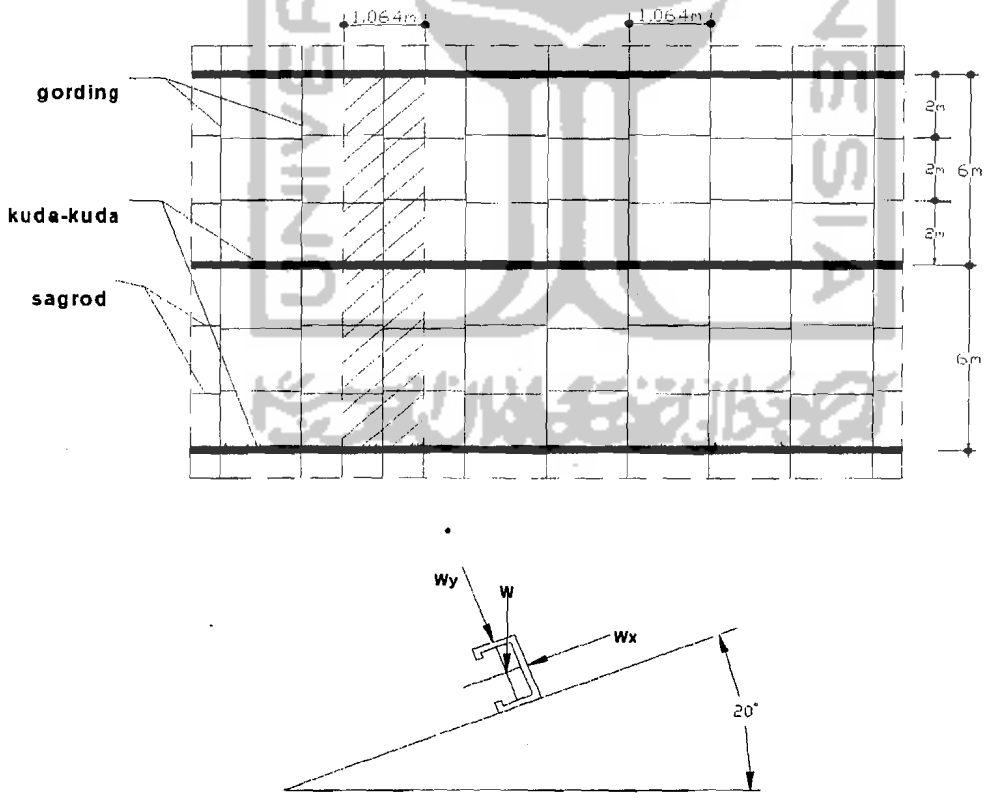
BAB IV

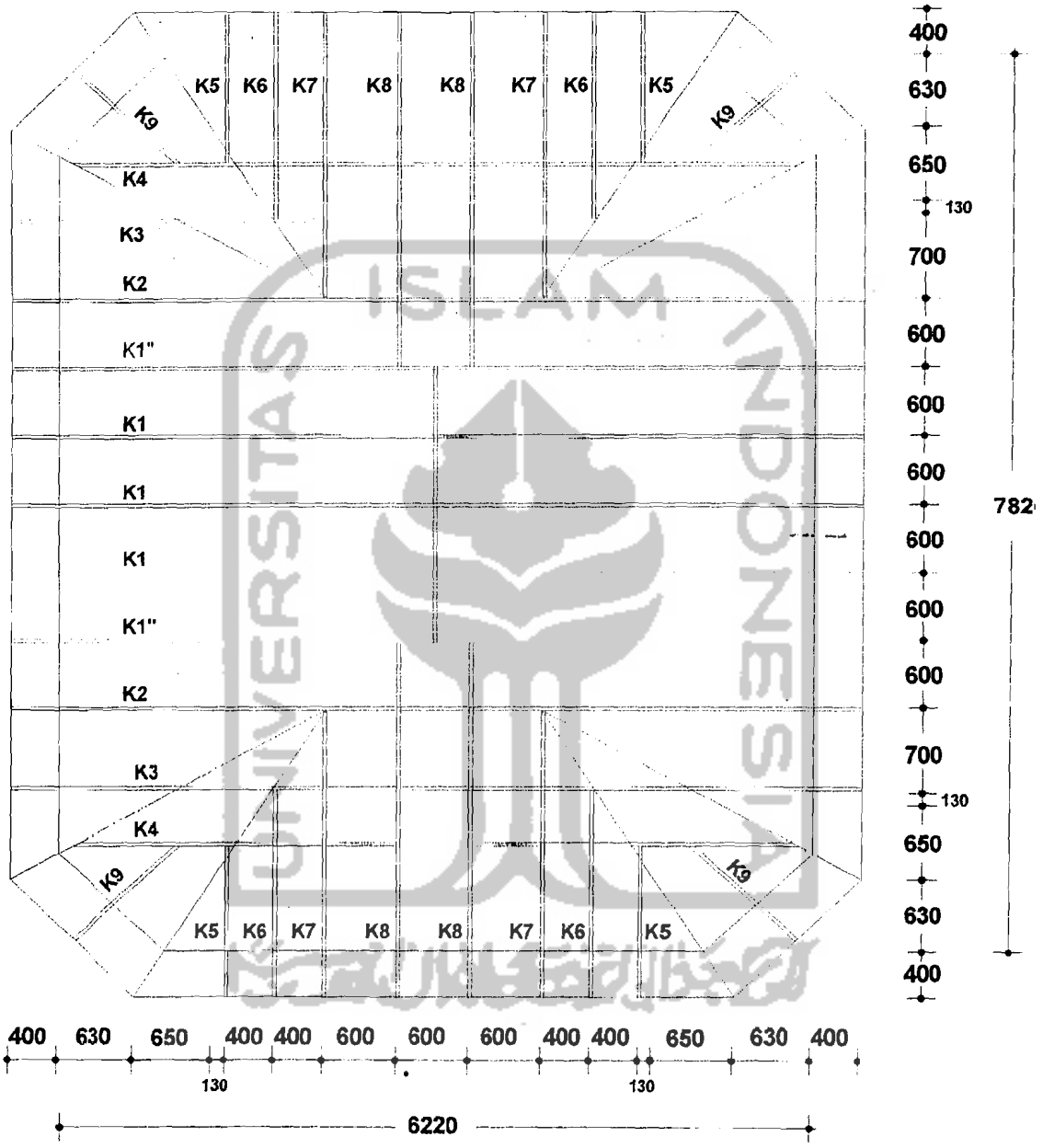
PERENCANAAN ATAP

Perencanaan atap meliputi, perencanaan gording, perencanaan sagrod, dan perencanaan rangka atap. Metode yang dipergunakan adalah metode LRFD 2000. Denah rencana atap disajikan dalam Gambar 4.2, Gambar 4.3, dan Gambar 4.4.

4.1 Perencanaan Gording (untuk kuda-kuda K_1,K_1',K_2,K_7,K_8)

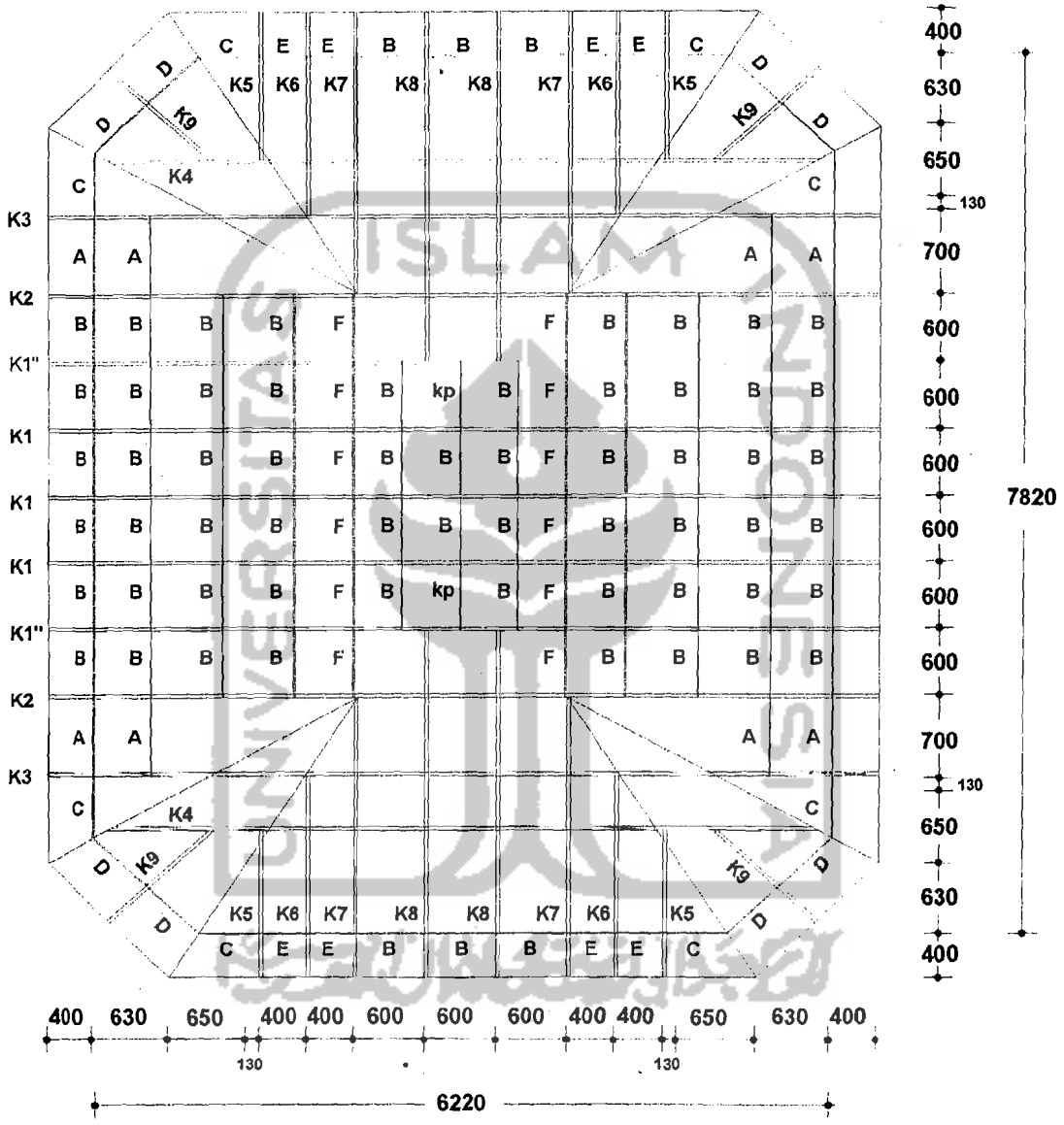


Gambar 4.1 Arah pembebanan gording bentang 6m



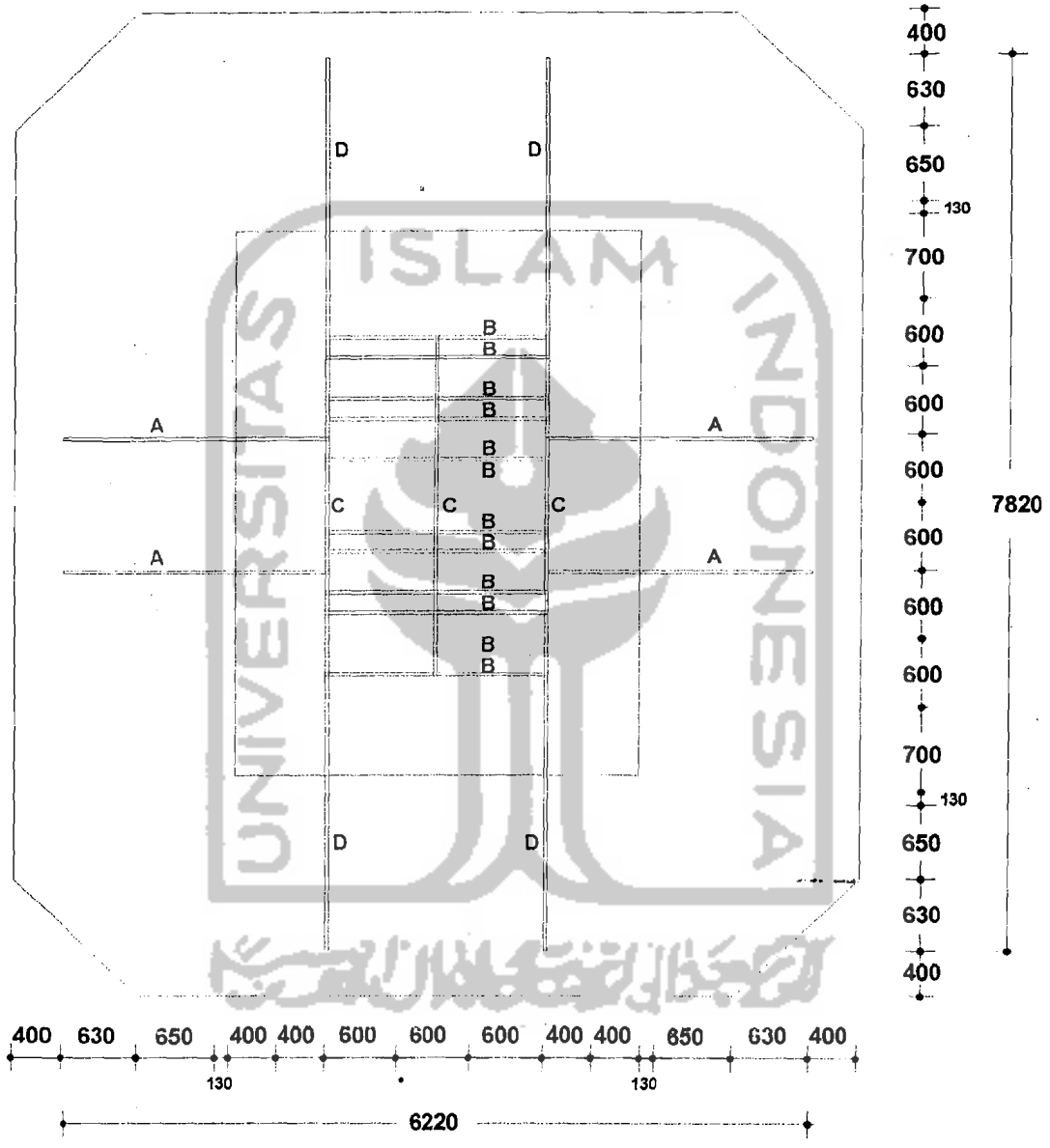
Gb. Denah Rencana Kuda-kuda

Gambar 4.2 Denah Rencana Kuda-kuda



Gb. Rencana Vertikal Bracing Atap Bawah

Gambar 4.3 Denah Rencana Vertikal Bracing Atap Bawah



Gb. Denah Rencana Catwalk

Gambar 4.4 Denah Rencana Catwalk

Tipe	Jarak (m)	Jumlah
A	700	8
B	600	64
C	560	8
D	560	8
E	400	8
F	600	12
KP	600	2

4.1.1 Pembebanan Gording

a. Beban mati (penutup atap galvallum = 0,1 kN/m^2)

- Galvallum : 0,1.1,064 = 0,106 kN/m
- Gording taksiran = 0,15 kN/m

q_D = 0,256 kN/m

b. Beban hidup

- Beban pekerja atap : P_L = 1 kN

c. Beban air hujan

- Beban air hujan : q_H = (40 – 0,8α).1,064 = 25,536 kg/m
  = 0,255 kN/m

d. Beban angin (w = 0,4 kN/m^2)

- Tiup angin :

c_1 = (0,02α) – 0,4 = (0,02.20) – 0,4 = 0

q_w,tiup = 0. 0,4 . 1,064 = 0

- Hisap angin

c_2 = -0,4

q_w,hisap = -0,4 . 0,4 . 1,064 = -0,170 kN/m

e. Momen arah sumbu x dan sumbu y

- Sumbu x (satu sagrod)

- Sumbu y (dua sagrod)

Tabel 4.1 Pembebanan, momen sumbu x dan sumbu y gording

No	Jenis Pembebanan	W_x (1)	W_y (2)	M_x (3)	M_y (4)
1.	Beban mati (D)	q_x= 0,087	q_y = 0,241	0,121	0,392
2.	Beban hidup (L)	P_x= 0,342	P_y = 0,940	0,470	0,513
3.	Beban hujan (R)	q_x= 0,087	q_y = 0,240	0,120	0,392
4.	Beban angin (W)				
	- Tiup	0	q_y = 0	0	0
	- Hisap	0	q_y = -0,170	-0,085	0

Keterangan **Tabel 4.1**:

(1) Pembebanan sejajar gording : $q_x = q.\sin 20°$ (kN/m untuk beban merata)

$P_x = P.\sin 20°$ (kN untuk beban terpusat)

(2) Pembebanan tegak lurus gording : $q_y = q.\cos 20°$ (kN/m untuk beban merata)

$P_y = P.\cos 20°$ (kN untuk beban terpusat)

(3) Momen sejajar gording : $M_x = 1/8.q_y.L_y^2$ (kNm untuk beban merata)

$M_x = 1/4.P_y.L_y$ (kNm untuk beban terpusat)

(4) Momen tegak lurus gording : $M_y = 1/8.q_x.L_x^2$ (kNm untuk beban merata)

M_y=1/4.P_x. L_x (kNm untuk beban terpusat)

Dengan L_x = 6,00 m dan L_y = 2,00 m

Tabel 4.2 Kombinasi pembebanan LRFD

No	Kombinasi	$M_{u,x}$ (kNm)	$M_{u,y}$ (kNm)
1.	1,4 M_D	0,169	0,549
2.	1,2 M_D + 1,6 M_L + 0,5 M_R	**0,957**	**1,487**
3.	1,2 M_D + 1,6 M_L + 0,8 $M_{W\ tiup}$	0,897	1,291
4.	1,2 M_D + 1,6 M_L + 0,8 $M_{W\ hisap}$	0,829	1,291
5.	1,2 M_D + 1,3 $M_{W\ tiup}$ + 0,5 M_L	0,380	0,727
6.	1,2 M_D + 1,3 $M_{W\ hisap}$ + 0,5 M_L	0,270	0,727

4.1.2 Dimensi Gording

a. Arah sumbu x (sejajar gording)

$M_{u,x}$ = 0,957 kNm (kombinasi maksimum)

f_y = 240 MPa

Asumsi penampang kompak, kuat desain :

$$S_y \geq \frac{0{,}957 \times 10^6}{0{,}9 \times 240} = 4430{,}56 \text{ mm}^3 = 4{,}431 \text{ cm}^3$$

Dipakai profil C 150×50×20×2,3 (*light lip channels*)

S_x = 28,0 cm^3 S_y = 6,33 cm^3 A = 6,322 cm^2

I_x = 210 cm^4 I_y = 21,9 cm^4 berat = 0,0496 kN/m

b. Arah sumbu y (tegak lurus gording)

$M_{u,y}$ = 1,487 kNm (kombinasi maksimum)

$$S_x = \frac{1{,}487 \times 10^6}{0{,}9 \times 240} = 6884{,}26 \text{ mm}^3 = 6{,}884 \text{ cm}^3$$

S_x profil = 28,0 $\text{cm}^3 > 6{,}884 \text{ cm}^3$

∴ Profil aman digunakan.

c. Kontrol lendutan

(1) Lendutan sejajar gording

E = 200000 MPa

L = 2000 mm

I_y = 21,9 cm^4

q_x = 0,087 kN/m

P_x = 0,342 kN

$$\delta_x = \frac{5}{384} q_x . \frac{L^4}{EI_y} + \frac{P_x . L^3}{48 . EI_y}$$

$$= \left(\frac{5}{384} \times 0{,}087 \times \frac{2000^4}{2.10^5 . 21{,}9 . 10^4} \right) + \frac{,342 . 2000^3}{48 . 2.10^5 . 21{,}9 . 10^4}$$

= 0,414 + 0,001

= 0,415 mm

(2) Lendutan tegak lurus gording

E = 200.000 MPa

L = 6000 mm

I_x = 280 cm^4

q_y = 0,241 kN/m

$P_y = 0{,}940$ kN

$$\delta_y = \frac{5}{384}.q_y.\frac{L^4}{EI_x} + \frac{P_y.L^3}{48.EI_x}$$

$$= \left(\frac{5}{384} \times 0{,}241 \times \frac{6000^4}{2.10^5.210.10^4}\right) + \frac{0{,}940.6000^3}{48.2.10^5.210.10^4}$$

$= 9{,}683 + 0{,}010 = 9{,}693$ mm

$$\delta = \sqrt{\delta_x^{\,2} + \delta_y^{\,2}}$$

$$= \sqrt{0{,}415^2 + 9{,}693^2} = 9{,}702\text{mm} < \frac{L}{360} = \frac{6000}{360} = 16{,}667\text{mm}$$ - ok-

Berdasarkan lendutan yang terjadi profil C 150x50x20x2,3 memenuhi.

