

# **PERENCANAAN** **JEMBATAN KOMPOSIT**

Data data perencanaan:

1. Bentang jembatan :

14m

2. Lebar jembatan :

8m

3. Lebar trotoar :

1m

4. Jarak gelegar memanjang :

2.00m

5. Jenis lantai :

$$\frac{\text{cover, beton}}{\text{cm}^2} := 22.8\text{mpa}$$
$$275 \cdot 0.83 = 228.25$$

6. Mutu beton k-2275( $f_c'$ ) :

360mpa

7. Mutu baja fe-510( $f_y$ ) :

0.2m

8. Tebal pelat lantai :

0.05m

9. Tebal aspal :

10. Tinggi genangan air hujan pada lantai jembatan:

0.05m

11. Modulus elastisitas baja :

200.000mpa

12. Spisifikasi pembebanan :

70 BH(jembatan kelas , 11

13. menurut PPPJJR (Pedoman Perencanaan Pembebanan Jembatan Jalan Raya)

diketahui berat volume untuk:

$$2400 \frac{\text{kg}}{\text{m}^3} (\text{y}^c)$$

Beton :

$$2200 \frac{\text{kg}}{\text{m}^3} (\text{y}^{\text{aspal}})$$

Aspal :

$$1000 \frac{\text{kg}}{\text{m}^3} (\text{y}^w)$$

Air :

## PERENCANAAN PLAT LANTIA JEMBATAN

- Menentukan Lebar Efektif.

$$be := \frac{L}{4}$$

$$\frac{14}{4} \text{m} = 3.5 \text{m}$$

$$be := b_0$$

$$2.00\text{m}$$

- Diambil nilai yang terkecil, maka  $be = 2.00 \text{ m}$

Perhitungan momen lentur

**Akibatbeban mati**

$$t \cdot \text{plat} \cdot \text{be} \cdot y_c$$

slab beton bertulang =

$$0.2 \cdot 2.00 \cdot 2400 \frac{\text{kg}}{\text{m}^3} = 960 \frac{\text{kg}}{\text{m}^3}$$

$$t \cdot \text{aspal} \cdot \text{be} \cdot y_{\text{aspal}}$$

lapisan aspal =

$$0.05 \cdot 2.00 \cdot 2200 \frac{\text{kg}}{\text{m}^3} = 220 \frac{\text{kg}}{\text{m}^3}$$

$$t \cdot \text{air} \cdot \text{be} \cdot y_w$$

genangan air =

$$0.05 \cdot 2.00 \cdot 1000 \frac{\text{kg}}{\text{m}^3} = 100 \frac{\text{kg}}{\text{m}^3}$$

$$Q_{\text{DLL}} := 1280 \frac{\text{kg}}{\text{m}}$$

$$Q_{\text{DLL}} := 12.8 \frac{\text{KN}}{\text{m}}$$

### Akibat beban hidup

Beban hidup yang direncanakan untuk kekuatan lentia kendaraan pada

jembatan adalah beban "T" Baser beban "T" untuk jembatan kelas 11

adalah 70% dan beban truk yang mempunyai roda ganda sebesar 10t

jadi beban "T" =  $10t \cdot 70\% = 7t = 70 \text{ KN}$

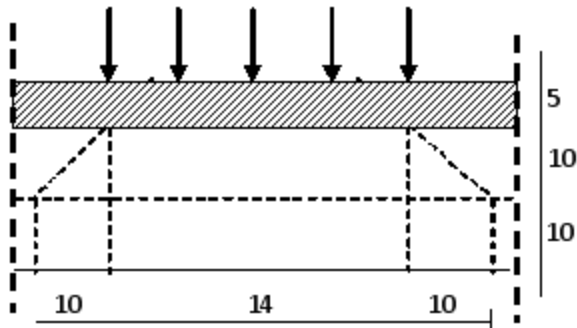
Dalam menggunakan beban "T", lebar bidang kontak antara roda kendaraan dengan

lantai kendaraan untuk pembebanan 70% adalah

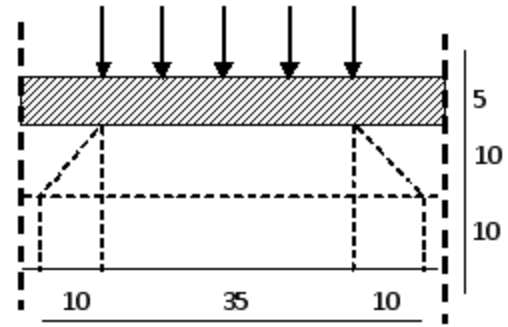
$$a_1 := a_2 = 14 \text{ cm}$$

$$b_1 := 9 \text{ cm}$$

$$b_2 := 35 \text{ cm}$$



Arah memanjang



Arah melintang

Dalam menghitung kekuatan lantai akibat beban "T" dianggap bahwa beban tersebut menyebar

ke bawah dengan arah  $45^\circ$  hingga ke tengah-tengah tebal pelat, maka:

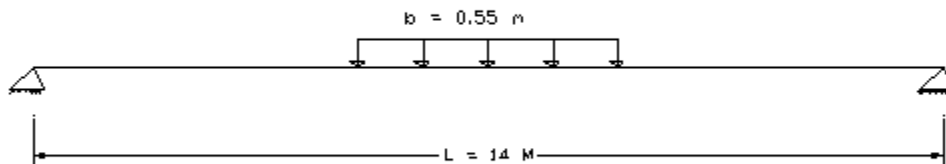
$$a := 0.14 \text{ m} + 2 \cdot 10 \text{ cm}$$

$$a := 0.34 \text{ m}$$

$$b := 0.35 \text{ m} + 2 \cdot 10 \text{ cm}$$

$$b := 0.55 \text{ m}$$

$$0.34 \text{ m}$$



Momen akibat beban roda dihitung sbb:

$$0.55 \text{ m}$$

**Kondisi arah memanjang**

$$Q := \frac{P}{b}$$

$$\frac{70}{0.55} = 127.273$$

$$\frac{\text{kn}}{\text{m}}$$

$$R_a := R_b$$

$$R := \frac{1}{2} \cdot q \cdot b$$

$$\frac{1}{2} \cdot 127.273 \cdot 0.55 = 35$$

$$\text{kN}$$

$$M_{\text{maks}} =$$

$$R_a \cdot \frac{1}{2} \cdot L - \left( \frac{1}{2} \cdot 0.55 \text{m} \right) \cdot \left( \frac{1}{4} \cdot 0.55 \text{m} \right)$$
$$35 \cdot \frac{1}{2} \cdot 14 - 127.273 \cdot \left( \frac{1}{2} \cdot 0.55 \right) \cdot \left( \frac{1}{4} \cdot 0.55 \right) = 240.187$$

