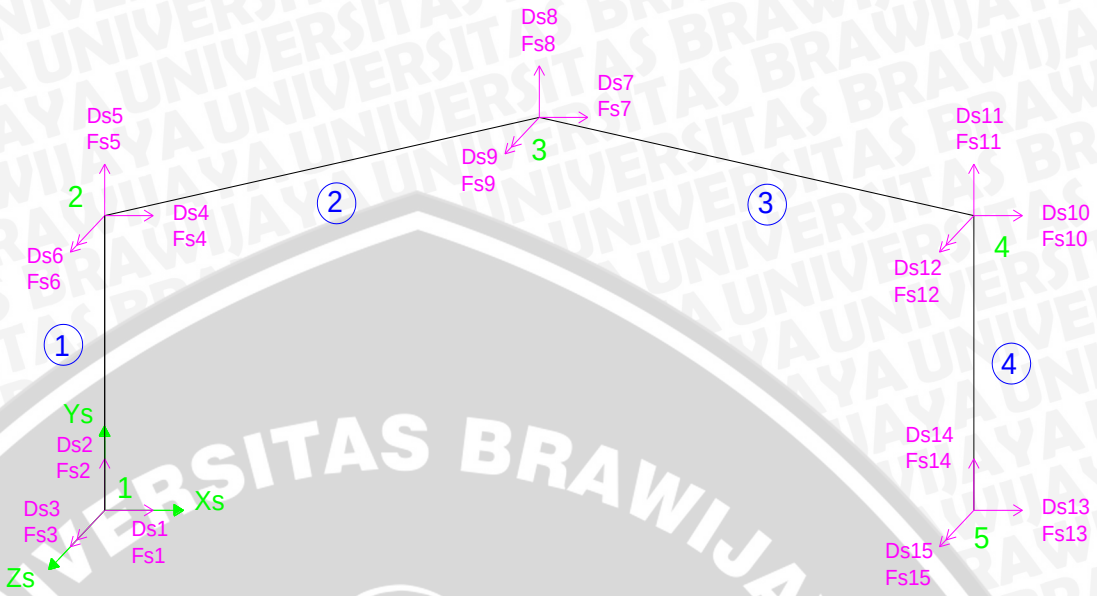
A = 84,12 cm^2

E = 2000000 kg/cm^2

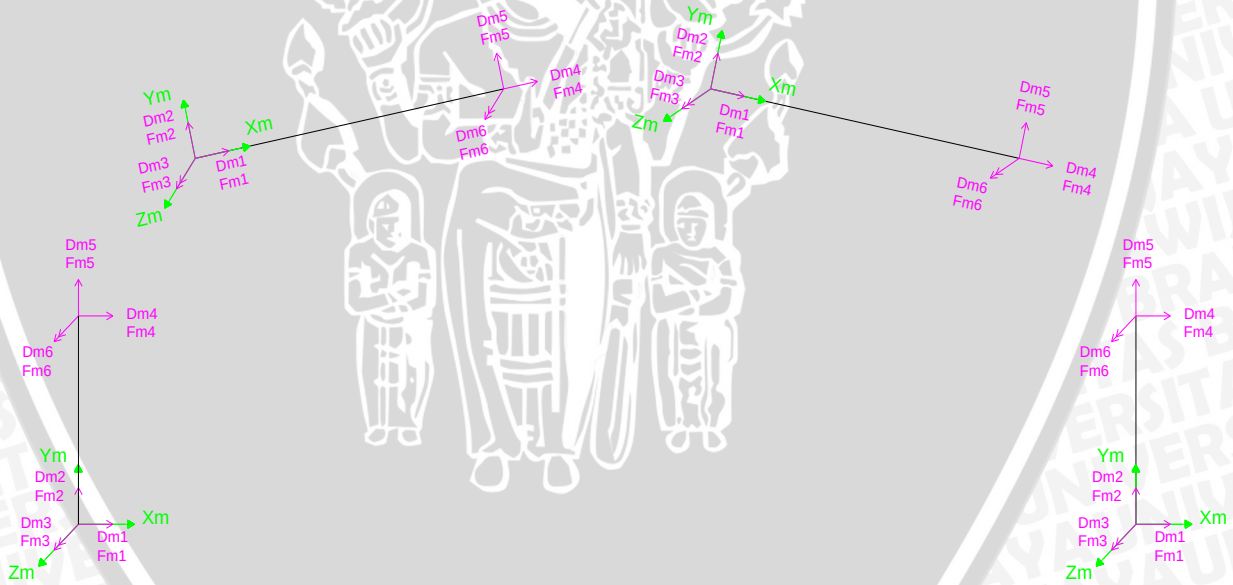
Ix = 23700 cm^4

No. Btg	Nomor Titik i	Nomor Titik j	L (m)	Sudut α	Cos α	Sin α	EA/L (kg/m)	$12EI/L^3$ (kg/m)	$6EI/L^2$ (kg)	4EI/L (kgm)	2EI/L (kgm)
1	1	2	7,5	90	0	1	22432000	134827	505600	2528000	1264000
2	2	3	15,7	12	0,978	0,208	10720753	14718	115484	1208188	604094
3	3	4	15,7	348	0,978	-0,208	10720753	14718	115484	1208188	604094
4	4	5	7,5	270	0	-1	22432000	134827	505600	2528000	1264000

SISTEM KOORDINAT GLOBAL (SKG)



SISTEM KOORDINAT LOKAL (SKL)



• **MATRIKS KEKAKUAN BATANG PADA SUMBU BATANG (XM-YM-ZM)**

Rumus Umum

$$[Sm]i = \begin{bmatrix} EA/L & 0 & 0 & -EA/L & 0 & 0 \\ 0 & 12EI/L^3 & 6EI/L^2 & 0 & -12EI/L^3 & 6EI/L^2 \\ 0 & 6EI/L^2 & 4EI/L & 0 & -6EI/L^2 & 2EI/L \\ -EA/L & 0 & 0 & EA/L & 0 & 0 \\ 0 & -12EI/L^3 & -6EI/L^2 & 0 & 12EI/L^3 & -6EI/L^2 \\ 0 & 6EI/L^2 & 2EI/L & 0 & -6EI/L^2 & 4EI/L \end{bmatrix}$$

$$[Sm]1 = \begin{bmatrix} 22432000 & 0 & 0 & -22432000 & 0 & 0 \\ 0 & 134827 & 505600 & 0 & -134827 & 505600 \\ 0 & 505600 & 2528000 & 0 & -505600 & 1264000 \\ -22432000 & 0 & 0 & 22432000 & 0 & 0 \\ 0 & -134827 & -505600 & 0 & 134827 & -505600 \\ 0 & 505600 & 1264000 & 0 & -505600 & 2528000 \end{bmatrix}$$

$$[Sm]2 = \begin{bmatrix} 10720753 & 0 & 0 & -10720753 & 0 & 0 \\ 0 & 14718 & 115484 & 0 & -14718 & 115484 \\ 0 & 115484 & 1208188 & 0 & -115484 & 604094 \\ -10720753 & 0 & 0 & 10720753 & 0 & 0 \\ 0 & -14718 & -115484 & 0 & 14718 & -115484 \\ 0 & 115484 & 604094 & 0 & -115484 & 1208188 \end{bmatrix}$$

$$[Sm]3 = \begin{bmatrix} 10720753 & 0 & 0 & -10720753 & 0 & 0 \\ 0 & 14718 & 115484 & 0 & -14718 & 115484 \\ 0 & 115484 & 1208188 & 0 & -115484 & 604094 \\ -10720753 & 0 & 0 & 10720753 & 0 & 0 \\ 0 & -14718 & -115484 & 0 & 14718 & -115484 \\ 0 & 115484 & 604094 & 0 & -115484 & 1208188 \end{bmatrix}$$

$$[Sm]4 = \begin{bmatrix} 22432000 & 0 & 0 & -22432000 & 0 & 0 \\ 0 & 134827 & 505600 & 0 & -134827 & 505600 \\ 0 & 505600 & 2528000 & 0 & -505600 & 1264000 \\ -22432000 & 0 & 0 & 22432000 & 0 & 0 \\ 0 & -134827 & -505600 & 0 & 134827 & -505600 \\ 0 & 505600 & 1264000 & 0 & -505600 & 2528000 \end{bmatrix}$$

• **MATRIKS ROTASI TRANSFORMASI**

Rumus Umum

$$[RT]i = \begin{pmatrix} \cos\alpha & \sin\alpha & 0 & 0 & 0 & 0 \\ -\sin\alpha & \cos\alpha & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & \cos\alpha & \sin\alpha & 0 \\ 0 & 0 & 0 & -\sin\alpha & \cos\alpha & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

$$[RT]1 = \begin{pmatrix} 0 & 1 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

$$[RT]2 = \begin{pmatrix} 0{,}978 & 0{,}208 & 0 & 0 & 0 & 0 \\ -0{,}208 & 0{,}978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0{,}978 & 0{,}208 & 0 \\ 0 & 0 & 0 & -0{,}208 & 0{,}978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

$$[RT]3 = \begin{pmatrix} 0{,}978 & -0{,}208 & 0 & 0 & 0 & 0 \\ 0{,}208 & 0{,}978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0{,}978 & -0{,}208 & 0 \\ 0 & 0 & 0 & 0{,}208 & 0{,}978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

$$[RT]4 = \begin{pmatrix} 0 & -1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

• **MATRIKS ROTASI TRANSFORMASI TRANSPOSE**

Rumus Umum

$$[RT]^{T}i = \begin{pmatrix} \cos\alpha & -\sin\alpha & 0 & 0 & 0 & 0 \\ \sin\alpha & \cos\alpha & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & \cos\alpha & -\sin\alpha & 0 \\ 0 & 0 & 0 & \sin\alpha & \cos\alpha & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

$$[RT]^{T}1 = \begin{pmatrix} 0 & -1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

$$[RT]^{T}2 = \begin{pmatrix} 0{,}978 & -0{,}208 & 0 & 0 & 0 & 0 \\ 0{,}208 & 0{,}978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0{,}978 & -0{,}208 & 0 \\ 0 & 0 & 0 & 0{,}208 & 0{,}978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

$$[RT]^{T}3 = \begin{pmatrix} 0{,}978 & 0{,}208 & 0 & 0 & 0 & 0 \\ -0{,}208 & 0{,}978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0{,}978 & 0{,}208 & 0 \\ 0 & 0 & 0 & -0{,}208 & 0{,}978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

$$[RT]^{T}4 = \begin{pmatrix} 0 & 1 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

- **PERAKITAN MATRIKS KEKAKUAN GLOBAL (XS-YS-ZS)**
  (Berdasarkan sumbu struktur)

[Ss] =

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	134827	0	-505600	-134827	0	-505600	0	0	0	0	0	0	0	0	0
2	0	22432000	0	0	-22432000	0	0	0	0	0	0	0	0	0	0
3	-505600	0	2528000	505600	0	1264000	0	0	0	0	0	0	0	0	0
4	-134827	0	505600	10392787	2177268	481590	-10257960	-2177268	-24010	0	0	0	0	0	0
5	0	-22432000	0	2177268	22909511	112960	-2177268	-477511	112960	0	0	0	0	0	0
6	-505600	0	1264000	481590	112960	3736188	24010	-112960	604094	0	0	0	0	0	0
7	0	0	0	-10257960	-2177268	24010	20515920	0	48021	-10257960	2177268	24010	0	0	0
8	0	0	0	-2177268	-477511	-112960	0	955021	0	2177268	-477511	112960	0	0	0
9	0	0	0	-24010	112960	604094	48021	0	2416375	-24010	-112960	604093,76	0	0	0
10	0	0	0	0	0	0	-10257960	2177268	-24010	10392787	-2177268	481590	-134827	0	505600
11	0	0	0	0	0	0	2177268	-477511	-112960	-2177268	22909511	-112960	0	-22432000	0
12	0	0	0	0	0	0	24010	112960	604094	481590	-112960	3736188	-505600	0	1264000
13	0	0	0	0	0	0	0	0	0	-134827	0	-505600	134827	0	-505600
14	0	0	0	0	0	0	0	0	0	0	-22432000	0	0	22432000	0
15	0	0	0	0	0	0	0	0	0	505600	0	1264000	-505600	0	2528000

- **Introduksi Kondisi Batas Pada Persamaan Global**

Rumus: {Fs} = [Ss] . {Ds}

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15			
F1	=	134827	0	-505600	-134827	0	-505600	0	0	0	0	0	0	0	0	0	1	x	Ds1
F2		0	22432000	0	0	-22432000	0	0	0	0	0	0	0	0	0	0	2		Ds2
F3		-505600	0	2528000	505600	0	1264000	0	0	0	0	0	0	0	0	0	3		Ds3
F4		-134827	0	505600	10392787	2177268	481590	-10257960	-2177268	-24010	0	0	0	0	0	0	4		Ds4
F5		0	-22432000	0	2177268	22909511	112960	-2177268	-477511	112960	0	0	0	0	0	0	5		Ds5
F6		-505600	0	1264000	481590	112960	3736188	24010	-112960	604094	0	0	0	0	0	0	6		Ds6
F7		0	0	0	-10257960	-2177268	24010	20515920	0	48021	-10257960	2177268	24010	0	0	0	7		Ds7
F8		0	0	0	-2177268	-477511	-112960	0	955021	0	2177268	-477511	112960	0	0	0	8		Ds8
F9		0	0	0	-24010	112960	604094	48021	0	2416375	-24010	-112960	604094	0	0	0	9		Ds9
F10		0	0	0	0	0	0	-10257960	2177268	-24010	10392787	-2177268	481590	-134827	0	505600	10		Ds10
F11		0	0	0	0	0	0	2177268	-477511	-112960	-2177268	22909511	-112960	0	-22432000	0	11		Ds11
F12		0	0	0	0	0	0	24010	112960	604094	481590	-112960	3736188	-505600	0	1264000	12		Ds12
F13		0	0	0	0	0	0	0	0	0	-134827	0	-505600	134827	0	-505600	13		Ds13
F14		0	0	0	0	0	0	0	0	0	0	-22432000	0	0	22432000	0	14		Ds14
F15		0	0	0	0	0	0	0	0	0	505600	0	1264000	-505600	0	2528000	15		Ds15

• **Penataan Ulang Persamaan Global**

		4	5	6	7	8	9	10	11	12	1	2	3	13	14	15			
F4	=	10392787	2177268	481590	-10257960	-2177268	-24010	0	0	0	-134827	0	505600	0	0	0	4	x	Ds4
F5		2177268	22909511	112960	-2177268	-477511	112960	0	0	0	0	-22432000	0	0	0	0	5		Ds5
F6		481590	112960	3736188	24010	-112960	604094	0	0	0	-505600	0	1264000	0	0	0	6		Ds6
F7		-10257960	-2177268	24010	20515920	0	48021	-10257960	2177268	24010	0	0	0	0	0	0	7		Ds7
F8		-2177268	-477511	-112960	0	955021	0	2177268	-477511	112960	0	0	0	0	0	0	8		Ds8
F9		-24010	112960	604094	48021	0	2416375	-24010	-112960	604094	0	0	0	0	0	0	9		Ds9
F10		0	0	0	-10257960	2177268	-24010	10392787	-2177268	481590	0	0	0	-134827	0	505600	10		Ds10
F11		0	0	0	2177268	-477511	-112960	-2177268	22909511	-112960	0	0	0	0	-22432000	0	11		Ds11
F12		0	0	0	24010	112960	604094	481590	-112960	3736188	0	0	0	-505600	0	1264000	12		Ds12
F1		-134827	0	-505600	0	0	0	0	0	0	134827	0	-505600	0	0	0	1		Ds1
F2		0	-22432000	0	0	0	0	0	0	0	0	22432000	0	0	0	0	2		Ds2
F3		505600	0	1264000	0	0	0	0	0	0	-505600	0	2528000	0	0	0	3		Ds3
F13		0	0	0	0	0	0	-134827	0	-505600	0	0	0	134827	0	-505600	13		Ds13
F14		0	0	0	0	0	0	0	-22432000	0	0	0	0	0	22432000	0	14		Ds14
F15		0	0	0	0	0	0	505600	0	1264000	0	0	0	-505600	0	2528000	15		Ds15

• Matriks Kekakuan Batang Pada Sumbu Struktur (XS-YS-ZS)

Rumus: $[Ss]i = [RT]^{T}i \times [Sm]i \times [RT]i$

dengan: $[Sm]i$ = Matriks kekakuan batang pada sumbu batang (SKL)

$[RT]i$ = Matriks rotasi

$[RT]^{T}i$ = Matriks rotasi transpose

$$[Ss]1 = \begin{pmatrix} 0 & -1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \times \begin{pmatrix} 22432000 & 0 & 0 & -22432000 & 0 & 0 \\ 0 & 134826,6667 & 505600 & 0 & -134826,667 & 505600 \\ 0 & 505600 & 2528000 & 0 & -505600 & 1264000 \\ -22432000 & 0 & 0 & 22432000 & 0 & 0 \\ 0 & -134826,6667 & -505600 & 0 & 134826,6667 & -505600 \\ 0 & 505600 & 1264000 & 0 & -505600 & 2528000 \end{pmatrix} \times \begin{pmatrix} 0 & 1 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

$$= \begin{pmatrix} 134826,67 & 0 & -505600 & -134826,7 & 0 & -505600 \\ 0 & 22432000 & 0 & 0 & -22432000 & 0 \\ -505600 & 0 & 2528000 & 505600 & 0 & 1264000 \\ -134826,67 & 0 & 505600 & 134826,7 & 0 & 505600 \\ 0 & -22432000 & 0 & 0 & 22432000 & 0 \\ -505600 & 0 & 1264000 & 505600 & 0 & 2528000 \end{pmatrix} \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \end{matrix}$$

$$\begin{matrix} 1 & 2 & 3 & 4 & 5 & 6 \end{matrix}$$

$$[Ss]2 = \begin{pmatrix} 0{,}978 & -0{,}208 & 0 & 0 & 0 & 0 \\ 0{,}208 & 0{,}978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0{,}978 & -0{,}208 & 0 \\ 0 & 0 & 0 & 0{,}208 & 0{,}978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \times \begin{pmatrix} 10720753 & 0 & 0 & -10720753 & 0 & 0 \\ 0 & 14718 & 115484 & 0 & -14718 & 115484 \\ 0 & 115484 & 1208188 & 0 & -115484 & 604094 \\ -10720753 & 0 & 0 & 10720753 & 0 & 0 \\ 0 & -14718 & -115484 & 0 & 14718 & -115484 \\ 0 & 115484 & 604094 & 0 & -115484 & 1208188 \end{pmatrix}$$

$$x \begin{pmatrix} 0{,}978 & -0{,}208 & 0 & 0 & 0 & 0 \\ -0{,}208 & 0{,}978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0{,}978 & -0{,}208 & 0 \\ 0 & 0 & 0 & 0{,}208 & 0{,}978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} = \begin{pmatrix} 10257960 & 2177268{,}294 & -24010{,}46 & -10257959{,}9 & -2177268{,}29 & -24010 \\ 2177268 & 477510{,}6228 & 112960{,}3 & -2177268{,}29 & -477510{,}623 & 112960 \\ -24010 & 112960{,}3461 & 1208188 & 24010 & -112960{,}346 & 604094 \\ -10257960 & -2177268{,}294 & 24010{,}46 & 10257959{,}93 & 2177268{,}294 & 24010 \\ -2177268 & -477510{,}6228 & -112960{,}3 & 2177268 & 477510{,}6228 & -112960 \\ -24010 & 112960{,}3461 & 604093{,}8 & 24010 & -112960{,}346 & 1208188 \\ 4 & 5 & 6 & 7 & 8 & 9 \end{pmatrix} \begin{matrix} 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \end{matrix}$$

$$[Ss]3 = \begin{pmatrix} 0{,}978 & 0{,}208 & 0 & 0 & 0 & 0 \\ -0{,}208 & 0{,}978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0{,}978 & 0{,}208 & 0 \\ 0 & 0 & 0 & -0{,}208 & 0{,}978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \times \begin{pmatrix} 10720753 & 0 & 0 & -10720753 & 0 & 0 \\ 0 & 14718 & 115484 & 0 & -14718 & 115484 \\ 0 & 115484 & 1208188 & 0 & -115484 & 604094 \\ -10720753 & 0 & 0 & 10720753 & 0 & 0 \\ 0 & -14718 & -115484 & 0 & 14718 & -115484 \\ 0 & 115484 & 604094 & 0 & -115484 & 1208188 \end{pmatrix}$$

$$x \begin{pmatrix} 0{,}978 & -0{,}208 & 0 & 0 & 0 & 0 \\ 0{,}208 & 0{,}978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0{,}978 & -0{,}208 & 0 \\ 0 & 0 & 0 & 0{,}208 & 0{,}978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} = \begin{pmatrix} 10257960 & -2177268{,}294 & 24010{,}46 & -10257959{,}9 & 2177268{,}294 & 24010 \\ -2177268 & 477510{,}6228 & 112960{,}3 & 2177268{,}294 & -477510{,}623 & 112960 \\ 24010 & 112960{,}3461 & 1208188 & -24010 & -112960{,}346 & 604094 \\ -10257960 & 2177268{,}294 & -24010{,}46 & 10257959{,}93 & -2177268{,}29 & -24010 \\ 2177268 & -477510{,}6228 & -112960{,}3 & -2177268 & 477510{,}6228 & -112960 \\ 24010 & 112960{,}3461 & 604093{,}8 & -24010 & -112960{,}346 & 1208188 \\ 7 & 8 & 9 & 10 & 11 & 12 \end{pmatrix} \begin{matrix} 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \end{matrix}$$

$$
[Ss]4 = \begin{pmatrix} 0 & 1 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} x \begin{pmatrix} 22432000 & 0 & 0 & -22432000 & 0 & 0 \\ 0 & 134827 & 505600 & 0 & -134827 & 505600 \\ 0 & 505600 & 2528000 & 0 & -505600 & 1264000 \\ -22432000 & 0 & 0 & 22432000 & 0 & 0 \\ 0 & -134827 & -505600 & 0 & 134827 & -505600 \\ 0 & 505600 & 1264000 & 0 & -505600 & 2528000 \end{pmatrix}
$$

$$
x \begin{pmatrix} 0 & -1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} = \begin{pmatrix} 134827 & 0 & 505600 & -134827 & 0 & 505600 \\ 0 & 22432000 & 0 & 0 & -22432000 & 0 \\ 505600 & 0 & 2528000 & -505600 & 0 & 1264000 \\ -134827 & 0 & -505600 & 134827 & 0 & -505600 \\ 0 & -22432000 & 0 & 0 & 22432000 & 0 \\ 505600 & 0 & 1264000 & -505600 & 0 & 2528000 \end{pmatrix}
$$