4.1.3 Perencanaan Sagrod

4.1.3.1 Pembebanan Sagrod

a. Beban mati

- Beban penutup atap = 0,1 . 33,096 . 6 = 19,858 kN
- Beban gording = 0,0496 . 6 = 0,406 kN
- Beban sagrod taksiran = 0,05 . 33,096 = 1,655 kN

$P_D = 21{,}919$ kN

b. Beban hidup

- Beban pekerja : $P_L = 1$ kN × 6 pekerja tiap gording = 6 kN

c. Beban hujan

- Beban hujan : $P_H = 0{,}255 . 33{,}096 . 6 = 50{,}367$ kN

Kombinasi pembebanan terbesar

$N_u = 1{,}2\ q_D + 1{,}6\ P_L + 0{,}5\ q_H$

$= 1{,}2.\ 21{,}919 + 1{,}6.6 + 0{,}5.\ 50{,}367$

$= 61{,}086$ kN

$N_{u,x} = 61{,}086.\ \sin 20° = 20{,}8939$ kN

4.1.3.2 Dimensi sagrod

$N_u \leq \phi\ N_n$

$N_u \leq 0{,}9\ .\ A_g\ .\ f_y$

$$A_g = \frac{N_{u,X}}{0.9.f_y} = \frac{20{,}893.10^3}{0{,}9.240} = 96{,}726\ \text{mm}^2$$

$A_g = \frac{1}{4}\pi D^2$

$96{,}726 = \frac{1}{4}\pi D^2$

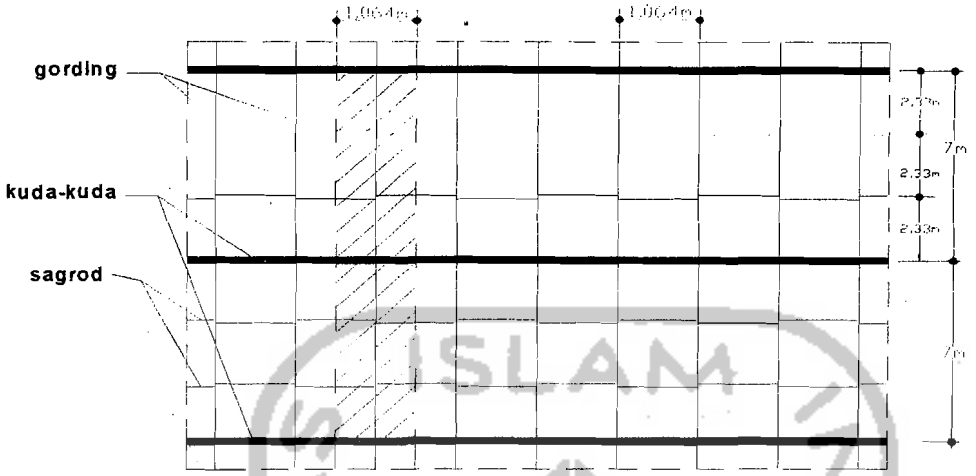
$D = 11{,}098$ mm, diambil $D = 12$ mm

A_g profil $= \frac{1}{4}\pi\ 12^2 = 113{,}097\ \text{mm}^2 > 96{,}726\ \text{mm}^2$ - aman-

Berat sendiri $= 78{,}50\ .\ 113{,}097.\ 10^{-6}$

$= 0{,}00888$ kN/m < berat taksiran = 0,05 kN/m -aman-

4.2 Perencanaan Gording (untuk kuda-kuda K_2,K_3,K_4,K_5,K_6)



Gambar 4.5 Arah pembebanan gording bentang 7m

4.2.1 Pembebanan Gording

a. Beban mati, (Penutup atap Galvallum = 0,1 kN/m^2)

- Galvallum : 0,1.1,064 = 0,106 kN/m
- Gording taksiran = 0,15 kN/m

q_D = 0,256 kN/m

b. Beban hidup, (L = 0,2 kN/m^2)

- Beban pekerja atap : P_L = 1 kN

c. Beban air hujan

- Beban air hujan : q_H = (40 – 0,8α) . 1,064 = 25,536 kg/m

= 0,255 kN/m

d. Beban angin (w = 0,4 kN/m^2)

- Tiup angin :

c_1 = (0,02α) – 0,4 = (0,02.20) – 0,4 = 0

q_w,tiup = 0. 0,4 . 1,064 = 0 kN/m

- Hisap angin

c_2 = -0,4

q_w,hisap = -0,4 . 0,4 . 1,064 = -0,170 kN/m

e. Momen arah sumbu x dan sumbu y

- Sumbu x (satu sagrod)

- Sumbu y (dua sagrod)

Tabel 4.3 Pembebanan, momen sumbu x dan sumbu y gording

No	Jenis Pembebanan	W_x (1)	W_y (2)	M_x (3)	M_y (4)
1.	Beban mati (D)	q_x= 0,087	q_y = 0,241	0,165	0,534
2.	Beban hidup (L)	P_x= 0,342	P_y = 0,940	0,548	0,598
3.	Beban hujan (R)	q_x= 0,087	q_y = 0,240	0,163	0,533
4.	Beban angin				
	- Tiup	0	q_y = 0	0	0
	- Hisap	0	q_y = -0,170	-0,116	0

Keterangan **Tabel 4.3** :

(1) Pembebanan sejajar gording : $q_x = q.\sin 20°$ (kN/m untuk beban merata)

$P_x = P.\sin 20°$ (kN untuk beban terpusat)

(2) Pembebanan tegak lurus gording : $q_y = q.\cos 20°$ (kN/m untuk beban merata)

$P_y = P.\cos 20°$ (kN untuk beban terpusat)

(3) Momen sejajar gording : $M_x = 1/8.q_y.L_y^2$ (kNm untuk beban merata)

$M_x = 1/4.P_y.L_y$ (kNm untuk beban terpusat)

(4) Momen tegak lurus gording : $M_y = 1/8.q_x.L_x^2$ (kNm untuk beban merata)

$M_y = 1/4.P_x.L_x$ (kNm untuk beban terpusat)

Dengan L_x = 7,00 m dan L_y = 2,33 m

Tabel 4.4 Kombinasi pembebanan LRFD

No	Kombinasi	$M_{u,x}$ (kNm)	$M_{u,y}$ (kNm)
1.	1,4 M_D	0,231	0,748
2.	1,2 M_D + 1,6 M_L + 0,5 M_R	**1,156**	**1,864**
3.	1,2 M_D + 1,6 M_L + 0,8 $M_{W\ tiup}$	1,075	1,598
4.	1,2 M_D + 1,6 M_L + 0,8 $M_{W\ hisap}$	0,982	1,598
5.	1,2 M_D + 1,3 $M_{W\ tiup}$ + 0,5 M_L	0,472	0,940
6.	1,2 M_D + 1,3 $M_{W\ hisap}$ + 0,5 M_L	0,321	0,940

4.2.2 Dimensi Gording

a. Arah sumbu x (sejajar gording)

$M_{u,x}$ = 1,156 kNm (kombinasi maksimum)

f_y = 240 MPa

Asumsi penampang kompak, kuat desain :

$$S_y \geq \frac{1{,}156 \times 10^6}{0{,}9 \times 240} = 5353{,}241 \text{ mm}^3 = 5{,}353 \text{ cm}^3$$

Dipakai profil C 150×50×20×3,2 (*light lip channels*)

S_x = 37,4 cm^3 S_y = 8,19 cm^3 A = 8,607 cm^2

I_x = 280 cm^4 I_y = 28,3 cm^4 berat = 0,0676 kN/m

b. Arah sumbu y (tegak lurus gording)

$M_{u,y}$ = 1,864 kNm (kombinasi maksimum)

$$S_x = \frac{1{,}864 \times 10^6}{0{,}9 \times 240} = 8629{,}63 \text{ mm}^3 = 8{,}630 \text{ cm}^3$$

S_x profil = 37,40 cm^3 > 8,630 cm^3 → ok

∴ Profil aman digunakan

c. Kontrol lendutan

(1) Lendutan sejajar gording

E = 200000 MPa

L = 2333,333 mm

I_y = 35,7 cm^4

q_x = 0,087 kN/m

P_x = 0,342 kN

$$\delta_x = \frac{5}{384}.q_x.\frac{L^4}{EI_y} + \frac{P_x.L^3}{48.EI_y}$$

$$= \left(\frac{5}{384} \times 0{,}087 \times \frac{2333{,}333^4}{2.10^5.28{,}3.10^4}\right) + \frac{342.2333{,}333^3}{48.2.10^5.28{,}3.10^4}$$

$$= 0{,}593 + 0{,}0016$$

$$= 0{,}595 \text{ mm}$$

(2) Lendutan tegak lurus gording

$E = 200.000$ MPa

$L = 7000$ mm

$I_x = 368 \text{ cm}^4$

$q_y = 0{,}241$ kN/m

$P_y = 0{,}940$ kN

$$\delta_y = \frac{5}{384}.q_y.\frac{L^4}{EI_x} + \frac{P_y.L^3}{48.EI_x}$$

$$= \left(\frac{5}{384} \times 0{,}241 \times \frac{7000^4}{2x10^5.280.10^4}\right) + \frac{0{,}940.7000^3}{48.2.10^5.280.10^4}$$

$$= 13{,}454 + 0{,}012$$

$$= 13{,}466 \text{ mm}$$

$$\delta = \sqrt{\delta_x^{\,2} + \delta_y^{\,2}}$$

$$= \sqrt{0{,}595^2 + 13{,}466^2} = 13{,}479 \text{ mm} < \frac{L}{360} = \frac{6000}{360} = 16{,}667 \text{mm} \text{ -ok-}$$

Berdasarkan lendutan yang terjadi profil C 150x50x20x3,2

memenuhi.

4.2.3 Perencanaan Sagrod

4.2.3.1 Pembebanan sagrod

a. Beban Mati

- Beban penutup atap = 0,1 . 33,096 . 7 = 23,167 kN
- Beban gording = 0,0676 . 7 = 0,473 kN
- Beban sagrod taksiran = 0,05 . 33,096 = 1,655 kN

P_D = 25,295 kN

b. Beban Hidup

- Beban pekerja : P_L = 1 kN × 6 pekerja tiap gording = 6 kN

c. Beban Hujan

- Beban hujan : q_H = 0,255 . 33,096 . 7 = 59,076 kN

Kombinasi pembebanan terbesar

$N_u = 1,2\ q_D + 1,6\ P_L + 0,5\ q_H$

$= 1,2.\ 25,295 + 1,6.6 + 0,5.\ 59,076$

$= 69,492$ kN

$N_{u,x} = 69,492.\ \sin 20° = 23,768$ kN

4.2.3.2 Dimensi sagrod

$N_u \leq \phi\ N_n$

$N_u \leq 0,9\ .\ A_g\ .\ f_y$

$$A_g = \frac{N_{u.x}}{0.9.f_y} = \frac{23,768.10^3}{0,9.240} = 110,035\ \text{mm}^2$$

$A_g = \frac{1}{4}\pi D^2$

$110{,}035 = \frac{1}{4}\pi D^2$

$D = 11{,}836$ mm, diambil $D = 12$ mm

A_g profil $= \frac{1}{4}\pi 12^2 = 113{,}097\ mm^2 > 110{,}035\ mm^2$ - aman-

Berat sendiri $= 78{,}50 \cdot 113{,}097 \cdot 10^{-6}$

$= 0{,}00888$ kN/m < berat taksiran = 0,05 kN/m -aman-

4.3 Perencanaan Rangka Kuda – kuda

4.3.1 Perencanaan Pembebanan Kuda-Kuda K1

4.3.1.1 Beban mati

P_2" : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . 1,064 = 0,638 kN

P_2" = 0,936 kN

P_1 : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . 0,5 . 1,064 = 0,319 kN

P_1 = 0,617 kN

Berat total $P_1 = P_1 + ½ P_2$" = 0,617 + (1/2.0,936) = 1,085 kN

P_2 : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . 1,064 = 0,638 kN

P_2 = 0,936 kN

Berat total $P_2 = P_2 + P_2$" = 0,936 + 0,936 = 1,872 kN

P_3 : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . 0,5 . 1,490 = 0,447 kN

P_3 = 0,745 kN

P_4 : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . (0,745 + 0,718) = 0,878 kN

P_4 = 1,176 kN

P_5 : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . (0,718 + 0,532) = 0,750 kN

P_5 = 1,048 kN

Berat total $P_5 = P_5 + 1/2P_2'' = 1,048 + (1/2.0,936) = 1,516$ kN

P_6 : berat gording $= 0,0496 . 6 = 0,298$ kN

berat galvallum $= 0,1 . 6 . (0,532 + 0,532) = 0,638$ kN

$P_6 = 0,936$kN

Berat total $P_6 = P_6 + 1/2P_2'' = 0,936 + 1/2.0,936 = 1,404$ kN

P_7 : berat gording $= 0,0496 . 6 . 2 = 0,595$kN

berat galvallum $= 0,1 . 6 . 1,064 = 0,638$ kN

$P_7 = 1,233$kN

P_1' : berat catwalk = 0,880 kN

P_2' : berat catwalk = 0,870 kN

P_3' : berat vertikal bracing B + berat catwalk = 2,190 kN

P_4' : berat catwalk = 0,830 kN

P_5' : berat catwalk = 0,860 kN

P_6' : berat catwalk = 1,260 kN

P_7' : berat catwalk = 0,770 kN

P_8' : berat catwalk = 0,720 kN

P_9' : berat catwalk = 0,700 kN

P_{10}': berat catwalk = 1,150 kN

P_{11}' : berat vertikal bracing B = 2 . 0,66 = 1,320 kN

P_{12}': berat vertikal bracing B = 2 . 0,66 = 1,320 kN

P_{13}': berat vertikal bracing F = 2 . 0,62 = 1,240 kN

P_{14}': berat vertikal bracing F = 2 . 1,120 = 2,240 kN

P_{15}': berat vertikal bracing B = 2 . 0,66 = 1,320 kN

P_{16}': berat vertikal bracing B = 2 . 0,66 = 1,320 kN

4.3.1.2 Beban hidup

$P_1 - P_7$ = beban hidup = 1 kN

4.3.1.3 Beban angin

Muatan angin = 0,4 kN/m^2

Koefisien angin tekan (C_1) = (0,02 x α) – 0,4 – 0

Koefisien angin hisap (C_2) = -0,4

Wt = 0 x 0,4 = 0

Wh = -0,4 x 0,4 = -0,16 kN/m^2

a. Angin kiri

- Sisi kiri (angin tekan)

  $Wt_1 - Wt_7 = 0$

- Sisi kanan (angin hisap)

  Wh_1 = -0,16 . 0,5 .2,128 . 6 = -1,021 kN

  Whx_1 = 1,021 . sin 20° = 0,349 kN

  Why_1 = 1,021 . cos 20° = 0,959 kN

  Wh_2 = -0,16 . 2,128 . 6 = -2,043 kN

  Whx_2 = 2,043 . sin 20° = 0,699 kN

  Why_2 = 2,043 . cos 20° = 1,920 kN

  Wh_3 = -0,16 . 0,5 .1,490 . 6 = -0,715 kN

  Whx_3 = 0,715 . sin 20° = 0,245 kN

  Why_3 = 0,715 . cos 20° = 0,672 kN

Wh_4 = -0,16 . 1,463 . 6 = -1,404 kN

Whx_4 = 1,404 . sin 20° = 0,480 kN

Why_4 = 1,404 . cos 20° = 1,320 kN

Wh_5 = -0,16 . 1,782 . 6 = -1,711 kN

Whx_5 = 1,711 . sin 20° = 0,585 kN

Why_5 = 1,711 . cos 20° = 1,608 kN

Wh_6 = -0,16 . 1,596 . 6 = -1,532kN

Whx_6 = 1,532 . sin 20° = 0,524 kN

Why_6 = 1,532 . cos 20° = 1,440 kN

Wh_7 = -0,16 . 1,064 . 6 = -1,021kN

Whx_7 = 1,021 . sin 20° = 0,349 kN

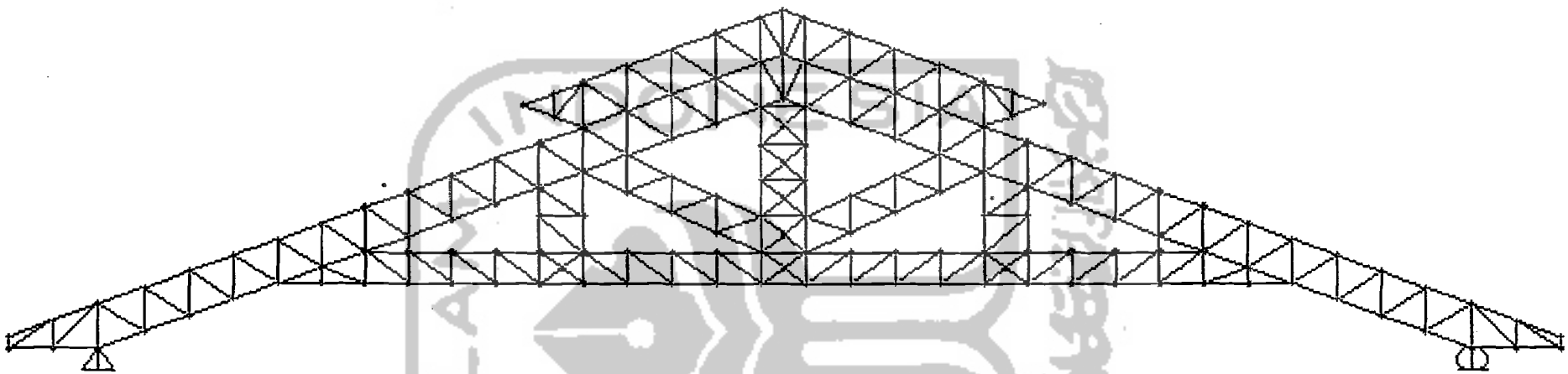
Why_7 = 1,021 . cos 20° = 1,960 kN

b. Angin kanan

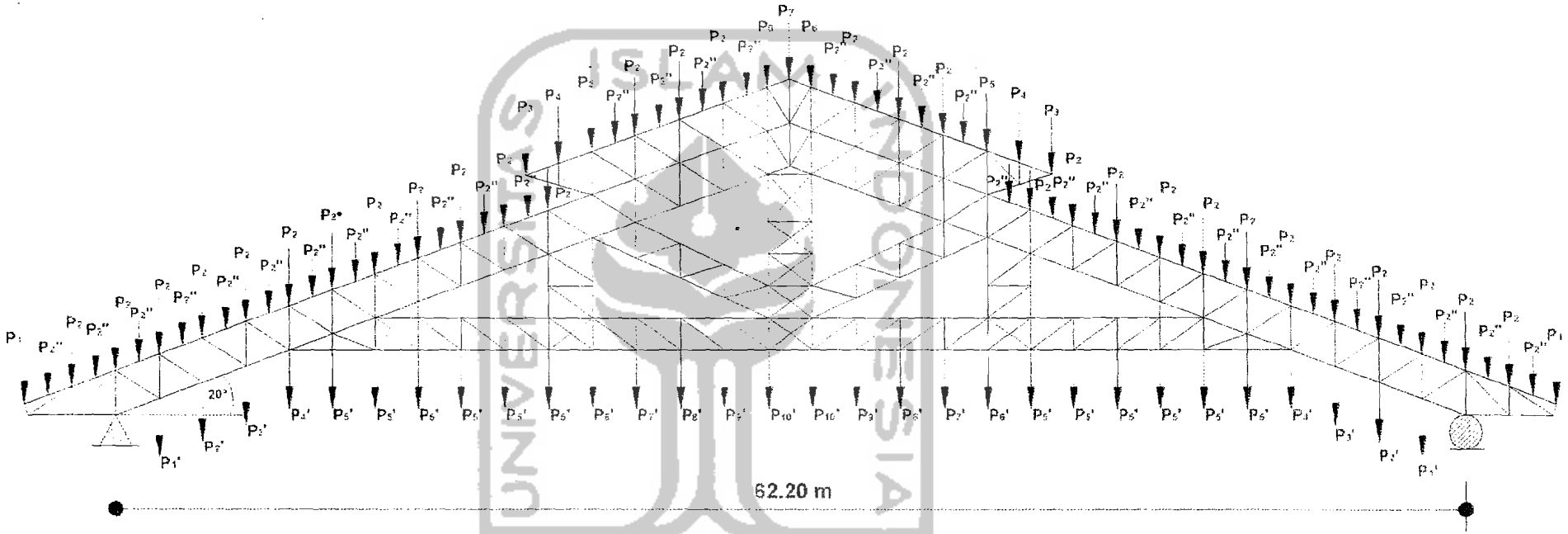
- Sisi kiri (angin hisap) = angin hisap pada beban angin kiri
- Sisi kanan (angin tekan)

$Wt_1 - Wt_7 = 0$

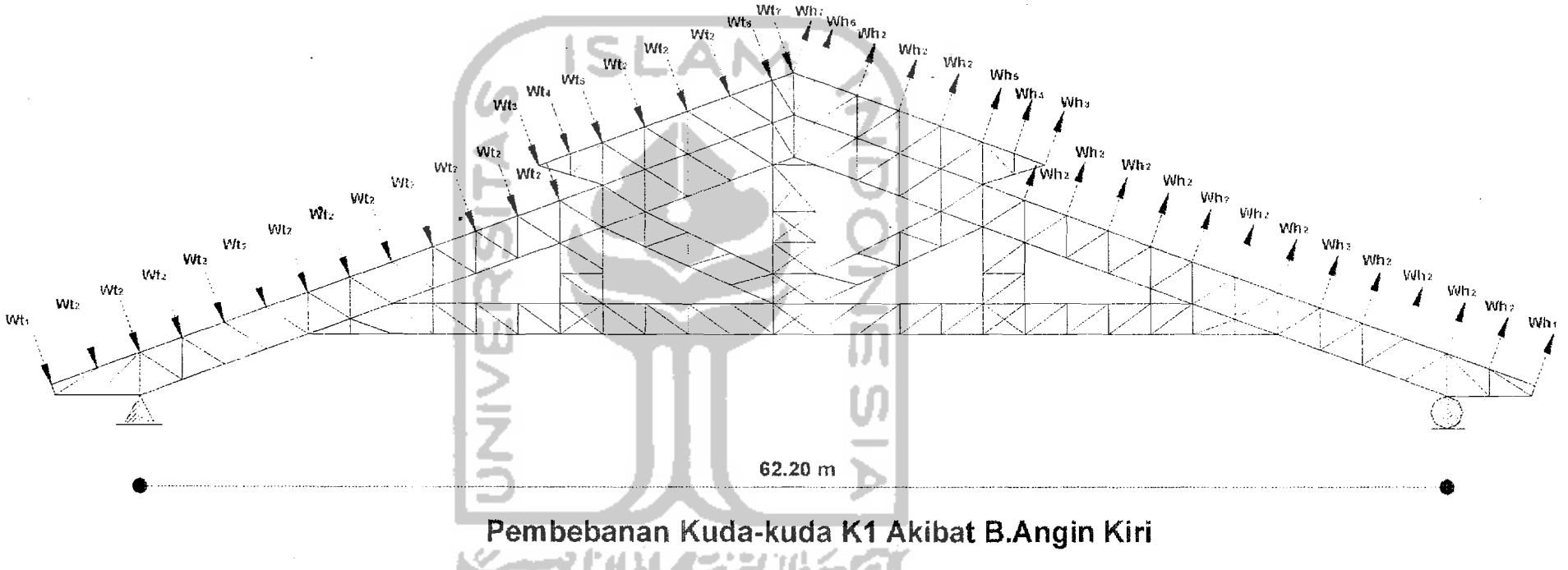
Gambar perencanaan kuda-kuda K1 disajikan dalam Gambar 4.6, Gambar 4.7, Gambar 4.8 dan Gambar 4.9.



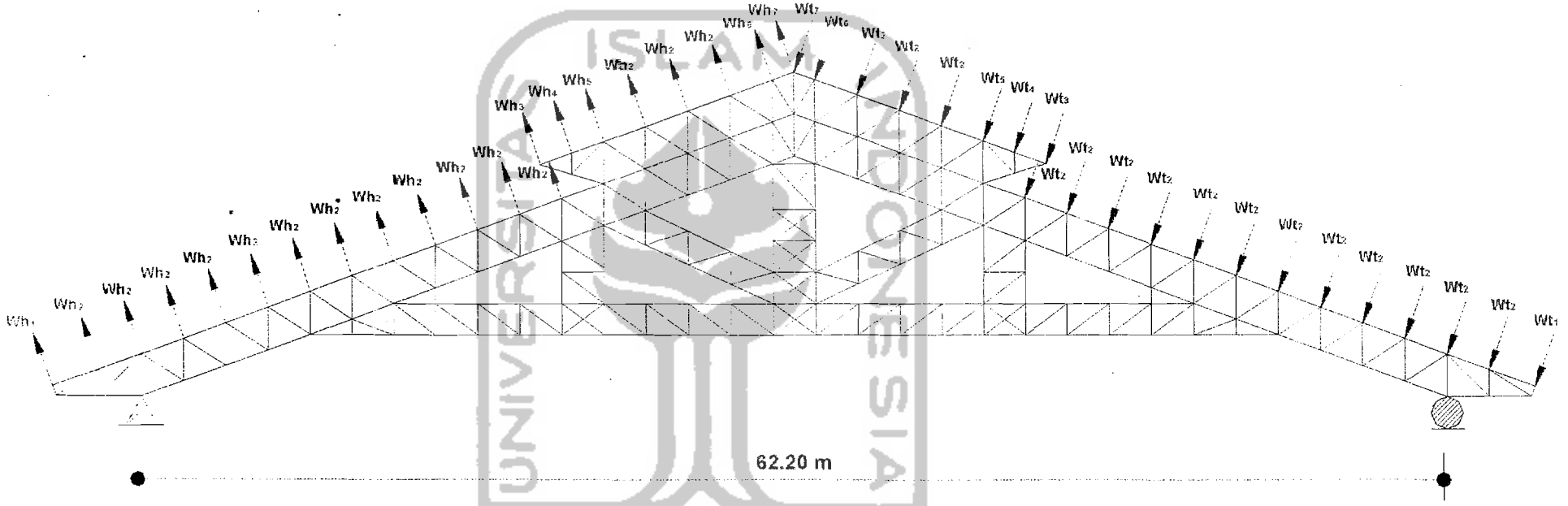
Gambar 4.6 Perencanaan Kuda-kuda K1



Gambar 4.7 Pembebanan Kuda-kuda K1 Akibat Beban Mati dan Beban Hidup



Gambar 4.8 Pembebanan Kuda-kuda K1 Akibat Beban Angin Kiri



Gambar 4.9 Pembebanan Kuda-kuda K1 Akibat Beban Angin Kanan

4.3.2 Perencanaan Pembebanan Kuda-Kuda K1"

4.3.2.1 Beban mati

P_2" : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . 1,064 = 0,638 kN

P_2" = 0,936 kN

P_1 : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . 0,5 . 1,064 = 0,319 kN

P_1 = 0,617 kN

Berat total $P_1 = P_1 + ½ P_2$" = 0,617 + (1/2.0,936) = 1,085 kN

P_2 : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . 1,064 = 0,638 kN

P_2 = 0,936 kN

Berat total $P_2 = P_2 + P_2$" = 0,936 + 0,936 = 1,872 kN

P_3 : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . 0,5 . 1,490 = 0,447 kN

P_3 = 0,745 kN

P_4 : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . (0,745 + 0,718) = 0,878 kN

P_4 = 1,176 kN

P_5 : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . (0,718 + 0,532) = 0,750 kN