$$\text{kn} \cdot \text{m}$$

$$\frac{1}{8} \cdot Q_{\text{LL}} \cdot 14 \text{m}^2$$

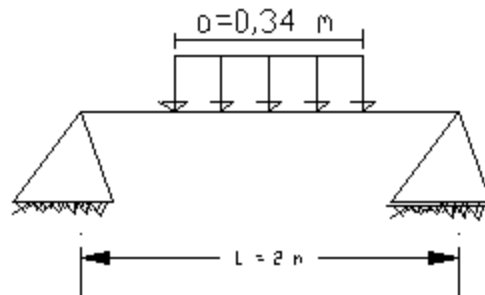
$$M_{\text{maks}} =$$

$$\frac{1}{8} \cdot Q_{\text{LL}} \cdot L^2$$

$$240.187 \text{ kNm} =$$

$$240.187 \text{ kNm} = 24.5 Q_{\text{II}} \text{m}^2$$

$$Q_{\text{II}} = 9.162 \frac{\text{kN}}{\text{m}}$$



### Kondisi Arah Melintang

$$Q := \frac{P}{a} = \blacksquare$$

$$\frac{70}{0.34} = 205.882$$

$$\frac{\text{kN}}{\text{m}}$$

$$R_A := R_B = \blacksquare \cdot \frac{1}{2} \cdot Q \cdot a$$

$$\frac{1}{2} \cdot 205.882 \cdot 0.34 = 35$$

kN

$$M_{\text{maks}} = \blacksquare \cdot R_A \cdot \frac{1}{2} \cdot L - Q \cdot \left(\frac{1}{2} \cdot a\right) \cdot \left(\frac{1}{4} \cdot a\right)$$

$$35 \cdot \frac{1}{2} \cdot (2.00) - 205.882 \cdot \left(\frac{1}{8} \cdot 0.34\right) = 26.25$$

kNm

$$M_{\text{maks}} = \blacksquare \cdot \frac{1}{8} \cdot Q_{LL} \cdot L^2$$

$$\blacksquare := 0.5 \cdot Q_{LL}$$

$$26.25 := \frac{1}{8} \cdot Q_{LL} \cdot 2^2$$

$$Q_{LL} := 52.05 \frac{\text{kN}}{\text{m}}$$

## Membran lentur untuk arah memanjang

$$W_u := 1.2 \cdot Q_{DL} + 1.6 \cdot Q_{LL}$$

$$1.2 \cdot (12.8) + 1.6 \cdot 9.162 = 30.019$$

$\frac{\text{kN}}{\text{m}}$

$\frac{\text{kN}}{\text{m}}$

$$M_u := \frac{1}{8} \cdot w_u \cdot L^2$$

$\text{kN} \cdot \text{m}$

$$\frac{1}{8} \cdot 30.019 \cdot 14^2 = 735.465$$

## Momen lentur untuk arah melintang

$$W_u := 1.2 \cdot Q_{DL} + 1.6 \cdot Q_{LL}$$

$$1.2(12.8) + 1.6 \cdot (52.05) = 98.64$$

$\frac{\text{kN}}{\text{m}}$

$\frac{\text{kN}}{\text{m}}$

$$M_u := \frac{1}{8} \cdot w_u \cdot L^2$$

$$\frac{1}{8} \cdot 98.64 \cdot (2.00)^2 = 49.32$$

$\text{kN} \cdot \text{m}$

## - Tulangan Tarik

Diketahui :

$$b := 1000 \text{ mm}$$

(lebar binjuran pelat)

$$h := 200 \text{ mm}$$

(t. plat)

$$M_{\text{maks}} := 49.32 \text{ kN} \cdot \text{m}$$

Direncanakan menggunakan tulangan

$\phi 22 \text{ mm}$ , maka

$d_c :=$  selimut

beton := 20 mm, maka

$$d := h - d_c - \frac{1}{2} \cdot \phi$$

$$d := 200 - 20 - \frac{1}{2} \cdot 22 = 1 \times 10^3 \frac{1}{\text{m}} \cdot 169 \text{ mm}$$

$$\frac{1.4}{360} = 3.889 \times 10^{-3}$$

$$M := \frac{f_y}{0.85 \cdot (f_c)}$$

$$M := \frac{360}{0.85 \cdot 22.8} = 18.576$$

$$R_n := \frac{M_n}{\phi_{\text{lentur}} \cdot b \cdot a^2}$$

$$R_n := \frac{49.32 \cdot 10^6}{0.8 \cdot 1000 \cdot (169)^2} = 2.159 \times 10^{-3} \frac{\text{s}^2}{\text{kg} \cdot \text{mm}}$$

$$\frac{1.4}{360} = 3.889 \times 10^{-3}$$

$$\rho_{\min} := \sqrt{\frac{f_c}{4 \cdot f_y}} = \blacksquare$$

$$\sqrt{\frac{22.8}{4 \cdot 360}} = 0.126$$

$$\rho_{\min} := 0.126$$

$$\rho := \frac{1}{m} \left[ 1 - \sqrt{1 - \frac{2 \cdot R_n}{0.85 \cdot (f_c)}} \right]$$

$$\rho := \frac{1}{18.576} \cdot \left( 1 - \sqrt{1 - \frac{2 \cdot 2.159}{0.85 \cdot 22.8}} \right) = 1.003 \cdot 0.006357$$

Θ ρ

$$\rho < \rho_{\min}$$

Dipakai ρ = 0.126

$$A_s \text{ perlu} := \rho \cdot b \cdot d$$

$$\blacksquare := 0.123 \cdot 1000 \cdot 169 = \blacksquare \cdot 2078.7 \text{mm}^2$$

$$A_s \text{ ada} := \frac{1}{4} \cdot \pi \cdot 22^2 = 10 \times 10^5 \frac{1}{\text{m}^2} \cdot 380.133 \text{mm}^2$$

