

BUKU TEKNIK SIPIL

SERI PERENCANAAN

KUDA-KUDA

Konstruksi Kayu

SUTANTO



Cipta ScienceTeam

- tekanan angin $\omega = 73 \text{ kg/m}^2$
- Kuda-kuda terletak diatas tiang-tiang.
- Perletakkan tiang-tiang pada lantai [pondasi] - dianggap sebagai sendi.
- Atap dari genteng
- Kayu kelas kuat II
- Atap tanpa plafond dan bangunan tanpa dinding.
- Jarak kuda-kuda = 4,00 m

$$CF = 2 [3,10] + 2,75 = 6,20 + 2,75 = 8,95 \text{ m}$$

$$\begin{aligned} BC &= \sqrt{8,95^2 + 5,56^2} = \sqrt{80,1025 + 30,877498} \\ &= \sqrt{110,979999} = 10,53704 = 10,53 \text{ m} \end{aligned}$$

Kuda - Kuda Konstruksi Kayu_____ **1**

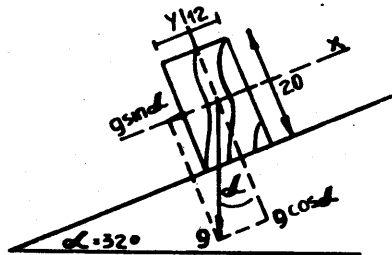
$$\sin \alpha = \frac{EF}{Ec} = \frac{5,56}{10,53} = 0,528$$

$$\alpha = 31^\circ 52' \approx 32^\circ$$

II. Perhitungan gording :

- Jarak kuda-kuda = 4,00 m
- Jarak gording = 2,63 m
- Ukuran gording = 12/20
- Atap dari genteng = 50 kg/m² P.M.I 1970.
- Kayu kelas kuat II --- B.D = 0,5 ton/m³
- Kemiringan atap --- = 32°

A) Perhitungan beban-beban :



a) Berat sendiri.

- Berat sendiri gording 12/20 = 0,12 x 0,20 x 0,6 x 1000 = 14,4 kg/m'
- Berat sendiri genteng+reng+usuk = 50 x 2,63 = 131,5 kg/m'
- g = 145,9 kg/m'
- 146 kg/m'

$$g_x = g \cos \alpha = 146 \cos 32^\circ = 146 \times 0,848048 = 123,81 \text{ kg/m'}$$

$$g_y = g \sin \alpha = 146 \sin 32^\circ = 146 \times 0,529919 = 77,37 \text{ kg/m'}$$

$$M_{x1} = \frac{1}{8} \times g \cos \alpha \times l^2 = \frac{1}{8} \times 123,81 \times 4^2 = 247,62 \text{ kg.m}$$

$$M_{y1} = \frac{1}{8} \times g \sin \alpha \times l^2 = \frac{1}{8} \times 77,37 \times 4^2 = 154,74 \text{ kg.m}$$

b) Beban kebetulan P = 100 kg

$$P_x = P \cos \alpha = 100 \cos 32^\circ = 100 \times 0,848048 = 84,8 \text{ kg}$$

$$P_y = P \sin \alpha = 100 \sin 32^\circ = 100 \times 0,529919 = 52,99 \text{ kg}$$

$$M_{x2} = \frac{1}{4} P \cos \alpha \cdot l = \frac{1}{4} \times 84,8 \times 4 = 84,8 \text{ kg}$$

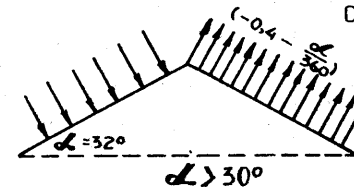
$$M_{y2} = \frac{1}{4} P \sin \alpha \cdot l = \frac{1}{4} \times 52,99 \times 4 = 52,99 \approx 53 \text{ kg.m}$$

$$c. \text{ Beban angin : } W = 73 \text{ kg/m}^2 \quad [\alpha = 32^\circ]$$

$$\text{Cara I : } C = 0,8$$

$$\text{Cara II : } C_1 = 0,5$$

$$C_2 = [-0,4 - \frac{32}{100}] = -0,51$$



$$I] \quad W \text{ isap} = -0,8 \times 73 = -58,4 \text{ kg/m}^2 \quad \text{--- } Q \text{ angin} = -58,4 \times 2,63 = -153,59 \text{ kg/m'}$$

$$II] \quad W \text{ tekan} = +0,5 \times 73 = +36,5 \text{ kg/m}^2$$

$$W \text{ isap} = -0,51 \times 73 = -37,23 \text{ kg/m}^2$$

$$Q \text{ angin} = +36,5 \times 2,63 = 95,995 \text{ kg/m' } \approx 96 \text{ kg/m'}$$

Dihitung arah x saja, karena arah angin ! bidang atap.

$$I]. \quad M_{x3} = \frac{1}{8} q \cdot l^2 = \frac{1}{8} \times 153,59 \times 4^2 = -307,18 \text{ kg.m}$$

$$M_{y3} = 0$$

$$II] \quad M_{x3}' = \frac{1}{8} \times 96 \times 4^2 = 192 \text{ kg.m}$$

$$M_{y3}' = 0$$

Kombinasi pembebanan :

- Untuk (a) + (b)

$$M_x = M_{x1} + M_{x2} = 247,62 + 84,3 = 332,42 \text{ kg.m}$$

$$M_y = M_{y1} + M_{y2} = 154,74 + 53 = 207,74 \text{ kg.m}$$

- Untuk (a) + (b)

$$M_x = M_{x1} + M_{x3}' = 247,62 + 192 = 439,62 \text{ kg.m}$$

$$M_y = M_{y1} + M_{y3}' = 154,74 + 0 = 154,74 \text{ kg.m}$$

B) Kontrol tegangan :

$$\text{Ukuran 12/20} \rightarrow I_x = \frac{1}{12} \times 12 \times 20^3 = 8000 \text{ cm}^4$$

$$I_y = \frac{1}{12} \times 20 \times 12^3 = 2880 \text{ cm}^4$$

$$W_x = \frac{I_x}{\frac{1}{2}h} = \frac{8000}{\frac{1}{2} \times 20} = \frac{8000}{10} = 800 \text{ cm}^3$$

$$W_y = \frac{I_y}{\frac{1}{2}h} = \frac{2880}{\frac{1}{2} \times 12} = \frac{2880}{6} = 480 \text{ cm}^3$$