P_5 = 1,048 kN

Berat total $P_5 = P_5 + 1/2P_2$" = 1,048 + (1/2.0,936) = 1,516 kN

P_2''' : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . 1,000 = 0,600 kN

P_2''' = 0,898 kN

P_6 : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . (0,532 + 0,500) = 0,619 kN

P_6 = 0,917 kN

Berat total $P_6 = P_6 + (1/2P_2'' + 1/2P_2''') = 0,917 + (1/2.0,936 + 1/2.0,898)$

= 1,834 kN

P_7 : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . (0,500 + 0,500) = 0,600 kN

P_7 = 0,898 kN

Berat total $P_7 = P_7 + 1/2P_2''' = 0,898 + (1/2.0,898) = 1,347$ kN

P_8 : berat gording = 0,0496 . 6 . 2 = 0,595 kN

berat galvallum = 0,1 . 6 . 1,000 = 0,600 kN

berat KP = 1,25 (0,5 . 3,090) = 1,931 kN

P_8 = 3,126 kN

P_1' : berat vertikal bracing B = 2 . 0,66 = 1,320 kN

P_2' : berat catwalk = 1,260 kN

P_3' : berat catwalk = 0,770 kN

P_4' : berat catwalk = 0,720 kN

P_5' : berat catwalk = 0,700 kN

P_6' : berat catwalk = 1,150 kN

P_7' : berat vertikal bracing B = 2 . 0,66 = 1,320 kN

P_8' : berat vertikal bracing B = 2 . 0,66 = 1,320 kN

P_9' : berat vertikal bracing F = 2 . 0,62 = 1,240 kN

P_{10}': berat vertikal bracing F = 2 . 1,120 = 2,240 kN

P_{11}' : berat vertikal bracing B = 2 . 0,66 = 1,320 kN

P_{12}': berat vertikal bracing B = 2 . 0,66 = 1,320 kN

4.3.2.2 Beban hidup

$P_1 - P_8$ = beban hidup = 1 kN

4.3.2.3 Beban angin

Muatan angin = 0,4 kN/m^2

Koefisien angin tekan (C_1) = (0,002 x α) – 0,4 = 0

Koefisien angin hisap (C_2) = -0,4

Wt = 0 x 0,4 = 0

Wh = -0,4 x 0,4 = -0,16 kN/m^2

a. Angin kiri

- Sisi kiri (angin tekan)

  $Wt_1 - Wt_6 = 0$

- Sisi kanan (angin hisap)

  Wh_1 = -0,16 . 0,5 .2,128 . 6 = -1,021 kN

  Whx_1 = 1,021 . sin 20° = 0,349 kN

  Why_1 = 1,021 . cos 20° = 0,959 kN

  Wh_2 = -0,16 . 2,128 . 6 = -2,043 kN

$Whx_2 = 2{,}043 \cdot \sin 20° = 0{,}699$ kN

$Why_2 = 2{,}043 \cdot \cos 20° = 1{,}920$ kN

$Wh_3 = -0{,}16 \cdot 0{,}5 \cdot 1{,}490 \cdot 6 = -0{,}715$ kN

$Whx_3 = 0{,}715 \cdot \sin 20° = 0{,}245$ kN

$Why_3 = 0{,}715 \cdot \cos 20° = 0{,}672$ kN

$Wh_4 = -0{,}16 \cdot 1{,}463 \cdot 6 = -1{,}404$ kN

$Whx_4 = 1{,}404 \cdot \sin 20° = 0{,}480$ kN

$Why_4 = 1{,}404 \cdot \cos 20° = 1{,}320$ kN

$Wh_5 = -0{,}16 \cdot 1{,}782 \cdot 6 = -1{,}711$ kN

$Whx_5 = 1{,}711 \cdot \sin 20° = 0{,}585$ kN

$Why_5 = 1{,}711 \cdot \cos 20° = 1{,}608$ kN

$Wh_6 = -0{,}16 \cdot 2{,}064 \cdot 6 = -1{,}981$ kN

$Whx_6 = 1{,}981 \cdot \sin 20° = 0{,}677$ kN

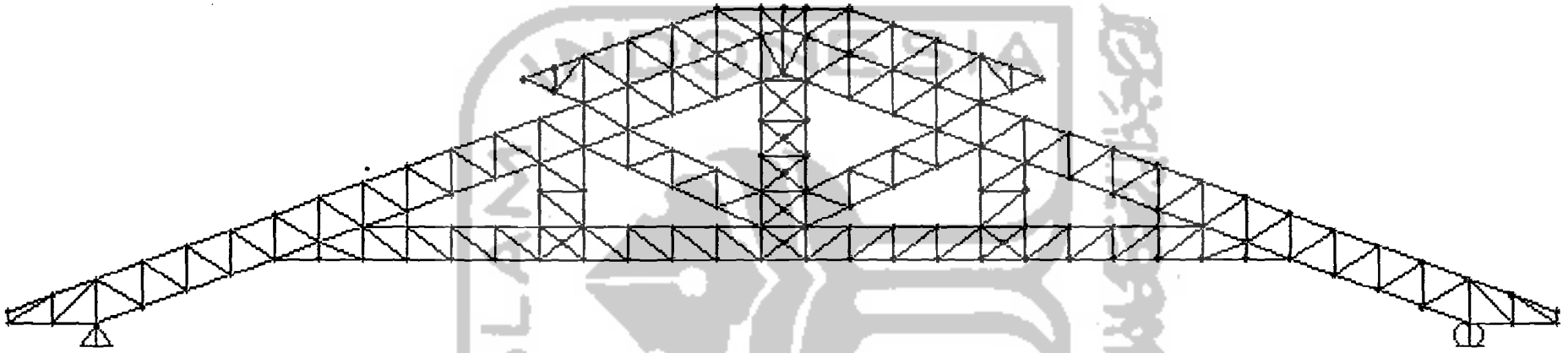
$Why_6 = 1{,}981 \cdot \cos 20° = 1{,}862$ kN

b. Angin kanan

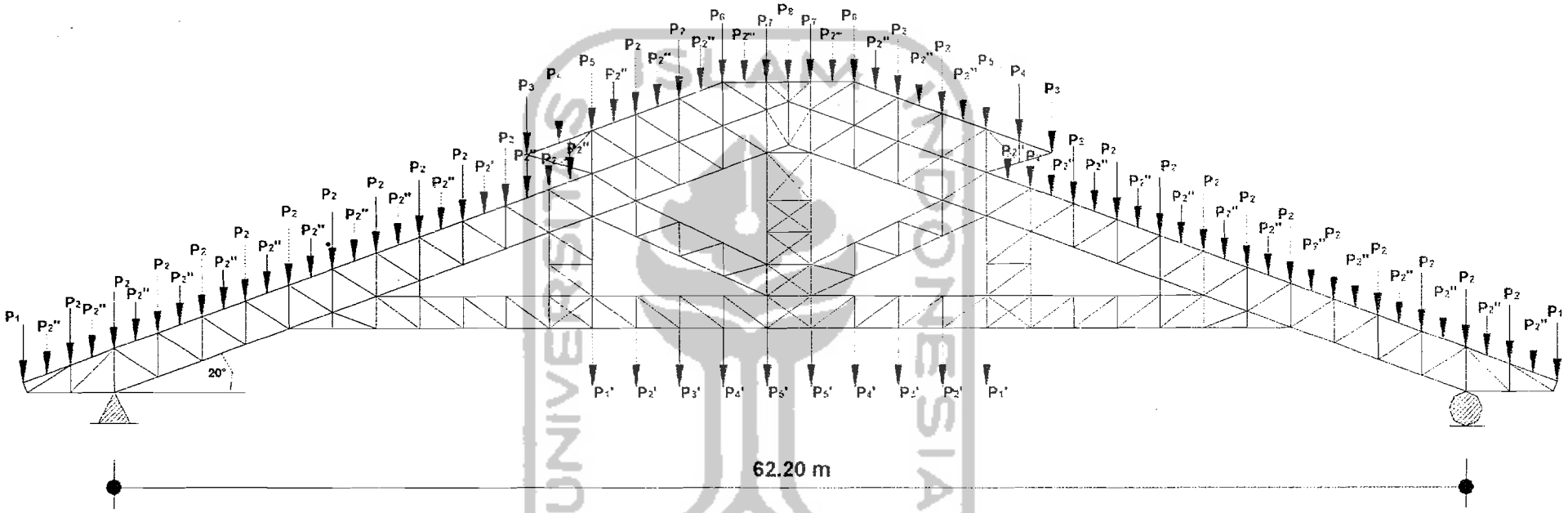
- Sisi kiri (angin hisap) = angin hisap pada beban angin kiri
- Sisi kanan (angin tekan)

$Wt_1 - Wt_6 = 0$

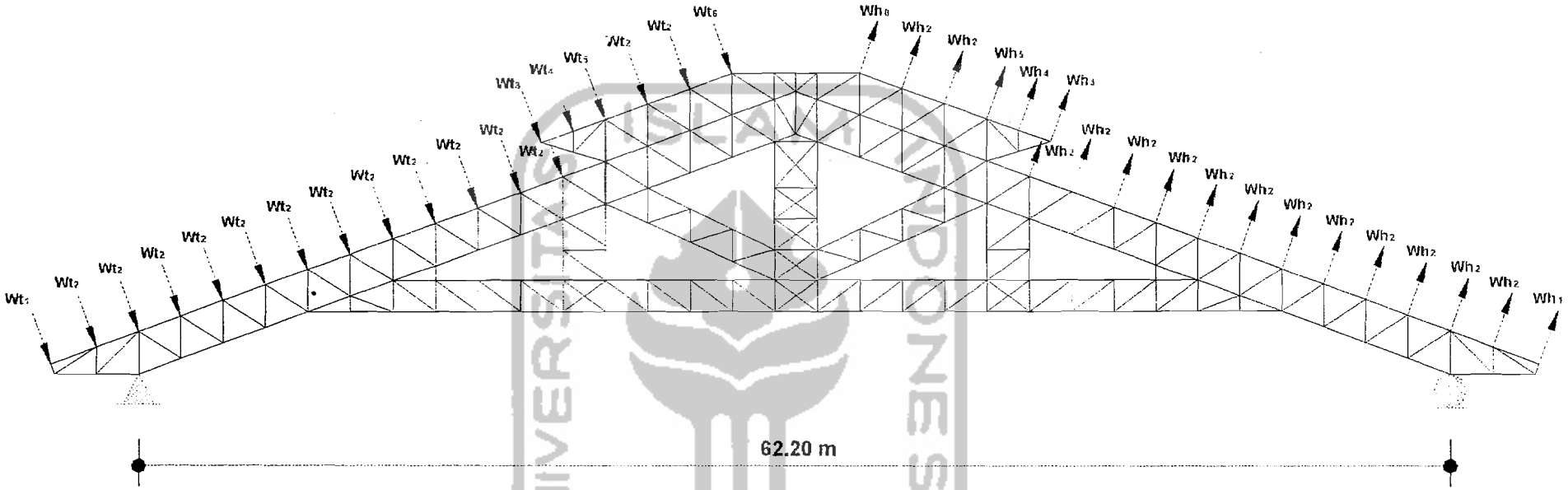
Gambar perencanaan kuda-kuda K1" disajikan dalam Gambar 4.10, Gambar 4.11, Gambar 4.12 dan Gambar 4.13.



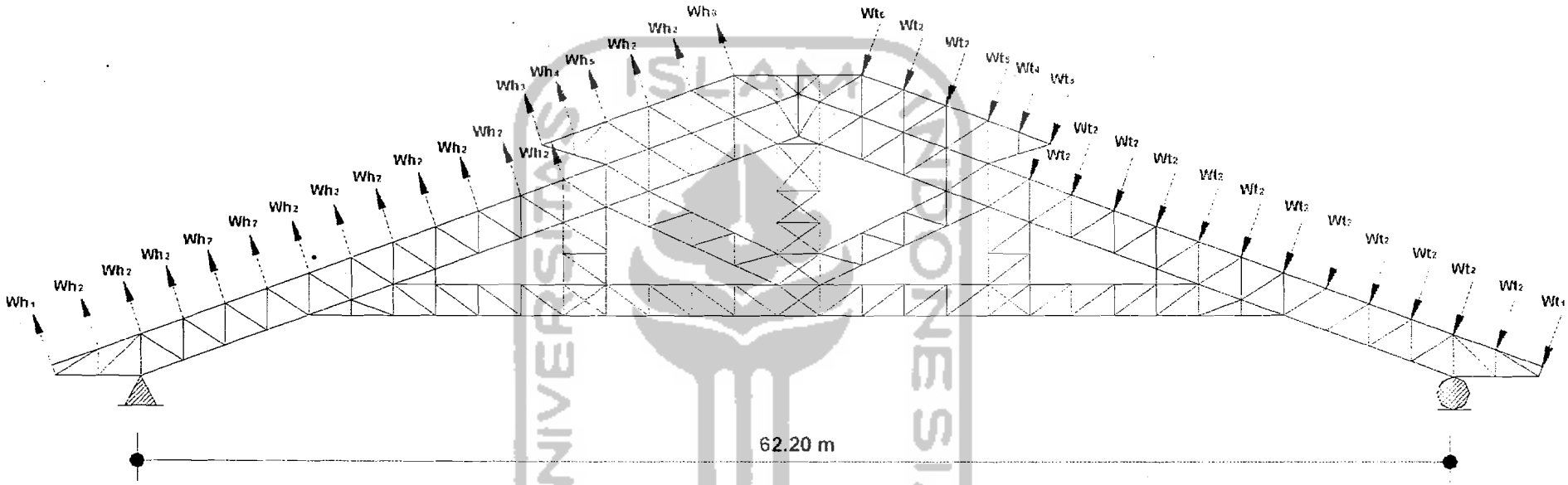
Gambar 4.10 Perencanaan Kuda-kuda K''



Gambar 4.11 Pembebanan Kuda-kuda K1'' Akibat Beban Mati dan Beban Hidup



Gambar 4.12 Pembebanan Kuda-kuda K1'' Akibat Beban Angin Kiri



Gambar 4.13 Pembebanan Kuda-kuda K1'' Akibat Beban Angin Kanan

4.3.3 Perencanaan Pembebanan Kuda-Kuda K2

4.3.3.1 Beban mati

P_2" : berat gording = 0,0676 . 7 = 0,473 kN

berat galvallum = 0,1 . 7 . 1,064 = 0,745 kN

P_2" = 1,218 kN

P_1 : berat gording = 0,0676 . 7 = 0,473 kN

berat galvallum = 0,1 . 7 . 0,5 . 1,064 = 0,372 kN

P_1 = 0,845 kN

Berat total $P_1 = P_1 + ½ P_2$" = 0,845 + (1/2.1,218) = 1,454 kN

P_2 : berat gording = 0,0676 . 7 = 0,473 kN

berat galvallum = 0,1 . 7. 1,064 = 0,745 kN

P_2 = 1,218 kN

Berat total $P_2 = P_2 + P_2$" = 1,218 + 1,218 = 2,436 kN

P_3 : berat gording = 0,0676 . 7 = 0,473 kN

beret galvallum = 0,1 . 7 . (0,532 + 1) = 1,072 kN

½ PK_7 = ½.1,333 = 0,667 kN

berat jurai = 2,270 kN

P_3 = 4,482 kN

P_2"': berat gording = 0,0676 . 7 = 0,473 kN

berat galvallum = 0,1 . 7 . 1 = 0,700 kN

P_2"' = 1,173 kN

Berat total $P_3 = P_1 + ½ P_2$"' = 4,482 + (1/2.1,173) = 5,068 kN

P_4 : berat gording = 0,0676 . 7 = 0,473 kN

berat galvallum = 0,1 . 7 . 1 = 0,700 kN

P_4 = 1,173 kN

Berat total $P_4 = P_4 + P_2''' = 1,173 + 1,173 = 2,346$ kN

P_5 : berat gording = 0,0676 . 7 = 0,473 kN

berat galvallum = 0,1 .7. 1 = 0,700 kN

PK_8 = 1,673 kN

P_5 = 2,846 kN

Berat total $P_5 = P_5 + P_2''' = 2,846 + 1,173 = 4,019$ kN

P_1' : berat catwalk = 1,260 kN

P_2' : berat vertikal bracing B = 0,66 kN

P_3' : berat vertikal bracing B = 0,66 kN

P_4' : berat vertikal bracing B = 0,66 kN

P_5' : berat vertikal bracing B+ A = 0,62 + 0,74 = 1,360 kN

4.3.3.2 Beban hidup

$P_1 - P_5$ = beban hidup = 1 kN

4.3.3.3 Beban angin

a. Angin kiri

- Sisi kiri (angin tekan)

  $Wt_1 - Wt_5 = 0$

- Sisi kanan (angin hisap)

  $Wh_1 = -0,16 . 0,5 .2,128 . 7 = -1,192$ kN

$Whx_1 = 1{,}192 \cdot \sin 20° = 0{,}408$ kN

$Why_1 = 1{,}192 \cdot \cos 20° = 1{,}120$ kN

$Wh_2 = -0{,}16 \cdot 2{,}128 \cdot 7 = -2{,}383$ kN

$Whx_2 = 2{,}383 \cdot \sin 20° = 0{,}815$ kN

$Why_2 = 2{,}383 \cdot \cos 20° = 2{,}240$ kN

$Wh_3 = -0{,}16 \cdot 0{,}5 \cdot 2{,}128 \cdot 7 = -1{,}192$ kN

$Whx_3 = 1{,}192 \cdot \sin 20° = 0{,}408$ kN

$Why_3 = 1{,}192 \cdot \cos 20° = 1{,}120$ kN

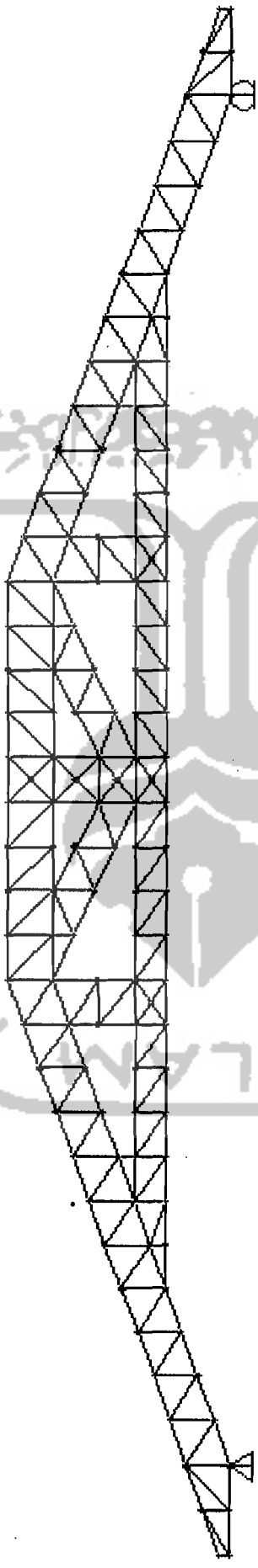
$Wh_4 = Wh_5 = 0$

b. Angin kanan

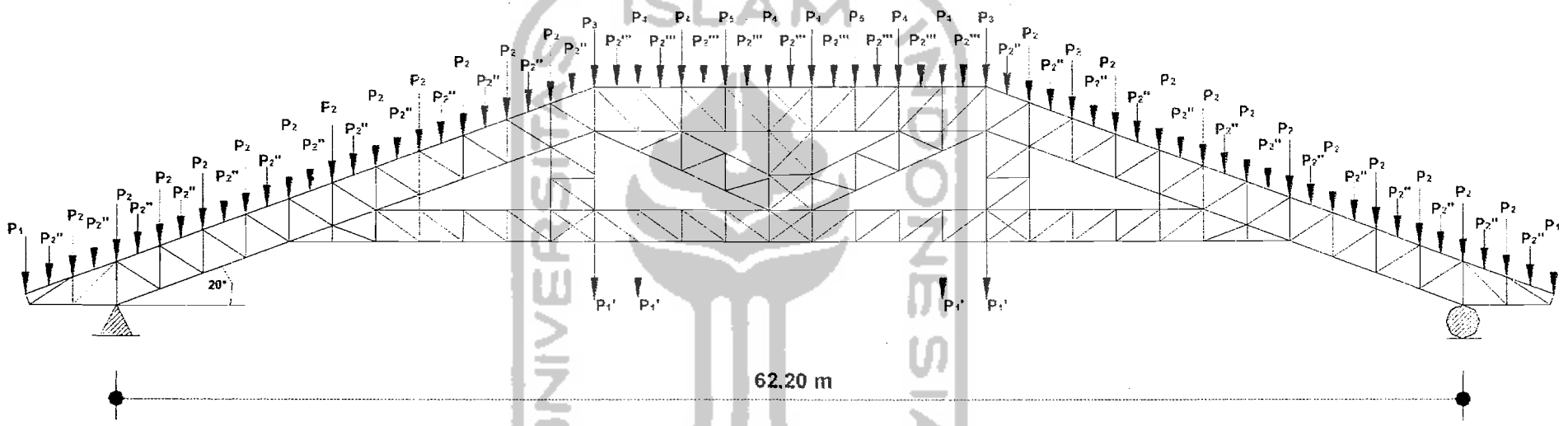
- Sisi kiri (angin hisap) = angin hisap pada beban angin kiri
- Sisi kanan (angin tekan)

$Wt_1 - Wt_5 = 0$

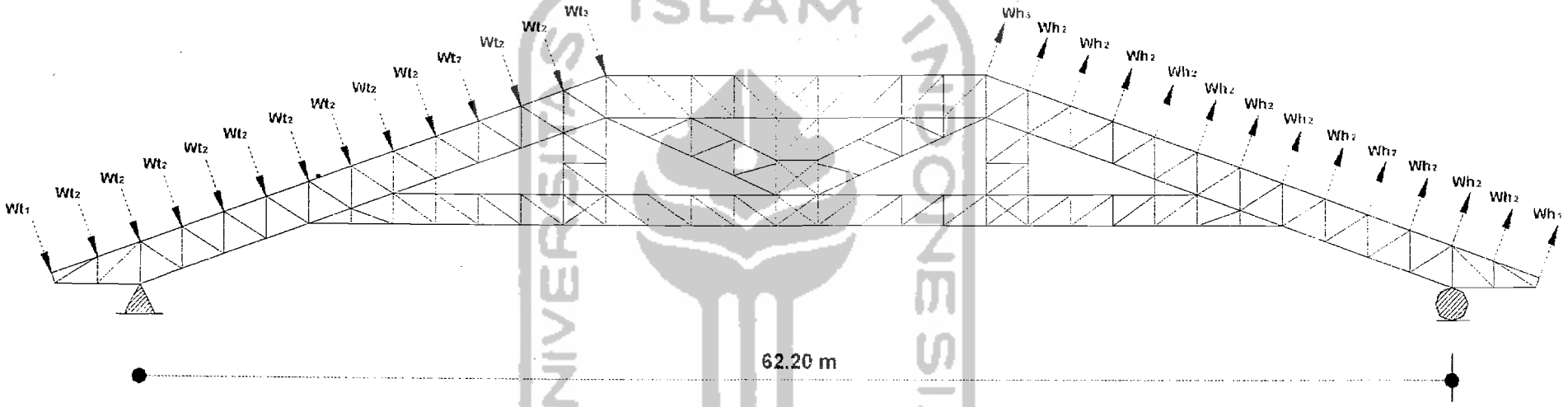
Gambar perencanaan kuda-kuda K2 disajikan dalam Gambar 4.14, Gambar 4.15, Gambar 4.16 dan Gambar 4.17.