-Sperlu

$$\blacksquare := \frac{A_s \text{ ada}}{A_s \text{ perlu}} \cdot b$$

$$\blacksquare := \frac{380.133 \text{mm}^2}{2078.7 \text{mm}^2} \cdot 1000 \text{mm}$$

$$\blacksquare := 182.871 \text{mm}$$

$$A_s := 2078.7 \text{mm}^2$$

$$\frac{2078.7 \cdot 360}{0.85 \cdot 22.8 \cdot 1000} = 38.614$$

**Kontrol Penampang Menahan Momen Lentur**

Keseimbangan gaya dalam:  $C = T$

$$0.85 \cdot f_c \cdot a \cdot b$$

$$= A_s \cdot \text{perlu} \cdot f_y$$

$$\text{Maka, } a := \frac{A_s \cdot \text{perlu} \cdot f_y}{0.85 \cdot f_c \cdot b} = \frac{2078.7 \cdot 360}{0.85 \cdot 22.8 \text{ mpa} \cdot 1000 \text{ mm}}$$

$$a := 38.614 \text{ mm}$$

$$M_n := A_s \cdot \text{perlu} \cdot f_y \cdot \left( d - \frac{a}{2} \right)$$

$$M_n := 2078.7 \text{ mm}^2 \cdot 360 \frac{\text{N}}{\text{mm}^2} \cdot \left( 169 - \frac{38.614}{2} \right)$$

$$M_n := 107.5300701 \cdot \text{N} \cdot \text{mm}$$

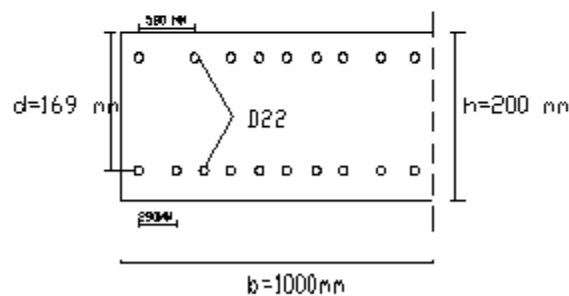
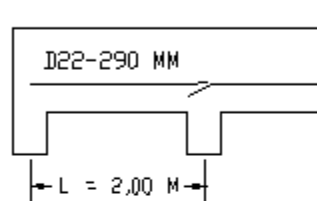
$$M_n := \phi \cdot M_n$$

$$M_n := 0.85 \cdot 107.530.070,1 \text{ N} \cdot \text{mm}$$

$$M_n := 86.02405608 \cdot \text{N} \cdot \text{mm}$$

$$M_n := 86.024 \cdot \text{kN} \cdot \text{m}$$

$$\phi < M_u := 86.99 \text{ KN} \cdot \text{m} \dots \text{ok}!!!!!!!!!!!!!!!!!!!!!!!!!!!!$$



-Tulangan Terik

$$A_{s \text{ perlu}} := \frac{1}{2} \cdot (A_{s \text{ perlu}})$$

$$A_{sperlu} := \frac{1}{2} \cdot 2078.7 \cdot \text{mm}^2$$

$$A_{sperl} = \blacksquare \cdot 1039.35 \text{mm}^2$$

$$S_{perlu} := \frac{380.133 \cdot \text{mm}^2}{1039.35} \cdot 1000 \text{mm}$$

$$S_{perlu} := 365.741 = \blacksquare \cdot 370 \cdot \text{mm}, \blacksquare$$

$$A_s := 1039.35 \text{mm}^2$$

Kontrol Penampang Menahan Momen Lentur.

$$a := \frac{A_s \cdot F_y}{0.85 \cdot f_c \cdot b} = \blacksquare \cdot \frac{1039.35 \cdot 360}{0.85 \cdot 22.8 \cdot \frac{\text{N}}{\text{mm}^2} \cdot 1000 \text{mm}}$$

$$a := 19.307 \text{mm}$$

$$0.8 \left[ 1039.35 \cdot 360 \cdot \left( 169 - \frac{19.307}{2} \right) \right] \cdot 10^6$$

$$\phi \cdot M_n := 0.8 \left[ A_s \cdot f_y \cdot \left( d - \frac{a}{2} \right) \right]$$

$$\phi M_n := 47.7 \text{kN} \cdot \text{m}$$

$$\phi M_n := 47.7 \text{kN} \cdot \text{m} < M_u = \blacksquare \cdot 86.99 \text{KN} \cdot \text{M}$$

## PERENCANAAN GELEGAR

Beban - beban:

a. Beban Mati ( $Q_{DL}$ )

$$Q_{\text{berat}}$$

slab beton =

$$0.2 \cdot 2 \cdot 2400 = 960$$

$$\frac{\text{kg}}{\text{m}}$$

$$\text{m}$$

$$Q_{\text{berat}}$$

lap. aspal =

$$0.05 \cdot 2 \cdot 2200 = 220$$

$$\frac{\text{kg}}{\text{m}}$$

$$\text{m}$$

$$\frac{\text{kg}}{\text{m}}$$

$$\text{m}$$

$$0.05 \cdot 2 \cdot 1000 = 100$$

$Q_{\text{berat}}$

genangan air =

$$25 \frac{\text{kg}}{\text{m}^2} \cdot 14$$
$$= 350 \frac{\text{kg}}{\text{m}}$$

$Q_{\text{berat gelegar}}$  =

$$\text{Total} := 1630 \frac{\text{kg}}{\text{m}}$$
$$Q_{\text{DL}} := 16.30 \frac{\text{KN}}{\text{m}}$$

b. Beban hidup ( $Q_{\text{LL}}$ )

Untuk perhitungan gelegar, susunan beban pada setiap jalur lalu - lintas

terdiri atas beban terbagi merata  $Q$  t/m per jalur

Beban  $Q$  ditentukan sbb :

$$L < 30\text{m}$$

$$Q := 2.2 \frac{\text{t}}{\text{m}}$$

$$Q := 2.2 - \frac{1.1}{60} - (L - 30) \frac{\text{t}}{\text{m}}$$

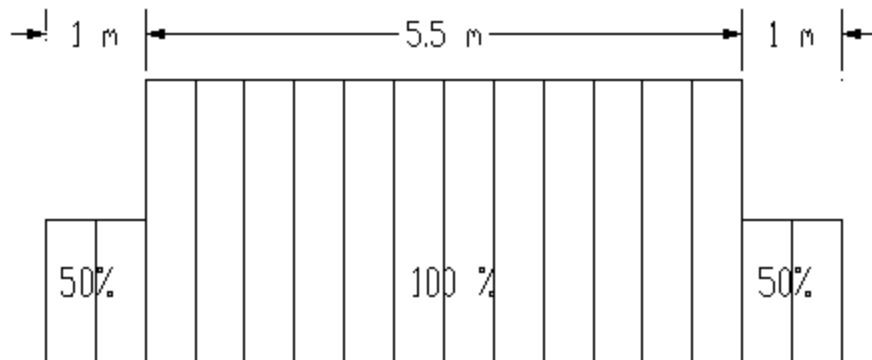
$$30\text{m} < L < 60\text{m}$$

$$Q := 1.1 \left( 1 + \frac{30}{L} \right) \frac{\text{t}}{\text{m}}$$

$$L > 60\text{m}$$

Bila tebal lantai kendaraan pada jembatan lebih besar dari 5,5 m, beban " D " 100%

dikerjakan pada lebar 5,5 m dan selebinnya dibebani beban " D " sebesar 50%



Maka beban hidup per meter lebar jembatan dihitung sbb:

$$\frac{Q \cdot T}{\frac{m}{2.75}}$$

Beban terbagi merata :

⊙ pembagi 2,75 m tetap, tidak tergantung lebar jalur lalu lintas

$$1 + \frac{20}{50 + L} := 1 + \frac{20}{50 + 14} = 1.313$$

Beban kejut (i) =

$$\alpha := 1$$

jika tanpa gelegr melintang.