10 11 12 13 14 15 10 11 12 13 14 15

- **Kombinasi 1**

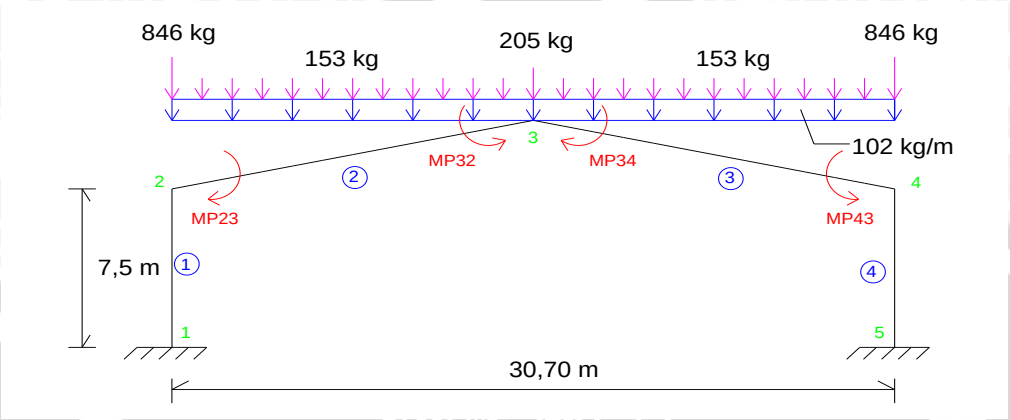
  1.4D

  1,4 q_D = 1,4 x 73 = 102 kg/m

  1,4 P_D: 1,4 x 109 = 153 kg

  1,4 x 147 = 205 kg

  1,4 x 604 = 846 kg



	ΣM3		ΣM2	
Beban	Jarak	PxL	Jarak	PxL
102	15,35	11974	15,35	11974
103	0	0	15,35	1575
846	15,35	12981	0	0
153	14,08	2149,4	1,27	194
	12,81	1955,2	2,54	388
	11,54	1761,1	3,81	582
	10,26	1566,9	5,09	777
	8,99	1372,8	6,36	971
	7,72	1178,7	7,63	1165
	6,45	984,55	8,90	1359
	5,18	790,41	10,17	1553
	3,91	596,28	11,44	1747
	2,63	402,15	12,72	1941
	1,36	208,01	13,99	2135
Jumlah		37921		26362
R2		2470	R3	1717

KONTROL					
102	x	15,35	=	1560	2470
153	x	11	=	1679	1717
205	x	1	=	103	
846	x	1	=	846	
Jumlah				4188	4188
				OK	

- Momen Primer

MP23 = -MP32 = MP34 = -MP43

$$= \frac{1}{12} qL^2 + \Sigma \frac{Pab^2}{L^2}$$

c	q	L^2	$\frac{1}{12} qL^2$
1/12	102	236	1995,7
P	a	b^2	$\frac{Pab^2}{L^2}$
846	0	236	0
153	1,27	198	163
153	2,54	164	270
153	3,81	133	329
153	5,09	105	347
153	6,36	81	333
153	7,63	60	295
153	8,90	42	240
153	10,17	27	177
153	11,44	15	113
153	12,72	7	57
153	13,99	2	17
205	15,35	0	0
MP23 (kgm)			**4337**

- **Beban Ekuivalen 1 {Fs}**

$$\{Fs\} = \begin{Bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ -2470 \\ -4337 \\ 0 \\ -3435 \\ 0 \\ 0 \\ -2470 \\ 4337 \\ 0 \\ 0 \\ 0 \end{Bmatrix}_{1\,2\,3\,4\,5\,6\,7\,8\,9\,10\,11\,12\,13\,14\,15} \quad \begin{Bmatrix} F4 \\ F5 \\ F6 \\ F7 \\ F8 \\ F9 \\ F10 \\ F11 \\ F12 \\ F1 \\ F2 \\ F3 \\ F13 \\ F14 \\ F15 \end{Bmatrix} = \begin{Bmatrix} 0 \\ -2470 \\ -4337 \\ 0 \\ -3435 \\ 0 \\ 0 \\ -2470 \\ 4337 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{Bmatrix}_{4\,5\,6\,7\,8\,9\,10\,11\,12\,1\,2\,3\,13\,14\,15}$$

•Kombinasi 1 - Perhitungan Perpindahan

Rumus: {Ds} = $[Ss]^{-1}$. {Fs}

4	5	6	7	8	9	10	11	12				
9,36E-06	3,21E-09	-1,21E-06	8,28E-06	4,91E-06	6,09E-07	7,20E-06	-3,21E-09	-1,23E-06	4	x	0	= -0,0169
3,21E-09	4,46E-08	-8,55E-10	7,94E-09	2,23E-08	-1,75E-09	3,21E-09	1,57E-12	-8,55E-10	5		-2470	-0,0002
-1,21E-06	-8,55E-10	4,60E-07	-1,22E-06	7,61E-08	-1,62E-07	-1,23E-06	8,55E-10	1,90E-07	6		-4337	-0,0014
8,28E-06	7,94E-09	-1,22E-06	8,33E-06	1,14E-20	6,08E-07	8,28E-06	-7,94E-09	-1,22E-06	7		0	0,0000
4,91E-06	2,23E-08	7,61E-08	7,53E-21	2,35E-05	9,41E-22	-4,91E-06	2,23E-08	-7,61E-08	8		-3435	-0,0813
6,09E-07	-1,75E-09	-1,62E-07	6,08E-07	6,38E-23	4,95E-07	6,09E-07	1,75E-09	-1,62E-07	9		0	0,0000
7,20E-06	3,21E-09	-1,23E-06	8,28E-06	-4,91E-06	6,09E-07	9,36E-06	-3,21E-09	-1,21E-06	10		0	0,0169
-3,21E-09	1,57E-12	8,55E-10	-7,94E-09	2,23E-08	1,75E-09	-3,21E-09	4,46E-08	8,55E-10	11		-2470	-0,0002
-1,23E-06	-8,55E-10	1,90E-07	-1,22E-06	-7,61E-08	-1,62E-07	-1,21E-06	8,55E-10	4,60E-07	12		4337	0,0014

•Kombinasi 1 - Perhitungan Reaksi Tumpuan

Rumus: {Fs} = [Ss] . {Ds}

4	5	6	7	8	9	10	11	12				
-134827	0	-505600	0	0	0	0	0	0	1	x	-0,0169	= 3007
0	-22432000	0	0	0	0	0	0	0	2		-0,0002	4188
505600	0	1264000	0	0	0	0	0	0	3		-0,0014	-10371
0	0	0	0	0	0	-134827	0	-505600	13		0,0000	-3007
0	0	0	0	0	0	0	-22432000	0	14		-0,0813	4188
0	0	0	0	0	0	505600	0	1264000	15		0,0000	10371
											0,0169	
											-0,0002	
											0,0014	

•Kombinasi 1 - Perhitungan Gaya-Gaya Dalam Akhir Batang (pada sumbu batang)

Rumus: $\{Fm^A\}i = \{Fm^B\}i + [Sm]i \times [RT]i \times \{Ds\}i$

dengan:
$\{Fm^A\}i$ = Gaya dalam batang
$\{Fm^B\}i$ = Gaya akibat beban luar
$[Sm]i$ = Matriks kekakuan batang (pada sumbu batang)
$[RT]i$ = Matriks rotasi
$\{Ds\}i$ = Perpindahan

$$\{Fm^A\}1 = \begin{Bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{Bmatrix} + \begin{pmatrix} 22432000 & 0 & 0 & -22432000 & 0 & 0 \\ 0 & 134827 & 505600 & 0 & -134827 & 505600 \\ 0 & 505600 & 2528000 & 0 & -505600 & 1264000 \\ -22432000 & 0 & 0 & 22432000 & 0 & 0 \\ 0 & -134827 & -505600 & 0 & 134827 & -505600 \\ 0 & 505600 & 1264000 & 0 & -505600 & 2528000 \end{pmatrix} \times \begin{pmatrix} 0 & 1 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \times \begin{Bmatrix} 0 \\ 0 \\ 0 \\ -0{,}0169 \\ -0{,}0002 \\ -0{,}0014 \end{Bmatrix} = \begin{Bmatrix} 4188 \\ -3007 \\ -10371 \\ -4188 \\ 3007 \\ -12180 \end{Bmatrix} \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \end{matrix}$$

$$\{Fm^A\}2 = \begin{Bmatrix} 514 \\ 2416 \\ 4337 \\ 357 \\ 1680 \\ -4337 \end{Bmatrix} + \begin{pmatrix} 10720753 & 0 & 0 & -10720753 & 0 & 0 \\ 0 & 14718 & 115484 & 0 & -14718 & 115484 \\ 0 & 115484 & 1208188 & 0 & -115484 & 604094 \\ -10720753 & 0 & 0 & 10720753 & 0 & 0 \\ 0 & -14718 & -115484 & 0 & 14718 & -115484 \\ 0 & 115484 & 604094 & 0 & -115484 & 1208188 \end{pmatrix} \times \begin{pmatrix} 0{,}978 & 0{,}208 & 0 & 0 & 0 & 0 \\ -0{,}21 & 0{,}978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0{,}978 & 0{,}208 & 0 \\ 0 & 0 & 0 & -0{,}21 & 0{,}978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \times \begin{Bmatrix} -0{,}0169 \\ -0{,}0002 \\ -0{,}0014 \\ 0{,}0000 \\ -0{,}0813 \\ 0{,}0000 \end{Bmatrix} = \begin{Bmatrix} 3812 \\ 3471 \\ 12180 \\ -2941 \\ 625 \\ 4372 \end{Bmatrix} \begin{matrix} 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \end{matrix}$$

$$\{Fm^A\}3 = \begin{Bmatrix} -357 \\ 1680 \\ 4337 \\ -514 \\ 2416 \\ -4337 \end{Bmatrix} + \begin{pmatrix} 10720753 & 0 & 0 & -10720753 & 0 & 0 \\ 0 & 14718 & 115484 & 0 & -14718 & 115484 \\ 0 & 115484 & 1208188 & 0 & -115484 & 604094 \\ -10720753 & 0 & 0 & 10720753 & 0 & 0 \\ 0 & -14718 & -115484 & 0 & 14718 & -115484 \\ 0 & 115484 & 604094 & 0 & -115484 & 1208188 \end{pmatrix} \times \begin{pmatrix} 0{,}978 & -0{,}21 & 0 & 0 & 0 & 0 \\ 0{,}208 & 0{,}978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0{,}978 & -0{,}21 & 0 \\ 0 & 0 & 0 & 0{,}208 & 0{,}978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \times \begin{Bmatrix} 0{,}0000 \\ -0{,}0813 \\ 0{,}0000 \\ 0{,}0169 \\ -0{,}0002 \\ 0{,}0014 \end{Bmatrix} = \begin{Bmatrix} 2941 \\ 625 \\ -4372 \\ -3812 \\ 3471 \\ -12180 \end{Bmatrix} \begin{matrix} 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \end{matrix}$$

$$\{Fm^A\}4 = \begin{Bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{Bmatrix} + \begin{pmatrix} 22432000 & 0 & 0 & -22432000 & 0 & 0 \\ 0 & 134827 & 505600 & 0 & -134827 & 505600 \\ 0 & 505600 & 2528000 & 0 & -505600 & 1264000 \\ -22432000 & 0 & 0 & 22432000 & 0 & 0 \\ 0 & -134827 & -505600 & 0 & 134827 & -505600 \\ 0 & 505600 & 1264000 & 0 & -505600 & 2528000 \end{pmatrix} \times \begin{pmatrix} 0 & -1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \times \begin{Bmatrix} 0{,}0169 \\ -0{,}0002 \\ 0{,}0014 \\ 0 \\ 0 \\ 0 \end{Bmatrix} = \begin{Bmatrix} 4188 \\ 3007 \\ 12180 \\ -4188 \\ -3007 \\ 10371 \end{Bmatrix} \begin{matrix} 10 \\ 11 \\ 12 \\ 13 \\ 14 \\ 15 \end{matrix}$$

•Kombinasi 1 - Perhitungan Gaya-Gaya Dalam Akhir Batang (pada sumbu struktur)

Rumus: $\{Fs^A\}i = [RT]^T i \times \{Fm^A\}i$

dengan: $\{Fs^A\}i$ = Gaya dalam akhir batang

$[RT]^T i$ = Matriks rotasi transpose

$\{Fm^A\}i$ = Gaya dalam batang

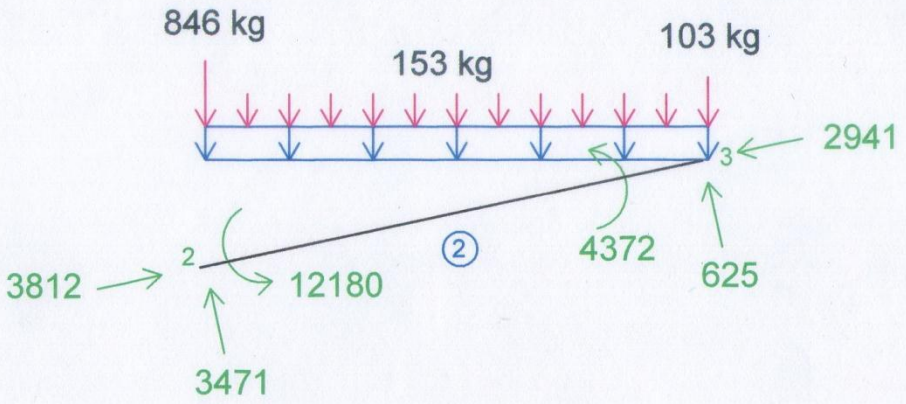
$$\{Fs^A\}1 = \begin{pmatrix} 0 & -1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \times \begin{Bmatrix} 4188 \\ -3007 \\ -10371 \\ -4188 \\ 3007 \\ -12180 \end{Bmatrix} = \begin{Bmatrix} 3007 \\ 4188 \\ -10371 \\ -3007 \\ -4188 \\ -12180 \end{Bmatrix} \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \end{matrix}$$

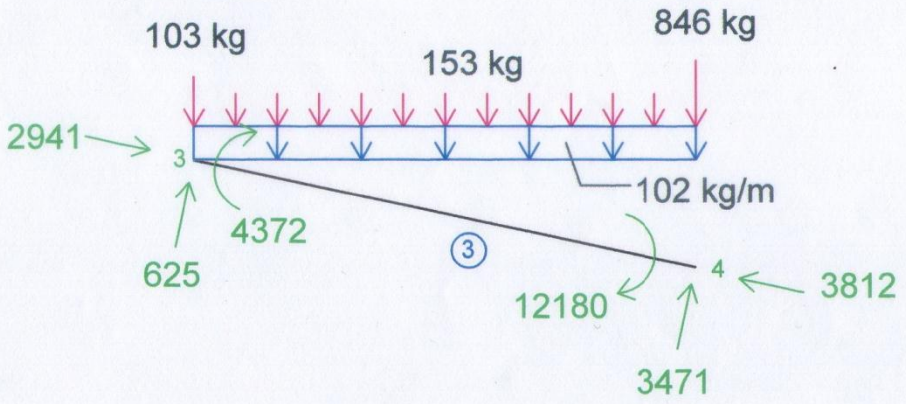
$$\{Fs^A\}2 = \begin{pmatrix} 0{,}978 & -0{,}208 & 0 & 0 & 0 & 0 \\ 0{,}208 & 0{,}978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0{,}978 & -0{,}208 & 0 \\ 0 & 0 & 0 & 0{,}208 & 0{,}978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \times \begin{Bmatrix} 3812 \\ 3471 \\ 12180 \\ -2941 \\ 625 \\ 4372 \end{Bmatrix} = \begin{Bmatrix} 3007 \\ 4188 \\ 12180 \\ -3007 \\ 0 \\ 4372 \end{Bmatrix} \begin{matrix} 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \end{matrix}$$

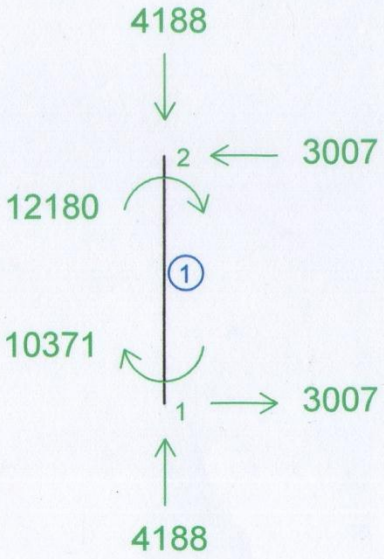
$$\{Fs^A\}3 = \begin{pmatrix} 0{,}978 & 0{,}208 & 0 & 0 & 0 & 0 \\ -0{,}208 & 0{,}978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0{,}978 & 0{,}208 & 0 \\ 0 & 0 & 0 & -0{,}208 & 0{,}978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \times \begin{Bmatrix} 2941 \\ 625 \\ -4372 \\ -3812 \\ 3471 \\ -12180 \end{Bmatrix} = \begin{Bmatrix} 3007 \\ 0 \\ -4372 \\ -3007 \\ 4188 \\ -12180 \end{Bmatrix} \begin{matrix} 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \end{matrix}$$

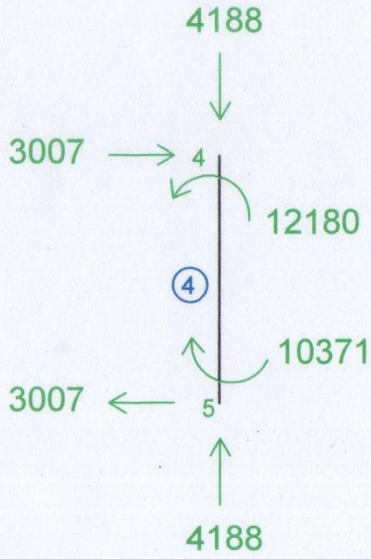
$$\{Fs^A\}4 = \begin{pmatrix} 0 & 1 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \times \begin{Bmatrix} 4188 \\ 3007 \\ 12180 \\ -4188 \\ -3007 \\ 10371 \end{Bmatrix} = \begin{Bmatrix} 3007 \\ -4188 \\ 12180 \\ -3007 \\ 4188 \\ 10371 \end{Bmatrix} \begin{matrix} 10 \\ 11 \\ 12 \\ 13 \\ 14 \\ 15 \end{matrix}$$

FBD KOMBINASI 1



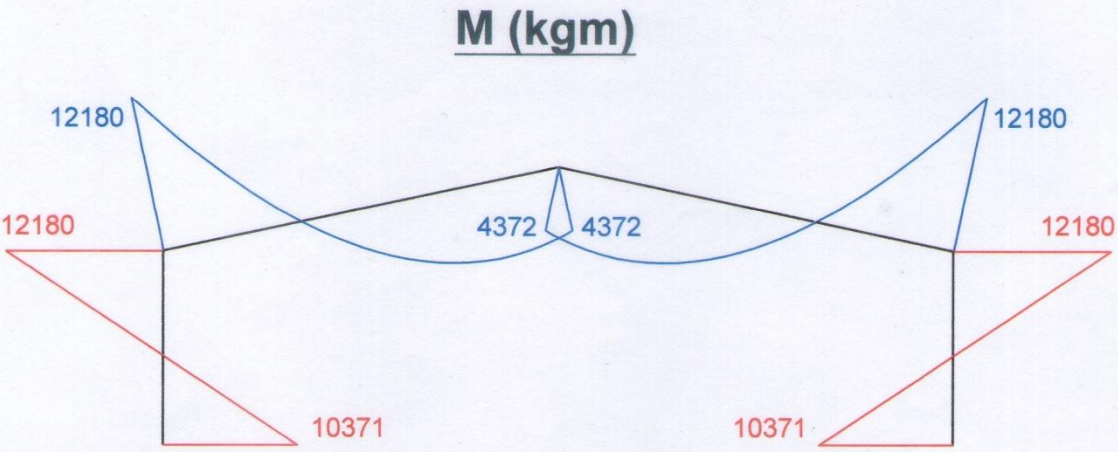


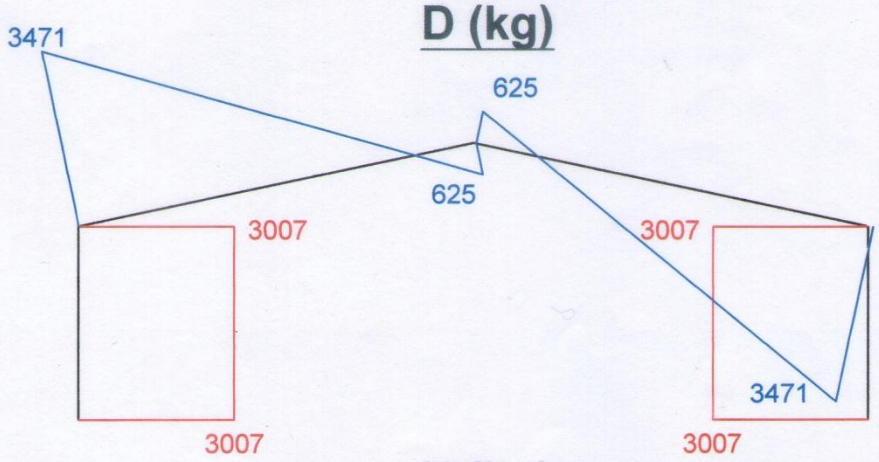


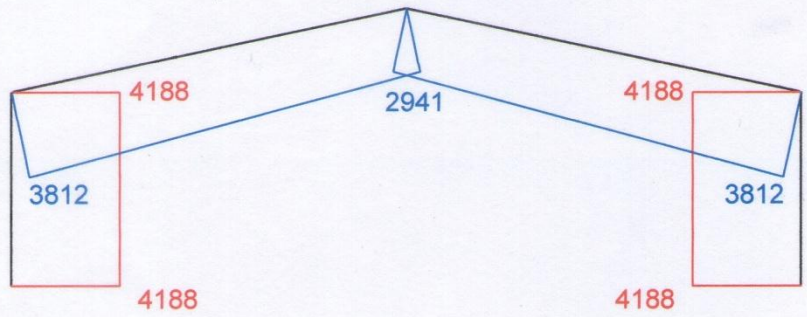


• Kombinasi 1 - Perhitungan Momen Per Interval Bentang 2

x →		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	15,693
M	-12180	-12180	-12180	-12180	-12180	-12180	-12180	-12180	-12180	-12180	-12180	-12180	-12180	-12180	-12180	-12180	-12180	-12180
q	-102	0	-49	-194	-438	-778	-1216	-1750	-2383	-3112	-3938	-4862	-5883	-7002	-8217	-9530	-10940	-11974
P	-846 x cos12 = -827	0	-827	-1654	-2482	-3309	-4136	-4963	-5790	-6618	-7445	-8272	-9099	-9926	-10753	-11581	-12408	-12981
V2	4188 x cos12 = 4096	0	4096	8193	12289	16385	20482	24578	28674	32771	36867	40963	45060	49156	53252	57348	61445	64283
H2	-3007 x sin12 = -625	0	-625	-1250	-1875	-2501	-3126	-3751	-4376	-5001	-5626	-6252	-6877	-7502	-8127	-8752	-9377	-9811
1,30	-153 x cos12 = -149			-105	-254	-403	-553	-702	-851	-1001	-1150	-1299	-1449	-1598	-1747	-1897	-2046	-2149
2,60					-60	-209	-358	-508	-657	-806	-956	-1105	-1254	-1404	-1553	-1702	-1852	-1955
3,90						-15	-164	-314	-463	-612	-762	-911	-1060	-1210	-1359	-1508	-1658	-1761
5,20								-119	-269	-418	-567	-717	-866	-1015	-1165	-1314	-1463	-1567
6,50									-75	-224	-373	-523	-672	-821	-971	-1120	-1269	-1373
7,80										-30	-179	-329	-478	-627	-777	-926	-1075	-1179
9,10												-134	-284	-433	-582	-732	-881	-985
10,40													-90	-239	-388	-538	-687	-790
11,70														-45	-194	-343	-493	-596
13,00																-149	-299	-402
14,30																	-105	-208
Jumlah		-12180	-9585	-7191	-5000	-3010	-1251	290	1630	2768	3690	4379	4867	5154	5238	5076	4712	4372
																	Kr(%)	0