$$\sigma_o = \frac{M_x}{W_x} + \frac{M_y}{W_y}$$

$$\text{Untuk a] + b] } \rightarrow \sigma_o = \frac{332,42}{800} + \frac{207,74}{480}$$

$$= 41,55 + 43,28$$

$$= 84,83 \text{ kg/cm}^2 < 100 \text{ kg/cm}^2$$

[Kayu kelas kuat II -- $\sigma_k = 100 \text{ kg/cm}^2$]

$$\text{Untuk a] + c] } \rightarrow \sigma_o = \frac{439,62}{800} + \frac{154,74}{480}$$

$$= 54,95 + 32,24$$

$$= 87,19 \text{ kg/cm}^2 < 100 \text{ kg/cm}^2$$

C) Kontrol lendutan :

$$\text{Kayu kelas kuat II} \rightarrow E = 10^5 \text{ kg/cm}^2$$

$$f = \frac{1}{200} L = \frac{1}{200} \times 400 = 2 \text{ cm}$$

Untuk a] + b]

$$f_x = \frac{5}{384} \frac{q \cos \alpha}{E \cdot I_x} l^4 + \frac{1}{48} \frac{P \cos \alpha}{E \cdot I_x} l^3$$

$$= \frac{5}{384} \frac{1,2381 [4 \times 10^2]^4}{10^5 \times 8000} + \frac{84,8 \times [4 \times 10^2]^3}{48 \times 10^5 \times 8000}$$

$$= 0,516 + 0,141 = 0,657 \text{ cm.}$$

$$f_y = \frac{5}{384} \frac{q \sin \alpha}{E \cdot I_y} l^4 + \frac{1}{48} \frac{P \sin \alpha}{E \cdot I_y} l^3$$

$$= \frac{5}{384} \frac{0,7737 \times [400]^4}{10^5 \times 2880} + \frac{53 \times 400^3}{48 \times 10^5 \times 2880}$$

$$= 0,895 + 0,245 = 1,140 \text{ cm}$$

$$f_o = \sqrt{f_x^2 + f_y^2} = \sqrt{0,657^2 + 1,14^2}$$

$$= \sqrt{0,43 + 1,30} = \sqrt{1,73} = 1,31 \text{ cm} < 2 \text{ cm.}$$

Untuk a] + c]

$$f_x = \frac{5}{384} \frac{q \cos \alpha}{E \cdot I_x} l^4 + \frac{5}{384} \frac{q \text{ angin}}{E \cdot I_x} l^4$$

$$= \frac{5}{384} \frac{1,2381}{10^5 \cdot 8000} 4^4 \times 10^2 + \frac{5}{384} \frac{0,96 \times 4^4 \times 10^8}{10^5 \times 8000}$$

$$= 0,52 + 0,4 = 0,92 \text{ cm}$$

$$f_y = \frac{5}{384} \frac{q \sin \alpha}{E \cdot I_y} l^4 + 0$$

$$= \frac{5}{384} \frac{0,7737}{10^5 \times 2880} \times 4^4 \times 10^8 + 0$$

$$= 0,895 + 0 = 0,895 \text{ cm}$$

$$f_o = \sqrt{f_x^2 + f_y^2} = \sqrt{0,92^2 + 0,895^2}$$

$$= \sqrt{0,8464 + 0,8010} = \sqrt{1,6474}$$

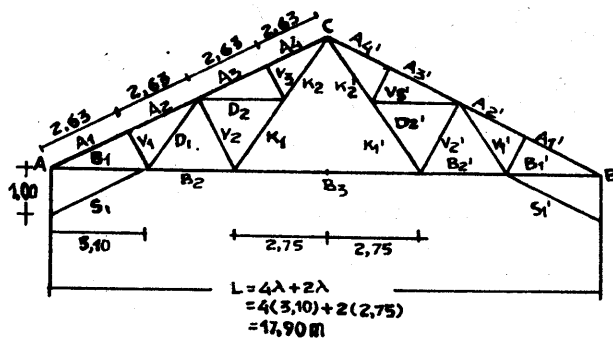
$$= 1,28 \text{ cm} < 2 \text{ cm}$$

kombinasi beban a] + b] yang menentukan ukuran gording 12/20 memenuhi. !!

III] Perhitungan kuda :

$$\cos 32^\circ = 0,848$$

$$\sin 32^\circ = 0,530$$



A) Mencari panjang batang :

- Batang-batang atas : $A_1 = A_2 = A_3 = A_4 = A_4' = A_3' = A_2' = A_1'$
 $= \frac{10,53}{4} = 2,63 \text{ m}$
- Batang-batang bawah : $B_1 = B_2 = B_2' = B_1' = \lambda = 3,10 \text{ m}$
- Batang-batang bawah : $B_3 = 2\lambda = 2 \times 2,75 = 5,50 \text{ m}$
- Batang-batang vertikal : $V_1 = V_3 = V_3' = V_1' = 3,10 \sin 32^\circ = 3,10 \times 0,53 = 1,64 \text{ m}$
- Batang-batang vertikal : $V_2 = V_2' = 6,20 \sin 32^\circ = 6,20 \times 0,53 = 3,28 \text{ m}$
- Batang-batang diagonal : $D_1 = D_2 = D_2' = D_1' = 3,10 \text{ m}$
- Batang-batang K : $K_1 = K_2 = K_2' = K_1' = \lambda = 3,10 \text{ m}$

B) ~~Beban~~-beban :

a) Berat sendiri kuda-kuda :

- Batang-batang atas : $2 \times 6/15 : 2[2 \times 10,06 \times 0,15 \times 10,52 \times 600] = 227,23 \text{ kg}$
- Batang-batang bawah : $1 \times 6/15 : 1[1 \times 0,06 \times 0,15 \times 17,90 \times 600] = 96,66 \text{ kg}$
- Batang-batang vertikal : $2 \times 4/8 : 4[2 \times 0,04 \times 0,08 \times 1,64 \times 600] = 25,19 \text{ kg}$
- Batang-batang vertikal : $2 \times 6/10 : 2[2 \times 0,06 \times 0,10 \times 3,28 \times 600] = 47,23 \text{ kg}$