PPPJJR = No. 12/1970, jembatan kelas 11 , HBH 70% sehingga,

$$\frac{Q}{2.75} \cdot \alpha \cdot s \cdot BH$$

beban terbagi merata,  $Q_{LL} =$

$$\frac{22}{2.75} \cdot 1.2 \cdot 70\% = 11.2$$

$$Q_{LL} := 11.2 \frac{\text{kN}}{\text{M}}$$

$$W_u := 1.2 \cdot Q_{DL} + 1.6 Q_{LL}$$

$$W_u := 1.2 \cdot 16.30 + 1.6(11.2) = 37.48$$

$$W_u := 37.5 \frac{\text{kN}}{\text{M}}$$

$$M_u := \frac{1}{8} \cdot W_u \cdot L^2$$

$$M_u := \frac{1}{8} \cdot 37.5 \cdot 14^2 = 918.75$$

$$M_u := 919 \text{ kN} \cdot \text{M}$$

## PEMILIHAN PROFIL

Asumsikan profile IWF kompak , dimana  $M_n = M_p$

$$\lambda = \lambda_p$$

$$M_n := M_p$$

$$\phi M_n := \phi M_p$$

$$\phi M_n := \phi \cdot b \cdot l_x \cdot f_y$$

$$\phi M_p := \phi \cdot b \cdot f \cdot s_x \cdot f_y$$

$$I := M_n$$

di pakai

$$F := 1.15$$

maka :

$$S_x := \frac{M_n}{\phi \cdot b \cdot f \cdot f_y}$$

$$S_x := \frac{919 \cdot 10^3 \cdot 10^3}{0.9 \cdot 1.15 \cdot 360} = 1 \times 10^3 \cdot 2466$$

$$S_x := 2466 \text{ cm}^3$$

Pemilihan profil ditentukan berdasarkan nilai  $S_x$

Dicoba Profil Baja 1 - 55 , dengan data-data sbb:

$$A := 263 \text{ cm}^2$$

$$b_x := 300 \text{ mm}$$

$$S_x := 2880 \text{ cm}^3$$

$$h := 550 \text{ mm}$$

$$t_w := 16.0 \text{ mm}$$

$$I_x := 140340 \text{ cm}^4$$

$$t_f := 30.0 \text{ mm}$$

$$Q := 207 \frac{\text{kg}}{\text{m}}$$

$$Q := 2.07 \frac{\text{kN}}{\text{m}}$$

$$\lambda := \lambda_p$$

Kelangsingan untuk bagian sayap

..... ok!!!!!!

$$\lambda \leq \lambda_p := \frac{170}{\sqrt{f_y}}$$

$$\lambda := \frac{170}{\sqrt{360}} = 8.96$$

$$\lambda_f := \frac{b}{2 \cdot t_f}$$

$$\lambda_f := \frac{300}{2 \cdot 30.0} = 5$$

Kelangsingan untuk bagian badan

$$\frac{170}{\sqrt{360}} = 8.96$$

$$\lambda \leq \lambda_p := \frac{1680}{\sqrt{f_y}}$$

$$\lambda := \frac{1680}{\sqrt{360}} = 88.544$$

..... ok!!!

$$\lambda_w := \frac{h}{t_w}$$

$$\lambda_w := \frac{550}{16.0} = 34.375$$

Berarti Profil Baja 1 - 55, merupakan penumpang kompak

Memeriksa Syarat kekuatan (Lentur Geser)

Kontrol Lentur (dengan berat sendiri profil)

$$D_L := Q_{DL} + Q$$

$$D_L := 16.30 + 227 \frac{\text{kN}}{\text{m}}$$

$$D_L := 18.57 \frac{\text{kN}}{\text{m}}$$

$$W_u := 1.2 \cdot DL + 1.6 \cdot Q_{LL}$$

$$1.2 \cdot 18.98 + 1.6 \cdot 11.2 = 40.696$$

$$M_u := \frac{1}{8} \cdot 40.696 \cdot 14^2 = 997.052$$

kN·m

$$M_n := M_p$$

$$I := Z_x \cdot f_y$$

$$I := f \cdot S_x \cdot f_y$$

$$M_n := 1.15 \cdot 5220 \cdot 10^3 \cdot 360 = 2.161 \times 10^9$$

$$M_n := 2161 \text{ kN} \cdot \text{m}$$

$$\phi_b \cdot M_n \geq M_u$$

$$0.9 \cdot 2161 \geq 984.998$$

$$1945 \text{ kN} \cdot \text{m} \geq 984.998 \text{ kN} \cdot \text{m} \dots \text{ok!!!!!!}$$

## Kontrol Geser

$$\phi_s \cdot \lambda_n$$

$$I := 0.9 \cdot 0.6 \cdot F_y \cdot A_w$$

$$A_w := [t_w \cdot (H - 2 \cdot t_f)]$$

$$\phi_s \cdot \lambda_n := 0.9 \cdot 0.6 \cdot 360 \cdot 97 \cdot (600 - 2 \cdot 96) = 7.694 \times 10^6$$

$$\phi_s \cdot \lambda_n := 76.94 \text{ KN}$$

$$\lambda_u := \frac{1}{2} \cdot W_u \cdot L$$

$$\lambda_u := \frac{1}{2} \cdot 40.694 \cdot 14 = 2.849 \times 10^5$$

$$\lambda_u := 28.14 \text{ kN}$$

$$\phi_s \cdot \lambda_n > \lambda_u$$

$$76.94 \text{ KN} > 28.14 \text{ KN} \dots \text{ok!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!}$$



$$\bar{\Delta} := \frac{14}{360} = 0.039$$

$$\underline{\Delta} := 39\text{mm}$$

$$\Delta_{\max} := 7.785\text{mm}$$

dan

$$\bar{\Delta} := 39\text{mm}$$

$$\Delta_{\max} \leq \bar{\Delta} \dots\dots\dots \text{ok!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!}$$

$$\Delta_{\max} \geq \underline{\Delta}$$

Berarti profil tidak memenuhi Syarat kekakuan.