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Job Title	Ref		
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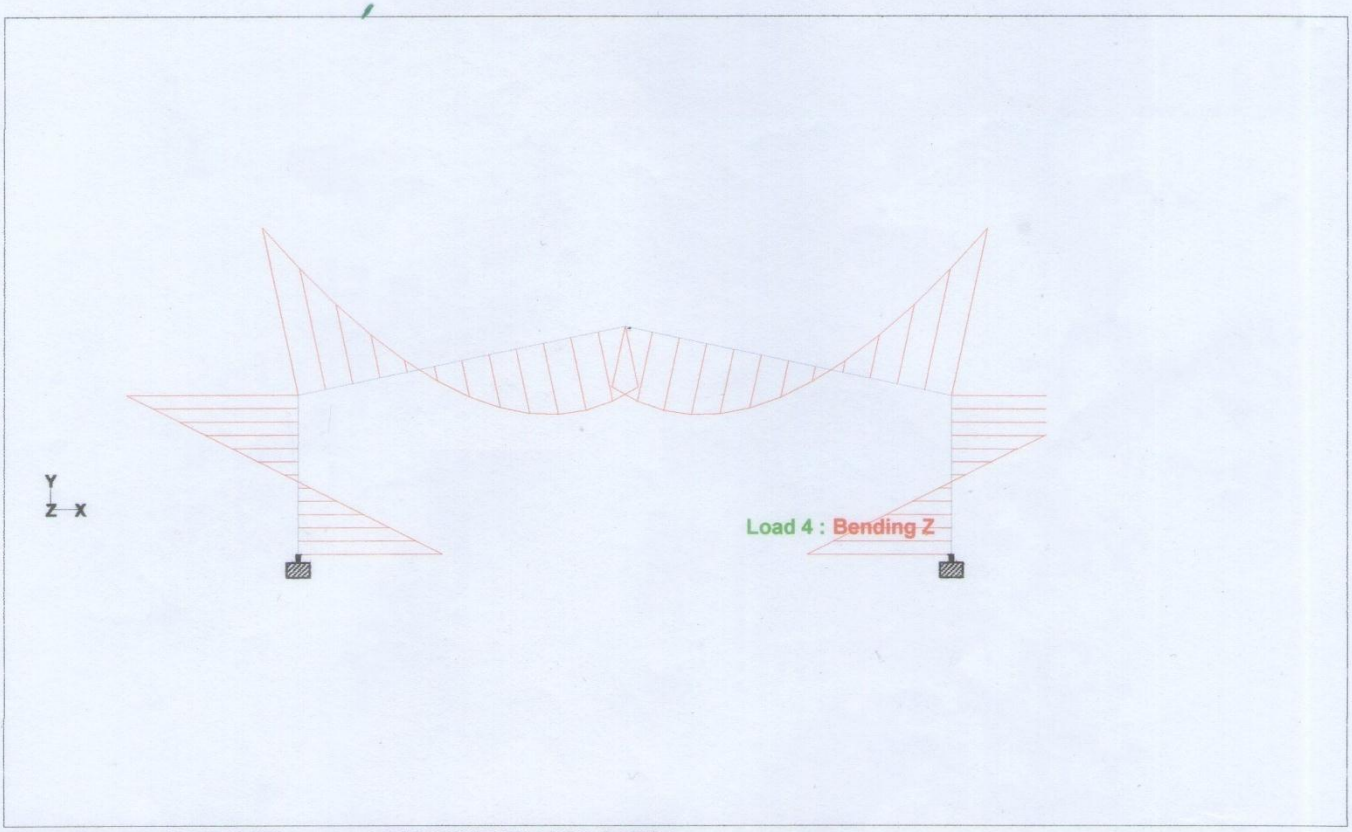
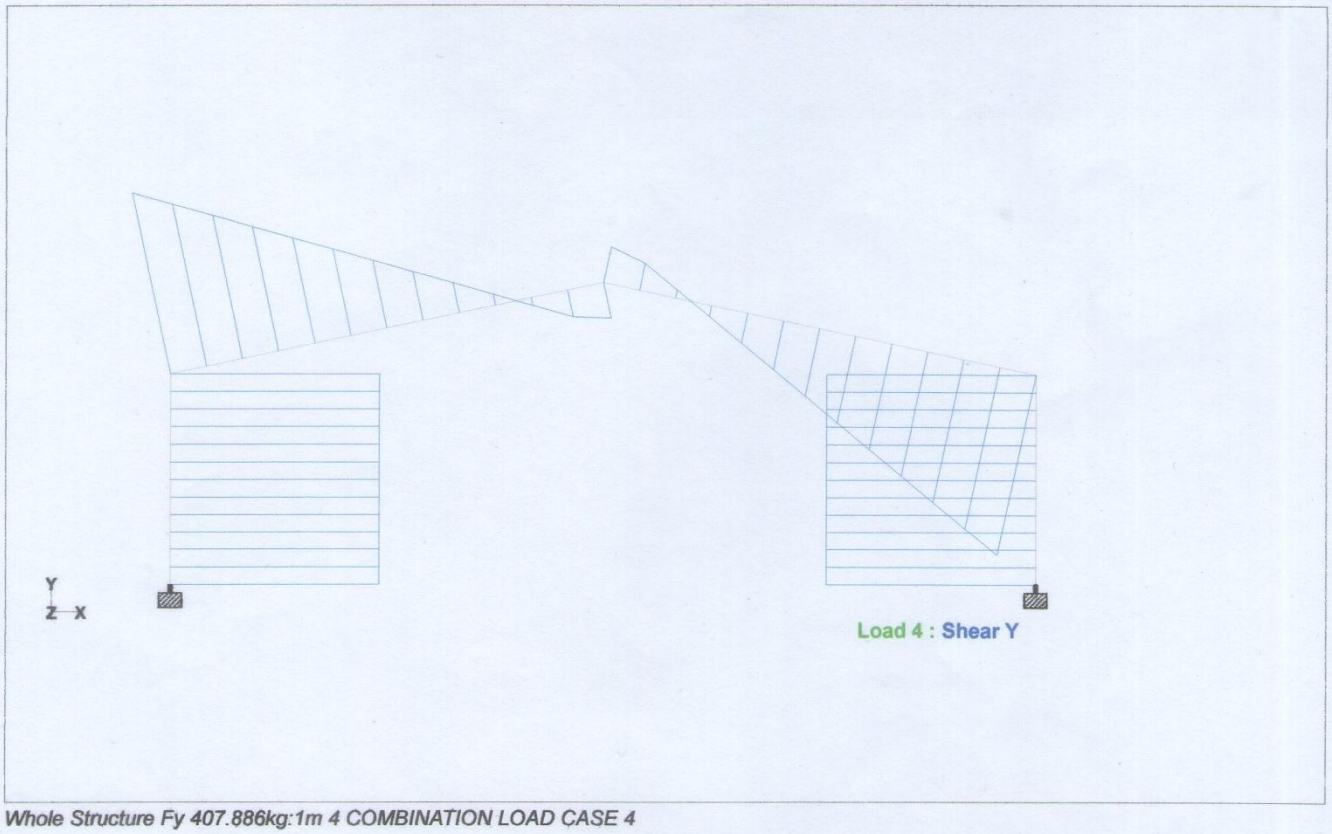


Whole Structure Mz 1529.57kg-m:1m 4 COMBINATION LOAD CASE 4



Whole Structure Fy 407.886kg:1m 4 COMBINATION LOAD CASE 4

- **Kombinasi 2**

  1.2D + 1.6L + 0.5(La atau H)

  La < H → dipakai H

  Kombinasi pembebanannya menjadi:

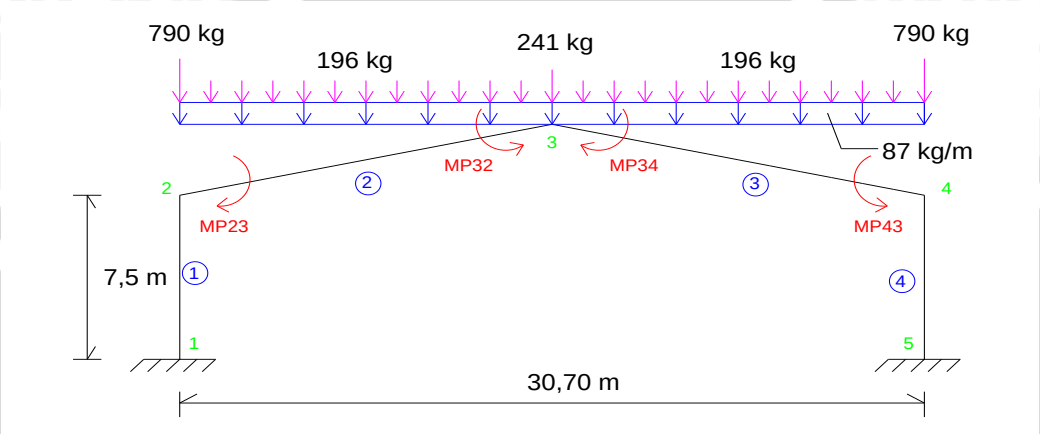
  1.2D + 0.5H

  1,2 q_D = 1,2 x 73 = 87 kg/m

  1,2 P_D: 1,2 x 109 + 0,5 130 = 196 kg

  1,2 x 147 + 0,5 130 = 241 kg

  1,2 x 604 + 0,5 130 = 790 kg



	ΣM3		ΣM2	
Beban	Jarak	PxL	Jarak	PxL
87	15,35	10264	15,35	10264
120	0	0	15,35	1849
790	15,35	12124	0	0
196	14,08	2757,4	1,27	249
	12,81	2508,3	2,54	498
	11,54	2259,3	3,81	747
	10,26	2010,2	5,09	996
	8,99	1761,2	6,36	1245
	7,72	1512,1	7,63	1494
	6,45	1263,1	8,90	1743
	5,18	1014	10,17	1992
	3,91	764,97	11,44	2241
	2,63	515,91	12,72	2491
	1,36	266,86	13,99	2740
Jumlah		39021		28550
R2		2542	R3	1860

KONTROL					
87	x	15,35	=	1337	2542
196	x	11	=	2154	1860
241	x	0,5	=	120	
790	x	1	=	790	
Jumlah				4402	4402
				OK	

- Momen Primer

MP23 = -MP32 = MP34 = -MP43

$$= \frac{1}{12} qL^2 + \Sigma \frac{Pab^2}{L^2}$$

c	q	L^2	$\frac{1}{12} qL^2$
1/12	87	235,6	1710,6
P	a	b^2	$\frac{Pab^2}{L^2}$
790	0	236	0
196	1,27	198	209
196	2,54	164	347
196	3,81	133	422
196	5,09	105	445
196	6,36	81	427
196	7,63	60	378
196	8,90	42	308
196	10,17	27	227
196	11,44	15	145
196	12,72	7	73
196	13,99	2	22
241	15,35	0	0
MP (kgm)			**4714**

•Kombinasi 2 - Beban Ekuivalen {Fs}

{Fs} =			F4 =		
	0	1	F5	0	4
	0	2	F6	-2542	5
	0	3	F7	-4714	6
	0	4	F8	0	7
	-2542	5	F9	-3720	8
	-4714	6	F10	0	9
	0	7	F11	0	10
	-3720	8	F12	-2542	11
	0	9		4714	12
	0	10	F1	0	1
	-2542	11	F2	0	2
	4714	12	F3	0	3
	0	13	F13	0	13
	0	14	F14	0	14
	0	15	F15	0	15

•Kombinasi 2 - Perhitungan Perpindahan

Rumus: {Ds} = $[Ss]^{-1}$. {Fs}

4	5	6	7	8	9	10	11	12						
9,36E-06	3,21E-09	-1,21E-06	8,28E-06	4,91E-06	6,09E-07	7,20E-06	-3,21E-09	-1,23E-06	4	x	0	=	-0,0183	m
3,21E-09	4,46E-08	-8,55E-10	7,94E-09	2,23E-08	-1,75E-09	3,21E-09	1,57E-12	-8,55E-10	5		-2542		-0,0002	m
-1,21E-06	-8,55E-10	4,60E-07	-1,22E-06	7,61E-08	-1,62E-07	-1,23E-06	8,55E-10	1,90E-07	6		-4714		-0,0016	rad
8,28E-06	7,94E-09	-1,22E-06	8,33E-06	1,14E-20	6,08E-07	8,28E-06	-7,94E-09	-1,22E-06	7		0		0,0000	m
4,91E-06	2,23E-08	7,61E-08	7,53E-21	2,35E-05	9,41E-22	-4,91E-06	2,23E-08	-7,61E-08	8		-3720		-0,0881	m
6,09E-07	-1,75E-09	-1,62E-07	6,08E-07	6,38E-23	4,95E-07	6,09E-07	1,75E-09	-1,62E-07	9		0		0,0000	rad
7,20E-06	3,21E-09	-1,23E-06	8,28E-06	-4,91E-06	6,09E-07	9,36E-06	-3,21E-09	-1,21E-06	10		0		0,0183	m
-3,21E-09	1,57E-12	8,55E-10	-7,94E-09	2,23E-08	1,75E-09	-3,21E-09	4,46E-08	8,55E-10	11		-2542		-0,0002	m
-1,23E-06	-8,55E-10	1,90E-07	-1,22E-06	-7,61E-08	-1,62E-07	-1,21E-06	8,55E-10	4,60E-07	12		4714		0,0016	rad

•Kombinasi 2 - Perhitungan Reaksi Tumpuan

Rumus: {Fs} = [Ss] . {Ds}

4	5	6	7	8	9	10	11	12					
-134827	0	-505600	0	0	0	0	0	0	1	x	-0,0183	=	3259
0	-22432000	0	0	0	0	0	0	0	2		-0,0002		4402
505600	0	1264000	0	0	0	0	0	0	3		-0,0016		-11238
0	0	0	0	0	0	-134827	0	-505600	13		0,0000		-3259
0	0	0	0	0	0	0	-22432000	0	14		-0,0881		4402
0	0	0	0	0	0	505600	0	1264000	15		0,0000		11238
											0,0183		
											-0,0002		
											0,0016		

•Kombinasi 2 - Perhitungan Gaya-Gaya Dalam Akhir Batang (pada sumbu batang)

Rumus: $\{Fm^A\}i = \{Fm^B\}i + [Sm]i \times [RT]i \times \{Ds\}i$

dengan:
$\{Fm^A\}i$ = Gaya dalam batang
$\{Fm^B\}i$ = Gaya akibat beban luar
$[Sm]i$ = Matriks kekakuan batang (pada sumbu batang)
$[RT]i$ = Matriks rotasi
$\{Ds\}i$ = Perpindahan

$$\{Fm^A\}1 = \begin{Bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{Bmatrix} + \begin{pmatrix} 22432000 & 0 & 0 & -22432000 & 0 & 0 \\ 0 & 134827 & 505600 & 0 & -134827 & 505600 \\ 0 & 505600 & 2528000 & 0 & -505600 & 1264000 \\ -22432000 & 0 & 0 & 22432000 & 0 & 0 \\ 0 & -134827 & -505600 & 0 & 134827 & -505600 \\ 0 & 505600 & 1264000 & 0 & -505600 & 2528000 \end{pmatrix} \times \begin{pmatrix} 0 & 1 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \times \begin{Bmatrix} 0 \\ 0 \\ 0 \\ -0{,}0183 \\ -0{,}0002 \\ -0{,}0016 \end{Bmatrix} = \begin{Bmatrix} 4402 \\ -3259 \\ -11238 \\ -4402 \\ 3259 \\ -13203 \end{Bmatrix} \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \end{matrix}$$

$$\{Fm^A\}2 = \begin{Bmatrix} 529 \\ 2487 \\ 4714 \\ 387 \\ 1819 \\ -4714 \end{Bmatrix} + \begin{pmatrix} 10720753 & 0 & 0 & -10720753 & 0 & 0 \\ 0 & 14718 & 115484 & 0 & -14718 & 115484 \\ 0 & 115484 & 1208188 & 0 & -115484 & 604094 \\ -10720753 & 0 & 0 & 10720753 & 0 & 0 \\ 0 & -14718 & -115484 & 0 & 14718 & -115484 \\ 0 & 115484 & 604094 & 0 & -115484 & 1208188 \end{pmatrix} \times \begin{pmatrix} 0{,}978 & 0{,}208 & 0 & 0 & 0 & 0 \\ -0{,}21 & 0{,}978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0{,}978 & 0{,}208 & 0 \\ 0 & 0 & 0 & -0{,}21 & 0{,}978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \times \begin{Bmatrix} -0{,}0183 \\ -0{,}0002 \\ -0{,}0016 \\ 0{,}0000 \\ -0{,}0881 \\ 0{,}0000 \end{Bmatrix} = \begin{Bmatrix} 4103 \\ 3628 \\ 13203 \\ -3188 \\ 678 \\ 4715 \end{Bmatrix} \begin{matrix} 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \end{matrix}$$

$$\{Fm^A\}3 = \begin{Bmatrix} -387 \\ 1819 \\ 4714 \\ -529 \\ 2487 \\ -4714 \end{Bmatrix} + \begin{pmatrix} 10720753 & 0 & 0 & -10720753 & 0 & 0 \\ 0 & 14718 & 115484 & 0 & -14718 & 115484 \\ 0 & 115484 & 1208188 & 0 & -115484 & 604094 \\ -10720753 & 0 & 0 & 10720753 & 0 & 0 \\ 0 & -14718 & -115484 & 0 & 14718 & -115484 \\ 0 & 115484 & 604094 & 0 & -115484 & 1208188 \end{pmatrix} \times \begin{pmatrix} 0{,}978 & -0{,}21 & 0 & 0 & 0 & 0 \\ 0{,}208 & 0{,}978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0{,}978 & -0{,}21 & 0 \\ 0 & 0 & 0 & 0{,}208 & 0{,}978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \times \begin{Bmatrix} 0{,}0000 \\ -0{,}0881 \\ 0{,}0000 \\ 0{,}0183 \\ -0{,}0002 \\ 0{,}0016 \end{Bmatrix} = \begin{Bmatrix} 3188 \\ 678 \\ -4715 \\ -4103 \\ 3628 \\ -13203 \end{Bmatrix} \begin{matrix} 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \end{matrix}$$

$$\{Fm^A\}4 = \begin{Bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{Bmatrix} + \begin{pmatrix} 22432000 & 0 & 0 & -22432000 & 0 & 0 \\ 0 & 134827 & 505600 & 0 & -134827 & 505600 \\ 0 & 505600 & 2528000 & 0 & -505600 & 1264000 \\ -22432000 & 0 & 0 & 22432000 & 0 & 0 \\ 0 & -134827 & -505600 & 0 & 134827 & -505600 \\ 0 & 505600 & 1264000 & 0 & -505600 & 2528000 \end{pmatrix} \times \begin{pmatrix} 0 & -1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \times \begin{Bmatrix} 0{,}0183 \\ -0{,}0002 \\ 0{,}0016 \\ 0 \\ 0 \\ 0 \end{Bmatrix} = \begin{Bmatrix} 4402 \\ 3259 \\ 13203 \\ -4402 \\ -3259 \\ 11238 \end{Bmatrix} \begin{matrix} 10 \\ 11 \\ 12 \\ 13 \\ 14 \\ 15 \end{matrix}$$

•Kombinasi 2 - Perhitungan Gaya-Gaya Dalam Akhir Batang (pada sumbu struktur)

Rumus: $\{Fs^A\}i = [RT]^T i \times \{Fm^A\}i$

dengan: $\{Fs^A\}i$ = Gaya dalam akhir batang

$[RT]^T i$ = Matriks rotasi transpose

$\{Fm^A\}i$ = Gaya dalam batang

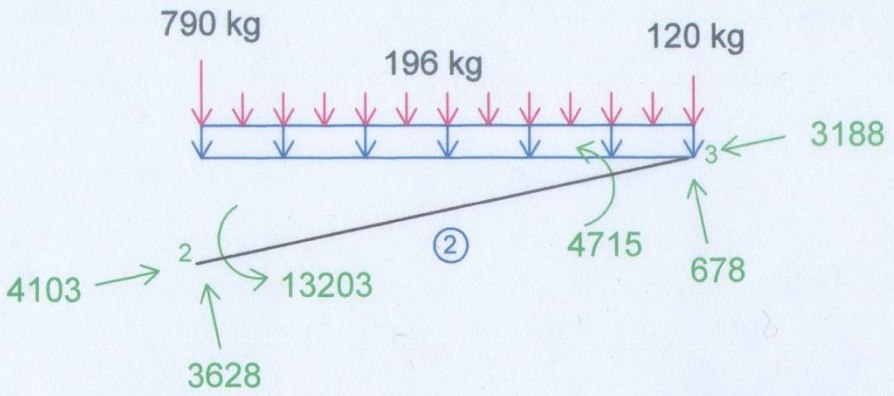
$$\{Fs^A\}1 = \begin{bmatrix} 0 & -1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{Bmatrix} 4402 \\ -3259 \\ -11238 \\ -4402 \\ 3259 \\ -13203 \end{Bmatrix} = \begin{Bmatrix} 3259 \\ 4402 \\ -11238 \\ -3259 \\ -4402 \\ -13203 \end{Bmatrix} \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \end{matrix}$$

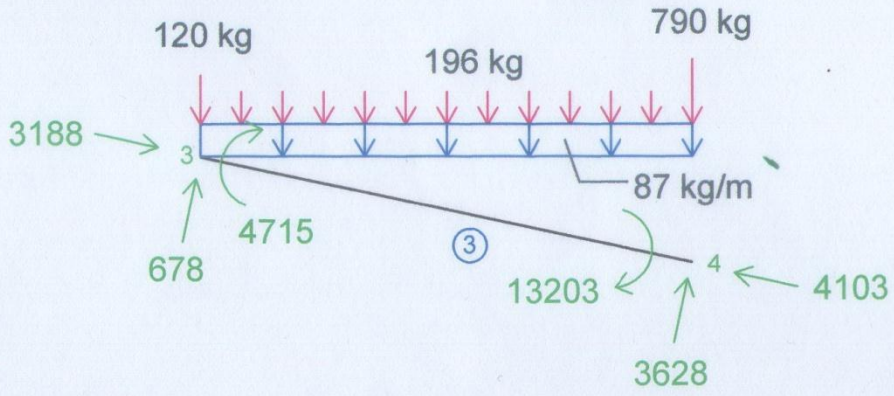
$$\{Fs^A\}2 = \begin{bmatrix} 0{,}978 & -0{,}208 & 0 & 0 & 0 & 0 \\ 0{,}208 & 0{,}978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0{,}978 & -0{,}208 & 0 \\ 0 & 0 & 0 & 0{,}208 & 0{,}978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{Bmatrix} 4103 \\ 3628 \\ 13203 \\ -3188 \\ 678 \\ 4715 \end{Bmatrix} = \begin{Bmatrix} 3259 \\ 4402 \\ 13203 \\ -3259 \\ 0 \\ 4715 \end{Bmatrix} \begin{matrix} 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \end{matrix}$$