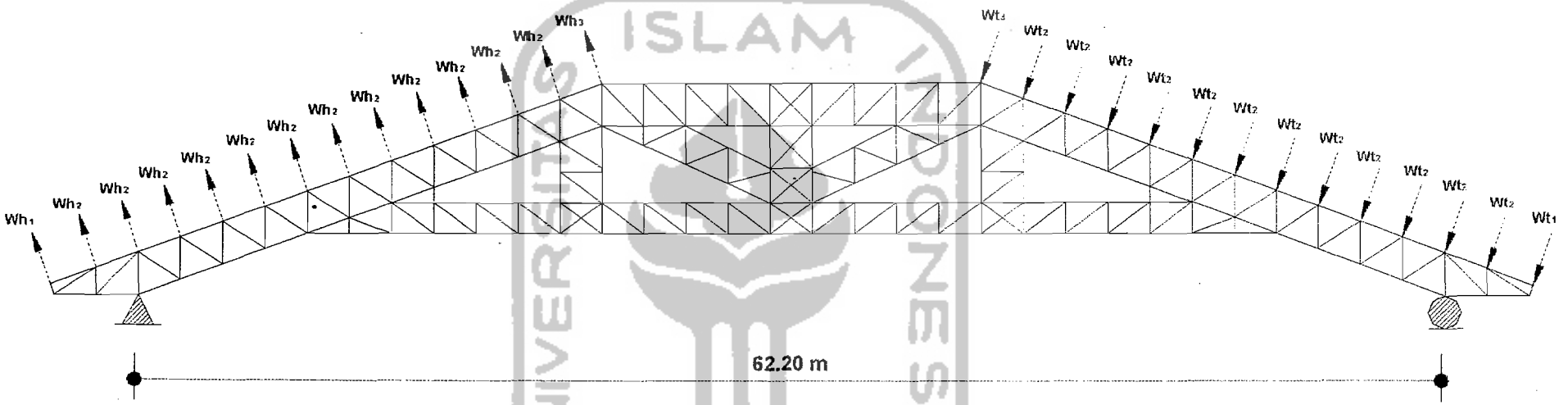
Gambar 4.14 Perencanaan Kuda-kuda K2



Gambar 4.15 Pembebanan Kuda-kuda K2 Akibat Beban Mati dan Beban Hidup



Gambar 4.16 Pembebanan Kuda-kuda K2 Akibat Beban Angin Kiri



Pembebanan Kuda-kuda K2 Akibat B.Angin Kanan

Gambar 4.17 Pembebanan Kuda-kuda K2 Akibat Beban Angin Kanan

4.3.4 Perencanaan Pembebanan Kuda-Kuda K3

4.3.4.1 Beban mati

P_a : berat gording = 0,0676 . 7 = 0,473 kN

berat galvallum = 0,1 . 7 . 1,064 = 0,745 kN

P_a = 1,218 kN

P_1 : berat gording = 0,0676 . 7 = 0,473 kN

berat galvallum = 0,1 . 7 . 0,5 . 1,064 = 0,372 kN

P_1 = 0,845 kN

Berat total $P_1 = P_1 + ½ P_a = 0,845 + (1/2.1,218) = 1,454$ kN

P_2 : berat gording = 0,0676 . 7 = 0,473 kN

berat galvallum = 0,1 . 7. 1,064 = 0,745 kN

P_2 = 1,218 kN

Berat total $P_2 = P_2 + P_a = 1,218 + 1,218 = 2,436$ kN

P_3 : berat gording = 0,0676 . 7 = 0,473 kN

berat galvallum = 0,1 . 7 . (0,787 + 0,532) = 0,932 kN

P_3 = 1,396 kN

Berat total $P_3 = P_1 + ½ P_a' = 1,396 + (1/2.1,218) = 2,005$ kN

P_4 : berat gording = 0,0676 . 7 = 0,473 kN

berat galvallum = 0,1 . 7 (0,787 + 0,557) = 0,941 kN

P_4 = 1,414 kN

P_b : berat gording = 0,0676 . 7 = 0,473 kN

berat galvallum = 0,1 . 7 . 1,113 = 0,779 kN

P_b = 1,252 kN

Berat total $P_4 = P_4 + ½.P_b = 1,414 + ½.1,252 = 2,040$ kN

P_5 : berat gording $= 0,0676 . 7 = 0,473$ kN

berat galvallum $= 0,1 .7. (0,557 + 0,515) = 0,750$ kN

$P_5 = 1,223$ kN

P_c : berat gording $= 0,0676 . 7 = 0,473$ kN

berat galvallum $= 0,1 . 7 . 1,031 = 0,722$ kN

$P_c = 1,195$ kN

Berat total $P_5 = P_5 + (1/2.P_b + 1/2.P_c) = 1,223 + (1/2.1,252 + ½.1,195) = 2,447$ kN

P_6 : berat gording $= 0,0676 . 7 = 0,473$ kN

berat galvallum $= 0,1 . 7 . 1,031 = 0,721$ kN

$P_6 = 1,194$ kN

Berat total $P_6 = P_6 + P_c = 1,194 + 1,195 = 2,390$ kN

P_7 : berat gording $= 0,0676 . 7 = 0,473$ kN

berat galvallum $= 0,1 . 7 (0,515 + 0,590) = 0,774$ kN

$P_7 = 1,247$ kN

P_d : berat gording $= 0,0676 . 7 = 0,473$ kN

berat galvallum $= 0,1 . 7 . 1,180 = 0,826$ kN

$P_d = 1,299$ kN

Berat total $P_7 = P_7 + (1/2.P_c + 1/2.P_d) = 1,247 + (1/2.1,195 + ½.1,299) = 2,494$ kN

P_8 : berat gording $= 0,0676 . 7 = 0,473$ kN

berat galvallum $= 0,1 . 7 (0,59 + 0,50) = 0,763$ kN

$P_8 = 1,236$ kN

P_c : berat gording $= 0,0676 . 7 = 0,473$ kN

berat galvallum = 0,1 . 7 . 1, = 0,700 kN

P_e = 1,173 kN

Berat total $P_8 = P_8 + (1/2.P_d + 1/2.P_e) = 1,236 + (1/2.1,299 + ½.1,173) = 2,472$ kN

P_9 : berat gording = 0,0676 . 7 = 0,473 kN

berat galvallum = 0,1 . 7 1 = 0,700 kN

P_9 = 1,173 kN

Berat total $P_9 = P_9 + P_e = 1,173 + 1,173 = 2,346$ kN

P_1' : berat catwalk = 1,260 kN

P_2' : berat vertikal bracing A = 0,740 kN

4.3.4.2 Beban hidup

$P_1 - P_9$ = beban hidup = 1 kN

4.3.4.3 Beban angin

Muatan angin = 0,4 kN/m^2

Koefisien angin tekan $(C_1)_a = (0,02 \times \alpha) - 0,4 = 0$

$= (0,02 \times 20°) - 0,4 = 0$

$(C_1)_b = (0,02 \times \alpha) - 0,4 = 0$

$= (0,02 \times 14°) - 0,4 = -0,12$

Koefisien angin hisap $(C_2) = -0,4$

$Wt_a = 0 \times 0,4 = 0$

$Wt_b = -0,12 \times 0,4 = -0,048$ kN/m^2

$Wh = -0,4 \times 0,4 = -0,16$ kN/m^2

a. Angin kiri

- Sisi kiri (angin tekan)

$Wt_1 - Wt_3 = 0$

$Wt_4 = -0,048 \cdot 0,5 \cdot 2,226 \cdot 7 = -0,374$ kN

$Wtx_4 = 0,374 \cdot \sin 14° = 0,090$ kN

$Wty_4 = 0,374 \cdot \cos 14° = 0,363$ kN

$Wt_5 = -0,048 \cdot (1,113 + 1,031) \cdot 7 = -0,720$ kN

$Wtx_5 = 0,720 \cdot \sin 14° = 0,174$ kN

$Wty_5 = 0,720 \cdot \cos 14° = 0,699$ kN

$Wt_6 = -0,048 \cdot 2,061 \cdot 7 = -0,692$ kN

$Wtx_6 = 0,692 \cdot \sin 14° = 0,168$ kN

$Wty_6 = 0,692 \cdot \cos 14° = 0,672$ kN

$Wt_7 = -0,048 \cdot 0,5 \cdot 2,061 \cdot 7 = -0,346$ kN

$Wtx_7 = 0,346 \cdot \sin 14° = 0,084$ kN

$Wty_7 = 0,346 \cdot \cos 14° = 0,336$ kN

$Wty_8 = Wty_9 = 0$

- Sisi kanan (angin hisap)

$Wh_1 = -0,16 \cdot 0,5 \cdot 2,128 \cdot 7 = -1,192$ kN

$Whx_1 = 1,192 \cdot \sin 20° = 0,408$ kN

$Why_1 = 1,192 \cdot \cos 20° = 1,120$ kN

$Wh_2 = -0,16 \cdot 2,128 \cdot 7 = -2,383$ kN

$Whx_2 = 2,383 \cdot \sin 20° = 0,815$ kN

$Why_2 = 2{,}383 \cdot \cos 20° = 2{,}240$ kN

$Wh_3 = -0{,}16 \cdot (1{,}064 + 0{,}787) \cdot 7 = -2{,}073$ kN

$Whx_3 = 2{,}073 \cdot \sin 20° = 0{,}709$ kN

$Why_3 = 2{,}073 \cdot \cos 20° = 1{,}948$ kN

$Wh_4 = -0{,}16 \cdot (0{,}787 + 1{,}113) \cdot 7 = -2{,}128$ kN

$Whx_4 = 2{,}128 \cdot \sin 14° = 0{,}515$ kN

$Why_4 = 2{,}128 \cdot \cos 14° = 2{,}065$ kN

$Wh_5 = -0{,}16 \cdot (1{,}113 + 1{,}031) \cdot 7 = -2{,}401$ kN

$Whx_5 = 2{,}401 \cdot \sin 14° = 0{,}581$ kN

$Why_5 = 2{,}401 \cdot \cos 14° = 2{,}329$kN

$Wh_6 = -0{,}16 \cdot 2{,}061 \cdot 7 = -2{,}308$ kN

$Whx_6 = 2{,}308 \cdot \sin 14° = 0{,}558$ kN

$Why_6 = 2{,}308 \cdot \cos 14° = 1{,}948$ kN

$Wh_7 = -0{,}16 \cdot 0{,}5 \cdot 2{,}061 \cdot 7 = -1{,}154$ kN

$Whx_7 = 1{,}154 \cdot \sin 14° = 0{,}279$kN

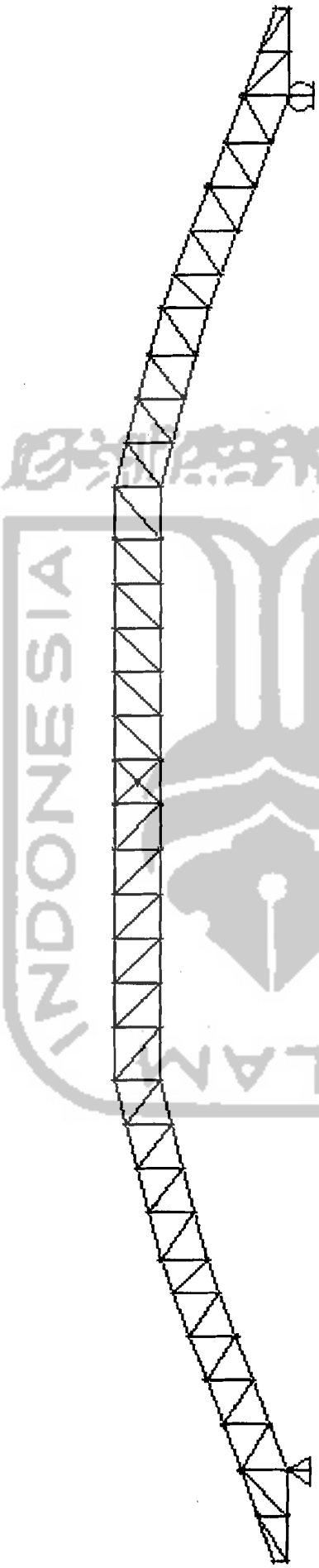
$Why_7 = 1{,}154 \cdot \cos 14° = 1{,}120$ kN

$Wh_8 = Wh_9 = 0$

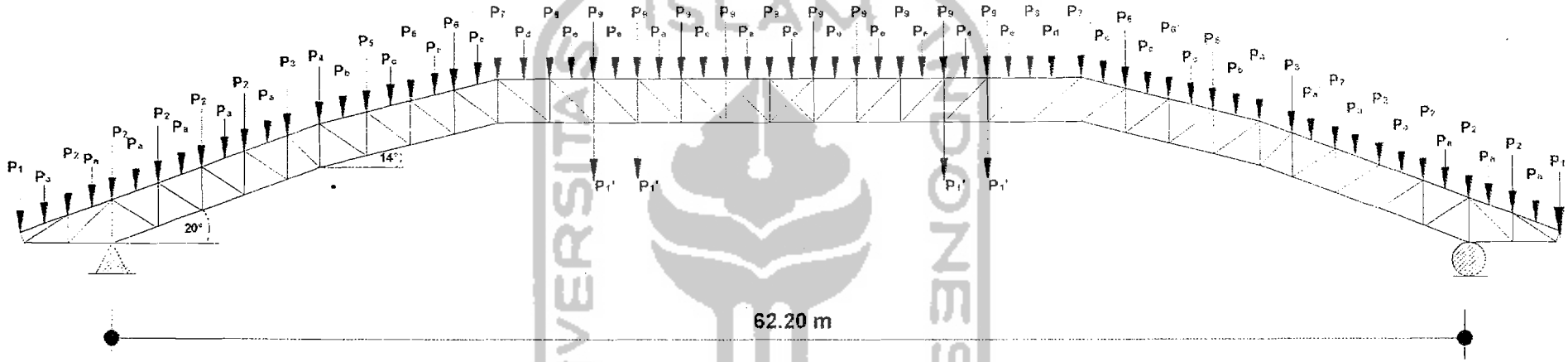
b. Angin kanan

- Sisi kiri (angin hisap) = angin hisap pada beban angin kiri
- Sisi kanan (angin tekan) = angin tekan pada beban angin kiri

Gambar perencanaan kuda-kuda K3 disajikan dalam Gambar 4.18, Gambar 4.19, Gambar 4.20 dan Gambar 4.21.

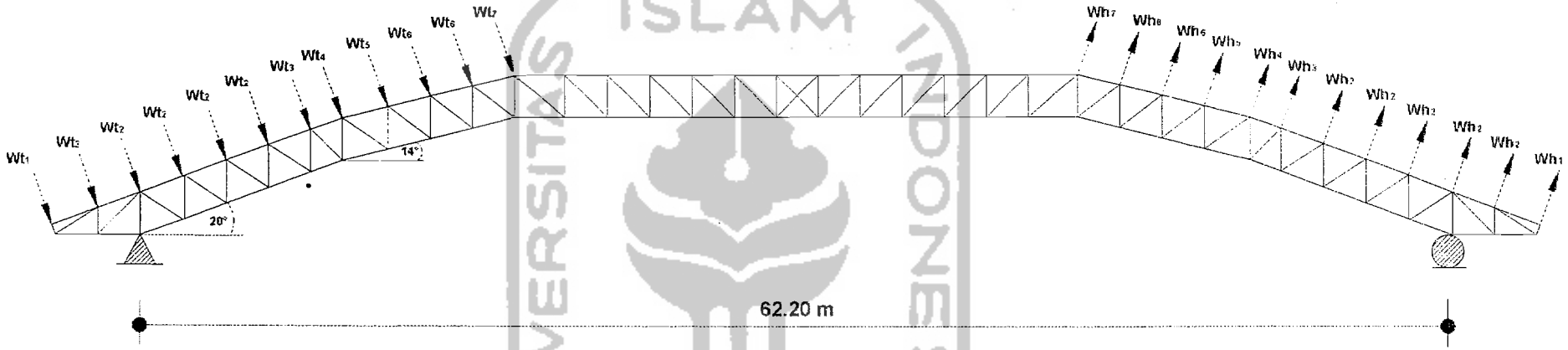


Gambar 4.18 Perencanaan Kuda-kuda K3



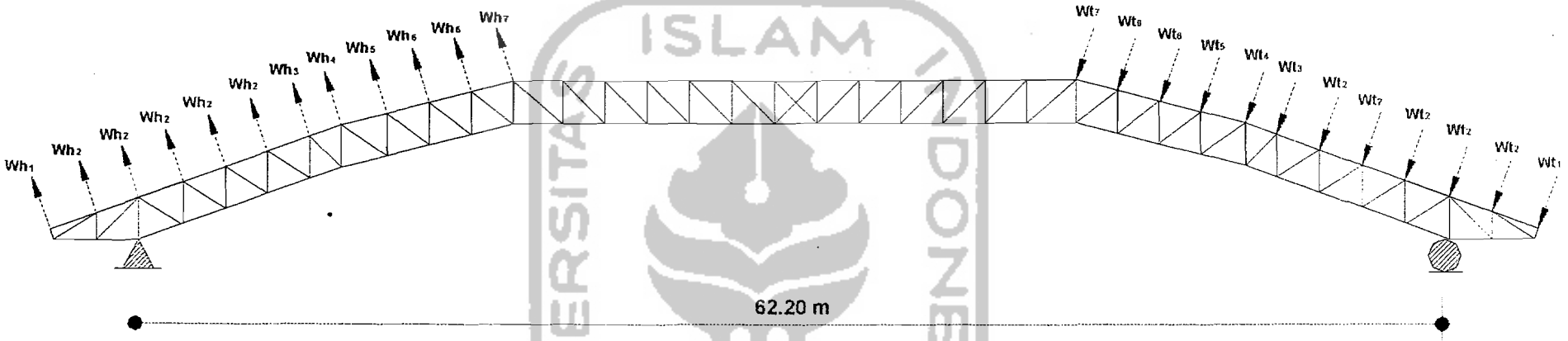
Pembebanan Kuda-kuda K3 Akibat B.Mati dan B.Hidup

Gambar 4.19 Pembebanan Kuda-kuda K3 Akibat Beban Mati dan Beban Hidup



Pembebanan Kuda-kuda K3 Akibat B.Angin Kiri

Gambar 4.20 Pembebanan Kuda-kuda K3 Akibat Beban Angin Kiri



Gambar 4.21 Pembebanan Kuda-kuda K3 Akibat Beban Angin Kanan

4.3.5 Perencanaan Pembebanan Kuda-Kuda K4

4.3.5.1 Beban mati

P_a : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . 1,064 = 0,638 kN

P_a = 0,936 kN

P_1 : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . 0,5 . 1,064 = 0,319 kN

P_1 = 0,617 kN

Berat total $P_1 = P_1 + ½ P_a = 0,617 + (1/2.0,936) = 1,085$ kN

P_2 : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6. 1,064 = 0,638 kN

P_2 = 0,936 kN

Berat total $P_2 = P_2 + P_a = 0,936 + 0,936 = 1,872$ kN

P_3 : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . (0,532 + 0,515) = 0,628 kN

P_3 = 0,926 kN

P_b: berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . 1,031 = 0,638 kN

P_b = 0,917 kN

Berat total $P_3 = P_1 + ½ (P_a + P_b) = 0,926 + ½(0,936 + 0,917) = 1,853$ kN

P_4 : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . 1,031 = 0,619 kN

P_4 = 0,917 kN

Berat total $P_4 = P_4 + P_b = 0,917 + 0,917 = 1,834$ kN

P_c : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 .6. 1 = 0,600 kN

P_c = 0,898 kN

P_5 : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 .6. (0,515 + 0,500) = 0,609 kN

P_5 = 0,907 kN

Berat total $P_5 = P_5 + ½(P_b + P_c) = 0,907 + ½(0,917 + 0,898) = 1,815$ kN

P_6 : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . 1 = 0,600 kN

P_6 = 0,898 kN

Berat total $P_6 = P_6 + P_c = 0,898 + 0,898 = 1,796$ kN

4.3.5.2 Beban hidup

$P_1 - P_6$ = beban hidup = 1 kN

4.3.5.3 Beban angin

Muatan angin = 0,4 kN/m^2

Koefisien angin tekan $(C_1)_a = (0,02 \times \alpha) - 0,4 = 0$

$= (0,02 \times 20°) - 0,4 = 0$

$(C_1)_b = (0,02 \times \alpha) - 0,4 = 0$

$= (0,02 \times 14°) - 0,4 = -0,12$

Koefisien angin hisap $(C_2) = -0,4$

$Wt_a = 0 \times 0,4 = 0$

$Wt_b = -0,12 \times 0,4 = -0,048\ kN/m^2$

$Wh = -0,4 \times 0,4 = -0,16\ kN/m^2$

a. Angin kiri

- Sisi kiri (angin tekan)

$Wt_1 - Wt_2 = 0$

$Wt_3 = -0,048 . 0,5 . 2,061 . 6 = -0,297\ kN$

$Wtx_3 = 0,297 . \sin 14° = 0,0718\ kN$

$Wty_3 = 0,297 . \cos 14° = 0,288\ kN$

$Wt_4 = -0,048 . 2,061 . 6 = -0,594\ kN$

$Wtx_4 = 0,594 . \sin 14° = 0,144\ kN$

$Wty_4 = 0,594 . \cos 14° = 0,576\ kN$

$Wt_5 = -0,048 . 0,5 . 2,061 . 6 = -0,297\ kN$

$Wtx_5 = 0,297 . \sin 14° = 0,0718\ kN$

$Wty_5 = 0,297 . \cos 14° = 0,288\ kN$

- Sisi kanan (angin hisap)

$Wh_1 = -0,16 . 0,5 . 2,128 . 6 = -1,021\ kN$

$Whx_1 = 1,021 . \sin 20° = 0,349\ kN$

$Why_1 = 1,021 . \cos 20° = 0,959\ kN$

$Wh_2 = -0,16 . 2,128 . 6 = -2,043\ kN$

$Whx_2 = 2,043 . \sin 20° = 0,699\ kN$

$Why_2 = 2,043 . \cos 20° = 1,920\ kN$

Wh_3 = -0,16 . (0,532 + 0,515) . 6 = -1,005 kN

Whx_3 = 1,005 . sin 20° = 0,344 kN

Why_3 = 1,005 . cos 20° = 0,944 kN

Wh_4 = -0,16 . 2,061 . 6 = -1,978 kN

Whx_4 = 1,978 . sin 14° = 0,479 kN

Why_4 = 1,978 . cos 14° = 1,920 kN

Wh_5 = -0,16 . 0,5 . 2,061 . 6 = -0,989 kN

Whx_5 = 0,989 . sin 14° = 0,239 kN

Why_5 = 0,989 . cos 14° = 0,960 kN

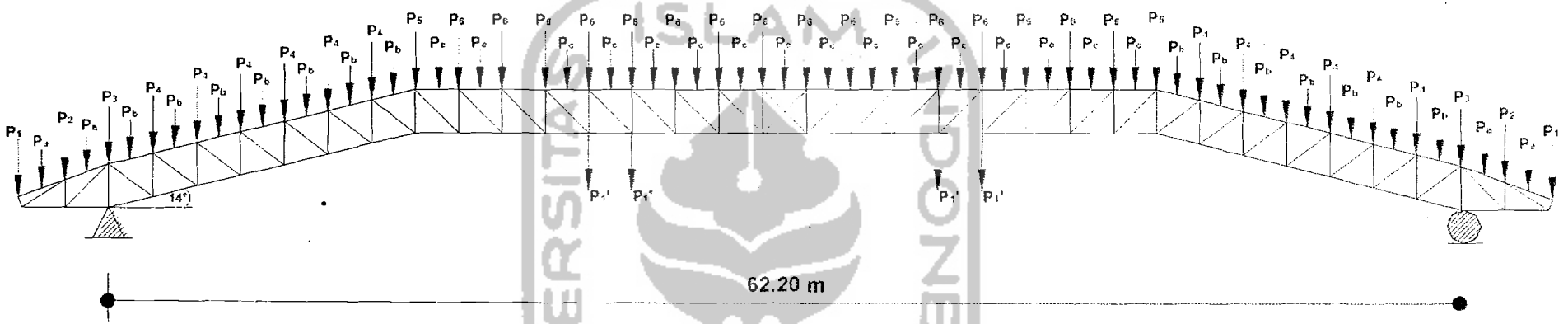
Wh_6 = 0

b. Angin kanan

- Sisi kiri (angin hisap) = angin hisap pada beban angin kiri
- Sisi kanan (angin tekan) = angin tekan pada beban angin kiri

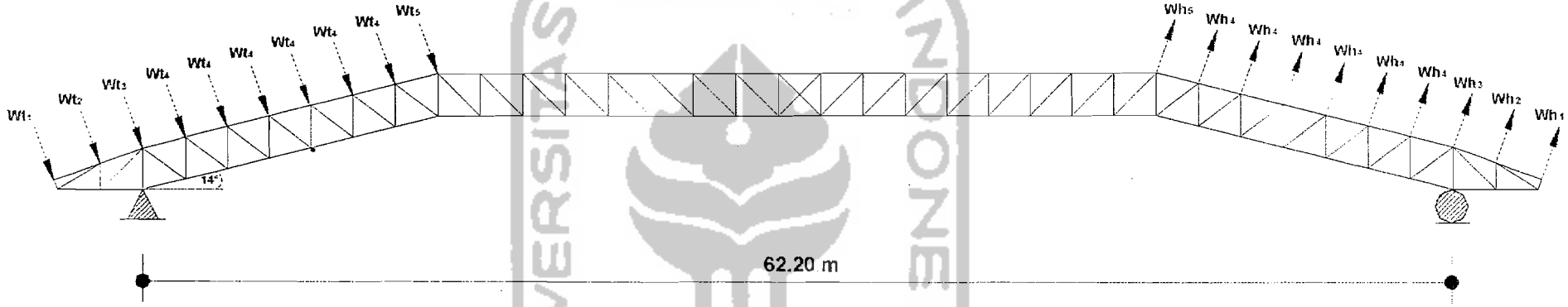
Gambar perencanaan kuda-kuda K4 disajikan dalam Gambar 4.22, Gambar 4.23, Gambar 4.24 dan Gambar 4.25.