- Batang-batang diagonal : $2 \times 6/10 : 4[2 \times 0,06 \times 0,10 \times 3,10 \times 600] = 89,28 \text{ kg}$
- Batang-batang diagonal : $2 \times 6/10 : 2[2 \times 0,06 \times 0,10 \times 6,20 \times 600] = 89,28 \text{ kg}$
- Batang-batang diagonal : $2 \times 6/10 : 2[2 \times 0,06 \times 0,10 \times 6,20 \times 600] = 89,28 \text{ kg}$

Berat sendiri kuda-kuda = $1,2 \times 574,87 \text{ kg} = 689,84 \text{ kg}$
 coefisien alat-alat penyambung.

$$P_1 = \frac{689,84}{9} = 76,65 \text{ kg}$$

b) Berat sendiri gording 12/20 :

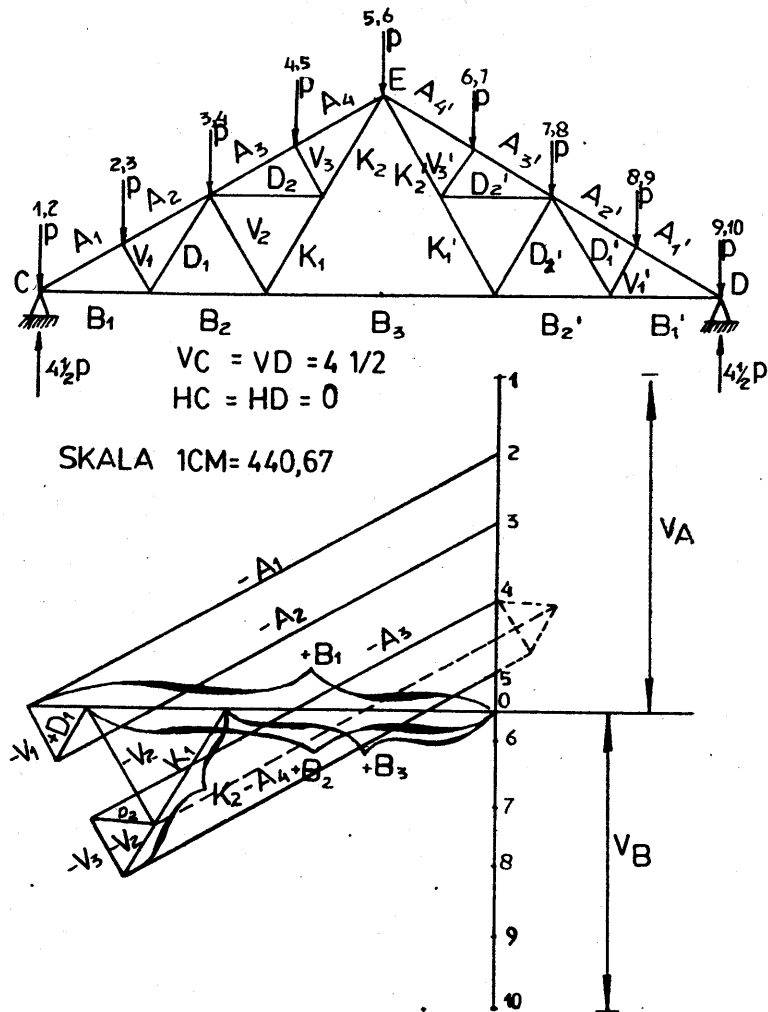
$$0,12 \times 0,20 \times 4,00 \times 600 = 57,6 \text{ kg} \quad \text{---} \quad P_2 = 57,6 \text{ kg}$$

c) Berat sendiri atap genteng :

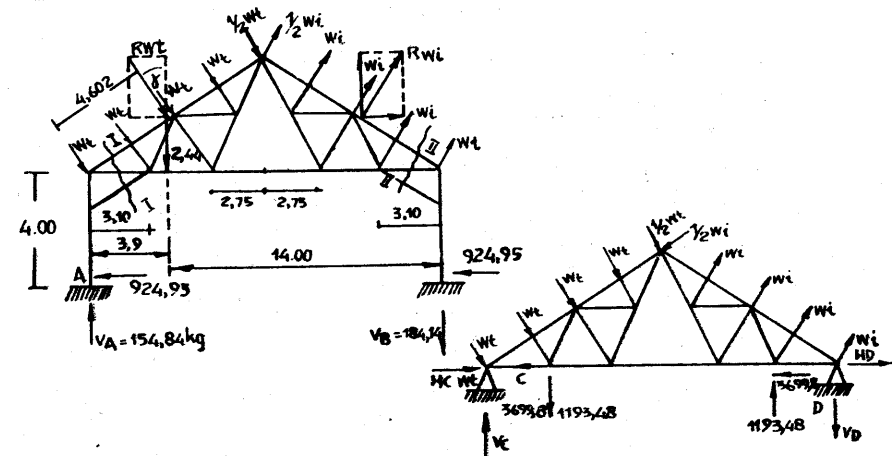
jarak kuda-kuda = 4,00 m
 jarak gording = 2,63 m
 berat atap = 50 kg/m²
 $P_3 = 50 \times 4,00 \times 2,63 = 526 \text{ kg}$

$$\begin{aligned} \text{Gaya pada tiap titik gording} &= P = P_1 + P_2 + P_3 \\ &= 76,65 + 57,6 + 526 \\ &= 660,25 \text{ kg} \quad \hookrightarrow \quad 661 \text{ kg} \end{aligned}$$

CREMONA BERAT SENDIRI



Cremona akibat angin kiri :



Tekanan angin : $w = 73 \text{ kg/m}^2 \rightarrow w_{\text{akan}} = +0,50 \times 73 \times 2,63 \times 4 = 383,98 \text{ kg}$
 $w_{\text{isap}} = -0,51 \times 73 \times 2,63 \times 4 = 391,66 \text{ kg}$

Jarak gording = 2,63 m
 Jarak kuda-kuda = 4,00 m
 $\cos 32^\circ = 0,848$
 $\sin 32^\circ = 0,530$

$C_1 = 0,5$

$C_2 = -0,51$

$Rw_t = 4,5 wt = 4,5 \times 383,98 = 1727,91 \text{ kg}$

$Rw_i = 4,5 wi = 4,5 \times 391,66 = 1762,47 \text{ kg}$

$[Rw_t]V = Rw_t \cos 32^\circ = 1727,91 \cos 32^\circ = 1727,91 \times 0,848 = 1465,27 \text{ kg}$

$[Rw_t]H = Rw_t \sin 32^\circ = 1727,91 \sin 32^\circ = 1727,91 \times 0,530 = 915,79 \text{ kg}$