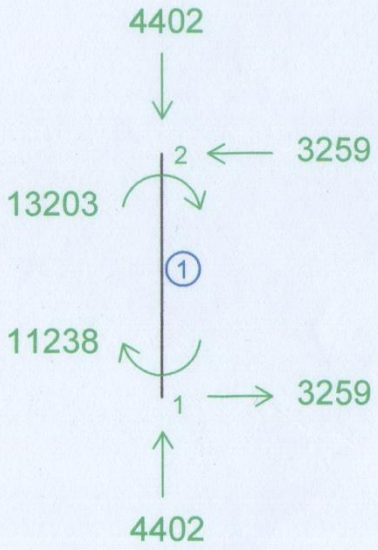
$$\{Fs^A\}3 = \begin{bmatrix} 0{,}978 & 0{,}208 & 0 & 0 & 0 & 0 \\ -0{,}208 & 0{,}978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0{,}978 & 0{,}208 & 0 \\ 0 & 0 & 0 & -0{,}208 & 0{,}978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{Bmatrix} 3188 \\ 678 \\ -4715 \\ -4103 \\ 3628 \\ -13203 \end{Bmatrix} = \begin{Bmatrix} 3259 \\ 0 \\ -4715 \\ -3259 \\ 4402 \\ -13203 \end{Bmatrix} \begin{matrix} 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \end{matrix}$$

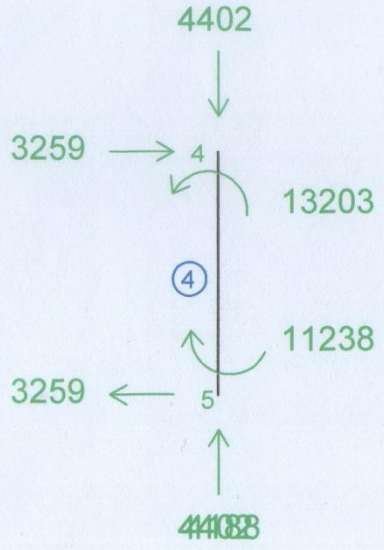
$$\{Fs^A\}4 = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{Bmatrix} 4402 \\ 3259 \\ 13203 \\ -4402 \\ -3259 \\ 11238 \end{Bmatrix} = \begin{Bmatrix} 3259 \\ -4402 \\ 13203 \\ -3259 \\ 4402 \\ 11238 \end{Bmatrix} \begin{matrix} 10 \\ 11 \\ 12 \\ 13 \\ 14 \\ 15 \end{matrix}$$

FBD KOMBINASI 2



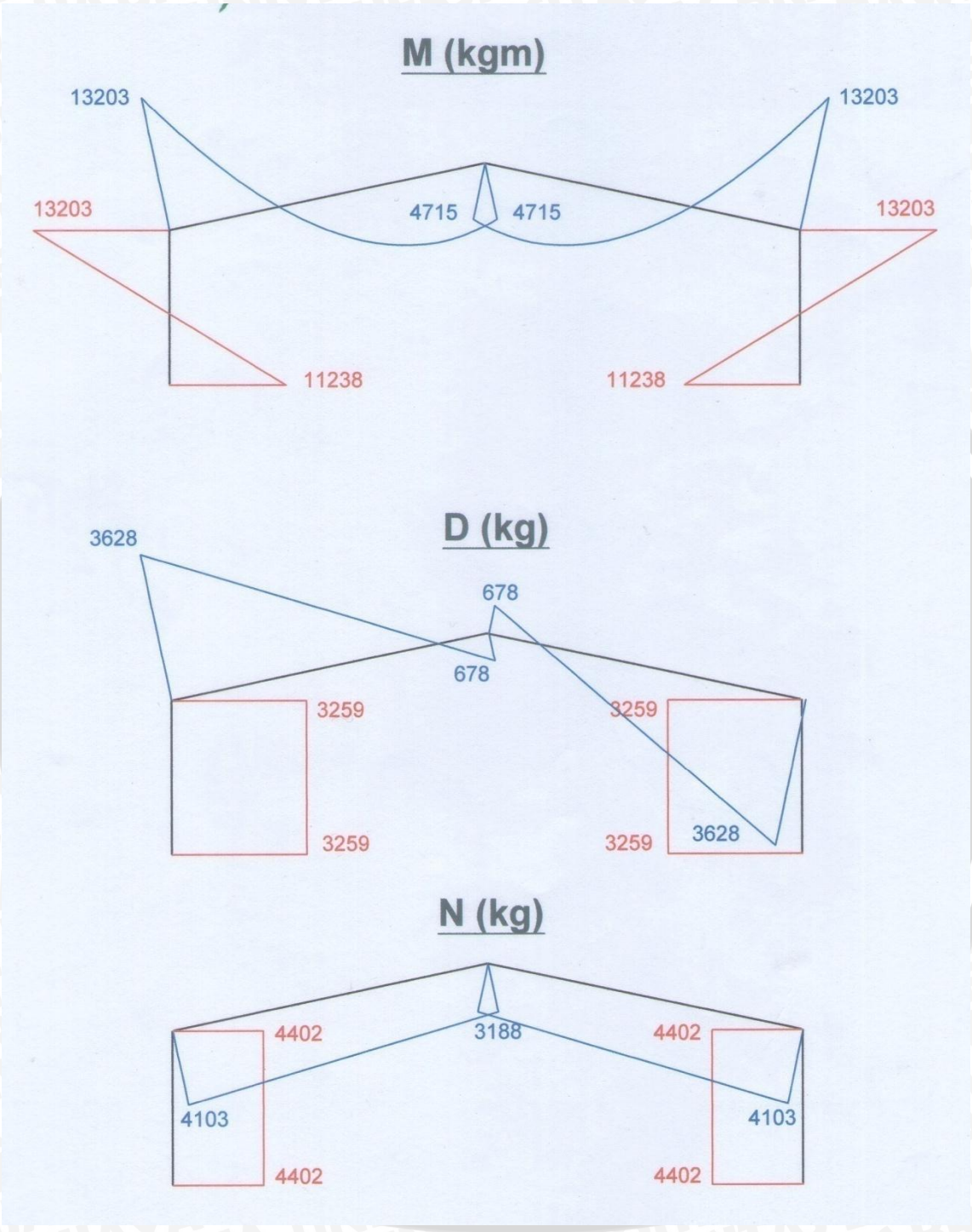






• Kombinasi 2 - Perhitungan Momen Per Interval Bentang 2

x →				0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	15,693
M	-13203			-13203	-13203	-13203	-13203	-13203	-13203	-13203	-13203	-13203	-13203	-13203	-13203	-13203	-13203	-13203	-13203	-13203
q	-87			0	-42	-167	-375	-667	-1042	-1500	-2042	-2667	-3376	-4168	-5043	-6001	-7043	-8169	-9377	-10264
P	-790	x cos12	= -773	0	-773	-1545	-2318	-3090	-3863	-4636	-5408	-6181	-6953	-7726	-8499	-9271	-10044	-10816	-11589	-12124
V2	4402	x cos12	= 4306	0	4306	8612	12918	17224	21529	25835	30141	34447	38753	43059	47365	51671	55976	60282	64588	67572
H2	-3259	x sin12	= -678	0	-677,5	-1355	-2033	-2710	-3388	-4065	-4743	-5420	-6098	-6775	-7453	-8130	-8808	-9486	-10163	-10633
1,30	-196	x cos12	= -192			-134	-326	-517	-709	-900	-1092	-1284	-1475	-1667	-1858	-2050	-2241	-2433	-2625	-2757
2,60							-77	-268	-460	-651	-843	-1035	-1226	-1418	-1609	-1801	-1992	-2184	-2376	-2508
3,90								-19	-211	-402	-594	-785	-977	-1169	-1360	-1552	-1743	-1935	-2127	-2259
5,20										-153	-345	-536	-728	-920	-1111	-1303	-1494	-1686	-1877	-2010
6,50											-96	-287	-479	-671	-862	-1054	-1245	-1437	-1628	-1761
7,80												-38	-230	-421	-613	-805	-996	-1188	-1379	-1512
9,10														-172	-364	-556	-747	-939	-1130	-1263
10,40															-115	-307	-498	-690	-881	-1014
11,70																-57	-249	-441	-632	-765
13,00																		-192	-383	-516
14,30																			-134	-267
Jumlah				-13203	-10389	-7792	-5413	-3252	-1346	324	1775	3010	4007	4749	5274	5581	5671	5485	5082	4715
																			Kr(%)	0



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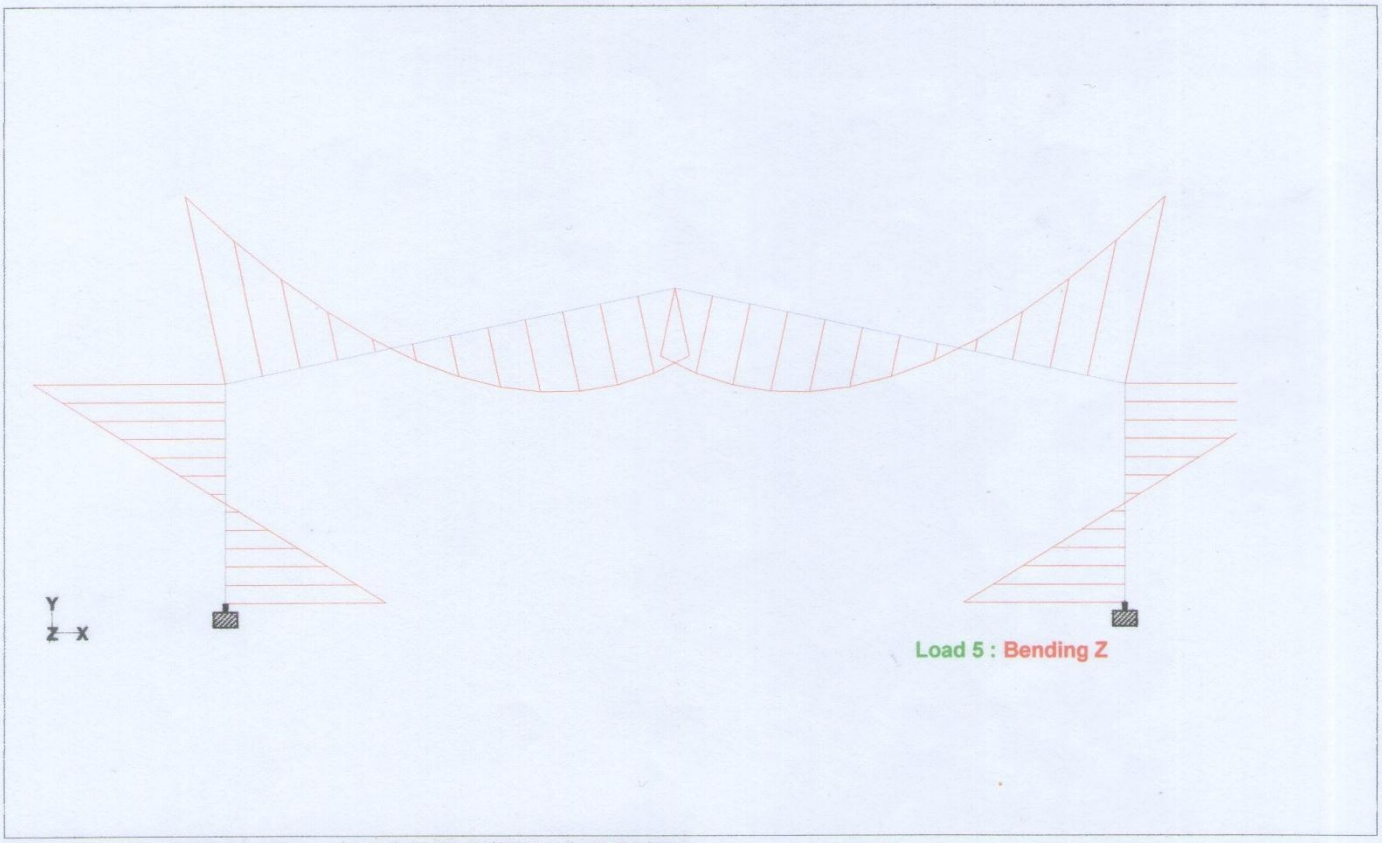
	Part		
Job Title	Ref		
	By	Date 12-Mar-13	Chd
Client	File Structure1.std	Date/Time 12-Mar-2013 13:24	



Whole Structure Mz 2039.43kg-m:1m 5 COMBINATION LOAD CASE 5

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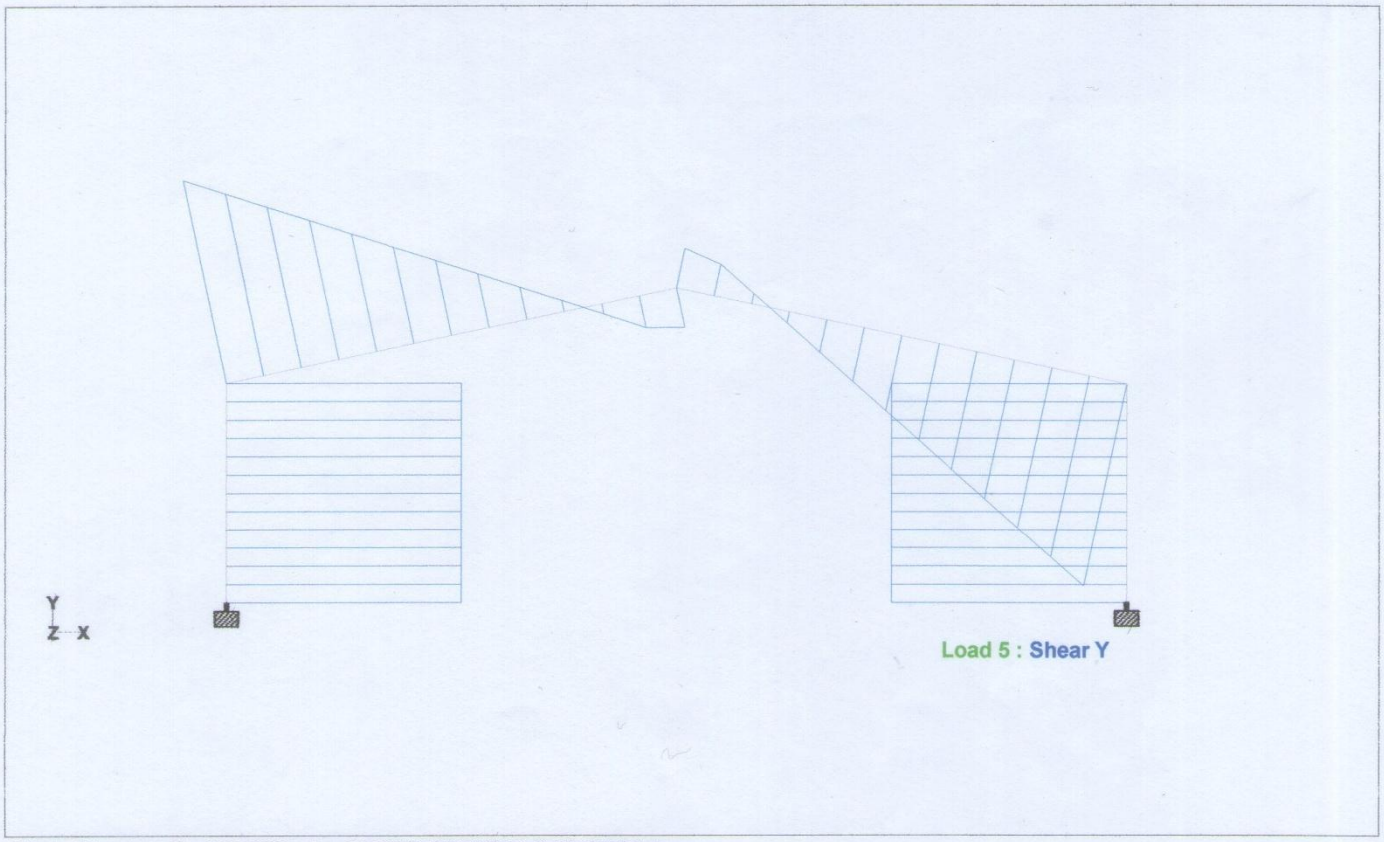
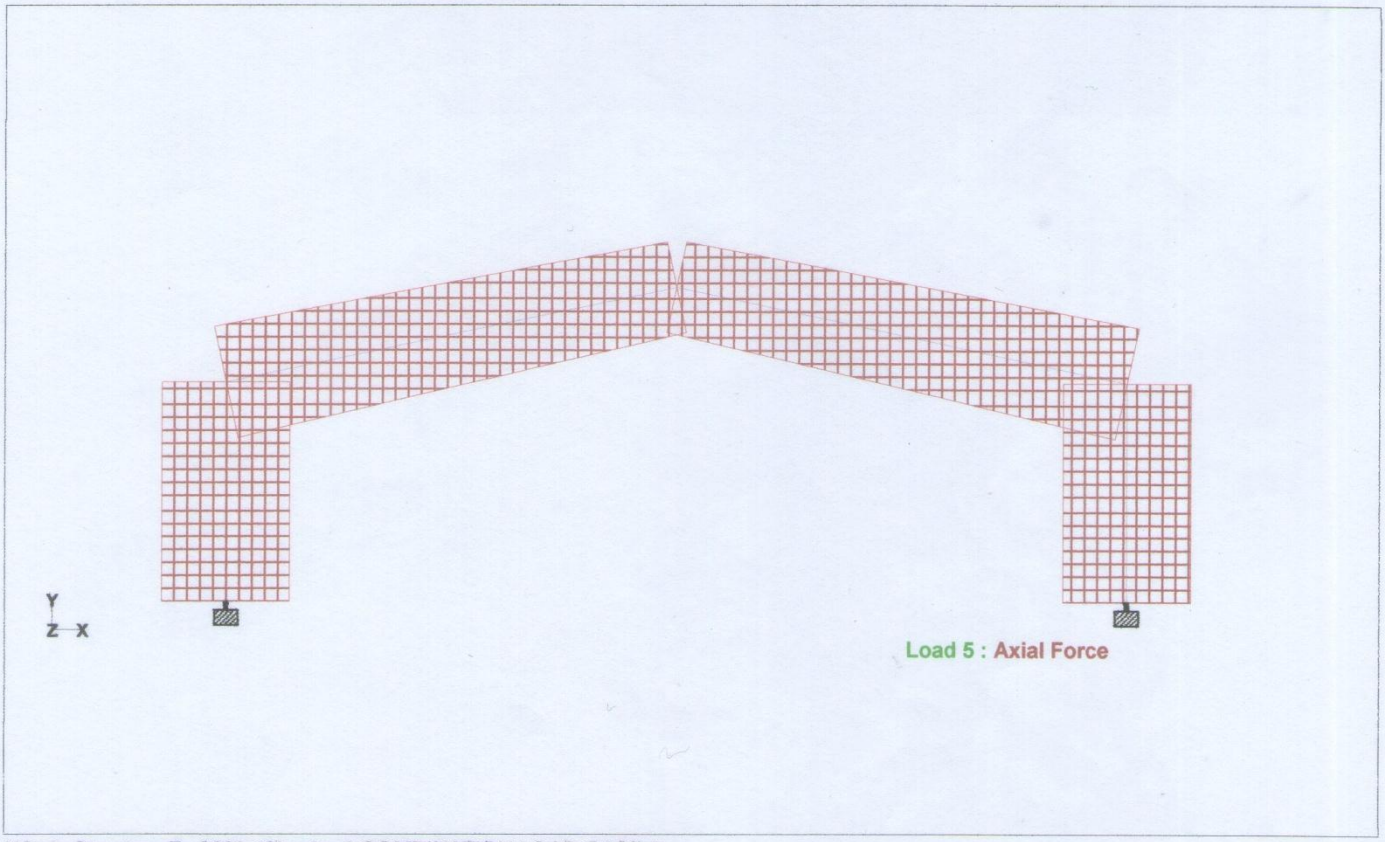
	Part		
Job Title	Ref		
	By	Date 12-Mar-13	Chd
Client	File Structure1.std	Date/Time 12-Mar-2013 13:24	



Whole Structure Fy 407.886kg:1m 5 COMBINATION LOAD CASE 5



Whole Structure Fx 2039.43kg:1m 5 COMBINATION LOAD CASE 5

- **Kombinasi 3**

  1.2D + 1.6(La atau H) + (γ_L.L atau 0.8W)

  La < H → dipakai H

  Kombinasi pembebanannya menjadi:

  1.2D + 1.6H + 0.8W

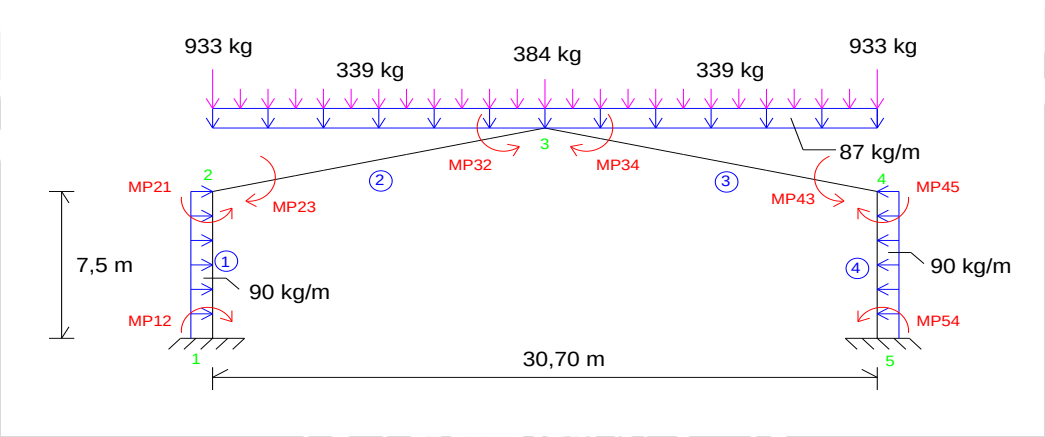
  1,2 q_D = 1,2 x 73 = 87 kg/m

  1,2 P_D: 1,2 x 109 + 1,6 130 = 339 kg

  1,2 x 147 + 1,6 130 = 384 kg

  1,2 x 604 + 1,6 130 = 933 kg

  0,8 W = 0,8 x 113 = 90 kg/m



	ΣM3		ΣM2	
Beban	Jarak	PxL	Jarak	PxL
87	15,35	10264	15,35	10264
192	0	0	15,35	2947
933	15,35	14319	0	0
339	14,08	4770,6	1,27	431
	12,81	4339,7	2,54	862
	11,54	3908,8	3,81	1293
	10,26	3477,9	5,09	1724
	8,99	3047	6,36	2154
	7,72	2616,2	7,63	2585
	6,45	2185,3	8,90	3016
	5,18	1754,4	10,17	3447
	3,91	1323,5	11,44	3878
	2,63	892,58	12,72	4309
	1,36	461,69	13,99	4740
Jumlah		53361		41649
R2		3476	R3	2713

KONTROL					
87	x	15,35	=	1337	3476
339	x	11	=	3727	2713
384	x	0,5	=	192	
933	x	1	=	933	
Jumlah				6190	6190
					OK

MP12= -MP21 = MP45 = -MP54

$$= \frac{1}{12} qL^2$$

= 421,88 kgm

H1 = H2 = H4 = H5 = 338 kg

- Momen Primer

MP23 = -MP32 = MP34 = -MP43

$$= \frac{1}{12} qL^2 + \Sigma \frac{Pab^2}{L^2}$$

c	q	L^2	$\frac{1}{12} qL^2$
1/12	87	235,6	1710,6
P	a	b^2	$\frac{Pab^2}{L^2}$
933	0	236	0
339	1,27	198	362
339	2,54	164	600
339	3,81	133	730
339	5,09	105	771
339	6,36	81	739
339	7,63	60	654
339	8,90	42	532
339	10,17	27	392
339	11,44	15	251
339	12,72	7	127
339	13,99	2	37
384	15,35	0	0
MP (kgm)			**6907**