Maka , perlu diganti dengan Profil yang lebih besar, kita coba:

Profil 1 - 80 , dengan data - data sbb:

$$A := 342\text{cm}^2$$

$$b := 300\text{mm}$$

$$S_x := 5220\text{cm}^3$$

$$h := 800$$

$$I_x := 366390\text{cm}^4$$

$$t_w := 18$$

$$Q := 268 \frac{\text{kg}}{\text{m}}$$

$$Q := 2.68 \frac{\text{kN}}{\text{m}}$$

$$t_f := 34$$

$$\Delta_{\max} := \frac{5}{384} \cdot \frac{w_u \cdot L^4}{E \cdot I_x}$$

$$\Delta_{\max} := \frac{5}{384} \cdot \frac{40204 \cdot \frac{10^3 \text{N}}{10^3 \text{mm}} \cdot (14 \cdot 10^3 \text{mm})^4}{2 \cdot 10^5 \frac{\text{N}}{\text{mm}^2} \cdot 366.390 \cdot 10^4 \text{mm}^4} = 1 \times 10^3 \text{m} \cdot 27.44$$

$$\underline{\Delta_{\max}} := 27.44\text{mm}$$

$$\Delta_{\max} \leq \bar{\Delta}$$

$$27.44\text{mm} \leq 39\text{mm} \dots\dots\dots \text{ok!!!!!!!!!!!!!!}$$

## PERHITUNGAN TEGANGAN

Menentukan Posisi Garis Netural Penumpang Transformasi (PNA)

⊖ Asumsi PNA di dalam slab ( $a < t_c$ )

Penumpang sembang :  $C = T$

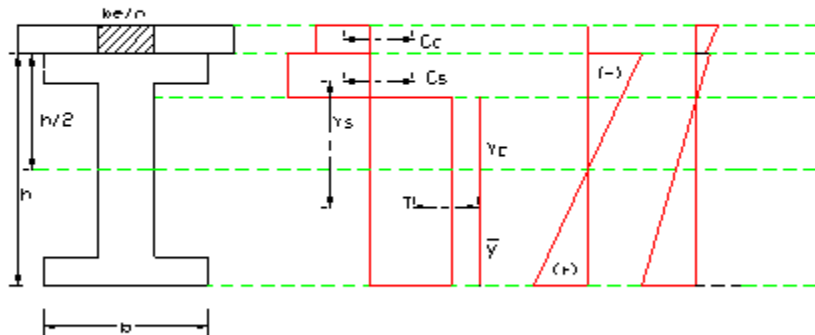
$$0.85 \cdot f_c \cdot a \cdot b_e = A_s \cdot F_y$$

$$a := \frac{A_s \cdot F_y}{0.85 \cdot F_c \cdot b_e}$$

$$a := \frac{342 \cdot 10^2 \text{ mm}^2 \cdot 360 \frac{\text{N}}{\text{mm}^2}}{0.85 \cdot 22.8 \frac{\text{N}}{\text{mm}^2} \cdot 2000 \text{ mm}} = 0.318 \text{ m}$$

$$a_s := 318 \text{ mm}$$

$$a_s > t_c := 200 \text{ mm}$$



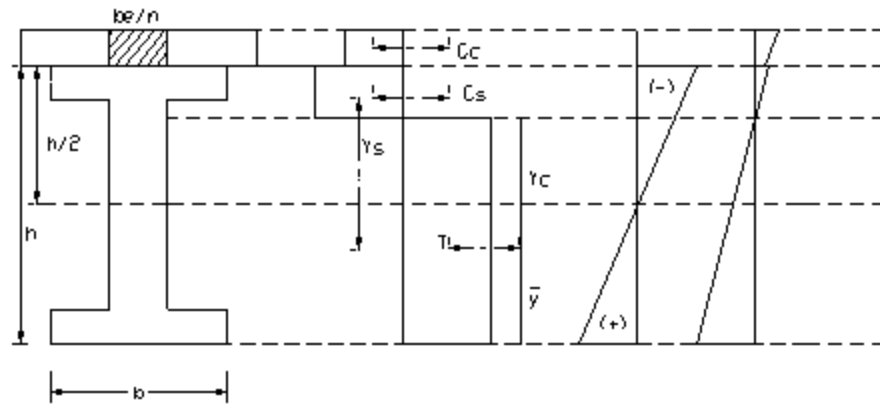
Berarti PNA tidak berada pada beton, kerana  $t_c + t_f = 200 + 34 = 234 \text{ mm}$

Artinya PNA juga tidak berada pada Sayap atas Profil baja, tetapi PNA berada di bagian Profil baja.

$$\sigma_c$$

$$\sigma_{BC}$$

$$\sigma_{BS}$$



$\sigma_a$

$$C_c = 0.85 \cdot F_c \cdot t_c \cdot b_e$$

$$C_c = 0.85 \cdot 22.8 \cdot 200 \cdot 2000$$

$$C_c = 7752 \text{ kN}$$

$$C_s = \frac{1}{2} \cdot A_s \cdot F_y - 0.85 \cdot F_c \cdot b_e \cdot t_c$$

$$C_s = \frac{1}{2} \cdot (342 \cdot 10^2 \cdot 360 - 0.85 \cdot 22.8 \cdot 2000 \cdot 200) = 2.28 \times 10^6$$

$$C_s = 228 \text{ kN}$$

$$\bar{X} = \frac{342 \cdot \frac{1}{2} \cdot 80 - (30 \cdot 3.4) \cdot \left(80 - \frac{1}{2} \cdot 3.4\right)}{342 - (30 \cdot 3.4)} = 23.723$$

$$\bar{X} = \frac{A_s \cdot \frac{1}{2} \cdot h - A_f \cdot \left(h - \frac{1}{2} \cdot t_f\right)}{A_s - A_f}$$

$$\bar{X} = 23.723 \text{ cm}$$

$$Y_c = 66.277 \text{ cm}$$

$$Y_c = h - \bar{X} + \frac{1}{2} \cdot t_c$$

$$Y_c = 80 - 23.723 + \frac{1}{2} \cdot 20 = 66.277$$

$$Y_s = h - \bar{X} - \frac{1}{2} \cdot t_f$$

$$Y_s := 80 - 23.722 + \frac{1}{2} \cdot 3.4 = 57.978$$

$$y_s := 57.978 \text{ cm}$$

$$M_n := C_c \cdot Y_c + C_s \cdot Y_s$$

$$M_n := 7752 \cdot 66.277 + 228 \cdot 57.978 = 5.27 \times 10^5$$

$$M_n := 727 \text{ kN}\cdot\text{m}$$

Kuat Lentur Rencana:

$$\phi_b \cdot M_n := 0.85 \cdot 727 = 617.95$$

kN·m

### ⊖ Mencari Momen Inersia

- Modulus Rasio (n)