$[Rw_i]V = Rw_i \cos 32^\circ = 1762,47 \cos 32^\circ = 1762,47 \times 0,848 = 1494,57 \text{ kg}$

$[Rw_i]H = Rw_i \sin 32^\circ = 1762,47 \sin 32^\circ = 1762,47 \times 0,530 = 934,11 \text{ kg}$

$\Sigma H = 0 \rightarrow [Rw_t]H + [Rw_i]H - 2 H_A = 0$

$915,79 + 934,11 - 2 H_A = 0$

$1849,9 = 2 H_A$

$$H_A = H_B = 924,95 \text{ kg [} \leftarrow \text{]}$$

$$\Sigma M_B = 0 \text{ -- } V_A \times 17,90 + RW_t \sin 32^\circ \times 6,44 - RW_t \cos 32^\circ \times 14,00 \\ + RW_i \cos 32^\circ \times 3,9 + RW_i \sin 32^\circ \times 6,44 = 0$$

$$V_A \times 17,90 + 915,79 \times 6,44 - 1465,27 \times 14,00 + 1494, \\ 57 \times 3,9 + 934,11 \times 6,44 = 0$$

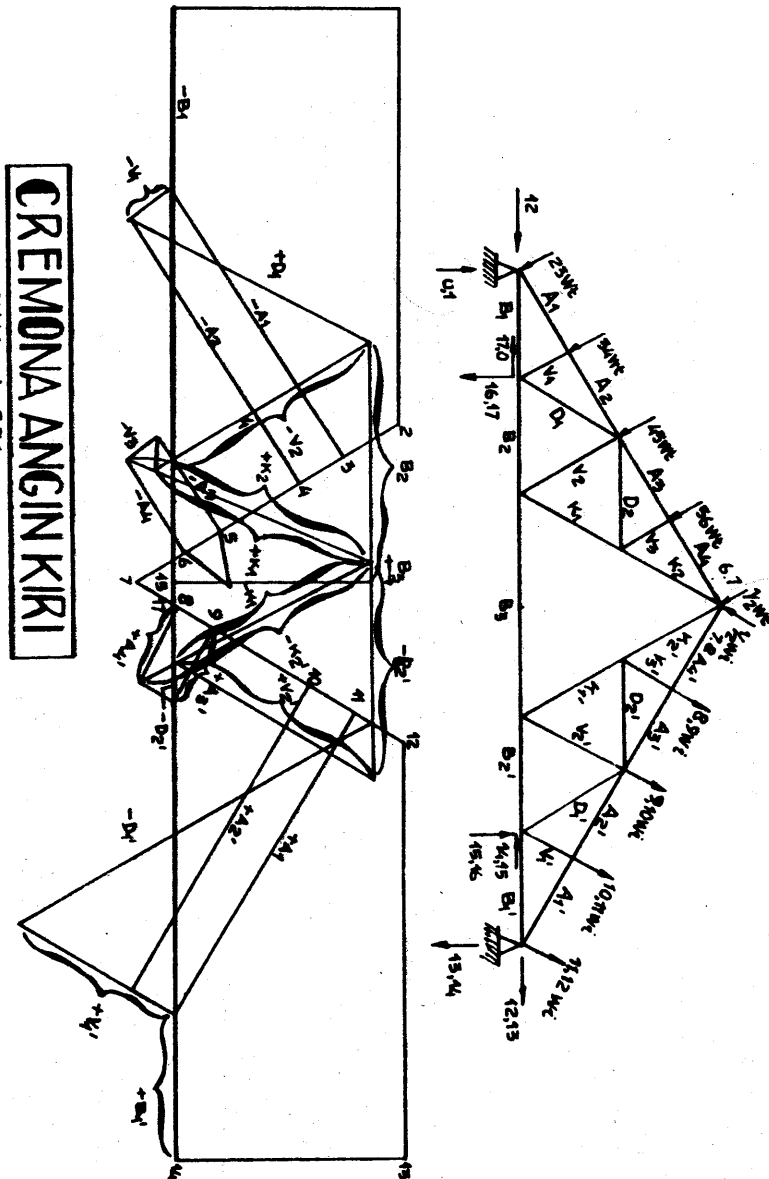
$$17,90 V_A + 5897,69 - 20.513,78 + 5828,82 + 6015,67 = 0$$

$$17,90 V_A + 17742,18 - 20.513,78 = 0$$

$$17,90 V_A = 20.513,78 - 17.742,18 = 2771,60 \text{ --- } V_A =$$

$$\frac{2771,60}{17,90} = 154,84$$

CREMONA ANGIN KIRI
SKAL : 1 : 256



DAFTAR CREMONA

BATANG	BERAT SENDIRI		ANGIN KIRI		ANGIN	KANAN
	TARIK	TEKAN	TARIK	TEKAN	TARIK	TEKAN
A ₁		4362,63		1817,6	2073,6	
A ₂		4032,13		1817,6	2073,6	
A ₃		3666,37		870,4	691,2	
A ₄		3305,02		870,4	691,2	
B ₁	3701,63		1344		1190,4	
B ₂	3181,64		1413,12			1292,8
B ₃	2119,62		25,6		25,6	
V ₁		533,21		384	1152	
V ₂		1123,71		1484,8	1345,2	
V ₃		533,21		396,8	384	
D ₁	506,77		1679,36			1400,32
D ₂	508,42		409,6			358,4
K ₁	1070,83		1400,32			1318,4
K ₂	1586,41		1817,6			1664
A ₁ '		4362,63	2073,6			1817,6
A ₂ '		4032,13	2073,6			1817,6
A ₃ '		3666,37	691,2			870,4
A ₄ '		3305,02	691,2			870,4
D ₁ '	3701,63		1190,4		1344	
D ₂ '	3181,64			-1292,8	1413,12	
V ₁ '		533,21	1152			384
V ₂ '		1123,71	1345,2			1484,8
V ₃ '		533,21	384			396,13
D ₁ '	506,77			1400,32	1679,36	
D ₂ '	508,42			358,4	409,6	
K ₁ '	1070,83			1318,4	1400,32	
K ₂ '	1586,41			1664	1817,6	

Lanjutan halaman 12

EKSTRIM	
TARIK	TEKAN
	6180,23
	5849,73
	4536,77
	4175,42
5045,63	
4594,76	
2145,22	
	917,21
	2608,51
	930,01
2186,13	
918,02	
2471,15	
3404,01	
	6180,23
	5849,73
	4536,77
	4175,42
5045,63	
4594,76	
	917,21
	2608,51
	930,01
2186,13	
918,02	
2471,15	
3404,01	
3890,76	3890,76
3890,76	3890,76