•Kombinasi 3 - Beban Ekuivalen {Fs}

{Fs} =			F4 =		
	338	1	F4	338	4
	0	2	F5	-3476	5
	-422	3	F6	-6485	6
	338	4	F7	0	7
	-3476	5	F8	-5427	8
	-6485	6	F9	0	9
	0	7	F10	-338	10
	-5427	8	F11	-3476	11
	0	9	F12	6485	12
	-338	10	F1	338	1
	-3476	11	F2	0	2
	6485	12	F3	-422	3
	-338	13	F13	-338	13
	0	14	F14	0	14
	422	15	F15	422	15

•Kombinasi 3 - Perhitungan Perpindahan

Rumus: {Ds} = $[Ss]^{-1}$. {Fs}

4	5	6	7	8	9	10	11	12					
9,36E-06	3,21E-09	-1,21E-06	8,28E-06	4,91E-06	6,09E-07	7,20E-06	-3,21E-09	-1,23E-06	4	x	338	=	-0,0260 m
3,21E-09	4,46E-08	-8,55E-10	7,94E-09	2,23E-08	-1,75E-09	3,21E-09	1,57E-12	-8,55E-10	5		-3476		-0,0003 m
-1,21E-06	-8,55E-10	4,60E-07	-1,22E-06	7,61E-08	-1,62E-07	-1,23E-06	8,55E-10	1,90E-07	6		-6485		-0,0022 rad
8,28E-06	7,94E-09	-1,22E-06	8,33E-06	1,14E-20	6,08E-07	8,28E-06	-7,94E-09	-1,22E-06	7		0		0,0000 m
4,91E-06	2,23E-08	7,61E-08	7,53E-21	2,35E-05	9,41E-22	-4,91E-06	2,23E-08	-7,61E-08	8		-5427		-0,1251 m
6,09E-07	-1,75E-09	-1,62E-07	6,08E-07	6,38E-23	4,95E-07	6,09E-07	1,75E-09	-1,62E-07	9		0		0,0000 rad
7,20E-06	3,21E-09	-1,23E-06	8,28E-06	-4,91E-06	6,09E-07	9,36E-06	-3,21E-09	-1,21E-06	10		-338		0,0260 m
-3,21E-09	1,57E-12	8,55E-10	-7,94E-09	2,23E-08	1,75E-09	-3,21E-09	4,46E-08	8,55E-10	11		-3476		-0,0003 m
-1,23E-06	-8,55E-10	1,90E-07	-1,22E-06	-7,61E-08	-1,62E-07	-1,21E-06	8,55E-10	4,60E-07	12		6485		0,0022 rad

•Kombinasi 3 - Perhitungan Reaksi Tumpuan

Rumus: {Fs} = [Ss] . {Ds}

4	5	6	7	8	9	10	11	12					
-134827	0	-505600	0	0	0	0	0	0	1	x	-0,0260	=	4598
0	-22432000	0	0	0	0	0	0	0	2		-0,0003		6190
505600	0	1264000	0	0	0	0	0	0	3		-0,0022		-15881
0	0	0	0	0	0	-134827	0	-505600	13		0,0000		-4598
0	0	0	0	0	0	0	-22432000	0	14		-0,1251		6190
0	0	0	0	0	0	505600	0	1264000	15		0,0000		15881
											0,0260		
											-0,0003		
											0,0022		

•Kombinasi 3 - Perhitungan Gaya-Gaya Dalam Akhir Batang (pada sumbu batang)

Rumus: $\{Fm^A\}i = \{Fm^B\}i + [Sm]i \times [RT]i \times \{Ds\}i$

dengan:
- $\{Fm^A\}i$ = Gaya dalam batang
- $\{Fm^B\}i$ = Gaya akibat beban luar
- $[Sm]i$ = Matriks kekakuan batang (pada sumbu batang)
- $[RT]i$ = Matriks rotasi
- $\{Ds\}i$ = Perpindahan

$$\{Fm^A\}1 = \begin{Bmatrix} 0 \\ 338 \\ 422 \\ 0 \\ 338 \\ -422 \end{Bmatrix} + \begin{pmatrix} 22432000 & 0 & 0 & -22432000 & 0 & 0 \\ 0 & 134827 & 505600 & 0 & -134827 & 505600 \\ 0 & 505600 & 2528000 & 0 & -505600 & 1264000 \\ -22432000 & 0 & 0 & 22432000 & 0 & 0 \\ 0 & -134827 & -505600 & 0 & 134827 & -505600 \\ 0 & 505600 & 1264000 & 0 & -505600 & 2528000 \end{pmatrix} \times \begin{pmatrix} 0 & 1 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \times \begin{Bmatrix} 0 \\ 0 \\ 0 \\ -0{,}0260 \\ -0{,}0003 \\ -0{,}0022 \end{Bmatrix} = \begin{Bmatrix} 6190 \\ -4261 \\ -15459 \\ -6190 \\ 4936 \\ -19028 \end{Bmatrix} \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \end{matrix}$$

$$\{Fm^A\}2 = \begin{Bmatrix} 723 \\ 3400 \\ 6907 \\ 564 \\ 2654 \\ -6907 \end{Bmatrix} + \begin{pmatrix} 10720753 & 0 & 0 & -10720753 & 0 & 0 \\ 0 & 14718 & 115484 & 0 & -14718 & 115484 \\ 0 & 115484 & 1208188 & 0 & -115484 & 604094 \\ -10720753 & 0 & 0 & 10720753 & 0 & 0 \\ 0 & -14718 & -115484 & 0 & 14718 & -115484 \\ 0 & 115484 & 604094 & 0 & -115484 & 1208188 \end{pmatrix} \times \begin{pmatrix} 0{,}978 & 0{,}208 & 0 & 0 & 0 & 0 \\ -0{,}21 & 0{,}978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0{,}978 & 0{,}208 & 0 \\ 0 & 0 & 0 & -0{,}21 & 0{,}978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \times \begin{Bmatrix} -0{,}0260 \\ -0{,}0003 \\ -0{,}0022 \\ 0{,}0000 \\ -0{,}1251 \\ 0{,}0000 \end{Bmatrix} = \begin{Bmatrix} 6115 \\ 5028 \\ 19028 \\ -4828 \\ 1026 \\ 6517 \end{Bmatrix} \begin{matrix} 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \end{matrix}$$

$$\{Fm^A\}3 = \begin{Bmatrix} -564 \\ 2654 \\ 6907 \\ -723 \\ 3400 \\ -6907 \end{Bmatrix} + \begin{pmatrix} 10720753 & 0 & 0 & -10720753 & 0 & 0 \\ 0 & 14718 & 115484 & 0 & -14718 & 115484 \\ 0 & 115484 & 1208188 & 0 & -115484 & 604094 \\ -10720753 & 0 & 0 & 10720753 & 0 & 0 \\ 0 & -14718 & -115484 & 0 & 14718 & -115484 \\ 0 & 115484 & 604094 & 0 & -115484 & 1208188 \end{pmatrix} \times \begin{pmatrix} 0{,}978 & -0{,}21 & 0 & 0 & 0 & 0 \\ 0{,}208 & 0{,}978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0{,}978 & -0{,}21 & 0 \\ 0 & 0 & 0 & 0{,}208 & 0{,}978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \times \begin{Bmatrix} 0{,}0000 \\ -0{,}1251 \\ 0{,}0000 \\ 0{,}0260 \\ -0{,}0003 \\ 0{,}0022 \end{Bmatrix} = \begin{Bmatrix} 4828 \\ 1026 \\ -6517 \\ -6115 \\ 5028 \\ -19028 \end{Bmatrix} \begin{matrix} 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \end{matrix}$$

$$\{Fm^A\}4 = \begin{Bmatrix} 0 \\ 338 \\ 422 \\ 0 \\ 338 \\ -422 \end{Bmatrix} + \begin{pmatrix} 22432000 & 0 & 0 & -22432000 & 0 & 0 \\ 0 & 134827 & 505600 & 0 & -134827 & 505600 \\ 0 & 505600 & 2528000 & 0 & -505600 & 1264000 \\ -22432000 & 0 & 0 & 22432000 & 0 & 0 \\ 0 & -134827 & -505600 & 0 & 134827 & -505600 \\ 0 & 505600 & 1264000 & 0 & -505600 & 2528000 \end{pmatrix} \times \begin{pmatrix} 0 & -1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \times \begin{Bmatrix} 0{,}0260 \\ -0{,}0003 \\ 0{,}0022 \\ 0 \\ 0 \\ 0 \end{Bmatrix} = \begin{Bmatrix} 6190 \\ 4936 \\ 19028 \\ -6190 \\ -4261 \\ 15459 \end{Bmatrix} \begin{matrix} 10 \\ 11 \\ 12 \\ 13 \\ 14 \\ 15 \end{matrix}$$

•Kombinasi 3 - Perhitungan Gaya-Gaya Dalam Akhir Batang (pada sumbu struktur)

Rumus: $\{Fs^A\}i = [RT]^T i \times \{Fm^A\}i$

dengan: $\{Fs^A\}i$ = Gaya dalam akhir batang

$[RT]^T i$ = Matriks rotasi transpose

$\{Fm^A\}i$ = Gaya dalam batang

$$\{Fs^A\}1 = \begin{bmatrix} 0 & -1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{Bmatrix} 6190 \\ -4261 \\ -15459 \\ -6190 \\ 4936 \\ -19028 \end{Bmatrix} = \begin{Bmatrix} 4261 \\ 6190 \\ -15459 \\ -4936 \\ -6190 \\ -19028 \end{Bmatrix} \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \end{matrix}$$

$$\{Fs^A\}2 = \begin{bmatrix} 0{,}978 & -0{,}208 & 0 & 0 & 0 & 0 \\ 0{,}208 & 0{,}978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0{,}978 & -0{,}208 & 0 \\ 0 & 0 & 0 & 0{,}208 & 0{,}978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{Bmatrix} 6115 \\ 5028 \\ 19028 \\ -4828 \\ 1026 \\ 6517 \end{Bmatrix} = \begin{Bmatrix} 4936 \\ 6190 \\ 19028 \\ -4936 \\ 0 \\ 6517 \end{Bmatrix} \begin{matrix} 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \end{matrix}$$

$$\{Fs^A\}3 = \begin{bmatrix} 0{,}978 & 0{,}208 & 0 & 0 & 0 & 0 \\ -0{,}208 & 0{,}978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0{,}978 & 0{,}208 & 0 \\ 0 & 0 & 0 & -0{,}208 & 0{,}978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{Bmatrix} 4828 \\ 1026 \\ -6517 \\ -6115 \\ 5028 \\ -19028 \end{Bmatrix} = \begin{Bmatrix} 4936 \\ 0 \\ -6517 \\ -4936 \\ 6190 \\ -19028 \end{Bmatrix} \begin{matrix} 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \end{matrix}$$

$$\{Fs^A\}4 = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{Bmatrix} 6190 \\ 4936 \\ 19028 \\ -6190 \\ -4261 \\ 15459 \end{Bmatrix} = \begin{Bmatrix} 4936 \\ -6190 \\ 19028 \\ -4261 \\ 6190 \\ 15459 \end{Bmatrix} \begin{matrix} 10 \\ 11 \\ 12 \\ 13 \\ 14 \\ 15 \end{matrix}$$

• Kombinasi 3 - Perhitungan Momen Per Interval Bentang 2

x →				0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	15,693
M	-19028			-19028	-19028	-19028	-19028	-19028	-19028	-19028	-19028	-19028	-19028	-19028	-19028	-19028	-19028	-19028	-19028	-19028
q	-87			0	-42	-167	-375	-667	-1042	-1500	-2042	-2667	-3376	-4168	-5043	-6001	-7043	-8169	-9377	-10264
P	-933	x cos12	= -912	0	-912	-1825	-2737	-3650	-4562	-5475	-6387	-7300	-8212	-9125	-10037	-10950	-11862	-12775	-13687	-14319
V2	6190	x cos12	= 6054	0	6054	12109	18163	24217	30272	36326	42380	48435	54489	60543	66597	72652	78706	84760	90815	95010
H2	-4936	x sin12	= -1026	0	-1026	-2052	-3079	-4105	-5131	-6157	-7183	-8210	-9236	-10262	-11288	-12314	-13341	-14367	-15393	-16104
1,30	-339	x cos12	= -331			-232	-563	-895	-1226	-1558	-1889	-2221	-2552	-2884	-3215	-3547	-3878	-4209	-4541	-4771
2,60							-133	-464	-795	-1127	-1458	-1790	-2121	-2453	-2784	-3116	-3447	-3779	-4110	-4340
3,90								-33	-365	-696	-1028	-1359	-1690	-2022	-2353	-2685	-3016	-3348	-3679	-3909
5,20										-265	-597	-928	-1260	-1591	-1922	-2254	-2585	-2917	-3248	-3478
6,50											-166	-497	-829	-1160	-1492	-1823	-2154	-2486	-2817	-3047
7,80												-66	-398	-729	-1061	-1392	-1724	-2055	-2386	-2616
9,10														-298	-630	-961	-1293	-1624	-1956	-2185
10,40															-199	-530	-862	-1193	-1525	-1754
11,70																-99	-431	-762	-1094	-1323
13,00																		-331	-663	-893
14,30																			-232	-462
Jumlah				-19028	-14954	-11195	-7752	-4624	-1878	519	2602	4369	5787	6824	7545	7951	8042	7718	7078	6517
																			Kr(%)	0

- **Kombinasi 4**

  1.2D + 1.3W + γ_L.L + 0.5(La atau H)

  La < H → dipakai H

  Kombinasi pembebanannya menjadi:

  1.2D + 1.3W + 0.5H

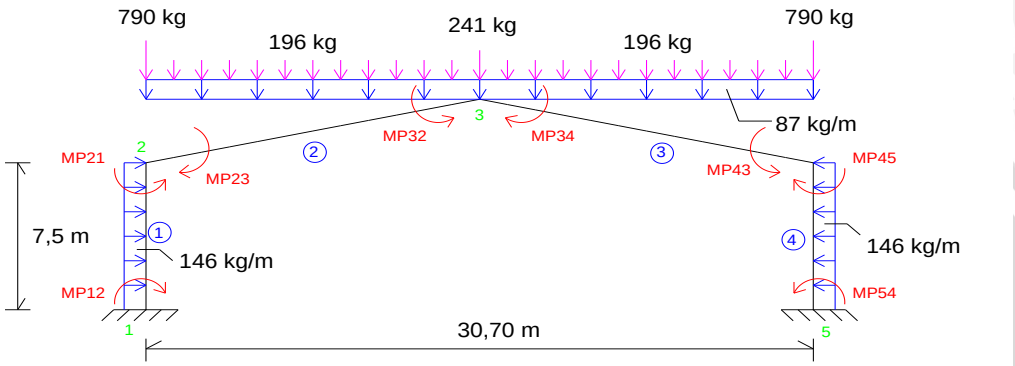
  1,2 q_D = 1,2 x 73 = 87 kg/m

  1,2 P_D: 1,2 x 109 + 0,5 130 = 196 kg

  1,2 x 147 + 0,5 130 = 241 kg

  1,2 x 604 + 0,5 130 = 790 kg

  1,3 W = 1,3 x 113 = 146 kg/m



	ΣM3		ΣM2	
Beban	Jarak	PxL	Jarak	PxL
87	15,35	10264	15,35	10264
120	0	0	15,35	1849
790	15,35	12124	0	0
196	14,08	2757,4	1,27	249
	12,81	2508,3	2,54	498
	11,54	2259,3	3,81	747
	10,26	2010,2	5,09	996
	8,99	1761,2	6,36	1245
	7,72	1512,1	7,63	1494
	6,45	1263,1	8,90	1743
	5,18	1014	10,17	1992
	3,91	764,97	11,44	2241
	2,63	515,91	12,72	2491
	1,36	266,86	13,99	2740
Jumlah		39021		28550
R2		2542	R3	1860

KONTROL					
87	x	15,35	=	1337	2542
196	x	11	=	2154	1860
241	x	0,5	=	120	
790	x	1	=	790	
Jumlah				4402	4402
				OK	

MP12= -MP21 = MP45 = -MP54

$$= \frac{1}{12} qL^2$$

= 685,55 kgm

H1 = H2 = H4 = H5 = 548 kg

- Momen Primer

MP23 = -MP32 = MP34 = -MP43

$$= \frac{1}{12} qL^2 + \Sigma \frac{Pab^2}{L^2}$$

c	q	L^2	$\frac{1}{12} qL^2$
1/12	87	235,6	1710,6
P	a	b^2	$\frac{Pab^2}{L^2}$
790	0	236	0
196	1,27	198	209
196	2,54	164	347
196	3,81	133	422
196	5,09	105	445
196	6,36	81	427
196	7,63	60	378
196	8,90	42	308
196	10,17	27	227
196	11,44	15	145
196	12,72	7	73
196	13,99	2	22
241	15,35	0	0
MP (kgm)			**4714**

•Kombinasi 4 - Beban Ekuivalen {Fs}

$$\{Fs\} = \begin{Bmatrix} 548 \\ 0 \\ -686 \\ 548 \\ -2542 \\ -4028 \\ 0 \\ -3720 \\ 0 \\ -548 \\ -2542 \\ 4028 \\ -548 \\ 0 \\ 686 \end{Bmatrix}_{\begin{matrix}1\\2\\3\\4\\5\\6\\7\\8\\9\\10\\11\\12\\13\\14\\15\end{matrix}} \begin{matrix} F4 \\ F5 \\ F6 \\ F7 \\ F8 \\ F9 \\ F10 \\ F11 \\ F12 \\ F1 \\ F2 \\ F3 \\ F13 \\ F14 \\ F15 \end{matrix} = \begin{Bmatrix} 548 \\ -2542 \\ -4028 \\ 0 \\ -3720 \\ 0 \\ -548 \\ -2542 \\ 4028 \\ 548 \\ 0 \\ -686 \\ -548 \\ 0 \\ 686 \end{Bmatrix}_{\begin{matrix}4\\5\\6\\7\\8\\9\\10\\11\\12\\1\\2\\3\\13\\14\\15\end{matrix}}$$

•Kombinasi 4 - Perhitungan Perpindahan

Rumus: {Ds} = $[Ss]^{-1}$. {Fs}

4	5	6	7	8	9	10	11	12						
9,36E-06	3,21E-09	-1,21E-06	8,28E-06	4,91E-06	6,09E-07	7,20E-06	-3,21E-09	-1,23E-06	4	x	548	=	-0,0171	m
3,21E-09	4,46E-08	-8,55E-10	7,94E-09	2,23E-08	-1,75E-09	3,21E-09	1,57E-12	-8,55E-10	5		-2542		-0,0002	m
-1,21E-06	-8,55E-10	4,60E-07	-1,22E-06	7,61E-08	-1,62E-07	-1,23E-06	8,55E-10	1,90E-07	6		-4028		-0,0014	rad
8,28E-06	7,94E-09	-1,22E-06	8,33E-06	1,14E-20	6,08E-07	8,28E-06	-7,94E-09	-1,22E-06	7		0		0,0000	m
4,91E-06	2,23E-08	7,61E-08	7,53E-21	2,35E-05	9,41E-22	-4,91E-06	2,23E-08	-7,61E-08	8		-3720		-0,0826	m
6,09E-07	-1,75E-09	-1,62E-07	6,08E-07	6,38E-23	4,95E-07	6,09E-07	1,75E-09	-1,62E-07	9		0		0,0000	rad
7,20E-06	3,21E-09	-1,23E-06	8,28E-06	-4,91E-06	6,09E-07	9,36E-06	-3,21E-09	-1,21E-06	10		-548		0,0171	m
-3,21E-09	1,57E-12	8,55E-10	-7,94E-09	2,23E-08	1,75E-09	-3,21E-09	4,46E-08	8,55E-10	11		-2542		-0,0002	m
-1,23E-06	-8,55E-10	1,90E-07	-1,22E-06	-7,61E-08	-1,62E-07	-1,21E-06	8,55E-10	4,60E-07	12		4028		0,0014	rad

•Kombinasi 4 - Perhitungan Reaksi Tumpuan

Rumus: {Fs} = [Ss] . {Ds}

4	5	6	7	8	9	10	11	12					
-134827	0	-505600	0	0	0	0	0	0	1	x	-0,0171	=	2999
0	-22432000	0	0	0	0	0	0	0	2		-0,0002		4402
505600	0	1264000	0	0	0	0	0	0	3		-0,0014		-10388
0	0	0	0	0	0	-134827	0	-505600	13		0,0000		-2999
0	0	0	0	0	0	0	-22432000	0	14		-0,0826		4402
0	0	0	0	0	0	505600	0	1264000	15		0,0000		10388
											0,0171		
											-0,0002		
											0,0014		

•Kombinasi 4 - Perhitungan Gaya-Gaya Dalam Akhir Batang (pada sumbu batang)

Rumus: $\{Fm^A\}i = \{Fm^B\}i + [Sm]i \times [RT]i \times \{Ds\}i$

dengan: $\{Fm^A\}i$ = Gaya dalam batang

$\{Fm^B\}i$ = Gaya akibat beban luar

$[Sm]i$ = Matriks kekakuan batang (pada sumbu batang)

$[RT]i$ = Matriks rotasi

$\{Ds\}i$ = Perpindahan

$$\{Fm^A\}1 = \begin{Bmatrix} 0 \\ 548 \\ 686 \\ 0 \\ 548 \\ -686 \end{Bmatrix} + \begin{bmatrix} 22432000 & 0 & 0 & -22432000 & 0 & 0 \\ 0 & 134827 & 505600 & 0 & -134827 & 505600 \\ 0 & 505600 & 2528000 & 0 & -505600 & 1264000 \\ -22432000 & 0 & 0 & 22432000 & 0 & 0 \\ 0 & -134827 & -505600 & 0 & 134827 & -505600 \\ 0 & 505600 & 1264000 & 0 & -505600 & 2528000 \end{bmatrix} \times \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{Bmatrix} 0 \\ 0 \\ 0 \\ -0{,}0171 \\ -0{,}0002 \\ -0{,}0014 \end{Bmatrix} = \begin{Bmatrix} 4402 \\ -2451 \\ -9702 \\ -4402 \\ 3548 \\ -12791 \end{Bmatrix} \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \end{matrix}$$

$$\{Fm^A\}2 = \begin{Bmatrix} 529 \\ 2487 \\ 4714 \\ 387 \\ 1819 \\ -4714 \end{Bmatrix} + \begin{bmatrix} 10720753 & 0 & 0 & -10720753 & 0 & 0 \\ 0 & 14718 & 115484 & 0 & -14718 & 115484 \\ 0 & 115484 & 1208188 & 0 & -115484 & 604094 \\ -10720753 & 0 & 0 & 10720753 & 0 & 0 \\ 0 & -14718 & -115484 & 0 & 14718 & -115484 \\ 0 & 115484 & 604094 & 0 & -115484 & 1208188 \end{bmatrix} \times \begin{bmatrix} 0{,}978 & 0{,}208 & 0 & 0 & 0 & 0 \\ -0{,}21 & 0{,}978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0{,}978 & 0{,}208 & 0 \\ 0 & 0 & 0 & -0{,}21 & 0{,}978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{Bmatrix} -0{,}0171 \\ -0{,}0002 \\ -0{,}0014 \\ 0{,}0000 \\ -0{,}0826 \\ 0{,}0000 \end{Bmatrix} = \begin{Bmatrix} 4385 \\ 3568 \\ 12791 \\ -3470 \\ 738 \\ 4184 \end{Bmatrix} \begin{matrix} 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \end{matrix}$$

$$\{Fm^A\}3 = \begin{Bmatrix} -387 \\ 1819 \\ 4714 \\ -529 \\ 2487 \\ -4714 \end{Bmatrix} + \begin{bmatrix} 10720753 & 0 & 0 & -10720753 & 0 & 0 \\ 0 & 14718 & 115484 & 0 & -14718 & 115484 \\ 0 & 115484 & 1208188 & 0 & -115484 & 604094 \\ -10720753 & 0 & 0 & 10720753 & 0 & 0 \\ 0 & -14718 & -115484 & 0 & 14718 & -115484 \\ 0 & 115484 & 604094 & 0 & -115484 & 1208188 \end{bmatrix} \times \begin{bmatrix} 0{,}978 & -0{,}21 & 0 & 0 & 0 & 0 \\ 0{,}208 & 0{,}978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0{,}978 & -0{,}21 & 0 \\ 0 & 0 & 0 & 0{,}208 & 0{,}978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{Bmatrix} 0{,}0000 \\ -0{,}0826 \\ 0{,}0000 \\ 0{,}0171 \\ -0{,}0002 \\ 0{,}0014 \end{Bmatrix} = \begin{Bmatrix} 3470 \\ 738 \\ -4184 \\ -4385 \\ 3568 \\ -12791 \end{Bmatrix} \begin{matrix} 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \end{matrix}$$

$$\{Fm^A\}4 = \begin{Bmatrix} 0 \\ 548 \\ 686 \\ 0 \\ 548 \\ -686 \end{Bmatrix} + \begin{bmatrix} 22432000 & 0 & 0 & -22432000 & 0 & 0 \\ 0 & 134827 & 505600 & 0 & -134827 & 505600 \\ 0 & 505600 & 2528000 & 0 & -505600 & 1264000 \\ -22432000 & 0 & 0 & 22432000 & 0 & 0 \\ 0 & -134827 & -505600 & 0 & 134827 & -505600 \\ 0 & 505600 & 1264000 & 0 & -505600 & 2528000 \end{bmatrix} \times \begin{bmatrix} 0 & -1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{Bmatrix} 0{,}0171 \\ -0{,}0002 \\ 0{,}0014 \\ 0 \\ 0 \\ 0 \end{Bmatrix} = \begin{Bmatrix} 4402 \\ 3548 \\ 12791 \\ -4402 \\ -2451 \\ 9702 \end{Bmatrix} \begin{matrix} 10 \\ 11 \\ 12 \\ 13 \\ 14 \\ 15 \end{matrix}$$

