Material Quantity Calculations:

Top / Bottom Cords — (2 top cords + 2 bottom cords) × cord length × mass / unit length

$$m_C = 4(24m)(35)$$

$$\boxed{m_C = 3360\ kg}$$

Vertical Members —

$$m_V = 14(3)(20)$$

$$\boxed{m_V = 840\ kg}$$

Diagonal Members —

$$m_D = 12(5)(25)$$

$$\boxed{m_D = 1500\ kg}$$

Floor Beams —

$$m_F = 7(3)(45)$$

$$\boxed{m_F = 945\ kg}$$

Longitudinal Stringers —

$$m_S = 3(24)(22)$$

$$\boxed{m_S = 1584\ kg}$$

Total Mass = 3360 kg + 840 kg + 1500 kg + 945 kg + 1584 kg

$$\boxed{= 8220\ kg}$$

Bracing & Connection Allowance (20%) —

$$m_A = 0.2(8229)\ kg$$

$$\boxed{= 1645.8\ kg}$$

Total Structural Steel Mass —

$$m_T = 8229 + 1645.8$$

$$= 9874.8\ kg$$

$$\boxed{m_T = 9.875\ \text{tonnes}}$$

Structural Loading Calculations:

Structural Steel Dead Load –

$$W = mg$$
$$= 9.8748(9.81)$$
$$\boxed{W = 96.87\ kN}$$

$$w_s = \frac{96.87\ kN}{24m}$$

$$\boxed{w_s = 4.0363\ kN/m} \rightarrow \text{Distributed Bridge Load}$$

Total Dead Load –

Deck & Additional –

$$w_d = (1.6 + 0.5)(3)$$ (3 = Bridge width)

$$\boxed{w_d = 6.3\ kN/m}$$

Structural Steel –

$$D = w_s + w_d$$
$$= 4.0363 + 6.3$$
$$\boxed{D = 10.3363\ kN/m}$$

Pedestrian Live Load – (Ped. live load, Bridge width)

$$L = 4(3m)$$
$$\boxed{L = 12 kN/m}$$

Snow Load –

$$S = 2(3m)$$
$$\boxed{S = 6\ kN/m}$$

Service Load Per Truss –

$$w_{service} = \frac{D + L}{2}$$
$$= \frac{10.3363 + 12}{2}$$
$$\boxed{w_{service} = 11.1682\ kN/m}$$

Factored Loading –

Case 1 → Dead/Pedestrian – (Load factors)

$$w_1 = \frac{1.25D + 1.5L}{2}$$ (2 → two trusses)
$$= \frac{1.25(10.3363) + 1.5(12)}{2}$$
$$\boxed{w_1 = 15.46\ kN/m}$$

Case 2 → Dead/snow –

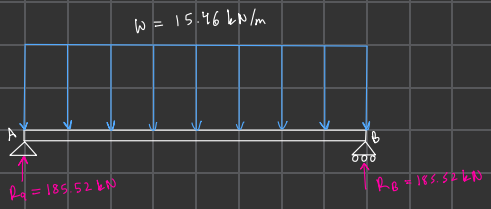
$$w_2 = \frac{1.25(10.3363) + 1.5(6)}{2}$$
$$\boxed{w_2 = 10.96\ kN/m}$$

Largest theoretical load according to cases –

$$\boxed{w_u = 15.46\ kN/m}$$

Support Reactions & Truss Analysis :

FBD –



Total Applied Load –

$$W = w_u L$$
$$= 15.46(24)$$
$$W = 371.0449 \text{ kN}$$

Moment about Support A –

$$\circlearrowleft \sum M_A = 0$$
$$R_B(24) - 371.0449(12) = 0$$
$$R_B = 185.52 \text{ kN}$$

Vertical Forces –

$$\uparrow \sum F_y = 0$$
$$R_A + 185.52 - 371.0449 = 0$$
$$R_A = 185.52 \text{ kN}$$