S'	
S ₁ '	
	3890,76
	3890,76
	3890,76
	3890,76

Lanjutan halaman 12

$$V_A = 154,84 \text{ kg}$$

$$\begin{aligned} \sum M_A = 0 \rightarrow & -V_B \cdot 17,9 - R w_i \cos 332^\circ [14,00] + R w_i \sin 32^\circ \\ & [6,44] + R w_t \cos 32^\circ [3,9] + R w_t \sin 32^\circ [6,44] = 0 \\ & -V_B \cdot 17,9 - 1494,57[14,00] + 934,11[6,44] + \\ & 1465,27[3,9] + 915,79[6,44] = 0 \\ & 17,9 V_B = -20.923,98 + 6015,67 + 5714,55 + 5897,69 \end{aligned}$$

$$= -20.923,98 + 17.627,91$$

$$= -3296,07 \text{ kg}$$

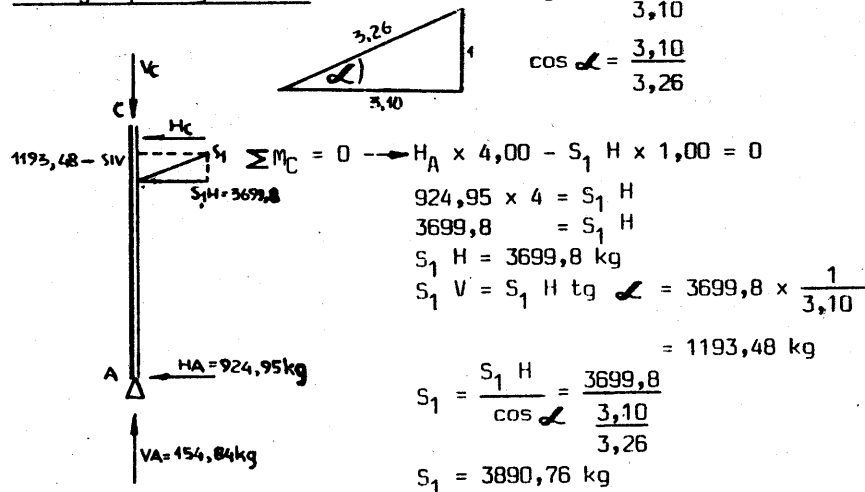
$$V_B = \frac{-3296,07}{17,9} = -184,14 \text{ kg} \quad \downarrow$$

Kontrol : $\sum V = 0$

$$\begin{aligned} V_A - V_B - R w_t \cos 32^\circ + R w_i \cos 32^\circ \\ = 154,84 - 184,14 - 1465,27 + 1494,57 \\ = -29,3 - 1465,27 + 1494,57 \\ = -1494,57 + 1494,57 = 0 \text{ [cocok]} \end{aligned}$$

Menghitung gaya Skur :

Ditinjau potongan I - I



$$\sum H = 0 \rightarrow H_C + H_A - 3699,8 = 0$$

$$H_C + 924,95 - 3699,8 = 0$$

$$H_C = 3699,8 - 924,95 = 0$$

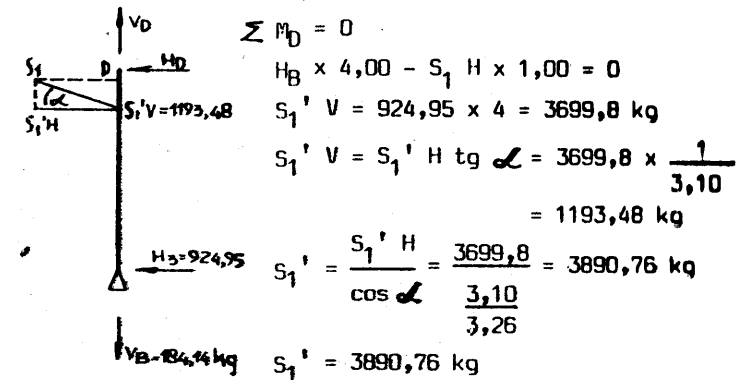
$$H_C = 2774,85 \text{ kg} \quad \leftarrow$$

$$\sum V = 0 \rightarrow V_A + S_1 V - V_C = 0$$

$$154,84 + 1193,48 = V_C$$

$$V_C = 1348,32 \text{ kg} \quad \downarrow$$

Ditinjau potongan II - II :



$$\sum H = 0 \rightarrow H_B + H_D - S_1 H = 0$$

$$924,95 + H_D - 3699,8 = 0$$

$$H_D = 3699,8 - 924,95 = 2774,85 \text{ kg} \quad \leftarrow$$

$$\sum V = 0 \rightarrow V_B + S_1 V - V_D = 0$$

$$V_D = V_B + S_1 V = 184,14 + 1193,48 \text{ kg}$$

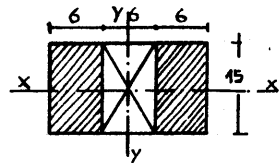
$$= 1377,62 \text{ kg} \quad \downarrow$$

Cremona angin kanan :

Karena bentuk konstruksi adalah symetris, maka gaya-gaya batang - disebelah kiri konstruksi untuk cremona angin kiri = gaya-gaya batang disebelah kanan konstruksi untuk cremona angin kanan, demikian berlaku sebaliknya. Jadi cremona angin kanan tidak perlu diulangi lagi.