•Kombinasi 4 - Perhitungan Gaya-Gaya Dalam Akhir Batang (pada sumbu struktur)

Rumus: $\{Fs^A\}i = [RT]^T i \times \{Fm^A\}i$

dengan: $\{Fs^A\}i$ = Gaya dalam akhir batang

$[RT]^T i$ = Matriks rotasi transpose

$\{Fm^A\}i$ = Gaya dalam batang

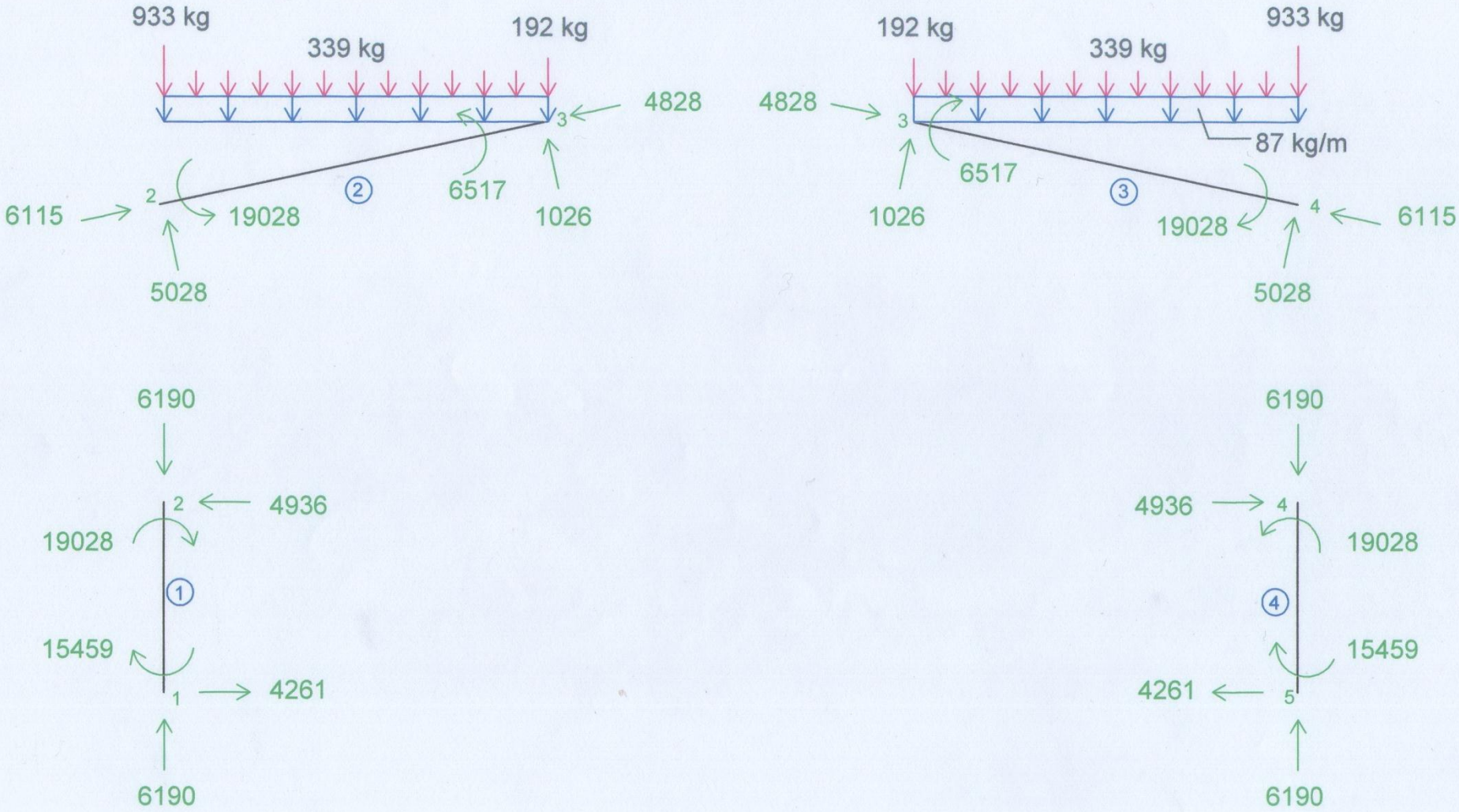
$$\{Fs^A\}1 = \begin{bmatrix} 0 & -1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{Bmatrix} 4402 \\ -2451 \\ -9702 \\ -4402 \\ 3548 \\ -12791 \end{Bmatrix} = \begin{Bmatrix} 2451 \\ 4402 \\ -9702 \\ -3548 \\ -4402 \\ -12791 \end{Bmatrix} \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \end{matrix}$$

$$\{Fs^A\}2 = \begin{bmatrix} 0{,}978 & -0{,}208 & 0 & 0 & 0 & 0 \\ 0{,}208 & 0{,}978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0{,}978 & -0{,}208 & 0 \\ 0 & 0 & 0 & 0{,}208 & 0{,}978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{Bmatrix} 4385 \\ 3568 \\ 12791 \\ -3470 \\ 738 \\ 4184 \end{Bmatrix} = \begin{Bmatrix} 3548 \\ 4402 \\ 12791 \\ -3548 \\ 0 \\ 4184 \end{Bmatrix} \begin{matrix} 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \end{matrix}$$

$$\{Fs^A\}3 = \begin{bmatrix} 0{,}978 & 0{,}208 & 0 & 0 & 0 & 0 \\ -0{,}208 & 0{,}978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0{,}978 & 0{,}208 & 0 \\ 0 & 0 & 0 & -0{,}208 & 0{,}978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{Bmatrix} 3470 \\ 738 \\ -4184 \\ -4385 \\ 3568 \\ -12791 \end{Bmatrix} = \begin{Bmatrix} 3548 \\ 0 \\ -4184 \\ -3548 \\ 4402 \\ -12791 \end{Bmatrix} \begin{matrix} 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \end{matrix}$$

$$\{Fs^A\}4 = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{Bmatrix} 4402 \\ 3548 \\ 12791 \\ -4402 \\ -2451 \\ 9702 \end{Bmatrix} = \begin{Bmatrix} 3548 \\ -4402 \\ 12791 \\ -2451 \\ 4402 \\ 9702 \end{Bmatrix} \begin{matrix} 10 \\ 11 \\ 12 \\ 13 \\ 14 \\ 15 \end{matrix}$$

FBD KOMBINASI 3



• Kombinasi 4 - Perhitungan Momen Per Interval Bentang 2

x →				0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	15,693
M	-12791			-12791	-12791	-12791	-12791	-12791	-12791	-12791	-12791	-12791	-12791	-12791	-12791	-12791	-12791	-12791	-12791	-12791
q	-87			0	-42	-167	-375	-667	-1042	-1500	-2042	-2667	-3376	-4168	-5043	-6001	-7043	-8169	-9377	-10264
P	-790	x cos12	= -773	0	-773	-1545	-2318	-3090	-3863	-4636	-5408	-6181	-6953	-7726	-8499	-9271	-10044	-10816	-11589	-12124
V2	4402	x cos12	= 4306	0	4306	8612	12918	17224	21529	25835	30141	34447	38753	43059	47365	51671	55976	60282	64588	67572
H2	-3548	x sin12	= -738	0	-737,6	-1475	-2213	-2950	-3688	-4425	-5163	-5901	-6638	-7376	-8113	-8851	-9588	-10326	-11064	-11575
1,30	-196	x cos12	= -192			-134	-326	-517	-709	-900	-1092	-1284	-1475	-1667	-1858	-2050	-2241	-2433	-2625	-2757
2,60							-77	-268	-460	-651	-843	-1035	-1226	-1418	-1609	-1801	-1992	-2184	-2376	-2508
3,90								-19	-211	-402	-594	-785	-977	-1169	-1360	-1552	-1743	-1935	-2127	-2259
5,20										-153	-345	-536	-728	-920	-1111	-1303	-1494	-1686	-1877	-2010
6,50											-96	-287	-479	-671	-862	-1054	-1245	-1437	-1628	-1761
7,80												-38	-230	-421	-613	-805	-996	-1188	-1379	-1512
9,10														-172	-364	-556	-747	-939	-1130	-1263
10,40															-115	-307	-498	-690	-881	-1014
11,70																-57	-249	-441	-632	-765
13,00																		-192	-383	-516
14,30																			-134	-267
Jumlah				-12791	-10037	-7501	-5181	-3080	-1234	375	1767	2941	3879	4561	5026	5273	5302	5057	4594	4184
																			Kr(%)	0

- **Beban Ekivalen Mntu {Fs}**

$$\{Fs\} = \begin{Bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ -3476 \\ -6907 \\ 0 \\ -5427 \\ 0 \\ 0 \\ -3476 \\ 6907 \\ 0 \\ 0 \\ 0 \end{Bmatrix}_{1\ 2\ 3\ 4\ 5\ 6\ 7\ 8\ 9\ 10\ 11\ 12\ 13\ 14\ 15} \quad \begin{matrix} F4 \\ F5 \\ F6 \\ F7 \\ F8 \\ F9 \\ F10 \\ F11 \\ F12 \\ \hline F1 \\ F2 \\ F3 \\ F13 \\ F14 \\ F15 \end{matrix} = \begin{Bmatrix} 0 \\ -3476 \\ -6907 \\ 0 \\ -5427 \\ 0 \\ 0 \\ -3476 \\ 6907 \\ \hline 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{Bmatrix}_{4\ 5\ 6\ 7\ 8\ 9\ 10\ 11\ 12\ 1\ 2\ 3\ 13\ 14\ 15}$$

- **Beban Ekivalen Mltu {Fs}**

$$\{Fs\} = \begin{Bmatrix} 338 \\ 0 \\ -422 \\ 338 \\ 0 \\ 422 \\ 0 \\ 0 \\ 0 \\ -338 \\ 0 \\ -422 \\ -338 \\ 0 \\ 422 \end{Bmatrix}_{1\ 2\ 3\ 4\ 5\ 6\ 7\ 8\ 9\ 10\ 11\ 12\ 13\ 14\ 15} \quad \begin{matrix} F4 \\ F5 \\ F6 \\ F7 \\ F8 \\ F9 \\ F10 \\ F11 \\ F12 \\ \hline F1 \\ F2 \\ F3 \\ F13 \\ F14 \\ F15 \end{matrix} = \begin{Bmatrix} 338 \\ 0 \\ 422 \\ 0 \\ 0 \\ 0 \\ -338 \\ 0 \\ -422 \\ \hline 338 \\ 0 \\ -422 \\ -338 \\ 0 \\ 422 \end{Bmatrix}_{4\ 5\ 6\ 7\ 8\ 9\ 10\ 11\ 12\ 1\ 2\ 3\ 13\ 14\ 15}$$

- **Perhitungan Perpindahan – Beban Gravitasi**

Rumus: {Ds} = [Ss]$^{-1}$. {Fs}

4	5	6	7	8	9	10	11	12						
9,36E-06	3,21E-09	-1,21E-06	8,28E-06	4,91E-06	6,09E-07	7,20E-06	-3,21E-09	-1,23E-06	4	x	0	=	-0,0268	m
3,21E-09	4,46E-08	-8,55E-10	7,94E-09	2,23E-08	-1,75E-09	3,21E-09	1,57E-12	-8,55E-10	5		-3476		-0,0003	m
-1,21E-06	-8,55E-10	4,60E-07	-1,22E-06	7,61E-08	-1,62E-07	-1,23E-06	8,55E-10	1,90E-07	6		-6907		-0,0023	rad
8,28E-06	7,94E-09	-1,22E-06	8,33E-06	1,14E-20	6,08E-07	8,28E-06	-7,94E-09	-1,22E-06	7		0		0,0000	m
4,91E-06	2,23E-08	7,61E-08	7,53E-21	2,35E-05	9,41E-22	-4,91E-06	2,23E-08	-7,61E-08	8		-5427		-0,1285	m
6,09E-07	-1,75E-09	-1,62E-07	6,08E-07	6,38E-23	4,95E-07	6,09E-07	1,75E-09	-1,62E-07	9		0		0,0000	rad
7,20E-06	3,21E-09	-1,23E-06	8,28E-06	-4,91E-06	6,09E-07	9,36E-06	-3,21E-09	-1,21E-06	10		0		0,0268	m
-3,21E-09	1,57E-12	8,55E-10	-7,94E-09	2,23E-08	1,75E-09	-3,21E-09	4,46E-08	8,55E-10	11		-3476		-0,0003	m
-1,23E-06	-8,55E-10	1,90E-07	-1,22E-06	-7,61E-08	-1,62E-07	-1,21E-06	8,55E-10	4,60E-07	12		6907		0,0023	rad

- **Perhitungan Reaksi Tumpuan – Beban Gravitasi**

Rumus: {Fs} = [Ss] . {Ds}

4	5	6	7	8	9	10	11	12				
-134827	0	-505600	0	0	0	0	0	0	1	x	-0,0268	=	4758
0	-22432000	0	0	0	0	0	0	0	2		-0,0003		6190
505600	0	1264000	0	0	0	0	0	0	3		-0,0023		-16404
0	0	0	0	0	0	-134827	0	-505600	13		0,0000		-4758
0	0	0	0	0	0	0	-22432000	0	14		-0,1285		6190
0	0	0	0	0	0	505600	0	1264000	15		0,0000		16404
											0,0268		
											-0,0003		
											0,0023		

- **Perhitungan Gaya-Gaya Dalam Akhir Batang (pada sumbu batang) – Beban Gravitasi**

Rumus: $\{Fm^A\}i = \{Fm^B\}i + [Sm]i \times [RT]i \times \{Ds\}i$

dengan: $\{Fm^A\}i$ = Gaya dalam batang

$\{Fm^B\}i$ = Gaya akibat beban luar

$[Sm]i$ = Matriks kekakuan batang (pada sumbu batang)

$[RT]i$ = Matriks rotasi

$\{Ds\}i$ = Perpindahan

$$\{Fm^A\}1 = \begin{Bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{Bmatrix} + \begin{bmatrix} 22432000 & 0 & 0 & -22432000 & 0 & 0 \\ 0 & 134827 & 505600 & 0 & -134827 & 505600 \\ 0 & 505600 & 2528000 & 0 & -505600 & 1264000 \\ -22432000 & 0 & 0 & 22432000 & 0 & 0 \\ 0 & -134827 & -505600 & 0 & 134827 & -505600 \\ 0 & 505600 & 1264000 & 0 & -505600 & 2528000 \end{bmatrix} \times \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{Bmatrix} 0 \\ 0 \\ 0 \\ -0{,}0268 \\ -0{,}0003 \\ -0{,}0023 \end{Bmatrix} = \begin{Bmatrix} 6190 \\ -4758 \\ -16404 \\ -6190 \\ 4758 \\ -19281 \end{Bmatrix} \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \end{matrix}$$

$$\{Fm^A\}2 = \begin{Bmatrix} 723 \\ 3400 \\ 6907 \\ 564 \\ 2654 \\ -6907 \end{Bmatrix} + \begin{bmatrix} 10720753 & 0 & 0 & -10720753 & 0 & 0 \\ 0 & 14718 & 115484 & 0 & -14718 & 115484 \\ 0 & 115484 & 1208188 & 0 & -115484 & 604094 \\ -10720753 & 0 & 0 & 10720753 & 0 & 0 \\ 0 & -14718 & -115484 & 0 & 14718 & -115484 \\ 0 & 115484 & 604094 & 0 & -115484 & 1208188 \end{bmatrix} \times \begin{bmatrix} 0{,}978 & 0{,}208 & 0 & 0 & 0 & 0 \\ -0{,}21 & 0{,}978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0{,}978 & 0{,}208 & 0 \\ 0 & 0 & 0 & -0{,}21 & 0{,}978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{Bmatrix} -0{,}0268 \\ -0{,}0003 \\ -0{,}0023 \\ 0{,}0000 \\ -0{,}1285 \\ 0{,}0000 \end{Bmatrix} = \begin{Bmatrix} 5941 \\ 5065 \\ 19281 \\ -4654 \\ 989 \\ 6843 \end{Bmatrix} \begin{matrix} 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \end{matrix}$$

$$\{Fm^A\}3 = \begin{Bmatrix} -564 \\ 2654 \\ 6907 \\ -723 \\ 3400 \\ -6907 \end{Bmatrix} + \begin{bmatrix} 10720753 & 0 & 0 & -10720753 & 0 & 0 \\ 0 & 14718 & 115484 & 0 & -14718 & 115484 \\ 0 & 115484 & 1208188 & 0 & -115484 & 604094 \\ -10720753 & 0 & 0 & 10720753 & 0 & 0 \\ 0 & -14718 & -115484 & 0 & 14718 & -115484 \\ 0 & 115484 & 604094 & 0 & -115484 & 1208188 \end{bmatrix} \times \begin{bmatrix} 0,978 & -0,21 & 0 & 0 & 0 & 0 \\ 0,208 & 0,978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0,978 & -0,21 & 0 \\ 0 & 0 & 0 & 0,208 & 0,978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{Bmatrix} 0,0000 \\ -0,1285 \\ 0,0000 \\ 0,0268 \\ -0,0003 \\ 0,0023 \end{Bmatrix} = \begin{Bmatrix} 4654 \\ 989 \\ -6843 \\ -5941 \\ 5065 \\ -19281 \end{Bmatrix} \begin{matrix} 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \end{matrix}$$

$$\{Fm^A\}4 = \begin{Bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{Bmatrix} + \begin{bmatrix} 22432000 & 0 & 0 & -22432000 & 0 & 0 \\ 0 & 134827 & 505600 & 0 & -134827 & 505600 \\ 0 & 505600 & 2528000 & 0 & -505600 & 1264000 \\ -22432000 & 0 & 0 & 22432000 & 0 & 0 \\ 0 & -134827 & -505600 & 0 & 134827 & -505600 \\ 0 & 505600 & 1264000 & 0 & -505600 & 2528000 \end{bmatrix} \times \begin{bmatrix} 0 & -1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{Bmatrix} 0,0268 \\ -0,0003 \\ 0,0023 \\ 0 \\ 0 \\ 0 \end{Bmatrix} = \begin{Bmatrix} 6190 \\ 4758 \\ 19281 \\ -6190 \\ -4758 \\ 16404 \end{Bmatrix} \begin{matrix} 10 \\ 11 \\ 12 \\ 13 \\ 14 \\ 15 \end{matrix}$$

- **Perhitungan Gaya-Gaya Dalam Akhir Batang (pada sumbu struktur) – Beban Gravitasi**

Rumus: $\{Fs^A\}i = [RT]^T i \times \{Fm^A\}i$

dengan: $\{Fs^A\}i$ = Gaya dalam akhir batang

$[RT]^T i$ = Matriks rotasi transpose

$\{Fm^A\}i$ = Gaya dalam batang

$$\{Fs^A\}1 = \begin{pmatrix} 0 & -1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \times \begin{Bmatrix} 6190 \\ -4758 \\ -16404 \\ -6190 \\ 4758 \\ -19281 \end{Bmatrix} = \begin{Bmatrix} 4758 \\ 6190 \\ -16404 \\ -4758 \\ -6190 \\ -19281 \end{Bmatrix} \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \end{matrix}$$

$$\{Fs^A\}2 = \begin{pmatrix} 0{,}978 & -0{,}208 & 0 & 0 & 0 & 0 \\ 0{,}208 & 0{,}978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0{,}978 & -0{,}208 & 0 \\ 0 & 0 & 0 & 0{,}208 & 0{,}978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \times \begin{Bmatrix} 5941 \\ 5065 \\ 19281 \\ -4654 \\ 989 \\ 6843 \end{Bmatrix} = \begin{Bmatrix} 4758 \\ 6190 \\ 19281 \\ -4758 \\ 0 \\ 6843 \end{Bmatrix} \begin{matrix} 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \end{matrix}$$

$$\{Fs^A\}3 = \begin{pmatrix} 0{,}978 & 0{,}208 & 0 & 0 & 0 & 0 \\ -0{,}208 & 0{,}978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0{,}978 & 0{,}208 & 0 \\ 0 & 0 & 0 & -0{,}208 & 0{,}978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \times \begin{Bmatrix} 4654 \\ 989 \\ -6843 \\ -5941 \\ 5065 \\ -19281 \end{Bmatrix} = \begin{Bmatrix} 4758 \\ 0 \\ -6843 \\ -4758 \\ 6190 \\ -19281 \end{Bmatrix} \begin{matrix} 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \end{matrix}$$

$$\{Fs^A\}4 = \begin{pmatrix} 0 & 1 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \times \begin{Bmatrix} 6190 \\ 4758 \\ 19281 \\ -6190 \\ -4758 \\ 16404 \end{Bmatrix} = \begin{Bmatrix} 4758 \\ -6190 \\ 19281 \\ -4758 \\ 6190 \\ 16404 \end{Bmatrix} \begin{matrix} 10 \\ 11 \\ 12 \\ 13 \\ 14 \\ 15 \end{matrix}$$