Gambar 4.22 Perencanaan Kuda-kuda K4



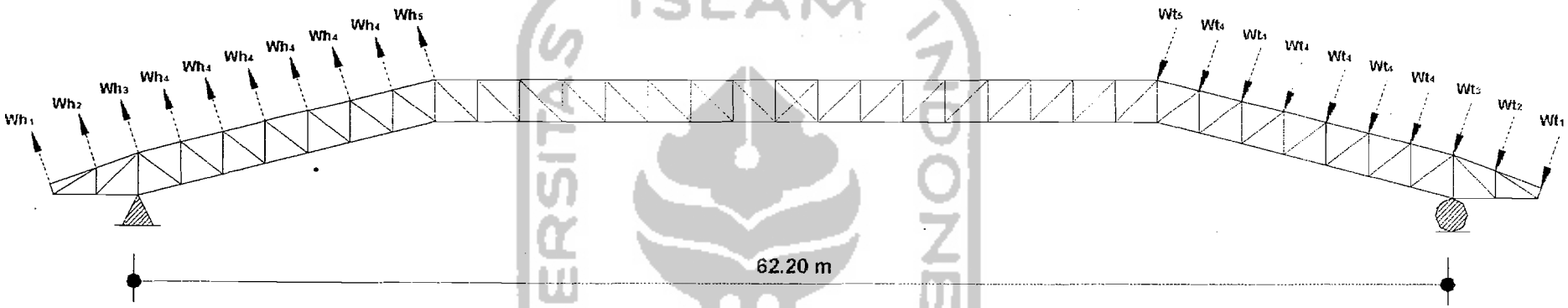
Pembebanan Kuda-kuda K4 Akibat B.Mati dan B.Hidup

Gambar 4.23 Pembebanan Kuda-kuda K4 Akibat Beban Mati dan Beban Hidup



Pembebanan Kuda-kuda K4 Akibat B.Angin Kiri

Gambar 4.24 Pembebanan Kuda-kuda K4 Akibat Beban Angin Kiri



Pembebanan Kuda-kuda K4 Akibat B.Angin Kanan

Gambar 4.25 Pembebanan Kuda-kuda K5 Akibat Beban Angin Kanan

4.3.6 Perencanaan Pembebanan Kuda-Kuda K5

4.3.6.1 Beban mati

P_a : berat gording = 0,0496 . 4 = 0,198 kN

berat galvallum = 0,1 . 4 . 1,064 = 0,426 kN

P_a = 0,624 kN

P_1 : berat gording = 0,0496 . 4 = 0,198 kN

berat galvallum = 0,1 . 4 . 0,5 . 1,064 = 0,213 kN

P_1 = 0,411 kN

P_2 : berat gording = 0,0496 . 4 = 0,198 kN

berat galvallum = 0,1 . 4. (0,532 + 0,532) = 0,426 kN

P_2 = 0,624 kN

Berat total $P_2 = P_2 + ½.P_a = 0,624 + ½.0,624 = 0,936$ kN

P_3 : berat gording = 0,0496 . 4 = 0,198 kN

berat galvallum = 0,1 . 4 . 1,064 = 0,426 kN

P_3 = 0,624 kN

Berat total $P_3 = P_3 + P_a = 0,624 + 0,624 = 1,248$ kN

P_4: berat gording = 0,0496 . 4 = 0,198 kN

berat galvallum = 0,1 . 4 . (0,532 + 0,426) = 0,383 kN

P_4 = 0,581 kN

P_5 : berat gording = 0,0496 . 4 = 0,198 kN

berat galvallum = 0,1 . 4 . 0,5 . 0,851 = 0,171 kN

P_5 = 0,369 kN

4.3.6.2 Beban hidup

$P_1 - P_5$ = beban hidup = 1 kN

4.3.6.3 Beban angin

a. Angin kiri

- Sisi kiri (angin tekan)

$Wt_1 - Wt_5 = 0$

- Sisi kanan (angin hisap)

$Wh_1 = -0,16 \cdot 0,5 \cdot 1,064 \cdot 4 = -0,340$ kN

$Whx_1 = 0,340 \cdot \sin 20° = 0,116$ kN

$Why_1 = 0,340 \cdot \cos 20° = 0,320$ kN

$Wh_2 = -0,16 \cdot 1,596 \cdot 4 = -1,021$ kN

$Whx_2 = 1,021 \cdot \sin 20° = 0,349$ kN

$Why_2 = 1,021 \cdot \cos 20° = 0,960$ kN

$Wh_3 = -0,16 \cdot 0,5 \cdot 2,128 \cdot 4 = -1,362$ kN

$Whx_3 = 1,362 \cdot \sin 20° = 0,466$ kN

$Why_3 = 1,362 \cdot \cos 20° = 1,128$ kN

$Wh_4 = -0,16 \cdot 1,490 \cdot 4 = -0,954$ kN

$Whx_4 = 0,954 \cdot \sin 20° = 0,326$ kN

$Why_4 = 0,954 \cdot \cos 20° = 0,896$ kN

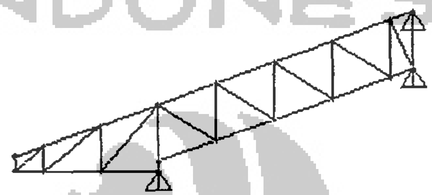
$Wh_5 = -0,16 \cdot 0,5 \cdot 0,851 \cdot 4 = -0,272$ kN

$Whx_5 = 0,272 \cdot \sin 20° = 0,093$ kN

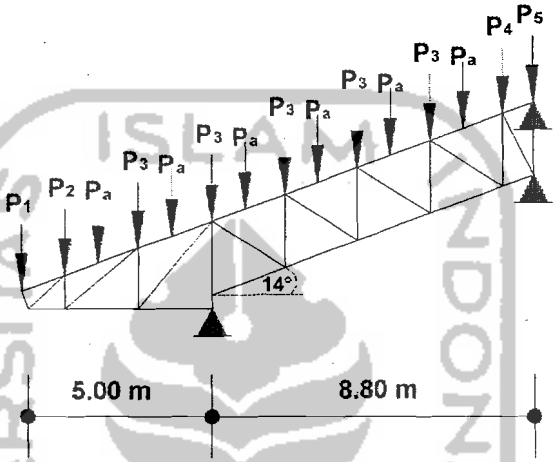
$Why_5 = 0,272 \cdot \cos 20° = 0,256$ kN

b. Angin kanan = 0

Gambar perencanaan kuda-kuda K5 disajikan pada Gambar 4.26, 4.27, 4.28, dan 4.29

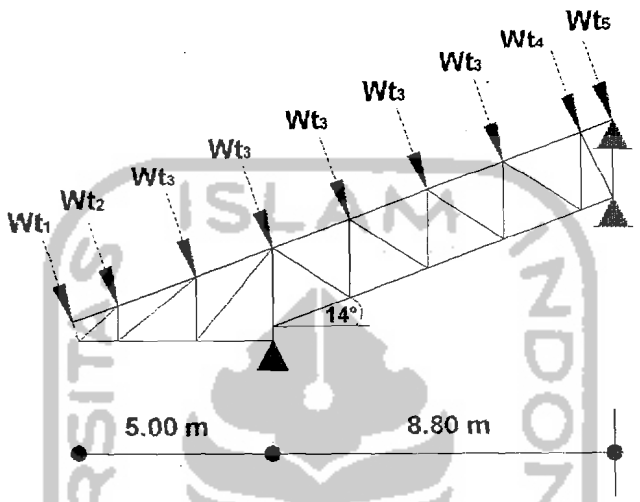


Gambar 4.26 Perencanaan Kuda-kuda K5



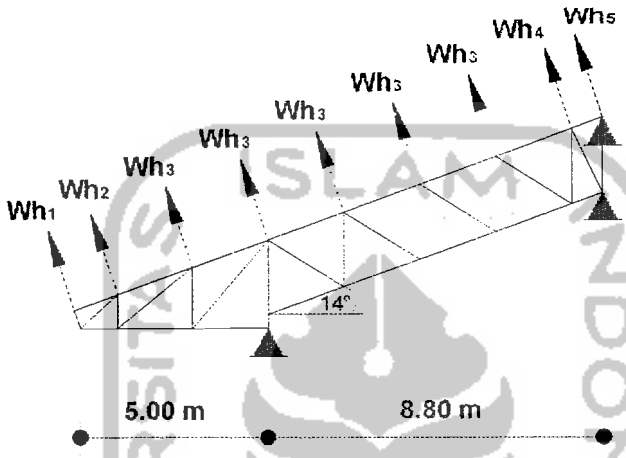
Pembebanan Kuda-kuda K5 Akibat B.Mati dan B.Hidup

Gambar 4.27 Pembebanan Kuda-kuda K5 Akibat Beban Mati dan Beban Hidup



Pembebanan Kuda-kuda K5 Akibat B.Angin Kiri

Gambar 4.28 Pembebanan Kuda-kuda K5 Akibat Beban Angin Kiri



Pembebanan Kuda-kuda K5 Akibat B.Angin Kanan

Gambar 4.29 Pembebanan Kuda-kuda K5 Akibat Beban Angin Kanan

4.3.7 Perencanaan Pembebanan Kuda-Kuda K6

4.3.7.1 Beban mati

P_a : berat gording = 0,0496 . 4 = 0,198 kN

berat galvallum = 0,1 . 4 . 1,064 = 0,426 kN

P_a = 0,624 kN

P_1 : berat gording = 0,0496 . 4 = 0,198 kN

berat galvallum = 0,1 . 4 . 0,5 . 1,064 = 0,213 kN

P_1 = 0,411 kN

P_2 : berat gording = 0,0496 . 4 = 0,198 kN

berat galvallum = 0,1 . 4. (0,532 + 0,532) = 0,426 kN

P_2 = 0,624 kN

Berat total $P_2 = P_2 + ½.P_a = 0,624 + ½.0,624 = 0,936$ kN

P_3 : berat gording = 0,0496 . 4 = 0,198 kN

berat galvallum = 0,1 . 4 . 1,064 = 0,426 kN

P_3 = 0,624 kN

Berat total $P_3 = P_3 + P_a = 0,624 + 0,624 = 1,248$ kN

P_4: berat gording = 0,0496 . 4 = 0,198 kN

berat galvallum = 0,1 . 4 . (0,532 + 0,426) = 0,383 kN

P_4 = 0,581 kN

P_5 : berat gording = 0,0496 . 4 = 0,198 kN

berat galvallum = 0,1 . 4 . (0,426 + 0,692) = 0,447 kN

P_5 = 0,645 kN

P_6 : berat gording = 0,0496 . 4 = 0,198 kN

berat galvallum = 0,1 . 4 . (0,692 + 0,532) = 0,490 kN

P_6 = 0,688 kN

Berat total $P_3 = P_6 + ½.P_a = 0,688 + ½.0,624 = 1,000$ kN

P_7: berat gording = 0,0496 . 4 = 0,198 kN

berat galvallum = 0,1 . 4 . 0,5 . 1,064 = 0,213 kN

P_7 = 0,411 kN

Berat total $P_7 = P_7 + ½.P_a = 0,411 + ½.0,624 = 0,723$ kN

4.3.7.2 Beban hidup

$P_1 - P_7$ = beban hidup = 1 kN

4.3.7.3 Beban angin

a. Angin kiri

- Sisi kiri (angin tekan)

$Wt_1 - Wt_7 = 0$

- Sisi kanan (angin hisap)

$Wh_1 = -0,16 . 0,5 . 1,064 . 4 = -0,340$ kN

$Whx_1 = 0,340 . \sin 20° = 0,116$ kN

$Why_1 = 0,340 . \cos 20° = 0,320$ kN

$Wh_2 = -0,16 . 1,596 . 4 = -1,021$ kN

$Whx_2 = 1,021 . \sin 20° = 0,349$ kN

$Why_2 = 1,021 . \cos 20° = 0,960$ kN

Wh_3 = -0,16 . 0,5 .2,128 . 4 = -1,362 kN

Whx_3 = 1,362 . sin 20° = 0,466 kN

Why_3 = 1,362 . cos 20° = 1,128 kN

Wh_4 = -0,16 . 1,490 . 4 = -0,954 kN

Whx_4 = 0,954 . sin 20° = 0,326 kN

Why_4 = 0,954 . cos 20° = 0,896 kN

Wh_5 = -0,16 . 1,117 . 4 = -0,715 kN

Whx_5 = 0,715 . sin 20° = 0,245 kN

Why_5 = 0,715 . cos 20° = 0,672 kN

Wh_6 = -0,16 . 1,756 . 4 = -1,124 kN

Whx_6 = 1,124 . sin 20° = 0,384 kN

Why_6 = 1,124 . cos 20° = 1,056 kN

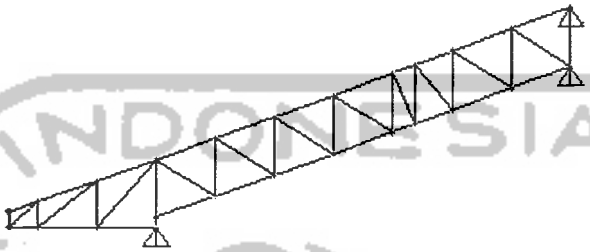
Wh_7 = -0,16 . 0,5 . 2,128 . 4 = -0,681 kN

Whx_7 = 0,681 . sin 20° = 0,233 kN

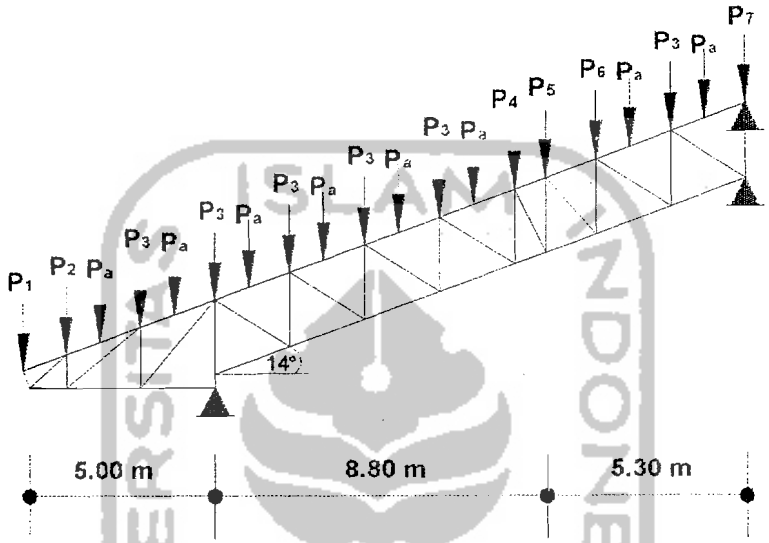
Why_7 = 0,681 . cos 20° = 0,640 kN

b. Angin kanan = 0

Gambar perencanaan kuda-kuda K6 disajikan dalam Gambar 4.30, Gambar 4.31, Gambar 4.32 dan Gambar 4.33.

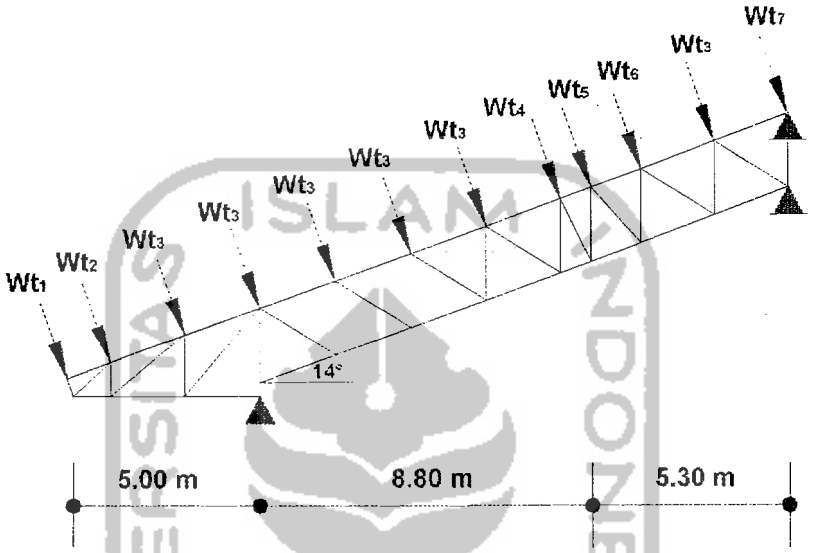


Gambar 4.30 Perencanaan Kuda-kuda K6



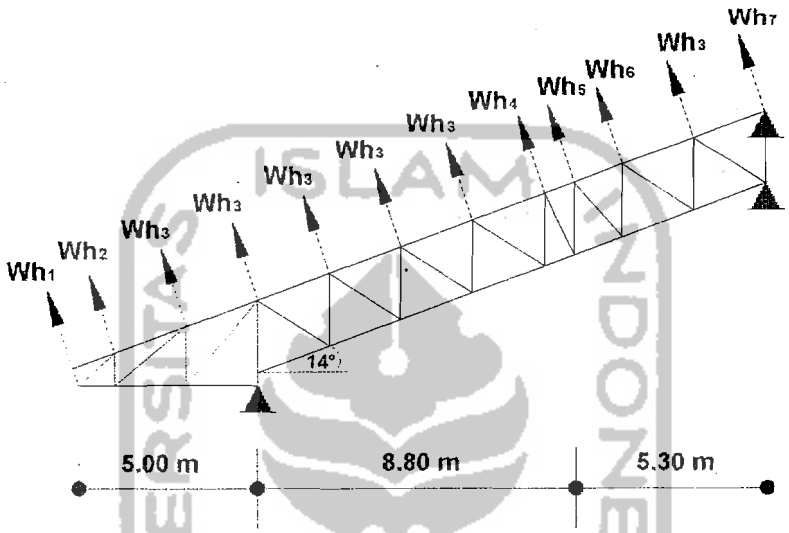
Pembebanan Kuda-kuda K6 Akibat B.Mati dan B.Hidup

Gambar 4.31 Pembebanan Kuda-kuda K6 Akibat Beban Mati dan Beban Hidup



Pembebanan Kuda-kuda K6 Akibat B.Angin Kiri

Gambar 4.32 Pembebanan Kuda-kuda K6 Akibat Beban Angin Kiri



Pembebanan Kuda-kuda K6 Akibat B.Angin Kanan

Gambar 4.33 Pembebanan Kuda-kuda K6 Akibat Beban Angin Kanan

4.3.8 Perencanaan Pembebanan Kuda-Kuda K7

4.3.8.1 Beban mati

P_a : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . 1,064 = 0,638 kN

P_a = 0,936 kN

P_1 : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . 0,5 . 1,064 = 0,319 kN

P_1 = 0,617 kN

P_2 : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6. 1,064 = 0,638 kN

P_2 = 0,936 kN

Berat total $P_2 = P_2 + ½.P_a = 0,936 + ½.0,936 = 1,404$ kN

P_3 : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . 1,064 = 0,638 kN

P_3 = 0,936 kN

Berat total $P_3 = P_3 + P_a = 0,936 + 0,936 = 1,872$ kN

P_4: berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . (0,532 + 0,426) = 0,575 kN

P_4 = 0,873 kN

Berat total $P_4 = P_4 + ½ P_a = 0,873 + ½.0,936 = 1,341$ kN

P_5 : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . (0,426 + 0,692) = 0,671 kN

P_4 = 0,969 kN

P_6 : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 .6. (0,692 + 0,532) = 0,734 kN

P_6 = 1,032 kN

Berat total $P_6 = P_6 + ½ P_a = 1,032 + ½.0,936 = 1,500$ kN

4.3.8.2 Beban hidup

$P_1 – P_6$ = beban hidup = 1 kN

4.3.8.3 Beban angin

a. Angin kiri

- Sisi kiri (angin tekan)

$Wt_1 – Wt_6 = 0$

- Sisi kanan (angin hisap)

$Wh_1 = -0,16 . 0,5 .1,064 . 6 = -0,511$ kN

$Whx_1 = 0,511 . \sin 20° = 0,175$ kN

$Why_1 = 0,511 . \cos 20° = 0,480$ kN

$Wh_2 = -0,16 . 1,596 .6 = -1,532$ kN

$Whx_2 = 1,532 . \sin 20° = 0,524$ kN

$Why_2 = 1,532 . \cos 20° = 1,440$ kN

$Wh_3 = -0,16 . 2,128 . 6 = -2,043$ kN

$Whx_3 = 2,043 . \sin 20° = 0,699$ kN

$Why_3 = 2,043 . \cos 20° = 1,920$ kN

$Wh_4 = -0,16 . 1,490 . 6 = -1,430$ kN

$Whx_4 = 1,430 . \sin 14° = 0,489$ kN

$Why_4 = 1{,}430 \cdot \cos 14° = 1{,}344$ kN

$Wh_5 = -0{,}16 \cdot 1{,}117 \cdot 6 = -1{,}073$ kN

$Whx_5 = 1{,}073 \cdot \sin 14° = 0{,}367$ kN

$Why_5 = 1{,}073 \cdot \cos 14° = 1{,}008$ kN

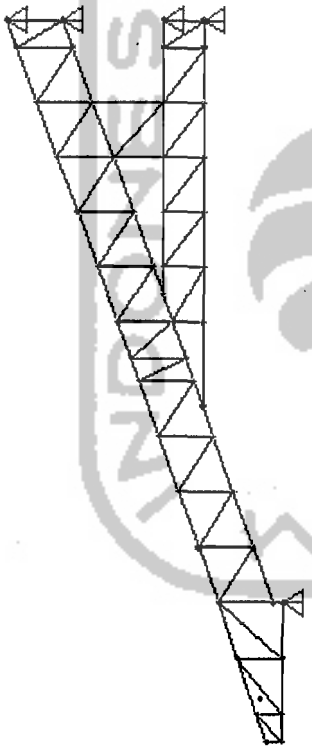
$Wh_6 = -0{,}16 \cdot 1{,}756 \cdot 6 = -1{,}685$ kN

$Whx_6 = 1{,}685 \cdot \sin 14° = 0{,}576$ kN

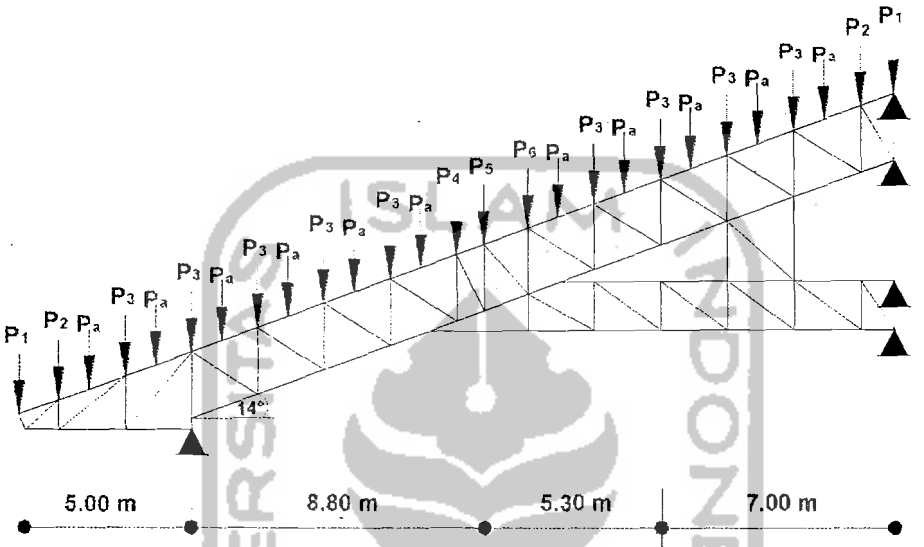
$Why_6 = 1{,}685 \cdot \cos 14° = 1{,}584$ kN

b. Angin kanan = 0

Gambar perencanaan kuda-kuda K7 disajikan dalam Gambar 4.34, 4.35, 4.36 dan 4.37.