F] Mendemensi Batang-batang :

Batang-batang atas :



A_1 s/d A_4 }
 A_1' s/d A_4' } dibuat sama

$S_{\max} = -6180,23 \text{ kg [tekan]}$ --- $A_1 = A_1'$
 $l_k = l = 263 \text{ cm}$

$i_x = 0,289 h = 0,289 \times 15 = 4,335 \text{ cm}$

$i_x = 4,335 \text{ cm}$

$$I_t = 2 \left[\frac{1}{12} h b^3 + a^2 \cdot F \right]$$

$$= 2 \left[\frac{1}{12} \cdot 15 \cdot 6^3 + 6^2 \times 6 \times 15 \right]$$

$$I_t = 2 [3510] = 7020 \text{ cm}^4$$

$$I_g = \frac{1}{12} h [2b]^3$$

$$= \frac{1}{12} \times 15 [12]^3$$

$$I_g = 2160 \text{ cm}^4$$

$$I_y = \frac{1}{12} [7020 + 3 \times 2160]$$

$$I_y = \frac{1}{12} [13.500] = 3375 \text{ cm}^4$$

$$I_y = \sqrt{\frac{3375}{180}} = 4,33 \text{ cm} < i_x$$

[i min]

$$\lambda = \frac{l_k}{i_{\min}} = \frac{263}{4,33} = 60,74 \text{ --- } w = 1,69$$

$$\therefore \sigma_{\text{tek}} = \frac{1,69 \times 6180,23}{180} = \frac{1044,59}{180}$$

$$= 58 \text{ kg/cm}^2 < 85 \text{ kg/cm}^2$$

Jadi : batang 2 x 6/15 memenuhi !

Batang-batang bawah : B_1, B_2, B_3 }
 B_1', B_2' } dibuat sama.

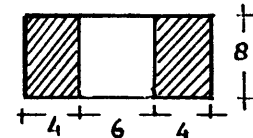
$S_{\max} = B_1 = B_1' = + 5045,53 \text{ kg [tarik]}$

Dipakai : $1 \times 6/15 = F_n = 0,8 \times 6 \times 15$
 $F_n = 72 \text{ cm}^2$

$$\sigma_{fa} = \frac{5045,53}{72} = 70,08 \text{ kg/cm}^2 < 85 \text{ kg/cm}^2$$

Jadi : batang 1 x 6/15 memenuhi !

Batang-batang Vertikal :



V_1, V_3 }
 V_1', V_3' } dibuat sama

$S_{\max} = - 930,01 \text{ kg [tekan]}$

$l_k = 164 \text{ cm}$

$$I_t = 2 \left[\frac{1}{12} \times 8 \times 4^3 + 5^2 \times 32 \right]$$

$$= 1685 \text{ cm}^4$$

$$I_g = \frac{1}{12} h [2b]^3 = \frac{1}{12} \times 8 \times 8^3 = 341 \text{ cm}^4$$

$$I_y = \frac{1}{12} 1685 + 3 \times 341 = 677 \text{ cm}^4$$

$$i_y = \sqrt{\frac{677}{64}} = 3,252 \text{ cm}$$

$$i_x = 0,289 \times h = 0,289 \times 8 = 2,312 \text{ cm}$$

$$< 3,252 \text{ cm}$$

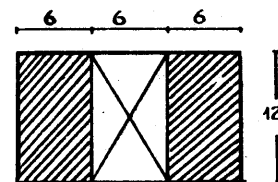
$$i_x = i_{\min}$$

$$\lambda = \frac{l_k}{i_{\min}} = \frac{164}{2,321} = 71 \text{ --- } w = 1,90$$

$$\sigma_{tk} = \frac{1,90 \times 930,01}{64} = 27,61 \text{ kg/cm}^2 < 85 \text{ kg/cm}^2$$

batang 2 x 4/8 memenuhi !

Untuk batang $V_2 = V_2'$



$S_{\max} = - 2608,51 \text{ kg [tekan]}$

$l_k = 328$

$i_x = 0,289 \times h = 0,289 \times 12 = 3,468 \text{ cm}$

$$I_t = 2 \left[\frac{1}{12} \times 12 \times 6^3 + 72 \times 36 \right]$$

$$= 5616 \text{ cm}^4$$

$$I_g = \frac{1}{12} \times 12 \times 12^3 = 1728 \text{ cm}^4$$

$$I_y = \frac{1}{12} [5616 + 3 \times 1728] = 2700 \text{ cm}^4$$

$$i_y = \sqrt{\frac{2700}{144}} = 4,33 > 3,468$$

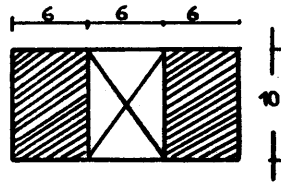
$$i_x = i_{\min}$$

$$\lambda = \frac{328}{3,468} = 94,58 \rightarrow w = 4,01$$

$$\sigma_{tk} = \frac{4,01 \times 2608,51}{144} = 72,64 \text{ kg/cm}^2 < 85 \text{ kg/cm}^2$$

batang : 2 x 6/12 memenuhi !

Batang-batang diagonal :



$$\left. \begin{matrix} D_1, D_2 \\ D_1', D_2' \end{matrix} \right\} \text{dibuat sama}$$

$$S_{\max} = +2186,13 \text{ [tarik]} \rightarrow D_2 = D_2'$$

$$\text{Dipakai : } 2 \times 6/10$$

$$F_n = 0,8 \times 2 \times 6 \times 10 = 96 \text{ cm}^2$$

$$\sigma_{tn} = \frac{P}{F_n} = \frac{2186,13}{96} = 22,77 \text{ kg/cm}^2 < 85 \text{ kg/cm}^2$$

Jadi : batang : 2 x 6/10 memenuhi

Batang-batang K :

$$\left. \begin{matrix} K_1, K_2 \\ K_1', K_2' \end{matrix} \right\} \text{dibuat sama}$$

$$S_{\max} = K_2 = K_2' = 3404,01 \text{ kg [tarik]}$$

$$\text{Dipakai } 2 \times 6/10 \rightarrow F_n = 0,8 \times 2 \times 6 \times 10 = 96 \text{ cm}^2$$

$$\sigma_{tk} = \frac{3404,01}{96} = 35,46 \text{ kg/cm}^2 < 85 \text{ kg/cm}^2$$

Jadi : batang : 2 x 6/10 memenuhi.