- **Perhitungan Perpindahan – Beban Horisontal**

Rumus: {Ds} = [Ss]$^{-1}$. {Fs}

4	5	6	7	8	9	10	11	12						
9,36E-06	3,21E-09	-1,21E-06	8,28E-06	4,91E-06	6,09E-07	7,20E-06	-3,21E-09	-1,23E-06	4	x	338	=	0,0007	m
3,21E-09	4,46E-08	-8,55E-10	7,94E-09	2,23E-08	-1,75E-09	3,21E-09	1,57E-12	-8,55E-10	5		0		0,0000	m
-1,21E-06	-8,55E-10	4,60E-07	-1,22E-06	7,61E-08	-1,62E-07	-1,23E-06	8,55E-10	1,90E-07	6		422		0,0001	rad
8,28E-06	7,94E-09	-1,22E-06	8,33E-06	1,14E-20	6,08E-07	8,28E-06	-7,94E-09	-1,22E-06	7		0		0,0000	m
4,91E-06	2,23E-08	7,61E-08	7,53E-21	2,35E-05	9,41E-22	-4,91E-06	2,23E-08	-7,61E-08	8		0		0,0034	m
6,09E-07	-1,75E-09	-1,62E-07	6,08E-07	6,38E-23	4,95E-07	6,09E-07	1,75E-09	-1,62E-07	9		0		0,0000	rad
7,20E-06	3,21E-09	-1,23E-06	8,28E-06	-4,91E-06	6,09E-07	9,36E-06	-3,21E-09	-1,21E-06	10		-338		-0,0007	m
-3,21E-09	1,57E-12	8,55E-10	-7,94E-09	2,23E-08	1,75E-09	-3,21E-09	4,46E-08	8,55E-10	11		0		0,0000	m
-1,23E-06	-8,55E-10	1,90E-07	-1,22E-06	-7,61E-08	-1,62E-07	-1,21E-06	8,55E-10	4,60E-07	12		-422		-0,0001	rad

- **Perhitungan Reaksi Tumpuan – Beban Horisontal**

Rumus: {Fs} = [Ss] . {Ds}

4	5	6	7	8	9	10	11	12					
-134827	0	-505600	0	0	0	0	0	0	1	x	0,0007	=	-160
0	-22432000	0	0	0	0	0	0	0	2		0,0000		0
505600	0	1264000	0	0	0	0	0	0	3		0,0001		523
0	0	0	0	0	0	-134827	0	-505600	13		0,0000		160
0	0	0	0	0	0	0	-22432000	0	14		0,0034		0
0	0	0	0	0	0	505600	0	1264000	15		0,0000		-523
											-0,0007		
											0,0000		
											-0,0001		

- **Perhitungan Gaya-Gaya Dalam Akhir Batang (pada sumbu batang) – Beban Horisontal**

Rumus: $\{Fm^A\}i = \{Fm^B\}i + [Sm]i \times [RT]i \times \{Ds\}i$

dengan:
$\{Fm^A\}i$ = Gaya dalam batang
$\{Fm^B\}i$ = Gaya akibat beban luar
$[Sm]i$ = Matriks kekakuan batang (pada sumbu batang)
$[RT]i$ = Matriks rotasi
$\{Ds\}i$ = Perpindahan

$$\{Fm^A\}1 = \begin{Bmatrix} 0 \\ 338 \\ 422 \\ 0 \\ 338 \\ -422 \end{Bmatrix} + \begin{bmatrix} 22432000 & 0 & 0 & -22432000 & 0 & 0 \\ 0 & 134827 & 505600 & 0 & -134827 & 505600 \\ 0 & 505600 & 2528000 & 0 & -505600 & 1264000 \\ -22432000 & 0 & 0 & 22432000 & 0 & 0 \\ 0 & -134827 & -505600 & 0 & 134827 & -505600 \\ 0 & 505600 & 1264000 & 0 & -505600 & 2528000 \end{bmatrix} \times \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{Bmatrix} 0 \\ 0 \\ 0 \\ 0{,}0007 \\ 0{,}0000 \\ 0{,}0001 \end{Bmatrix} = \begin{Bmatrix} 0 \\ 497 \\ 945 \\ 0 \\ 178 \\ 254 \end{Bmatrix} \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \end{matrix}$$

$$\{Fm^A\}2 = \begin{Bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{Bmatrix} + \begin{bmatrix} 10720753 & 0 & 0 & -10720753 & 0 & 0 \\ 0 & 14718 & 115484 & 0 & -14718 & 115484 \\ 0 & 115484 & 1208188 & 0 & -115484 & 604094 \\ -10720753 & 0 & 0 & 10720753 & 0 & 0 \\ 0 & -14718 & -115484 & 0 & 14718 & -115484 \\ 0 & 115484 & 604094 & 0 & -115484 & 1208188 \end{bmatrix} \times \begin{bmatrix} 0{,}978 & 0{,}208 & 0 & 0 & 0 & 0 \\ -0{,}21 & 0{,}978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0{,}978 & 0{,}208 & 0 \\ 0 & 0 & 0 & -0{,}21 & 0{,}978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{Bmatrix} 0{,}0007 \\ 0{,}0000 \\ 0{,}0001 \\ 0{,}0000 \\ 0{,}0034 \\ 0{,}0000 \end{Bmatrix} = \begin{Bmatrix} 174 \\ -37 \\ -254 \\ -174 \\ 37 \\ -326 \end{Bmatrix} \begin{matrix} 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \end{matrix}$$

$$\{Fm^A\}3 = \begin{Bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{Bmatrix} + \begin{bmatrix} 10720753 & 0 & 0 & -10720753 & 0 & 0 \\ 0 & 14718 & 115484 & 0 & -14718 & 115484 \\ 0 & 115484 & 1208188 & 0 & -115484 & 604094 \\ -10720753 & 0 & 0 & 10720753 & 0 & 0 \\ 0 & -14718 & -115484 & 0 & 14718 & -115484 \\ 0 & 115484 & 604094 & 0 & -115484 & 1208188 \end{bmatrix} x \begin{bmatrix} 0,978 & -0,21 & 0 & 0 & 0 & 0 \\ 0,208 & 0,978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0,978 & -0,21 & 0 \\ 0 & 0 & 0 & 0,208 & 0,978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} x \begin{Bmatrix} 0,0000 \\ 0,0034 \\ 0,0000 \\ -0,0007 \\ 0,0000 \\ -0,0001 \end{Bmatrix} = \begin{Bmatrix} 174 \\ 37 \\ 326 \\ -174 \\ -37 \\ 254 \end{Bmatrix} \begin{matrix} 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \end{matrix}$$

$$\{Fm^A\}4 = \begin{Bmatrix} 0 \\ 338 \\ 422 \\ 0 \\ 338 \\ -422 \end{Bmatrix} + \begin{bmatrix} 22432000 & 0 & 0 & -22432000 & 0 & 0 \\ 0 & 134827 & 505600 & 0 & -134827 & 505600 \\ 0 & 505600 & 2528000 & 0 & -505600 & 1264000 \\ -22432000 & 0 & 0 & 22432000 & 0 & 0 \\ 0 & -134827 & -505600 & 0 & 134827 & -505600 \\ 0 & 505600 & 1264000 & 0 & -505600 & 2528000 \end{bmatrix} x \begin{bmatrix} 0 & -1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} x \begin{Bmatrix} -0,0007 \\ 0,0000 \\ -0,0001 \\ 0 \\ 0 \\ 0 \end{Bmatrix} = \begin{Bmatrix} 0 \\ 178 \\ -254 \\ 0 \\ 497 \\ -945 \end{Bmatrix} \begin{matrix} 10 \\ 11 \\ 12 \\ 13 \\ 14 \\ 15 \end{matrix}$$

- **Perhitungan Gaya-Gaya Dalam Akhir Batang (pada sumbu struktur) – Beban Horisontal**

Rumus: $\{Fs^A\}i = [RT]^T i \times \{Fm^A\}i$

dengan: $\{Fs^A\}i$ = Gaya dalam akhir batang

$[RT]^T i$ = Matriks rotasi transpose

$\{Fm^A\}i$ = Gaya dalam batang

$$\{Fs^A\}1 = \begin{pmatrix} 0 & -1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \times \begin{Bmatrix} 0 \\ 497 \\ 945 \\ 0 \\ 178 \\ 254 \end{Bmatrix} = \begin{Bmatrix} -497 \\ 0 \\ 945 \\ -178 \\ 0 \\ 254 \end{Bmatrix} \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \end{matrix}$$

$$\{Fs^A\}2 = \begin{pmatrix} 0{,}978 & -0{,}208 & 0 & 0 & 0 & 0 \\ 0{,}208 & 0{,}978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0{,}978 & -0{,}208 & 0 \\ 0 & 0 & 0 & 0{,}208 & 0{,}978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \times \begin{Bmatrix} 174 \\ -37 \\ -254 \\ -174 \\ 37 \\ -326 \end{Bmatrix} = \begin{Bmatrix} 178 \\ 0 \\ -254 \\ -178 \\ 0 \\ -326 \end{Bmatrix} \begin{matrix} 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \end{matrix}$$

$$\{Fs^A\}3 = \begin{pmatrix} 0{,}978 & 0{,}208 & 0 & 0 & 0 & 0 \\ -0{,}208 & 0{,}978 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0{,}978 & 0{,}208 & 0 \\ 0 & 0 & 0 & -0{,}208 & 0{,}978 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \times \begin{Bmatrix} 174 \\ 37 \\ 326 \\ -174 \\ -37 \\ 254 \end{Bmatrix} = \begin{Bmatrix} 178 \\ 0 \\ 326 \\ -178 \\ 0 \\ 254 \end{Bmatrix} \begin{matrix} 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \end{matrix}$$

$$\{Fs^A\}4 = \begin{pmatrix} 0 & 1 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \times \begin{Bmatrix} 0 \\ 178 \\ -254 \\ 0 \\ 497 \\ -945 \end{Bmatrix} = \begin{Bmatrix} 178 \\ 0 \\ -254 \\ 497 \\ 0 \\ -945 \end{Bmatrix} \begin{matrix} 10 \\ 11 \\ 12 \\ 13 \\ 14 \\ 15 \end{matrix}$$

C.3 Analisis Portal Tidak Bergoyang

➢ **Aksi Kolom**

- Faktor kekakuan masing-masing elemen:

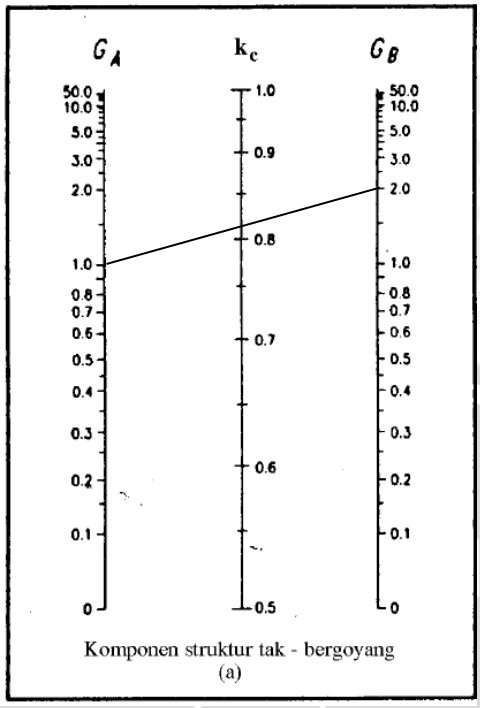
Elemen	I (cm^4)	L(cm)	I/L
12	23700	750	31,6
23	23700	1569	15,10
34	23700	1569	15,10
45	23700	750	31,6

- Faktor G tiap-tiap *joint*:

Joint	$\sum(I/L)_c / \sum(I/L)_b$	G
1	-	1
2	31,6 / 15,10	2,092
4	31,6 / 15,10	2,092
5	-	1

- Faktor panjang efektif *k*, masing-masing kolom:

Kolom	G_A	G_B	k
12	1	2,092	1,47
45	2,092	1	1,47



Komponen struktur tak - bergoyang
(a)

$k_s = 0{,}815$

$$\lambda_c = \frac{1}{\pi}\frac{k_b L}{r_y}\sqrt{\frac{f_y}{E}}$$

$$= \frac{1}{\pi}\frac{1{,}0 \times 7500}{45{,}4}\sqrt{\frac{240}{200000}}$$

$= 1{,}82157124 \geq 1{,}2$, maka

$$N_k = \phi A_g \frac{f_y}{1{,}25\lambda_c{}^2}$$

$$= 0{,}85 \times 8412 \frac{240}{1{,}25 \times 1{,}4846^2}$$

$= 413739{,}6062$ N

$$\frac{N_u}{N_k} = \frac{44021}{413739{,}6062} = 0{,}106397839 < 0{,}2 \text{ maka memakai persamaan:}$$

$$\frac{N_u}{2\phi N_n} + \frac{M_{ux}}{\phi_b M_{nx}} \leq 1{,}0$$

➢ **Aksi Balok**

$$\lambda = \frac{d - 2 \times (r + t_f)}{t_w}$$

$$= \frac{400 - 2 \times (16 + 13)}{8}$$

$$= 42{,}75$$

$$N_{ny} = \frac{N_u}{0{,}9 A_g f_y}$$

$$= \frac{44021}{0{,}9 \times 8412 \times 240}$$

$$= 0{,}024$$

$N_{ny} \leq 0{,}125$, maka

$$\lambda_p = \frac{1680}{\sqrt{f_y}}(1 - 2{,}75 N_{ny})$$

$$= \frac{1680}{\sqrt{240}}(1 - 2{,}75 \times 0{,}024)$$

$$= 101{,}2185$$

$$\lambda_r = \frac{2550}{\sqrt{f_y}}(1 - 0{,}745 N_{ny})$$

$$= \frac{2550}{\sqrt{240}}(1 - 0{,}745 \times 0{,}024)$$

$$= 161{,}631$$

$(\lambda = 42{,}75) \leq (\lambda_p = 101{,}2185)$, merupakan penampang kompak, sehingga

$$M_{n1} = 1{,}5 f_y S$$

$$= 1{,}5 \times 240 \times 1190000$$

$$= 428400000 \text{ N.mm}$$

$$M_r = S(f_y - f_r)$$

$$= 1190000(240 - 70)$$

$$= 202300000 \text{ N.mm}$$

$$M_p = 1{,}5 f_y S$$

$$= 1{,}5 \times 240 \times 1190000$$

= 428400000 N.mm

$$f_L = f_y - f_r$$

$$= 240 - 70$$

$$= 170\ MPa$$

$$h = d - 2 \times (r + t_f)$$

$$= 400 - 2 \times (16 + 13)$$

$$= 342 \text{ mm}$$

$$J = \sum \frac{1}{3} bt^3$$

$$= \frac{1}{3}(2 \times 200 \times 13^3 + 342 \times 8^3)$$

$$= 351301 \text{ mm}^4$$

$$I_w = \frac{h^2}{4} I_y$$

$$= \frac{342^2}{4} \times 17400000$$

$$= 508793400000 \text{ mm}^6$$

$$X_1 = \frac{\pi}{S} \sqrt{\frac{EGJA}{2}}$$

$$= \frac{\pi}{1190000} \sqrt{\frac{200000 \times 80000 \times 351301 \times 8412}{2}}$$

$$= 12836{,}228 \text{ MPa}$$

$$X_2 = 4\left(\frac{S_x}{GJ}\right)^2 \frac{I_w}{I_y}$$

$$= 4\left(\frac{1190000}{80000 \times 351301}\right)^2 \frac{508793400000}{17400000}$$

$$= 2{,}097 \times 10^{-4} \left({}^{1}/_{\text{MPa}}\right)^2$$

$$L_p = 1{,}76\sqrt{\frac{I_y \times E}{A \times f_y}}$$

$$= 1{,}76\sqrt{\frac{17400000 \times 200000}{8412 \times 240}}$$

$$= 2311 \text{ mm}$$

$$L_r = \frac{X_1}{f_L}\sqrt{\frac{I_y}{A}}\sqrt{1+\sqrt{1+X_2 {f_L}^2}}$$

$$= \frac{12836{,}228}{170}\sqrt{\frac{17400000}{8412}}\sqrt{1+\sqrt{1+2{,}097\times10^{-4}\times170^2}}$$

$$= 6567 \text{ mm}$$

$(L_p = 2311) < (L_r = 6567) < (\mathrm{L} = 7500)$, merupakan bentang panjang, sehingga

PERHITUNGAN M_A, M_B, M_C

x →					0	3,9232	7,8465	11,77	15,693
M	-13203				-13203	-13203	-13203	-13203	-13203
q	-87				0	-641,5	-2566	-5773	-10264
P	-790	x cos12	=	-773	0	-3031	-6062	-9093	-12124
V2	4402	x cos12	=	4306	0	16893	33786	50679	67572
H2	-3259	x sin12	=	-678	0	-2658	-5316	-7974	-10633
1,30	-196	x cos12	=	-192		-503	-1254	-2006	-2757
2,60						-254	-1005	-1757	-2508
3,90						-4	-756	-1508	-2259
5,20							-507	-1259	-2010
6,50							-258	-1010	-1761
7,80							-9	-761	-1512
9,10								-511	-1263
10,40								-262	-1014
11,70								-13	-765
13,00									-516
14,30									-267
Jumlah					-13203	-3401	2849	5549	4715
						M_A	**M_B**	**M_C**	

$$C_b = \frac{12{,}5M_u}{2{,}5M_u + 3M_A + 4M_B + 3M_C}$$

$$= \frac{12{,}5 \times 13203}{2{,}5 \times 13203 + 3 \times 3401 + 4 \times 2849 + 3 \times 5549}$$

$$= 2{,}316$$

$$M_{n2} = C_b \frac{\pi}{L} \sqrt{EI_y GJ + \left(\frac{\pi E}{L}\right)^2 I_y I_w}$$

$$= 2{,}316 \frac{\pi}{7500} \sqrt{\begin{matrix} 2 \times 10^5 \times 1{,}74 \times 10^7 \times 8 \times 10^4 \times 351301 \\ + \left(\frac{\pi \times 2 \times 10^5}{7500}\right)^2 \times 1{,}74 \times 10^7 \times 508793400000 \end{matrix}}$$

$M_{n2} = 388006196 < M_{n1} = 428400000$, maka

$M_{nx} = M_{n2} = 388006196$ N.mm

➢ **Perbesaran Momen Struktur Tak Bergoyang**

$$C_m = 0{,}6 - 0{,}4 \frac{M_1}{M_2}$$

$$= 0{,}6 - 0{,}4 \frac{11238}{13203}$$

$$= 0{,}260$$

$$N_{crb} = \frac{\pi^2 E A_g}{\left(k_b {}^{L}/_{r_x}\right)^2}$$

$$= \frac{\pi^2 \times 200000 \times 8412}{\left(1{,}0\, {}^{7500}/_{168}\right)^2}$$

$$= 8331535 \text{ N}$$

$$\delta_b = \frac{C_m}{1 - \frac{N_u}{N_{crb}}}$$

$$= \frac{0{,}260}{1 - \frac{44021}{8331535}}$$

$= 0{,}261 < 1 \rightarrow$ diambil 1

➢ **Periksa Persamaan Balok Kolom**

$$M_{ux} = \delta_b M_{ntu}$$

$$= 1 \times 132031512$$

$$= 132031512 \text{ N.mm}$$

$$\frac{N_u}{2\phi N_n} + \frac{M_{ux}}{\phi_b M_{nx}} \leq 1{,}0$$

$$\frac{0{,}1064}{2} + \frac{132031512}{0{,}9 \times 388006196} = 0{,}4313 \leq 1{,}0 \rightarrow \textbf{AMAN} \,\&\, SANGAT\ BOROS$$

C.4 Analisis Portal Bergoyang

- **Aksi Kolom (Gravitasi)**

$$\frac{N_u}{N_k} = \frac{61896}{413739{,}6062} = 0{,}1496 < 0{,}2\ maka\ memakai\ persamaan:$$

$$\frac{N_u}{2\phi N_n} + \frac{M_{ux}}{\phi_b M_{nx}} \leq 1{,}0$$

- **Aksi Balok (Gravitasi)**

$$N_{ny} = \frac{N_u}{0{,}9 A_g f_y}$$

$$= \frac{61896}{0{,}9 \times 8412 \times 240}$$

$$= 0{,}034$$

$N_{ny} \leq 0{,}125$, maka

$$\lambda_p = \frac{1680}{\sqrt{f_y}}\left(1 - 2{,}75 N_{ny}\right)$$

$$= \frac{1680}{\sqrt{240}}(1 - 2{,}75 \times 0{,}034)$$

$$= 98{,}284$$

$$\lambda_r = \frac{2550}{\sqrt{f_y}}\left(1 - 0{,}745 N_{ny}\right)$$

$$= \frac{2550}{\sqrt{240}}(1 - 0{,}745 \times 0{,}034)$$

$$= 160{,}424$$

$(\lambda = 42{,}75) \leq (\lambda_p = 98{,}284)$, merupakan penampang kompak, sehingga

$M_{n1} = 428400000$ N.mm

$L_p = 2311$ mm

$L_r = 6567$ mm

$(L_p = 2311) < (L_r = 6567) < (\mathrm{L} = 7500)$, merupakan bentang panjang, sehingga

PERHITUNGAN M_A, M_B, M_C

x →				0	3,9232	7,8465	11,77	15,693
M	-19281			-19281	-19281	-19281	-19281	-19281
q	-87			0	-641	-2566	-5773	-10264
P	-933	x cos12	= -912	0	-3580	-7160	-10740	-14319
V2	6190	x cos12	= 6054	0	23752	47505	71257	95010
H2	-4758	x sin12	= -989	0	-3881	-7762	-11643	-15524
1,30	-339	x cos12	= -331		-869	-2170	-3470	-4771
2,60					-439	-1739	-3039	-4340
3,90					-8	-1308	-2608	-3909
5,20						-877	-2178	-3478
6,50						-446	-1747	-3047
7,80						-15	-1316	-2616
9,10							-885	-2185
10,40							-454	-1754
11,70							-23	-1323
13,00								-893
14,30								-462
Jumlah				-19281	-4947	4180	8100	6843
					M_A	**M_B**	**M_C**	

$$C_b = \frac{12{,}5M_u}{2{,}5M_u + 3M_A + 4M_B + 3M_C}$$

$$= \frac{12{,}5 \times 19281}{2{,}5 \times 19281 + 3 \times 4947 + 4 \times 4180 + 3 \times 8100}$$

$$= 2{,}316$$

$$M_{n2} = C_b \frac{\pi}{L} \sqrt{EI_y GJ + \left(\frac{\pi E}{L}\right)^2 I_y I_w}$$

$$= 2{,}316 \frac{\pi}{7500} \sqrt{\frac{2 \times 10^5 \times 1{,}74 \times 10^7 \times 8 \times 10^4 \times 351301}{+\left(\frac{\pi \times 2 \times 10^5}{7500}\right)^2 \times 1{,}74 \times 10^7 \times 508793400000}}$$