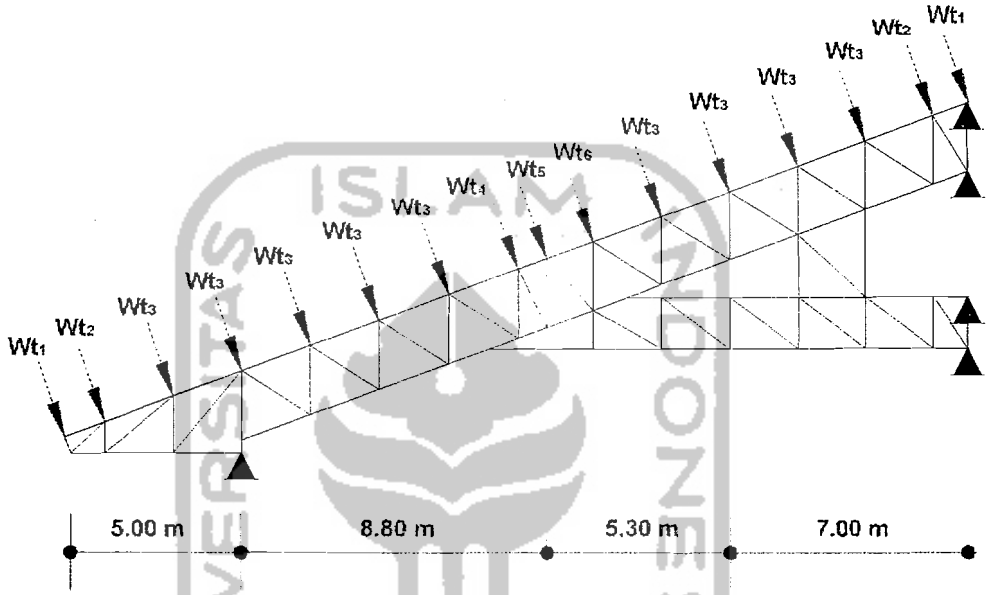


Gambar 4.34 Perencanaan Kuda-kuda K7



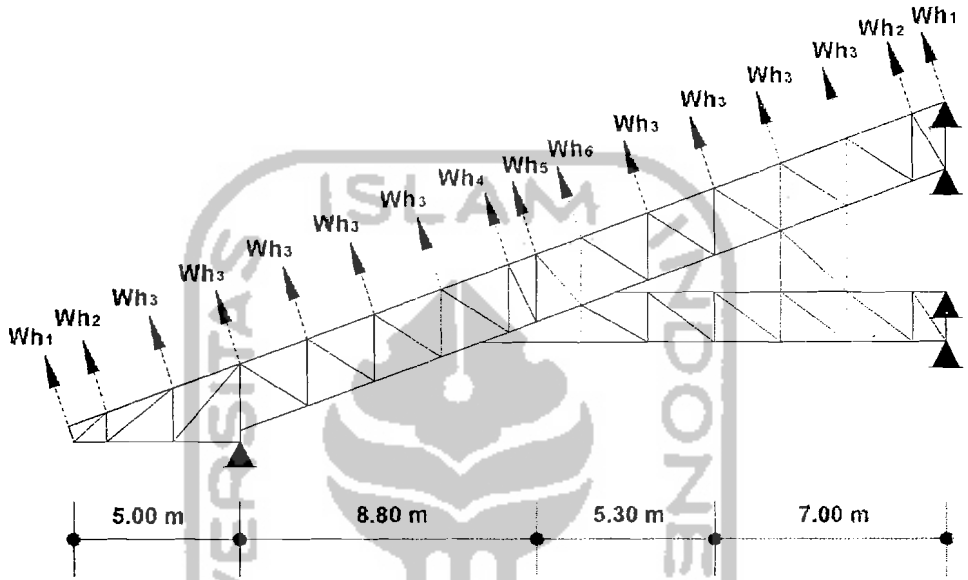
Pembebanan Kuda-kuda K7 Akibat B.Mati dan B.Hidup

Gambar 4.35 Pembebanan Kuda-kuda K7 Akibat Beban Mati dan Beban Hidup



Pembebanan Kuda-kuda K7 Akibat B.Angin Kiri

Gambar 4.36 Pembebanan Kuda-kuda K7 Akibat Beban Angin Kiri



Gambar 4.37 Pembebanan Kuda-kuda K7 Akibat Beban Angin Kanan

4.3.9 Perencanaan Pembebanan Kuda-Kuda K8

4.3.9.1 Beban mati

P_a : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . 1,064 = 0,638 kN

P_a = 0,936 kN

P_1 : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . 0,5 . 1,064 = 0,319 kN

P_1 = 0,617 kN

P_2 : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6. 1,064 = 0,638 kN

P_2 = 0,936 kN

Berat total $P_2 = P_2 + ½.P_a = 0,936 + ½.0,936 = 1,404$ kN

P_3 : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . 1,064 = 0,638 kN

P_3 = 0,936 kN

Berat total $P_3 = P_3 + P_a = 0,936 + 0,936 = 1,872$ kN

P_4: berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . (0,532 + 0,426) = 0,575 kN

P_4 = 0,873 kN

Berat total $P_4 = P_4 + ½ P_a = 0,873 + ½.0,936 = 1,341$ kN

P_5 : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . (0,426 + 0,692) = 0,671 kN

P_4 = 0,969 kN

P_6 : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 .6. (0,692 + 0,532) = 0,734 kN

P_6 = 1,032 kN

Berat total $P_6 = P_6 + ½ P_a = 1,032 + ½.0,936 = 1,500$ kN

P_7 : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . 0,5 . 1,490 = 0,447 kN

P_7 = 0,745 kN

P_8: berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . (0,745 + 0,718) = 0,878 kN

P_8 = 1,176 kN

P_9 : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 . 6 . (0,718 + 0,532) = 0,750 kN

P_9 = 1,048 kN

Berat total $P_9 = P_9 + ½ P_a = 1,048 + ½.0,936 = 1,516$ kN

P_{10} : berat gording = 0,0496 . 6 = 0,298 kN

berat galvallum = 0,1 .6. 0,5 . 1,064 = 0,319 kN

P_{10} = 0,617 kN

Berat total $P_{10} = P_{10} + ½ P_a = 0,617 + ½.0,936 = 1,085$ kN

4.3.9.2 Beban hidup

$P_1 – P_{10}$ = beban hidup = 1 kN

4.3.9.3 Beban angin

a. Angin kiri

- Sisi kiri (angin tekan)

$Wt_1 - Wt_{10} = 0$

- Sisi kanan (angin hisap)

$Wh_1 = -0,16 \cdot 0,5 \cdot 1,064 \cdot 6 = -0,511$ kN

$Whx_1 = 0,511 \cdot \sin 20° = 0,175$ kN

$Why_1 = 0,511 \cdot \cos 20° = 0,480$ kN

$Wh_2 = -0,16 \cdot 1,596 \cdot 6 = -1,532$ kN

$Whx_2 = 1,532 \cdot \sin 20° = 0,524$ kN

$Why_2 = 1,532 \cdot \cos 20° = 1,440$ kN

$Wh_3 = -0,16 \cdot 2,128 \cdot 6 = -2,043$ kN

$Whx_3 = 2,043 \cdot \sin 20° = 0,699$ kN

$Why_3 = 2,043 \cdot \cos 20° = 1,920$ kN

$Wh_4 = -0,16 \cdot 1,490 \cdot 6 = -1,430$ kN

$Whx_4 = 1,430 \cdot \sin 20° = 0,489$ kN

$Why_4 = 1,430 \cdot \cos 20° = 1,344$ kN

$Wh_5 = -0,16 \cdot 1,117 \cdot 6 = -1,073$ kN

$Whx_5 = 1,073 \cdot \sin 20° = 0,367$ kN

$Why_5 = 1,073 \cdot \cos 20° = 1,008$ kN

$Wh_6 = -0,16 \cdot 1,756 \cdot 6 = -1,685$ kN

$Whx_6 = 1,685 \cdot \sin 20° = 0,576$ kN

$Why_6 = 1,685 \cdot \cos 20° = 1,584$ kN

Wh_7 = -0,16 . 0,5 . 1,490 . 6 = -0,715 kN

Whx_7 = 0,715 . sin 20° = 0,245 kN

Why_7 = 0,715 . cos 20° = 0,672 kN

Wh_8 = -0,16 . 1,463 . 6 = -1,404 kN

Whx_8 = 1,404 . sin 20° = 0,480 kN

Why_8 = 1,404 . cos 20° = 1,320 kN

Wh_9 = -0,16 . 1,782 . 6 = -1,711 kN

Whx_9 = 1,711 . sin 20° = 0,585 kN

Why_9 = 1,711 . cos 20° = 1,608 kN

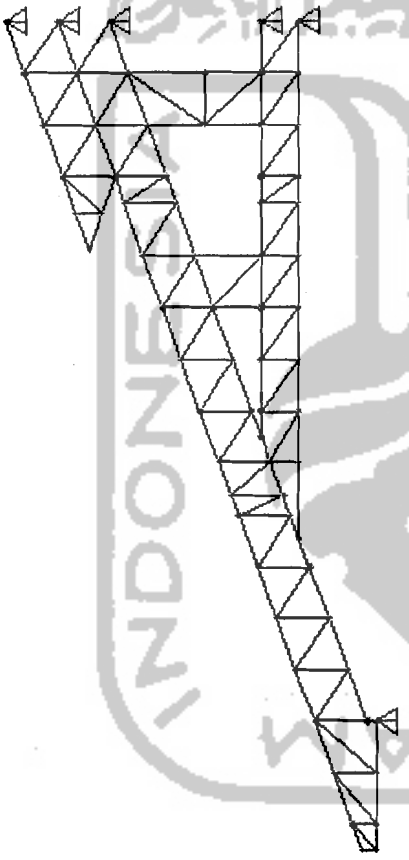
Wh_{10} = -0,16 . 0,5 . 2,128 . 6 = -1,021 kN

Whx_{10} = 1,021 . sin 20° = 0,349 kN

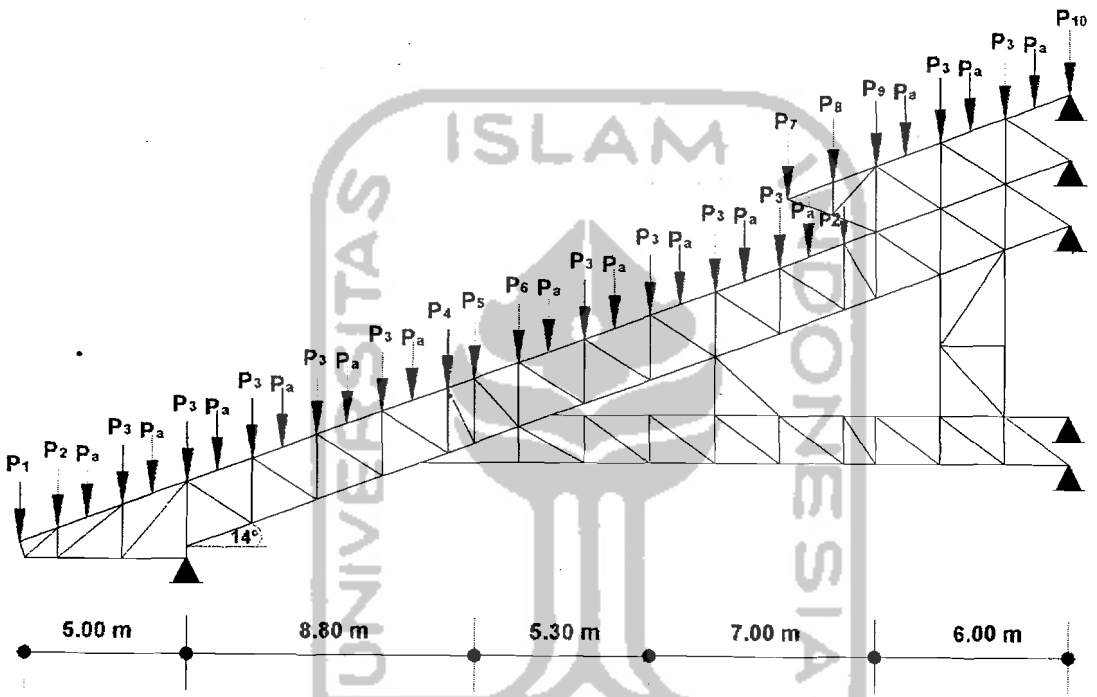
Why_{10} = 1,021 . cos 20° = 0,960 kN

b. Angin kanan = 0

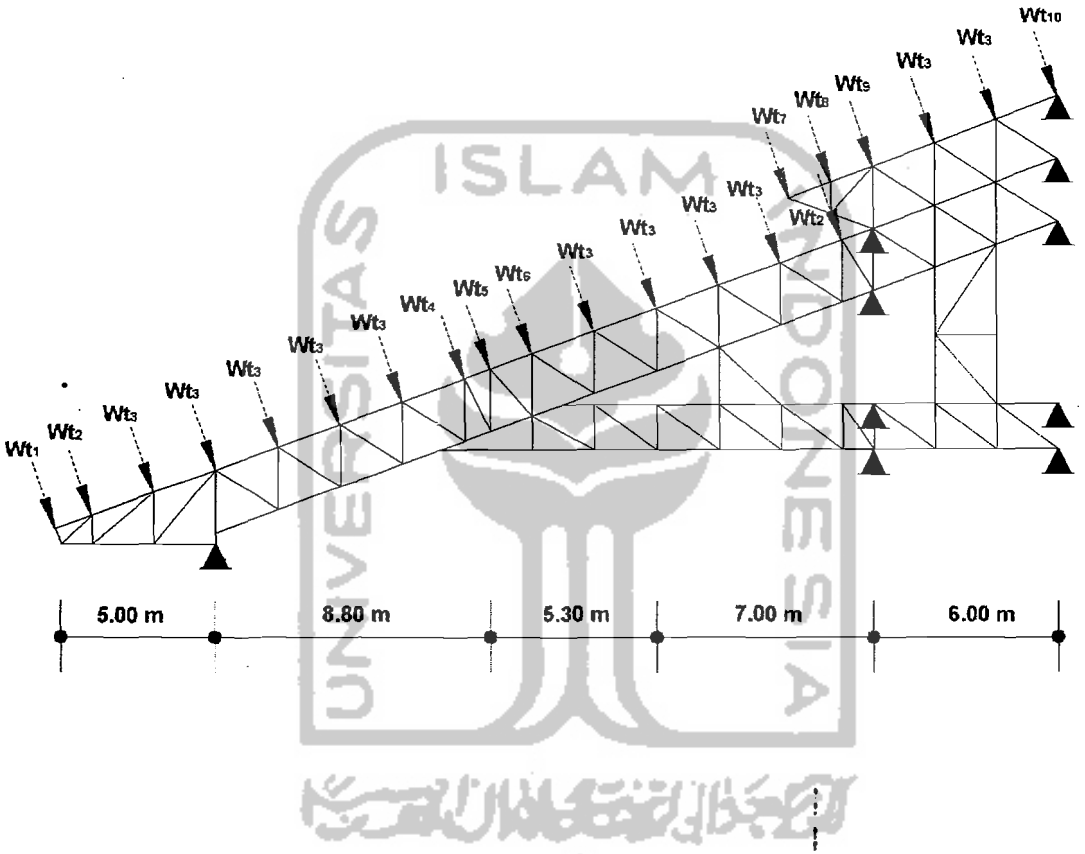
Gambar perencanaan kuda-kuda K8 disajikan dalam Gambar 4.38, 4.39, 4.40 dan 4.41.



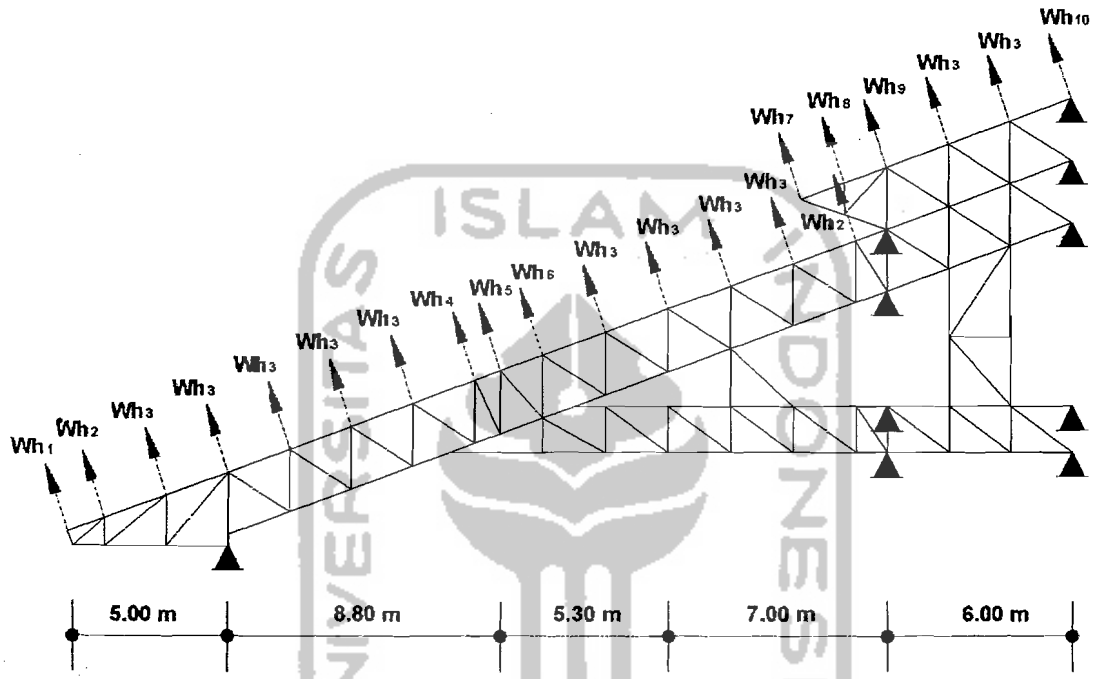
Gambar 4.38 Perencanaan Kuda-kuda K8



Gambar 4.39 Pembebanan Kuda-kuda K8 Akibat Beban Mati dan Beban Hidup



Gambar 4.40 Pembebanan Kuda-kuda K8 Akibat Beban Angin Kiri



Gambar 4.41 Pembebanan Kuda-kuda K8 Akibat Beban Angin Kanan

4.4 Pendimensian Rangka Kuda-Kuda

4.4.1 Dimensi Rangka Kuda-Kuda K1

1. Batang A

a. Perencanaan batang desak

- Gaya desak maksimum, N_u = -786,0972 kN (frame 29)

L = 2,128 m

f_y = 240 MPa = 240 . 10^3 kN/m^2

Dicoba profil H Beam 200x200x8x12x13

A_g = 6353 mm^2

I_x = 4,720 . 10^4 mm^4

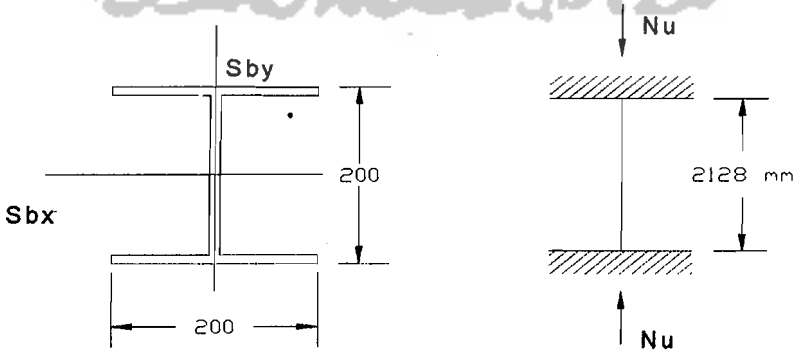
I_y = 1,600 . 10^4 mm^4

i_x = 86,2 mm

i_y = 50,2 mm = r_{min}

- Cek angka perbandingan kelangsingan batang tekan : $\frac{L_k}{r} < 200$

$L_k = k \,.\, L = 1 \,.\, 2128 = 2128$ mm



Gambar 4.42 Penampang Profil H Beam 200x200x8x12x13

$$\frac{L_k}{r} = \frac{2128}{50,2} = 42,390 < 200$$ -aman-

- Parameter kelangsingan batang tekan

$$\lambda_c = \frac{1}{\pi}\frac{L_k}{r}\sqrt{\frac{f_y}{E}}$$

$$= \frac{1}{\pi}\frac{2128}{50,2}\sqrt{\frac{240}{2.10^5}} = 0,467 \quad ; (0,25 < \lambda_c < 1,2)$$

maka $\omega = \frac{1,43}{(1,6 - 0,6.0,467)} = 1,084$

- Kuat tekan nominal

$$\phi N_n = \phi . A_g . \left(\frac{f_y}{\omega}\right) . 10^{-3}$$

$$= 0,85 . 6353 . \left(\frac{240}{1,084}\right) . 10^{-3} = 1195,737 \text{ kN}$$

$(\phi N_n = 1195,737 \text{ kN}) > (N_u = 786,0972 \text{ kN})$ - aman-

b. Perencanaan Batang Tarik

- Gaya tarik maksimum ; $N_u = 582,7788$ kN (frame 329)

L = 2,128 m

Dicoba profil H Beam 200x200x8x12x13

Dengan : $A_g = 6353 \text{ mm}^2$

i_x = 86,2 mm

i_y = 50,2 mm = r_{min}

- Cek angka perbandingan kelangsingan batang tarik

$$\frac{L}{r} = \frac{2128}{50,20} = 42,390 \quad < \quad 240 \qquad \text{-aman-}$$

- Kuat tarik nominal batang tarik

$\phi N_n = \phi \, . \, A_g \, . \, 240 \, . \, 10^{-3}$

$= 0,90 \, . \, 6353 \, . \, 240 \, . \, 10^{-3} = 1372,248$ kN

$(\phi N_n = 1372,248 \text{ kN}) > (N_u = 582,7788 \text{ kN})$ -aman-

2. Batang B

a. Perencanaan batang desak

- Gaya desak maksimum, N_u = -197,8661 kN (frame 9)

L = 2,000 m

f_y = 240 MPa $= 240 \, . \, 10^3$ kN/m^2

Dicoba profil IWF 200x100x5,5x8x11

$A_g = 2716$ mm^2

$I_x = 1,840 \, . \, 10^4$ mm^4

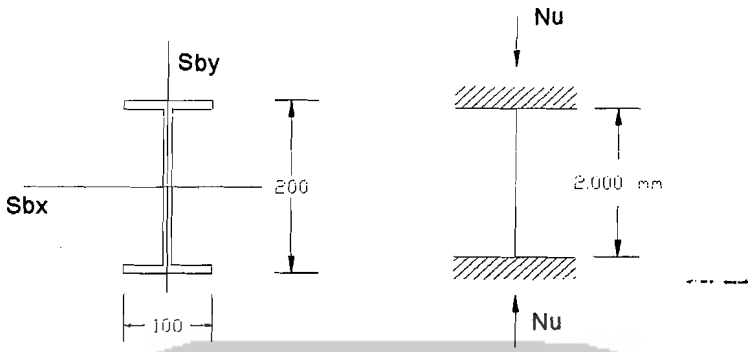
$I_y = 0,134 \, . \, 10^4$ mm^4

$i_x = 82,4$ mm

$i_y = 22,2$ mm $= r_{min}$

- Cek angka perbandingan kelangsingan batang tekan : $\frac{L_k}{r} < 200$

$L_k = k \, . \, L = 1 \, . \, 2000 = 2000$ mm



Gambar 4.43 Penampang Profil IWF 200x100x5,5x8x11

$$\frac{L_k}{r} = \frac{2000}{22,2} = 90,090 < 200$$ -aman-

- Parameter kelangsingan batang tekan

$$\lambda_c = \frac{1}{\pi}\frac{L_k}{r}\sqrt{\frac{f_y}{E}}$$

$$= \frac{1}{\pi}\frac{2000}{22,2}\sqrt{\frac{240}{2.10^5}} = 0,993 \quad ; (0,25 < \lambda_c < 1,2)$$

maka $\omega = \dfrac{1,43}{(1,6 - 0,6.0,993)} = 1,424$

- Kuat tekan nominal

$$\phi N_n = \phi . A_g . \left(\frac{f_y}{\omega}\right). 10^{-3}$$

$$= 0,85 . 6353 . \left(\frac{240}{1,424}\right). 10^{-3} = 388,878 \text{ kN}$$

$(\phi N_n = 388,878 \text{ kN}) > (N_u = 197,8661 \text{ kN})$ - aman-

b. Perencanaan Batang Tarik

- Gaya tarik maksimum; N_u = 221,6719 kN (frame 11)