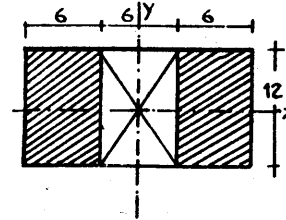
Batang-batang Skur :

$$\text{Gaya batang max} = 3890,76 \text{ kg}$$

$$S_{\max} = 3890,76 \text{ kg}$$

$$l_k = 1 = \sqrt{1^2 + 3,10^2} = \sqrt{1 + 9,61} = \sqrt{10,61} = 3,26 \text{ m} = 326 \text{ cm}$$

$$\text{Dipakai : } 2 \times 6/12 \rightarrow i_x = 0,289 \times 12 = 3,468 \text{ cm}^2$$



$$I_t = 2 \left[\frac{1}{12} \times 12 \times 6^3 + 6^2 \times 72 \right]$$

$$= 2 \{ 2808 \} = 5616 \text{ cm}^4$$

$$I_g = \frac{1}{12} \times 12 \times 12^3$$

$$I_y = \frac{1}{4} \times 5616 + 3 \times 1728 = 2700 \text{ cm}^4$$

$$i_y = \sqrt{\frac{2700}{144}} = 4,330 \text{ cm} > i_x$$

$$i_x = i_{\min} = 3,468 \text{ cm}$$

$$\lambda = \frac{l_k}{i_{\min}} = \frac{326}{3,468} = 94 \rightarrow w = 2,68$$

$$\sigma_{tk} = \frac{2,68 \times 3890,76}{144} = 72,41 \text{ kg/cm}^2 < 85 \text{ kg/cm}^2$$

batang : 2 x 6/12 memenuhi !

G) Menghitung jumlah bout :

- Kayu kelas II : B.D = 0,6

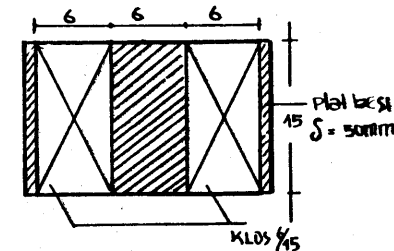
- Muatan tetap : $\eta = 1$

- Konstruksi terlindung : $\phi = 1$

- Sambungan pelat besi : tebal : $\delta = 0,5 \text{ cm}$

bout : $\phi \frac{1}{2} = 1,27 \text{ cm}$

- Batang atas :



Sambungan lempeng

$$P = 40 \text{ d. l. } [1 - 0,6 \sin \alpha] = 40 \times 1,27 \times 6 [1 - 0] = 304,8 \approx 305 \text{ kg}$$

$$P = 215 \text{ d}^2 [1 - 0,35 \sin \alpha] = 215 \times 1,27^2 \times [1 - 0] = 347 \text{ kg}$$

$$P \text{ terkecil} = 305 \text{ kg}$$

Sambungan dengan plat besi : $P = 1,25 \times 305 = 381 \text{ kg}$.

$$p_1 \text{ bout} = 381 \text{ kg}$$

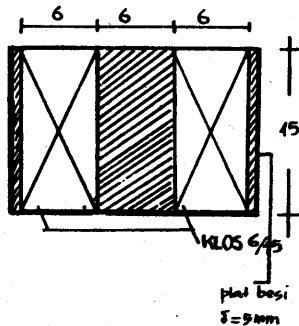
$$- A_1 = A_1' = 6180,23 \text{ kg} \rightarrow n = \frac{1}{381} \times 6180,23 = 8,11 \approx 9 \text{ bout}$$

$$- A_2 = A_2' = 5849,73 \text{ kg} \rightarrow n = \frac{1}{381} \times 5849,73 = 7,67 \approx 8 \text{ bout}$$

$$- A_3 = A_3' = 4536,77 \text{ kg} \rightarrow n = \frac{\frac{1}{2} \times 4536,77}{381} = 5,95 \sim 6 \text{ bout}$$

$$- A_4 = A_4' = 4175,42 \text{ kg} \rightarrow n = \frac{\frac{1}{2} \times 4175,42}{381} = 5,48 \sim 5 \text{ bout}$$

Batang Bawah :

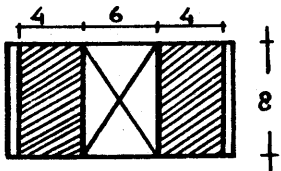


$$- B_1 = B_1' = 5845,63 \text{ kg} \quad n = \frac{5845,63}{868} = 5,81 \sim 6 \text{ bout}$$

$$- B_2 = B_2' = 4594,76 \text{ kg} \quad n = \frac{4594,76}{868} = 5,29 \sim 6 \text{ bout}$$

$$- B_3 = 2145,22 \text{ kg} \quad n = \frac{2145,22}{868} = 2,47 \sim 3 \text{ bout}$$

Batang vertikal :



Sambungan tumpang 1 :

$$\bar{P} = 40 \cdot [1 - 0,6 \sin \alpha]$$

$$= 40 \times 1,27 \times 4 [1 - 0,6 \sin 0] = 203$$

$$\bar{P} = 215 d^2 [1 - 0,35 \sin \alpha]$$

$$= 215 \times 1,27^2 [1 - 0] = 347 \text{ kg}$$

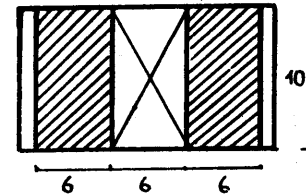
$$\bar{P} \text{ terkecil} = 203 \text{ kg}$$

Sambungan dengan plat besi : $\bar{P} = 1,25 \times 203 = 254 \text{ kg}$

Jadi P_1 bout = 254 kg

$$- V_1 = V_1' = 917,21 \text{ kg} \rightarrow n = \frac{\frac{1}{2} \times 917,21}{254} = 1,8 \sim 2 \text{ bout}$$

$$- V_3 = V_3' = 930,01 \text{ kg} \rightarrow n = \frac{\frac{1}{2} \times 930,01}{254} = 1,83 \sim 2 \text{ bout}$$



Sambungan tumpang 1 :

$$\bar{P} = 40 d \cdot [1 - 0,6 \sin \alpha]$$

$$= 40 \times 1,27 \times 6 \times [1 - 0] = 305 \text{ kg}$$

$$\bar{P} = 215 d^2 [1 - 0,35 \sin \alpha]$$

$$= 215 \times 1,27^2 \times [1 - 0] = 347 \text{ kg}$$

$$\bar{P} \text{ terkecil} = 305 \text{ kg.}$$

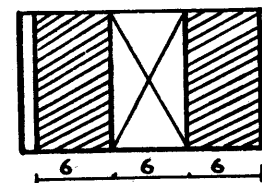
Sambungan dengan plat besi : $\bar{P} = 1,25 \times 305 = 381 \text{ kg}$

Jadi \bar{P}_1 bout = 381 kg

$$- V_2 = V_2' = 2608,51 \text{ kg} \rightarrow n = \frac{\frac{1}{2} \times 2608,51}{381} = 3,42 \sim 4 \text{ bout}$$

Batang diagonal :