$M_{n2} = 387982186 < M_{n1} = 428400000$, maka

$M_{nx} = M_{n2} = 387982186$ N.mm

➢ **Perbesaran Momen Struktur Tak Bergoyang**

$$C_m = 0{,}6 - 0{,}4\frac{M_1}{M_2}$$

$$= 0{,}6 - 0{,}4\frac{16404}{19281}$$

$$= 0{,}260$$

$$N_{crb} = \frac{\pi^2 E A_g}{\left(k_b {}^{L}/_{r_x}\right)^2}$$

$$N_{crb} = 8331535 \text{ N}$$

$$\delta_b = \frac{C_m}{1 - \frac{N_u}{N_{crb}}}$$

$$= \frac{0{,}260}{1 - \frac{61896}{8331535}}$$

$$= 0{,}262 < 1 \rightarrow \text{diambil } 1$$

➢ **Periksa Persamaan Balok Kolom (Gravitasi)**

$$M_{ux} = \delta_b M_{ntu}$$

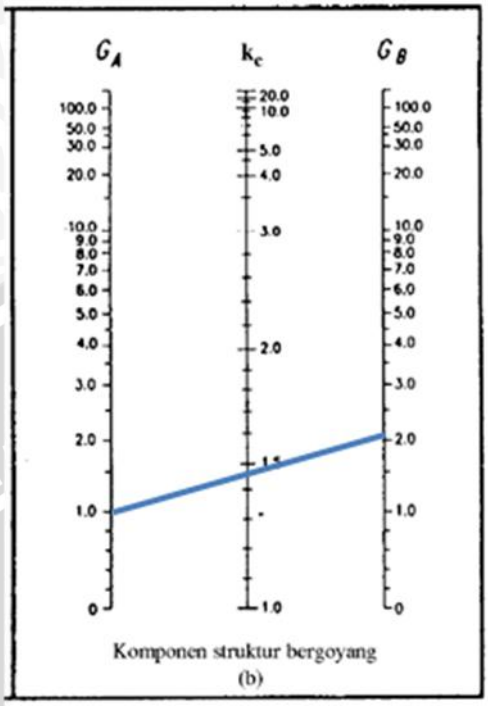
$$= 1 \times 192814828$$

$$= 192814828 \text{ N.mm}$$

$$\frac{N_u}{2\phi N_n} + \frac{M_{ux}}{\phi_b M_{nx}} \leq 1{,}0$$

$$\frac{0{,}1496}{2} + \frac{192814828}{0{,}9 \times 387982186} = 0{,}627 \leq 1{,}0 \rightarrow \textbf{AMAN} \;\&\; \textit{SANGAT BOROS}$$

➢ **Aksi Kolom (Gravitasi + Angin)**



$$k_s = 1{,}47$$

$$\frac{N_u}{N_k} = \frac{61900}{413739{,}6062} = 0{,}1496 < 0{,}2 \; maka \; memakai \; persamaan:$$

$$\frac{N_u}{2\phi N_n} + \frac{M_{ux}}{\phi_b M_{nx}} \leq 1{,}0$$

➢ **Aksi Balok (Gravitasi + Angin)**

$$N_{ny} = \frac{N_u}{0{,}9 A_g f_y}$$

$$= \frac{61900}{0{,}9 \times 8412 \times 240}$$

$$= 0{,}034$$

$N_{ny} \leq 0{,}125$, maka

$$\lambda_p = \frac{1680}{\sqrt{f_y}}\left(1 - 2{,}75 N_{ny}\right)$$

$$= \frac{1680}{\sqrt{240}}\left(1 - 2{,}75 \times 0{,}034\right)$$

$$= 98{,}284$$

$$\lambda_r = \frac{2550}{\sqrt{f_y}}(1 - 0{,}745N_{ny})$$

$$= \frac{2550}{\sqrt{240}}(1 - 0{,}745 \times 0{,}034)$$

$$= 160{,}424$$

$(\lambda = 42{,}75) \leq (\lambda_p = 98{,}284)$, merupakan penampang kompak, sehingga

$M_{n1} = 428400000$ N.mm

$L_p = 2311$ mm

$L_r = 6567$ mm

$(L_p = 2311) < (L_r = 6567) < (\mathrm{L} = 7500)$, merupakan bentang panjang, sehingga

PERHITUNGAN M_A, M_B, M_C

x →				0	3,9232	7,8465	11,77	15,693
M	-19028			-19028	-19028	-19028	-19028	-19028
q	-87			0	-641	-2566	-5773	-10264
P	-933	x cos12 =	-912	0	-3580	-7160	-10740	-14319
V2	6190	x cos12 =	6054	0	23752	47505	71257	95010
H2	-4936	x sin12 =	-1026	0	-4026	-8052	-12078	-16104
1,30	-339	x cos12 =	-331		-869	-2170	-3470	-4771
2,60					-439	-1739	-3039	-4340
3,90					-8	-1308	-2608	-3909
5,20						-877	-2178	-3478
6,50						-446	-1747	-3047
7,80						-15	-1316	-2616
9,10							-885	-2185
10,40							-454	-1754
11,70							-23	-1323
13,00								-892,6
14,30								-461,7
Jumlah				-19028	-4839	4144	7918	6517
					M_A	**M_B**	**M_C**	

$$C_b = \frac{12{,}5M_u}{2{,}5M_u + 3M_A + 4M_B + 3M_C}$$

$$= \frac{12{,}5 \times 19028}{2{,}5 \times 19028 + 3 \times 4839 + 4 \times 4144 + 3 \times 7918}$$

$$= 2{,}322$$

$$M_{n2} = C_b \frac{\pi}{L} \sqrt{EI_y GJ + \left(\frac{\pi E}{L}\right)^2 I_y I_w}$$

$$= 2{,}322 \frac{\pi}{7500} \sqrt{\begin{matrix} 2 \times 10^5 \times 1{,}74 \times 10^7 \times 8 \times 10^4 \times 351301 \\ + \left(\frac{\pi \times 2 \times 10^5}{7500}\right)^2 \times 1{,}74 \times 10^7 \times 508793400000 \end{matrix}}$$

$M_{n2} = 389045004 < M_{n1} = 428400000$, maka

$M_{nx} = M_{n2} = 389045004$ N.mm

- **Perbesaran Momen Struktur Tak Bergoyang**

$$C_m = 0{,}6 - 0{,}4 \frac{M_1}{M_2}$$

$$= 0{,}6 - 0{,}4 \frac{15459}{19028}$$

$$= 0{,}275$$

$$N_{crb} = \frac{\pi^2 E A_g}{\left(k_b {}^{L}/_{r_x}\right)^2}$$

$N_{crb} = 8331535$ N

$$\delta_b = \frac{C_m}{1 - \frac{N_u}{N_{crb}}}$$

$$= \frac{0{,}275}{1 - \frac{61900}{8331535}}$$

$= 0{,}277 < 1 \rightarrow$ diambil 1

- **Perbesaran Momen Struktur Bergoyang**

$$N_{crs} = \frac{\pi^2 E A_g}{\left(k_s {}^{L}/_{r_x}\right)^2}$$

$$= \frac{\pi^2 \times 200000 \times 8412}{\left(1{,}47 \, {}^{7500}/_{168}\right)^2}$$

$= 3855586$ N

$$\delta_s = \frac{1}{1 - \frac{N_u}{N_{crs}}}$$

$$= \frac{1}{1 - \frac{61900}{3855586}}$$

$$= 1{,}016$$

- **Periksa Persamaan Balok Kolom (Gravitasi + Angin)**

$$M_{ux} = \delta_b M_{ntu} + \delta_s M_{ltu}$$

$$= 1 \times 192814828 + 1{,}016 \times 9451360$$

$$= 202420402 \text{ N.mm}$$

$$\frac{N_u}{2\phi N_n} + \frac{M_{ux}}{\phi_b M_{nx}} \leq 1{,}0$$

$$\frac{0{,}1496}{2} + \frac{202420402}{0{,}9 \times 3890450043} = 0{,}65 \leq 1{,}0 \rightarrow \textbf{AMAN} \,\&\, SANGAT\ BOROS$$

Lampiran 7. *Form (Code)* Program

```
Private Sub Command1_Click()
ANny = Val(TextNu) / (0.9 * Val(TextAg) * Val(Tfy))
If ANny <= 0.125 Then
LamdaP = 1680 * (1 - 2.75 * ANny) / Sqr(Tfy)
ElseIf ANny > 0.125 Then
LamdaP2 = 500 * (2.33 - ANny) / Sqr(Tfy)
 If LamdaP2 >= 665 / Sqr(Tfy) Then
  LamdaP = 500 * (2.33 - ANny) / Sqr(Tfy)
 ElseIf LamdaP2 < 665 / Sqr(Tfy) Then
  LamdaP = 665 / Sqr(Tfy)
 End If
End If
AMr = TSx * (Tfy - Tfr)
AMp = 1.5 * Tfy * TSx
Lamda = (Textd - (2 * (Val(Textr) + Val(Ttf)))) / Ttw
LamdaR = 2550 * (1 - (0.745 * ANny)) / Sqr(Tfy)
If LamdaR <= Lamda Then
 Mn1 = AMr * ((LamdaR / Lamda) ^ 2)
 LPenampang.Caption = "PENAMPANG LANGSING"
ElseIf Lamda <= LamdaP Then
 Mn1 = 1.5 * Tfy * TSx
 LPenampang.Caption = "PENAMPANG KOMPAK"
Else
 Mn1 = AMp - ((AMp - AMr) * (Lamda - LamdaP) / (LamdaR - LamdaP))
 LPenampang.Caption = "PENAMPANG TIDAK KOMPAK"
End If
Afl = Tfy - Tfr
h = Textd - (2 * (Val(Textr) + Val(Ttf)))
J = (2 * Tbf * (Ttf ^ 3) + Val(h) * (Ttw ^ 3)) / 3
Iw = (h ^ 2) * TIy / 4
```

```
X1 = 3.141592654 * ((Val(TextE) * Val(TextG) * J * Val(TextAg) / 2) ^ 0.5) / Val(TSx)
X2 = 4 * ((Val(TSx) / (TextG * J)) ^ 2) * Iw / Val(TIy)
Cb = 12.5 * TMu / (2.5 * TMu + 3 * TMa + 4 * TMb + 3 * TMc)
Lp = 1.76 * ((TIy * TextE / (TextAg * Tfy)) ^ 0.5)
Lr = X1 * ((TIy / TextAg) ^ 0.5) * ((1 + ((1 + ((Afl ^ 2) * X2)) ^ 0.5)) ^ 0.5) / Afl
If Lr <= Val(TextL) Then
 Mcr = Cb * 3.141592654 * (((Val(TextE) * Val(TIy) * Val(TextG) * J) + (((3.141592654 * Val(TextE) / Val(TextL)) ^ 2) * Val(TIy) * Iw)) ^ 0.5) / Val(TextL)
 If Mcr <= AMp Then
  Mn2 = Mcr
  LLateral.Caption = "PENAMPANG BENTANG PANJANG"
 ElseIf Mcr > AMp Then
  Mn2 = AMp
  LLateral.Caption = "PENAMPANG BENTANG PANJANG"
 End If
ElseIf Val(TextL) <= Lp Then
 Mn2 = AMp
 LLateral.Caption = "PENAMPANG BENTANG PENDEK"
Else
 Mn2 = Cb * (AMr + ((AMp - AMr) * (Lr - Val(TextL)) / (Lr - Lp)))
 LLateral.Caption = "PENAMPANG BENTANG MENENGAH"
End If
If Mn1 > Mn2 Then
 Mnx = Mn2
Else
 Mnx = Mn1
End If
Ncrb = (3.141592654 ^ 2) * TextE * Val(TextAg) / ((Tkb * TextL / Textrx) ^ 2)
Sbb = TCm / (1 - (Val(TextNu) / Ncrb))
If Sbb >= 1 Then
 Sb = Sbb
Else
 Sb = 1
```

```
End If
Ncrs = (3.141592654 ^ 2) * TextE * Val(TextAg) / ((Tks * TextL / Textrx) ^ 2)
Sss = TCm / (1 - (Val(TextNu) / Ncrs))
If Sss >= 1 Then
 Ss = Sss
Else
 Ss = 1
End If
Mux = (Sb * TMntu) + (Ss * TMltu)
ALk = Tks * TextL
Lamdac = ALk * ((Val(Tfy) / Val(TextE)) ^ 0.5) / (3.141592654 * Val(Textry))
If Lamdac <= 0.25 Then
 Nkk = 0.85 * Val(TextAg) * Val(Tfy)
ElseIf Lamdac >= 1.2 Then
 Nkk = 0.85 * Val(TextAg) * Val(Tfy) / (1.25 * (Lamdac ^ 2))
Else
 Nkk = 0.85 * Val(TextAg) * Val(Tfy) * (1.6 - (0.67 * Lamdac)) / 1.43
End If
bantu2 = TextNu / Nkk
AMmy = Mux / (0.9 * Mnx)
If bantu2 >= 0.2 Then
bantu3 = ANny + (8 * AMmy / 9)
 If bantu3 <= 1 Then
 bantu3 = ANny + (8 * AMmy / 9)
  If bantu3 <= 0.7 Then
  Labelc = "Profil yang Anda pakai AMAN namun SANGAT BOROS"
  LabelM = bantu3
  ElseIf bantu3 >= 0.9 Then
  Labelc = "Profil yang Anda pakai AMAN dan EFISIEN"
  LabelM = bantu3
  Else
  Labelc = "Profil yang Anda pakai AMAN namun CUKUP BOROS"
  LabelM = bantu3
  End If
```

```
 Else
 Labelc = "Profil yang Anda pakai TIDAK AMAN"
 LabelM = bantu3
 End If
ElseIf bantu2 < 0.2 Then
bantu4 = (0.5 * ANny) + AMmy
 If bantu4 <= 1 Then
 bantu4 = (0.5 * ANny) + AMmy
  If bantu4 <= 0.7 Then
  Labelc = "Profil yang Anda pakai AMAN namun SANGAT BOROS"
  LabelM = bantu4
  ElseIf bantu4 >= 0.9 Then
  Labelc = "Profil yang Anda pakai AMAN dan EFISIEN"
  LabelM = bantu4
  Else
  Labelc = "Profil yang Anda pakai AMAN namun CUKUP BOROS"
  LabelM = bantu4
  End If
 Else
 Labelc = "Profil yang Anda pakai TIDAK AMAN"
 LabelM = bantu4
 End If
End If
End Sub

Private Sub Command2_Click()
ANny = Val(TextNu) / (0.9 * Val(TextAg) * Val(Tfy))
If ANny <= 0.125 Then
LamdaP = 1680 * (1 - 2.75 * ANny) / Sqr(Tfy)
ElseIf ANny > 0.125 Then
LamdaP2 = 500 * (2.33 - ANny) / Sqr(Tfy)
 If LamdaP2 >= 665 / Sqr(Tfy) Then
  LamdaP = 500 * (2.33 - ANny) / Sqr(Tfy)
 ElseIf LamdaP2 < 665 / Sqr(Tfy) Then
```

```
 LamdaP = 665 / Sqr(Tfy)
 End If
End If
AMr = TSx * (Tfy - Tfr)
AMp = 1.5 * Tfy * TSx
Lamda = (Textd - (2 * (Val(Textr) + Val(Ttf)))) / Ttw
LamdaR = 2550 * (1 - (0.745 * ANny)) / Sqr(Tfy)
If LamdaR <= Lamda Then
 Mn1 = AMr * ((LamdaR / Lamda) ^ 2)
 LPenampang.Caption = "PENAMPANG LANGSING"
ElseIf Lamda <= LamdaP Then
 Mn1 = 1.5 * Tfy * TSx
 LPenampang.Caption = "PENAMPANG KOMPAK"
Else
 Mn1 = AMp - ((AMp - AMr) * (Lamda - LamdaP) / (LamdaR - LamdaP))
 LPenampang.Caption = "PENAMPANG TIDAK KOMPAK"
End If
Afl = Tfy - Tfr
h = Textd - (2 * (Val(Textr) + Val(Ttf)))
J = (2 * Tbf * (Ttf ^ 3) + Val(h) * (Ttw ^ 3)) / 3
Iw = (h ^ 2) * TIy / 4
X1 = 3.141592654 * ((Val(TextE) * Val(TextG) * J * Val(TextAg) / 2) ^ 0.5) /
Val(TSx)
X2 = 4 * ((Val(TSx) / (TextG * J)) ^ 2) * Iw / Val(TIy)
Cb = 12.5 * TMu / (2.5 * TMu + 3 * TMa + 4 * TMb + 3 * TMc)
Lp = 1.76 * ((TIy * TextE / (TextAg * Tfy)) ^ 0.5)
Lr = X1 * ((TIy / TextAg) ^ 0.5) * ((1 + ((1 + ((Afl ^ 2) * X2)) ^ 0.5)) ^ 0.5) / Afl
If Lr <= Val(TextL) Then
 Mcr = Cb * 3.141592654 * (((Val(TextE) * Val(TIy) * Val(TextG) * J) +
(((3.141592654 * Val(TextE) / Val(TextL)) ^ 2) * Val(TIy) * Iw)) ^ 0.5) / Val(TextL)
 If Mcr <= AMp Then
  Mn2 = Mcr
  LLateral.Caption = "PENAMPANG BENTANG PANJANG"
 ElseIf Mcr > AMp Then
```

```
 Mn2 = AMp
 LLateral.Caption = "PENAMPANG BENTANG PANJANG"
 End If
ElseIf Val(TextL) <= Lp Then
 Mn2 = AMp
 LLateral.Caption = "PENAMPANG BENTANG PENDEK"
Else
 Mn2 = Cb * (AMr + ((AMp - AMr) * (Lr - Val(TextL)) / (Lr - Lp)))
 LLateral.Caption = "PENAMPANG BENTANG MENENGAH"
End If
If Mn1 > Mn2 Then
 Mnx = Mn2
Else
 Mnx = Mn1
End If
LabelM = Mnx
Ncrb = (3.141592654 ^ 2) * TextE * Val(TextAg) / ((Tkb * TextL / Textrx) ^ 2)
Sbb = TCm / (1 - (Val(TextNu) / Ncrb))
If Sbb >= 1 Then
 Sb = Sbb
Else
 Sb = 1
End If
Mux = Sb * TMntu
ALk = Tkb * TextL
Lamdac = ALk * ((Val(Tfy) / Val(TextE)) ^ 0.5) / (3.141592654 * Val(Textry))
If Lamdac <= 0.25 Then
 Nkk = 0.85 * Val(TextAg) * Val(Tfy)
ElseIf Lamdac >= 1.2 Then
 Nkk = 0.85 * Val(TextAg) * Val(Tfy) / (1.25 * (Lamdac ^ 2))
Else
 Nkk = 0.85 * Val(TextAg) * Val(Tfy) * (1.6 - (0.67 * Lamdac)) / 1.43
End If
bantu2 = TextNu / Nkk
```

```
AMmy = Mux / (0.9 * Mnx)
If bantu2 >= 0.2 Then
bantu3 = ANny + (8 * AMmy / 9)
 If bantu3 <= 1 Then
 bantu3 = ANny + (8 * AMmy / 9)
  If bantu3 <= 0.7 Then
  Labelc = "Profil yang Anda pakai AMAN namun SANGAT BOROS"
  LabelM = bantu3
  ElseIf bantu3 >= 0.9 Then
  Labelc = "Profil yang Anda pakai AMAN dan EFISIEN"
  LabelM = bantu3
  Else
  Labelc = "Profil yang Anda pakai AMAN namun CUKUP BOROS"
  LabelM = bantu3
  End If
 Else
 Labelc = "Profil yang Anda pakai TIDAK AMAN"
 LabelM = bantu3
 End If
ElseIf bantu2 < 0.2 Then
bantu4 = (0.5 * ANny) + AMmy
 If bantu4 <= 1 Then
 bantu4 = (0.5 * ANny) + AMmy
  If bantu4 <= 0.7 Then
  Labelc = "Profil yang Anda pakai AMAN namun SANGAT BOROS"
  LabelM = bantu4
  ElseIf bantu4 >= 0.9 Then
  Labelc = "Profil yang Anda pakai AMAN dan EFISIEN"
  LabelM = bantu4
  Else
  Labelc = "Profil yang Anda pakai AMAN namun CUKUP BOROS"
  LabelM = bantu4
  End If
 Else
```

```
Labelc = "Profil yang Anda pakai TIDAK AMAN"
LabelM = bantu4
End If
End If
End Sub


Private Sub Command3_Click()
TextE.Text = ""
Tfr.Text = ""
Tfy.Text = ""
TextG.Text = ""
TextL.Text = ""
Textd.Text = ""
Tbf.Text = ""
TextAg.Text = ""
Tweight.Text = ""
Ttf.Text = ""
Ttw.Text = ""
TIy.Text = ""
Textr.Text = ""
TSx.Text = ""
Textrx.Text = ""
Textry.Text = ""
TNu.Text = ""
TMu.Text = ""
TMa.Text = ""
TMb.Text = ""
TMc.Text = ""
Tkb.Text = ""
Tks.Text = ""
TCm.Text = ""
TMntu.Text = ""
TMltu.Text = ""
```

```
LLateral.Caption = ""
LPenampang.Caption = ""
Labelk.Caption = ""
LabelM.Caption = ""
Labelc.Caption = ""
End Sub

Private Sub Command4_Click()
End
End Sub

Private Sub Tbf_Change()
Labelk = "Lebar Profil"
End Sub

Private Sub TCm_Change()
Labelk = "Koefisien lentur kolom (struktur tak bergoyang tanpa beban transversal = 0,6
- 0,4Bm; Ujung sederhana = 1; Ujung kaku = 0,85"
End Sub

Private Sub TextAg_Change()
Labelk = "Luas penampang"
End Sub

Private Sub Textd_Change()
Labelk = "Tinggi profil"
End Sub

Private Sub TextE_Change()
Labelk = "Modulus elastisitas baja "
End Sub

Private Sub TextG_Change()
Labelk = "Moudulus geser baja "
```

```
End Sub

Private Sub TextL_Change()
Labelk = "Panjang komponen struktur"
End Sub

Private Sub Textr_Change()
Labelk = "Jari-jari peralihan penampang"
End Sub

Private Sub Textrx_Change()
Labelk = "Jari-jari girasi komponen struktur terhadap sumbu-x"
End Sub

Private Sub Textry_Change()
Labelk = "Jari-jari girasi terhadap sumbu-y"
End Sub

Private Sub Tfr_Change()
Labelk = "Tegangan tekan sisa pada pelat sayap, diambil sebesar 70 MPa untuk penampang dirol dan 115 MPa untuk penampang dilas"
End Sub

Private Sub Tfy_Change()
Labelk = "Tegangan leleh"
End Sub

Private Sub TIy_Change()
Labelk = "Momen inersia terhadap sumbu-y"
End Sub

Private Sub Tkb_Change()
Labelk = "Faktor panjang tekuk untuk struktur tidak bergoyang"
End Sub
```

```
Private Sub Tks_Change()
Labelk = "Faktor panjang tekuk untuk struktur bergoyang"
End Sub

Private Sub TMa_Change()
Labelk = "Momen lentur pada 1/4 bentang"
End Sub

Private Sub TMb_Change()
Labelk = "Momen lentur pada tengah bentang"
End Sub

Private Sub TMc_Change()
Labelk = "Momen lentur pada 3/4 bentang"
End Sub

Private Sub TMltu_Change()
Labelk = "Momen lentur terfaktor yang diakibatkan oleh beban-beban yang dapat menimbulkan goyangan"
End Sub

Private Sub TMntu_Change()
Labelk = "Momen lentur terfaktor yang diakibatkan oleh beban-beban yang tidak menimbulkan goyangan"
End Sub

Private Sub TMu_Change()
Labelk = "Momen lentur terfaktor maksimal pada struktur"
End Sub

Private Sub TNu_Change()
Labelk = "Gaya aksial terfaktor tekan yang terbesar pada komponen struktur"
End Sub
```

```
Private Sub TSx_Change()
Labelk = "Modulus penampang elastis"
End Sub

Private Sub Ttf_Change()
Labelk = "Tebal pelat sayap"
End Sub

Private Sub Ttw_Change()
Labelk = "Tebal pelat badan"
End Sub

Private Sub Tweight_Change()
Labelk = "Berat penampang"
End Sub
```