L = 2,436 m

Dicoba profil IWF 200x100x5,5x8x11

Dengan : A_g = 2716 mm^2

i_x = 82,4 mm

i_y = 22,2 mm = r_{min}

- Cek angka perbandingan kelangsingan batang tarik

$$\frac{L}{r} = \frac{2436}{22,20} = 109,755 \quad < \quad 240$$ -aman-

- Kuat tarik nominal batang tarik

$\phi N_n = \phi \, . \, A_g \, . \, 240 \, . \, 10^{-3}$

$= 0,90 \, . \, 2716 \, . \, 240 \, . \, 10^{-3} = 586,656$ kN

(ϕN_n = 586,656 kN) > (N_u = 221,6719 kN) -aman-

3. Batang C

a. Perencanaan batang desak

- Gaya desak maksimum, N_u = -12,8721 kN (frame 6)

L = 2,000 m

f_y = 240 MPa = 240 . 10^3 kN/m^2

Dicoba profil 2L 80.80.8

A_g = 1230 mm^2

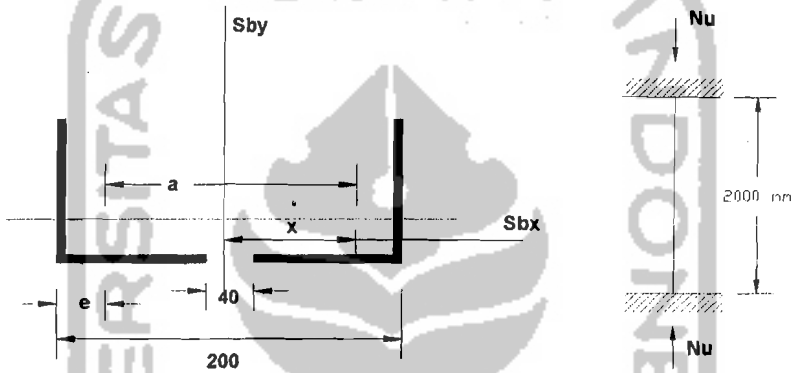
$I_x = I_y$ = 72,3 . 10^4 mm^4

e = 22,6 mm

- Cek angka perbandingan kelangsingan batang tekan : $\frac{L_k}{r} < 200$

$L_k = k \,.\, L = 1 \,.\, 2000 = 2000$ mm

Mencari r pilih yang terkecil untuk profil 2L 80.80.8



Gambar 4.44 Penampang Profil 2L 80.80.8

$x = (b - e) + t_p/2 = (80\text{-}22{,}6) + 40/2 = 77{,}4$ mm

I_y dua profil = $2(I_y \,.\, A \,.\, x^2) = 2(72{,}3 \,.\, 10^4 + 1230 \,.\, 77{,}4^2)$

$= 16183269{,}60$ mm^4

$$r_y = \sqrt{\frac{I_y}{A_g}} = \sqrt{\frac{16183269{,}60}{2.1230}} = 24{,}245mm$$

I_x dua profil = $2 \,.\, I_x = 2 \,.\, 72{,}3 \,.\, 10^4 = 144{,}60 \,.\, 10^4$ mm^4

$$r_x = \sqrt{\frac{I_x}{A_g}} = \sqrt{\frac{144{,}6.10^4}{2.1230}} = 24{,}245 \text{ mm}$$

dipilih r terkecil ; $r = r_x = 24{,}245$ mm

$$\frac{L_k}{r_x} = \frac{2000}{24,245} = 82,491 < 200 \qquad \text{-aman-}$$

- Parameter kelangsingan batang tekan

$$\lambda_c = \frac{1}{\pi}\frac{L_k}{r}\sqrt{\frac{f_y}{E}}$$

$$= \frac{1}{\pi}\frac{2000}{24,245}\sqrt{\frac{240}{2.10^5}} = 0,909 \quad ; (0,25 < \lambda_c < 1,2)$$

maka $\omega = \dfrac{1,43}{(1,6 - 0,6.0,909)} = 1,356$

- Kuat tekan nominal

$$\phi N_n = \phi . A_g . \left(\frac{f_y}{\omega}\right). 10^{-3}$$

$$= 0,85 . 2 . 1230 . \left(\frac{240}{1,356}\right). 10^{-3} = 369,878 \text{ kN}$$

$(\phi N_n = 369,878 \text{ kN}) > (N_u = 12,8721 \text{ kN})$ - aman-

b. Perencanaan Batang Tarik

- Gaya tarik maksimum: $N_u = 9,704$ kN (frame 7)

$L = 2,828$ m

Dicoba profil 2L 80.80.8

Dengan : $A_g = 1230 \text{ mm}^2$

$r = r_x = 24,2$ mm

- Cek angka perbandingan kelangsingan batang tarik

$$\frac{L}{r} = \frac{2828}{24,20} = 116,860 \quad < \quad 240 \qquad \text{-aman-}$$

- Kuat tarik nominal batang tarik

$\phi N_n = \phi \,.\, A_g \,.\, 240 \,.\, 10^{-3}$

$= 0{,}90 \,.\, (2 \,.\, 1230) \,.\, 240 \,.\, 10^{-3} = 531{,}360$ kN

$(\phi N_n = 531{,}360 \text{ kN}) > (N_u = 9{,}704 \text{ kN})$ -aman-

4. Batang D

a. Perencanaan batang desak

- Gaya desak maksimum, N_u = -52,4598 kN (frame 143)

L = 2,197 m

f_y = 240 MPa = $240 \,.\, 10^3$ kN/m^2

Dicoba profil 2L 70.70.7

$A_g = 940$ mm^2

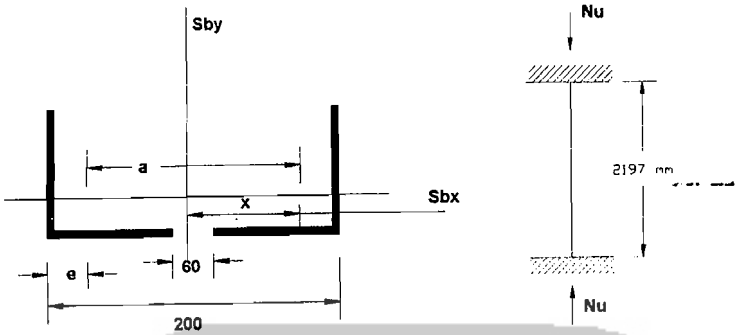
$I_x = I_y = 42{,}40 \,.\, 10^4$ mm^4

e = 19,70 mm

- Cek angka perbandingan kelangsingan batang tekan : $\frac{L_k}{r} < 200$

$L_k = k \,.\, L = 1 \,.\, 2197 = 2197$ mm

Mencari r pilih yang terkecil untuk profil 2L 70.70.7



Gambar 4.45 Penampang Profil 2L 70.70.7

$x = (b - e) + t_p/2 = (70\text{-}19{,}7) + 60/2 = 80{,}30$ mm

I_y dua profil $= 2(I_y \,.\, A \,.\, x^2) = 2(42{,}40 \,.\, 10^4 + 940 \,.\, 80{,}30^2)$

$= 12970409{,}20\ \text{mm}^4$

$$r_y = \sqrt{\frac{I_y}{A_g}} = \sqrt{\frac{12970409{,}20}{2.940}} = 83{,}061mm$$

I_x dua profil $= 2 \,.\, I_x - 2 \,.\, 42{,}40 \,.\, 10^4 = 84{,}80 \,.\, 10^4\ \text{mm}^4$

$$r_x = \sqrt{\frac{I_x}{A_g}} = \sqrt{\frac{84{,}80.10^4}{2.940}} = 21{,}238\,\text{mm}$$

dipilih r terkecil ; $r = r_x = 21{,}238$ mm

$$\frac{L_k}{r_x} = \frac{2197}{21{,}238} = 103{,}445 < 200$$ -aman-

- Parameter kelangsingan batang tekan

$$\lambda_c = \frac{1}{\pi}\frac{L_k}{r}\sqrt{\frac{f_y}{E}}$$

$$= \frac{1}{\pi}\frac{2197}{21{,}238}\sqrt{\frac{240}{2.10^5}} = 1{,}141 \quad ; (0{,}25 < \lambda_c < 1{,}2)$$

maka $\omega = \dfrac{1{,}43}{(1{,}6 - 0{,}6.1{,}141)} = 1{,}562$

- Kuat tekan nominal

$$\phi N_n = \phi . A_g . \left(\frac{f_y}{\omega}\right). 10^{-3}$$

$$= 0{,}85 . 2 . 940 . \left(\frac{240}{1{,}562}\right). 10^{-3} = 245{,}561 \text{ kN}$$

$(\phi N_n = 245{,}561 \text{ kN}) > (N_u = 52{,}3546 \text{ kN})$ - aman-

b. Perencanaan Batang Tarik

- Gaya tarik maksimum: $N_u = 295{,}7023$ kN (frame 97)

L = 2,000 m

Dicoba profil 2L 70.70.7

Dengan : $A_g = 940$ mm^2

$r = i_x = 21{,}2$ mm

- Cek angka perbandingan kelangsingan batang tarik

$$\frac{L}{r} = \frac{2000}{21{,}20} = 94{,}340 \quad < \quad 240$$ -aman-

- Kuat tarik nominal batang tarik

$\phi N_n = \phi . A_g . 240 . 10^{-3}$

$= 0{,}90 . (2 . 940) . 240 . 10^{-3} = 406{,}080$ kN

$(\phi N_u = 406{,}080 \text{ kN}) > (N_u = 295{,}7023 \text{ kN})$

5. Batang E

a. Perencanaan batang desak

- Gaya desak maksimum, N_u = -76,9944 kN (frame 178)

L = 2,000 m

f_y = 240 MPa = 240 . 10^3 kN/m^2

Dicoba profil 2L 60.60.6

A_g = 691 mm^2

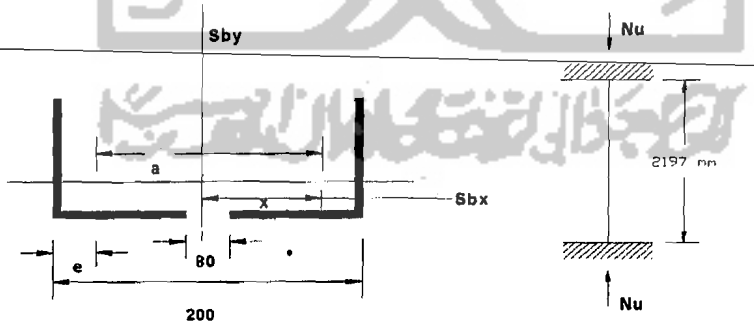
$I_x = I_y$ = 22,8 . 10^4 mm^4

e = 16,9 mm

- Cek angka perbandingan kelangsingan batang tekan : $\frac{L_k}{r} < 200$

$L_k = k \,.\, L = 1 \,.\, 2000 = 2000$ mm

Mencari r pilih yang terkecil untuk profil 2L 60.60.6



Gambar 4.46 Penampang Profil 2L 60.60.6

$x = (b - e) + t_p/2 = (60\text{-}16{,}9) + 80/2 = 83{,}10$ mm

I_y dua profil $= 2(I_y \,.\, A \,.\, x^2) = 2(22{,}8 \,.\, 10^4 + 691 \,.\, 83{,}10^2)$

$= 9999553{,}02$ mm^4

$$r_y = \sqrt{\frac{I_y}{A_g}} = \sqrt{\frac{9999553{,}02}{2.691}} = 85{,}062mm$$

I_x dua profil $= 2 \,.\, I_x = 2 \,.\, 22{,}8 \,.\, 10^4 = 45{,}60 \,.\, 10^4$ mm^4

$$r_x = \sqrt{\frac{I_x}{A_g}} = \sqrt{\frac{45{,}60.10^4}{2.691}} = 18{,}165 \text{ mm}$$

dipilih r terkecil ; $r = r_x = 18{,}165$ mm

$$\frac{L_k}{r_x} = \frac{2000}{18{,}165} = 110{,}104 < 200$$ -aman-

- Parameter kelangsingan batang tekan

$$\lambda_c = \frac{1}{\pi}\frac{L_k}{r}\sqrt{\frac{f_y}{E}}$$

$$= \frac{1}{\pi}\frac{2000}{18{,}165}\sqrt{\frac{240}{2.10^5}} = 1{,}214 \quad ; (\lambda_c \geq 1{,}2)$$

maka $\omega = 1{,}25.\lambda_c^2$

$= 1{,}25 \,.\, 1{,}214^2 = 1{,}842$

- Kuat tekan nominal

$$\phi N_n = \phi \,.\, A_g \,.\, \left(\frac{f_y}{\omega}\right) . \, 10^{-3}$$

$$= 0{,}85 \,.\, 2 \,.\, 691 \,.\, \left(\frac{240}{1{,}842}\right) . \, 10^{-3} = 152{,}8682 \text{ N}$$

$(\phi N_n = 152{,}8682 \text{ N}) > (N_u = 77{,}0402 \text{ kN})$ - aman-

b. Perencanaan Batang Tarik

- Gaya tarik maksimum: N_u = 65,5505 kN (frame 181)

  L = 1,237 m

  Dicoba profil 2L 60.60.6

  Dengan : A_g = 691 mm^2

  $r = i_x$ = 18,2 mm

- Cek angka perbandingan kelangsingan batang tarik

$$\frac{L}{r} = \frac{1237}{18,20} = 67,967 \quad < \quad 240$$ -aman-

- Kuat tarik nominal batang tarik

$\phi N_n = \phi \, . \, A_g \, . \, 240 \, . \, 10^{-3}$

$= 0,90 \, . \, (2 \, . \, 691) \, . \, 240 \, . \, 10^{-3} = 298,512$ kN

$(\phi N_n = 298,512 \text{ kN}) > (N_u = 65,5505 \text{ kN})$

6. Batang H

Perencanaan Batang Tarik

- Gaya tarik maksimum: N_u = 426,5765 kN (frame 39)

  L = 2,000 m

  Dicoba profil 2L 90.90.9

  Dengan : A_g = 1550 mm^2

  $r = i_x$ = 27,40 mm

- Cek angka perbandingan kelangsingan batang tarik

$$\frac{L}{r} = \frac{2000}{27,40} = 72,993 \quad < \quad 240$$ -aman-

- Kuat tarik nominal batang tarik

$\phi N_n = \phi \, . \, A_g \, . \, 240 \, . \, 10^{-3}$

$= 0{,}90 \, . \, (2 \, . \, 1550) \, . \, 240 \, . \, 10^{-3} = 669{,}600$ kN

$(\phi N_n = 669{,}600 \text{ kN}) > (N_u = 426{,}5765 \text{ kN})$

4.4.2 Perencanaan Sambungan Baut

1. Batang A

Sebagai contoh perhitungan ditinjau pada perencanaan sambungan baut kuda-kuda K1 dengan pelat buhul 12 mm, sebagai berikut ini:

- Profil H Beam 200x200x8x12x13

Tegangan putus minimum baja profil, f_u = 370 MPa

Gaya batang kombinasi faktor beban maksimum, N_u = 786,0972 kN

- Data- data baut yang digunakan untuk menyambung

Mutu baut non fulldrat A325-X

Tegangan tarik putus baut f_{ub} = 825 MPa (baut mutu tinggi), diameter baut d = 19 mm.

- Kekuatan satu baut

1. Kuat geser rencana baut

$\phi f.R_{ng} = \phi f . r_1 . f_{ub} . A_b$

dengan :

$\phi f.R_{ng}$ = kuat geser rencana baut

ϕf = 0,75 (faktor reduksi kekuatan untuk fraktur)

r_1 = 0,4 (untuk baut dengan ulir pada bidang geser)

f_{ub} = 825 MPa (tegangan tarik putus baut)

A_b = $\frac{1}{4}.\pi.19^2$ = 283,529 mm^2 (luas brutto penampang baut)

$\phi f.R_{ng}$ = 0,75 . 0,4 . 825 . 283,529 = 70173,428 N = 70,173 kN

2. Kuat tarik rencana baut

$\phi f. R_{n,ta} = \phi f . 0,75 . f_{ub} . A_b$

$\phi f.\ R_{n,\,ta} = 0{,}75 \,.\, 0{,}75 \,.\, 825 \,.\, 283{,}529$

$= 131575{,}177\ \text{N} = 131{,}575\ \text{kN}$

3. Kuat tumpu rencana baut

$\phi f.\ R_{n,\,tu} = 2{,}4 \,.\, \phi f \,.\, d_b \,.\, t_p \,.\, f_u$

dengan :

$\phi f.\ R_{n,\,tu}$ = kuat tumpu rencana baut

t_p = 12 mm (tebal pelat buhul)

t_f = 12 mm (tebal profil)

$t_f = t_p$; maka dipakai t_p = 12 mm

$\phi f.\ R_{n,\,tu} = 2{,}4 \,.\, 0{,}75 \,.\, 19 \,.\, 12 \,.\, 370$

$= 151848\ \text{N} = 151{,}848\ \text{kN}$

- Menghitung jumlah baut sambungan

Dari perhitungan di atas, kuat rencana baut yang terkecil adalah kuat baut dalam geser, yaitu: $\phi f.\ R_n = 70{,}173$ kN

Jumlah baut , $n = N_u / (\phi f.\ R_n) = {}^{786{,}0972}\!/_{70{,}173} = 11{,}21$

Jumlah baut

- Vertikal : $n/2 = 5{,}60$ jumlah baut terpasang, $n_p = 6$ baut
- Horizontal : $n/2 = 5{,}60$ jumlah baut terpasang, $n_p = 6$ baut

- Cek kegagalan robekan pada lubang baut

1. Pelelehan geser-robekan tarik

$\phi f.\ T_{n1} = \phi\ (0{,}6 \,.\, f_y \,.\, A_{vg} + f_u \,.\, A_{nt})$

dengan:

$\phi f.\ T_{n1}$ = kekuatan nominal tarik pelat profil pelelehan geser-retakan tarik

ϕ = 0,75

f_y = 240 MPa

$A_{vg} = (s' + (n_p - 1).s)\ .\ t_p$

dengan:

s' = 40 mm (jarak lubang baut dengan tepi pelat profil)

s = 110 mm (jarak antar baut)

$A_{vg} = (40 + (6 - 1).110).12$

= 7080 mm^2 (luas bruto pelelehan geser)

$A_{nt} = (b/2 - (d_b + 1)/2)t_f$

dengan:

b = 200 mm (panjang kaki profil)

$A_{nt} = (200/2 - (19 + 1)/2).12$

= 1080 mm^2 (luas bersih retakan tarik)

$\phi f.\ T_{n1} = 0{,}75(0{,}6\ .\ 240\ .\ 7080 + 370\ .\ 1080)$

= 1064340 N = 1064,34 kN $\geq N_u$ = 786,0972 kN - aman-

2. Retakan geser-pelelehan tarik

$\phi f.\ T_{n2} = \phi\ (0{,}6\ f_u\ .\ A_{ns} + f_y\ .\ A_{tg})$

dengan:

$\phi f.\ T_{n2}$ = kekuatan nominal tarik pelat profil retakan geser- pelelehan tarik

$A_{ns} = (s' + (n_p - 1)s - n_p\ .\ d_b).t_p$

= (40 + (6 – 1)110 – 6 . 19).12 = 5712 mm^2 (luas bersih retakan geser)

$A_{tg} = (l_p/2).t$

$= (200/2).12 = 1200\ mm^2$ (luas kotor pelelehan tarik)

$\phi f.\ T_{n2} = 0{,}75\ (0{,}6\ .\ 370\ .\ 5712 + 240.\ 1200)$

$= 1167048\ N = 1167{,}05\ kN \geq N_u = 786{,}0972\ kN$ -aman-

2. Batang B

Gaya tarik maksimum; $N_u = 396{,}1197\ kN$

- Kekuatan satu baut

1. Kuat geser rencana baut

$\phi f.R_{ng} = \phi f\ .\ r_1\ .\ f_{ub}\ .\ A_b$

$A_b = \frac{1}{4}.\pi.16^2 = 201{,}062\ mm^2$ (luas brutto penampang baut)

$\phi f.R_{ng} = 0{,}75\ .\ 0{,}4\ .\ 825\ .\ 201{,}062$

$= 49762{,}845\ N = 49{,}763\ kN$

2. Kuat tarik rencana baut

$\phi f.\ R_{n,\ ta} = \phi f\ .\ 0{,}75\ .\ d_b\ .\ f_{ub}\ .\ A_b$

$\phi f.\ R_{n,\ ta} = 0{,}75\ .\ 0{,}75\ .\ 825\ .\ 201{,}062$

$= 93305{,}334\ N - 93{,}305\ kN$

3. Kuat tumpu rencana baut

$\phi f.\ R_{n,\ tu} = 2{,}4\ .\ \phi f\ .\ d_b\ .\ t_p\ .\ f_u$

t_p = 12 mm (tebal pelat buhul)

t_f = 8 mm (tebal profil)

$t_f < t_p$; maka dipakai $t_f = 8$ mm

$\phi f.\ R_{n,\ tu} = 2{,}4\ .\ 0{,}75\ .\ 16\ .\ 8\ .\ 370 = 85248\ N = 85{,}248\ kN$

- Menghitung jumlah baut sambungan

Dari perhitungan di atas, kuat rencana baut yang terkecil adalah kuat baut dalam geser, yaitu: $\phi f.\ R_n = 49{,}763$ kN

Jumlah baut , $n = N_u / (\phi f.\ R_n) = {}^{396{,}1197}/_{49{,}763} = 7{,}96$

Jumlah baut

- Vertikal : $n/2 = 3{,}98$ jumlah baut terpasang, $n_p = 4$ baut
- Horizontal : $n/2 = 3{,}98$ jumlah baut terpasang, $n_p = 4$ baut

- Cek kegagalan robekan pada lubang baut

1. Pelelehan geser-robekan tarik

$\phi f.\ T_{n1} = \phi\ (0{,}6\ .\ f_y\ .\ A_{vg} + f_u\ .\ A_{nt})$

$A_{vg} = (s' + (n_p - 1).s)\ .\ t_p$

dengan:

s' = 40 mm (jarak lubang baut dengan tepi pelat profil)

s = 70 mm (jarak antar baut)

$A_{vg} = (40 + (6 - 1).70).8 = 3120\ \text{mm}^2$

$A_{nt} = (b/2 - (d_b + 1)/2)t_f$

dengan:

b = 100 mm (panjang kaki profil)

$A_{nt} = (100/2 - (16 + 1)/2).8 = 332\ \text{mm}^2$

$\phi f.\ T_{n1} = 0{,}75(0{,}6\ .\ 240\ .1440 + 370\ .\ 332)$

$= 429090$ N $= 429{,}09$ kN $\geq N_u = 396{,}1197$ kN - aman-

2. Retakan geser-pelelehan tarik

$\phi f.\ T_{n2} = \phi\ (0{,}6\ .f_u\ .\ A_{ns} + f_y\ .\ A_{tg})$

$A_{ns} = (s' + (n_p - 1)s - n_p\ .\ d_b).t_p$

$= (40 + (6 - 1)70 - 6\ .\ 16).8 = 2352\ mm^2$

$A_{tg} = (l_p/2).t$

$= (100/2).8 = 400\ mm^2$ (luas kotor pelelehan geser)

$\phi f.\ T_{n2} = 0{,}75\ (0{,}6\ .\ 370\ .\ 1056 + 240\ .\ 400)$

$= 463608\ N = 463{,}608\ kN \geq N_u = 396{,}1197\ kN$ -aman-

3. Batang C

Gaya tarik maksimum; $N_u = 12{,}8721$ kN

Profil yang digunakan 2L 80.80.8

- Data- data baut yang digunakan untuk menyambung

Mutu baut non fulldrat A325-X

Tegangan tarik putus baut $f_{ub} = 410$ MPa (baut mutu normal), diameter baut, $d = 12$ mm.