Horizontal Forces –

$$\rightarrow \sum F_x = 0$$
$$R_{Ax} = 0 \text{ kN}$$

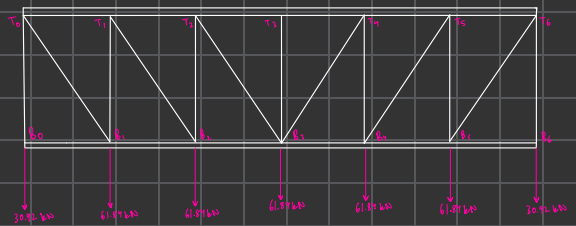
Equivalent Joint Loads –

Full panel load –

$$P_{inner} = w_u L_p$$
$$= 15.46(4)$$
$$P_{inner} = 61.84 \text{kN}$$

Half panel load –

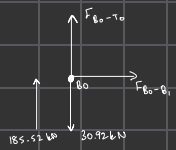
$$P_{outer} = \frac{61.84}{2}$$
$$P_{outer} = 30.92 \text{ kN}$$



$$\uparrow \sum P = 2(30.92) + 5(61.84)$$
$$= 371.04 \text{kN} \quad \checkmark$$

Internal Forces Calculations :

Joints –



$\sum F_y = 0$

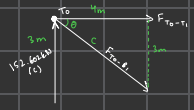
$185.52 - 30.92 + F_{B_0T_0} = 0$

$F_{B_0T_0} = -152.602$

$F_{B_0T_0} = 152.602\ kN\ (C)$

$\sum F_x = 0$

$F_{B_0B_1} = 0\ kN$



$C = \sqrt{3^2 + 4^2}$

$C = 5\ m$

$\theta = \arctan\left(\frac{3}{4}\right)$

$\theta = 36.87°$

$\sum F_y = 0$

$154.602 - F_{T_0B_1}\sin 36.87° = 0$

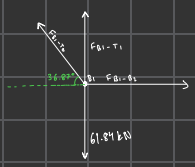
$F_{T_0B_1} = 257.67\ kN\ (T)$

$\sum F_x = 0$

$F_{T_0T_1} + 257.67\cos 36.87° = 0$

$F_{T_0T_1} = -206.14$

$F_{T_0T_1} = 206.14\ kN\ (C)$



$\sum F_x = 0$

$F_{B_1B_2} - 257.67\cos 36.87° = 0$

$F_{B_1B_2} = 206.14\ kN\ (T)$

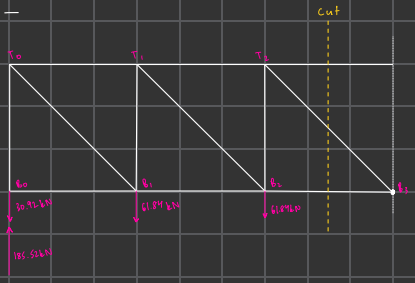
$\sum F_y = 0$

$F_{B_1T_1} - 61.84 + 257.67\sin 36.87° = 0$

$F_{B_1T_1} = -92.76$

$F_{B_1T_1} = 92.76\ kN\ (C)$

Section Cut –



$\sum M_{B_3} = 0$

$-185.52(12) + 30.92(12) + 61.84(8) + 61.84(4) - F_{T_1T_2}(3) = 0$

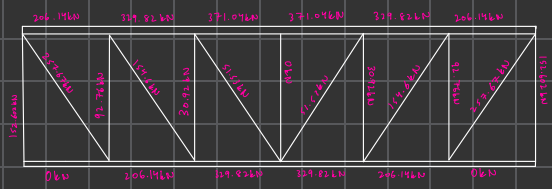
$F_{T_1T_2} = -371.0449$

$F_{T_1T_2} = 371.0449\ kN\ (C)$

$\sum M_{T_2} = 0$

$-185.52(8) + 30.92(8) + 61.84(4) + F_{B_2B_3}(3) = 0$

$F_{B_2B_3} = 329.82\ kN\ (T)$



Shear & Bending Moment:

Shear Force Diagram –

$$V(x) = R_A - W_u x$$

$x = 0\,m$

$$V(0) = 185.52 - 15.46(0)$$

$$= 185.52\,kN$$

$x = 12\,m$

$$V(12) = 185.52 - 15.46(12)$$

$$= 185.52 - 185.52$$

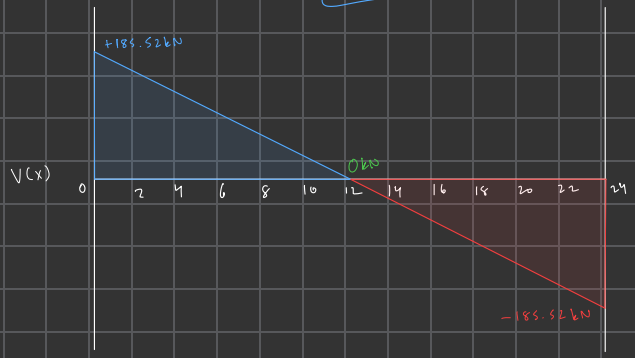
$$= 0\,kN$$

$x = 24\,m$

$$V(24) = 185.52 - 15.46(24)$$

$$= 185.52 - 371.04$$

$$= -185.52\,kN$$

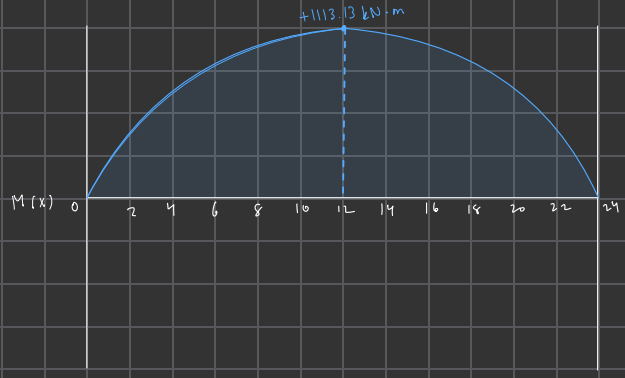


Bending Moment Diagram –

$$M_{max} = \frac{W_u L^2}{8}$$

$$= \frac{15.46(24)^2}{8}$$

$$M_{max} = 1113.13\,kN \cdot m$$



Axial Stress & Elastic Stability :