	$A(\text{cm})^2$	$Y(\text{cm})$	$A \cdot Y(\text{cm})^3$	$A Y^2(\text{cm})^4$	$I_o(\text{cm})^4$
Slab beton	482	50	24100	1205000	160642,5
Baja	342	0	0	0	366390
$\Sigma$	824	50	24100	1205000	527032,5

$$n := \frac{E_s}{E_c}$$

$$n := \frac{E_s}{0.043 \cdot W^{1.5} \sqrt{F_c}}$$

$$n := \frac{200.000}{0.043 \cdot (2400)^{1.5} \sqrt{22.8}} = 8.285 \times 10^{-3}$$

$$A(\text{cm})^2$$

$$Y(\text{cm})$$

$$A \cdot Y(\text{cm})^3$$

$$A Y^2(\text{cm})^4$$

$$I_o(\text{cm})^4$$

Slab

beton

482

50

24100

1205000

160642.5

$n := 8.3$

Baja

$$\frac{be}{n} := \frac{2000}{8.3} = 240.964$$

mm

342

0

0

0

366390

$\Sigma$

824

50

24100

1205000

527032.5

$$A := \frac{be}{n} \cdot tc$$

$$Y := \frac{1}{2}h + \frac{1}{2}tc$$

$$I_o := \frac{1}{12} \cdot \frac{be}{n} \cdot tc^3$$

### Momen Inersia terhadap garis berat profil baja

$$I_x := \Sigma I_o + \Sigma AY^2$$

$$I_x := 527032.5 + 1205000$$

$$I_x := 1732032.5 \text{ cm}^4$$

Posisi garis netural penumpang komposit

$$\bar{Y} := \frac{\Sigma AY}{\Sigma A}$$

$$\bar{Y} := \frac{24100}{824} = 29.248$$

cm

### Momen inersia terhadap garis berat penumpang komposit

$$I_{tr} := I_x - A \cdot (\bar{Y})^2$$

$$I_{tr} := 1732032.5 - 824 \cdot (29.248)^2$$

$$I_{tr} := 146.459,626 \text{ cm}^4$$

⊖ Perhitungan Tegangan dengan Metode Pelaksanaan Tanpa Sekor / Penmpang

⊖ Balok baja dipasang sebelum beton mengeras (baja berfungsi memikul berat sendiri & plat beton).

Beban Mati ( $Q_{DL}$ )

- Slab beton =

$$be \cdot tc \cdot w := 2m \cdot 0.2m \cdot 2400 \frac{\text{kg}}{\text{m}^3} = 960 \frac{\text{kg}}{\text{m}}$$

- Profil baja =

(tabel baja)

$$\rho := 268 \frac{\text{kg}}{\text{m}}$$

$$Q_{DL} := 1228 \frac{\text{kg}}{\text{m}}$$

$$Q_{DL} := 12.28 \frac{\text{kN}}{\text{m}}$$

$$W_u := 1.4 \cdot Q_{DL}$$

$$W_u := 1.4 \cdot 12.28 = 17.192$$

$$\frac{\text{kN}}{\text{m}}$$

$$M_d := \frac{1}{8} \cdot 17.192 \cdot 14^2 = 421.204$$

kN·m

$$\sigma_{al} := \frac{M_d \cdot \frac{1}{2} \cdot h}{I_x}$$

$$\sigma_{al} := \frac{421.204 \cdot \frac{1}{2} \cdot 0.8}{366.390 \cdot 10^{-8}}$$

$$\sigma_{al} := 4598 \frac{\text{kN}}{\text{m}^2}$$

$$\sigma_{bl} := 4598 \frac{\text{kN}}{\text{m}^2}$$

$$Y_a := \frac{1}{2} \cdot h + \bar{Y}$$

$$Y_a := \frac{1}{2} \cdot 0.8 + 0.29 = 0.69$$

m

$$Y_c := \frac{1}{2} \cdot h - \bar{Y} + t_c$$

$$Y_c := \frac{1}{2} \cdot 0.8 - 0.29 + 0.2 = 0.31$$

m

$$Y_b := y_c - t_c$$

$$Y_b := 0.31 - 0.2 = 0.11$$

m

### Balok baja dipasang pasca beton mengeras (beban hidup bersama oleh baja & pelat beton)

Beban hidup ( $Q_{LL}$ ) = 11.2 kN/m

$$W_u := 1.6 \cdot Q$$

$$W_u := 1.6 \cdot 11.2 = 17.92$$

$\frac{\text{kN}}{\text{m}}$

$$M_1 := \frac{1}{8} \cdot 17.92 \cdot (14)^2 = 439.04 \text{ kN} \cdot \text{m}$$

### Tegangan Beton

$$\sigma_c := \frac{M_1 \cdot Y_c}{n \cdot I_{tr}}$$

$$\sigma_c := \frac{439.04 \cdot 0.31}{8.3 \cdot 145.459,626} = 11.28 \frac{\text{kN}}{\text{m}^2}$$

$$\bar{\sigma}_c := \frac{1}{3} \cdot 275 = 91.667$$

$\frac{\text{kg}}{\text{cm}^2}$

$$\sigma_c < \bar{\sigma}_c := 11.28 < 91.678 \frac{\text{N}}{\text{mm}^2} \dots\dots\dots \text{ok!!!!!!!!!!!!!!}$$

$\frac{1128}{100}$

$$\sigma_{BC} := \frac{M_1 \cdot Y_b}{n \cdot I_{tr}}$$

$$\sigma_{BC} := \frac{439.04 \cdot 0.11}{8.3 \cdot 145.459,626} = 400.1 \frac{\text{kN}}{\text{m}^2}$$

## Teganga Baja

$$\frac{6681}{100} = 66.81$$

$$\sigma_{a2} := \frac{429.04 \cdot 0.69}{145.459626 \cdot 10^{-8}} = 97.705 \frac{1}{\text{Pa}} \cdot 2083 \frac{\text{kN}}{\text{m}^2}$$

$$\sigma_{a2} := \frac{M1 \cdot Y_a}{itr}$$

$$\sigma_{bs} := \frac{M1 \cdot Y_b}{Itr}$$

$$\sigma_{bs} := \frac{439.04 \cdot 0.11}{145.459626 \cdot 10^{-8}} = 9.091 \frac{1}{\text{Pa}} \cdot 3652 \frac{\text{kN}}{\text{m}^2}$$