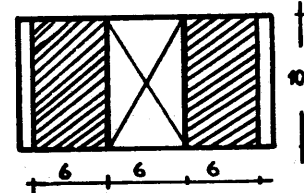
Sudah dihitung : \bar{P}_1 bout = 381 kg [sambung an tumpang 1]



$$D_2 = D_2' = 918,02 \text{ kg} \rightarrow n = \frac{\frac{1}{2} \times 918,02}{381} = 1,2 \sim 2 \text{ bout}$$

$$D_1 = D_1' = 2186,13 \text{ kg} \rightarrow n = \frac{\frac{1}{2} \times 2186,13}{381} = 2,86 \sim 3 \text{ bout}$$

Batang K :

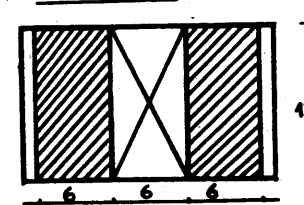


Sudah dihitung \bar{P}_1 bout = 381 kg

$$K_1 = K_1' = 2471,15 \text{ kg} \rightarrow n = \frac{\frac{1}{2} \times 2471,15}{381} = 3,24 \sim 4 \text{ bout}$$

$$K_2 = K_2' = 3404,01 \text{ kg} \rightarrow n = \frac{\frac{1}{2} \times 3404,01}{381} = 4,47 \sim 5 \text{ bout}$$

Batang Skur :



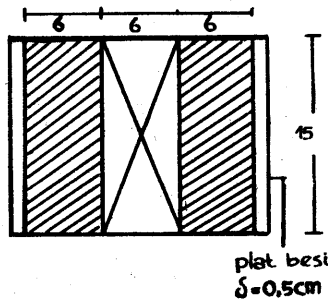
Idem : \bar{P}_1 bout = 381 kg

$$S \text{ max} = 3890,76 \text{ kg}$$

$$h = \frac{\frac{1}{2} \times 3890,76}{381} = 5,10 \sim 6 \text{ bout}$$

H) Kontrol Kekuatan Plat Buhul :

Batang Atas :



$$S_{\max} = A_1 = A_1' = -6180,23 \text{ kg [tekan]}$$

$$h = 15 \text{ cm} \\ \delta = 0,5 \text{ cm} \left\{ I_{\min} = \frac{1}{12} \times 15 \times [0,5]^3 = 0,156 \text{ cm}^4 \right.$$

$$i_{\min} = \sqrt{\frac{0,156}{0,5 \times 15}} = 0,144 \text{ cm}$$

$$\text{Jarak min 2 bout} = 6d = 6 \times 1,27 = 7,62 \text{ cm}$$

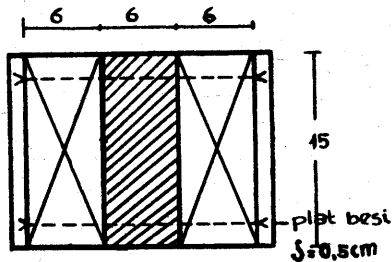
$$\lambda = \frac{10}{0,144} = 69,44 \rightarrow \alpha = 0,675$$

$$\sigma_k = 0,675 \times 1400 = 945 \text{ kg/cm}^2$$

$$\sigma_0 = \frac{\frac{1}{2} \times 6180,23}{0,5 \times 15} = 412 \text{ kg/cm}^2$$

$$\sigma_0 < \sigma_k \rightarrow \text{safe}$$

Batang bawah :



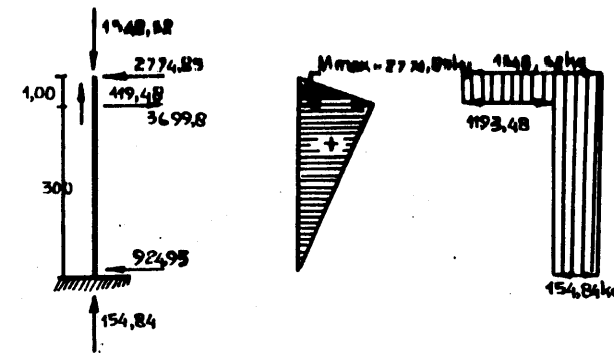
$$S_{\max} = B_1 = B_1' = +5045,63 \text{ kg [tarik]}$$

$$F_n = 0,5 \times [15 - 2 \times 1,27] = 6,23 \text{ cm}^2$$

$$\sigma_0 = \frac{5045,63}{6,23} = 809,9 \text{ kg/cm}^2 < 1400 \text{ kg/cm}^2 \rightarrow \text{safe}$$

Jadi plat buhul tebal 5 mm memenuhi hi. !

Perhitungan kolom :

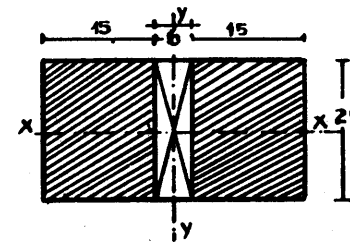


A) Kontrol σ :

$$M_{\max} = 2774,85 \times 1 = 2774,85 \text{ kg.m} = 277485 \text{ kgcm}$$

$$P_{\max} = 1348,32 \text{ kg}$$

$$\text{Dipakai} : 2 \times 15/25$$



$$i_x = 0,209 \text{ h} = 0,209 \times 25 = 7,225 \text{ cm}$$

$$I_t = 2 \left[\frac{1}{12} \times 25 \times 15^3 + 10,5^2 \times 15 \times 25 \right]$$

$$I_t = 96.750 \text{ cm}^4$$

$$I_g = \frac{1}{12} \times 25 \times 30^3 = 56.250 \text{ cm}^4$$

$$I_y = \frac{1}{12} [96.750 + 3 \times 56.250] = 66.375 \text{ cm}^4$$

$$i_y = \sqrt{\frac{66.375}{2 \times 15 \times 25}} = 9,41 \text{ cm} > i_x$$

$$i_x = i_{\min} = 7,225$$

$$\lambda = \frac{l_k}{i_{\min}} = \frac{300}{7,225} = 41,52$$

$$w = 1,385$$

$$\alpha = \frac{\sigma}{\sigma_k} \frac{t_k}{l_k} = \frac{85}{100} = 0,85$$

$$\sigma = \frac{w \cdot P}{F} + \frac{\alpha \cdot M}{w}$$

$$\sigma = \frac{1,385 \times 154,84}{2 \times 15 \times 25} + \frac{0,85 \times 277485}{2 \times \frac{1}{6} \times 15 \times 25^2}$$