Max tensile stress –

$$A_t = 4500\ mm^2$$

$$\sigma_t = \frac{F_t}{A_t}$$

$$= \frac{329.82\ (1000)}{4500}$$

$$\boxed{\sigma_t = 73.29\ MPa}$$

Max compressive stress –

$$\sigma_c = \frac{F_c}{A_c}$$

$$= \frac{371.0449\ (1000)}{4500}$$

$$\boxed{\sigma_c = 82.45\ MPa}$$

Diagonal member stress –

$$A_d \quad 3200\ mm^2$$

$$\sigma_d = \frac{257.67\ (1000)}{3200}$$

$$\boxed{\sigma_d = 80.52\ MPa}$$

Euler buckling calculation –

$$E = 200000\ N/mm^2$$

$$I = 9 \times 10^6\ mm^4$$

$$k = 1$$

$$L = 4000mm$$

$$P_{cr} = \frac{\pi^2 EI}{(kL)^2}$$

$$= \frac{\pi^2 (200000)(9 \times 10^6)}{[(1)(4000)]^2}$$

$$\boxed{P_{cr} = 1110.33\ kN}$$

Radius of gyration & slenderness ratio –

$$r = \sqrt{\frac{I}{A}}$$

$$r = \sqrt{\frac{9 \times 10^6}{4500}}$$

$$\boxed{r = 44.72\ mm}$$

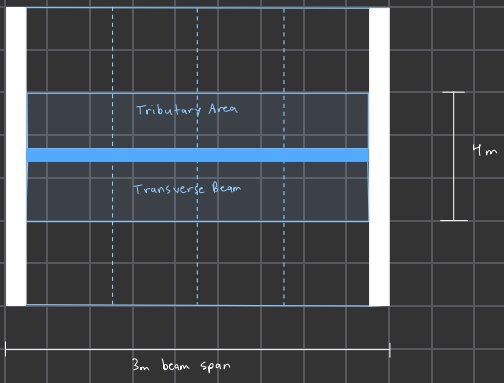
$$\lambda = \frac{kL}{r}$$

$$= \frac{(1)(4000)}{44.72}$$

$$\boxed{\lambda = 89.44}$$

Floor Beam Analysis:

Transverse beam loading –



Total floor beam & stringer mass –

$$m_f = 945 + 1584 = 2529 \text{ kg}$$

Equivalent floor steel area load –

$$q_L = \frac{2529(9.81)}{1000(72)}$$

$$q_L = 0.3446 \text{ kPa}$$

Total floor system dead load –

$$q_D = 1.6 + 0.5 + 0.3446$$

$$q_D = 2.4446 \text{ kPa}$$

Factored illustrative load –

$$q_u = 1.25(2.4446) + 1.5(4)$$

$$q_u = 9.0557 \text{ kPa}$$

Interior beam line load –

$$w_b = q_b L_p$$

$$= (9.0557)(4)$$

$$w_b = 36.2229 \text{ kN/m}$$

Max. floor beam shear –

$$V_{max} = \frac{w_b L_b}{2}$$

$$= \frac{36.2229(3)}{2}$$

$$V_{max} = 54.33 \text{ kN}$$

Max. floor beam bending moment –

$$M_{max} = \frac{w_b L_b^2}{8}$$

$$= \frac{36.2229(3)^2}{8}$$

$$M_{max} = 40.75 \text{ kN.m}$$

Floor beam bending stress —

$$Z = 450000\ mm^3$$

$$\sigma_b = \frac{M_{max}}{Z}$$

$$\sigma_b = \frac{40.75(10^6)}{450000}$$

$$\boxed{\sigma_b = 90.56\ MPa}$$

Floor beam elastic deflection —

$$w = (2.444576 + 4)(4)$$

$$\boxed{w = 25.7783\ N/mm}$$

$$I = 75 \times 10^6\ mm^4$$

$$L_b = 3000\ mm$$

$$\delta_{max} = \frac{5wL_b^4}{384EI}$$

$$= \frac{5(27.7783)(3000)^4}{384(200000)(75\times10^6)}$$

$$\boxed{\delta_{max} = 1.81\ mm}$$

Longitudinal stringer analysis —

$$b_t = \frac{3}{3} = 1\ m$$

$$w = 9.0557(1) = 9.0557\ kN/m$$

$$V_{max} = \frac{9.0557(4)}{2}$$

$$\boxed{V_{max} = 18.11\ kN}$$

$$M_{max} = \frac{9.0557(4)^2}{8}$$

$$\boxed{M_{max} = 18.11\ kN}$$

Truss Deflection Calculation:

Sample calculation for member $T_2 - T_3$ —

$N = -268.03596\,kN$

$n = -2$

$L = 4000\,mm$

$A = 4500\,mm^2$

$$\delta_{T_2-T_3} = \sum_{i=1}^{25} \frac{N_i n_i L_i}{A_i E}$$

$$\delta_{T_2-T_3} = \frac{(-268035.9)(-2)(4000)}{4500(200000)}$$

$$\delta_{T_2-T_3} = 2.3825\,mm$$

For all 25 members —

Top cords	8.4713 mm
Bottom cords	3.7062 mm
Diagonal members	4.3626 mm
Vertical members	1.2062 mm
Total	17.7462

$\delta_{truss} = 17.75\,mm$