Tegangan total baja :

$$\sigma_A := \sigma_{A1} + \sigma_{A2}$$

## Perhitungan Tegangan Dengan Metode Pelaksanaan "Dengan Sekor / Penopang"

Balok baja dipasang sebelum beton mengeras (baja dan beton tidak memikul beban)

$$\sigma_A := 4598 + 22.9 = 6.916 \times 10^{-4} \frac{1}{\text{Pa}} \cdot 6681 \frac{\text{kN}}{\text{m}^2}$$

$$\sigma \leq \frac{F_y}{1.5}$$

Balok baja dipasang setelah beton sudah mengeras (seluruh beban dipikul penumpang komposit)

⊖

$$M_D := 421.204 \text{ kN} \cdot \text{m}$$

$$M_L := 439.04 \text{ kN} \cdot \text{m}$$

$$\sigma_A := 66.81 \frac{\text{N}}{\text{mm}^2} \leq \frac{360 \frac{\text{N}}{\text{mm}^2}}{1.5} = 240 \frac{\text{N}}{\text{mm}^2} \dots \text{ok!!!!!!!!!!!!!!!!!!!!!!!!!!!!}$$

$$M := 860.244 \text{ kN} \cdot \text{m}$$

## Tegangan Beton

$$\sigma_c := \frac{M \cdot Y_c}{n \cdot Itr}$$

$$\sigma_c := \frac{860.244 \cdot 0.31}{8.3 \cdot 145.459626 \cdot 10^{-8}} = 2209 \frac{\text{kN}}{\text{m}^2}$$

$$2209 \frac{\text{kN}}{\text{m}^2} \leq 0.85 \cdot \phi \cdot f_c := 15504 \frac{\text{kN}}{\text{m}^2}$$

$$\sigma_{BC} := \frac{M \cdot Y_b}{I_{tr}}$$

$$\sigma_{Bc} := \frac{860.244 \cdot 0.11}{8.3 \cdot 145.459626 \cdot 10^{-8}} = 7838 \frac{\text{kN}}{\text{m}^2}$$

$$7838 \frac{\text{kN}}{\text{m}^2} \leq 0.85 \cdot \phi \cdot f_c := 15504 \frac{\text{kN}}{\text{m}^2} \dots\dots\dots \text{ok!!!!!!!!!!}$$

Tegangan Baja.

$$\sigma_A := \frac{M \cdot Y_a}{I_{tr}}$$

$$\sigma_A := \frac{860.24 \cdot 0.69}{145.459626 \cdot 10^{-8}} = 4081 \frac{\text{kN}}{\text{m}^2}$$

$$4081 \frac{\text{kN}}{\text{m}^2} \leq 0.85 \cdot \phi \cdot F_y := 288000 \frac{\text{kN}}{\text{m}^2}$$

$$\sigma_{BS} := \frac{M \cdot Y_b}{I_{tr}}$$

$$\sigma_{BS} := \frac{860.24 \cdot 0.11}{145.459626 \cdot 10^{-8}} = 6505 \frac{\text{kN}}{\text{m}^2}$$

$$6505 \frac{\text{kN}}{\text{m}^2} \leq \phi \cdot F_y := 288000 \frac{\text{kN}}{\text{m}^2} \dots\dots\dots \text{ok!!!!!!!!!!!!}$$

### PERENCANAAN PENYAMBUNG GESER (SHEAR CONNECTO)

Menghitung Jumlah Sc yang diperlukan

Bila Struktur balok sederhana maka kuat geser perlu (Vnh) diambil dari nilai terkecil dari:

$$c := 0.85 \cdot f_c \cdot b_e \cdot t_c$$

$$T := A_s \cdot f_y$$

$$c_c := 0.85 \cdot (22.8) \cdot 2000 \cdot 200 = 7.752 \times 10^6$$

$$T_s := 342 \cdot 10^2 \cdot 360 = 1.231 \times 10^7$$

$$T_s := 1231 \text{N}$$

$$c_c := 7752 \text{N}$$

$$\Sigma Q_n$$

Direncanakan menggunakan Sc tupa stud berukuran (19 x 75) mm

(ds xNs) sehingga

$$A_{sc} := \frac{1}{4} \cdot \pi \cdot ds^2$$

$$A_{sc} := \frac{1}{4} \cdot 3.14 \cdot (19)^2 = 283.385$$

mm<sup>2</sup>

$$E_c := 0.041 \cdot w^{1.5} \cdot \sqrt{f_c}$$

$$E_c := 2302 \text{ MPa}$$

$$E_c := 0.041 \cdot 2400^{1.5} \cdot \sqrt{22.8} = 2.302 \times 10^4$$

$$Q_n := 0.5 \cdot A_{sc} \cdot \sqrt{f_c \cdot E_c}$$

$$Q_n := 0.5 \cdot 283.385 \cdot \sqrt{22.8 \cdot 2302} = 3.246 \times 10^4$$

$$Q_n := 324.6 \text{ kN}$$

Bila  $\Sigma Q_n$  yang menentukan, maka kekuatan nominal penimpang komposit,

$M_n$  dipengaruhi / ditentukan oleh jumlah  $S_c$  yang dipasang

$$N_s \geq \frac{v_n h}{Q_n}$$

$$\frac{7752}{324.6} = 23.882$$

24 buah

$S_c$  dipasang sepanjang daerah momen positif,  $L'$

$$L_s := 30 \text{ cm}$$

$$L_s := \frac{L}{N_s}$$

$$L_s := \frac{\frac{1}{2} \cdot L}{N_s}$$

$$L_s := \frac{\frac{1}{2} \cdot 1400}{24} = 29.167$$

Batasan

$S_c$

stud

$$N_s \leq 4ds$$

$$75 \leq 4 \cdot 19$$

$$75 \leq 76$$

$$4 \cdot 19 = 76$$

$$6 \cdot ds$$

$$6 \cdot 19 = 114$$

mm

8 · tc

$$8 \cdot 200 = 1.6 \times 10^3$$

1600mm

$$114\text{mm} \leq l_s \leq 1600\text{mm}$$

$$\frac{121.739}{2} = 60.87$$

$$N_s := \frac{14000\text{mm}}{115\text{mm}} = 121.739$$

122buah

Diambil  $l_s = 115$

Tinjauan Longitudinal shear

pada perhitungan tegangan, didapat nilai DL nilia DL diasumsikan sebagai Q, sehingga:

$$Q := DL$$

$$16.55 \frac{\text{kN}}{\text{m}}$$

$$Q_u := 1.4 \cdot DL$$

$$Q_u := 1.4 \cdot 16.55 = 23.17$$

$$\frac{\text{kN}}{\text{m}}$$

$$Du_1 := \frac{1}{2} \cdot Q_u \cdot L$$

$$Du_1 := \frac{1}{2} \cdot 23.17 \cdot 14 = 162.19$$

kN

$$P := LL$$

$$Q := 11.2\text{kN}$$

$$P_u := 1.6 \cdot 11.2 = 17.92$$

$$\frac{\text{kN}}{\text{m}}$$

$$Du_2 := \frac{1}{2} \cdot p_u \cdot L$$

$$Du_2 := \frac{1}{2} \cdot 17.92 \cdot 14 = 125.44$$

kN

Perhitungan D dilakukan menurut 50% beban yang dipikul P baja 100% beban yang dipikul

penampang komposit.