- Kekuatan satu baut

1. Kuat geser rencana baut

$\phi f.R_{ng} = \phi f\ .\ r_1\ .\ f_{ub}\ .\ A_b$

$A_b = \frac{1}{4}.\pi.12^2 = 113{,}097\ mm^2$ (luas brutto penampang baut)

$\phi f.R_{ng} = 0{,}75\ .\ 0{,}4\ .\ 410.\ 113{,}097$

$= 13910{,}931\ N = 13{,}911\ kN$

2. Kuat tarik rencana baut

$\phi f.\ R_{n,\ ta} = \phi f\ .\ 0{,}75\ .\ d_b\ .\ f_{ub}\ .\ A_b$

$\phi f.\ R_{n,\,ta} = 0{,}75 \,.\, 0{,}75 \,.\, 410 \,.\, 113{,}097$

$= 26082{,}996\ \text{N} = 26{,}083\ \text{kN}$

3. Kuat tumpu rencana baut

$\phi f.\ R_{n,\,tu} = 2{,}4 \,.\, \phi f \,.\, d_b \,.\, t_p \,.\, f_u$

t_p = 12 mm (tebal pelat buhul)

t_f = 8 mm (tebal profil)

$t_f < t_p$; maka dipakai t_f = 8 mm

$\phi f.\ R_{n,\,tu} = 2{,}4 \,.\, 0{,}75 \,.\, 12 \,.\, 8 \,.\, 370$

$= 63936\ \text{N} = 63{,}936\ \text{kN}$

- Menghitung jumlah baut sambungan

Dari perhitungan di atas, kuat rencana baut yang terkecil adalah kuat baut dalam geser, yaitu: $\phi f.\ R_n = 13{,}911$ kN

Jumlah baut , $n = N_u \,./(\phi f.\ R_n) = {}^{12{,}8721}\!/_{13{,}911} = 0{,}93$

Jumlah baut

- Vertikal : $n/2 = 0{,}46$ jumlah baut terpasang, $n_p = 2$ baut
- Horizontal : $n/2 = 0{,}46$ jumlah baut terpasang, $n_p = 2$ baut

- Cek kegagalan robekan pada lubang baut

1. Pelelehan geser-robekan tarik

$\phi f.\ T_{n1} = \phi\ (0{,}6 \,.\, f_y \,.\, A_{vg} + f_u \,.\, A_{nt})$

$A_{vg} = (s' + (n_p - 1).s) \,.\, t_p$

dengan:

s' = 40 mm (jarak lubang baut dengan tepi pelat profil)

s = 60 mm (jarak antar baut)

A_{vg} = (40 + (2 – 1).60).8 = 800 mm^2

A_{nt} = (b/2 – (d_b + 1)/2)t_f

dengan:

b = 80 mm (panjang kaki profil)

A_{nt} = (80/2 – (12 + 1)/2).8 = 268 mm^2

$\phi f.\ T_{n1}$ = 0,75(0,6 . 240 .800 + 370 . 268)

= 160770 N = 160,77 kN (untuk satu profil)

$\phi f.\ T_{n1}$ = 2 . 160,77 = 321,54 kN (untuk dua profil) ≥ N_u = 12,9721 kN

- aman-

2. Retakan geser-pelelehan tarik

$\phi f.\ T_{n2} = \phi$ (0,6 f_u . A_{ns} + f_y . A_{tg})

A_{ns} = (s' + (n_p – 1)s – n_p . d_b).t_p

= (40 + (2 – 1)60 – 2. 12).8 = 608 mm^2

A_{tg} = (l_p/2).t

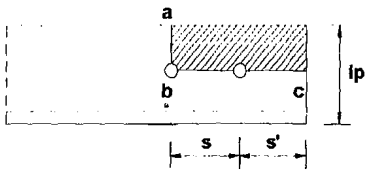
= (80/2).8 = 320 mm^2 (luas kotor pelelehan geser)

$\phi f.\ T_{n2}$ = 0,75 (0,6 . 370 . 608 + 240 . 320)

= 158832 N = 158,832 kN (untuk satu profil)

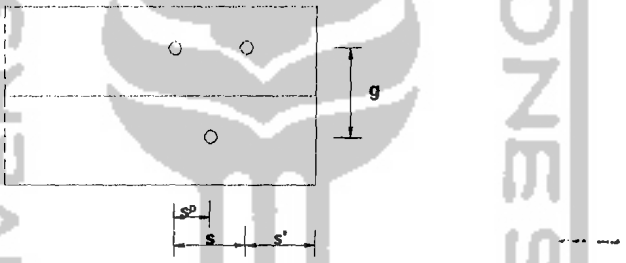
$\phi f.\ T_{n2}$ = 2 . 158,832 = 317,664kN (untuk dua profil) ≥ N_u = 12,9721 kN

-aman-



Gambar 4.47 Daerah yang diarsir dapat terjadi kegagalan robekan

- Cek kuat tarik profil dengan luas netto profil



Gambar 4.48 Profil siku dengan kaki-kaki yang diratakan menjadi satu bidang datar

$\phi f.\, T_{n2} = \phi \,.\, A_{netto} \,.\, f_u$

$A_{netto} = l_p - 2\,(d_p + 1) + (s_p{}^2/4.g)$

$s_p \quad = s/_2 = 60/2 = 30$ mm

$g \quad = g_a + g_b - t_f$

$\quad = b/2 + b/2 - t_f = 80/2 + 80/2 - 8 = 72$ mm

$A_{netto} = 2((2\,.\,80 - 8) - 2(12 + 1) + (30^2/4\,.\,72)).8 = 2066\ \text{mm}^2$

$\phi f.\, T_{n2} = 0{,}75\,.\,2066\,.\,370\,.\,10^{-3}$

$= 573{,}315$ kN $\geq N_u = 12{,}9721$ kN -aman-

4. Batang D

Gaya tarik maksimum; $N_u = 295{,}7023$ kN

Profil yang digunakan 2L 70.70.7

- Data- data baut yang digunakan untuk menyambung

Mutu baut non fulldrat A325-X

Tegangan tarik putus baut $f_{ub} = 825$ MPa (baut mutu tinggi), diameter baut, d = 16 mm.

- Kekuatan satu baut

1. Kuat geser rencana baut

$\phi f.R_{ng} = \phi f \,.\, r_1 \,.\, f_{ub} \,.\, A_b$

$A_b = \frac{1}{4}.\pi.16^2 = 201{,}062$ mm^2 (luas brutto penampang baut)

$\phi f.R_{ng} = 0{,}75 \,.\, 0{,}4 \,.\, 410 \,.\, 201{,}062 \,.\, 10^{-3}$

$= 49{,}763$ kN

2. Kuat tarik rencana baut

$\phi f.\, R_{n,\,ta} = \phi f \,.\, 0{,}75 \,.\, d_b \,.\, f_{ub} \,.\, A_b$

$\phi f.\, R_{n,\,ta} = 0{,}75 \,.\, 0{,}75 \,.\, 825 \,.\, 201{,}062 \,.\, 10^{-3}$

$= 93{,}305$ kN

3. Kuat tumpu rencana baut

$\phi f.\, R_{n,\,tu} = 2{,}4 \,.\, \phi f \,.\, d_b \,.\, t_p \,.\, f_u$

t_p = 12 mm (tebal pelat buhul)

t_f = 7 mm (tebal profil)

$t_f < t_p$; maka dipakai $t_f = 7$ mm

$\phi f.\ R_{n,\,tu} = 2{,}4\ .\ 0{,}75\ .\ 16.\ 7\ .\ 370\ .\ 10^{-3} = 74{,}592$ kN

- Menghitung jumlah baut sambungan

Dari perhitungan di atas, kuat rencana baut yang terkecil adalah kuat baut dalam geser, yaitu: $\phi f.\ R_n = 49{,}763$ kN

Jumlah baut , $n = N_u / (\phi f.\ R_n) = {}^{295{,}7023}\!/_{49{,}763} = 5{,}95$

Jumlah baut

- Vertikal : $n/2 = 2{,}97$ jumlah baut terpasang, $n_p = 3$ baut
- Horizontal : $n/2 = 2{,}97$ jumlah baut terpasang, $n_p = 3$ baut

- Cek kegagalan robekan pada lubang baut

1. Pelelehan geser-robekan tarik

$\phi f.\ T_{n1} = \phi\ (0{,}6\ .\ f_y\ .\ A_{vg} + f_u\ .\ A_{nt})$

$A_{vg} = (s' + (n_p - 1).s)\ .\ t_p$

dengan:

s' = 40 mm (jarak lubang baut dengan tepi pelat profil)

s = 60 mm (jarak antar baut)

$A_{vg} = (40 + (3 - 1).60).7 = 1120$ mm^2

$A_{nt} = (b/2 - (d_b + 1)/2)t_f$

dengan:

b = 70 mm (panjang kaki profil)

$A_{nt} = (70/2 - (16 + 1)/2).7 = 185{,}500$ mm^2

$\phi f.\ T_{n1} = 0{,}75(0{,}6\ .\ 240\ .1120 + 370\ .\ 185{,}500)\ .\ 10^{-3}$

= 172,4365 kN (untuk satu profil)

$\phi f.\ T_{n1} = 2\ .\ 172{,}4365 = 344{,}873$ kN (untuk dua profil) $\geq N_u = 295{,}7023$ kN

- aman-

2. Retakan geser-pelelehan tarik

$\phi f.\ T_{n2} = \phi\ (0{,}6\ f_u\ .\ A_{ns} + f_y\ .\ A_{tg})$

$A_{ns} = (s' + (n_p - 1)s - n_p\ .\ d_b).t_p$

$= (40 + (3 - 1)60 - 3\ .\ 16).7 = 784\ mm^2$

$A_{tg} = (l_p/2).t$

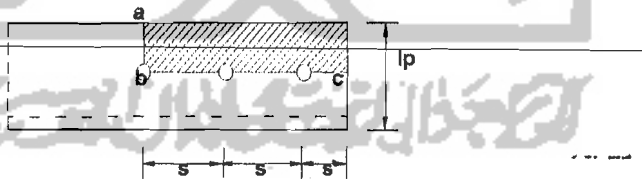
$= (70/2).7 = 245mm^2$ (luas kotor pelelehan geser)

$\phi f.\ T_{n2} = 0{,}75\ (0{,}6\ .\ 370\ .\ 784 + 240\ .\ 245)\ .\ 10^{-3}$

$=$ 174,636 kN (untuk satu profil)

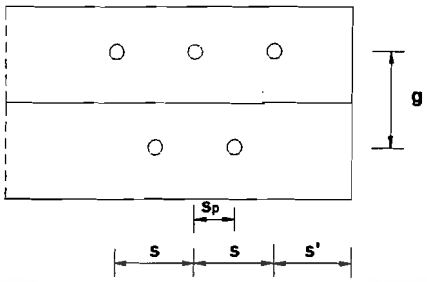
$\phi f.\ T_{n2} = 2\ .\ 174{,}636 = 349{,}272$ kN (untuk dua profil) $\geq N_u = 295{,}7023$ kN

-aman-



Gambar 4.49 Daerah yang diarsir dapat terjadi kegagalan robekan

- Cek kuat tarik profil dengan luas netto profil



Gambar 4.50 Profil siku dengan kaki-kaki yang diratakan menjadi satu bidang datar

$\phi f.\ T_{n2} = \phi\ .\ A_{netto}\ .\ f_u$

$A_{netto} = l_p - 2\ (d_p + 1) + (s_p^2/4.g)$

$s_p \quad = s/_2 = 60/2 = 30$ mm

$g \quad = g_a + g_b - t_f$

$= h/2 + h/2 - t_f = 70/2 + 70/2 - 7 = 63$ mm

$A_{netto} = 2((2\ .\ 70 - 7) - 2(16 + 1) + (30^2/4\ .\ 63)).7 = 1436\ mm^2$

$\phi f.\ T_{n2} = 0{,}75\ .\ 1436\ .\ 370\ .\ 10^{-3}$

$= 398{,}490\ kN \geq N_u = 295{,}7023\ kN$ -aman-

5. Batang E

Gaya tarik maksimum; $N_u = 65{,}5505$ kN

Profil yang digunakan 2L 60.60.6

- Data- data baut yang digunakan untuk menyambung

Mutu baut non fulldrat A325-X

Tegangan tarik putus baut f_{ub} = 825 MPa(baut mutu tinggi), diameter baut, d = 16 mm.

- Kekuatan satu baut

1. Kuat geser rencana baut

$\phi f.R_{ng} = \phi f \,.\, r_1 \,.\, f_{ub} \,.\, A_b$

A_b = ¼.π.16^2 = 201,062 mm^2 (luas brutto penampang baut)

$\phi f.R_{ng}$ = 0,75 . 0,4 . 410. 201,062 . 10^{-3}

= 49,763 kN

2. Kuat tarik rencana baut

$\phi f.\, R_{n,\,ta} = \phi f \,.\, 0{,}75 \,.\, d_b \,.\, f_{ub} \,.\, A_b$

$\phi f.\, R_{n,\,ta}$ = 0,75 . 0,75 . 825 . 201,062 . 10^{-3}

= 93,305 kN

3. Kuat tumpu rencana baut

$\phi f.\, R_{n,\,tu} = 2{,}4 \,.\, \phi f \,.\, d_b \,.\, t_p \,.\, f_u$

t_p = 12 mm (tebal pelat buhul)

t_f = 6 mm (tebal profil)

$t_f < t_p$; maka dipakai t_f = 6 mm

$\phi f.\, R_{n,\,tu}$ = 2,4 . 0,75 . 16. 6. 370 . 10^{-3}

= 63,936 kN

- Menghitung jumlah baut sambungan

Dari perhitungan di atas, kuat rencana baut yang terkecil adalah kuat baut dalam geser, yaitu: $\phi f.\, R_n$ = 49,763 kN

Jumlah baut , $n = N_u / (\phi f.\ R_n) = {}^{65,5503}/_{49,763} = 1,32$

Jumlah baut

- Vertikal : $n/2 = 0,66$ jumlah baut terpasang, $n_p = 1$ baut

- Horizontal : $n/2 = 0,66$ jumlah baut terpasang, $n_p = 1$ baut

- Cek kegagalan robekan pada lubang baut

1. Pelelehan geser-robekan tarik

$\phi f.\ T_{n1} = \phi\ (0,6\ .\ f_y\ .\ A_{vg} + f_u\ .\ A_{nt})$

$A_{vg} = (s' + (n_p - 1).s)\ .\ t_p$

dengan:

s' = 40 mm (jarak lubang baut dengan tepi pelat profil)

s = 60 mm (jarak antar baut)

$A_{vg} = (40 + (1 - 1).60).6 = 240\ mm^2$

$A_{nt} = (b/2 - (d_b + 1)/2)t_f$

dengan:

b = 60 mm (panjang kaki profil)

$A_{nt} = (60/2 - (16 + 1)/2).6 = 129\ mm^2$

$\phi f.\ T_{n1} = 0,75(0,6\ .\ 240\ .240 + 370\ .\ 129)\ .\ 10^{-3}$

= 61,7175 kN (untuk satu profil)

$\phi f.\ T_{n1}$ = 2 . 61,7175 = 123,435 kN (untuk dua profil) $\geq N_u$ = 65,5505 kN

- aman-

2. Retakan geser-pelelehan tarik

$\phi f.\ T_{n2} = \phi\ (0,6\ f_u\ .\ A_{ns} + f_y\ .\ A_{tg})$

$A_{ns} = (s' + (n_p - 1)s - n_p\ .\ d_h).t_p$

$= (40 + (1 - 1)60 - 1 \,.\, 16).6 = 144 \text{ mm}^2$

$A_{tg} = (l_p/2).t$

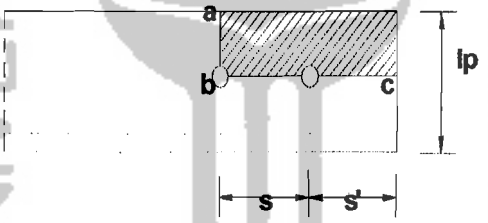
$= (60/2).6 = 180\text{mm}^2$ (luas kotor pelelehan geser)

$\phi f.\ T_{n2} = 0{,}75\ (0{,}6 \,.\, 370 \,.\, 144 + 240 \,.\, 180) \,.\, 10^{-3}$

$= 75{,}168$ kN (untuk satu profil)

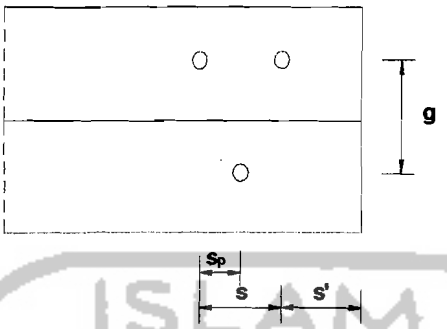
$\phi f.\ T_{n2} = 2 \,.\, 75{,}168 = 150{,}336$ kN (untuk dua profil) $\geq N_u = 65{,}5505$ kN

-aman-



Gambar 4.51 Daerah yang diarsir dapat terjadi kegagalan robekan

- Cek kuat tarik profil dengan luas netto profil



Gambar 4.52 Profil siku dengan kaki-kaki yang diratakan menjadi satu bidang datar

$\phi f.\ T_{n2} = \phi\ .\ A_{netto}\ .\ f_u$

A_{netto} $l_p - 2\ (d_p + 1) + (s_p^2/4.g)$

s_p $= s/2 = 60/2 = 30$ mm

g $= g_a + g_b - t_f$

$= b/2 + b/2 - t_f = 60/2 + 60/2 - 6 = 54$ mm

$A_{netto} = 2((2\ .\ 60 - 6) - 2(16 + 1) + (0^2/4\ .\ 54)).6 = 960\ mm^2$

$\phi f.\ T_{n2} = 0{,}75\ .\ 960\ .\ 370\ .\ 10^{-3}$

$= 266{,}4kN > N_u = 65{,}5505$ kN -aman-

6. Batang H

Gaya tarik maksimum; $N_u = 429{,}8559$ kN

Profil yang digunakan 2L 90.90.9

- Data- data baut yang digunakan untuk menyambung

Mutu baut non fulldrat A325-X

Tegangan tarik putus baut f_{ub} = 825 MPa(baut mutu tinggi), diameter baut, d = 16 mm.

- Kekuatan satu baut

1. Kuat geser rencana baut

$\phi f.R_{ng} = \phi f \,.\, r_1 \,.\, f_{ub} \,.\, A_b$

A_b = ¼.π.16^2 = 201,062 mm^2 (luas brutto penampang baut)

$\phi f.R_{ng}$ = 0,75 . 0,4 . 410. 201,062 . 10^{-3}

= 49,763 kN

2. Kuat tarik rencana baut

$\phi f.\ R_{n,\,ta} = \phi f \,.\, 0{,}75 \,.\, d_b \,.\, f_{ub} \,.\, A_b$

$\phi f.\ R_{n,\,ta}$ = 0,75 . 0,75 . 825 . 201,062 . 10^{-3}

= 93,305 kN

3. Kuat tumpu rencana baut

$\phi f.\ R_{n,\,tu} = 2{,}4 \,.\, \phi f \,.\, d_b \,.\, t_p \,.\, f_u$

t_p = 12 mm (tebal pelat buhul)

t_f = 9 mm (tebal profil)

$t_f < t_p$; maka dipakai t_f = 9 mm

$\phi f.\ R_{n,\,tu}$ = 2,4 . 0,75 . 16. 9 . 370 . 10^{-3}

= 95,904 kN

- Menghitung jumlah baut sambungan

Dari perhitungan di atas, kuat rencana baut yang terkecil adalah kuat baut dalam geser, yaitu: $\phi f.\ R_n$ = 49,763 kN

Jumlah baut , $n = N_u / (\phi f.\ R_n) = {}^{429,8559}/_{49,763} = 8,64$

Jumlah baut

- Vertikal : $n/2 = 4,32$ jumlah baut terpasang, $n_p = 5$ baut

- Horizontal : $n/2 = 4,32$ jumlah baut terpasang, $n_p = 5$ baut

- Cek kegagalan robekan pada lubang baut

1. Pelelehan geser-robekan tarik

$\phi f.\ T_{n1} = \phi\ (0,6\ .\ f_y\ .\ A_{vg} + f_u\ .\ A_{nt})$

$A_{vg} = (s' + (n_p - 1).s)\ .\ t_p$

dengan:

s' = 40 mm (jarak lubang baut dengan tepi pelat profil)

s = 100 mm (jarak antar baut)

$A_{vg} = (40 + (5 - 1).100).9 = 3960\ mm^2$

$A_{nt} = (b/2 - (d_b + 1)/2)t_f$

dengan:

~~b = 90 mm (panjang kaki profil)~~

$A_{nt} = (90/2 - (16 + 1)/2).9 = 328,500\ mm^2$

$\phi f.\ T_{n1} = 0,75(0,6\ .\ 240\ .3960 + 370\ .\ 328,500)\ .\ 10^{-3}$

= 518,84 kN (untuk satu profil)

$\phi f.\ T_{n1} = 2\ .\ 518,84 = 1037,68$ kN (untuk dua profil) $\geq N_u = 429,8559$ kN

- aman-

2. Retakan geser-pelelehan tarik

$\phi f.\ T_{n2} = \phi\ (0,6\ f_u\ .\ A_{ns} + f_y\ .\ A_{tg})$

$A_{ns} = (s' + (n_p - 1)s - n_p\ .\ d_b).t_p$

$= (40 + (5 - 1)100 - 5 \,.\, 16).9 = 3240 mm^2$

$A_{tg} = (l_p/2).t$

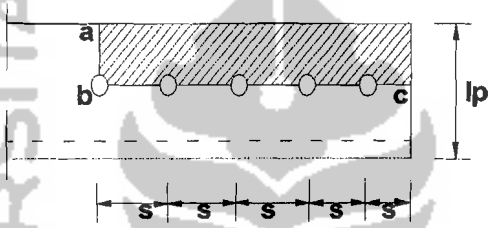
$= (90/2).9 = 405\ mm^2$ (luas kotor pelelehan geser)

$\phi f.\ T_{n2} = 0{,}75\ (0{,}6 \,.\, 370 \,.\, 3240 + 240 \,.\, 405) \,.\, 10^{-3}$

$= 612{,}36$ kN (untuk satu profil)

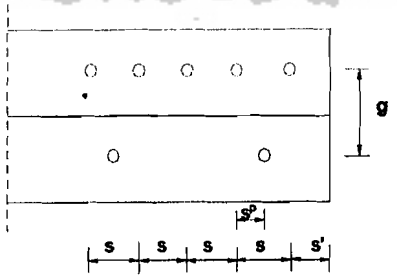
$\phi f.\ T_{n2} = 2 \,.\, 612{,}36 = 1224{,}72$ kN (untuk dua profil) $\geq N_u = 429{,}8559$ kN

-aman-



Gambar 4.53 Daerah yang diarsir dapat terjadi kegagalan robekan

- Cek kuat tarik profil dengan luas netto profil



$\phi f.\ T_{n2} = \phi\ .\ A_{netto}\ .\ f_u$

$A_{netto} = l_p - 2\ (d_p + 1) + (s_p^2/4.g)$

$s_p \quad = s/_2 = 100/2 = 50$ mm

$g \quad = g_a + g_b - t_f$

$= b/2 + b/2 - t_f = 90/2 + 90/2 - 9 = 81$ mm

$A_{netto} = 2((2\ .\ 90 - 9) - 2(16 + 1) + (50^2/4\ .\ 81)).9 = 2604{,}89\ mm^2$

$\phi f.\ T_{n2} = 0{,}75\ .\ 2604{,}89.\ 370\ .\ 10^{-3}$

$= 722{,}857$ kN $\geq N_u = 429{,}8559$ kN -aman-