Gaya lintang pada penumpang

$$D_u := 50\% \cdot D_{u_1} + 100\% \cdot D_{u_2}$$

$$D_u := 50 \cdot 162.19 + 100 \cdot 125.44 = 2.065 \times 10^4$$

$$D_u := 206.5 \text{ kN}$$

Statis momen less eksivalan beban terhadap garis netral penampang komposit:

$$S := (t_c \cdot t_c) Y_c$$

$$S := (0.2 \cdot 0.2) \cdot 0.3 = 0.012$$

$$m^3$$

$$V := \frac{D_u \cdot S}{I_{tr}}$$

$$V := \frac{206.5 \cdot 0.012}{1454.59626 \cdot 10^8}$$

$$V := 170.4 \frac{\text{kN}}{m}$$

Bila jarak antar  $S_c = L$ , maka geser yang dipakulnya adalah:

$$V \cdot L \leq Q_n$$

$$L \leq \frac{Q_n}{V}$$

$$\frac{324.6}{170.4} = 1.905$$

$$m$$

Sesuai dengan besarnya harga  $D$  sepanjang balok, maka  $S_c$  dipasang rapat dibagian ujung

dan tenggang di bagian tengah.

Perhitungan Jarak  $L_s$ :

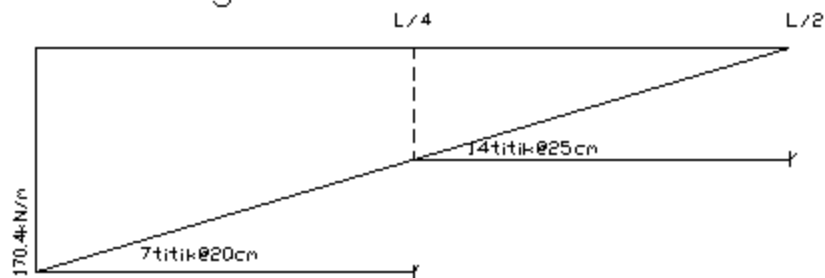
$$N_s := 61$$

buah

$$114 \text{ mm} \leq l_s \leq 1600 \text{ mm}$$

kalou dipasang 2 buah  $S_c$  pada tiap titik, berarti jumlah titik 61 buah

### Perhitungan Jarak Ls:



Pada bentang

0

$$m = \frac{L}{4}$$

diambil

$$L_s := 20$$

cm

$$V_{20} := \blacksquare$$

$$\frac{\frac{L}{2} \cdot Q_n}{L_s} := \frac{\frac{1}{2} \cdot 324.6}{0.2} = 4.86 \times 10^3$$

$$486 \frac{\text{kN}}{\text{m}}$$

pada bentang

$$\frac{L}{4m} = \frac{L}{2m}$$

diambil

$$L_s := 25$$

cm

$$V_{25} := \frac{\frac{1}{2} \cdot 324.6}{0.25} = 649.2$$

$$\frac{\text{kN}}{\text{m}}$$

PENGAJU (STIFFNER)

Pengaku Antara (Intermediate Stiffener)

Pengaku Vertikal pada Pelat beban ini harus dipasang bila  $h/t > 260$  dan di bawah beban terpusat

$$\frac{h}{t} := \frac{h - 2 \cdot t_f}{t_w}$$
$$\frac{800 - 2 \cdot 34}{18} = 40.667$$
$$40.67 < 260$$

tidak ada gaya terpusat, maka :

Pelat beban tidak memerlukan pengaku antara.

b

Pengaku tumpu (Bearing stiffener)

Dipasang pada posisi tumpuan / perletakan, Pengaku ini bersama-sama pelat beban

berfungsi sebagai kolom

$$I_s := 2 \cdot \left( \frac{1}{12} \cdot 1 \cdot 10^3 \cdot 1 + 10 \cdot 5.9^2 \right) + \frac{1}{12} \cdot 21.6 \cdot 1^3 = 864.667$$

cm<sup>4</sup>

$$A := 2 \cdot 1 \cdot 10 + 21.6 \cdot 1.8 = 58.88$$

cm<sup>2</sup>

$$i := \sqrt{\frac{I_s}{A}}$$

$$i := \sqrt{\frac{864.667}{58.88}} = 3.832$$

cm

$$\frac{\frac{3}{4} \cdot 73.2}{3.832} = 14.327$$

$$\lambda := \frac{L_k}{i}$$

$$\lambda := \frac{\frac{3}{4} \cdot h}{i}$$

$$\lambda_g := \pi \cdot \sqrt{\frac{E}{0.7 \cdot f_y}}$$

$$\lambda_g := 3.14 \cdot \sqrt{\frac{2 \cdot 10^5}{0.7 \cdot 360}} = 88.459$$

$$\lambda_s := \frac{\lambda}{\lambda_g}$$

$$\lambda_s := \frac{14.327}{88.459} = 0.162$$

0.162 ≤ 1.2, maka

$$w := \frac{1.41}{1.593 - \lambda_s}$$

$$w := \frac{1.41}{1.593 - 0.162} = 0.985$$

$$\sigma := \frac{w \cdot N}{A}$$

$$\sigma := \frac{0.985 \cdot 303.78}{58.88} = 5.082$$

$$\sigma := 508.2 \frac{\text{kn}}{\text{m}^2}$$

$$\sigma := 50.82 \frac{\text{N}}{\text{mm}^2}$$

$$\sigma < \bar{\sigma}$$

$$\bar{\sigma} := \frac{f_y}{1.5}$$

$$\frac{360}{1.5} = 240$$

Mpa

$$\bar{\sigma} := 240 \frac{\text{N}}{\text{mm}^2}$$

$$50.82 \frac{\text{N}}{\text{mm}^2} < 240 \frac{\text{N}}{\text{mm}^2} \dots\dots\dots \text{ok!!!!!!!!!!!!!!!!!!!!!!!!!!!!!! 1}$$